



HANFORD SITE

ENVIRONMENTAL REPORT



FOR CALENDAR YEAR 2013

DOE-RL-2013-47, Revision 0

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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

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The cover photo shows purple sage (*Salvia dorei*) taken on the Hanford Site at Gable Butte. The photo is from the U.S. Department of Energy, courtesy of Tom Ferns. The cover design is by Heather Maples, Lockheed Martin Services, Inc. Carol Lynch, Mission Support Alliance, edited the report.

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) 2013. The report also is a DOE resource for communicating environmental protection performance information to the 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 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. 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 2013*.

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 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. [Section 1.0]

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. [Section 1.3]

The Hanford Climate and 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. The average temperature for 2013 was 53.9°F (12.2°C), which is normal. Precipitation totaled 5.38 inches (13.7 centimeters), which is 75 percent of normal precipitation (7.14 inches [18.1 centimeters]). Snowfall for 2013 totaled 2.0 inches (5.1 centimeters), compared to normal snowfall of 15.2 inches

(38.6 centimeters). Average wind speed was 7.4 miles per hour (3.3 meters per second), which was 0.1 mile per hour (0.1 meter per second) below normal. [Section 1.4]

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. [Section 1.5]

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 (WDOH), 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. 1989a](#)) 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 (Tri-Party agencies) 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 2013, 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 1.6]

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 TPA ([Ecology et al. 1989a](#)) (see Section 1.6.1). During 2013, a total of 77 regulatory agency inspections were conducted at DOE facilities on the Hanford Site. Of these, 36 were conducted by Ecology, 36 were conducted by WDOH, 4 were conducted by EPA, Region 10, and 1 was conducted by the city of Richland. Of these inspections there were 10 concerns, 12 findings, and 5 compliance actions issued by the regulators. A total of \$136,000 of fines and penalties

were assessed and paid (see Section 2.10). The 2013 compliance with federal, state, and local laws and regulations include the following:

- **CERCLA Compliance.** Field inspections of institutional controls were conducted in 2013 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 (OU), 221-U Facility, and 200-ZP-1 OU did not identify deficiencies with land-use management, entry restrictions, groundwater management, or warning signs.
- **RCRA Compliance.** Ecology performed 36 [RCRA](#) inspections on the Hanford Site in 2013 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 WDOH, 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 2013, the regulatory agencies conducted over 40 [Clean Air Act](#) inspections at the Hanford Site; those inspections resulted in one Notice of Correction for failure to identify and report all potential pathways for release of radionuclides to the environment, and one Notice of Deficiency associated with the Notice of Construction (NOC) permit for double-shell tank (DST) 241-AW-102 (see Section 2.10).
- **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) 2013, over 1,689 tons (1,717 metric tons) of non-hazardous and hazardous wastes were recycled through Hanford Site programs administered through the Mission Support Contract.
- **Toxic Chemical Release Inventory.** 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 2.4
- **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 2013, there were no events for Category 1, 2, and 3; however, 42 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 (EMS). 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; environmental non-compliances; and greenhouse gas reduction. Objectives for 2013 were achieved for all performance measures except acquisition for alternative fuel vehicles, vehicle fleet reduction target, and standard electricity use; and the acquisition target for alternative fuel vehicles and electronic product

environmental assessment tool was surpassed (Section 3.1). This section also provides information on the Hanford Site awards and recognition for environmental stewardship. The Hanford Site also received one of the 2014 three honorable mentions for the annual Presidential Migratory Bird Stewardship Award from DOE for implementation of the Avian Protection Program. The Avian Protection program is fully integrated with the Hanford NEPA compliance program and the EMS (Section 3.2.1). The Hanford Site did not receive any other federal agency, state agency, or industry-sponsored environmental awards or recognition in 2013; however, individual Hanford contractors won awards for environmental and safety performance (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 2013 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 (MEI) at an offsite location, evaluated by using a multimedia pathway assessment ([DOE O 458.1](#), Section 4.2.1); 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 an MEI 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; 7) Dose to non-human biota (Section 4.2.5).

External Radiation Measurements. During 2013, external radiation fields were monitored in the 100-K Area, 100-N shoreline area (N Springs), 200 Area, 300 Area, 400 Area, and 618-10 Burial Ground were similar to levels measured in 2012 (Section 4.1.1).

100-K Area. Cleanup activities for the K Basins Closure Project during 2013 resulted in similar average dose rates compared to 2012 levels (Figure 4.1). Dose-rate levels in 2013 when compared to 2012 were 4 percent higher in the 100-K East Area, 7 percent higher at the Cold Vacuum Drying Facility (CVDF) and 6 percent higher in the 100-K West Area.

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 2013 average dose rate was slightly higher than in 2012, and was less than 100 mrem (1 millisievert) per year.

200 East and 200 West Areas. Dose rate levels measured during 2013 in the 200 East and 200 West Areas were slightly increased compared to 2012 (Figure 4.1). Average dose rates measured in 2013 at Environmental Restoration Disposal Facility (ERDF) (located near the 200 West Area) were essentially unchanged from 2012 levels.

200 North Area. One thermoluminescent dosimeter (TLD) monitoring site, located in the 200-North Area at the contaminated 212-R Railroad Car Disposition Area, continued to show reduced average dose rate levels in 2013. As in 2012, the 2013 levels were significantly lower than levels measured in 2011 and years previous. 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 2013 in the 300 and 400 Areas and at the 200 Area Treated Effluent Disposal Facility (TEDF) were generally higher by approximately 10 percent compared to 2012 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 2013 were approximately 8 percent higher than 2012 levels.

Integrate Disposal Facility. The average dose rates in 2013 were slightly higher (2 percent) than 2012 levels.

Active and Inactive Waste Disposal Sites Radiological Surveys. During 2013, a total of 924 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 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 mrem (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 2013 releases indicate that the MEI is located at the Pacific Northwest National Laboratory (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 MEI was 0.15 mrem (1.5 microsievert) per year (Section 4.2.1). The average individual dose from Hanford Site operations in 2013, based on the 50-mile (80-kilometer) radius population exposed to air emissions and the Tri-Cities (Richland, Pasco and Kennewick) populations exposed to water pathways releases to the Columbia River, was approximately 0.0070 mrem (0.070 microsievert) per year. To place the average individual estimated dose into perspective, the estimated doses may be compared with doses received from other routinely encountered sources of radiation. The National Council on Radiation Protection (NCRP) issued Report 160 in March 2009 that estimated the overall average exposure to ionizing radiation for the average American to be 620 mrem (6,200 microsievert) per year (National Council on Radiation Protection and Measurements 2009 [NCRP 2009]). Approximately 50 percent of the 620 mrem (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 Hanford Site Property. No property with detectable residual radioactivity above authorized levels was released in 2013 from the Hanford Site (Section 4.3).

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. Over 10,000 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 2013 using these hard-to-detect authorized limits. The estimated total residual radioactivity for these items was less than 5 curies (Section 4.3.1).

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 95,640 pounds (43,380 kilograms) of granular activated carbon was shipped offsite in 2013 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 River Corridor closure, cleanup and remediation, facility decommissioning, waste management operations, 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. During 2013, 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 were completed in 2011 and 2012 to evaluate the impacts from Hanford Site releases to the upland, riparian, and near shore areas of the River Corridor (DOE/RL-2007-21, Vols. I and II, [Part 1](#) and [Part 2](#), Rev. 0). In addition, human health and ecological risk assessments were completed in 2012 to evaluate potential impacts to the Columbia River from Hanford Site releases ([DOE/RL-2010-117, Vols. I and II, Rev. 0](#)). These risk assessment results are reflected in the development of the River Corridor remedial investigation/feasibility study (RI/FS) reports and decisions (Section 5.1.1).

River Corridor RI/FS Process. The RI/FS process is being implemented for six decision areas of the River Corridor established by the Tri-Party agencies (100-B/C, 100-K, 100-N, 100-D/H, 100-F/IU-2/IU-6, and 300 Area). In November 2013, a final action record of decision (ROD) was issued for the 300 Area. Completion of RI/FS reports, public review of proposed actions, and development of RODs for the remaining five decision areas are scheduled during 2014 to 2017. Proposed actions for the 100-F Area are anticipated to undergo public review in the spring of 2014. RI/FS reports for the 100-D/H Area and 100-N Area are anticipated to be finalized in 2014. A schedule for the 100-K Area RI/FS is under negotiation pending completion of additional characterization activities near the reactor. The 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.

Long-Term Stewardship. The long-term stewardship task is focused on documenting completed cleanup actions and facilitating 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. Within the MSA, key elements of the long-term stewardship work scope includes integrating the draft transition and turnover packages provided by the River Corridor Closure contractor and managing the long-term stewardship responsibilities for geographic areas previously transitioned to the MSA.

Transition and turnover packages were completed in 2013 for Segment 5 of the 300 Area Decision Area and the 100-F 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 specific geographic areas.

100 Area Waste Sites. 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 2013 in the 100-B/C, 100-D, 100-K, 100-H, 100-N and IU-2/6 Areas (Section 5.1.2.1).

100-K Basins. 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. 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 2013, remediation activities included facility demolition, waste site remediation, cleanout of the 100-K West Basin, and groundwater pump-and-treat operations. The K West Basin and the CVDF are the only remaining operating nuclear facilities, and the K-West Basin is undergoing cleanout that involves removing radioactive contaminated sludge and debris as a precursor to facility deactivation and demolition (Section 5.1.2.2).

100-K Area Remediation Progress and Accomplishments. In 2013, activity continued on the 105-KE Reactor Building interim safe storage, engineering for reactor penetration sealing and the safe storage enclosure, demolition and disposal of the 183.2-KE Sedimentation and Filter Basins, groundwater pump-and-treat operations, and 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 Canister Storage Building (CSB) for interim storage (Section 5.1.2.3).

200 Area Central Plateau. 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 National Priorities List site. The Central Plateau has a large physical inventory of chemical processing and support facilities, tank systems, liquid- and solid-waste disposal and storage facilities, utility systems, administrative facilities, and groundwater monitoring wells. 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-B, 100-D and 100-N Areas. These actions, summarized below, 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 (18.0 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, removal of plutonium-contaminated process equipment continued in 2013, with a particular focus on removing gloveboxes, associated piping, and ductwork. The total gloveboxes removed to date is now at 85 percent complete.

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 OU. 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 2005b](#)), *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. In 2013, significant progress was made on removing below-grade portions of two high-hazard facilities; the 309 Plutonium Recycle Test Reactor and the 340 Waste Neutralization Facility vault (Section 5.2.3).

400 Area Facilities – Fast Flux Test Facility (FFTF) Deactivation. FFTF is a DOE-owned, formerly operating 400-megawatt (thermal) liquid-metal cooled (sodium) research and test reactor located in the 400 Area, which 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 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 (Section 5.3).

Solid Waste Management. Solid waste management includes the 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 site. Onsite solid waste facilities include the Central Waste Complex (CWC), Waste Receiving and Processing Facility (WRAP), T Plant Complex, Low-Level Burial Grounds (LLBG), 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 2013 totaled approximately 377,958 cubic feet (10,704 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 a National Repository (Section 5.3.3.4).

Low-Level Burial Grounds. The LLBGs 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 LLBGs have been operational under a RCRA Part A permit since 1985. Transuranic waste has not been placed in the LLBGs without specific DOE approval since August 19, 1987. In 2013, a total of 5,473 cubic feet (155 cubic meters) of waste were disposed in Trenches 31 and 34 (Section 5.3.3.5.1). Trench 94 (218-E-12B Burial Ground) did not receive any defueled U.S. Navy reactor compartments in 2013. The total number of reactor compartments received into Trench 94 to date is 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 2013 (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 IDF is referenced in [DOE/EIS-0391](#) as a future disposal option for Hanford Site wastes. 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 (TEDF), 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 2013 was approximately 8 million gallons (30 million liters). This wastewater was primarily leachate from ERDF and LLBG Trenches 31 and 34, with some wastewater from the 100-K Basins (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 LLBG Trenches 31 and 34, and other aqueous waste. The volume of wastewater received for LERF basin storage in 2013 was approximately 2.56 million gallons (9.69 million liters). The majority of wastewater received at the LERF was pipeline-transported CERCLA-regulated leachate from ERDF, totaling approximately 2.14 million gallons (8.10 million liters). Another major contributor to wastewater received into LERF during 2013 was approximately 0.28 million gallons (1.06 million liters) of leachate from LLBG Trenches 31 and 34 received by tanker truck. Approximately 0.13 million gallons (0.50 million liters) of wastewater was received by tanker trucks from various other facilities. No process condensate was received from the 242-A Evaporator in 2013. The volume of wastewater being stored in the LERF at the end of 2013 was approximately 10.1 million gallons (38.2 million liters) (Section 5.3.4.2).

200 Area Treated Effluent Disposal Facility (TEDF). Located east of the 200 East Area, the 200 Area TEDF 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 to this facility in 2013 was approximately 27.8 million gallons (105 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 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, Rev. 8C); however, in 2013 the 242-A Evaporator did not perform waste volume reduction activities (Section 5.3.4.4).

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 (SSTs), 83 SSTs are located in the 200 West Area, with another 66 SSTs 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 SSTs 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 SSTs (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

Table ES-1 provides the waste summary data for 2013.

Table ES-1. Hanford Site Waste Summary

Activity	Waste Type	Amount (tons)	Amount (metric tons)
Solid waste generated On the Hanford Site during cleanup activities	Mixed waste	206	187,089
	Radioactive waste	513	465,777
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	36.5	33,158
	Radioactive waste	62.8	56,960
Dangerous waste shipped off the Hanford Site	See Table 5.4	116	105,300
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	5,473	155
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	70,000	263,000
Waste added to underground double-shell waste storage tanks	Liquid waste	153,000	579,000
Waste volume in underground double-shell waste storage tanks	Liquid waste	26,733,000	101,195,000
Aqueous waste volume received at the LERF	Wastewater containing low levels of organic compounds and tritium	10,100,000	38,200,000
Volume of wastewater treated and disposed at the 200 Area ETF	Wastewater containing toxic metals, radionuclides, ammonia, and organic compounds	8,000,000	30,000,000
Effluent volume disposed of at the 200 Area Treated Effluent Disposal Facility	Uncontaminated, treated liquid waste	27,800,000	105,000,000

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 WDOH 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 92 locations across the Hanford Site was used during 2013 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 2013 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 Hanford Site operational areas, and naturally occurring radionuclides, beryllium-7, and potassium-40 were routinely identified. (Section 6.2.1).

Air sampling was conducted at 21 locations in the 200 East Area during 2013. Generally, radionuclide levels measured in the 200 East Area ambient air composite samples in 2013 were similar to those measured in previous years. Uranium-234 and uranium-238 were detected in approximately 65 percent of the samples, strontium-90 in 38 percent and all other radionuclides were either detected in less than 15 percent of the samples or not at all. Cesium-137 concentrations at two air-sampling locations (N976 and N984) at C Farm were greater than 10 percent of the EPA concentration value ([40 CFR 61](#), Appendix E, Table 2) for the composite samples collected during the first-half of 2013. These elevated values may have been associated with a radiological incident on August 21, 2013, where higher than expected beta radiation readings were observed during the nighttime monitoring of SST 241-C-101 sluicing equipment. Required notifications regarding the elevated air sample results were made to the WDOH. The cesium-137 air sample concentrations returned to normal levels at these two stations during the second half of the year.

SECTION 7, WATER MONITORING. This section discusses the drinking water systems on the Hanford Site. Eight 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. Samples at all three drinking water treatment facilities were routinely collected and analyzed 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 WDOH. 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 2013. Contaminant concentrations measured during the year were similar to those observed in recent years as described in Hanford Site environmental reports for 2011 ([DOE/RL-2011-119](#)), and for 2012 ([DOE/RL-2013-18](#)).

Radiological Monitoring. Scientists conducted radiological monitoring of Hanford Site drinking water at one DOE-owned pump and three water treatment facilities during 2013. 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 2013 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 minimum detectable concentration (i.e., concentrations were too low to measure). The 400 Area source of drinking water for 2013 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 and sediment on and near the Hanford Site were collected and analyzed to determine the concentrations of radiological, inorganic, and organic contaminants in the aquatic environment attributed to the Hanford Site. Surface-water bodies monitored included the Columbia River, Hanford Site 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 2013 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 radionuclides, inorganics, and organics (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 in 2013 and for the previous 5 years are summarized in Appendix C, Table C.6. All individual radiological contaminant concentrations measured in Columbia River water during 2013 were less than 1/25 of the DOE-derived concentration guides (Appendix D).

Radionuclide Results. Radionuclide concentrations monitored in Columbia River water were low throughout 2013. Tritium, uranium-234, and uranium-238 were consistently measured in river water at levels greater than their reported minimum detectable concentrations. Uranium-235 was 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 2013 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-234 concentrations were slightly elevated at the Hanford Slough, McNary Dam, and White Bluffs Slough in 2013 as compared to values measured in 2008 through 2012. In 2013, 100-F Slough sediment also had slightly elevated results for uranium-234, uranium-235, and uranium-238 when compared to the previous 5 years of data. Other radionuclide concentrations reported in river sediment were similar to those reported for previous years and there were no obvious differences between locations. The values for cesium-137 at the White Bluffs Slough was slightly elevated compared to Priest Rapids Dam, and were lower than elevated values measured in 2008 through 2012. Previous studies of sediment 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 (2008 through 2013) 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. Lead concentrations were detected at higher rates in Priest Rapids sediment as well. This is likely due to natural erosion through the weathering of rocks when lead is released to surrounding soils and aquatic systems and made available to biota within those ecosystems. 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 periodically during 2013. Water samples were collected quarterly in 2013 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 decreased slightly during 2013 when compared to 2012. Tritium concentrations in FFTF Pond water were slightly lower in 2013 than they were in 2012. West Lake was analyzed for 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](#)). Figure 7.17 shows the annual average concentrations of uranium-234 in West Lake surface water and West Lake seep water from 2012 and 2013 (Section 7.5).

Offsite Irrigation Water. Water samples were collected in 2013 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 2013 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, strontium-90, and tritium. Most radionuclide concentrations measured in irrigation water in 2013 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. Alpha results from both areas were lower than levels detected in upstream river transect samples. Beta results from the Horn Rapids and Riverview areas were slightly higher than levels detected in the Columbia River. Strontium-90 results had a similar juxtaposition between Horn Rapids and Riverview irrigation results, although levels were lower than those recorded in 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](#); [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 2013 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 2013 is the 616-A Crib, also known as the State-Approved Land Disposal Site (Section 7.7).

SECTION 8, GROUNDWATER MONITORING. At the Hanford Site, liquid waste released to the ground over many years has reached the groundwater. This section presents the results of Hanford Site groundwater monitoring for 2013. 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/>. The *Hanford Site Groundwater Monitoring Report for 2013* (DOE/RL-2014-32) can be accessed at <http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=0084842>.

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 2013 were higher than the concentrations in samples collected farther away. The data also shows, as expected, that concentrations of certain radionuclides in 2013 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 (Section 9.2).

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, grapes, leafy vegetables, milk, potatoes, tomatoes, and wine) were collected in 2013 at locations near the Hanford Site. Samples were analyzed to determine radiological contaminant concentrations. Radionuclide concentrations in most food and farm product samples in 2013 were below levels that could be detected by analytical laboratories; however, some contaminants that could have potentially originated from the Hanford Site (e.g., tritium and beryllium) 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. The fish and wildlife species sampled and analyzed for Hanford Site operations-produced contaminants included mountain whitefish (*Prosopium williamsoni*), Nuttall’s cottontail (*Sylvilagus nuttallii*), and Canada Goose (*Branta Canadensis*). 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. 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 (Section 10.2).

Vegetation 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 historical offsite vegetation samples are analyzed for information about atmospheric deposition of contaminants in and around operational areas onsite and in uncultivated areas offsite. 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.

In general, radionuclide concentrations in vegetation samples collected from, or adjacent to, waste disposal facilities in 2013 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 Areas and 600 Area, and uranium in the 300 Area and 400 Area (Section 10.3).

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 of plants in contaminated or potentially contaminated areas, and monitoring, controlling, and removing unwanted (noxious) plant species. Approximately 2,218 acres (898 hectares) were treated with herbicides in 2013 on radiological waste sites, around operations areas, and along roadways to keep 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 more than one herbicide application (Section 10.3.2).

Waste Site Remediation and Revegetation. In 2013, 8.5 acres (3.4 hectares) 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 waste sites and to repair damage from ground-disturbing maintenance operations. An unusually dry fall prevented good seed germination, and discouraged further seeding efforts (Section 10.4).

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 federal Endangered Species Act in April 2013 ([78 FR 23984](#), “Endangered and Threatened Wildlife and Plants”); 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).

Cultural and Historic Resource Protection. The Hanford Cultural and Historic Resources Program (CHRP), which is managed by RL, 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 97 NHPA Section 106 CRRs, including 50 proposed projects that did not involve ground disturbance. These projects were determined exempt by Hanford Site archaeologists after meeting the RL-approved Historic Buildings Programmatic Agreement exemption criteria (PA Exemptions) following an initial review, or had satisfied the requirements of NHPA Section 106 under a prior review (Cultural Assessments). Hanford Site archaeologists reviewed and completed seven projects under an emergency declaration (Post Reviews) in accordance with Section 5.1.1 of [DOE/RL-98-10](#). Most projects cleared under these expedited reviews occurred in the 200 Areas of the Hanford Site (Figure 11.17). Hanford Site archaeologists also reviewed 40 undertakings in 2013 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 measures, if necessary^a. Of the 40 undertakings, 21 were identified as *No Historic Properties Affected*, while 19 were determined to have *No Adverse Effects* to historic properties. No project was identified as

^a This number does not reflect all full cultural resources reviews initiated in 2013. Additional reviews were initiated in 2013, but completed in 2014, and are not included in this report.

having *Adverse Effects* (Figure 11.17). Approximately 6,085 acres (2,463 hectares) of new ground was surveyed for cultural resources, because of the 40 undertakings that had the potential to affect physically cultural resources. In addition, some undertakings required National Register of Historic Places (NRHP) ([36 CFR 60](#)) eligibility evaluations, including sub-surface 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 environmental surveillance activities are subject to an overall QA program. This program satisfies the requirements for collecting and assessing environmental data in compliance with [10 CFR 830](#), “Nuclear Safety Management, Subpart A, Quality Assurance Requirements”, [DOE O 414.1D](#), *Quality Assurance*, DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD) [Vol. 1](#) and [Vol. 2](#), [EPA/240/B-01/003](#), *EPA Requirements for Quality Assurance Project Plans*, and Richland Requirements Document 008, *Quality Assurance Program Requirements*. Project-specific QA plans and documentation are found in MSC-23333 and describe the QA/QC elements associated with the Environmental Surveillance Program. 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, duplicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

Acronyms

AEA	<i>Atomic Energy Act</i>
AFRI	Applied Field Research Initiative
ALARA	as low as reasonably achievable
ALARCT	As Low As Reasonably Achievable Control Technology
AR/PIR	Administrative Record/Public Information Repository
ARAR	applicable or relevant and appropriate requirement
ASCEM	Advanced Simulation Capability for Environmental Management
ASME	American Society of Mechanical Engineers
ATL	Advanced Technologies and Laboratories, Inc.
BNI	Bechtel National, Inc.
BRMP	<i>Biological Resources Management Plan</i>
Bq	Becquerel
C	Celsius
CAFO	Consent Agreement and Final Order
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CFR	<i>Code of Federal Regulations</i>
CHPRC	CH2M HILL Plateau Remediation Company
CHRP	Cultural and Historic Resources Program
CLUP-EIS	<i>Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement, DOE/EIS-0222-F</i>
CRR	Cultural Resource Review
CSB	Canister Storage Building
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CVDF	Cold Vacuum Drying Facility
CWC	Central Waste Complex
CY	calendar year
D4	deactivation, decommission, decontamination and demolition
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
EA	environmental assessment
Ecology	Washington State Department of Ecology
EDP	environmental data point
ETF	200 Area Effluent Treatment Facility
EIS	Environmental Impact Statement
EM	U.S. Department of Energy, Office of Environmental Management
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ERT	electrical resistance tomography
F	Fahrenheit
FBR	fluidized bed reactors

FFTF	Fast Flux Test Facility
FIFRA	<i>Federal Insecticide, Fungicide, and Rodenticide Act</i>
FONSI	Finding of No Significant Impact
FR	Federal Register
FY	fiscal year
GEA	gamma energy analysis
GIS	Geographic Information System
HAB	Hanford Advisory Board
HAMMER	Hazardous Materials Management and Emergency Response Training Facility
HASQARD	Hanford Analytical Services Quality Assurance Requirements Document
HCP-EIS	<i>Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement</i>
HEPA	high-efficiency particulate absorber
HLW	high-level waste
HRNM	Hanford Reach National Monument
HSS	U.S. Department of Energy, Office of Health, Safety, and Security
HTO	tritiated water vapor
HQ	U.S. Department of Energy, Headquarters
IAP	Injury Assessment Plan
ICRP	International Commission on Radiological Protection
IDF	Integrated Disposal Facility
IRT	Independent Review Team
ISMS	Integrated Safety Management System
IT	Information Technology
kg	kilogram
KBC	K Basins Closure Project
lb	pound
LERF	Liquid Effluent Retention Facility
LLBG	low-level burial ground
LLW	low-level waste
LLWMA	Low-Level Waste Management Area
MAPEP	Mixed Analyte Performance Evaluation Program
MARS	Mobile Arm Retrieval System
MEI	maximally exposed individual
mg/L	milligrams per liter
MRAD	Environmental Resource Associates
mrem	millirem
MSA	Mission Support Alliance, LLC
NCRP	National Council on Radiation Protection
NEPA	<i>National Environmental Policy Act</i>
NESHAP	<i>National Emission Standards for Hazardous Air Pollutants</i>
NOAA	National Oceanic and Atmospheric Administration
NOC	Notice of Construction
NPS	National Park Service
NRDWL	Nonradioactive Dangerous Waste Landfill
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRDAR	natural resource damage assessment and restoration
NRHP	National Register of Historic Places

OFI	opportunities for improvements
ORP	U.S. Department of Energy, Office of River Protection
OSHA	Occupational Safety and Health Administration
OU	operable unit
PCB	polychlorinated biphenyls
pCi/L	picocuries per liter
PED	Preliminary Estimate of Damage
PFP	Plutonium Finishing Plant
PHOENIX	PNNL On-Line Environmental Information Exchange
PNL	Pacific Northwest Laboratory
PNNL	Pacific Northwest National Laboratory
ppm	parts per million
PQL	practical quantitation limit
PRF	Plutonium Reclamation Facility
PRTR	Plutonium Recycle Test Reactor
PRZ	Periodically Rewetted Zone
PUREX	Plutonium/Uranium Extraction (Plant)
QA	quality assurance
QC	quality control
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
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
SCWE	Safety Conscious Work Environment
SDWA	<i>Safe Drinking Water Act</i>
SHPO	Washington State Historic Preservation Office
SOW	statement of work
SST	single-shell tank
Sv	sievert
SWL	Solid Waste Landfill
TCP	Traditional Cultural Property
TEDF	Treated Effluent Disposal Facility
THP	total petroleum hydrocarbons
TLD	thermoluminescent dosimeter
TPA	<i>Hanford Federal Facility Agreement and Consent Order</i> , aka Tri-Party Agreement
TRIDEC	Tri-Cities Economic Development Council
Tri-Party agencies	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
TSCA	<i>Toxic Substances Control Act</i>
TSD	treatment, storage, and disposal
TWG	Technical Work Group
µg/L	micrograms per liter

USC	United States Code
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey
VOA	volatile organic analyses
VPP	Voluntary Protection Program
VPPPA	Voluntary Protection Program Participants Association
WAC	<i>Washington Administrative Code</i>
WCH	Washington Closure Hanford, LCC
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health
WESF	Waste Encapsulation and Storage Facility
WIPP	Waste Isolation Pilot Plant
WMA	waste management area
WNHP	Washington Natural Heritage Program
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 year (CY)2013 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/page.cfm/environmentalreports2001-latest>; and reports from 2001 to present are available at <http://msa.hanford.gov/page.cfm/enviroreports1959-2000>. 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 for the 2013 monitoring efforts are provided in the *Hanford Site Environmental Monitoring Plan* ([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 *Hanford Federal Facility Agreement and Consent Order* ([Ecology et al. 1989a](#)) (also known as the Tri-Party Agreement or TPA) by DOE, the U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) (Tri-Party Agencies), 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.

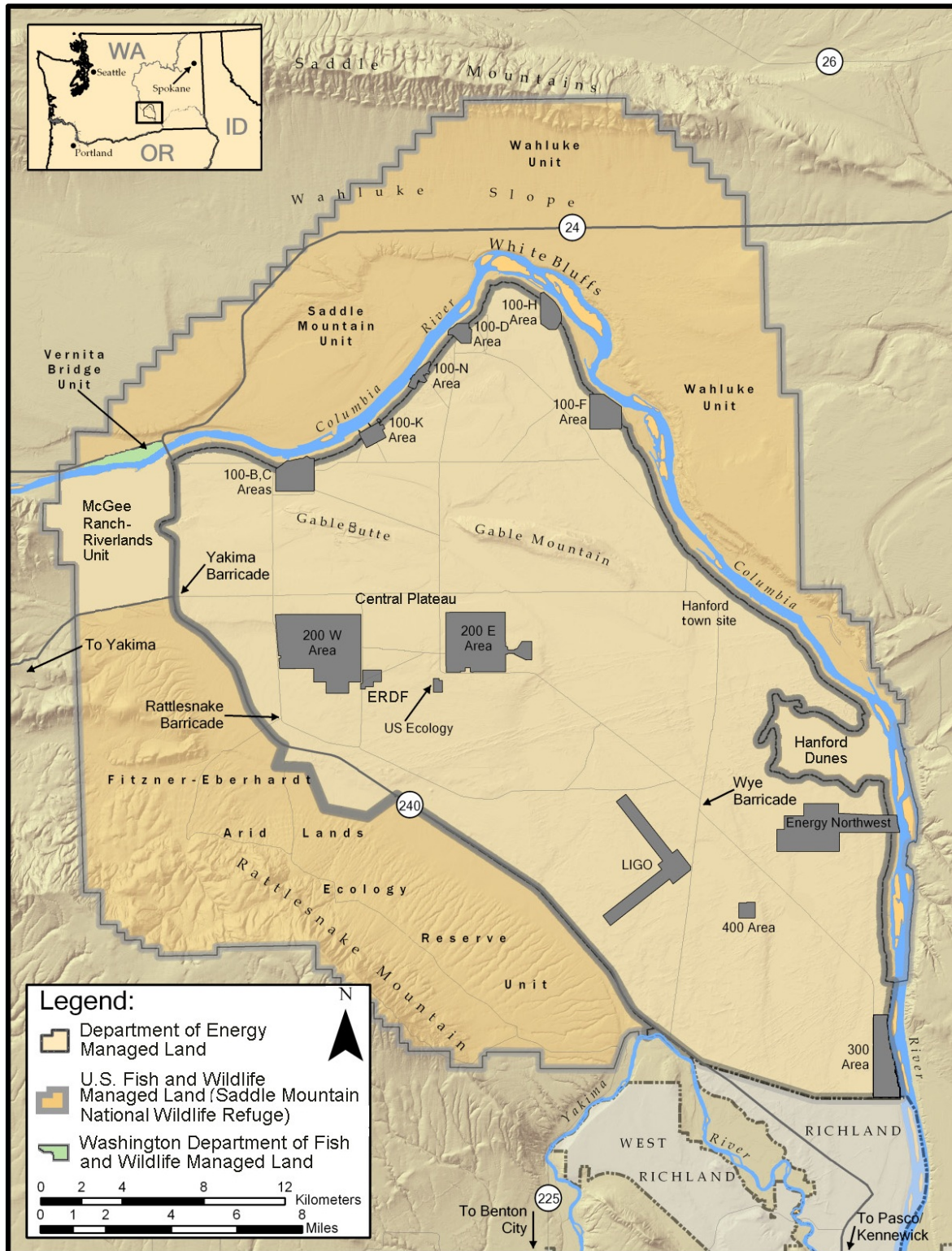
1.2.1 Operational, Research, and Administrative Areas

Areas within and surrounding the Hanford Site includes the following:

- **100 Area** – The 100 Areas consist of five 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 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 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 Fast Flux Test Facility (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 Facility) – 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.

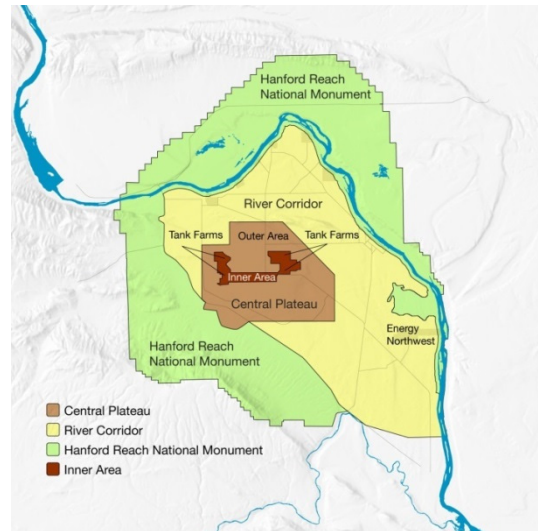
Figure 1.1. Hanford Site and Surrounding Areas



1.3 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 (WDFW) 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. CHPRC 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 prime 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 Environmental Restoration Disposal Facility (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. HPMC 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 Waste Treatment and Immobilization Plant (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 WTP that is located on a 0.1-square-mile (0.26-square-kilometer) 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.

The WDFW 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.

1.4 Climate and Meteorology

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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 2013 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.

1.4.1 Historical Climatological Information

The following are climatological records set on the Hanford Site. From 1945 through 2013, 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).

1.4.2 Monitoring

The average temperature for 2013 was 53.9°F (12.2°C), which is normal. Seven months during 2013 were warmer than normal; five months were cooler than normal. July had the greatest positive departure at 3.6°F (2.0°C). December had the greatest negative departure at 4.2°F (2.3°C) below normal.

Precipitation totaled 5.38 inches (13.7 centimeters), which is 75 percent of normal precipitation (7.14 inches [18.1 centimeters]). Snowfall for 2013 totaled 2.0 inches (5.1 centimeters), compared to normal snowfall of 15.2 inches (38.6 centimeters).

Average wind speed was 7.4 miles per hour (3.3 meters per second), which was 0.1 mile per hour (0.1 meter per second) below normal. The peak gust for the year was 61 miles per hour (27.3 meters per second) on November 2, 2013. In addition, five 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 (1945-2013).

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]

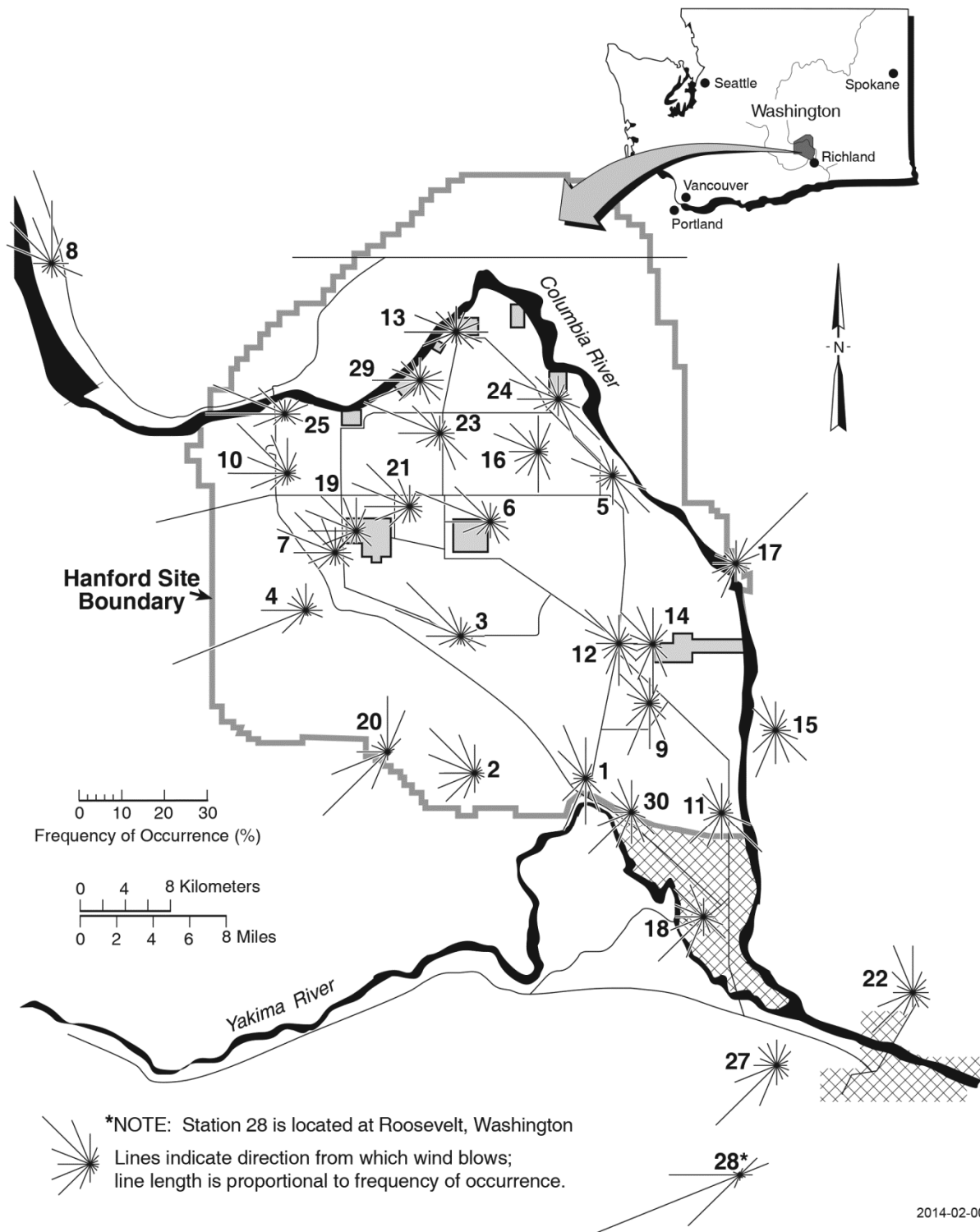


Table 1.1. Meteorology Station Monthly and Annual Climatological Data
Hanford Meteorology Station 2013, 25 miles (40 kilometers) northwest of Richland, Washington
latitude 46° 34'N, longitude 119° 35'W, elevation 733 feet (223 meters)

Month	Temperatures, °F								Precipitation (inches)				Relative Humidity (percent)		15-m Wind ¹				
	Averages				Extremes				Snowfall						Peak Gusts				
	Daily Maximum	Daily Minimum	Monthly	Departure ²	Highest	Date	Lowest	Date	Total	Departure ²	Total	Departure ²	Average	Departure ²	Average Speed (mph)	Departure ²	Speed (Mph)	Direction	Date
Jan	35.5	24.0	29.8	-3.6	58	30	12	16 ⁴	0.16	-0.78	1.6	-3.0	82.3	+2.5	4.8	-1.5	43	S	Jan-8
Feb	50.5	27.5	39.0	+0.8	56	27 ⁴	18	11	0.09	-0.61	0	-2.3	68.8	-1.9	6.7	-0.2	47	WSW	Feb-22
Mar	58.4	34.4	46.4	-0.1	74	31	22	24	0.39	-0.18	T ³	-0.4	56.6	-0.6	7.9	0	52	SW	Mar-20
Apr	67.1	40.1	53.6	+0.2	85	26	28	17	0.30	-0.25	0	0	45.8	-2.5	10.2	+1.7	50	W	Apr-13
May	77.0	49.5	63.2	+0.9	98	10	32	1	1.60	+1.09	0	0	44.7	+1.5	7.8	-1.0	53	SW	May-13
Jun	82.7	56.9	69.8	+0.2	99	30	45	12	1.36	+0.85	0	0	47.4	+7.8	8.3	-0.7	46	SSW	Jun-17
Jul	97.0	64.4	80.7	+3.6	109	2	53	14	0.01	-0.22	0	0	25.3	-8.8	8.8	+0.2	44	WNW	Jul-4
Aug	92.7	62.6	77.7	+1.9	100	7 ⁴	54	2527	0.24	+0.06	0	0	37.9	+2.2	7.4	-0.6	51	WSW	Aug-9
Sep	81.9	56.7	69.3	+2.9	99	13	44	25	0.42	+0.11	0	0	48.6	+5.6	8.5	+1.2	58	W	Sep-15
Oct	65.5	39.5	52.5	-1.0	74	22	26	30	0.38	-0.11	0	0	58.5	+2.4	6.0	-0.7	49	NE	Oct-28
Nov	47.7	29.0	38.4	-2.1	65	1	12	22	0.36	-0.59	0	-2.0	71.8	-2.1	7.1	+0.4	61	WSW	Nov-2
Dec	36.1	17.6	26.9	-4.2	58	23	-2	8	0.07	-1.13	0.4	-5.5	75.8	-5.4	5.1	-0.8	39	SW	Dec-1
Year ⁵	66.0	41.9	53.9	0.0	109	Jul 2	-2	Dec 8	5.38	-1.76	2.0	-13.2	55.3	0	7.4	-0.2	61	WSW	Nov-2

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.

1.5 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* (NHPA) ([16 United States Code \[USC\] 470](#)), 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*). 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: <http://www.hanford.gov/page.cfm/inp>.

1.5.2 Cultural and Historic Resource Consultations

MK Wright

The NHPA ([16 USC 470](#)) 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 Cultural and Historic Resource Protection ([CHRP](#)) program 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 on a monthly basis 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 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, 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 WDFW
- 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 (NRDAR) 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, Inc., (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 NRDAR 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 (HAB) on Trustee guiding principles, the 100-K Area remedial investigation/feasibility study (RI/FS), NRDAR 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 NRDAR 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 NRDAR data management and received a proposal for implementing and maintaining the data management system.

In December 2012, litigation concerning funding the NRDAR 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/hnrtc>.

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 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 November 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 administering 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/files.cfm/tpa_pi_calendar_fy_2014_november_2013.pdf. 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 the HAB 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://pdw.hanford.gov/arpir/>; and for proposed changes to the TPA that underwent public comment, on the TPA website: <http://www.hanford.gov/?page=81>.

- 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://pdw.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. 1989a](#), CERCLA, RCRA, and the NEPA; HAB 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

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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 (HAB)

TL Nguyen

The HAB is a broadly representative body consisting of a balanced mix of members that represent diverse interests affected by Hanford Site cleanup decisions. The HAB 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 HAB comprises 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 HAB 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 HAB, including its charter (operating ground rules) is available on the following website: <http://www.hanford.gov/?page=449>.

1.6 Hanford Site Regulatory Oversight

SA Thompson

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 (WDOH), 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)

RE Piippo

The TPA ([Ecology et al. 1989a](#)) is an agreement among the Tri-Party Agencies to achieve environmental regulation compliance on the Hanford Site with CERCLA and RCRA treatment, storage and disposal (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 [TPA 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 January 14, 2014, a total of 1,208 TPA milestones were completed

and 324 target dates were met. During 2013, 33 specific cleanup milestones were scheduled for completion; of those 31 milestones were completed on time and 2 milestones were missed.

1.6.1.2 Tri-Party Agreement Approved Modifications

During 2013, 15 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/>.

1.7 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/>
- BNL: <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/>
- ORP: <http://www.hanford.gov/page.cfm/contactus/>
- 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.areva.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; 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 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 [Public Law 102-386](#) 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 2013, the reporting requirement was met by the *Calendar Year 2012 Hanford Site Mixed Waste Land Disposal Restrictions Summary Report* ([DOE/RL-2013-19](#)).

2.1.2 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* ([Public Law 98-616](#)) 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 *Washington Administrative Code* ([WAC](#)) 173-303, “[Dangerous Waste Regulations](#).”

2.1.2.1 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, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste* (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 *Hanford Facility Dangerous Waste 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^b; PNNL; WCH; and WRPS. No TSD unit additions or deletions occurred during 2013. However, unit-specific Permit conditions for the following TSD units were modified in 2013 pursuant to following [WAC 173-303-830](#), “Permit Changes”:

- Liquid Effluent Retention Facility (LERF) and 200 Area Effluent Treatment Facility (ETF) (Operating Unit 3)
- 242-A Evaporator (Operating Unit 4)
- WTP, (Operating Unit 10)
- Integrated Disposal Facility (IDF) (Operating Unit 11)
- 400 Area Waste Management Unit (Operating Unit 16)
- 183-H Solar Evaporation Basins (Post Closure Unit 2).

^b MSA is a Permittee, but not a “Co-operator.”

2.1.2.2 Regulatory Agency Inspections

JW Cammann

During 2013, a total of 77 regulatory agency inspections were conducted at DOE facilities on the Hanford Site. Of these, 36 were conducted by Ecology, 36 were conducted by WDOH, 4 were conducted by EPA, Region 10, and 1 was conducted by the city of Richland. Of these inspections there were 10 concerns, 12 findings, and 5 compliance actions issued by the regulators. A total of \$136,000 of fines and penalties were assessed and paid (see Section 2.10).

Regulatory agency inspections of DOE facilities on the Hanford Site are documented in the Regulatory Agency Inspection Database. Regulatory agency inspections can result in noncompliance or enforcement actions for alleged violations of applicable federal, state, and local laws and regulations. As such, the Regulatory Agency Inspection Database is linked to the Environmental Action Tracking System. The Environmental Action Tracking System is used to document alleged regulatory noncompliance and enforcement actions and their status (see Section 2.10).

2.1.2.2.1 RCRA Inspections

The Ecology inspections focused on compliance of TSD units with the *Hanford Facility Dangerous Waste Permit* (WA7890008967, 1994). The TSD units included the Solid Waste Operations Complex (i.e., Central Waste Complex (CWC), Waste Receiving and Processing (WRAP) Facility, T-Plant, Low-Level Burial Grounds (LLBG) Trenches 31 and 34), LLBG Trench 94, LERF, 200 Area ETF, WSCF, 222-S Laboratory, Tank Farms, 242-A Evaporator, satellite accumulation areas, 90-day accumulation areas, and universal waste management.

Section II.O of the RCRA Permit addresses general inspection requirements. General inspections are in addition to the TSD unit inspections specified in Parts III, V, and/or VI of the RCRA Permit. The RCRA Permit requires general inspections of the 100, 200 East, 200 West, 300, 400 areas and the Columbia River Shoreline. These areas are inspected annually to identify potential malfunctions, deterioration, operator errors, and discharges which may cause or lead to the release of dangerous waste constituents to the environment, or that threaten human health.

2.1.2.2.2 Clean Air Act Inspections

The WDOH inspections focused on compliance of major and minor stack air emission units with the Air Operating Permit and Radioactive Air Emissions License (FF-01) ([DOH 2012](#)). The EPA inspections focused on asbestos management under the *Clean Air Act* and the *National Emission Standards for Hazardous Air Pollutants for Asbestos* ([40 CFR Part 61, Subpart M](#)). The city of Richland inspection was limited to the 300 Area of the Hanford Site and involved implementation of the terms and conditions of the Industrial Wastewater Permit (CR-IU-010) and discharges to the publicly-owned treatment works.

2.1.2.3 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 Integrated Disposal Facility (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 2013 is provided in Section 8 and the detailed groundwater monitoring information for 2013 will be available in September 2014 with the release of *Hanford Site Groundwater Monitoring Report for 2013*.

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.

2.1.3 Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

JW Cammann

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 National Priorities List (NPL) ([59 FR 43314](#)) pursuant to CERCLA.

CERCLA was promulgated to address response, compensation, and liability for past releases or potential releases of hazardous substances, pollutants, and contaminants to the environment. CERCLA was amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA) (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 NPL ([59 FR 43314](#)) must enter into an interagency agreement (TPA) ([Ecology et al. 1989a](#)) 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.

In anticipation of the NPL listing, the Tri-Party Agencies entered into the TPA ([Ecology et al. 1989a](#)) 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 compliance and permitting. The TPA is a legally binding agreement among the Tri-Party Agencies 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); as a result 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](#), 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 record of decision (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. Institutional controls and NRDARs also may be required.

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 Area, 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. In the interim, DOE is ensuring that the exposure pathways that could result in unacceptable risks are being controlled, and the remedies comply with the decision documents and are functioning as intended.

Institutional controls are used when contamination is first discovered, when remedies are ongoing, and when residual contamination remains onsite at a level that does not allow unlimited use and unrestricted exposure. Institutional controls are non-engineered instruments, such as administrative and legal controls, that minimize potential exposure to contamination and/or protect the integrity of response actions. Institutional controls work by limiting land and/or resource use or by providing information that guides human behavior at a site. Institutional controls are a subset of land use controls that include engineering and physical barriers, such as fences and security. If residual contamination remains onsite, then institutional controls are considered to ensure that unacceptable risk does not occur. Response actions such as capping waste in place, construction of containment facilities, monitored natural attenuation, and pumping and treating of groundwater, may leave residual contamination onsite where institutional controls supplement engineering controls to protect human health and the environment.

Section 107(f) of CERCLA identifies and defines natural resource trustees, who are authorized to act in the public interest with regard to natural resources. For the Hanford Site, seven trust entities are organized under a Memorandum of Understanding to form the Hanford Natural Resource Trustee Council. The trustees include DOE, U.S. Department of the Interior (represented by the USFWS), states of Washington and Oregon, Yakama Nation, CTUIR, and Nez Perce Tribe. These natural resource trustees are authorized to evaluate the impacts to resources resulting from the release of hazardous substances to the environment through a process called a *Natural Resource Damage Assessment and Restoration* (NRDAR) and to use the results of that assessment to direct restoration activities aimed at replacing the resources and services lost due to a hazardous substance release.

2.1.4 Superfund Amendments and Reauthorization Act of 1986 (SARA)

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* (SARA) was enacted on October 17, 1986, which amended and reauthorized CERCLA. SARA reflected EPA's experience in administering the complex Superfund Program during its first 6 years and made several important changes and additions to the program. Changes and additions under SARA 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.

SARA 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](#)).

SARA attempted to accelerate the cleanup of hazardous waste sites and resolve questions of jurisdiction. Section 120 of SARA 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 Section 120, subsection (g) of SARA 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. SARA 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 SARA. The *Emergency Planning and Community Right-To-Know Act of 1986*, also known as *SARA 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 fiscal year (FY) 1995. 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 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 overall goal of the *Integrated Cleanup Initiative* is to make better use of EPA's assessment and cleanup authorities in an integrated, transparent, and accountable fashion to address a greater number of contaminated sites, accelerate cleanups where possible, and put those sites back into productive use while protecting human health and the environment. Land based cleanup programs throughout the EPA have evolved as a result of the actions of the *Integrated Cleanup Initiative*.

As of November 12, 2013, the Superfund Program is consolidating several data systems and reporting tools into the [Superfund Enterprise Management System](#). By consolidating multiple systems, the Superfund remedial program will be in a position to link planning and performance data with supporting documentation in a manner that yields direct evidence of program decisions and outcomes. Planned to be launched in FY2014, the [Superfund Enterprise Management System](#) will allow the program to improve the planning, tracking, and reporting of key performance measures in order to provide valuable evidence of outcomes and results. In addition, the Superfund remedial program is conducting a comprehensive and coordinated effort to review operational processes and support tools. The goal is to identify efficiencies and cost effective changes to the program to bring projects to completion in a more cost effective and timely manner. In FY2013, the EPA applied 'Lean Government' principles to the facility investigation phase of RCRA corrective action cleanups to accelerate the process for a typical facility by several years, and began implementation. Applying EPA proven techniques, the intent is to optimize the RCRA facility investigation process by reducing time and transaction costs through documented initial agreements on critical cleanup decisions.

2.1.5 National Environmental Policy Act of 1969 (NEPA)

JW Cammann

NEPA was enacted to ensure that potential environmental impacts as well as technical factors and costs are considered during federal agency decision-making. 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 [Atomic Energy Act of 1954](#) [[Public Law 105-394](#)], or other authorities) and are subject to the categorical exclusion process previously discussed. In addition, 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*, documents this process.

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.) during CY 2013. The NEPA documentation for the Hanford Site is available online at <http://www.hanford.gov/page.cfm/officialdocuments>.

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)

On October 30, 2009, a notice of availability for the *Draft Tank Closure and Waste Management Environmental Impact Statement* ([DOE/EIS-0391](#)) was issued in the FR ([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 (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.

In February 2012, DOE issued the [*Supplement Analysis of the Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*](#) (DOE/EIS-0391D-SA-01).

December 13, 2013, the DOE published the ROD in the FR ([FR 75913-75919](#), Vol. 78, No. 240). This was the first in a series of RODs that DOE intends to issue pursuant to the final EIS. DOE also issued a 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.

2.1.5.1.2 Natural Gas Pipeline Environmental Impact Statement (DOE/EIS-0467)

RL is currently preparing the Natural Gas Pipeline EIS to evaluate the proposed action to contract with Cascade Natural Gas Corporation (Cascade) to own, construct, operate, and maintain a natural gas pipeline to provide natural gas utility service to the WTP (Section 5.6), and 242-A Evaporator (Section 5.4.4.4). The proposed pipeline would begin from a new interconnect tap on the existing Williams Northwest Pipe transmission line in Franklin County, north of the Pasco, Washington, airport, and then run westerly across non-DOE lands and under the Columbia River, crossing near the Hanford Site 300 Area, before turning northwest and paralleling Route 4S. The pipeline would terminate at the WTP and 242-A Evaporator.

The purpose of providing natural gas utility service to the WTP and the 242-A Evaporator is to enhance operational flexibility for steam generation [i.e., increase operational reliability by having dual-fired boilers (both natural gas and diesel fuel)], with potential for significant lifecycle operations fuel cost savings and achieve substantial savings to tax payers, and reduction of future greenhouse gas emissions and other consequences associated with the use of diesel fuel to support the Federal Government's energy sustainability and efficiency goals. Currently, the WTP steam boiler annex is designed to use diesel fuel when operational, and the 242-A Evaporator steam annex boilers use diesel fuel during their periodic campaigns.

On January 23, 2012, DOE published a Notice of Intent informing the public that the Natural Gas Pipeline EIS would be prepared and formally announced the beginning of the public scoping process ([77 FR 3255](#)). On February 9, 2012, a public scoping meeting was held, and public comment is planned for the Fall of 2014. The final EIS is scheduled for 2015, and the ROD would be issued no less than 30 days after issuance of the final EIS.

In November 2013, Cascade completed an engineering feasibility study that identified and evaluated alternative Natural Gas Pipeline route alignments from the Williams Northwest interconnect to the 200 East Area (WTP and 242-A Evaporator), including alternative horizontal directional drill locations for routing the natural gas pipeline across the Columbia River. The EIS is independently evaluating the engineering feasibility study data and information in conjunction with the proposed natural gas pipeline interface alternatives within in the 200 East Area (WTP and 242-A Evaporator). The EIS will analyze potential issues and impacts at a level of detail commensurate with their importance. Areas being evaluated include 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 of 100 years for the purposes of analysis. Areas being evaluated include geological resources; soils; air quality; water resources; biological resources; cultural resources; land use, recreation, and visual resources; noise; waste management; socioeconomics and environmental justice; human health and safety; accidents and intentional destructive acts; and cumulative impacts.

2.1.5.1.3 Final Long-Term Management and Storage of Elemental Mercury Supplemental Environmental Impact Statement (DOE/EIS-0423-S1)

Pursuant to the *Mercury Export Ban Act of 2008* ([Public Law 110-414](#)), DOE was directed to designate a facility or facilities for the long-term management and storage of elemental mercury generated within the United States. As a result, the DOE issued the *Final Long-Term Management and Storage of Elemental Mercury Environmental Impact Statement (Mercury Storage EIS)* ([DOE/EIS-0423](#)) in January 2011. The *Mercury Storage EIS*, identified the Waste Control Specialists, LLC, site near Andrews, Texas, as the Preferred Alternative for the long-term management and storage of elemental mercury.

On January 1, 2013, the prohibition on the export of elemental mercury went into effect pursuant to the *Mercury Export Ban Act of 2008*. As of August 31, 2013, seven waste management companies have notified DOE of their intent to store elemental mercury at RCRA-permitted facilities in accordance with Section 5(g)(2)(B) of the Act. All of these companies have certified that they will ship the elemental mercury to a DOE-designated facility, when such a facility is operational and ready to accept the mercury. Until such time that DOE has designated a facility and is ready to accept elemental mercury for long-term management and storage, similar notifications may be received by DOE from other waste management companies. DOE decision will be announced in a ROD and published in the FR.

2.1.5.1.4 Supplement Analysis to the Hanford Comprehensive Land Use Plan Environmental Impact Statement (DOE/EIS-0222-SA2)

The DOE prepared the *Hanford Comprehensive Land Use Plan Environmental Impact Statement* ([DOE-EIS-0222](#)) (HCP-EIS) to evaluate the potential environmental impacts associated with implementing a comprehensive land-use plan (CLUP) for the Hanford Site for the next 50 years. The DOE is expected to use the CLUP in its decision-making process to establish what is the 'highest and best use' of the land (*Federal Property Management Regulations*, [41 CFR 101-47](#)). The final selection of a land-use map, land-use designations, land-use policies, and implementing procedures created the working CLUP through the signing of the HCP-EIS ROD in November 1999 (64 FR 61615).

In June 2008, DOE published a Supplement Analysis ([DOE/EIS-0222-SA-01](#)) to the [HCP-EIS](#). DOE did not identify any significant changes in circumstances or substantial new information that has evolved since the [HCP-EIS](#) was published in 1999 that would affect the basis for its decisions as documented in the [HCP-EIS ROD](#). DOE found that preparation of a new HCP-EIS or a supplement to the existing HCP-EIS was not warranted at that time. DOE committed to publishing an amended ROD to clarify that other regulatory processes, additional implementation controls, and stakeholder involvement processes are acceptable methods for addressing whether proposed activities at the Hanford Site are consistent with the CLUP land-use map, designations, policies, and procedures.

DOE published an amended [HCP-EIS ROD](#) (73 FR 55825) in September 2008 to clarify two points. First, when considering land use proposals, DOE will use regulatory processes in addition to the implementing procedures in Chapter 6 of the [HCP-EIS](#) to ensure consistency with the CLUP. In addition, DOE will continue to apply the process discussed in Chapter 6 of the HCP-EIS to modify or amend the land use map, designations, policies, and procedures, as needed.

During the latter part of CY2013, efforts were initiated to prepare the second supplemental analysis to the HCP-EIS. Unlike the first supplement analysis that analyzed completed projects for consistency with HCP-EIS land-use designations, map, policies, and procedures; the second supplement analysis will focus on proposed and foreseeable future projects to determine whether new information and changing circumstances warrant preparation of a supplemental or new HCP-EIS or other appropriate NEPA document.

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)*

This EA ([DOE/EA-1707](#)) provides information and analyses of proposed DOE activities associated with closure of the DOE Hanford Site's Nonradioactive Dangerous Waste Landfill (NRDWL) and the Solid Waste Landfill (SWL), located southeast of the Central Plateau off Army Loop Road (refer to Section 5.2.2.2.2).

Because the NRDWL is a RCRA-permitted TSD site, closure is being managed in accordance with [WAC 173-303](#). The Solid Waste Landfill is regulated under [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* (BRMP) ([DOE/RL-96-32](#)) and *Hanford Site Revegetation Manual* ([DOE/RL-2011-116](#)).

2.1.5.2.2 *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 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 intent to prepare an EA to assess the potential environmental effects of conveying approximately 1,641 acres of Hanford Site land to a local economic development organization. Conveyance of the land could include title transfer, lease, easement, license, or a combination of these realty actions. The Tri-City Development Council, a DOE designated Community Reuse Organization and 501(c)(6) nonprofit corporation, submitted a proposal to DOE in May 2011 (amended October 2011) requesting the transfer of approximately 1,641 acres of land located in the southeastern corner of the Hanford Site near the city of Richland in Benton County, Washington, for economic development purposes.

2.1.5.2.3 *Final Environmental Assessment for Expansion of Borrow Areas on the Hanford Site (DOE/EA-1934)*

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 EA includes 11 existing borrow pits (Pits F, H, N, 6, 9, 18, 21, 23, 24, 30, and 34) and an option to develop one new borrow pit near 100-N and 100-K Reactor Areas. The EA also addressed closure of the borrow pits. The EA did not include borrow sources of silt loam soil for surface barriers because DOE plans to conduct a separate NEPA process to identify borrow sources of silt loam soil at a later date. The final EA and FONSI were signed on August 15, 2013, and the *Expansion of Borrow Areas on the Hanford Site Mitigation Action Plan for DOE/EA-1934* ([WCH-561](#)) was issued on October 15, 2013. Cleanup activities can result in large excavated areas needing to be backfilled and revegetated. The purpose of the proposed action in this EA is to meet DOE's need to secure raw aggregate sand and gravel material (approximately 10,714,000 bank cubic meters) to support ongoing environmental cleanup 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.

Currently, the DOE is considering a reassessment of the use of all borrow sources on the Hanford Site in response to concerns voiced by the Native American Tribes over the use of Borrow Area C and the anticipated need for mineral resources to support site remediation and closure. Borrow Area C is a primary source of Warden Silt Loam used in support 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. DOE is considering preparing a new EA to analyze mineral resource needs and sources on the Hanford Site. The other major source of Warden Silt Loam on the Hanford Site is McGee Ranch; however, it is located on land designated for the Hanford Reach National Monument. Both Borrow Area C and McGee Ranch have deep deposits of Warden Silt Loam that would result in less surface disturbance and potential impacts on natural, cultural, and ecological resources that may exist.

2.1.5.2.4 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](#)). Nearly 23,000 comments were received on the public comment period closed on February 11, 2013. Greater than 99 percent of the public comments expressed concern about the protectiveness of radiological clearance standards. The final Programmatic EA and comment response document are undergoing review by DOE senior management. The EA evaluated alternatives for the management of scrap metal originating from DOE radiological control areas, including the proposed action to allow for the recycle of uncontaminated scrap metal that meets the requirements of *Radiation Protection of the Public and the Environment* ([DOE O 458.1](#)) (metals with volumetric radioactive contamination are not included in the scope of this Programmatic EA).

DOE plans to complete the Programmatic EA, and as appropriate, issue a FONSI or prepare a Programmatic 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 DOE facilities.

2.1.5.3 Hanford Site Categorical Exclusions

Categorical exclusions encompass classes of actions that DOE has analyzed and determined that they 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](#), “Limitations on Actions During NEPA Process” or [10 CFR 1021.211](#), “Interim Actions: Limitations on Actions During the NEPA Process”; 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, HQ published modifications to its NEPA implementing procedures (i.e., [10 CFR 1021](#)) in the FR ([76 FR 63764](#), “National Environmental Policy Act Implementing Procedures”).

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/categorialexclusions>.

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 polychlorinated biphenyls (PCB). 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 *2012 Hanford Site Polychlorinated Biphenyl Annual Document Log* ([DOE/RL-2013-27](#)) and the *2012 Hanford Site Polychlorinated Biphenyl Annual Report* ([DOE/RL-2013-26](#)) to EPA on July 1, 2013, 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 2013, including but not limited to single-shell tank (SST) waste retrieval activities in accordance with EPA Phase I and II risk-based disposal approvals for the use of double-shell tank (DST) PCB remediation waste in accordance with [40 CFR 761.61\(c\)](#), “PCB Remediation Waste.” **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 SARA 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>.

MSA is responsible for managing institutional controls related to Hanford Site access control and the wastes sites in the 100-F Area. No excavation permits were issued in the 100-F Area for digging activities at 100-F Area waste sites. All warning signs along the Site boundary are in place. No broken fences were observed.

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 the time frame since the previous assessment. In addition, approved excavation permits were in place for all active remediation activities assessed. 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 2013 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 to 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.

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

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

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 2.2 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 2013 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory (DOE/RL-2014-02), 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 Department on February 26, 2014. The Hanford Site had 47 hazardous chemicals that exceeded the reporting thresholds. 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 2.3 lists the average quantities of the 10 hazardous chemicals stored in greatest quantity on the Hanford Site in 2013.

The 2013 Hanford Site Toxic Chemical Release Inventory report ([DOE/RL-2014-03](#)), was submitted to EPA and Ecology on June 25, 2014. During CY2013, the Hanford Site exceeded activity thresholds for 5 chemicals and 1 chemical category; lead, naphthalene, nitrate compounds, propylene, toluene, and xylene. Information concerning these chemicals is described in Table 2.4.

Table 2.2 provides an overview of reporting under the [Emergency Planning and Community Right-to-Know Act of 1986](#) during 2013 and early 2014.

Table 2.1. 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 2.2. 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	

Table 2.3. 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 2.4. 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

2.2 Radiation Protection

JW DeMers and FM Roddy

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 (AEA)

The [AEA](#) was promulgated to ensure the proper management of radioactive materials. The [AEA](#) 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

The purpose of [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](#).

Table 2.5 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](#), "National Primary Drinking Water Regulations; Radionuclides; Final Rule"); [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

RH Anderson

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 WDOH regulates radioactive air emissions on the Hanford Site by enforcing applicable federal requirements in [40 CFR 61](#), “National Emission Standards for Hazardous Air Pollutants,” Subparts A and H, as well as the state requirements in [WAC 173-480, “Ambient Air Quality Standards and Emission Limits for Radionuclides,”](#) and [WAC 246-247, “Radiation Protection-Air Emissions.”](#) 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 WDOH 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 WDOH in February 2012. The FF-01 license is a compilation of all applicable radioactive air emission requirements (ALARACT) 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-2014-14](#), *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2013*).\

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 WDOH and the Benton Clean Air Agency, Ecology issued Renewal 2 of the Air Operating Permit for a period of 5 years, effective April 1, 2013. 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 WDOH 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 re-issued in 2013 to incorporate new WDOH and Ecology air emission licenses, approval orders, and updated regulatory requirements. Renewal 2 of the Air Operating Permit was issued on April 1, 2013.

The WDOH, 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 2013, the regulatory agencies conducted over 60 *Clean Air Act* inspections on the Hanford Site, and no violations were issued. However, Ecology and WDOH issued a notice of correction on September 11, 2013 ([13-NWP-095](#)), alleging that incomplete information was submitted to both Departments following a September 2012 inspection, concerning all applicable control technology components that control release or potential release of pollutants to the atmosphere. ORP submitted a modification to Notice of Construction (NOC) Order DE05NWP-001, Revision 1, consisting of an ALARACT demonstration for air pathways from AW Tank Farm to the 242-A Evaporator, the environment, and other facilities and structures on December 5, 2013 ([13-ECD-0087](#)). ORP submitted a schedule for ALARACT demonstration document listing potential pathways; physical, engineered, and administrative controls for pathways; adequacy of controls; and warning devices and operational status of controls on January 8, 2014 ([13-ECD-0091](#)). Documentation for closure of corrective action is anticipated to be completed by July 30, 2014.

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](#)). 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 2013 ([ST-4500](#), [ST-4502](#), [ST-4507](#), [ST-4511](#), and [ST-0045514](#)). One permit was cancelled (ST-4507) since the facility that it applied to ceased operation. 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 2013, [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 WDOH. WDOH 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 allows discharges from the 300 Area facilities.

2.4.4 Safe Drinking Water Act of 1974 (SDWA)

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 WDOH 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 WDOH 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 drinking water standards (DWS). 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 2013,

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 2013 for microbiological, chemical, physical, and radiological constituents. There were no microbiological detections during the 2013 monitoring cycle, and all chemical concentrations in drinking water were well below the maximum contaminant levels established by EPA. Table 2.6 provides selected DWSs; and system-specific information and analytical results for 2013 radiological monitoring are summarized in Section 7.1.3. Table 2.7 provides the selected surface freshwater quality criteria for toxic pollutants and Table 2.8 provides the Washington State water quality criteria for the Hanford Reach of the Columbia River.

Table 2.6. Selected Drinking Water Standards

Constituent	DWS ¹		Agency ²
Antimony	6 µg/L	0.006 ppm	EPA, WDOH
Arsenic	10 µg/L	0.01 ppm	EPA, WDOH
Barium	2,000 µg/L	2 ppm	EPA, WDOH
Cadmium	5 µg/L	0.005 ppm	EPA
Carbon tetrachloride	5 µg/L	0.005 ppm	EPA, WDOH
Chloroform trihalomethanes ³	80 µg/L	0.08 ppm	EPA
Chromium	100 µg/L	0.1 ppm	EPA, WDOH
cis-1,2-Dichloroethene	70 µg/L	0.07 ppm	EPA, WDOH
Copper	1,300 µg/L	1.3 ppm	EPA
Cyanide	200 µg/L	0.2 ppm	EPA, WDOH
Fluoride	4 mg/L	4 ppm	EPA, WDOH
Lead	15 µg/L	0.015 ppm	EPA
Mercury (inorganic)	2 µg/L	0.002 ppm	EPA, WDOH
Methylene chloride	5 µg/L	0.005 ppm	EPA, WDOH
Nitrate, as NO ₃ ⁻	45 mg/L	45 ppm	EPA, WDOH
Nitrite, as NO ₂ ⁻	3.3 mg/L	3.3 ppm	EPA, WDOH
Selenium	50 µg/L	0.05 ppm	EPA, WDOH
Tetrachloroethene	5 µg/L	0.005 ppm	EPA, WDOH
Thallium	2 µg/L	0.002 ppm	EPA, WDOH
Trichloroethene	5 µg/L	0.005 ppm	EPA, WDOH
Antimony-125	300 pCi/L ⁴	11.1 Bq/L	EPA
Beta particle and photon activity	4 mrem/yr ⁵	40 µSv/yr	EPA, WDOH
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, WDOH
Technetium-99	900 pCi/L ⁴	33.3 Bq/L	EPA
Total alpha (excluding uranium)	15 pCi/L ⁴	0.56 Bq/L	EPA, WDOH
Tritium	20,000 pCi/L ⁴	740 Bq/L	EPA, WDOH
Uranium	30 µg/L	0.03 ppm)	EPA, WDOH

¹ Maximum contaminant level for drinking water supplies.² WDOH = 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 2.7. 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 2.8. Washington State Water Quality Criteria for the Columbia River, Hanford Reach¹

Parameter	Permissible Levels
Fecal coliform	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	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	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."

2.5 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* ([16 USC 668-668c](#)), 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 191 ecological compliance reviews performed during 2013, including 97 reviews to support general Hanford Site activities, and 94 reviews for River Corridor environmental restoration activities.

2.5.1.1 Endangered Species Act of 1973 (16 USC 1531)

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 [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, Final Bull Trout Critical Habitat Designation](#)). Two plant species, the Umtanum desert buckwheat (*Eriogonum codium*) and White Bluffs bladderpod (*Physaria douglasii* ssp. *tupleshensis*) are now listed under [16 USC 1531](#). Other species on the Hanford Site are listed by the WDFW as endangered, threatened, or sensitive (refer to Section 11.2).

2.5.1.2 Migratory Bird Treaty Act (16 USC 703)

[16 USC 703](#) 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 [16 USC 703](#). 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 migratory bird permits issued by the USFWS (MB14155A-2 & MB81249A-1) 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 (16 USC 668)

[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 2013 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 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 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 \(Public Law 107-303\)](#), 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

TE Marceau

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* ([16 USC 433](#)), *Historic Sites Act of 1935* ([16 USC 461](#)), *National Historic Preservation Act of 1966* ([16 USC 470](#)), NEPA, *Archaeological and Historic Preservation Act of 1974* ([16 USC 469](#)), *American Indian Religious Freedom Act of 1978* ([42 USC 1996](#)), *Archaeological Resources Protection Act of 1979* ([16 USC 470](#)), 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 Sustainability

Information regarding additional statutes is presented in the following sections.

2.6.1 Chemical Management Systems

RH Anderson

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 (42 USC 133)

DM Huff

The [Pollution Prevention Act of 1990](#) (42 USC 133) 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 [42 USC 133](#).

[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 FY2013.

Table 2.10. Recycle Quantities

FY2013 Recycled Material	Quantity (Metric Tons)
Non-Hazardous Material	
Cardboard	34.13
CI Shredded Paper	841.32
Furniture	159.99
Plastic Bottles	20.27
Tires	23.89
Wood Pallets	40.36
Software/Media	9.60
Hard Media	24.95
CHPRC Zero Waste Picnic	0.769
WCH Scrap Metal	135.81
Brass Metals	2.04
Ferrous Metals	168.46
Non-Ferrous Metals	29.10
Subtotal	1,490.69
Regulated Solid Wastes	
Aerosol Cans	0.36
Antifreeze	5.80
Antifreeze - Fleet	3.34
Ballasts	0.57
Batteries	4.32
Fluorescent Bulbs	2.01
Lamps	1.29
Lead Acid Batteries	29.07
Lead Acid Batteries (Fleet)	17.24
Polychlorinated Biphenyl (PCB) Waste Oil <50 ppm	98.38
Toner Cartridges	11.62
Used Engine Oils (Fleet)	27.69
Used Oil	24.65
Subtotal	226.34
Total	1,717.03

CHPRC = CH2M HILL Plateau Remediation Company

FY = Fiscal Year

WCH = Washington Closure Hanford

2.6.2.1 Pollution Prevention and Waste Minimization Accomplishments and Awards

The Hanford Site did not receive any DOE, federal agency, state agency, or industry-sponsored awards for pollution prevention and waste minimization accomplishments.

2.6.2.2 Contractor-Specific Accomplishments

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

- In FY2013, over 330 computers, monitors, printers, televisions, and servers were recycled through a certified recycler. In addition, Hanford transferred/donated 2,808 computers, monitors, televisions, printers, and servers through the PC Nationalization Program.
- Eliminated the receipt and distribution of phonebooks across the Hanford Site. Employees are encouraged to recycle old phonebooks and access the phonebook electronically via the internet rather than requesting a new one. This effort is expected to eliminate the generation of 6,420 pounds (2,915 kilograms) of paper waste each year.
- Sent 24.95 metric tons (24.5 tons) of hard media (e.g., floppy discs, micro film) to the Spokane Waste to Energy Facility, where the waste was burned, and the heat generated electricity. This process allowed for the secure destruction of the potentially sensitive material, while still meeting the sustainability goals to divert waste from the landfills.
- MSA took action to “green” the janitorial products in FY2013, by procuring one BioPreferred and two Certified Green Seal products.

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

- The zero waste picnic event for employees diverted more than 1,500 pounds (681 kilograms) of waste. The 2013 event hosted more than 2,200 participants. Through careful segregation, 98.5 percent of waste generated at the picnic was diverted from the local landfill. Glass, cardboard, plastic, aluminum and bottle caps were separated and distributed to the appropriate recycling facilities. The food scraps were sent to a commercial compost facility, leaving only 24 pounds (11 kilograms) of garbage to be sent to the local landfill.
- CHPRC’s Information Technology (IT) Department automated the development, review, approval, and distribution of procedures through an integrated electronic workflow tool that streamlined the procedure process. The new system is expected to reduce approximately 450 cases of paper per year.

WRPS sustainability performance activities which are implemented, documented and tracked through the Environmental Management System’s Objective and Target Program included the following:

- Implementation of computer streamed video and web conferencing for meetings, conserving petroleum use and greenhouse gasses while maximizing electronic stewardship.
- The iPad testing performed by Safety and Health, Work Control, Engineering, Environmental and Regulatory Affairs is now mostly complete and many groups have or are switching to field tablets of one kind or another 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, such as permits, approvals and paperwork processes.
- Support the site-wide domestic recycling efforts, such as paper, aluminum, plastic, hard hats, etc., managing and deferring solid wastes from the landfills.

- Increasing awareness of all of the Sustainable Program elements such as maximizing sustainable acquisition, increasing energy efficiencies, reduction of petroleum based fuels, etc.

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

- Completed a campaign to backfill remediated waste sites and burial ground in the 100 Area at the Hanford Site. This effort used 39,000 truckloads, and 1.3 million tons (1.2 million metric tons) of soil.
- Reused overburden soil as clean backfill when possible, based on sampling requirements. In FY2013, WCH reused 908,123.5 metric tons of clean overburden soil.
- Recycled approximately 135.81 metric tons (149 tons) of scrap metal from D&D activities in the 300 Area.

2.6.3 Environmental Orders

AS Nagel

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 Environmental Management System (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](#) 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 2013 with input from DOE and Hanford Site contractors. The plan describes the energy management program; and identifies planned energy efficiency, water conservation, transportation fleet management, and sustainable buildings activities, as required by [DOE O 436.1](#). Environmental objectives developed in 2010 were maintained in 2013, as were plans for recycling, environmentally preferred procurement management, and electronic asset stewardship (refer to Section 3.0).

2.7 Environmental Occurrences

TH Pysto

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 the reporting period. 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 during the reporting period, 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, rodents, and birds 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. Rodents eat vegetation located in contaminated areas, and then deposit contaminated feces outside of the contaminated area. Birds build nests and occasionally use materials 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 2013, there were 42 documented occurrences of legacy contamination.

2.8 Standards and Permits

JK Perry, RH Anderson, 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 2.9.

Table 2.9. Environmental Permits

Dangerous Waste Permit (RCRA)

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 2.1.2.1).

Table 2.9. Environmental Permits

Air Permits

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 *Clean Air Act* 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).

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.

Drinking Water Permits

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.

Wastewater Permits

Permit [CR-IU010](#), 300 Area Industrial Wastewater Discharge 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 HAN074 permits onsite 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 0004502](#), *State Waste Discharge Permit* allows treated effluent from the 200 East and 200 West Areas to be discharged to the 200 Area Treated Effluent Disposal Facility. This permit is effective until June 30, 2017.

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 was submitted. 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 approved this request on February 7, 2013 and canceled Permit ST-4507.

Table 2.9. Environmental Permits

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 remained in effect until January 1, 2014.

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, and storm water associated with Ready Mix Concrete operations. Bechtel National is the owner of the permit. 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 Pit 30 Quarry in the 200 East Area. Ecology issued the permit to BNI as the owner and 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 construction sand and gravel.

Wildlife Permits

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, 2014.

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.

Permit MB81249A-1, 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.

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.

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.

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.

Table 2.9. Environmental Permits

Permit 13-075, Scientific Collection Permit issued by the Washington Department of Fish and Wildlife to MSA for May 2013 through May 2014; 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 Waste Water Permit Deviations

During CY2013 there were 3 waste water permit deviations.

On February 1, 2013, a permit deviation (Permit ST 4502) was reported to Ecology for a vacuum relief valve leak at Pump Station 1 on the TEDF transfer line; and on February 6, 2013, the 5-day report was delivered to Ecology.

On May 22, 2013, a permit deviation (Permit ST4500) was reported to Ecology for a new influent stream (wastewater used to slurry sediments from the 105-B transfer pits into a dewatering unit) that was inadvertently not included in the January-March 2013 Discharge Monitoring Report.

On August 5, 2013, a permit deviation (Permit HAN013) was reported to the WDOH for not being able to locate the WTP Visitor Center Holding Tank System operations and maintenance manual.

2.10 Environmental Noncompliance

JW Cammann

During CY2013 there were 10 concerns, 12 findings, and 5 compliance actions issued by the regulators. A total of \$251,000 of fines and penalties were assessed and paid.

On January 16, 2013, the EPA issued a Notice of Noncompliance to the RL alleging that RL delivered the 2011 PCB Annual Report and Document Log 46 days late on August 31, 2012. DOE is required to take steps necessary to correct the violation and ensure all aspects of operation are conducted in accordance with all applicable regulations. EPA expects the Annual Report and Annual Document Log to be submitted by July 15 each year. No fines or penalties were assessed at the time.

On March 27, 2013, Ecology issued an inspection report to ORP and WRPS for the Dangerous Waste Compliance Inspection of the 242-A Evaporator conducted on November 13, 2012. The purpose of the inspection was to determine compliance with WAC 173-303 and the Hanford Site Dangerous Waste Permit (WA7890008967). The inspection specifically focused on the operation and maintenance of the 242-A Evaporator seal loops and associated conductivity alarms. Alleged violations included maintenance and monitoring records and other reports and records required by the permit were not maintained at the facility as required. Also, maintenance was not performed in a timely manner. No fines or penalties were assessed at the time.

On April 25, 2013, EPA issued a letter to RL requesting information related to asbestos demolition activities at several CHPRC, Fluor Hanford, and WCH facilities. The request is related to site inspections conducted by EPA on August 7-8, 2012 for asbestos removal and demolition projects conducted on the Hanford Site between January 2007 and July 2012. No fines or penalties were assessed at that time.

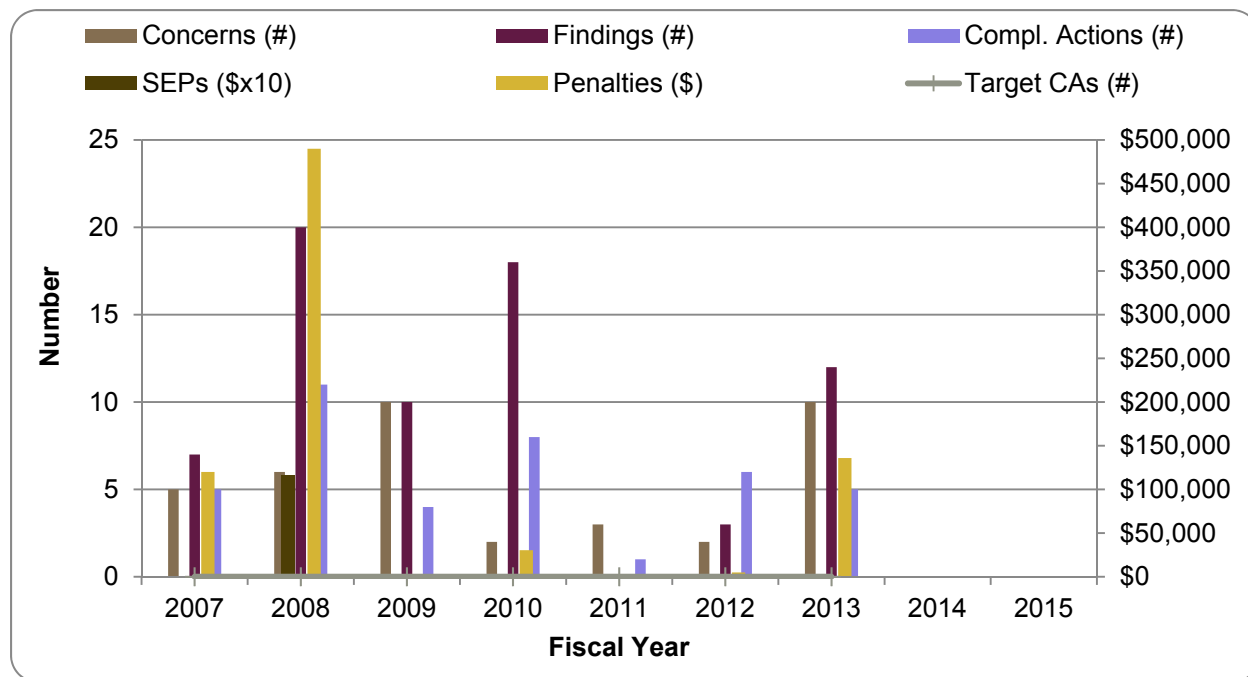
On June 19, 2013, CHPRC Decommissioning and Remediation Projects received a letter transmitting a Compliance Report from Ecology. The Compliance Report alleged potential noncompliances at the 400 Area Waste Management Unit with WAC 173-303 and the Hanford Site Dangerous Waste Permit (WA7890008967). No fines or penalties were assessed at the time.

On June 24, 2013, RL received a Consent Agreement and Final Order (CAFO) issued by the EPA. The CAFO alleged that RL stored various types of hazardous wastes without a permit at T-Plant, CWC, and LLBG. The CAFO also alleged that RL failed to meet closure plan requirements for Solid Waste Operations Complex facilities and failed to submit closure plans and closure notices for the 221-T railroad tunnel and 2401-W Building. The CAFO stipulated a fine of \$136,000 and required RL to submit permit modifications or closure plans for these units to Ecology. RL must also cease placement of prohibited wastes in LLBG Trenches 31 and 34 without first satisfying applicable treatment standards in accordance with [WAC 173-303-140](#), "Land Disposal Restrictions."

On September 11, 2013, Ecology and the WDOH issued a Notice of Correction to ORP and WRPS for failure to identify and report all potential pathways for release of radionuclides to the environment. Ecology and the WDOH performed a joint inspection of the 242-A Evaporator and DST 241-AW-102 on September 18, 2012, in response to an incident that occurred between July and August 2012 at the 242-A Evaporator where an open air pathway was discovered between the 242-A Evaporator and DST 241-AW-102. The open air pathway was created when the condenser room steam condensate divert-drain piping was opened for maintenance without seal loop C103-2 being operational, creating a single joined system with the potential for flow between the formally separate units as a function of differential pressures. Ecology had no findings at the time of the inspection. However, the subsequent review of requested information determined that the NOC permit for DST 241-AW-102 was deficient in identifying all controls in place for all pathways with the potential to circumvent the permitted exhaust system. Ecology and WDOH required that WRPS perform an As Low As Reasonably Achievable Control Technology (ALARCT) demonstration and submit a request to modify NOC Order DE05NWP-001. WRPS must also submit a schedule to modify NOC Orders DE05NWP-001 and DE11NWP-001, and submit documentation for all other Tank Farm facilities. No fines or penalties were assessed at the time. Figure 2.1 provides the environmental noncompliance's by fiscal year.

On October 21, 2013 RL received a Notice of Violation and Stipulated Penalty from the US EPA for alleged improper management of asbestos demolition materials at several Hanford facilities. The allegations are a result of an EPA NESHAP compliance inspection conducted on August 7-8, 2012. The field inspection included 13 Hanford sites where facilities had been demolished or asbestos work was underway. A total of 22 samples were collected at 6 sites, with 19 samples testing positive for asbestos. EPA identified 3 alleged violations which were assessed penalties totaling \$115,000.00 and 2 additional alleged violations which were not assessed penalties.

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

AS Nagel

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

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

MSA as the services and infrastructure contractor for the Hanford Site developed a sustainability plan for the Hanford Site in 2013 with input from site contractors. The plan describes the energy management program; identifies planned energy efficiency, water conservation, transportation fleet management, and sustainable buildings activities, as required by [DOE O 436.1](#). Environmental objectives, developed in 2010, were maintained in 2013, as were plans for recycling, environmentally preferred procurement management, and electronic asset stewardship.

Several contractors have made their environmental policy and environmental aspects available to the public through company Internet websites (Table 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; environmental non-compliances; and greenhouse gas reduction. 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 HQ.

Fleet Management. The acquisition target for alternative fuel vehicles was not met in FY2013 (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 not met in FY2013 as Hanford procured 72 percent (Figure 3.2). As part of a DOE-wide vehicle reduction effort, a requirement was set for Hanford to reduce its January 2011 fleet inventory of 1,567 non-mission critical vehicles by 369 vehicles (35 percent of the FY2005 inventory of 1,053 vehicles) to reach 1,198 non-mission critical vehicles by the end of FY2014 ([DOE O 436.1](#)). The DOE-wide goal was met in FY2013 and, therefore, vehicle inventory tracking ended in FY2013 (Figure. 3.2).

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)
Contractor Start Date	October 1, 2012	October 1, 2008	August 24, 2009	August 27, 2005	May 5, 2005	December 11, 2000	October 1, 2008
DOE Approval of Contractor ISMS	NA	November 2009	January 2011	November 2007	March 2006	February 2003	September 2009
Direction to Implement DOE EO 13423	October 2012	October 2008	August 2009	June 2009	NA	NA	October 2008
Direction to Implement DOE EO 13514	NA	June 2012	May 2011	October 2012	NA	NA	March 2011
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	October 2012	June 2009	August 2009	June 2009	November 2009	NA	October 2009
Direction to Cancel DOE O 450.1A	October 2012	July 2012	December 2012	October 2012	September 2013	NA	NA
Direction to Implement DOE O 436.1	NA	July 2012	July 2012	October 2012	NA	NA	October 2013
Contractor EMS Established	October 2012	November 2009	December 2009	September 2009	NA	NA	September 2009
ISO 14001 Certification	NA	July 2012	September 2011	NA	NA	NA	NA
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	September 2012	November 2012	NA	NA	September 2012
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/files.cfm/ems.pdf	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 FY2013 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 FY2015, relative to a FY2005 baseline ([Executive Order 13514](#) [74 FR 52117]).

Potable and Non-Potable Water Use. The target objectives for potable and non-potable water were met in FY2013 (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.

Electricity Use. The target objective for green electricity was met; however, the target objective for standard electricity was not met in FY2013 (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 Use. The target objectives for facility fuel use were met in FY2013 (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 FY2013 (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 in FY2013, 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 FY2013.

Regulated Waste Reduction. The target objective for regulated waste reduction was met in FY2013 (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 FY2013 (Figure 3.11).

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

3.2 Hanford Site Awards and Recognition

DM Huff

3.2.1 Presidential Migratory Bird Stewardship

J.W. Wilde

The Presidential Migratory Bird Stewardship Award annually recognizes a single project or action conducted by or in partnership with a Federal agency that meets the intent and spirit of the [Executive Order 13186](#), *Responsibilities of Federal Agencies to Protect Migratory Birds*, by focusing on migratory bird conservation. The project or action may involve reducing existing or potential adverse impacts to migratory birds and their habitats, restoring or enhancing migratory bird habitat, and incorporating conservation of migratory birds and their habitat into agency plans, guidance, or other activities. The action demonstrates leadership in inspiring others to further migratory bird conservation. This can include developing and implementing best-management practices, a policy action, or research. Every year the DOE selects a winner from submissions from DOE sites around the country.

The MSA Public Safety and Resource Protection and RL submission received one of the 2014 three honorable mentions from DOE for implementation of the Avian Protection Program through MSA's Public Safety and Resource Protection program. Program components include monitoring of key avian species, implementing focused and active protection measures where needed, evaluating the impacts of all projects on migratory birds, training site personnel about migratory bird protection, and preserving and replacing important migratory bird habitat. The Avian Protection program is fully integrated with the Hanford NEPA compliance program and the EMS. Highlights from the 2014 nomination include; Bald Eagle night roost and nest buffering; Ferruginous Hawk nest buffering; Burrowing Owl burrow locating and coordination with USFWS in banding effort; Barn Swallow and Cliff Swallow nest take avoidance; providing training and site wide notifications for employees; and migratory bird nest compliance. This is the second honorable mention award for this program.

In addition, several Hanford Site contractors developed internal environmental awards programs to recognize leadership in environmental, energy, and transportation stewardship part of their EMS.

3.2.2 Advanced Technologies and Laboratories

DM Huff

In February 2014, DOE-HQ completed its Voluntary Protection Program (VPP) recertification of ATL and recommend that ATL maintain its VPP Star status. In August 2013, ATL received the DOE-HQ VPP Star of Excellence Award for having occupational injury and illness rates greater than 50% below the industry average. At this same time, ATL received the Voluntary Protection Programs Participants' Association's Outreach Award for mentoring other VPP sites. In October 2013, ATL received EHS Today Magazine's - America's Safest Companies Award for demonstrating transformation environment, safety, and health leadership in the form of support from management and employee involvement; innovative solutions to safety challenges; injury and illness rates significantly lower than the average for their industries; comprehensive training programs; evidence that prevention of incidents is the cornerstone of the 2014, ATL completed 3 years without a recordable or lost workday injury or illness event. Finally, ATL has worked in a Hazard Category 3 nuclear facility since May 2005 without a radiological skin or clothing contamination event or and uptake of radiological material.

3.2.3 CH2M Hill Plateau Remediation Company

CHPRC maintains its Voluntary Protection Program Merit status through 2013. CHPRC also maintained certification of its [ISO 14001:2004](#) status in 2013 by successfully passing an external surveillance. The audit team had zero findings and zero opportunities for improvements (OFIs). In October 2013, CHPRC

won the 2013 City of Richland Green Living Award for “Green Event of the Year” based on the 2012 and 2013 company picnics.

3.2.4 Mission Support Alliance, LLC

MSA maintained certification to the ISO 14001:2004 standard in 2013 by successfully passing an external surveillance of its EMS. In October 2013, MSA received three DOE Superior Star Status awards – one each for the Hammer Federal Training Facility, the Safeguards and Security organization and for Mission Support Services. MSA employees participated in a site wide VPP team that received the National Voluntary Protection Program Participants Association (VPPPA) Outreach Award.

3.2.5 Washington Closure Hanford, LLC

WCH received two VPP awards, which include the Outreach Award, which was received along with other Hanford contractors for supporting and promoting VPP standards; and the Legacy of Stars Award, this award recognized WCH for four consecutive years of achieving Star of Excellence status.

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 7 million hours without a lost-workday injury.

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

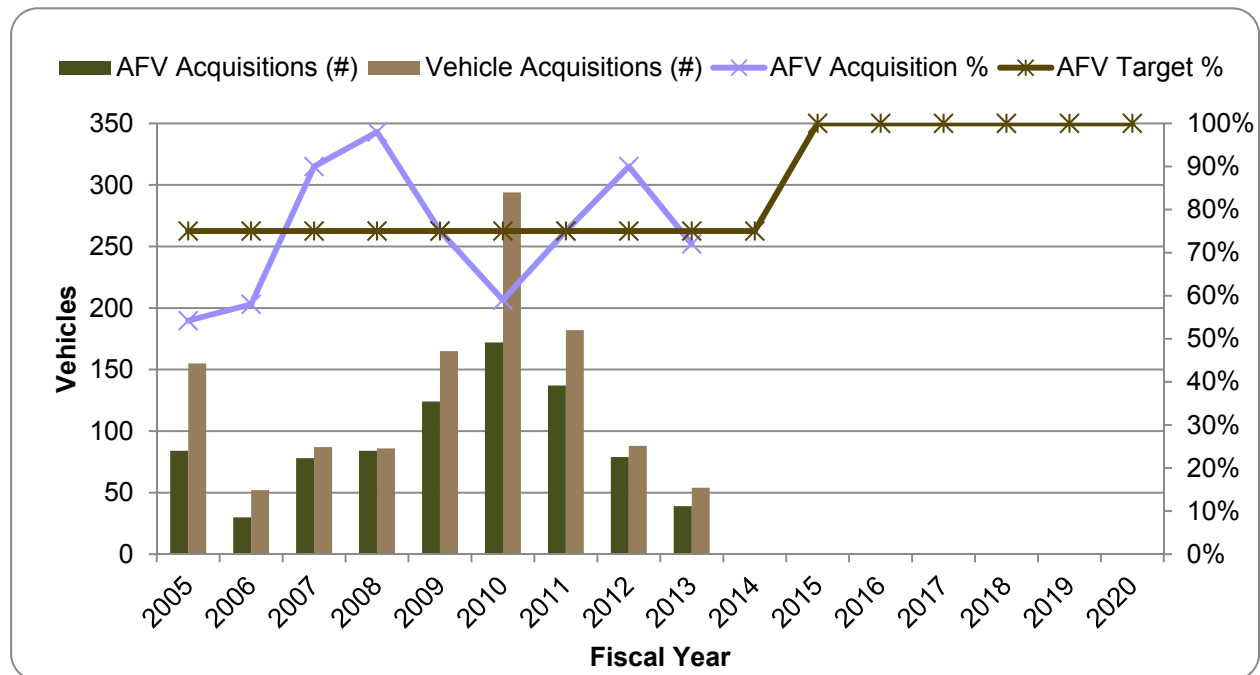


Figure 3.2. Fleet Management – Reduction
(FY2005 through FY2012, Target Objectives through 2015)

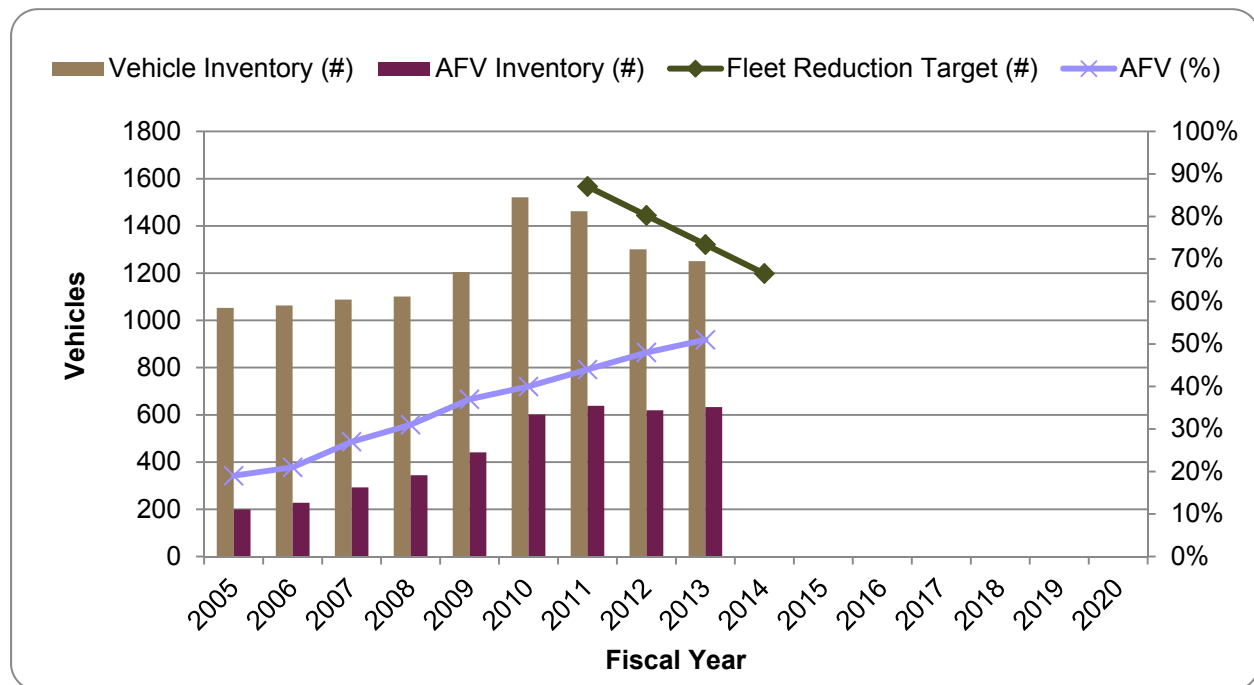


Figure 3.3. Vehicle Fuel Use
(FY2005 through FY2012, Target Objectives through 2020)

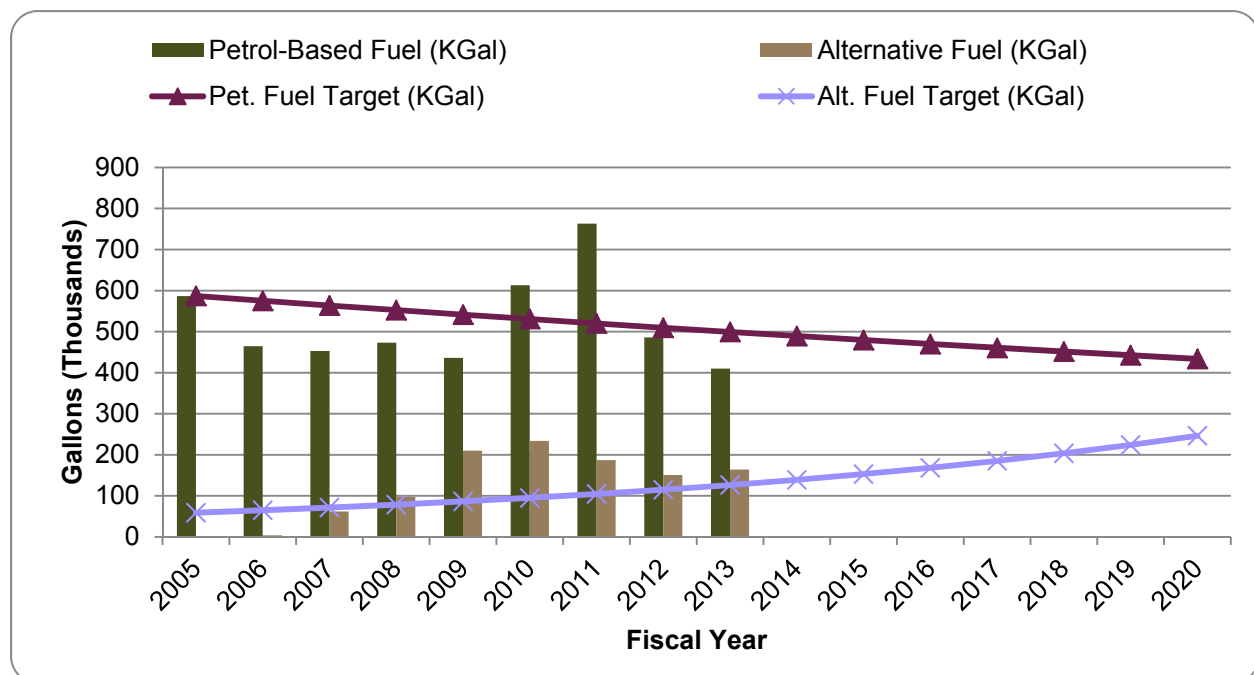


Figure 3.4. Water Use
(FY2007 through FY2012, Target Objectives through 2015)

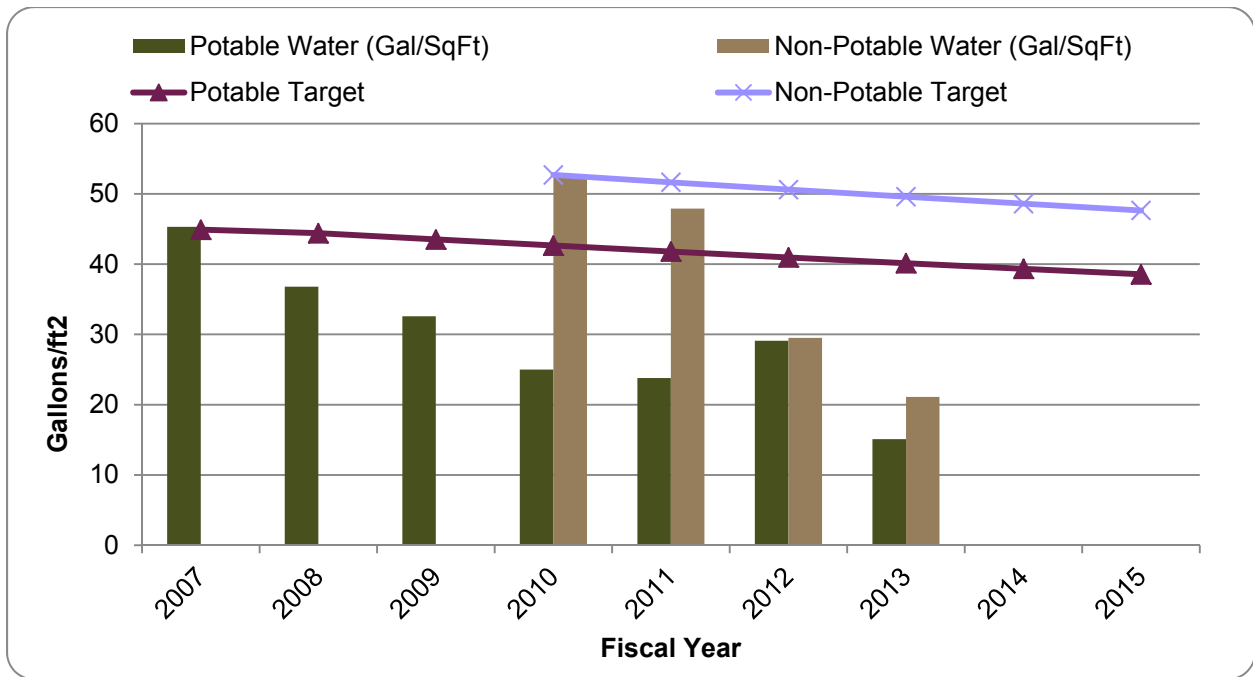


Figure 3.5. Electricity Use
(FY2003 through FY2012, Target Objectives through 2015)

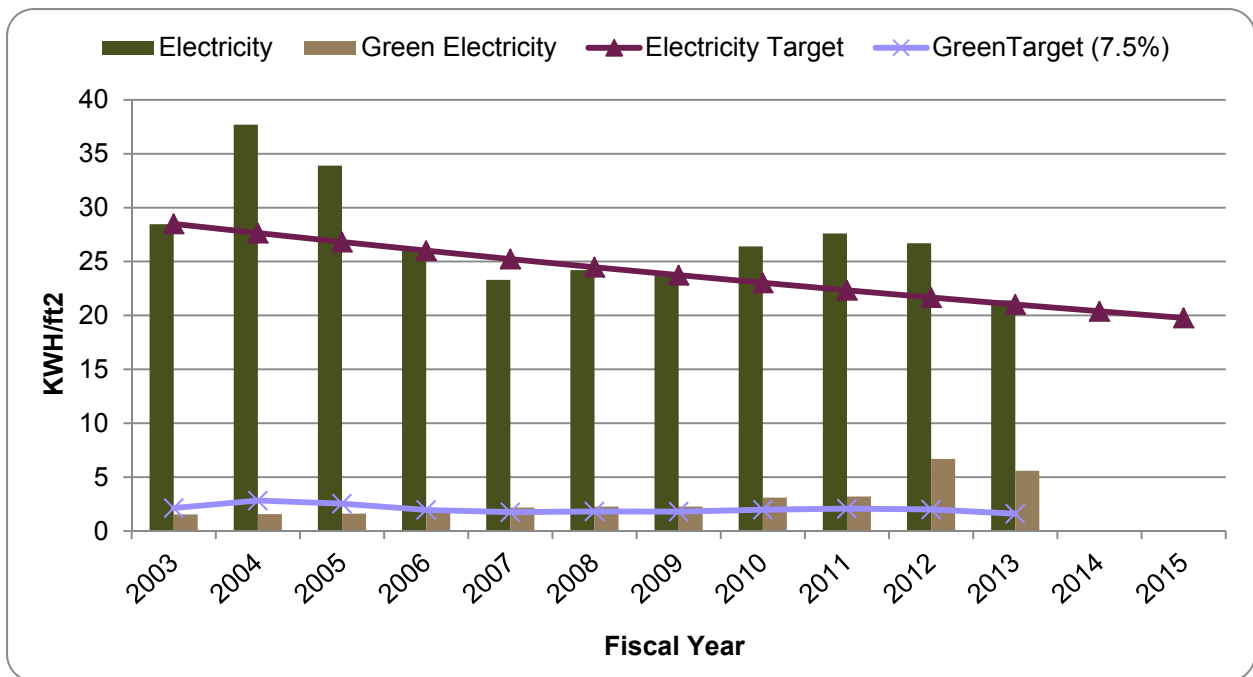


Figure 3.6. Facility Fuel Use
(FY2003 through FY2012, Target Objectives through 2015)
KBTU = one thousand British thermal units

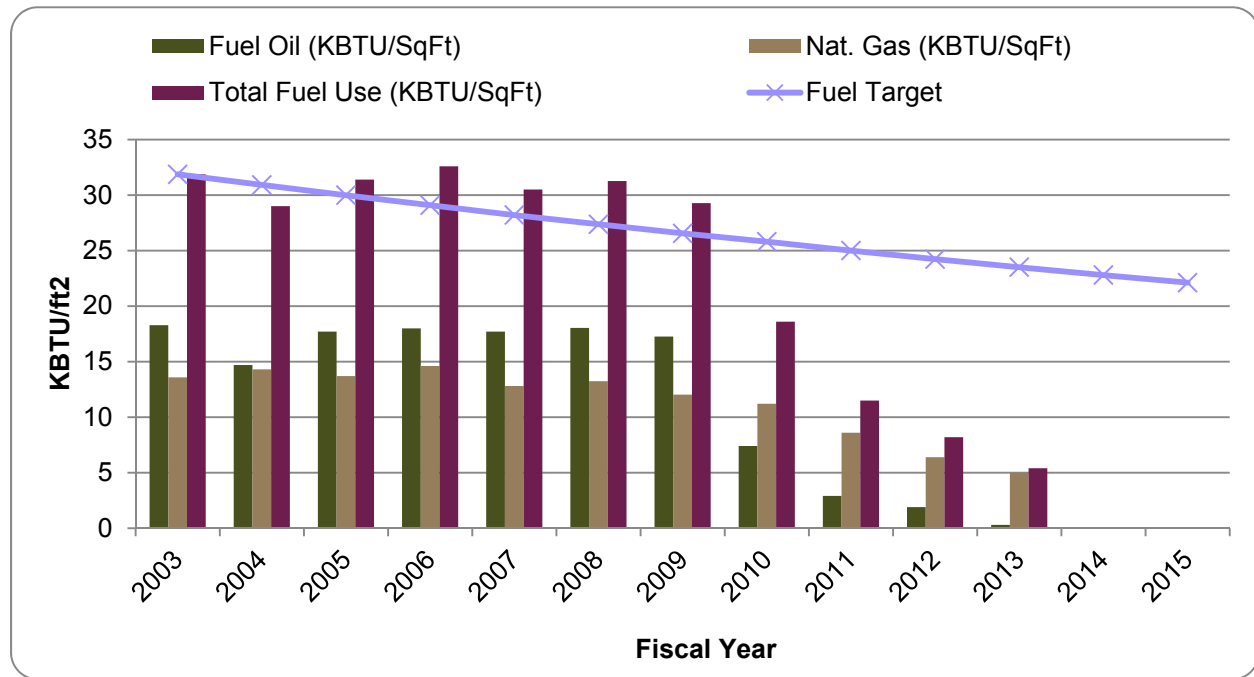


Figure 3.7. Facility Energy Use
(FY2003 through FY2012, Target Objectives through 2015)
KBTU = one thousand British thermal units

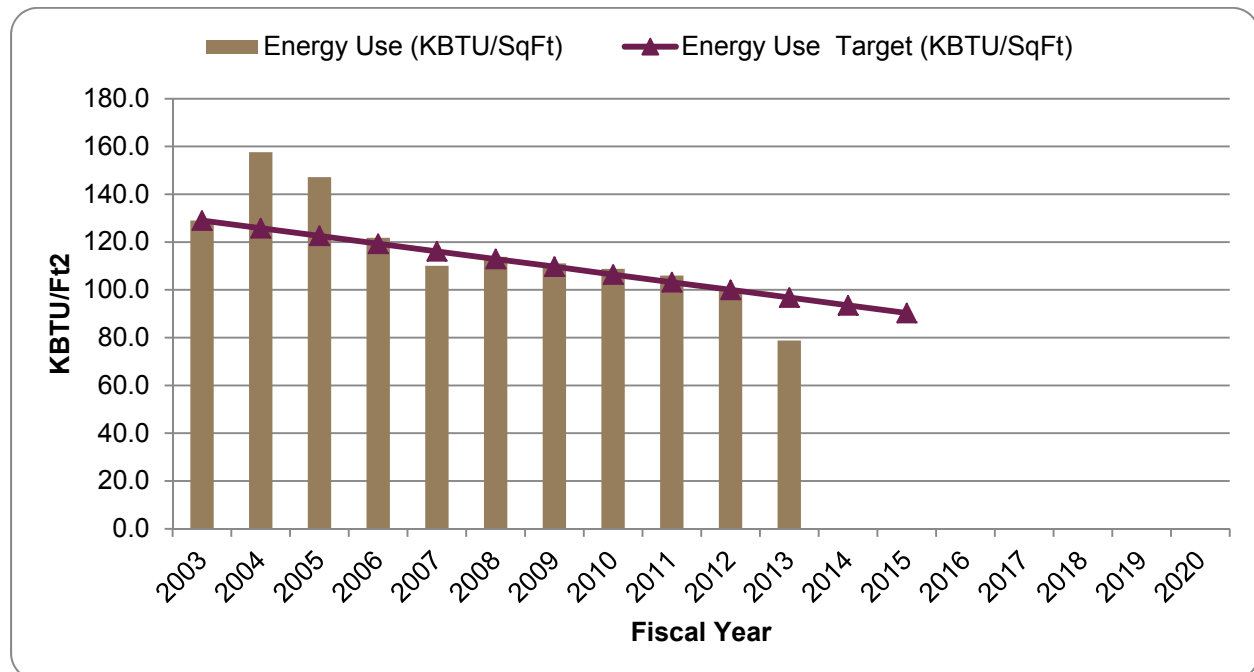


Figure 3.8. Electronic Product Environmental Assessment Tool Standards Compliance
(FY2009 through FY2012, with Target Objectives through 2015)

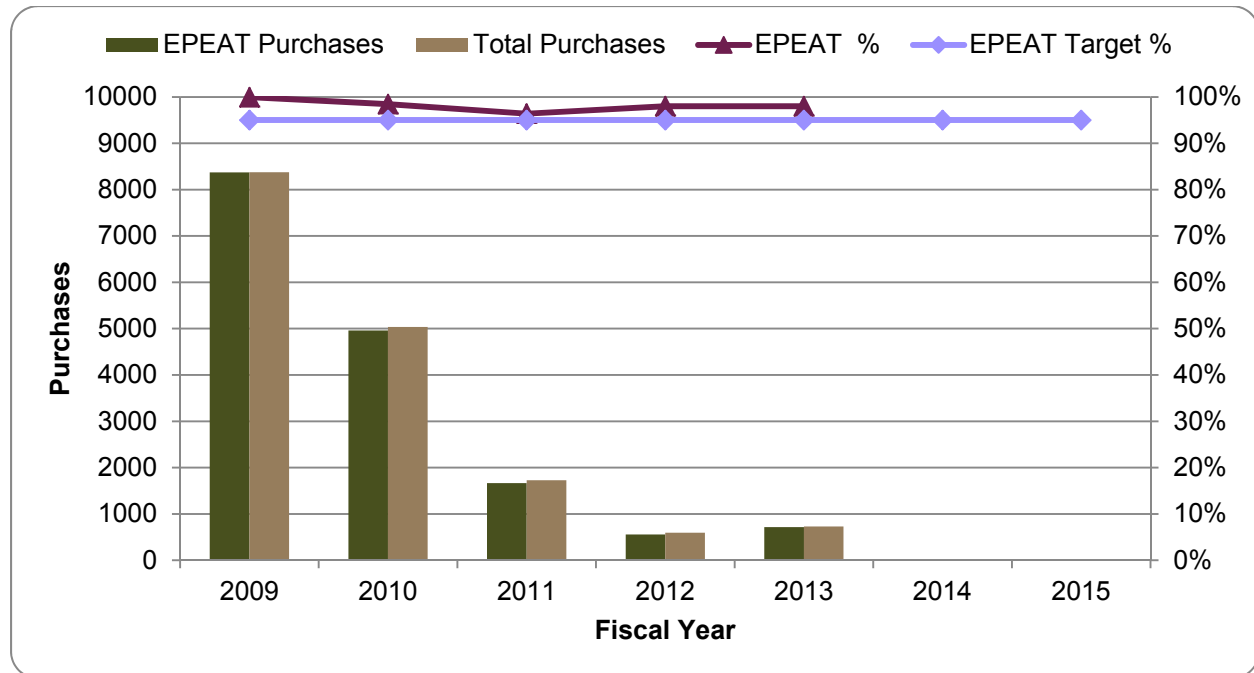


Figure 3.9. Sanitary Waste Reduction
(FY2008 through FY2012, Target Objectives through 2015)

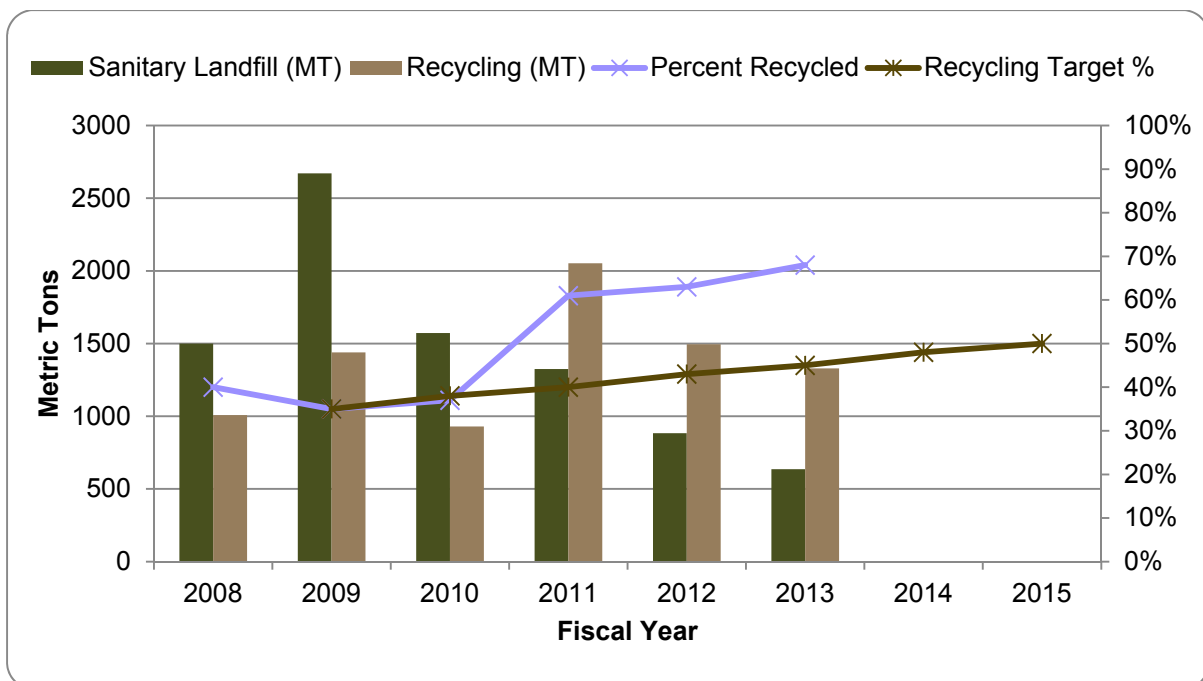
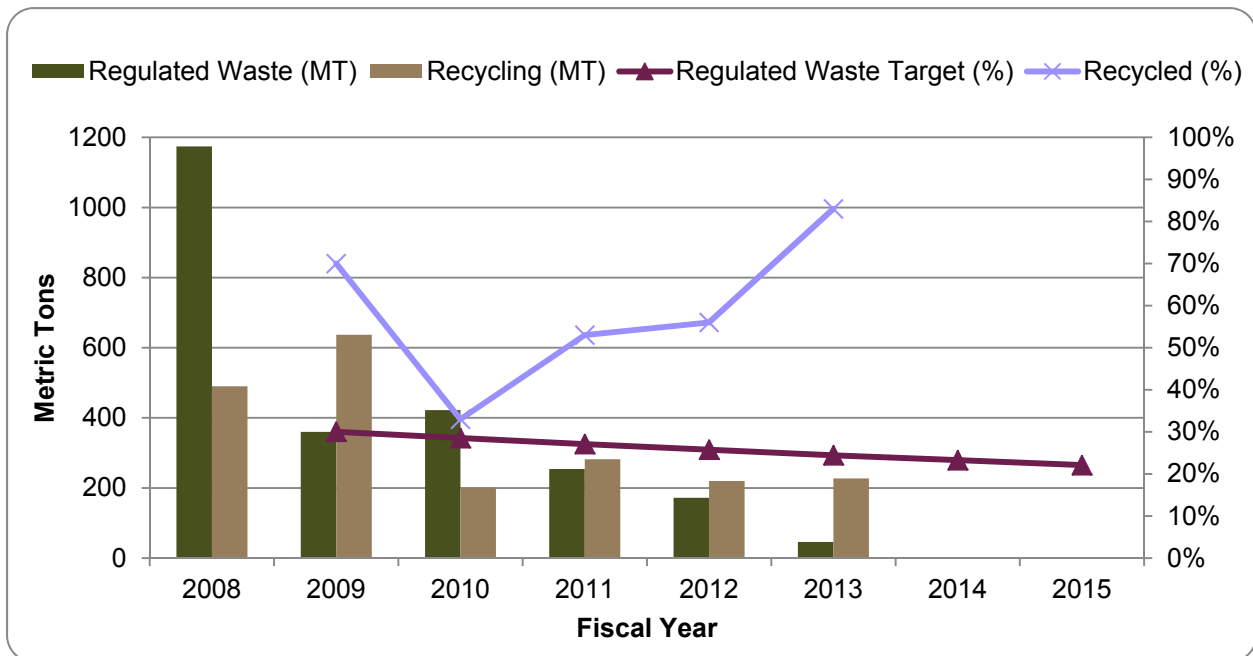
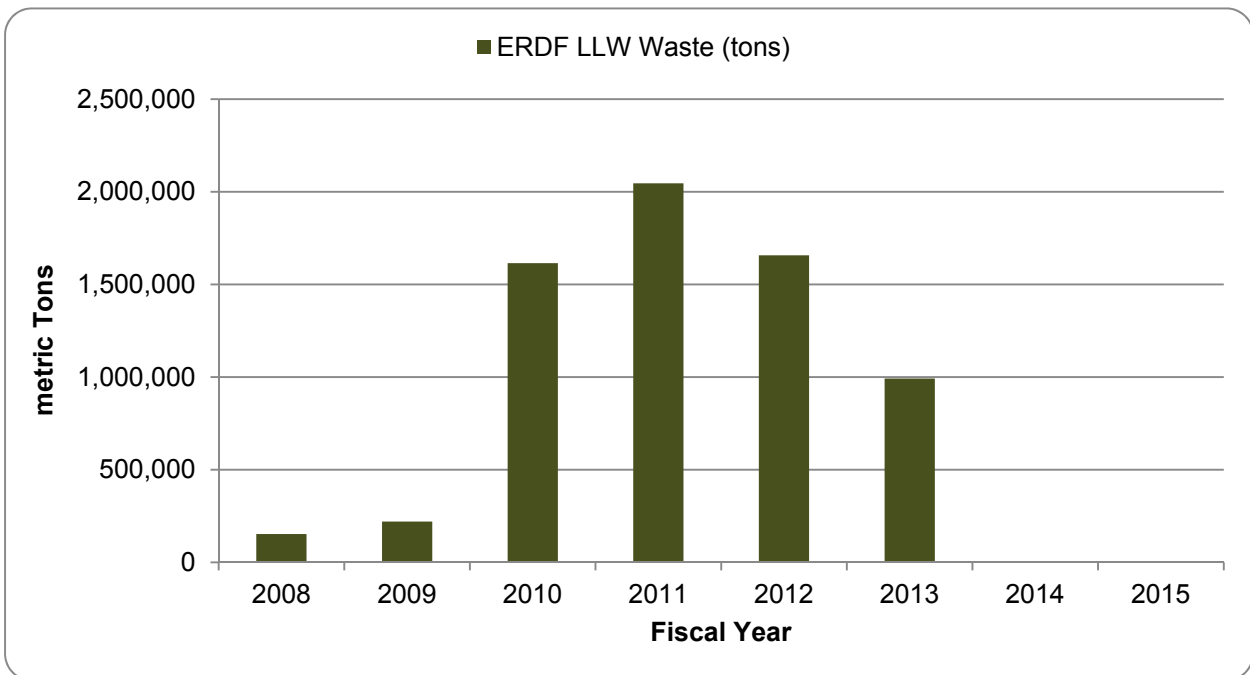


Figure 3.10. Regulated Waste Reduction

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

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.

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 2013 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 2012 and 2013 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.

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. The average dose rates levels seen at the K Basins Closure Project during 2013 were generally similar to 2012 levels (Figure 4.1). Dose-rate levels in 2013 when compared to 2012 were 4 percent higher in the 100-K East Area, 7 percent higher at the Cold Vacuum Drying Facility (CVDF) and 6 percent higher in the 100-K West Area.

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

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 2013 average dose rate was slightly higher than in 2012, and was less than 100 mrem (1 millisievert) per year.

200 East and 200 West Areas. Dose rate levels measured during 2013 in the 200 East and 200 West Areas were slightly increased compared to 2012 (Figure 4.1). Average dose rates measured in 2013 at ERDF (located near the 200 West Area) were essentially unchanged from 2012 levels.

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 reduced average dose rate levels in 2013. As in 2012, the 2013 levels were significantly lower than levels measured in 2011 and years previous. 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 2013 in the 300 and 400 Areas and at the 300 Area Treated Effluent Disposal Facility were generally higher by approximately 10 percent compared to 2012 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 2013 were approximately 8 percent higher than 2012 levels.

Integrated Disposal Facility. The average dose rates in 2013 were slightly higher (2 percent) than 2012 levels.

Figure 4.1. Average Thermoluminescent Dosimeter Results

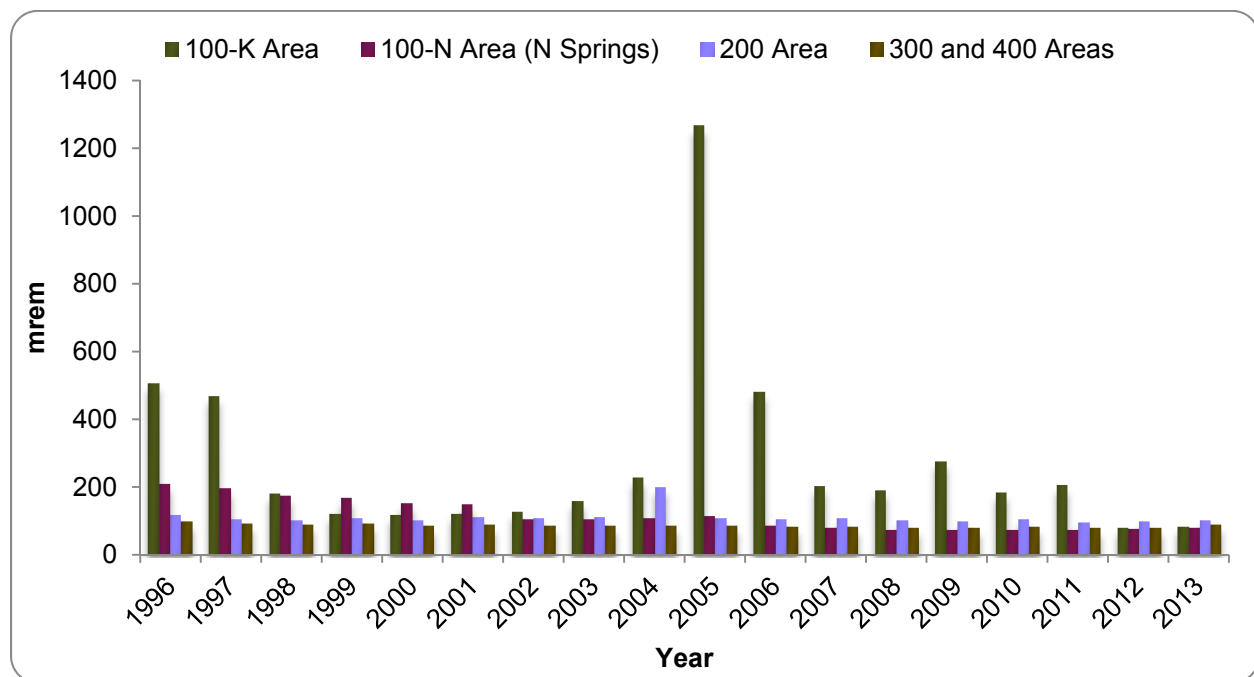


Table 4.1. Thermoluminescent Dosimeter Results
(mrem/year)^a

Location	No. of Dosimeters	2012		2013		Percentage Change ^e
		Maximum ^b	Average ^{c, d}	Maximum ^b	Average ^{c, d}	
100-K	14	107 ± 16	82 ± 16	112 ± 12	86 ± 17	5
100-N	1	87 ± 13	79 ± 13	87 ± 13	84 ± 7	7
200 East	42	176 ± 87	102 ± 48	230 ± 131	105 ± 56	4
200 West	24	151 ± 12	100 ± 40	158 ± 9	104 ± 41	4
200-North (212-R) ^f	1	88 ± 13	83 ± 9	91 ± 14	86 ± 14	4
300 Area	8	111 ± 20	86 ± 23	124 ± 9	95 ± 26	11
300 TEDF	6	86 ± 16	83 ± 6	93 ± 13	91 ± 4	9
400 Area	7	91 ± 8	82 ± 8	100 ± 58	92 ± 9	11
618-10	4	80 ± 20	77 ± 6	84 ± 11	83 ± 3	8
CVDF	4	76 ± 12	75 ± 2	82 ± 13	80 ± 3	7
ERDF	3	101 ± 26	89 ± 20	91 ± 11	88 ± 6	<1
IDF ^f	1	98 ± 15	89 ± 12	102 ± 15	92 ± 16	2

^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 2012 mean.^f Maximum value represents highest quarterly value ± analytical uncertainty.

CVDF = Cold Vacuum Drying Facility (100 K Area).

ERDF = Environmental Restoration Disposal Facility (200 West Area).

IDF = Integrated Disposal Facility (200 East Area).

TEDF = 300 Area Treated Effluent Disposal Facility.

4.1.2 Waste Disposal Sites Radiological Surveys

JW Wilde

During 2013, a total of 924 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 mrem (0.01 millisievert) per hour, although direct dose-rate readings from isolated radioactive specks could have been higher.

Underground radioactive material areas are regions where radioactive materials occur below the soil surface. These areas are typically stabilized cribs, burial grounds, covered ponds, trenches, and ditches. Barriers have been placed over the contamination sources to inhibit radionuclide transport to the surface. These areas are surveyed at least annually to assess the effectiveness of the barriers.

Contamination areas and soil contamination areas may or may not be associated with an underground structure containing radioactive material. A breach in the surface barrier of a contaminated underground area may result in the growth of contaminated vegetation. Insects or animals may burrow into the soil and bring contamination to the surface. Vent pipes or risers from an underground structure may be sources of speck contamination (particles with a diameter less than 0.25 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.

4.2 Potential Radiological Doses

R Perona and RT Ryti

Potential radiological doses to the public and biota from Hanford Site operations in 2013 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 (MEI) at an offsite location, evaluated by using a multimedia pathway assessment [DOE O 458.1](#), Chg. 3; 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 2013 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 can be 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. In specific instances, such as ambient air measurements of tritium at offsite locations near the 300 Area,

radionuclide concentrations may be distinguishable from background levels and are used to support the dose assessment.

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 International Commission on Radiological Protection (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 MEI (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 groundwater-related contributions from other 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 2013. 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 and seep 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. Tritium and uranium isotopes were found in the Columbia River downstream of the Hanford Site (Richland Pumphouse station, HRM 46.4) in 2013 at concentrations statistically greater than upstream (Priest Rapids Dam station) 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 short-lived 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 are provided in Appendix D.

4.2.1 Maximally Exposed Individual Dose (Offsite Resident)

The MEI 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 2013. 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. 3; 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 MEI represent a

hypothetical upper bound of potential individual dose rather than an anticipated dose to an actual individual.

The location of the hypothetical MEI 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 MEI (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, so the domestic drinking water pathway is also applied here. Both Riverview and Horn Rapids Road are locations where Columbia River water is withdrawn for irrigation.

Dose calculations for 2013 releases indicate that the MEI 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 MEI evaluated using GENII Version 2.10 ([PNNL-14583, Rev 3a](#)) is provided in Figure 4.3. Additional information related to the selection of the MEI 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 MEI are provided in Appendix D.

The total dose to the MEI at Horn Rapids Road in 2013 was calculated to be 0.15 mrem (1.5 microsievert) per year (Table 4.4; Figure 4.4). This dose is 0.15 percent of the 100 mrem (1,000 microsievert) per year public dose limit specified in [DOE O 458.1](#), Chg. 3 and 0.60 percent of the 25-mrem (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 40 percent of the total dose of 0.15 mrem (1.5 microsievert) per year, with the remaining 60 percent related to air pathway exposures.

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

- *Air Releases:* Consumption of food products containing tritium released from the 300 Area contributed approximately 60 percent of the total air pathways dose of 0.087 mrem (0.87 microsievert) per year. Inhalation of the radioactivity progeny of radon-220 released from the 300 Area contributed most of the remaining 40 percent of the of the total air pathways dose.
- *Water Releases:* Consumption of fish from the Columbia River contributed 53 percent of the total water pathways dose of 0.060 mrem/year. Consumption of food grown using Columbia River water

withdrawn downstream from the Hanford Site contributed 32 percent of the 0.060 mrem/year total, and drinking water ingestion contributed the remaining 15 percent. Isotopes of uranium and their progeny, particularly uranium-234 and uranium-238, contributed over 95 percent of the water pathways dose.

The MEI dose in 2013 is slightly lower than the 0.19 mrem/year calculated in 2012 ([DOE/RL-2013-18](#), *Hanford Site Environmental Report for Calendar Year 2012*). One difference between 2012 and 2013 dose estimates is that naturally occurring potassium-40 was included in the 2012 water pathways dose calculations. The 2012 downstream concentrations were statistically greater than upstream concentrations and potassium-40 was therefore included in the 2012 dose calculations for water releases. The 2013 MEI dose of 0.15 mrem/year is about 70% higher than the 2012 dose without the contribution of potassium-40 (0.086 mrem/year), largely due to higher tritium emission from the 300 Area in 2013. The relationship of 2013 MEI dose to values calculated for the period of 2009 to 2001 is shown in Figure 4.4.

The dose estimate incorporates a number of conservative assumptions to ensure that pathway doses are protective and therefore calculated doses are likely to be overestimated. In the air pathways calculations, measurements of gross alpha and gross beta radiation in stack emissions from the 100, 200, and 300 Areas 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 MEI 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 MEI are resident species rather than anadromous fish, such as salmon or steelhead. Because anadromous fish spend most of their lives in the ocean they would have a much lesser exposure to contaminants associated with the Hanford Reach compared to species that spend their entire lives in the Hanford Reach, such as sturgeon.

Figure 4.2. Locations Important to Hanford Site Dose Calculations

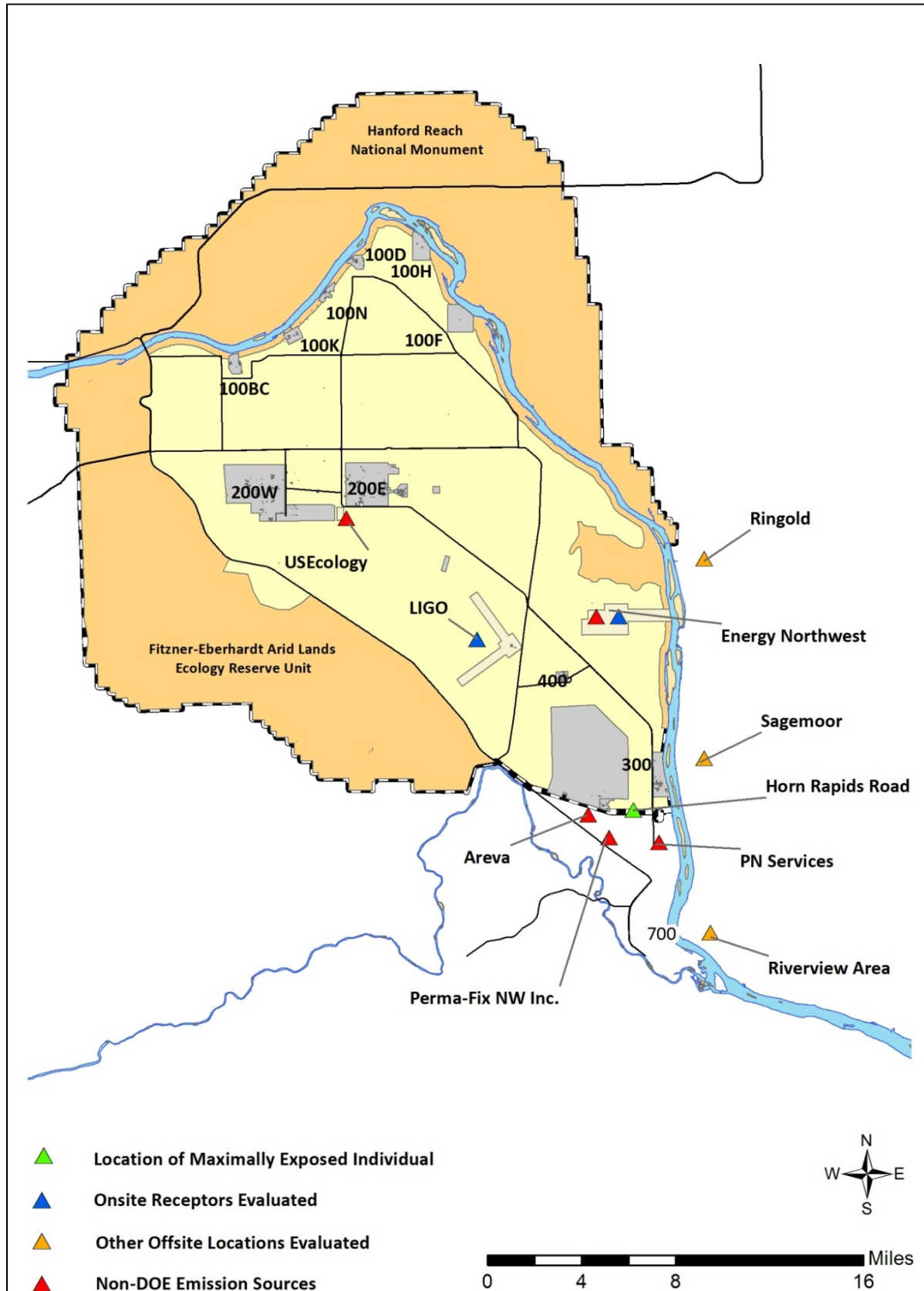


Figure 4.3 Conceptual Site Model of Exposure Pathways Evaluated in Dose Calculations
(Horn Rapids Road MEI)

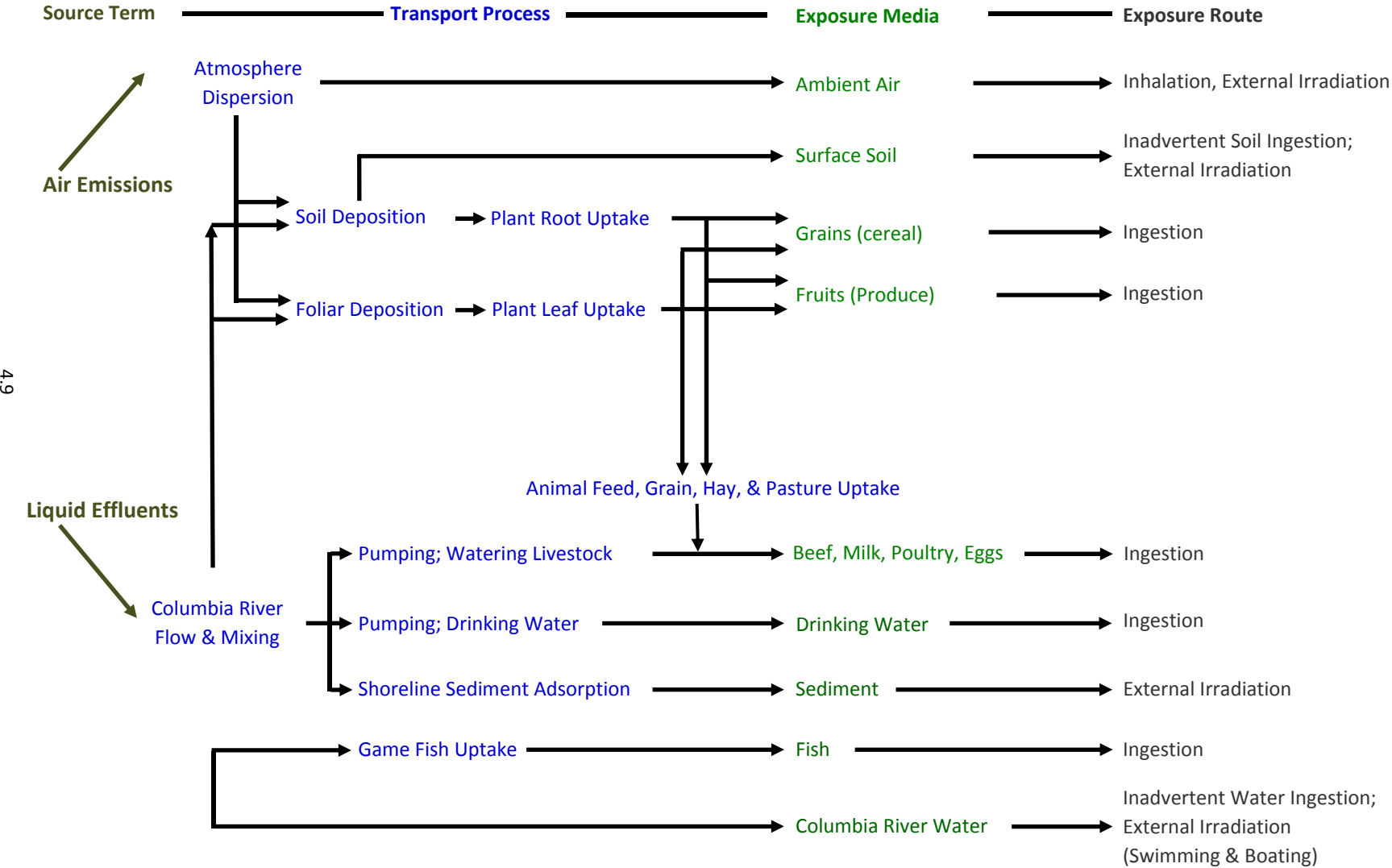


Table 4.2. Pathway Doses for the Hypothetical, Maximally Exposed Individual Residing at Horn Rapids Road

Release Type	Exposure Pathway	Dose Contributions from Operational Areas, mrem ^a				
		100 Area	200 Area ^(c)	300 Area ^(d)	400 Area	Pathway Total
Air	Food Ingestion	2.4E-07	8.4E-05	0.053	3.1E-07	0.053
	Inhalation	1.9E-06	5.0E-05	0.034	7.5E-07	0.034
	External, Soil Ingestion	1.7E-09	2.4E-07	0.00053	1.1E-08	0.00053
	Subtotal Air	2.1E-06	0.00013	0.087	1.1E-06	0.087
Water	Irrigation (food and soil ingestion; external)	NA ^(b)	0.019 ^(c)	NA	NA	0.019
	Drinking Water Ingestion	NA ^(b)	0.0088 ^(c)	NA	NA	0.0088
	Recreation (river water and sediments; external and ingestion)	NA ^(b)	0.00019 ^(c)	NA	NA	0.00019
	Fish Ingestion	NA ^(b)	0.032 ^(c)	NA	NA	0.032
	Subtotal Water	NA	0.060	NA	NA	0.060
Air + Water Total		2.1E-06	0.060	0.087	1.1E-06	0.15

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

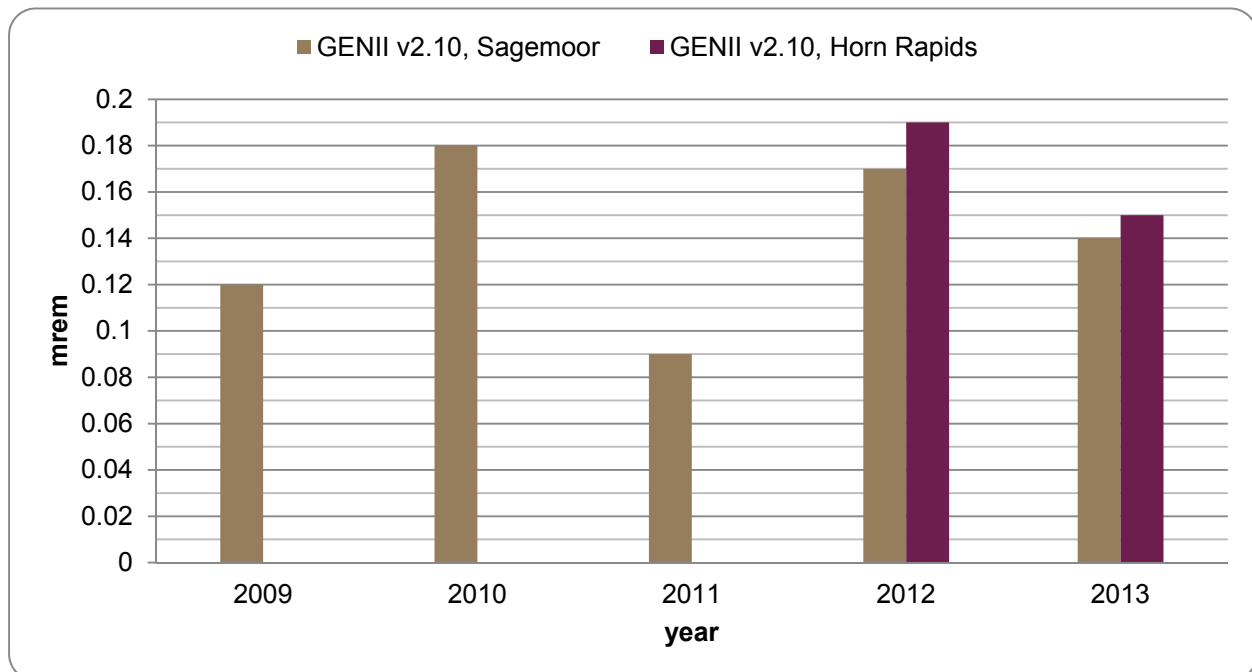
^b No measured releases; the last 100 Areas NPDES-permitted outfall (1908-K Outfall) ceased releases in March 2011.

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

^d Measured tritium air concentrations at offsite locations near the 300 Area indicate modeled air pathways doses may be biased low by up to approximately 0.05 mrem; refer to text.

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

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



Because releases of tritium from the 300 Area are the major source of calculated Hanford-related air pathways doses for the hypothetical MEI, 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 modeled annual-average air concentrations of tritiated water vapor (HTO) at the Horn Rapids Road MEI location and averages based on measured values at three offsite locations south and east of the 300 Area. Measured monthly tritium concentrations vary substantially at each monitoring location. The monthly minimum and maximum of the measured values is shown on Figure 4.5 in addition to the annual average.

The modeled annual-average tritium concentration at the Horn Rapids Road MEI location is below the mean of the measured values at three nearby offsite monitoring locations but within the range of the individual monthly measurements. The potential significance of the higher mean values for the measured concentrations of tritium at the nearby offsite monitoring stations depends on their having a relationship to Hanford Site 300 Area annual tritium emissions. A relationship between 300 Area monthly tritium air emissions and onsite ambient air concentrations in 2006 was shown by Barfuss (2007), but there was little correlation of monthly emissions and air concentrations for a combined group of four nearby offsite monitoring locations. The relationship of 300 Area HTO emissions and measured annual-average air concentrations at onsite stations in the 300 Area, and at three nearby offsite stations, for the period of 1994 through 2013 is shown in Figure 4.6.

Figure 4.6 shows a weak correlation for the onsite and Byers Landing air stations, a somewhat stronger correlation for the Dogwood air station, and no relationship for the Battelle Complex station. Nevertheless, the magnitude of the annual averages relative to regional background levels of tritium that range between approximately 1.5 and 4 pCi/m³ (Barfuss 2007; Figure 11) indicates that these air monitoring stations are frequently measuring tritium most likely released from the 300 Area. Although the correlation between annual HTO emissions and annual-average air concentrations appears strongest for the Dogwood station, the magnitude of the HTO concentrations are lower than at the other monitoring locations which are closer to the 300 Area. GENII air dispersion calculations were performed to compare modeled and measured annual emissions for these specific locations with the following results:

Monitoring Location	Measured Concentration (pCi/m ³)	Modeled Concentration (pCi/m ³)
Battelle Complex	16	5.9
Byers Landing	16	4.1
Dogwood	4.3	1.3

It is possible the discrepancy between modeled and measured annual-average HTO air concentrations in 2013 is related to the high degree of variability in the range of monthly HTO measurements (Figure 4.5). This variability is likely due in part to episodic HTO releases that are not incorporated in the GENII air dispersion modeling, which assumes a constant rate of HTO emissions. Note that the modeled tritium values do not account for regional background levels of tritium, which would add between 1.5 and 4 pCi/m³ to the modeled values (Barfuss 2007; Figure 11). Even if annual-average HTO concentrations were underestimated for the MEI receptor at 638 Horn Rapids Road, doubling or even tripling the tritium dose would add approximately another 0.05 to 0.1 mrem/year to the MEI dose for an adjusted dose of 0.2 to 0.25 mrem/year, which is still negligible relative to the 100 mrem/year public dose limit.

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

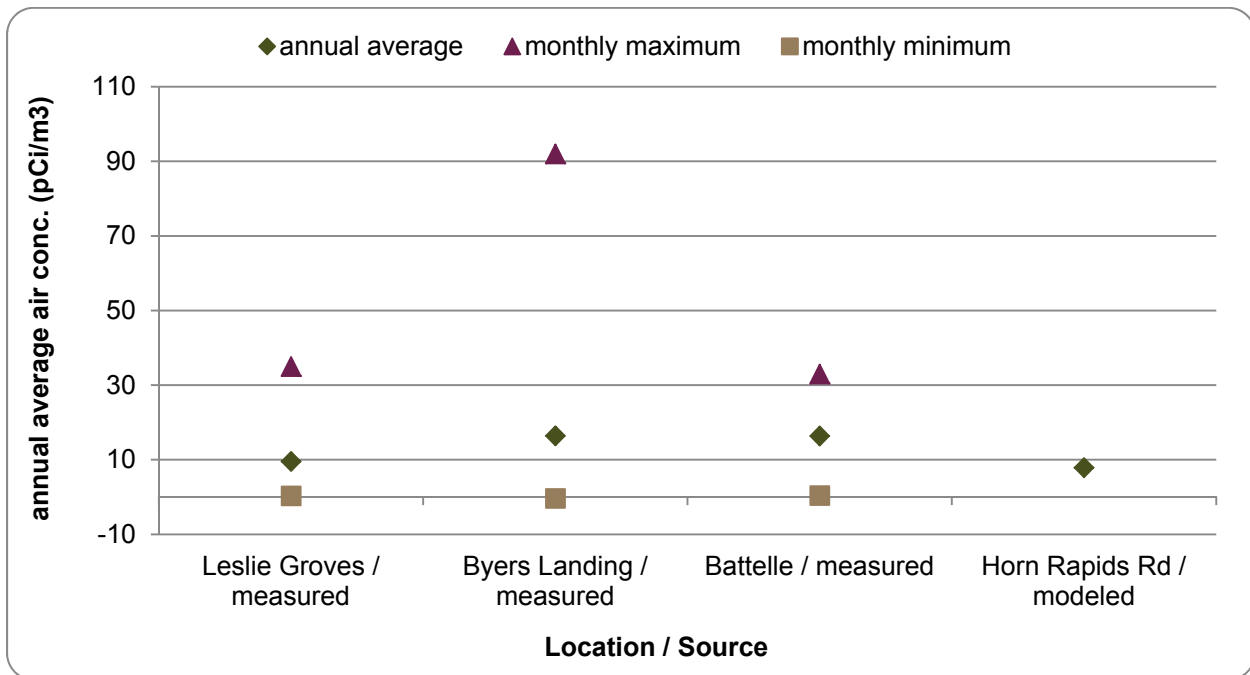
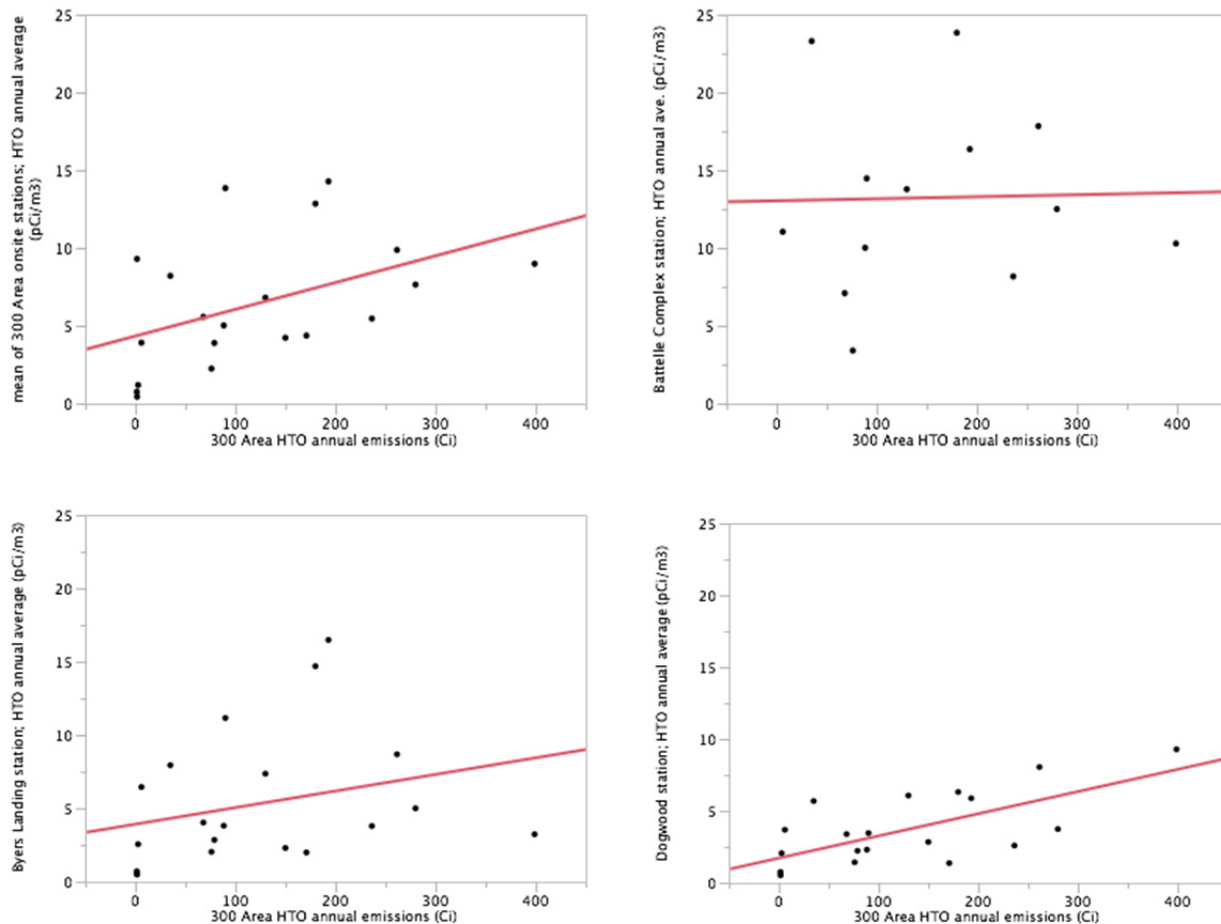


Figure 4.6. Relationship of Ambient Air H-3 Concentrations at Selected Locations to HTO Emissions (1994 to 2013)



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 2013 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. 3; 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 Horn Rapids Road MEI shown in Figure 4.3 is also applicable to the collective dose calculations. Like the Horn Rapids Road, MEI 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 wells adjacent to the river. In addition to the drinking water pathway, a primary distinction between the MEI 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 air pathways collective dose calculations employ 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 2013 was 1.7 person-rem (0.017 person-sievert) per year (Table 4.5), which is higher than the collective doses calculated between 2009 and 2012 (Figure 4.7). Water pathway contributions assigned to the 200 Area and air pathway contributions from releases in the 300 Area contributed approximately equally to the total collective dose of 1.7 person-rem.

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

- Air Releases:** Consumption of food products grown downwind of the 300 Area contributed approximately 60 percent of the of the air pathways collective dose of 0.67 person-rem. The remaining air pathways collective dose is primarily related to inhalation. About 70 percent of these food and inhalation air pathways doses, which combined account for approximately 97 percent of the total air pathways collective dose, are due to releases of tritium from the 300 Area. The remaining 30 percent of the total air pathways collective dose of 0.67 person-rem is largely associated with inhalation of the radioactive progeny of radon-220 released from the 300 Area. Air releases from the 100, 200 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 97 percent of the total water pathways collective dose of 0.99 person-rem. Consumption of food products grown with Columbia River irrigation water and consumption of Columbia River fish contributed approximately equally to the remaining 3 percent. Naturally occurring isotopes of uranium (uranium-234, uranium-235, and uranium-238) and their progeny from releases assigned to the 200 Area were the largest contributors (approaching 90 percent) to the drinking water collective dose.

Table 4.3. Collective Pathway Doses
(Within a 50-mile (80-Kilometer) Radius)

Release		Dose Contributions from Operational Areas, mrem ^a				
		100 Area	200 Area	300 Area	400 Area	Pathway Total
Air	Food Ingestion	4.2E-05	0.0086	0.39	1.2E-05	0.40
	Inhalation	0.00065	0.0092	0.25	4.3E-05	0.26
	External, Soil Ingestion	3.9E-07	2.3E-05	0.0036	3.9E-07	0.0036
	Subtotal Air	0.00069	0.0178	0.65	5.6E-05	0.67
Water	Irrigation (food and soil ingestion; external)	NA ^b	0.019 ^c	NA	NA	0.019
	Recreation (river water and sediments; external and ingestion)	NA ^b	0.0016 ^c	NA	NA	0.0016
	Fish Ingestion	NA ^b	0.012 ^c	NA	NA	0.012
	Drinking Water	NA ^b	0.96 ^c	NA	NA	0.96
Subtotal Water		NA	0.99	NA	NA	0.99
Air + Water Total		0.00069	1.0	0.65	5.6E-05	1.7

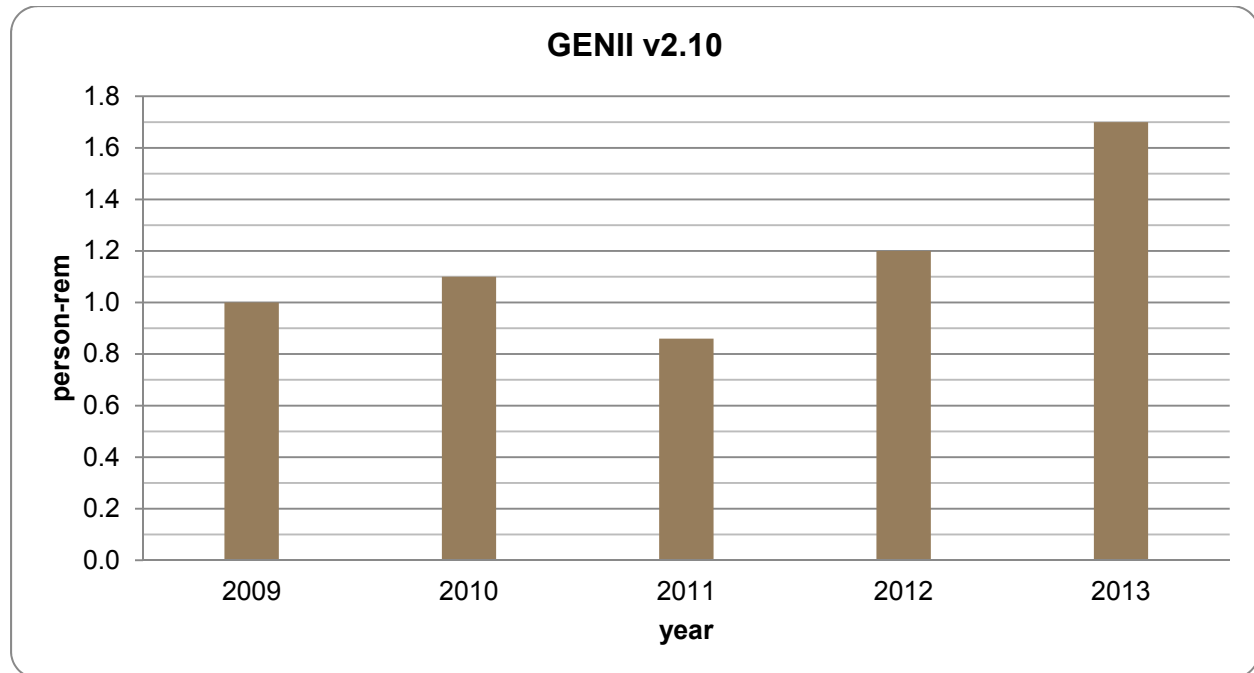
^a To convert person-rem to International System dose units (person-Sievert), divide by 100.

^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.

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

Figure 4.7 Collective Total Dose
(Within 50-Mile (80-Kilometer) Radius)



The dose for the MEI in 2013 was 0.15 mrem (1.5 microsievert) per year (Section 4.2.1). The average individual dose from Hanford Site operations in 2013, 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 0.0070 mrem (0.070 microsievert) per year. To place the MEI 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 (NCRP) issued Report 160 in March 2009 that estimated the overall average exposure to ionizing radiation for the average American to be 620 mrem (6,200 microsievert) per year (National Council on Radiation Protection and Measurements 2009 [NCRP 2009]). Approximately 50 percent of the 620 mrem (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 4.8). 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 4.9. The calculated radiological doses from Hanford Site operations in 2013 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 4.9, where each increment represents a factor of 10. For example, the national annual average terrestrial radiation dose (approximately 19 mrem [190 microsievert]) is over 100 times larger than the 2013 Hanford Operations dose to the MEI (0.15 mrem [1.5 microsievert]).

Figure 4.8 United States Annual Average Radiological Doses from Various Sources
(2009 National Council on Radiation Protection and Measurement)

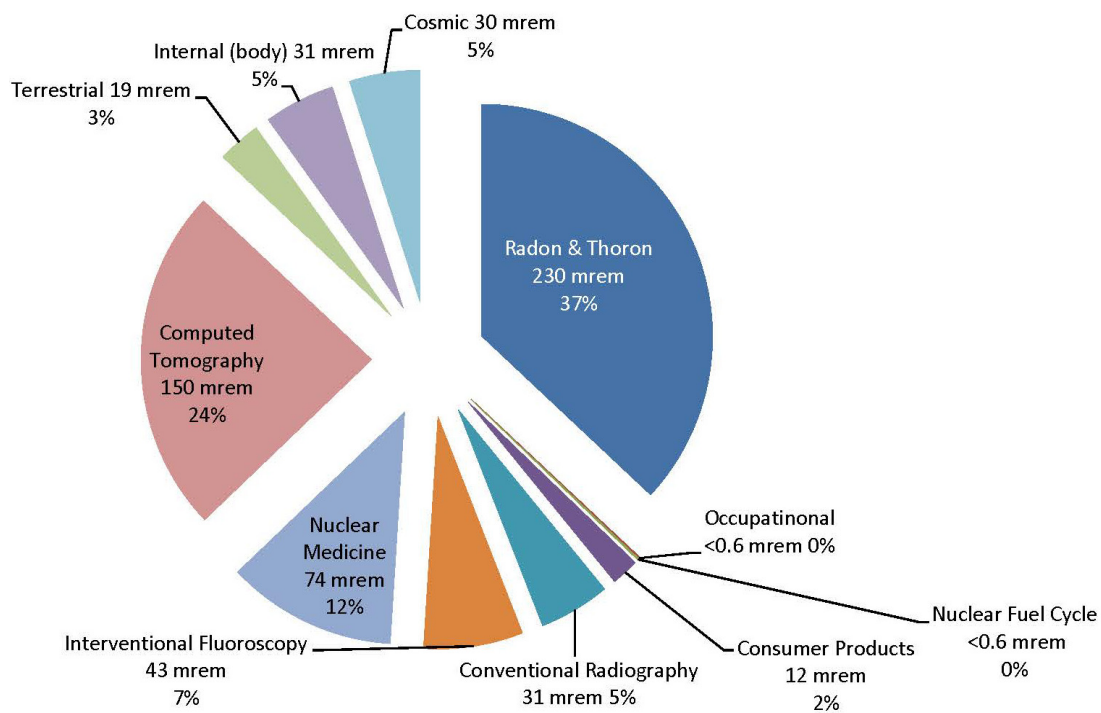
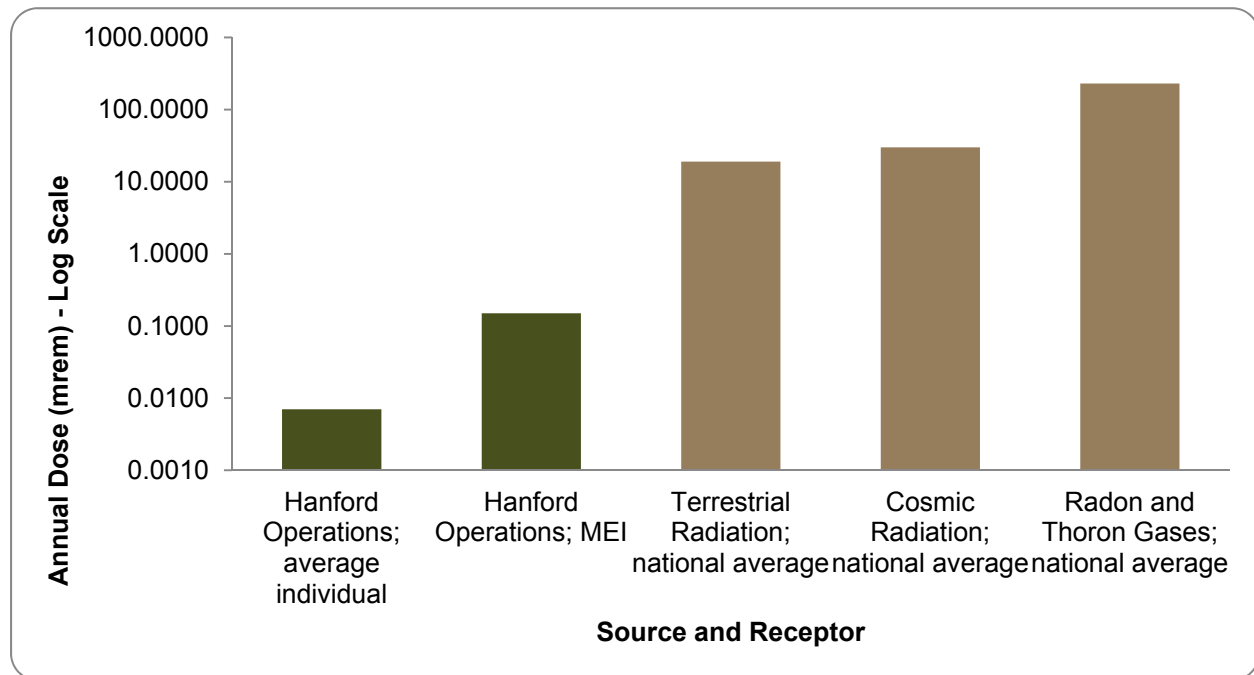


Figure 4.9 Radiological Doses from Hanford Site Operations Compared with Annual Average from Natural Sources



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 MEI dose; however, the MEI dose is currently calculated by two different methods in response to two different requirements. One MEI dose computation is required by [DOE O 458.1](#), Chg. 3 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 MEI 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. 3 (100-mrem [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 mrem (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 MEI, 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 MEI for air pathways assessed under [40 CFR 61](#), Subpart H, may be evaluated at a different location from the all-pathways MEI 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 2013 air emissions at the Hanford Site, refer to DOE's report to EPA ([DOE/RL-2014-14](#), *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2013*).

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 MEI at that location calculated using the CAP-88 computer code was determined to be 0.025 mrem (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-mrem (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 curies 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 MEI dose standard for diffuse and fugitive emissions ([DOE/RL-2013-12](#)). The estimated dose from diffuse emissions to a MEI at Horn Rapids Road in 2012 was calculated using the CAP-88 computer code to be 0.0086 mrem (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 mrem (0.336 microsievert) per year, well below the 10 mrem (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 WDOH 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 MEIs. 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 mrem (0.25 microsievert) per year dose calculated with CAP-88 to an offsite MEI at Horn Rapids Road. Combined stack emissions and diffuse/fugitive emissions dose for the Columbia Generating Station was 0.0038 mrem (0.038 microsievert) per year, and for the Laser Interferometer Gravitational Wave Observatory was 0.0048 mrem (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 MEI were selected to provide a scenario yielding a reasonable upper bound dose estimate. The MEI dose calculations are based on measurements of radionuclide releases from stack emissions (air pathways) and differences between downstream and upstream radionuclide concentrations in the Columbia River (water pathways), followed by modeling of environmental transport related to a number of different exposure pathways (Figure 4-3). Exposure pathways utilizing other radionuclide measurements also 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 has 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.

Radionuclides were analyzed in tissue samples collected in 2013 from cottontail rabbit and Canada goose. Various tissues were sampled, including bone, muscle, and the whole organism. For estimating dose from ingestion of game meat, only radionuclide concentrations in muscle tissue are employed. Four muscle tissue samples were available in 2013 for cottontail rabbit and six for Canada goose. The only radionuclide detected in the muscle tissue of either cottontail rabbit or Canada goose was potassium-40, a naturally occurring primordial radioisotope not of Hanford Site origin.

Four muscle tissue samples were also obtained from whitefish in the 100 Area region of the Columbia River and analyzed for gamma-emitting radionuclides and isotopes of uranium. In addition to potassium-40, uranium-234 was detected in one of the four samples. Although also naturally occurring radionuclides like potassium-40, uranium-234 is associated with Hanford Site operations. The measured muscle concentration of uranium-234 in this whitefish sample was 0.00031 pCi/g, which is approximately 8 times lower than the uranium-234 fish tissue concentration of 0.0025 pCi/g (9.25×10^{-5} Bq/g) modeled in [GENII Version 2.10 \(PNNL-14583\)](#) from the difference in upstream and downstream uranium-234 concentrations.

Although the measured uranium-234 in the whitefish sample is well below levels modeled to be attributable to Hanford Site releases, the radiation dose received from consumption of whitefish would in any case be negligible. Assuming annual fish consumption of 40 kilograms (88 pounds) for a MEI (see Table D.4), the annual radiation dose related to fish ingestion for fish that contains 0.0025 pCi/g [9.25×10^{-5} Bq/g] of uranium-234 is estimated to be 0.018 mrem (0.18 microsievert) per year.

This dose estimate was derived using a uranium-234 ingestion dose factor of 1.8×10^{-4} mrem/pCi (4.9×10^{-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:

$$\begin{aligned} 0.0025 \text{ pCi uranium-234/g} \times 40 \text{ kg} \times 1,000 \text{ g/kg} \times 1.8 \times 10^{-4} \text{ mrem/pCi} = \\ 0.018 \text{ mrem (0.18 microsievert) per year.} \end{aligned}$$

4.2.4.2 Hanford Site Drinking Water Dose

Drinking water was sampled and analyzed for tritium, strontium-90, gross alpha radiation, and gross beta radiation during 2013 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. All gross alpha radiation concentrations measured during 2013 were below the applicable drinking water standard of 15 pCi/L. 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 the single drinking water sample from the 100-K Area, the single sample from the 200 West Area, or the single samples from the two sources in the 400 Area. Tritium was not detected in a single sample from both the 100-K and 200 West Areas. Tritium

was detected in all five drinking water samples collected from the two sources in the 400 Area. Based on four quarterly samples, the annual average 400 Area drinking water tritium concentration was 1,350 pCi/L (50 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 2013 would be approximately 0.023 mrem (0.23 microsievert). A single tritium sample was also collected from Well P-14 in the 400 Area, where a value of 12,300 pCi/L was reported. Based on this single measurement, an annual worker drinking water dose for this well would be 0.21 mrem (2.1 microsievert). These estimates are well below EPA's drinking water dose limit of 4 mrem (40 microsievert) per year for beta-emitting radionuclides in public drinking water supplies. The dose estimates were 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:

$$1,350 \text{ pCi tritium/L} \times 1 \text{ L/day} \times 250 \text{ d/year} \times 6.7 \times 10^{-8} \text{ mrem/pCi} = 0.023 \text{ mrem/year.}$$

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

Doses from non-DOE sources was not quantified in 2013 because the MEI dose of 0.15 mrem (1.5 microsievert) per year from DOE-related sources (Section 4.2.1) was far below the threshold of 25 mrem (250 microsievert) per year at which the contribution of non-DOE sources must be included. [DOE O 458.1](#), Chg. 3; 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 MEI is 25 mrem (250 millisievert) in a year or less. If the DOE-related dose is greater than 25 mrem (250 millisievert) 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 US 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 mrem (0.04 microsievert) per year. The *Hanford Site Environmental Report for Calendar Year 2010* is online at http://msa.hanford.gov/files.cfm/2010_pnnl-20548_env-report.pdf.

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. 3, 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 2013 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-134, cesium-137, plutonium-239/240, strontium-90, technetium-99, 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 4.5 show the concentrations in all Columbia River sediment and water samples passed the Tier 1 screen, except for the 100-K Area and indicating that the calculated doses were below dose limits (sum of fractions less than one). Except for the 100-K Area 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).

At the 100-K Area, the estimated biota dose was about 3.5 times the acceptable limit. Nearly 100 percent of this estimated dose was from carbon-14 to the riparian animal through the water pathway. Although carbon-14 had previously been detected at the 100-K Area springs, the concentration measured in 2013 was nearly 40 times greater than that measured in 2012. Only a single water sample was collected at the 100-K Area so averaging results to obtain a Tier 2 dose estimate was not possible. There are no site-specific available to derive a lumped parameter or bioaccumulation value from water to biota, but there is a more recent literature value from Hosseini (2008). This value was used in a Tier 3 calculation and yielded a sum of fractions of 0.4. In addition, the spatial extent of the 100-K Area carbon-14 concentrations on the shoreline is not known but it is likely that the area use factor for the riparian animal should be less than 100 percent. Further documentation of the Columbia River biota dose calculations is provided in Appendix D.

Table 4.4. Estimated Doses to Biota associated with Columbia River Sediment and Water
(Using RESRAD-BIOTA¹ Computer Code)

Location	Media Evaluated for Key Radionuclides	Tier 1 Screen	
		Sum of Fractions ²	Pass or Fail
Priest Rapids Dam	Sediment, Water ³	0.25	Pass
100-B Area	Sediment ³ , Water	<0.01	Pass
100-K Area	Sediment ³ , Water	3.5	Fail
100-N Area	Sediment ³ , Water	0.16	Pass
100-D Area	Sediment, Water	0.03	Pass
100-H Area	Sediment ³ , Water	0.02	Pass
Locke Island	Sediment, Water ³	0.26	Pass
White Bluffs Slough	Sediment, Water ³	0.16	Pass
100-F Area	Sediment, Water	0.11	Pass
Hanford Town Site	Sediment, Water	0.54	Pass
Savage Island	Sediment, Water ³	0.15	Pass
300 Area Spring	Sediment ³ , Water	0.47	Pass
McNary Dam	Sediment, Water ³	0.28	Pass

¹ A screening method to estimate radiological doses to aquatic and riparian biota.

² 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.

³ 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 2013 and data tabulated (Appendix C, Tables C.2 and C.3).

The RESRAD-BIOTA results of the screening calculations listed in Table 4.6 show the West Lake sediment and water concentrations passed the Tier 1 screen based on the maximum concentration. Further documentation of the West Lake biota dose calculations is provided in Appendix D.

Table 4.5. 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	0.15	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 2006, [Health Risks from Exposure to Low Levels of Ionizing Radiation, Phase 2](#)) 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](#), *Biological Mechanisms of Radiation Actions at Low Doses*). 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 mrem (10 microsievert) ([EPA/520/1-89-005](#), *Risk Assessments Methodology Environmental Impact Statement NESHAPS for Radionuclides Background Information Document – Volume 1*). Additional data ([National Research Council, 2006](#)) 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 mrem (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 4.6. Estimated Risk from Various Activities and Exposures

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

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

4.3 Radiological Clearance of Hanford Site Property

JW DeMers

Principle requirements for the control and clearance of DOE property containing residual radioactivity are in [DOE O 458.1](#), Chg. 3. 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](#), Chg. 3.

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](#), Chg. 3) 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](#), Chg. 3) 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](#), Chg. 3.

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 mrem (10 microsievert) in any year to the MEI 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 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. In addition to this request, in 2013 CHPRC requested and was approved an authorized limit to apply the general beta-gamma limits to the low energy beta emitter, Plutonium-241, (1,000 dpm/100 cm² removable limit and 5,000 dpm/100 cm² total contamination limit).

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 2013 using these hard-to-detect authorized limits. The estimated total residual radioactivity for these items was less than 5 curies.

Table 4.7. 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 shipped for burial at ERDF. Previously the resin was shipped offsite for regeneration and reuse.

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](#), Chg. 3 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 mrem (10 microsievert) in any year to the MEI, 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 mrem/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 HQ personnel, these authorized limits 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. Modification of the authorized limits was approved in February 2011 following changes to the regeneration process (Table 4.8). The new limits ensure that resin shipped to the regenerating facility is consistent with the requirements of any licensing and permits held by the facility.

No resin was shipped offsite in 2013 for regeneration under these approved authorized limits, since CHPRC has changed to non-regenerative resins, which will be disposed in ERDF, eliminating offsite resin regeneration shipments.

Table 4.8. Approved Modified Authorized Limits for Offsite Shipment and Regeneration of Ion-Exchange Resin

Radionuclide	Authorized Limit(pCi/g)
Tritium	20,000
Strontium/yttrium-90	400
Technetium-99	400,000
Carbon 14	800
Uranium-234	930
Uranium-235	79
Uranium-238	600
Unidentified Beta Emitter	7
Unidentified Alpha Emitter	35
Unidentified Gamma Emitter	25

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](#), Chg. 3) 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 2008, approved authorized limits for offsite shipment and regeneration of granular activated carbon was approved for use by CHPRC.

In anticipation of placing the new 200 West Area Pump and Treat facility online, increasing the volume of spent GAC being sent offsite, a request to modify the authorized limits was made by CHPRC and approved by DOE in October 2010 (Table 4.9). This modification to the authorized limits does not change the expected dose to the public.

Approximately 95,640 pounds (43,380 kilograms) of granular activated carbon was shipped offsite in 2013 for regeneration under these approved modified authorized limits.

Table 4.9. 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
Nickel-63	100
Plutonium-238	26
Plutonium-239	24
Plutonium-240	24
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

4.3.4 Hanford Reach National Monument (HRNM) Land Conveyance

The [DOE O 458.1](#), Chg. 3 Authorizes Limits for the radiological release of the Hanford Reach National Monument (HRNM) to the USFWS were approved in 2004. In 2013, a finding was made by an independent verification contractor that the HRNM property met those Authorized Limits. The cultural resource review under [36 CFR 800.106](#), "Protection of Historic Properties," remains to be accomplished.

4.3.5 Tri-Cities Development Council (TRIDEC) Land Conveyance

The DOE O 458.1 Authorized Limits for the radiological release of the proposed land conveyance to Tri-Cities Development Council (TRIDEC) were approved in December 2013. Efforts are currently underway to sample and survey the property to ensure that these Authorized Limits are met. An Independent Verification contractor, Oak Ridge Associated Universities (ORAU), has been contracted to provide that independent verification required by the order. The EA is being performed by Los Alamos Technical Associates (LATA).

5.0 Environmental Restoration and Waste Management

Environmental restoration and waste management activities continued on the Hanford Site during 2013. 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 Cleanup and Remediation Activities

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

5.1.1 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).

5.1.1.1 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 were completed in 2011 and 2012 to evaluate the impacts from Hanford Site releases to the upland, riparian, and near shore areas of the River Corridor (DOE/RL-2007-21, Vols. I and II, [Part 1](#) and [Part 2](#), Rev. 0). In addition, human health and ecological risk assessments were completed in 2012 to evaluate potential impacts to the Columbia River from Hanford Site releases ([DOE/RL-2010-117, Vols. I and II, Rev. 0](#)). These risk assessment results are reflected in the development of the River Corridor RI/FS reports and decisions.

River Corridor RI/FS Process. The RI/FS process is being implemented for six decision areas of the river corridor established by the Tri-Parties (100-B/C, 100-K, 100-N, 100-D/H, 100-F/IU-2/IU-6, and 300 Area). In November 2013, a final action ROD was issued for the 300 Area. Completion of RI/FS reports, public review of proposed actions, and development of RODs for the remaining five decision

areas are scheduled during 2014 to 2017. Proposed actions for the 100-F Area are anticipated to undergo public review in the spring of 2014. RI/FS reports for the 100-D/H Area and 100-N Area are anticipated to be finalized in 2014. A schedule for the 100-K Area RI/FS is under negotiation pending completion of additional characterization activities near the reactor. The 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.

5.1.1.2 Long-Term Stewardship

JA Lerch and DG Ranade

The long-term stewardship task is focused on documenting completed cleanup actions and facilitating 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. Within the MSA, key elements of the long-term stewardship work scope includes integrating the draft transition and turnover packages provided by the River Corridor Closure contractor and managing the long-term Stewardship responsibilities for geographic areas previously transitioned to the MSA.

Transition and turnover packages were completed in 2013 for Segment 5 of the 300 Area Decision Area and the 100-F 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 specific geographic areas.

5.1.2 100 Area

5.1.2.1 100-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 2013 in the 100-B/C, 100-D, 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 hexavalent chromium release sites, pipeline sites and miscellaneous waste sites. Due to the high mobility associated with past hexavalent chromium releases, excavation to groundwater is often necessary to ensure complete remediation of these sites.

Miscellaneous waste sites vary in the nature and extent of contamination and are generally smaller-size areas when compared to hexavalent chromium release sites. 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 and the Action Memorandum for General Hanford Site Decommissioning Activities 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 887,700 tons (805,300 metric tons) of contaminated soil and debris from 100 Area remediation activities in 2013 were disposed at ERDF. Quantities and respective locations are as follows:

- 80,000 tons (72,600 metric tons) from the 100-B/C Area
- 339,500 tons (308,000 metric tons) from the 100-D Area
- 132,300 tons (120,000 metric tons) from 100-H Area
- 10,700 tons (9,700 metric tons) from the 100-K Area
- 286,300 tons (259,700 metric tons) from the 100-N Area
- 32,000 tons (29,000 metric tons) from the IU-2/6 Area
- 6,600 tons (6,300 metric tons) for Miscellaneous Restoration activities in the 100 Areas.

5.1.2.2 100-K Basins

BM Barnes and DJ Watson

The 100-K Area remediation activities included facility demolition, waste site remediation, cleanout of the 100-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.

5.1.2.2.1 100-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 Canister Storage Building (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 100-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 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.

5.1.2.2.2 K Basins Progress on Defense Nuclear Facilities Safety Board Recommendations

RA Quintero

In a letter dated December 19, 2013 ([DNFSB 2013a](#)), the Defense Nuclear Facilities Safety Board (DNFSB) closed Board Recommendation 2000-1, *Prioritization for Stabilizing Nuclear Materials* ([DNFSB 2000-1](#)). The DOE commitments for completing K Basins sludge removal, treatment, and packaging will continue to be tracked in the TPA.

In the DNFSB 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* ([DNFSB 2013b](#)), dated December 26, 2013, the DNFSB closed Hanford Site, K-Basin Closure Sludge Treatment Project, a previously identified issue concerning spray leak consequence analyses. DOE is working with DNFSB staff to resolve the one remaining issue concerning safety instrumented systems identified in the DNFSB 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*).

5.1.3 200 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 (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.

5.1.3.1 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.

5.1.3.1.1 200-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 the Plutonium Uranium Extraction (PUREX) Plant. Specific sites are listed in the *Hanford Federal Facility Agreement and Consent Order Action Plan* ([Ecology et al. 1989b](#)), [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 (WIPP) in Carlsbad, New Mexico; and 3) dispose at ERDF or WIPP. 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 WIPP, 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 WIPP. 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 WIPP, 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.

5.1.3.1.2 200-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 TPA Action Plan ([Ecology et al. 1989b](#)), [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.

5.1.3.1.3 200-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 TPA Action Plan ([Ecology et al. 1989b](#)), [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.

5.1.3.1.4 200-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 TPA Action Plan ([Ecology et al. 1989b](#)), [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.

5.1.3.1.5 200-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 TPA Action Plan ([Ecology et al. 1989b](#)), [Appendix C](#). Portions of the burial grounds listed in the RCRA 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.

5.1.3.1.6 200-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 TPA Action Plan ([Ecology et al. 1989b](#)), [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.

5.1.3.1.7 200-CB-1 Operable Unit (B Plant Canyon)

This operable unit includes the B Plant Canyon Building (221-B) and the Waste Encapsulation Storage Facility (WESF), along with exterior ventilation system components for each of the structures (e.g., high-efficiency particulate air filters [HEPA], sand filter), and 17 soil waste sites within the vicinity. Specific sites are listed in the TPA Action Plan ([Ecology et al. 1989b](#)), [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.

5.1.3.1.8 200-CU-1 Operable Unit (U Plant Canyon)

This operable unit includes the U Plant Canyon Building (221-U) and other structures included in the ROD for the U Plant Canyon ([DOE et al. 2005](#), *Record of Decision 221-U Facility (Canyon Disposition Initiative) Hanford Site Washington*). 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.

5.1.3.1.9 200-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 TPA Action Plan ([Ecology et al. 1989b](#)), [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.

5.1.3.1.10 200-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 TPA Action Plan ([Ecology et al. 1989b](#)), [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.

5.1.3.2 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.

5.1.3.2.1 200-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.

5.1.3.2.2 Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill (NRDWL)

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](#). The Solid Waste Landfill is regulated under [WAC 173-350](#). Evaluation of the closure actions are being conducted in accordance with the NEPA.

5.1.4 300 Area

DE Faulk, and CP Strand

Remediation efforts in 2013 focused on the 300-FF-2 Operable Unit waste sites. The 300-FF-2 Operable Unit interim 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. The 300-FF-2 final ROD was issued in November 2013. The final ROD continues to authorize remediation activities and also authorizes the alternative remediation method of enhanced attenuation of uranium using sequestration in the vadose zone, Periodically Rewetted Zone (PRZ) and top of the aquifer.

Waste generated from the cleanup of waste sites in the 300-F-2 Operable Unit is disposed at the ERDF, located on the Central Plateau, and other EPA-approved disposal facilities. Approximately 35,800 tons (32,500 metric tons) of contaminated soil from the 300-FF-2 Operable Unit were disposed in 2013 at the ERDF. The 340 Building remediation and 340 Vault removal continues with completion scheduled for 2014. The 309 Plutonium Recycle Test Reactor was removed clearing the way to initiate waste site and piping remediation associated with reactor operations. Remedial designs have been initiated on all remaining waste sites south of Apple Street.

The 618-10 Burial Ground (Figure 5.1), 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 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 5.1 618-10 and 618-11 Burial Grounds

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.

Remediation of the 618-10 Burial Ground trenches began in April 2011 and continued through 2013. The 2013 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 augured 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

CD McCurley

Deactivation, decontamination, decommissioning, and demolition activities in the 100 Area included demolition (Figure 5.2) actions at the 100-B, 100-D, and 100-N Areas. These actions, summarized below, were conducted as non-time-critical removal actions under CERCLA.

100 Area facilities demolished in 2013:

- 105-B Wash Pad Annex Building
- 151-B Switch House Building
- 151-D Switch House Building
- 183-D Water Treatment Plant
- 1724-N Nitrogen Electrical Controls Facility
- 1904-N Sewage Lagoon
- 1904-NA Lift Station #1.

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

- 151-B Primary Electrical Substation
- 151-D Primary Electrical Substation
- 181-N Cable Float Barriers.

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 5.3). DOE issued a shutdown order for 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, immobilize, repackage, and/or properly dispose of nearly 19.8 tons (18 metric tons) of plutonium-bearing materials in the plant.



Figure 5.2. 183-D Water Treatment Plant



Figure 5.3 Plutonium Finishing Plant before Demolition

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 2013. Significant accomplishments at PFP during 2013 include the following:

5.2.2.1.1 234-5Z, Plutonium Finishing Plant

Removal of plutonium-contaminated process equipment continued, with a particular focus on removing gloveboxes, associated piping, and ductwork. The total gloveboxes removed to date is now at 85 percent complete.

- Removed 20 gloveboxes - 85 percent of all PFP glove boxes and hoods
- Removed 219 linear feet of asbestos for a total of 17,491 feet (73 percent complete)
- Removed 433 linear feet of process lines for a total of 6,963 feet (75 percent complete).

5.2.2.1.2 236-Z, Plutonium Reclamation Facility (PRF)

- Repaired Plutonium Reclamation Facility (PRF) crane
- Removed, size reduced and dispositioned 5 pencil tank units (59 percent complete).

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 [DOE et al. 2005](#), selecting the close in place - partially demolished structure alternative for the remediation of the 221-U Facility. The ROD calls for the process equipment already in the plant to be consolidated into the belowground plant process cells, and for the cells, two lower galleries, and other void spaces to be filled with grout, the exterior walls and roof to be collapsed in place; and the site to 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 and transferred to the CWC for interim storage pending final treatment, packaging, and shipment to WIPP. Facility voids below the canyon deck level (process cells, 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 2013.

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 2005b](#)), *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 several other 300 Area facilities.

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.

Decommission efforts in 2013 included significant progress on removing below-grade portions of two high-hazard facilities; the 309 Plutonium Recycle Test Reactor (PRTR) and the 340 Waste Neutralization Facility vault. The 309 PRTR work included wire-sawing the 75 megawatt reactor free from the below-grade position and finalizing engineering on the heavy lift system that will be used to extract the reactor and place on a transportation system. Work on the 340 Vault focused on preparations to install shoring casing beneath the structure to install a heavy-lift system that will jack the vault up for placement of a transportation system beneath.

The 300 Area buildings and structures demolished in 2013 are as follows:

- 310 TEDF
- 323 Boiler Annex
- 326 Material Sciences Laboratory
- 326 Boiler Annex
- 327 Boiler Annex
- 329 Chemical Sciences Laboratory
- 331C Storage Facility
- 331D Biomagnetic Effects Laboratory
- 331G Interim Tissue Repository
- 331H Aerosol Wind Tunnel Research Facility
- 337 Boiler Annex (slab)
- 340 Complex (above-grade)



Figure 5.4. 340 Complex Excavation

- 382 Pump House
- 382B Fire Pump Station
- 382 Boiler Annex
- 382C Fire Water Storage Tank
- 382D Fire Water Storage Tank
- 3503B Electrical Cable Pit
- 3506A Powerhouse Maintenance Shop (slab)
- 3506B Maintenance Shop (slab)
- 3631BC Emergency Generator Building
- 3701D Hanford Patrol Headquarters (basement)
- 3707H Change House (slab)
- 3730 Gamma Irradiation Facility
- 3731 Laboratory Equipment Pool (slab)
- 3731A Graphite Machine Shop (slab)
- 3760 Hanford Technical Library
- 3906 Sanitary/Process Sewer Lift Station
- 3906B Sanitary/Process Sewer Lift Station
- MO-059 Mobile Office
- MO-744 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

5.2.4.1 Fast Flux Test Facility

DR Turlington

FFTF is a DOE-owned, formerly operating 400-megawatt (thermal) liquid-metal cooled (sodium) research and test reactor located in the 400 Area (Figure 5.5). 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 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



Figure 5.5. Fast Flux Test Facility

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 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 Activities

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 SST and DST. 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, on aboveground storage pads, and underground pending future retrieval. A DOE annual report lists the dangerous and mixed wastes that are generated, treated, and disposed onsite or shipped offsite (Hanford Site Annual Dangerous Waste Report). 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		2008	2009	2010	2011	2012	2013
Mixed	tons	346	281	286	522	305	206
	kilograms	314,000	255,000	260,000	474,000	277,000	187,089
Radioactive	tons	398	696	725	4022	343	513
	kilograms	361,000	632,000	658,000	3,649,000	311,000	465,777

¹ Solid waste includes containerized liquid waste.

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

Waste Category		2008	2009	2010	2011	2012	2013
Mixed ²	tons	459	257	152	320	66	36.5
	kilograms	416,000	233,000	138,000	291,000	60,000	33,158
Radioactive ²	tons	445	196	388	257	82	62.8
	kilograms	404,000	178,000	352,000	233,000	74,000	56,960

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

² Total includes Hanford Site-generated waste treated by an offsite contractor and returned as newly generated waste. Includes both low-level radioactive and transuranic waste.

Table 5.4. Dangerous Waste¹ Quantities Shipped Off the Hanford Site

Waste Category		2008	2009	2010	2011	2012	2013
Containerized (DW Only)	tons	128	47	55	53	18	65.4
	kilograms	116,000 ²	42,800 ²	49,700 ²	47,800 ²	16,600 ²	59,400
Containerized (MW Only)	tons	56	79	37	43	91	50.6
	kilograms	50,900 ³	71,300 ³	33,900 ³	38,700 ³	82,800 ³	45,900
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	57	2	0	0	0	—
	kilograms	51,900	2,050	0	0	0	—
Bulk Liquids (Non-Rad/Non-DW)	tons	164	0	0	0	0	—
	kilograms	149,000	0	0	0	0	—
Totals	tons	405	211	322	242	129	116
	kilograms	367,000	191,000	292,000	219,000	116,100	105,300

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

LC Petersen

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

LC Petersen

The CWC (Figure 5.6), 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 377,958 cubic feet (10,704 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 outside 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 Outside Storage Areas is 201,267 cubic feet (5,700 cubic meters).

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



Figure 5.6. Central Waste Complex

5.3.3.2 Waste Receiving and Processing (WRAP) Facility

LC Petersen

The WRAP Facility (Figure 5.7) 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.



Figure 5.7. Waste Receiving and Processing Facility

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 WIPP 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 RCRA Permit (WA7890008967), WRAP Facility Part A Form. Refer to Section 2.1.1.1 for additional information on the RCRA Permit (WA7890008967).

5.3.3.3 T Plant Complex

LC Petersen

The T Plant Complex (Figure 5.8) 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 RCRA Permit (WA7890008967), T-Plant Complex Part A Form. Refer to Section 2.1.1.1 for additional information on the RCRA Permit (WA7890008967).

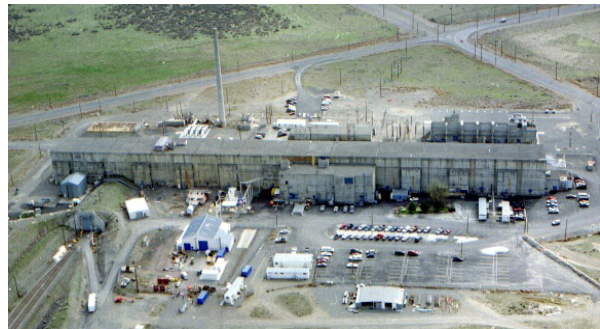


Figure 5.8. T Plant Complex

5.3.3.4 Canister Storage Building (CSB)

LC Petersen

The CSB (Figure 5.9) 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 5.9. 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 (LLBG)

LC Petersen

The LLBGs 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 LLBGs are operating under interim status standards specified in the RCRA Permit (WA7890008967), Low-Level Burial Grounds Part A Form. Refer to Section 2.1.1.1 for additional information on the RCRA Permit (WA7890008967). In addition, the LLBGs 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 LLBGs 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.

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

Trenches 31 and 34 (Figure 5.10) 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.



Figure 5.10. LLBG Trenches 31 and 34

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 2013, a total of 5,473 cubic feet (155 cubic meters) of waste were disposed in Trenches 31 and 34 as follows:

- Trench 34 has approximately 182,588 cubic feet (5,171 cubic meters) of waste in 5,290 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 2013, Trench 34 was filled to approximately 82 percent of waste capacity.
- Trench 31 has approximately 193,675 cubic feet (5,485 cubic meters) of waste in 3,416 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

The LLBG Trench 94 (Figure 5.11) did not receive any defueled U.S. Navy reactor compartments in 2013. The total number of reactor compartments received into Trench 94 (218-E-12B Burial Ground) to date is 125. All U.S. Navy reactor compartments shipped to the Hanford Site for disposal originated from decommissioned defueled 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).



Figure 5.11. LLBG Trench 94

5.3.3.6 Waste Encapsulation and Storage Facility (WESF)

LC Petersen

The WESF (Figure 5.12), 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. Of these, 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 5.12 Waste Encapsulation and Storage Facility

The WESF is operating under interim status standards specified in the RCRA 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 RCRA 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.

5.3.3.7 Integrated Disposal Facility (IDF)

LC Petersen

The IDF (Figure 5.13) 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 5.13. Integrated Disposal Facility

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

5.3.3.8 Environmental Restoration Disposal Facility (ERDF)

MA Casbon

ERDF (Figure 5.14) 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](#), *Record of Decision Hanford 200 Area*) 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



Figure 5.14. Environmental Restoration Disposal Facility

Subtitle C minimum technology requirements, which includes a double liner and leachate collection system ([40 CFR 264.301](#), Subpart N, “Landfills”). 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); over 15 million tons (13.6 million metric tons) of waste has been disposed in ERDF. 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 (ETF)

LC Petersen

The 200 Area ETF (Figure 5.15) 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 RCRA Permit (WA7890008967, Rev. 8C). Refer to Section 2.1.1.1 for additional information on the RCRA 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 2013 was approximately 8 million gallons (30 million liters). This wastewater was primarily leachate from ERDF and LLBG Trenches 31 and 34, with some wastewater from the 100-K Basins.



Figure 5.15. 200 Area Effluent Treatment Facility and Liquid Effluent Retention Facility

5.3.4.2 Liquid Effluent Retention Facility (LERF)

LC Petersen

The LERF (Figure 5.15) 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 LLBG 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, this became unnecessary after the ROD for ERDF was amended in 2007 to allow receipt of all RCRA and CERCLA waste ([DOE et al. 2007](#), *Amended Record of Decision for the Environmental Restoration Disposal Facility*). Segregation of RCRA and CERCLA wastewater is no longer required in the LERF basins.

LERF operates in accordance with the RCRA Permit (WA7890008967, Rev. 8C). Refer to Section 2.1.1.1 for additional information on the RCRA Permit (WA7890008967).

The volume of wastewater received for LERF basin storage in 2013 was approximately 2.56 million gallons (9.69 million liters). The majority of wastewater received at the LERF was pipeline-transported CERCLA-regulated leachate from ERDF, totaling approximately 2.14 million gallons (8.10 million liters). Another major contributor to wastewater received into LERF during 2013 was approximately 0.28 million gallons (1.06 million liters) of leachate from LLBG Trenches 31 and 34 received by tanker truck. Approximately 0.13 million gallons (0.50 million liters) of wastewater was received by tanker trucks from various other facilities. No process condensate was received from the 242-A Evaporator in 2013.

The volume of wastewater being stored in the LERF at the end of 2013 was approximately 10.1 million gallons (38.2 million liters).

5.3.4.3 200 Area Treated Effluent Disposal Facility (TEDF)

LC Petersen

The 200 Area TEDF (Figure 5.16), 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](#).

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 2013 was approximately 27.8 million gallons (105 million liters).



Figure 5.16. 200 Area TEDF Pond A and B

5.3.4.4 242-A Evaporator

WF Johnson

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.



Figure 5.17. 242-A Evaporator

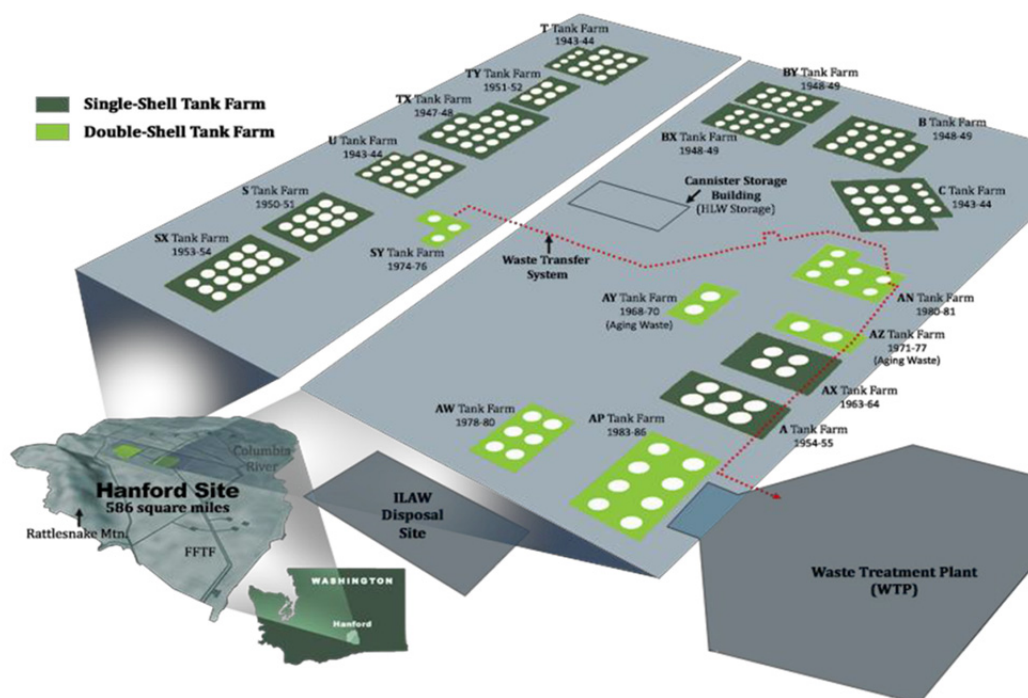
The *American Recovery and Reinvestment Act of 2009* funded the majority of the upgrade activities in 2011 to extend the 242-A Evaporator service life through 2032.

The 242-A Evaporator operates in accordance with the RCRA Permit (WA7890008967, Rev. 8C). Waste volume reduction activities at the 242-A Evaporator are managed in accordance with the RCRA Permit (WA7890008967); however, in 2013 the 242-A Evaporator did not perform waste volume reduction activities. Refer to Section 2.1.1.1 for additional information on the RCRA Permit (WA7890008967).

5.4 Underground Waste Storage Tanks

WF Johnson

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 (Figure 5.18). 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 2013 related to their operation and closure.



5.4.1 Single-Shell Tank (SST) 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 over 1 million gallons. 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.

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

In FY2013 progress continued in retrieving waste from the C-Farm tanks and transferring it to newer, safer DSTs to prepare to feed tank waste to the WTP. More than 98 percent of waste has been retrieved from tank C-110, 93 percent of the waste from tank C-101, and 90 percent of the waste from tank C-107 using the Mobile Arm Retrieval System (MARS). MARS is a robotic arm mounted on a central mast that uses powerful jets to wash down the inside of the tank and drive the waste to a central pump. C-Farm (Figure 5.19) is one of 18 tanks farms located on the Hanford Site. Within the C-Farm there are 16 tanks; 10 have been emptied, 1 is nearly complete, and work continues on 3 additional tanks.



Figure 5.19. Cutting a Hole in the Dome of Tank C-105

5.4.2 Double-Shell Tank (DST) System

The DST system includes 28 DSTs (25 tanks in 200 East Area and 3 tanks in 200 West Area) located in five tank farms (AN, AP, AW, AY, AZ, and SY) that were constructed between the years 1968 and 1986 to store mixed waste generated on the Hanford Site. One of the tanks (AY-102) is assumed to have leaked waste into the annulus. 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). In FY2013, sample ports were installed in ventilation exhaust ducts to directly measure flow rates from the tank waste in the ventilation outlet to address flammable gas safety concerns, including installing sample ports in ventilation exhaust to directly measure gases from the tank waste in the tank ventilation outlet.

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

At the end of 2013, there were 26.7 million gallons (101 million liters) of waste in the DSTs. Quantities of liquid waste generated in 2013 and stored in underground storage tanks are provided in the *Hanford Site Annual Dangerous Waste Report Calendar Year 2013* ([DOE/RL-2014-07](#)). Table 5.5 summarizes the liquid waste generated and stored from 2009 through 2013 in underground storage tanks.

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

Type of Waste	Units	2009	2010	2011	2012	2013
DSTs waste added	Gallons	325	412	113	632	153
	Liters	1,230	1,560	428	2,392	579
DSTs year-end volume	Gallons	25,971	25,835	25,948	26,580	26,733
	Liters	98,311	97,796	98,224	98,000	101,195
242-A Evaporator volume evaporated	Gallons	960	548	0	0	0
	Liters	3,634	2,074	0	0	0
Single-Shell Tanks volume pumped	Gallons	102 ³	240 ³	560 ³	238 ³	70 ³
	Liters	386 ³	909 ³	2120 ³	900 ³	263 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 2013, 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 2013:

- Tank 241-AY-102
- SST Level changes
- Tank Farms Waste Transfer System
- Tank Farms Ventilation Systems.

5.4.3.1 Defense Nuclear Facilities Safety Board Recommendation 2012-2

On September 28, 2012, the DNFSB issued Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*. The DNFSB's 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.

On June 6, 2013, DOE delivered the [Implementation Plan for Recommendation 2012-2](#) (DOE 2013a) to the DNFSB. DOE has agreed that the DST ventilation system should be designated as safety-significant and has committed to taking a phased approach to upgrading the ventilation and associated instrumentation systems to safety-significant. Phase 1 involved completing the implementation of the upgraded *Tank Farms Documented Safety Analysis*. This included supplementing the flammable gas monitoring control with a new control that will measure ventilation flow through each tank on a periodic basis. The Documented Safety Analysis also establishes priorities for DST primary tank ventilation system maintenance, commensurate with the importance of maintaining active ventilation on these tanks. DOE notified the DNFSB that Phase 1 was completed on February 21, 2013 ([DOE 2013b](#)). An evaluation of air flow meters to be used to monitor DST ventilation is near completion. Once complete, the selected air flow meter will be installed and used to monitor DST ventilation exhaust flow in real time. All related information for Recommendation 2012-2, is available on the DNFSB website at <http://www.dnfsb.gov/board-activities/recommendations/hanford-tank-farms-flammable-gas-safety-strategy>.

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 2013, final field characterization was completed in C Tank Farm as required by the *Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C* ([RPP-PLAN-39114](#)), and new characterization and test activities for interim measures were initiated in 200 West Area under the *200 West Area Tank Farms Interim Measures Investigation Work Plan* ([RPP-PLAN-53808](#)). 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 TX Tank Farm during 2013. Eight direct push boreholes were placed in TX Tank Farm. Each borehole was logged for moisture and gamma-emitting radionuclides, then a companion borehole was placed next to the first borehole, and soils samples were obtained at selected depths. During decommissioning of the logging boreholes, deep electrodes were placed to support future electrical resistivity work.

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 2013, electrical resistivity data was collected, and analyzed in C Tank Farm, near the C-200 Tanks, in support of the Phase 2 RCRA Facility Investigation Report. Electrical resistivity data was also collected and analyzed in U Tank Farm as part of the 200 West Area Interim Measures Investigation. Both activities made use of surface and depth electrode to provide a 3-dimensional representation of the soil properties.

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*). Barrier monitoring continued during 2013, with a new monitoring report issued annually. Monitoring results collected in 2012 were analyzed in 2013 and were reported in *T-TY Tank Farm Interim Surface Barrier Demonstration – Vadose Zone Monitoring FY12*

([RPP-RPT-55143](#)). The barriers are resulting in slow drying of the vadose zone as water, which would normally recharge the surface, is diverted.

Two interim barriers were previously 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 that is being completed in 2014.

5.4.4.4 Interim Measures Pore Water Extraction Test

A proof of principle test for pore water extraction was initiated in 2013 under the Interim Measures Investigation Work Plan. The test used the direct push unit to place small diameter boreholes into the soil south of SX Tank Farm. A vacuum system was used to extract potentially contaminated pore water from the soil. Testing will continue in 2014 to determine if the small diameter boreholes can be configured for effective pore water extraction. If successful, the method would offer a tool for remediation of soil contamination in Tank Farms.

5.5 Waste Treatment and Immobilization Plant (WTP)

HM Groce

The WTP (Figure 5.20) is being built on 65 acres (26 hectares) located on the Central Plateau in the 200 East Area 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 support buildings and associated infrastructure (Balance of Facilities). Construction of the WTP is managed in accordance with the RCRA Permit (WA7890008967).

At the end of 2013, more than 2,300 employees at the WTP worked on engineering, procurement, and construction activities to meet the priorities and guidance provided by DOE. In 2013, the WTP Contractor completed construction of the steam plant and placed structural steel to the 77-foot (23-meter) level of the High-Level Waste (HLW) Vitrification Facility. Workers also made substantial progress on construction of the Analytical Laboratory.

The WTP continues to make significant progress on the Low-Activity Waste Vitrification Facility and other support facilities. Work at the HLW Facility continues in the areas not affected by remaining technical decisions. A description of the WTP facilities/activities is provided below:

Pretreatment Facility: Workers performed maintenance activities necessary to preserve the facility in a condition to prevent deterioration due to inclement weather and to allow construction to resume in the future. Construction on the facility was suspended in early 2012 pending review of technical decisions.

High-Level Waste Vitrification Facility: Construction continued in 2013 as concrete placements reached 58 feet (18 meters) high. Workers placed structural steel to 37 feet (11 meters) high, meeting the deadline in a consent decree between DOE and the State of Washington. Additionally, 30 tons (27 metric tons) of structural steel were set to a 77-foot (23-meter) height. In general, work continued in the HLW Facility, except for the areas affected by review of technical decisions.

Low-Activity Waste Vitrification Facility: Construction continued on interior equipment and commodities installation. Work began on the melter refractory and lidding equipment installation, composed of 18 cubic feet (.5 cubic meters) of casting, more than 200 refractory bricks, and more than 30 wall and gas barrier lid placements.

Analytical Laboratory: Significant work was completed in 2013, which places the facility in an excellent position to begin turning over some systems to the start-up team by the end of 2014. Employees completed installing 32 stainless steel through-plugs for the facility's hot cell exterior. Each plug weighs about 160 pounds (73 kilograms) and will provide shielding during operations. Architectural wall installation was completed, and employees continued to pull cable and emplace terminations throughout the facility.

Emphasis in 2013 continued on facility completion efforts to support upcoming turnovers for startup testing. Construction work activities in the steam plant and chiller compressor plant were completed. Switchgear buildings 87 and 91 were turned over to startup, and more than 1.0 mile (1.6 kilometers) of steam piping was installed on overhead pipe racks throughout the site. Additionally, work began on the standby diesel generator foundation.



Figure 5.20. Waste Treatment and Immobilization Plant

In 2013, WTP employees completed the year with the lowest number of recordable injuries since the project began, which was 50 percent lower than in 2012. DOE recommended that WTP's Voluntary Protection Program Star Status be renewed for an additional 3 years.

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

JM Garcia

Throughout 2013, ORP and its contractors met with and provided information to the DNFSB and its technical staff to resolve commitments and review the following WTP technical topics. The following issues were addressed in 2013:

- WTP fire protection systems in the Low-Activity Waste Facility, Analytical Laboratory and Balance of Facilities
- HLW HEPA Loading and Aerosol Entrainment Coefficient Testing
- WTP Ammonia Hazards
- Low-Activity Waste Hazard Categorization
- Instrumentation and Control Design for Low-Activity Waste
- WTP Full-Scale Testing.

5.5.1.1 Defense Nuclear Facility Safety Board Recommendation 2010-2

On December 17, 2010, the DNFSB issued Recommendation 2010-2 focusing on the need for large-scale testing of pulsejet mixing systems to demonstrate the performance of mixing and transfer systems using representative simulants. DOE submitted its [Implementation Plan \(DNFSB 2010-2\)](#) to address the Waste Treatment and Immobilization Plant Vessel Mixing Issues, on November 10, 2011 (DOE 2011a), and the DNFSB accepted it on January 19, 2012. Subsequently, DOE's testing program generated results that were inconsistent with an important assumption in the implementation plan. As a result, in a November 9, 2012, letter, the Secretary of Energy informed the DNFSB that a full-scale testing program would become the new technical basis for implementing DNFSB Recommendation 2010-2. This change in strategy resulted in the need to complete a major revision to DOE's implementation plan. Technical teams of independent technical experts were formed by the Secretary of Energy to assess WTP technical issues including those issues specific to pulse jet mixing at the WTP.

During FY 2013, technical teams also completed an evaluation of the vessel testing program approach to demonstrate mixing and transfer system performance. This evaluation provided input into revision of the vessel testing and analysis program to allow for directly closing issues associated with nuclear safety hazards. As a result, issue closure approaches will use a combination of pulsejet mixing control system testing and analysis and testing of large-scale vessels to confirm the effectiveness of required safety controls. In addition, DOE is considering a tank waste characterization and staging capability to ensure that waste provided to the WTP meets acceptance requirements. DOE has provided the DNFSB with a schedule to complete the revision of the 2010-2 implementation plan by February 22, 2014, based on the newly developed approach.

Note: On January 28, 2014, the [DNFSB closed Board Recommendation 2010-2](#) citing DOE's new technical approach to resolving safety-related pulsejet mixing issues.

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. The following information reports on activities that occurred during 2013. In January 2013, ORP conducted an ISMS Safety Conscious Work Environment (SCWE) Self-Assessment. ORP staff provided suggestions to

further improve the organizational culture, safety culture, and a SCWE. Comments and suggestions for improvement were obtained from employees through individual interviews and focus group sessions to aid in ORP identifying the next set of focused improvement actions. The [self-assessment report was issued in February 2013](#) to fulfill Criterion 7 of the declaration report and Action 2-5 of the DOE [Implementation Plan for DNFSB Recommendation 2011-1](#).

On April 30, 2013, [Deliverable 2 of Action 1-8 of the DOE Implementation Plan for DNFSB Recommendation 2011-1](#), by transmitting a letter to the DNFSB stating that ORP had completed the action plan by April 2013. ORP completed nine near-term safety culture improvement actions that were identified by the DOE Office of Health, Safety, and Security (HSS), in its 2011 *Independent Oversight Assessment of Nuclear Safety Culture and Management of Nuclear Safety Concerns at the Hanford Site WTP* report.

On May 2013, ORP completed [Action 1-9 of the DOE Implementation Plan for DNFSB Recommendation 2011-1](#) by transmitting a letter to the DNFSB stating that the ORP Safety Culture Team completed a validation and effectiveness review of the nine near-term safety culture improvement actions contained in the April 2012 ORP Safety Culture Improvement Plan. The review was conducted from May 13 through 17, 2013, and was required by Action 1-9 of the [Implementation Plan for DNFSB Recommendation 2011-1](#), *Safety Culture at the Waste Treatment and Immobilization Plant*. The review also reported on the status of BNI actions to improve the nuclear safety and quality culture at the WTP. By May 2013, BNI completed 27 of the 50 nuclear safety and quality culture improvement actions.

To sustain its ongoing organizational and safety culture improvement efforts, ORP updated the ORP Safety Culture Improvement Plan during August through September 2013. The plan consists of four near-term improvement actions that were identified by ORP staff from the 2012 Federal Employee Viewpoint Survey, 2012 Hanford Organizational Climate and SCWE Survey (Speak-Up), ORP 2013 SCWE self-assessment, ORP senior management, and the ORP Organizational and Safety Culture Improvement Council. The plan was issued in October 2013.

HSS is scheduled to conduct a follow-on assessment review in December 2013 on the WTP safety culture. The follow-on review will be similar to the independent oversight review of safety culture for WTP that was conducted in 2011, based on the January 30, 2012, letter to the DNFSB, in which the senior advisor to the DOE Office of Environmental Management (EM) committed to having HSS conduct a WTP safety culture progress assessment approximately 12 to 18 months from the issuance of the HSS WTP Safety Culture 2012 Report. All related information for Recommendation 2011-1, is available on the DNFSB website at <http://www.dnfsb.gov/board-activities/recommendations/safety-culture-waste-treatment-and-immobilization-plant>.

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 (IRT) 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®^d) 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 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

^d A registered trademark of Haynes International, Inc., Humble, Texas.

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 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.

5.6 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, and the DOE EM Office of Soil and Groundwater Remediation. The contributions included performing evaluations, analyzing data, providing reviews, preparing and operating special facilities, and creating new technologies to address site cleanup challenges. The 2013 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 full-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 was transferred to evaluate the potential for spray releases in the WTP. The team completed testing and documentation of 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 was evaluated as technology 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.

Speciation of Technetium in Tank Waste. During 2013, researchers started an effort to identify the speciation of technetium in tank wastes. Under normal processing conditions, technetium is usually present as the pertechnetate ion. However, a significant portion of the technetium in Hanford waste tanks is present as a complexed soluble species. Work was started on explaining the nature of these complexes.

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 subsurface 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 2013, the AFRI focused on defining risk-informed alternative strategies for site closure and long-term management, developing flux-based methods for supporting vadose zone remediation decisions, developing methods and approaches for vadose zone and groundwater remediation, and refining non-invasive remote characterization and monitoring approaches. The AFRI also developed a remedial investigation work plan for pre-Hanford orchards lands.

The Deep Vadose Zone AFRI led a multi-national laboratory effort to develop a framework for defining systems-based, risk-informed endpoints to enable soil and groundwater remediation. The framework is centered on developing and refining conceptual models in conjunction with assessing risks and evaluating potential endpoints that are permitted by regulations. The framework is being applied to the Hanford Site to evaluate remediation strategies and endpoints for iodine-129, plutonium, americium, technetium-99, and uranium. The technical understanding of how these contaminants behave in the subsurface and biogeochemical processes that impact their migration is being developed to support risk-informed remediation strategies. A system-scale model of the 300 Area uranium plume was developed based on updates to the conceptual model of the site ([PNNL-22886](#), *System-Scale Model of Aquifer, Vadose Zone, and River Interactions for the Hanford 300 Area – Application to Uranium Reactive Transport*). Simulations were performed with the model to identify scientific and technical uncertainties associated with the 300 Area uranium and planned remediation activities.

A mass-flux discharge framework was applied to perched water contamination within WMA B, BX, BY ([PNNL-22499](#), *Perched-Water Evaluation for the Deep Vadose Zone Beneath the B, BX, and BY Tank Farms Area of the Hanford Site*). The analysis demonstrated that perched water removal performed by CHPRC will reduce the flux of water and associated contaminants to the underlying groundwater. The analysis further demonstrated that perched-water removal combined with reducing the recharge rate (e.g., by surface barriers) would result in the most significant decrease in contaminant flux to groundwater. Another aspect of applying the mass flux-based framework at the Hanford Site consisted of continuing studies of historical waste disposal practices and the importance of disposal chemistries on attenuation mechanisms, transport, and fate of uranium and technetium-99. These studies will provide knowledge to support future remedial decisions.

During 2013, AFRI scientists provided technical input to several remediation activities at the Hanford Site:

- Applied understanding of pore-water extraction processes and subsurface characteristics to support design and demonstration of pore-water extraction at WMA S-SX
- Evaluated biological communities present in the 200 West Area pump-and-treat fluidized bed reactors (FBRs) that remove carbon tetrachloride and nitrate from groundwater. Molecular tools (microbial fingerprinting and sequencing) were applied to determine the spatiotemporal identify, composition, and function of the microbial community within the FBR to support performance optimization
- An in-line sensor was deployed within the 200 West Area pump-and-treat system to quantify aqueous technetium-99 concentrations in effluent streams. Advanced microfluidic technology was integrated with radioanalytic separations to deploy the in-line sensor, which provides on-demand data to evaluate and optimize system operation.

Efforts continued on recharge and barrier performance to support remediation activities. The scientific and technical knowledge obtained from these studies is used to design surface barrier systems that control vadose zone mass flux. Ongoing activities during 2013 included:

- Collection and evaluation of monitoring data for the 200-BP-1 Prototype Hanford Barrier. This monitoring effort, which has been ongoing for more than 20 years, provides understanding and technical validation for use of engineered barriers for vadose zone cleanup and closure
- Collection and evaluation of monitoring data at the Field Lysimeter Test Facility.
- Development efforts continued for non-invasive, remote characterization and monitoring using electrical resistance tomography (ERT). These efforts included:
- Enhancements to the high-performance geophysical imaging code, FERM3D, enabling explicit inversion modeling of metallic infrastructure to distinguish subsurface contamination using ERT.

These capabilities are critical for characterization of subsurface contamination in waste management areas with extensive infrastructure, such as tank farms

- Development of complex resistivity inversion methods for inclusion in FERM3D to enable monitoring field-scale transport of contaminants and application of subsurface remediation approaches.

Development of the PNNL On-Line Environmental Information Exchange (PHOENIX) web application (phoenix.pnnl.gov) continued. PHOENIX presents groundwater monitoring and remediation treatment performance on a Geographic Information System framework. During 2013, a specific application of PHOENIX was developed for annual groundwater monitoring compliance reports at the Hanford Site. The report is now published online, significantly reducing the time and schedule required.

The AFRI led development of a Remedial Investigation Work Plan for the Pre-Hanford Orchards Lands Operable Unit. Farmstead communities existed adjacent to the Columbia River before the Hanford Site, including approximately 8,300 acres (3,359 hectares) of farmlands, of which 5,000 acres (2,023 hectares) are historical orchard lands. The primary contaminant of concern for this operable unit is residual lead arsenate, used as a pesticide. The AFRI facilitated integration among DOE, regulators, and stakeholders to determine whether there is risk to human health and the environment from the arsenate.

Advanced Simulation Capability for Environmental Management (ASCEM). ASCEM is being developed as a scientific tool and approach for understanding and predicting contaminant fate and transport in natural and engineered systems. The capability includes modular and open source toolsets that will facilitate integrated approaches 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. The ASCEM project focused activities on development of a first end-user release, completed at the end of 2013, available for downloading at ascemdoe.org. The release includes documentation and tutorials for end users to test and evaluate the capabilities.

6.0 Air Monitoring

CJ Perkins and DJ Rokkan

[DOE O 458.1](#), Chg. 3, 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 also support the Hanford Site *Safety Management System Policy* ([DOE P 450.4](#)) and its EMS (Section 3) component. 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. 3 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 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 the 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 WDOH 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 1 percent of the standard for public dose, which is 10 mrem (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 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, sampling criteria provided in contractor environmental compliance manuals, and the potential of each radionuclide to contribute to the public dose. Continuous air monitoring systems with alarms also are used at selected emission points where 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 are as follows:

- In the 100 Areas, two radioactive emission points were active. Emissions originated from 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, B Plant, WESF, underground tanks storing high-level radioactive waste, a waste evaporator, the WRAP Facility, 222-S Laboratory, 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 WSCF where low-level radiological and chemical analyses were performed on various types of samples (e.g., particulate air filters, liquids, soil, and vegetation).

Air emission data collected in 2013 were comparable to those collected in 2012. Table 6.1 summarizes Hanford Site radioactive airborne emissions in 2013.

6.1.2 Criteria and Toxic Air Pollutants

Criteria and toxic air pollutants emitted from chemical-processing and electricity-generating engines fueled by petroleum are monitored when activities are known to release pollutants of concern, such as: 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 petroleum fuel consumed at Hanford Site power plants, emissions were calculated using EPA-approved formulas ([AP-42](#), *Compilation of Air Pollutant Emission Factors*, Volume I: *Stationary Point and Area Sources*). Table 6.2 summarizes the Hanford Site emissions of nonradioactive pollutants discharged to the atmosphere.

Also in Table 6.2 are values of ammonia emissions, all of which originated from the Tank Farms in the 200 Areas. Further listed in the same table are the release amounts of three toxic pollutants: carbon tetrachloride, dichloromethane, and trichlorofluoromethane.

Table 6.1. Hanford Site Radioactive Airborne Emissions

Radionuclide	Half-Life	2013 Releases, Ci ^a				
		100 Area	200-East Area	200-West Area	300 Area	400 Area
Actinium-227	21.6 years	NA	NA	NA	7.3×10^{-11}	NA
Alpha (gross)	NA	3.6×10^{-6}	9.7×10^{-7}	2.8×10^{-5}	4.9×10^{-8}	NA
Americium-241	432.2 years	1.5×10^{-6}	2.4×10^{-8}	3.6×10^{-6}	2.3×10^{-10}	NA
Americium-243	7,380 years	NA	NA	NA	2.3×10^{-8}	NA
Beta (gross)	NA	1.3×10^{-5}	1.1×10^{-4}	1.1×10^{-5}	3.3×10^{-6}	NA
Carbon-14	5,700 years	NA	NA	NA	1.0×10^{-6}	NA
Cesium-134	2.1 years	NM	NM	NM	NM	NM
Cesium-137	30 years	3.4×10^{-6}	9.2×10^{-5}	9.0×10^{-7}	6.7×10^{-9}	$8.4 \times 10^{-7 (c)}$
Curium-243/-244	29.1 years	NA	NA	NA	ND	NA
Europium-152	13.5 years	NM	NM	NM	1.3×10^{-8}	NA
Europium-154	8.6 years	2.4×10^{-8}	NM	NM	2.6×10^{-7}	NA
Gadolinium-153	240.4 days	NA	NA	NA	5.4×10^{-11}	NA
Iodine-129	16,000,000 years	NA	7.4×10^{-4}	NA	NA	NA
Krypton-85	10.7 years	NA	NA	NA	5.5×10^{-3}	NA
Neptunium-237	2,144,000 years	NA	NA	NA	2.6×10^{-10}	NA
Plutonium-238	87.7 years	2.5×10^{-7}	ND	9.5×10^{-8}	2.3×10^{-10}	NA
Plutonium-239/240	24,110 years	1.6×10^{-6}	2.8×10^{-8}	1.8×10^{-5}	6.8×10^{-9}	$7.5 \times 10^{-8 (d)}$
Plutonium-241	14.4 years	1.0×10^{-5}	ND	5.2×10^{-6}	2.0×10^{-7}	NA
Protactinium-231	32,760 years	NA	NM	NA	NA	NA
Radium-226	1,600 years	NA	NA	NA	2.3×10^{-10}	NA
Radon-220	55.6 seconds	NA	NA	NA	$2.5 \times 10^{+2}$	NA
Sodium-22	2.6 years	NA	NA	NA	NA	$1.4 \times 10^{-9 (b)}$
Strontium-90	29.1 years	2.9×10^{-6}	1.8×10^{-4}	8.0×10^{-7}	7.6×10^{-8}	NA
Technetium-99	211,100 years	NA	NA	NA	1.6×10^{-6}	NA
Tritium (elemental)	12.3 years	NA	NA	NA	$5.7 \times 10^{+1}$	NA
Tritium (tritiated water vapor)	12.3 years	NA	NA	NA	$1.9 \times 10^{+2}$	1.8×10^{-3}
Uranium-232	68.9 years	NA	NA	NA	2.9×10^{-10}	NA
Uranium-233	159,200 years	NA	NA	NA	3.1×10^{-9}	NA
Yttrium-90	1.5 seconds	NA	6.6×10^{-9}	NA	NA	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.

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	2013 Releases	
	lb	kg
Particulate matter-total	0	0
Particulate matter-10	0	0
Particulate matter-2.5	0	0
Lead	0	0
Nitrogen oxides	18,000	8,200
Sulfur oxides	0	0
Carbon monoxide	16,000	7,300
Volatile organic compounds	10,000	4,500
Ammonia	10,000	4,500
Carbon Tetrachloride	6	2.7
Dichloromethane	1	0.45
Trichlorofluoromethane	1	0.45

6.2 Ambient Air Monitoring

CJ Perkins

Atmospheric releases of radioactive materials from Hanford Site facilities and operations to the surrounding region are potential sources of exposure to humans. At the Hanford Site, radioactive constituents in air are monitored at Hanford Site 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

A network of continuously operating samplers at 71 locations across the Hanford Site was used during 2013 to monitor radioactive airborne materials in air near Hanford 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 2013 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 onsite 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 mrem (100 microsievert) per year under conditions of continuous exposure. The 2013 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 Hanford Site operational areas, and naturally occurring radionuclides, beryllium-7, and potassium-40 were routinely identified. Appendix C, Table C.5 shows the annual average and maximum concentrations of radionuclides in air samples collected near Hanford Site facilities and operations during 2013.

Air monitoring results from the stations at the 100-D and 100-H Area Field Remediation projects and at the 100-N Area deactivation, decommission, decontamination and demolition (D4) project were at or below typical Hanford Site levels in 2013. Uranium-234 and uranium-238 were consistently detected while plutonium-239/240 was detected only at the 100-H Area and strontium-90 at 100-D and 100-H Area locations. Americium-241 was not detected in the 100-D, 100-H, and 100-N Area samples. Clean-up activities at the 100-D and 100-H Area locations were completed and air sampling was subsequently concluded in September 2013.

Ambient air was monitored in 2013 at seven locations in the 100-K Area and analytical results showed radionuclide concentrations at or below typical Hanford Site levels. Uranium-234 and uranium-238 were detected in approximately 65 percent of the samples. Tritium was detected at approximately 60 percent of the samples, and strontium-90 in only 13 percent. Plutonium-239/240, plutonium-241, americium-241, and cesium-137 were not detected.

Air sampling was conducted at 21 locations in the 200-East Area during 2013. Generally, radionuclide levels measured in the 200-East Area ambient air composite samples in 2013 were similar to those measured in previous years. Uranium-234 and uranium-238 were detected in approximately 65 percent of the samples, strontium-90 in 38 percent and all other radionuclides were either detected in less than 15 percent of the samples or not at all. Cesium-137 concentrations at two air-sampling locations (N976 and N984) at C Farm were greater than 10 percent of the EPA concentration value ([40 CFR 61](#), Appendix E, Table 2) for the composite samples collected during the first-half of 2013. These elevated values may have been associated with a radiological incident on August 21, 2013, where higher than expected beta radiation readings were observed during the nighttime monitoring of tank C-101 sluicing equipment. Required notifications regarding the elevated air sample results were made to the WDOH. The cesium-137 air sample concentrations returned to normal levels at these two stations during the second half of the year (see Figure 6.2).

Air sampling was conducted at 25 locations in the 200-West Area during 2013. 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 60 percent of the samples. Strontium-90 and plutonium-239/240 were detected in approximately 35 percent and 20 percent of the samples, respectively. Noteworthy for 2013 was that there were no elevated plutonium-239/240 concentrations at air-sampling location N165, located near the 216-Z-9 Trench (see Figure 6.3).

Air sampling in support of remediation work in the 300-FF-2 Operable Unit (near the 300 Area) and decontamination and decommissioning activities at the 300 Area D4 project continued in 2013. Uranium-234 and uranium-238 were detected in 50 percent of the samples at levels similar to those measured in previous years.

Air sampling was conducted at six locations 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 70 percent of the samples; plutonium-239/240 was detected in approximately 40 percent of the samples and strontium-90 in 30 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, with plutonium-239/240 and americium-241 detected more frequently and with slightly higher concentrations than typical Hanford Site levels.

Table 6.3. Hanford Site Monitoring Locations and Analyses for Ambient Air Monitoring Samples

Site/Project	Number of Samplers	EDP Code	Analyses	
			Bi-Weekly	Composite
100-D Area Field Remediation ^a	4	N467, N468, N514, N515	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238, americium-241
100-H Area Field Remediation ^a	3	N509, N510, N574	Alpha, Beta	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
100-K Basins Closure	7	N476, N534, N535, N575, N576 ^b , N577, N578	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238, americium-241
100-N Area D4 Project	3	N102, N103, N106	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238, americium-241
200 East Area	17	N019, N158, N498, N499, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984 ^b , N985, N999	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238
Canister Storage Building (200 East Area)	2	N480, N481	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238
Integrated Disposal Facility (200 East Area)	2	N532, N559	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238
200 West Area	23	N155, N161, N165 ^b , N168, N200, N304, N433, N441, N442, N449, N456, N457, N554, N555, N956, N963, N964, N965, N966, N974, N975, N987, N994	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238
300 Area D4 and Field Remediation projects ^a	2	N557, N130	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238
Environmental Restoration Disposal Facility	5	N482 ^b , N168, N517, N518, N963	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238
600 Area (WYE Barricade)	1	N981 ^b	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238
618-10 Burial Ground	4	N548, N549, N579, N580	Alpha, Beta	GEA, strontium-90, plutonium-238, -239/240, uranium-234/-235/-238

^a. Offsite air sampling station(s) provide supplemental air monitoring data. See Table 6.4 for a listing of locations.

^b. Collocated sampling location with Washington State Department of Health.

D4 = deactivation, decommission, decontamination and demolition.

EDP = Environmental data point 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.*

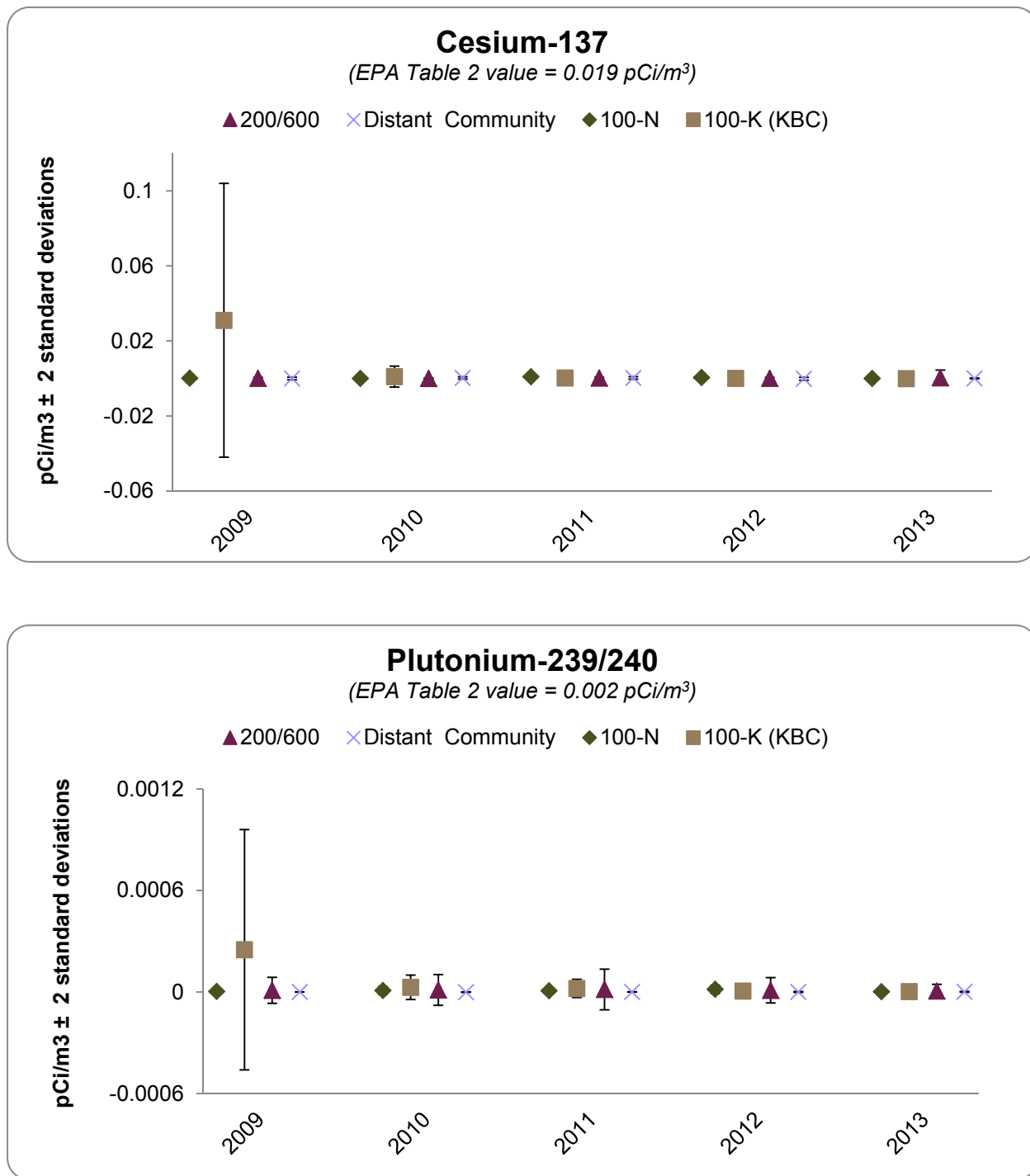


Figure 6.1 Hanford Site Average Radionuclide Concentrations in Ambient Air Samples Compared to Distant Communities Samples (Cont.)

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.
KBC = K Basins Closure Project.*

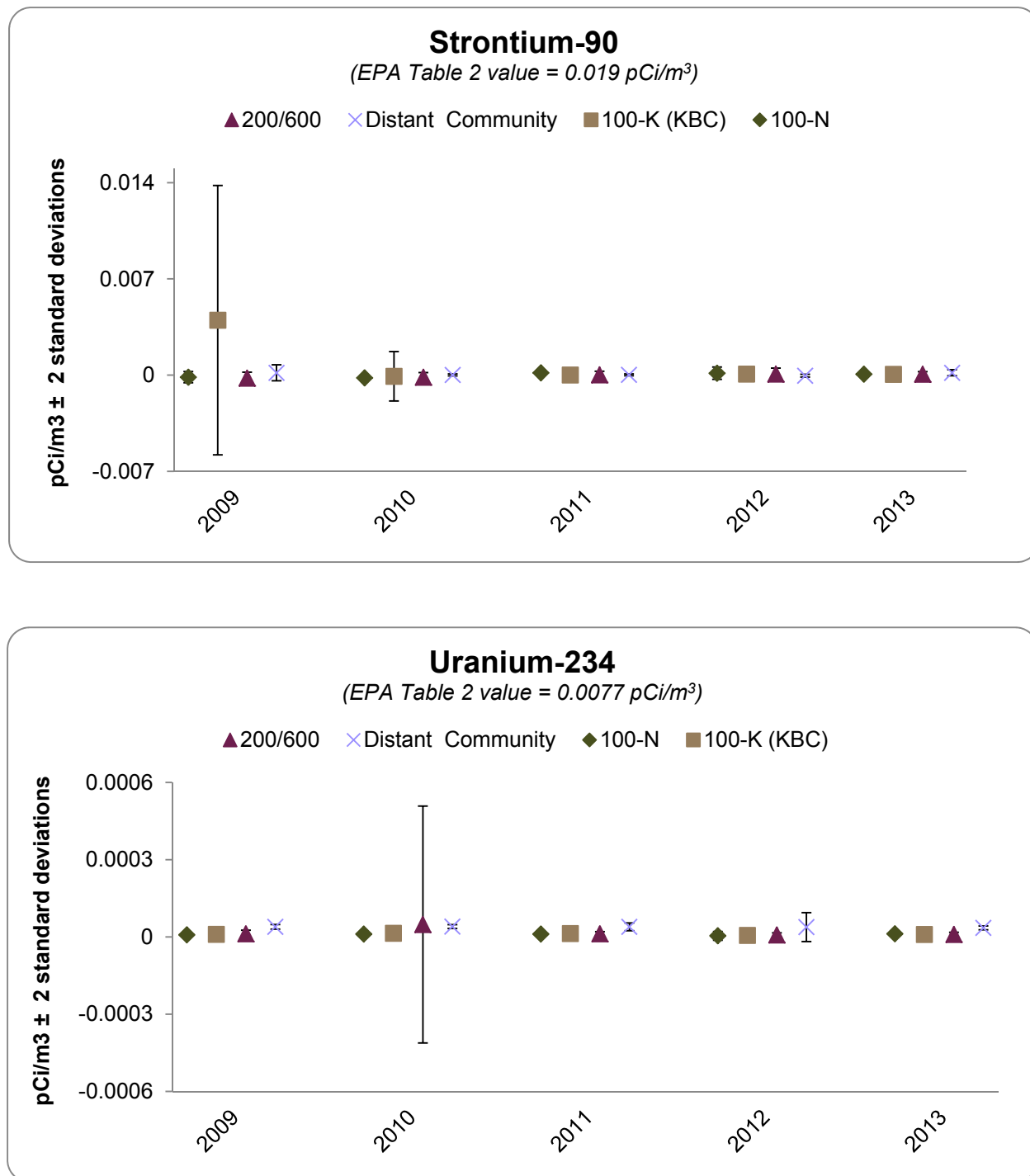


Figure 6.1 Hanford Site Average Radionuclide Concentrations in Ambient Air Samples Compared to Distant Communities Samples (Cont.)

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.
KBC = K Basins Closure Project.*

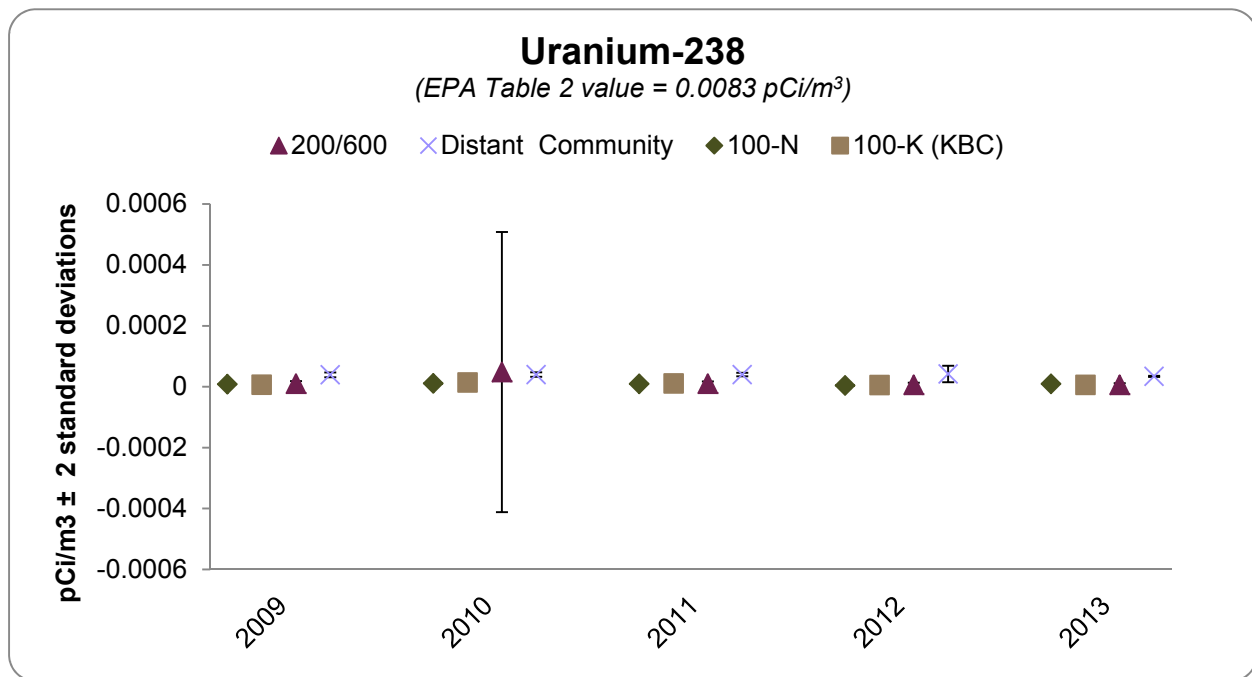


Figure 6.2. Cesium-137 Air Concentrations at C Tank Farm

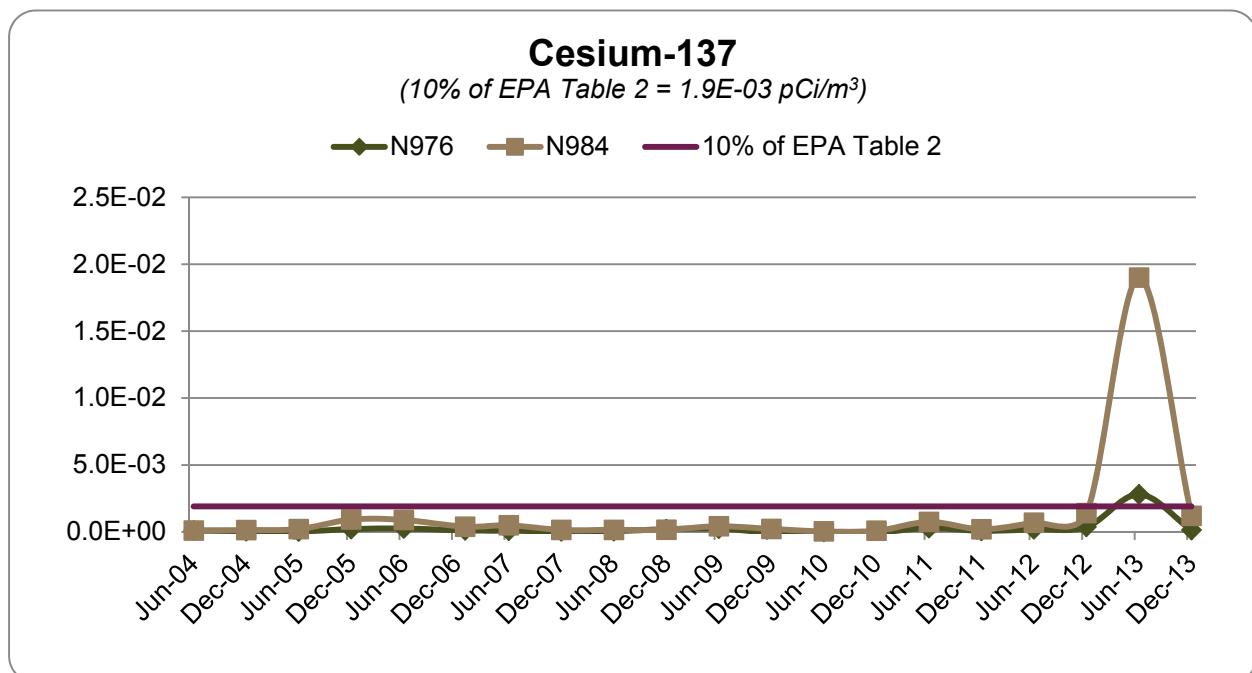
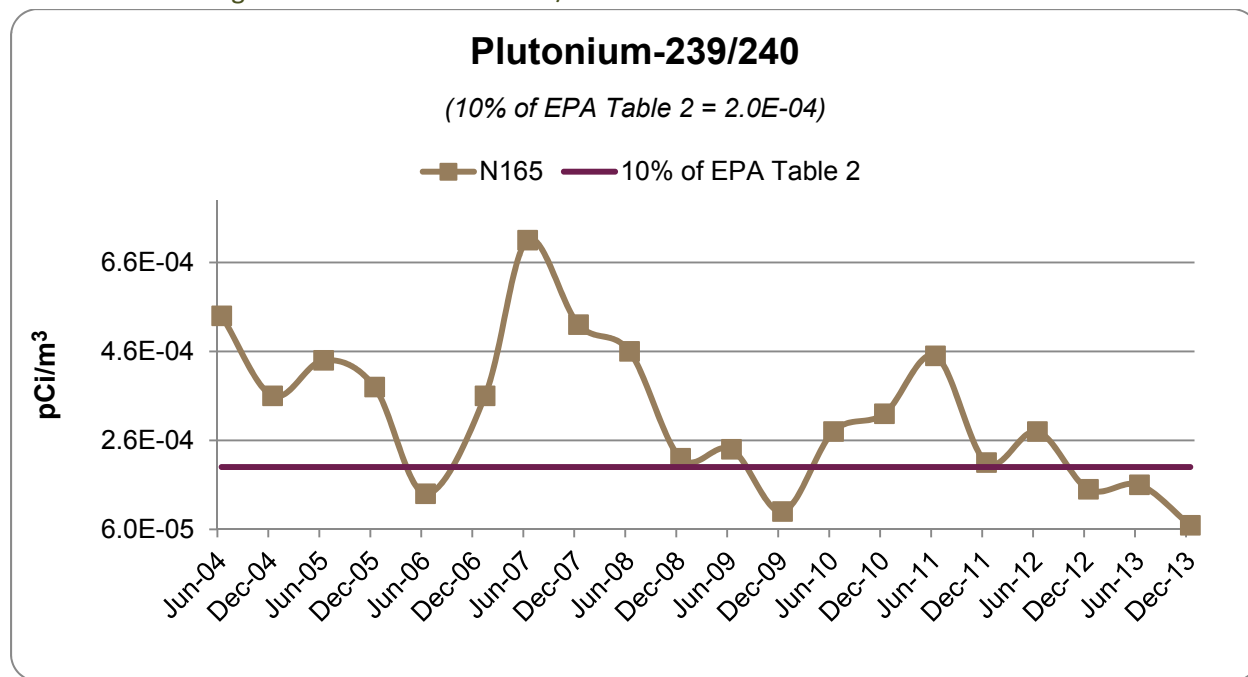


Figure 6.3. Plutonium-239/240 Air Concentrations at 216-Z-9 Trench



6.2.2 Hanford Site and Offsite Ambient Air Monitoring

Airborne radionuclide samples were collected in 2013 by 40 continuously operating samplers at or in the vicinity of the Hanford Site. The sampling stations were grouped into four location classifications: 1) Hanford Site (21 stations), 2) perimeter (11 stations), 3) nearby Hanford Site communities (7 stations), and 4) distant community (1 station) (Figure 6.4 and Table C.6, Appendix C). Hanford Site 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 to a schedule established prior to the monitoring year for offsite samples ([DOE/RL-2013-01](#), *Hanford Site Environmental Surveillance Far Field Sampling Schedule Calendar Year 2013*). Airborne particle samples were collected biweekly at each location by continuously drawing air through a glass-fiber filter. The filter samples were transported to an analytical laboratory and stored for at least 72 hours. The storage 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. Selected filters were also analyzed for gross alpha radiation. Historically, for most radionuclides, the amount of radioactive material collected on a filter during a 2-week period has been too small to analyze accurately individual radionuclides of concern. Biweekly samples were combined into semiannual composite samples to increase the sensitivity and accuracy of the analysis. The compositing procedure results in a 26-week average concentration for specific radionuclides present in the atmosphere as particulates. The composite samples were analyzed for gamma-emitting radionuclides, and most were analyzed for strontium-90, uranium-234, uranium-235,

plutonium-238, uranium-238, and plutonium-239/240. Table 6.4 shows the analyses for the discrete filters and composite samples.

Atmospheric water vapor was collected for tritium analysis at 20 locations in 2013 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 Adsorbent*. 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 2013 showed very low radiological concentrations in air. All radionuclide concentrations (Table C.6, Appendix C) were less than their respective EPA Table 2 and/or DOE-derived concentration guide. The derived concentration guides are concentrations that would result in a dose of 100 mrem (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 mrem (100 microsievert) per year from airborne radiological material.

Gross alpha concentrations in the air samples collected in 2013 from Hanford Site, perimeter, and offsite nearby Hanford Site communities location classes were comparable to each other and slightly higher than samples from the distant community. Gross alpha concentrations in 2013 were comparable to concentrations seen in the previous 5 years.

Gross beta and gross alpha concentrations in air peaked during the fall and winter months in 2013 (Figure 6.5), repeating a pattern of natural radioactivity fluctuations (Eisenbud, 1987, *Environmental Radioactivity from Natural, Industrial, and Military Sources*). This fluctuation is seen in both the Hanford Site and distant locations.

Plutonium-239/240 was detected in 1 out of 59 air samples collected in 2013. This was at a Hanford Site location and the result was less than 1 percent of the EPA concentration value. Figure 6.6 shows that plutonium-239/240 concentrations in the air samples collected in 2013 are at levels similar to those measured in previous years. There were no plutonium-238 detects in 2013.

Uranium-234 and uranium-238 were both detected in all of the air samples collected in 2013 from all four-location classes. Figure 6.6 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 one percent of the EPA concentration values for both radionuclides.

Cesium-137, cobalt-60, and strontium-90 were not detected in any of the samples collected during 2013.

Figure 6.4. Ambient Air Sampling Locations

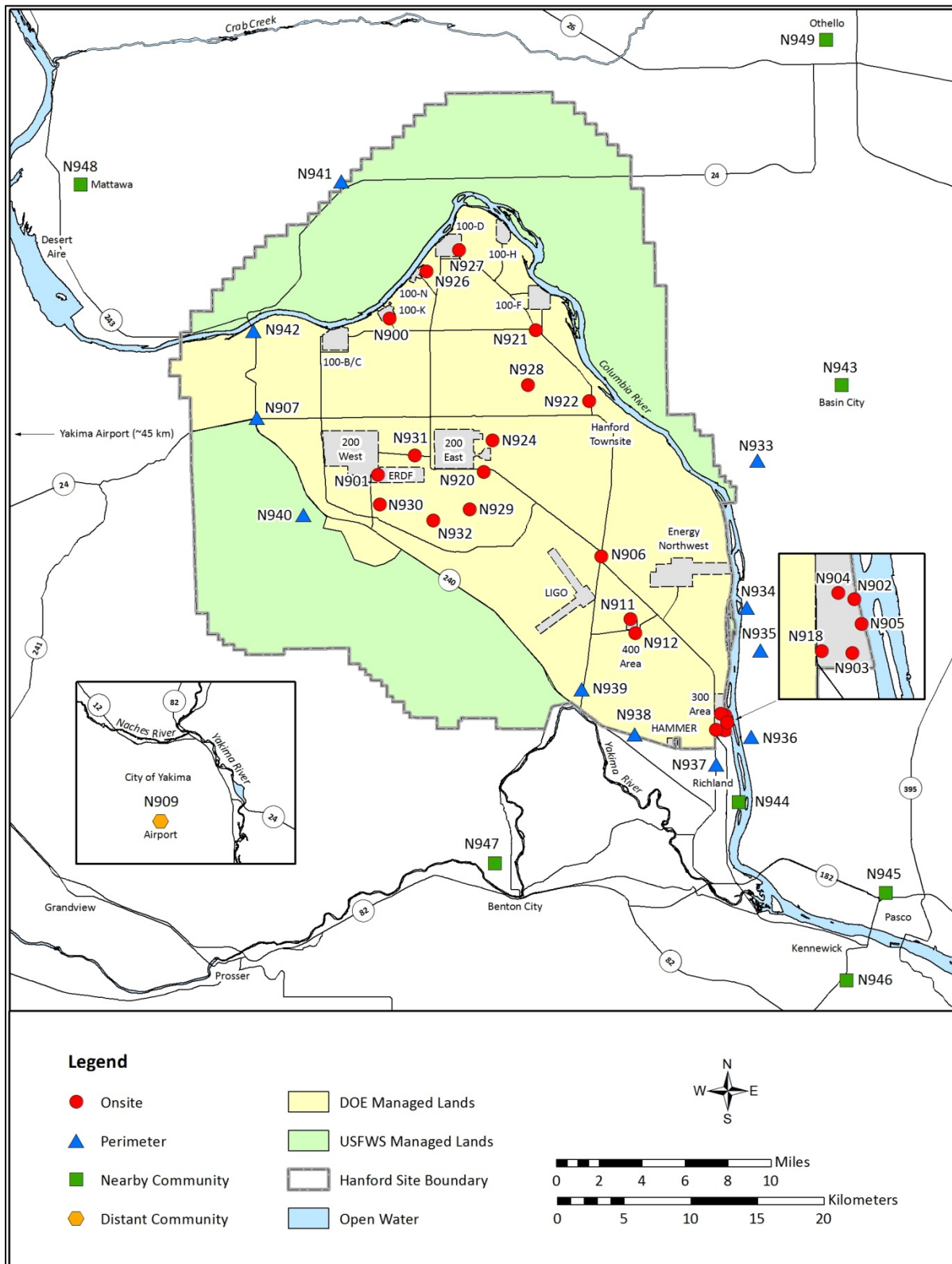


Table 6.4. Hanford Site and Offsite Ambient Air Sampling Locations and Analytes

EDP Code ^a	Location	Analyses		
		Bi-Weekly	Monthly ^b	Composite
Hanford Site				
N900	100 K Area	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N926	100 N-1325 Crib	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N927	100 D Area	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N921	100 F Met Tower	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N922	Hanford Townsite	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N928	Gable Mountain	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N920	200 ESE	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N929	S of 200-E	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N924	B Pond	Alpha, Beta		GEA, plutonium-238/-239/240, uranium-234/-235/-238
N930	Army Loop Camp	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N931	200 Tel. Exchange	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N932	SW of B/C Cribs	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N901	200 W SE	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N905	300 Water Intake ^{c, d}	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N903	300 South Gate ^e	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N918	300 South West	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N904	300 Trench	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N902	300 NE	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240
N911	400 N	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240
N912	400 S	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240
N906	Wye Barricade ^{c, f}	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
Hanford Site Perimeter				
N933	Ringold Met Tower	Alpha, Beta	Tritium	GEA, plutonium-238/-239/240
N934	W End of Fir Road ^{c, d}	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N935	Dogwood Met Tower	Alpha, Beta	Tritium	GEA, strontium-90, uranium-234/-235/-238
N936	Byers Landing	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N937	Battelle Complex ^{c, d}	Alpha, Beta	Tritium	GEA, uranium-234/-235/-238
N938	Horn Rapids Substation	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240
N939	Prosser Barricade ^{c, d}	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240
N907	Yakima Barricade ^c	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240

Table 6.4. Hanford Site and Offsite Ambient Air Sampling Locations and Analytes

EDP Code ^a	Location	Analyses		
		Bi-Weekly	Monthly ^b	Composite
N940	Rattlesnake Springs	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240
N941	Wahluke Slope	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240
N942	South End Vernita Bridge	Beta, Alpha		GEA, strontium-90, plutonium-238/-239/240
Nearby Hanford Site Communities				
N943	Basin City School	Alpha, Beta	Tritium	GEA, plutonium-238/-239/240, uranium-234/-235/-238
N944	Leslie Groves-Richland	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N945	Pasco	Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N946	Kennewick-Ely Street	Alpha, Beta		GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238
N947	Benton City	Beta		GEA
N948	Mattawa	Beta		GEA
N949	Othello	Beta		GEA, uranium-234/-235/-238
Distant Hanford Site Community				
N909	Yakima	Alpha, Beta	Tritium	GEA, strontium-90, plutonium-238/-239/240, uranium-234/-235/-238

^a. EDP Code = Environmental data point code = sampler location code. Refer to Figure 6.2.

^b. Atmospheric water vapor samples for tritium analysis are collected every 4 weeks using silica gel columns.

^c. WDOH particulate air sampler also at this location.

^d. WDOH tritium air sampler also at this location.

^e. Two tritium samples are collected from this location, one as a Quality Assurance duplicate sample.

^f. Quality Assurance duplicate sample collected at this location.

GEA = Gamma energy analysis.

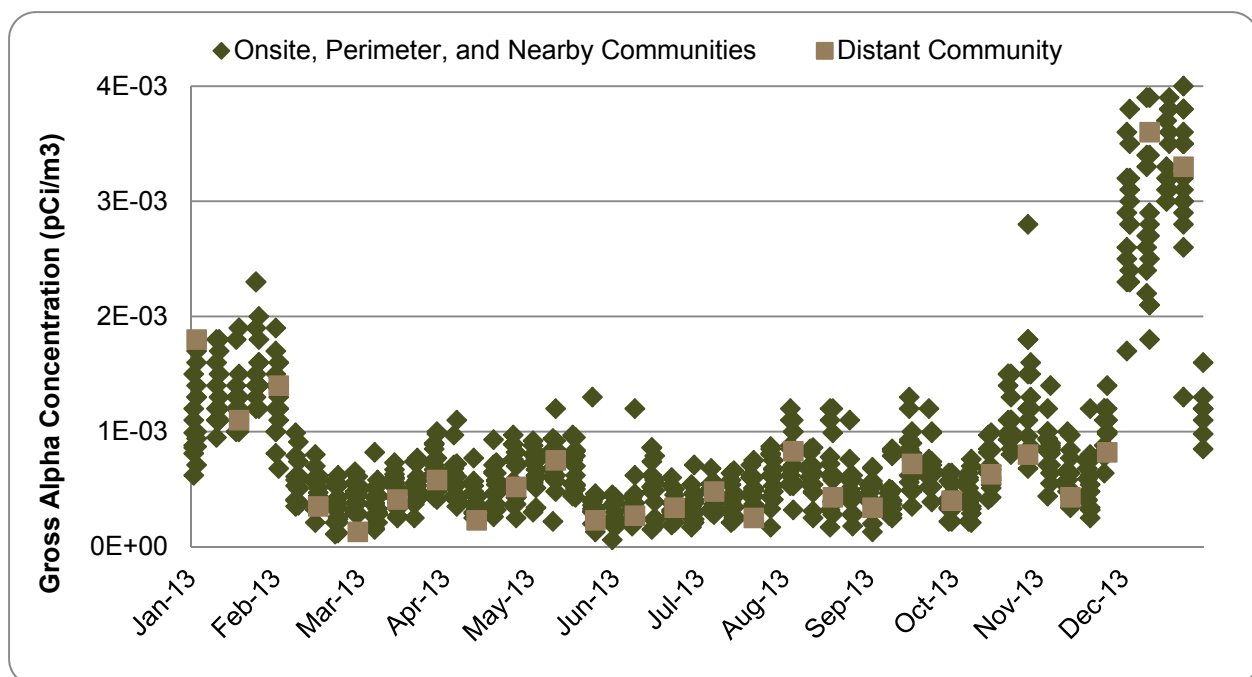
Figure 6.5. Gross Alpha and Beta Concentrations in Airborne Particulate Samples

Figure 6.6. Radionuclide Concentrations in Ambient Air Samples
(1 pCi = 0.037 Bq)

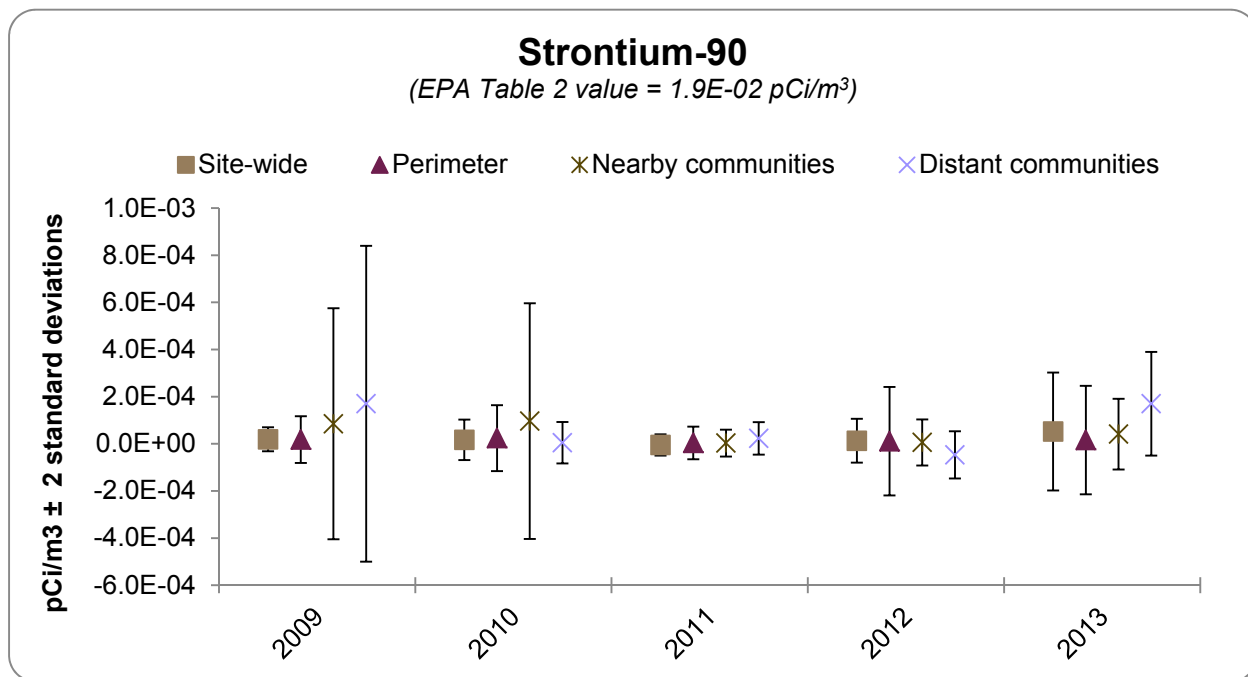
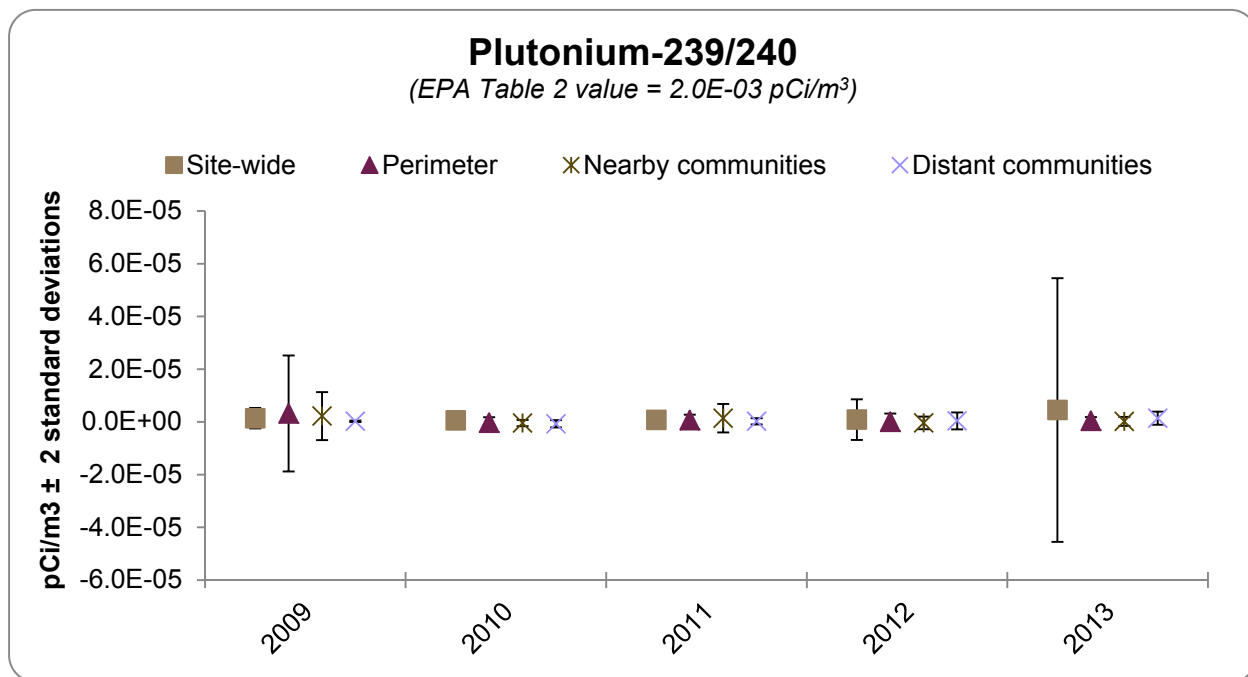


Figure 6.6. Radionuclide Concentrations in Ambient Air Samples (Cont.)
(1 pCi = 0.037 Bq)

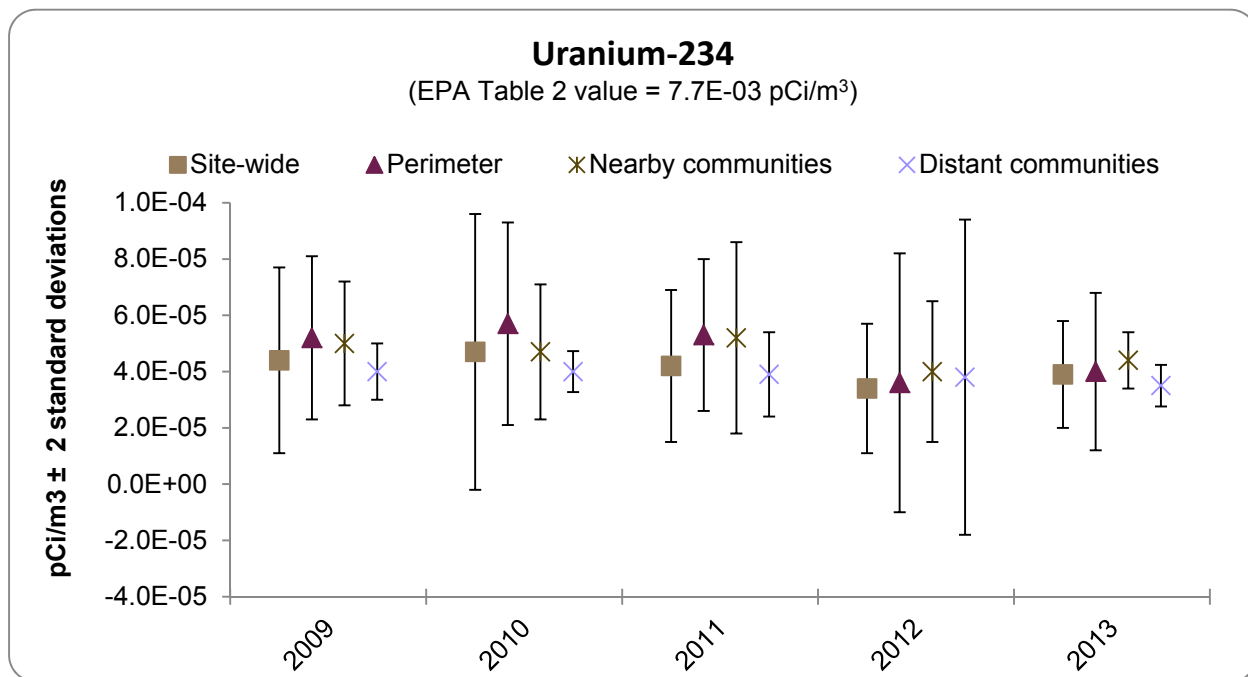
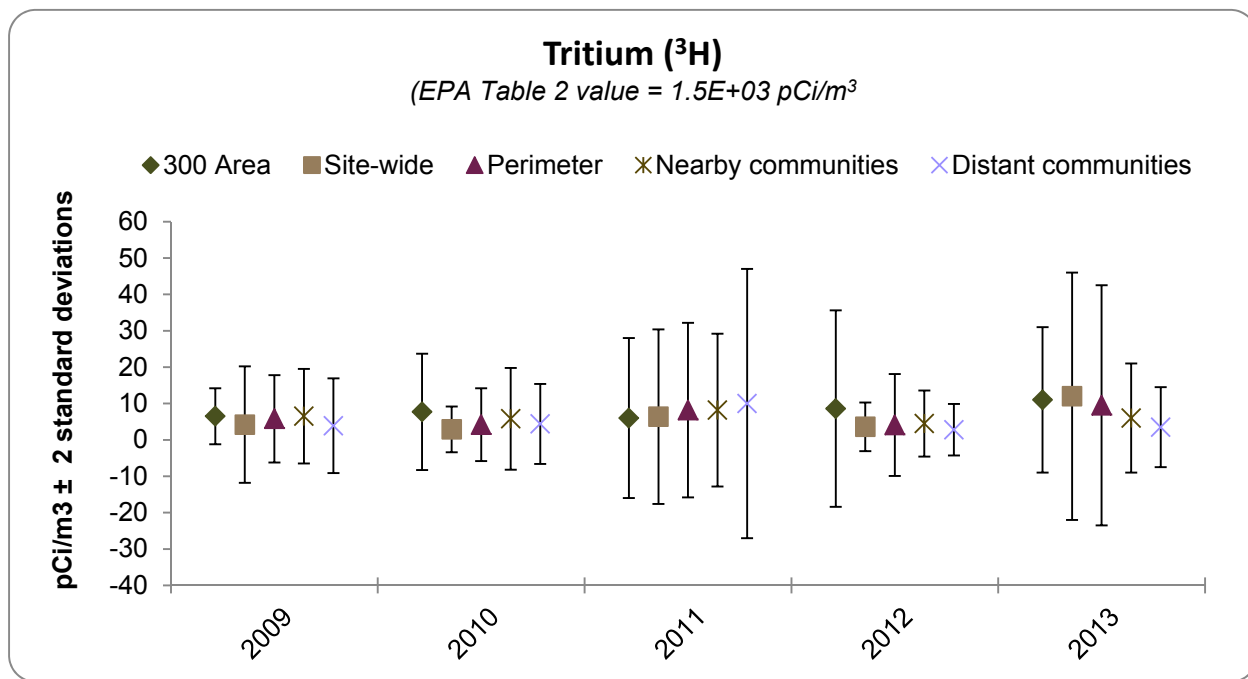
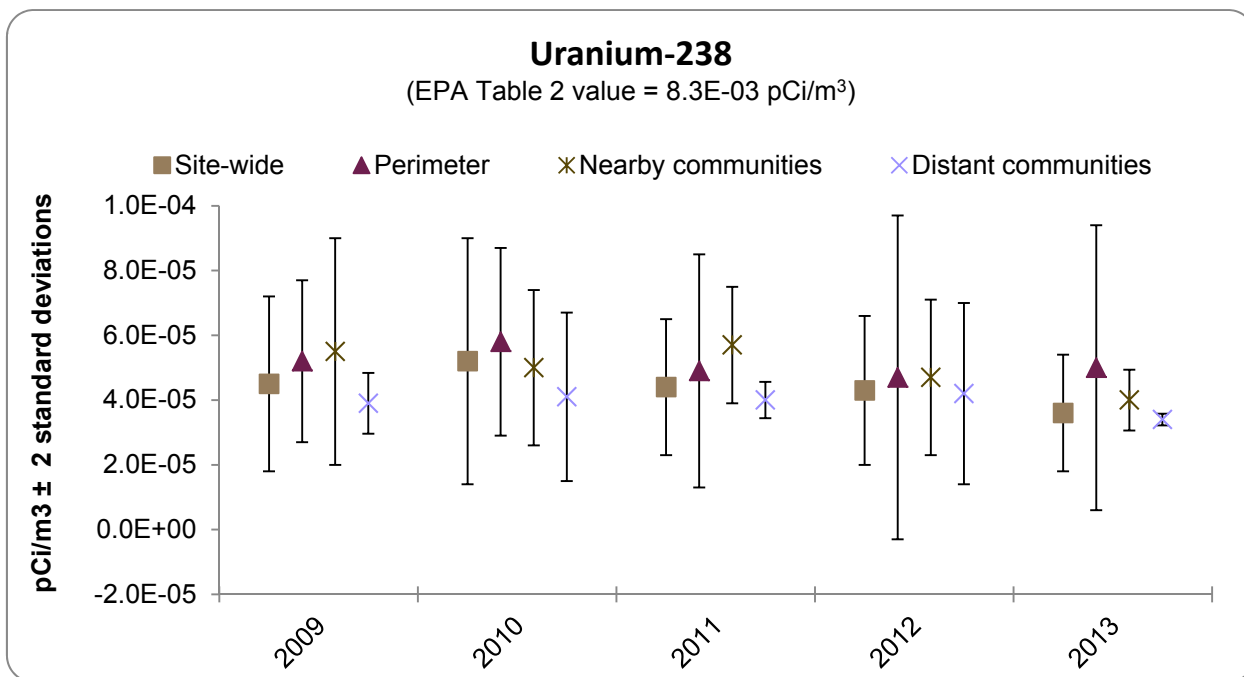


Figure 6.6. Radionuclide Concentrations in Ambient Air Samples (Cont.)
(1 pCi = 0.037 Bq)



7.0 Water Monitoring

7.1 Drinking Water Systems

LE Bisping and LM Kelly

Eight DOE-owned, contractor-operated, public water systems supply drinking water to DOE facilities on the Hanford Site (Table 7.1). MSA operates five of the public water systems, WCH operates one system, and CHPRC operates two systems. The city of Richland supplied water to the 300 Area, the Richland North Area, and HAMMER. Table 7.1 identifies the operator and water source for the eight public water systems.

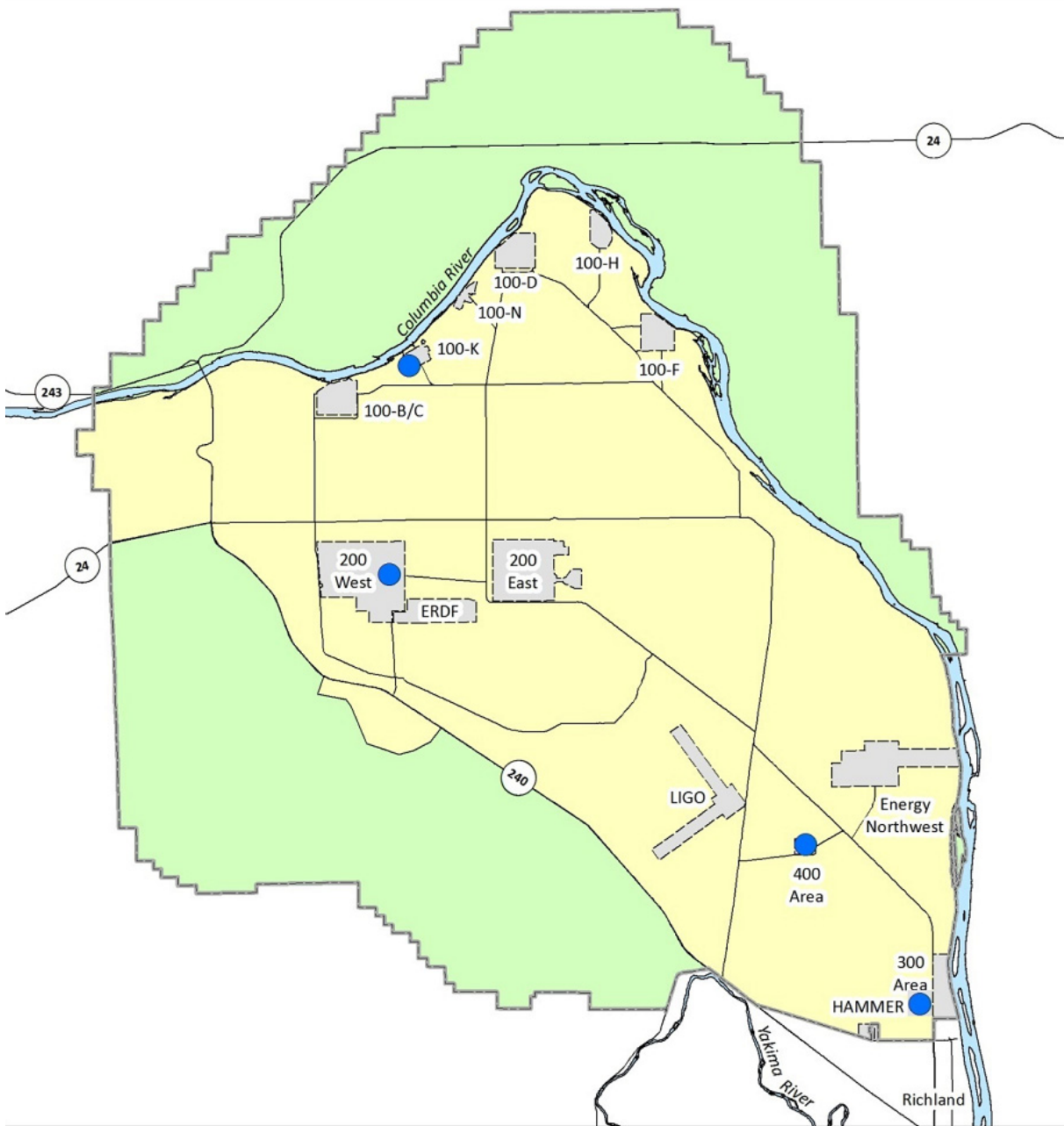
Table 7.1. Drinking Water Systems

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

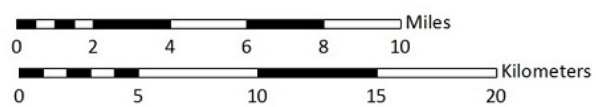
7.1.1 Drinking Water Treatment Facilities

Source water was treated at four DOE-owned water treatment facilities in the 100-K, 200 West, 300 and 400 Areas (Figure 7.1). All facilities treated the water with a form of chlorine to ensure adequate disinfection prior to distribution. The source of supply water for the 100-K Area and 200 West Area facilities was the Columbia River (Table 7.1). The 100-K Area water treatment plant (189-K) employed membrane filtration, a pressure driven process, and coagulation to remove particulate matter and microbial pathogens from the water. The 200 West water treatment plant (283-W) utilized conventional filtration treatment, which is a series of processes including coagulation, flocculation, sedimentation, and filtration that together achieved substantial particulate removal. The city of Richland supplied water to the 300 Area booster pumping station (385) where sodium hypochlorite was added as necessary prior to distribution to 300 Area consumers. 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 2013. Emergency backup wells 499-S0-8 (P-14) and 499-S0-7 (P-15) did not supply water to 400 Area consumers during the reporting period.

Figure 7.1. Drinking Water Treatment Facilities

**Legend**

- Drinking Water Treatment Facility
- DOE Managed Lands
- USFWS Managed Lands
- Hanford Site Boundary
- Open Water



7.1.2 Monitoring

Samples at 100-K, 200 West, and 400 Area 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 <https://www.ci.richland.wa.us/documentcenter/view/7671>.

7.1.3 Radiological Results

PNNL staff conducted radiological monitoring of drinking water at one DOE-owned pump and three water treatment facilities. MSA, the site water-compliance organization, conducted routine chemical, physical, and microbiological monitoring of Hanford Site 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 WDOH. 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 2013. Contaminant concentrations measured during the year were similar to those observed in recent years as described in Hanford Site environmental reports for 2011 ([DOE/RL-2011-119](#)), and for 2012 ([DOE/RL-2013-18](#)).

Drinking water samples collected for radiological analysis in 2013 were analyzed for gross alpha, gross beta, tritium, and strontium-90 and summarized in 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 mrem (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 mrem (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 mrem (0.04 millisievert).

Annual average concentrations of all monitored radionuclides in Hanford Site drinking water in 2013 were below state and federal maximum allowable contaminant levels (Table 7.2). 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 minimum detectable concentration (i.e., concentrations were too low to

measure). The 400 Area source of drinking water for 2013 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. Drinking Water Annual Average Concentrations of Selected Radiological Constituents

Constituent	Systems	Samples Analyzed at Each Location	Annual Average ^a (pCi/L) ^b	Standard
Gross alpha ^c	100-K Area	4 ^d	-0.050 ± 1.132	15 ^{e, f}
	200 West Area	4 ^d	0.212 ± 0.872	
	400 Area	4 ^d	1.003 ± 2.018	
Gross beta ^c	100-K Area	4 ^d	1.19 ± 3.770	50 ^f
	200 West Area	4 ^d	1.110 ± 4.858	
	400 Area	4	6.818 ± 3.161	
Tritium ^g	100-K Area	1 ^d	64 ± 298	20,000 ^f
	200 West Area	1 ^d	99 ± 300	
	400 Area	4	1353 ± 343	
Strontium-90 ^g	100-K Area	1 ^d	0.016 ± 0.98	8 ^{e, f}
	200 West Area	1 ^d	1.18 ± 1.13	
	400 Area	1 ^d	0.306 ± 0.957	

^a Annual average is ± 2 times the standard deviation, unless only one sample analyzed in which case it is the single result ± total propagated analytical error.

^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 are below the minimum detectable concentration.

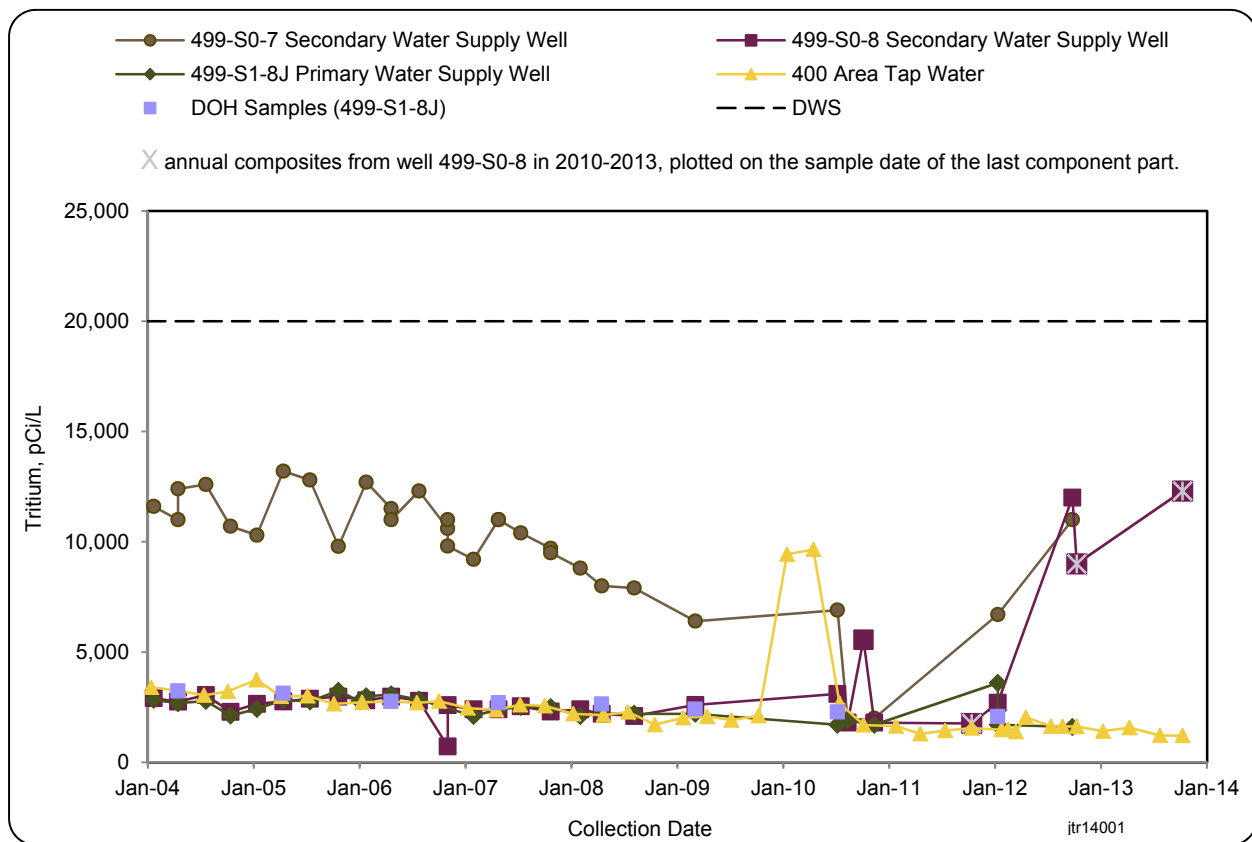
^e WAC 246-290.

^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.

A tritium plume originating in the 200 East Area and extending under the 400 Area historically has affected tritium concentrations in all of the 400 Area drinking water wells (Figure 7.2). In 2013, raw (untreated) water samples from the 400 Area drinking water backup well 499-S0-8 (P-14) was collected. Samples were collected quarterly, composited for a single annual tritium analysis (12300 ± 2350 pCi/L), and fell below the 20,000-pCi/L (740-Bq/L) state and federal annual average DWS. In previous years, the CHPRC Soil and Groundwater Remediation Project personnel collected and analyzed raw (untreated) water samples from the primary 400 Area drinking water well 499-S1-8J (P-16) and the two backup wells 499-S0-8 (P-14) and 499-S0-7 (P-15); however, in 2013 CHPRC did not collect and analyze raw (untreated) water samples from the 400 Area drinking water wells.

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

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Samples of surface water and sediment on and near the Hanford Site were collected and analyzed to determine the concentrations of radiological, inorganic, and organic compounds in the aquatic environment that may be attributed to the Hanford Site. Surface-water bodies monitored included the Columbia River, Hanford Site ponds, and offsite irrigation sources (Figure 7.3). Aquatic sediment monitoring was conducted for the Columbia River and one Hanford Site pond. Tables 7.3 and 7.4 summarize the sampling locations, types, and frequencies, as well as sample analyses included in surface-water and sediment monitoring during 2013. 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 Hanford Site 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. 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 unimpeded. 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 2013. The annual average flow of the Columbia River downstream of Priest Rapids Dam in 2013 was approximately 124,944 cubic feet (3,538 cubic meters) per second which was slightly above the 10-year average annual flow rate of 115,831 cubic feet (3,280 cubic meters) per second (U.S. Geological Survey [[USGS](#)] 2013b, *USGS Water-Data Report for 2013, 12472800 Columbia River Below Priest Rapids Dam, WA*). The Columbia River had above normal flows in 2013; the average daily flow rate downstream of Priest Rapids Dam was 125,035 cubic feet (3,541 cubic meters) per second. The highest monthly average flow rate occurred during May (195,504 cubic feet [5,536 cubic meters] per second) (Figure 7.4). The lowest monthly average flow rate occurred during October (75,574 cubic feet [2,140 cubic meters] per second), based on mean daily flows. Daily average flow rates varied from 48,316 to 243,789 cubic feet (1,368 to 6,903 cubic meters) per second in 2013. 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

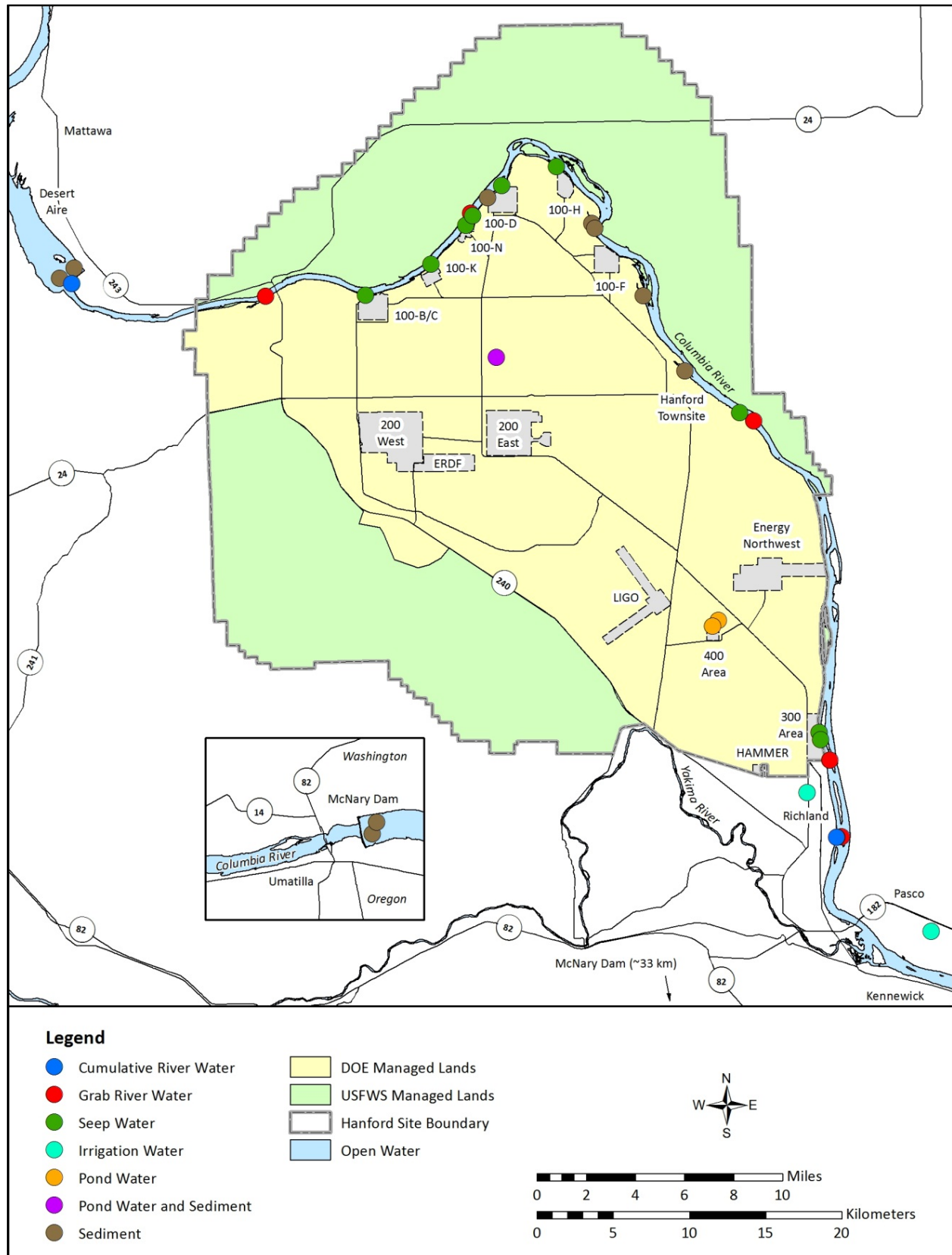


Table 7.3. Surface-Water Surveillance

Location	Sample Type	Frequency	Analyses
Columbia River – Radiological			
Priest Rapids Dam, and Richland Pump House	Cumulative	Monthly Composite ^a	Alpha ^b , beta ^b , low tritium ^c , strontium-90, technetium-99, uranium-234, -235, -238
	Particulate (filter)	Monthly	Gamma energy analysis
		Quarterly	Plutonium-238,-239/240
	Soluble (resin)	Continuous ^d	Gamma energy analysis
		Quarterly	Plutonium-238,-239/240
Vernita Bridge	Grab (transects)	Annually	Low tritium ^c , strontium-90, plutonium-238,-239/240, uranium-234, -235, -238, technetium-99
Richland	Grab (transects)	Annually	Low tritium ^c , strontium-90, plutonium-238,-239/240, uranium-234, -235, -238, technetium-99
100-N Area, 300 Area, and Hanford townsite	Grab (transects)	Annually	Low tritium ^c , strontium-90, plutonium-238,-239/240, uranium-234, -235, -238, technetium-99
Columbia River – Inorganic and Organic Chemical			
Vernita Bridge	Grab (transects)	Annually	Metals (filtered and unfiltered), anions, mercury Volatile organic compounds
Richland	Grab (transects)	Annually	Metals (filtered and unfiltered), anions, mercury Volatile organic compounds
Hanford Site Ponds			
FFTF Pond	Grab	Quarterly	Alpha, beta, tritium, gamma energy analysis
West Lake Seep	Grab	Annually ^f	Tritium, uranium-234, -235, -238
West Lake Water	Grab	Annually ^g	Tritium, uranium-234, -235, -238
Offsite Irrigation Water			
Riverview Irrigation Canal	Grab	3/year	Alpha, beta, low- tritium ^c , strontium-90, gamma energy analysis
Horn Rapids	Grab	3/year	Alpha, beta, low- tritium ^c , strontium-90, gamma energy analysis

^a Monthly Composite indicates river water was collected at set intervals and composited monthly for analysis.

^b Gross alpha and gross beta were sampled in January 2013 only.

^c Low tritium = Low-level tritium analysis (10-pCi/L detection limit).

^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.

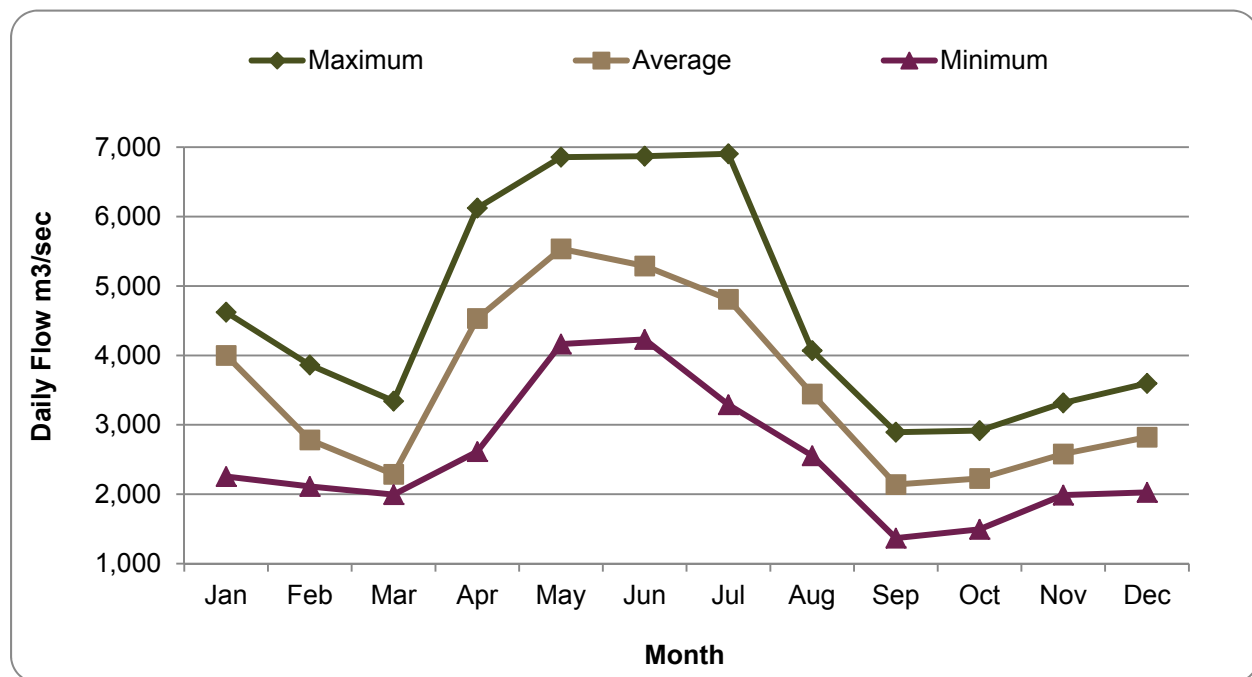
^e Quarterly Continuous = River water was sampled for 2 weeks by continuous flow through a filter and resin column, and multiple samples were composited quarterly for analysis.

^f West Lake standing water sampled during first quarter.

^g West Lake seep water collected during second quarter.

Table 7.4. Columbia River Sediment Surveillance

Location ^a	Frequency	Analyses
Hanford Reach ^b	Annually	Anions, chromium ⁺⁶ , gamma energy analysis, plutonium-238,-239/240, uranium-234, -235, -238, metals, mercury, total organic carbon, and strontium-90
Hanford Reach Contiguous Islands (Locke and Savage)	Annually	Anions, chromium ⁺⁶ , gamma energy analysis, plutonium-238,-239/240, uranium-234, -235, -238, metals, mercury, total organic carbon, and strontium-90
McNary Dam (2 locations near dam)	Annually	Anions, chromium ⁺⁶ , gamma energy analysis, plutonium-238,-239/240, uranium-234, -235, -238, metals, mercury, total organic carbon, and strontium-90
Priest Rapids Dam (2 locations near dam)	Annually	Anions, chromium ⁺⁶ , gamma energy analysis, plutonium-238,-239/240, uranium-234, -235, -238, metals, mercury, total organic carbon, and strontium-90

^a Refer to Figure 7.3.^b Hanford Reach consists of sediment collected at the 100-F Slough, Hanford Slough, and White Bluffs Slough.Figure 7.4. Columbia River Flow Rates at Priest Rapids Dam
(multiply m^3/sec by 35.31 to obtain ft^3/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 2013 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 radionuclides, inorganic and organic compounds (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 14 days. The samplers collect water at set intervals of time (e.g., 1 hour) and set incremental volumes (e.g., 55 mL). These bi-weekly samples were combined into monthly and quarterly composite samples for radiological analyses (Table 7.3). 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 analyses based on the following criteria:

- Their presence in historical effluent discharges from Hanford Site facilities or in groundwater underlying the Hanford Site near the Columbia River.
- 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. One gross alpha and gross beta measurement was made as an indicator of the general radiological quality of the river and provided a base mean to compare with historical levels. 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 because of findings of a special study conducted in the late 1980s. 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.

The transect sampling strategy has been modified numerous times since its inception. Some mid-river sampling points have been shifted to near-shore locations near original transect. More recently, sampling efforts have also changed with decreasing concentrations of contaminants that may have been associated with past Hanford Site practices.

Overall, these changes in the sampling approach allowed cross-river concentration profiles to be determined and provide information over a larger portion of the Hanford Site shoreline where the highest contaminant concentrations of concern would be expected.

In 2013, four to six evenly spaced cross-river transect samples were obtained. Of those collected, two were taken at near-shore locations (typically less than 16 feet [5 meters] from shore). The city of Richland transects and near-shore locations were sampled annually during 2013. The Vernita Bridge transects and near-shore locations were sampled annually during 2013. Annual transect and near-shore sampling were conducted at the 100-N Area, Hanford townsite, 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 transects water samples collected during 2013 were analyzed for radiological, inorganic, and organic contaminants (Table 7.3). Specific metals and anions were selected for analyses 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*). 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 2013 and for the previous 5 years are summarized in Appendix C, Table C.6. All individual radiological contaminant concentrations measured in Columbia River water during 2013 were less than 1/25 of the DOE-derived concentration guides (Appendix D). The DOE-derived concentration guides are based on a 100-mrem (1-milliseivert) per year standard; dividing by 25 allows for more direct comparison to the 4-mrem (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 2013. Tritium, uranium-234, and uranium-238 were consistently measured in river water at levels greater than their reported minimum detectable concentrations. Uranium-235 was 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 2013 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 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 2013 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 2013 annual average tritium concentrations measured upstream and downstream of the Hanford Site were similar to concentrations measured in recent years (Figure 7.7). 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. Average tritium concentrations in Columbia River water collected at the city of Richland were 0.17 percent of the Washington State ambient surface-water quality criterion of 20,000 Ci/L (740 Bq/L). The Hanford Site source of tritium entering the river is groundwater upwellings and shoreline 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 townsite downstream to the 300 Area. The plume is not completely mixed within the Columbia River at the city of Richland due to close proximity to the city of Richland water intake structure itself. Sampling along cross-river transects at the city of Richland during 2013 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)

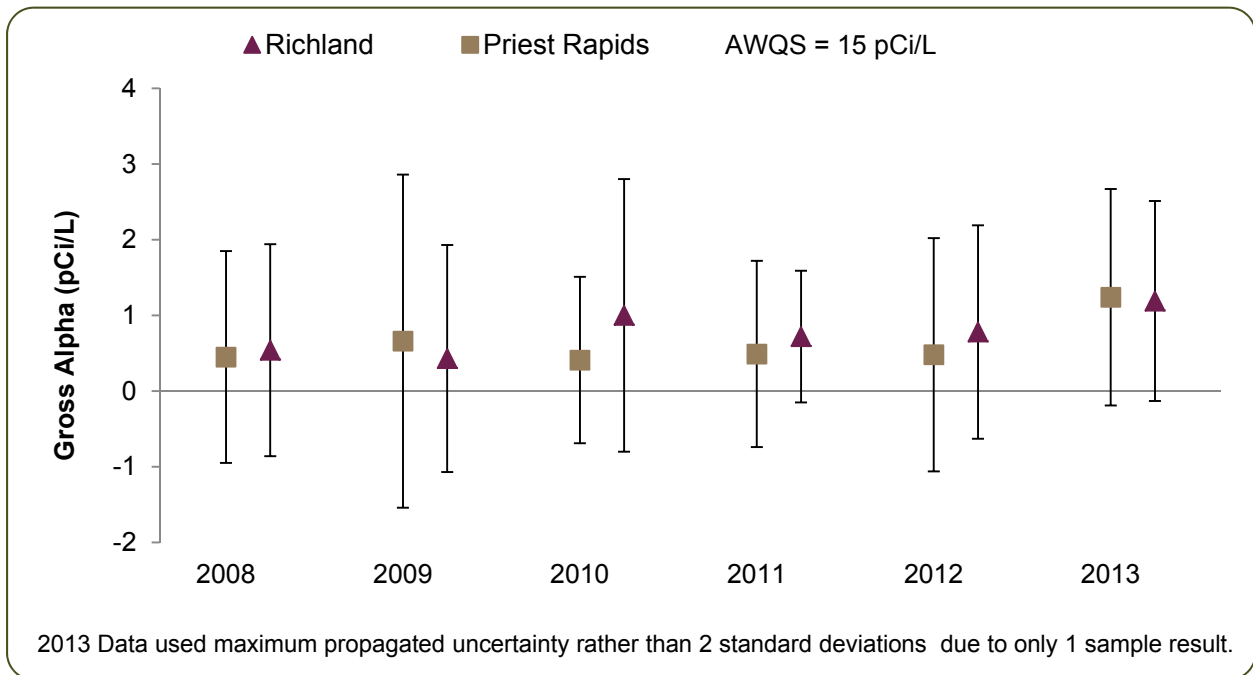


Figure 7.6. Gross Beta Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
(± 2 standard deviations, AWQS = ambient water quality standard)

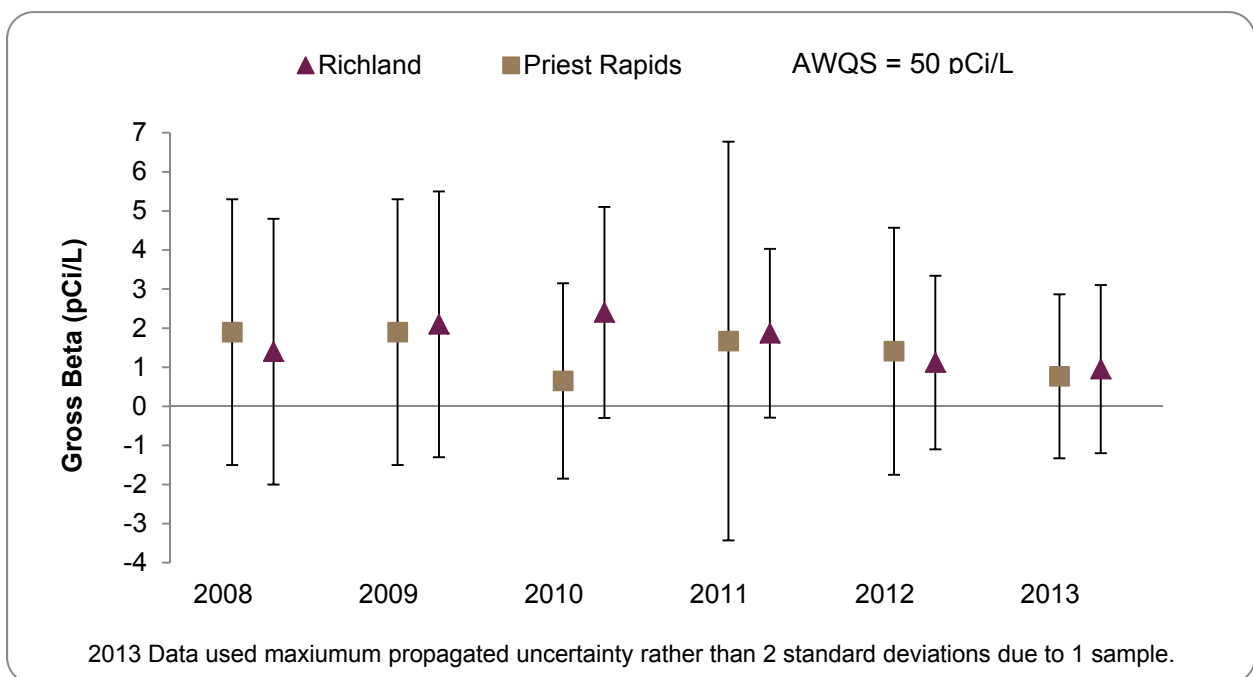
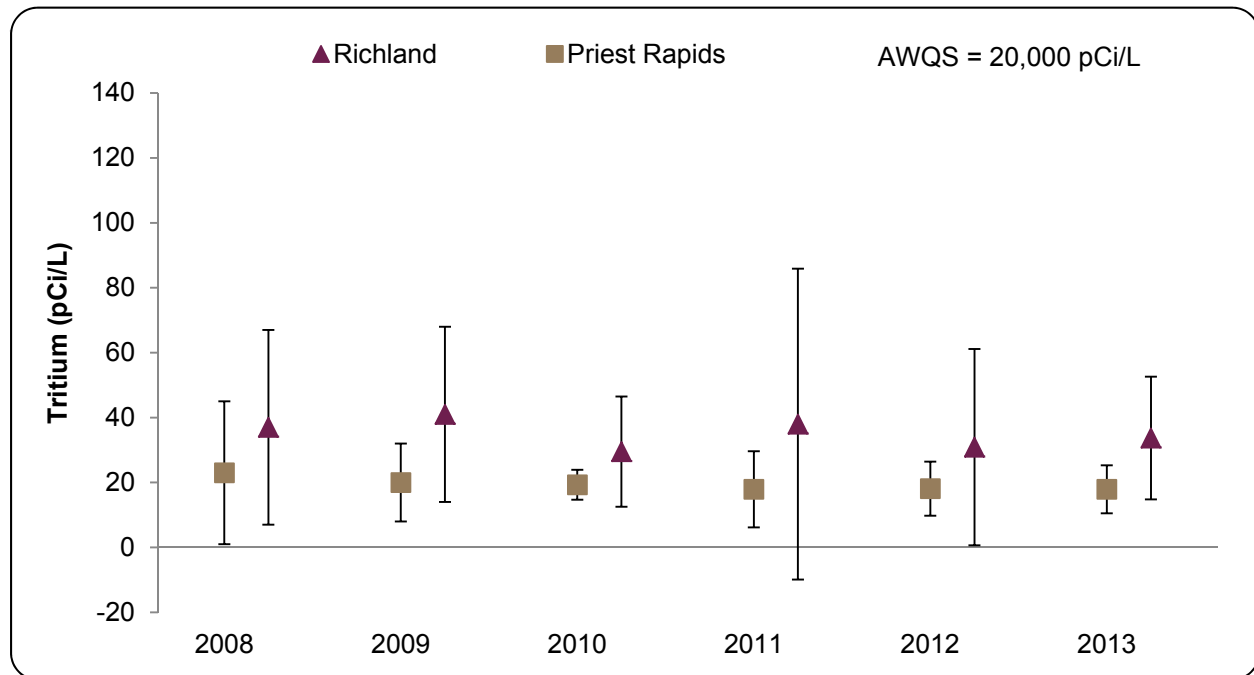


Figure 7.7. Tritium Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
(± 2 standard deviations, AWQS = ambient water quality standard)



Average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2013 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 Hanford Site groundwater are the result of past discharges to the 100-N Area liquid waste disposal facilities. Although strontium-90 concentrations at Priest Rapids Dam and the city of Richland were under minimum detection limits (0.06 pCi/L), they were statistically compared, as it has not been done in recent years due to low levels. Both had maximum concentrations of 0.05 pCi/L (0.0019 Bq/L), respectively. Average strontium-90 concentrations in Columbia River water at the city of Richland were less than 0.23 percent of the Washington State ambient surface-water quality criterion (8 pCi/L [0.30 Bq/L]) while those at Priest Rapids measured 0.35 percent on average.

Annual average uranium-234 and uranium-238 concentrations measured in water samples collected upstream and downstream of the Hanford Site in 2013 were similar to those observed during recent years (Figure 7.9). Monthly uranium concentrations measured at the city of Richland in 2013 were slightly 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*). 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 use 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 2013 were well below the EPA DWS of 30 $\mu\text{g/L}$ (approximately 20 pCi/L [0.74 Bq/L], Appendix D).

Plutonium-238 and plutonium-239/240 concentrations for river water samples at the city of Richland in 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 upstream and downstream concentrations were less than the reported minimum detectable concentrations.

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 townsite, 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. Uranium-235 was detected occasionally, and most levels 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 townsite, 300 Area, and the city of Richland during 2013 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 townsite, 300 Area, and the city of Richland transects have higher tritium concentrations near the Hanford Site shore (Benton County) when comparing levels to the opposite shoreline. 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 merged within the river water at the city of Richland. The gradient is most pronounced during periods of relatively low river flow. Historically, 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., highest estimate) of the fixed-location monitoring station. This also was true with samples collected in 2013 as the Richland transect results had a maximum of 23.2 ± 8.36 pCi/L (0.86 ± 0.31 Bq/L) and the fixed monitoring station had a maximum result of 48.4 ± 14.4 pCi/L (1.79 ± 0.53 Bq/L). The highest tritium concentration measured in cross-river transect water was 100 ± 27 pCi/L (3.7 ± 1.0 Bq/L) at the Hanford townsite. Slightly elevated conductivity results for the 2013 transect water samples collected at the 100-N Area and 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 2013 were similar to reference concentrations for most locations. The maximum strontium-90 concentration was 0.056 ± 0.04 pCi/L (0.0021 ± 0.0015 Bq/L) for a water sample collected along the Hanford townsite transect. The average strontium-90 concentrations found during transect sampling at the city of Richland were similar to those measured in monthly composite samples at the Richland Pump house and at Priest Rapids Dam.

The total uranium concentrations in all transect samples collected during 2013 were below the EPA DWS of 30 μ g/L (approximately 20 pCi/L [0.74 Bq/L]). Uranium isotopes were monitored in transect water samples collected in 2013 from just upstream of Vernita Bridge, 100-N Area, Hanford townsite, 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 were higher than the 300 Area–1 HRM 43.1 concentrations and are associated with its presence in groundwater as 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 7.8. Strontium-90 Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
(± 2 standard deviations, AWQS = ambient water quality standard)

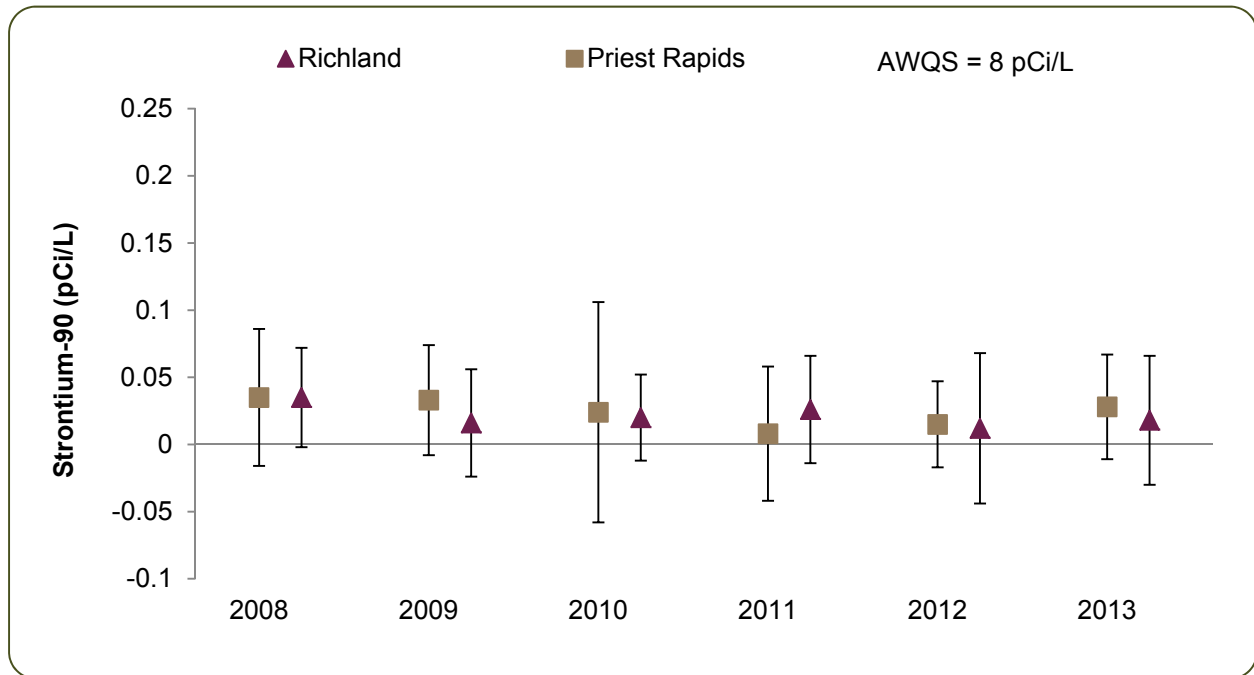


Figure 7.9. Uranium Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
(± 2 standard deviations)

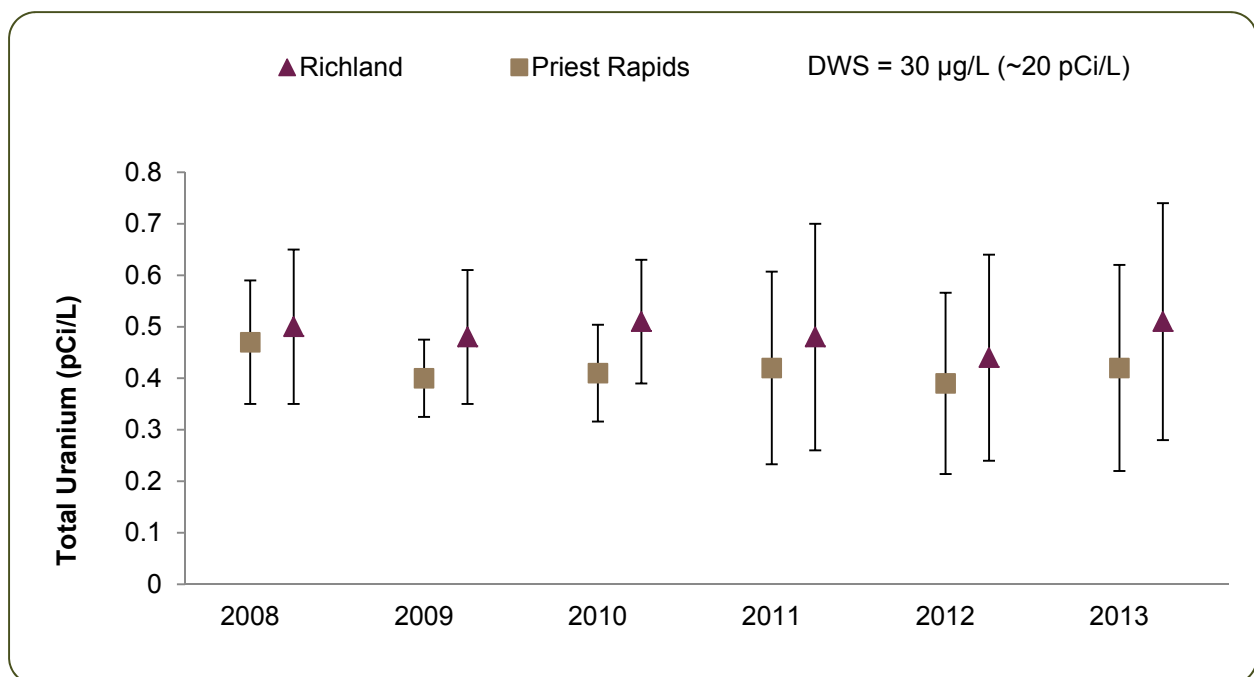
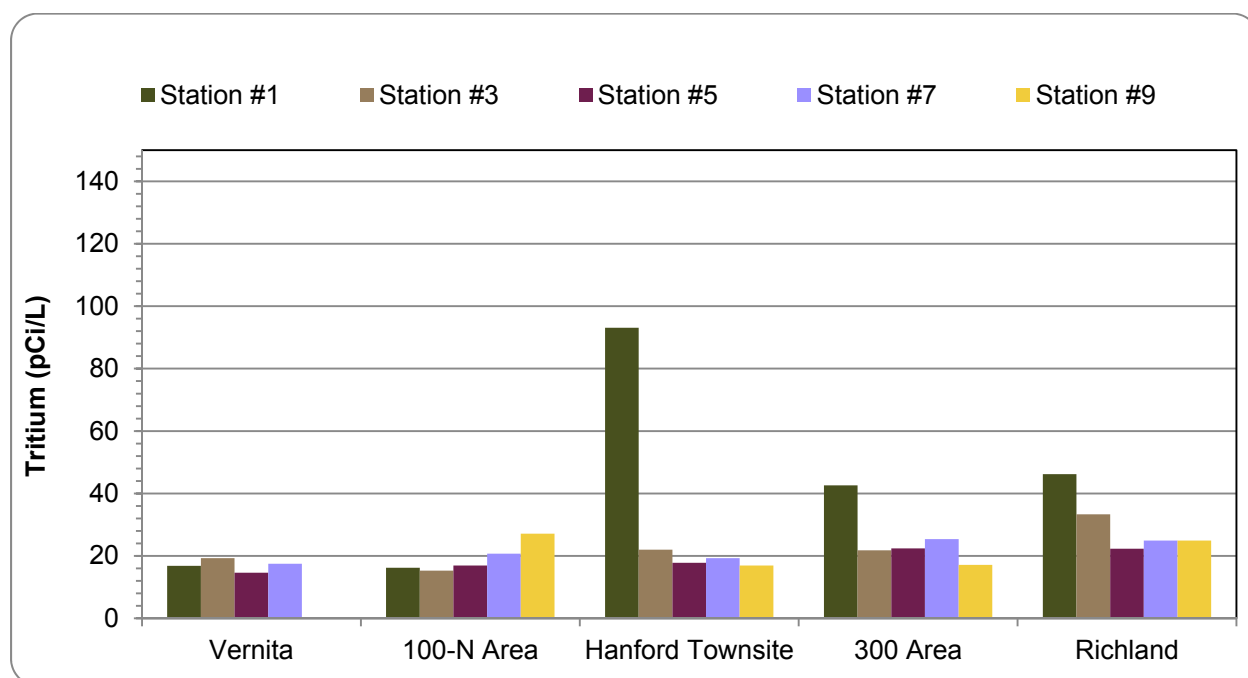


Figure 7.10. Tritium Concentrations in Cross-River Transect Water Samples
(Hanford Reach, Columbia River)

Washington State ambient water quality standard for tritium is 20,000 pCi/L (740 Bq/L)



7.2.3 Inorganic and Organic Chemical Results

Inorganic and organic water quality data was compiled in 2013 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 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 just upstream from the Vernita Bridge, 100-N Area, and 300 Area. Arsenic also was detected in several samples collected just upstream from the Vernita Bridge, and the 100-N Area. Antimony, beryllium, cadmium, chromium, lead, selenium, silver, and thallium were not detected in any Columbia River transect water samples. All dissolved metal 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).

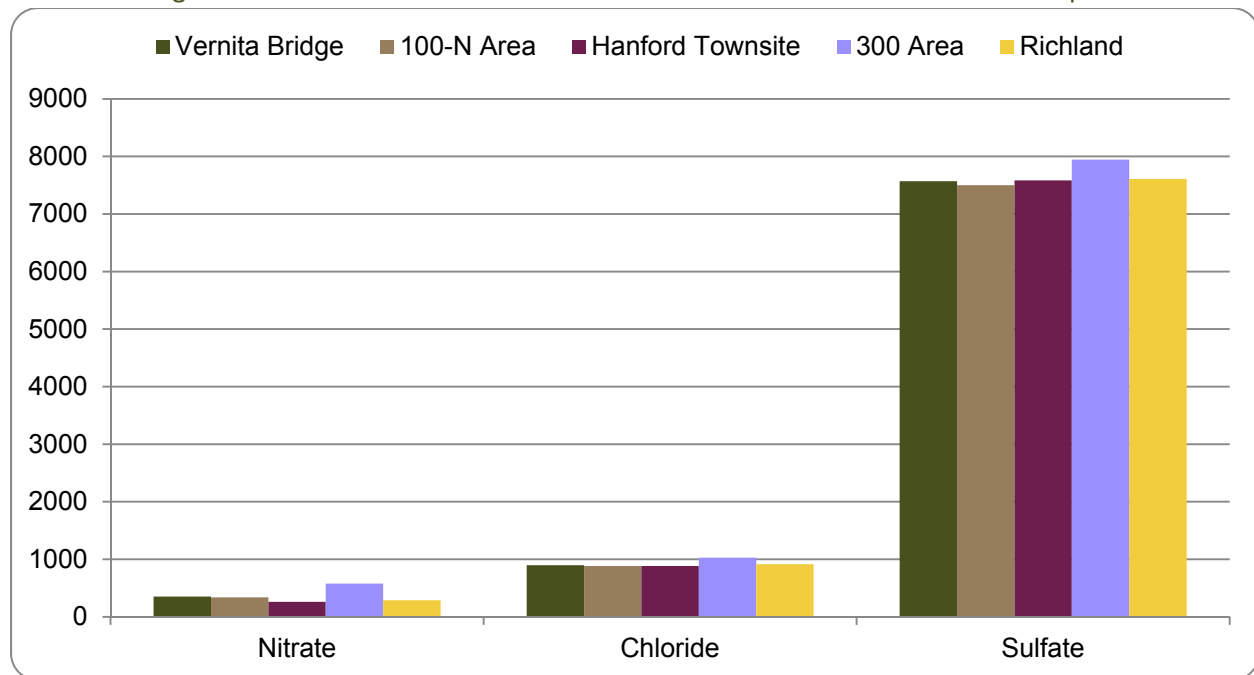
Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent ([WAC 173-201A](#)). Increased water hardness (i.e., primarily higher concentrations of calcium and magnesium ions) can reduce the toxicity of some metals by limiting 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 USGS monitoring of Columbia River water near Vernita Bridge and the city of Richland in recent years.

For samples collected on the cross-river transects, there were no reportable detections of nitrites. Concentrations of nitrate, chloride, and sulfate were slightly elevated near the 300 Area in comparison to other transect locations (see Figure 7.11). In many cases, the highest anion concentrations were found in samples collected along the Grant-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 USGS, 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](#); [USGS Circular 1144, Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992-95](#)). Average annual concentrations of chloride, nitrate, and sulfate were mirrored at the city of Richland transect when compared with Vernita Bridge transect results. The highest concentrations of nitrates were measured at the 300 Area transect.

Additional anion analysis of fluoride in Columbia River transect collections resulted in reportable concentrations ($>33 \mu\text{g/L}$) of fluoride in all samples; however, these results were less than required detection limits ($500 \mu\text{g/L}$) per DOE guidelines. When compared to concentrations from 2008-2012, the overall average has dropped from $122 \mu\text{g/L}$ to $82 \mu\text{g/L}$ in transect samples.

Concentrations of chromium (reported 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 2013 had chromium concentrations below the minimum detectable concentration.

Figure 7.11. Selected Anion Concentrations in Columbia River Transect Samples



7.3 Columbia River Sediment

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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 operations of upriver hydroelectric dams, annual spring high river flows, and occasional floods have resulted in re-suspension, 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 re-suspension 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.

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, from the Hanford and White Bluffs Slough on the Hanford Reach, and downstream of the site in the reservoir pool located above McNary Dam.

7.3.1 Monitoring

Samples of the surface layer of Columbia River sediment were collected in 2013 at depths of 0 to 6.3 inches (0 to 16 centimeters) from 10 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 using a clamshell style sediment dredge sampler (petite ponar), capturing several years of integrated deposits, including various sediment grains. 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 (*An Investigation of the Origin of ^{152}Eu in Columbia River Sediments*, [Gibbons 2000](#)). Assuming a maximum sediment sampling depth of 6.3 inches (16 centimeters) with the petite ponar dredge, the samples may 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. Sediment samples also were collected at 100-D Spring 102-1, 100-F Slough, Hanford Slough, White Bluffs Slough, and locations adjacent to Locke and Savage Islands located 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 the 100-D Spring (seep) 102-1 location and an additional from the 100-F Slough. The White Bluffs Slough monitoring site consisted of two sampling locations; however, only one sampling location was sampled successfully in 2013 due to rock and debris inclusions in the collection process. One sample was collected at a location in Hanford Slough and two additional samples from locations adjacent to islands. Samples were collected using a clamshell style sediment dredge; this sampling method is discussed in *Environmental Surveillance Sampling* (Process to Significantly Reduce Pathogens [PSRP]-DI-001). 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 2013 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-234 concentrations were slightly elevated at the Hanford Slough, McNary Dam, and White Bluffs Slough in 2013 as compared to values measured in 2008 through 2012. In 2013, 100-F Slough sediment also had slightly elevated results for uranium-234, uranium-235, and uranium-238 when compared to the previous 5 years of data. Other radionuclide concentrations reported in river sediment were similar to those reported for previous years and there were no obvious differences between locations.

The values for cesium-137 at the White Bluffs Slough were slightly elevated compared to Priest Rapids Dam, and were lower than elevated values measured in 2008 through 2012. Previous studies of sediment 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 (2008 through 2013) are presented in Figures 7.12, 7.13, and 7.14.

7.3.3 Inorganic and Organic 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. Lead concentrations were detected at higher rates in Priest Rapids sediment as well. This is likely due to natural erosion through the weathering of rocks when lead is released to surrounding soils and aquatic systems and made available to biota within those ecosystems. 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.)

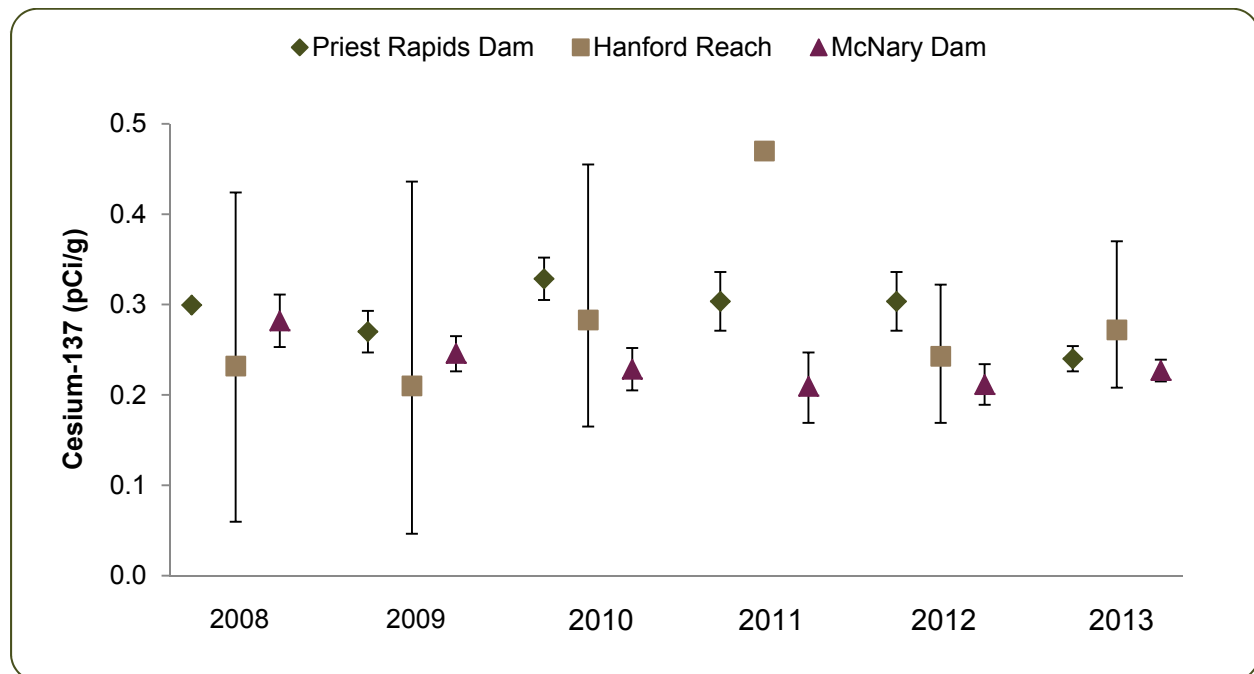


Figure 7.13. Plutonium 239/240 Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

(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.)

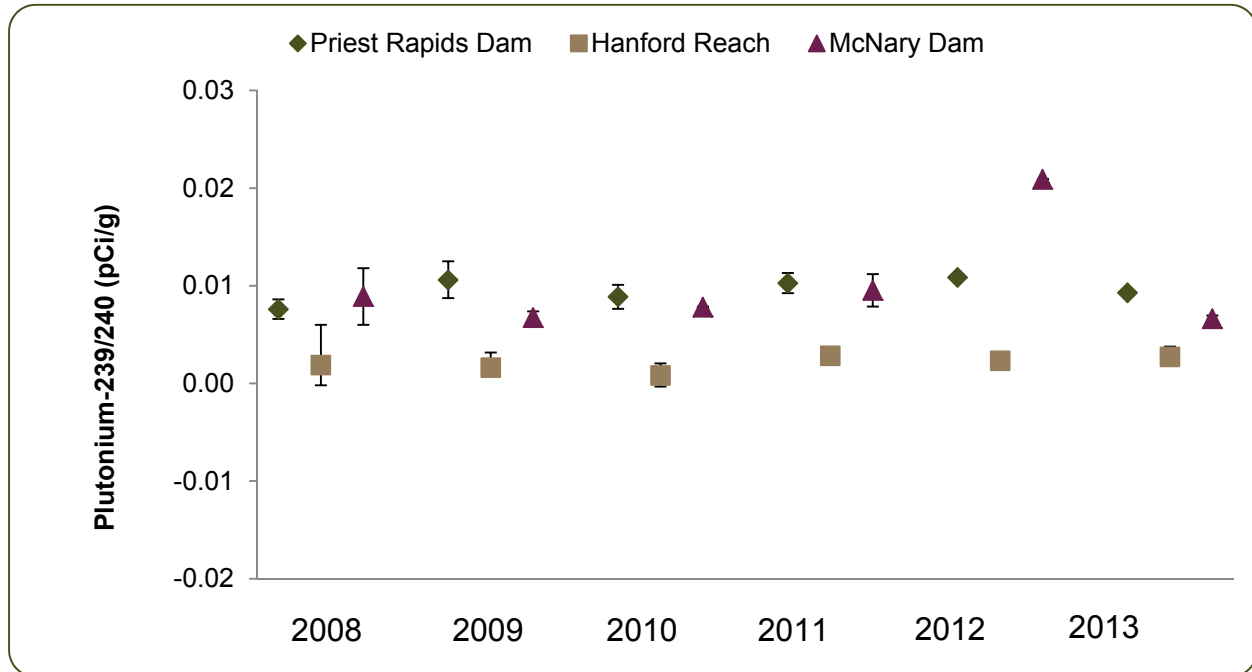


Figure 7.14. Uranium Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

(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.)

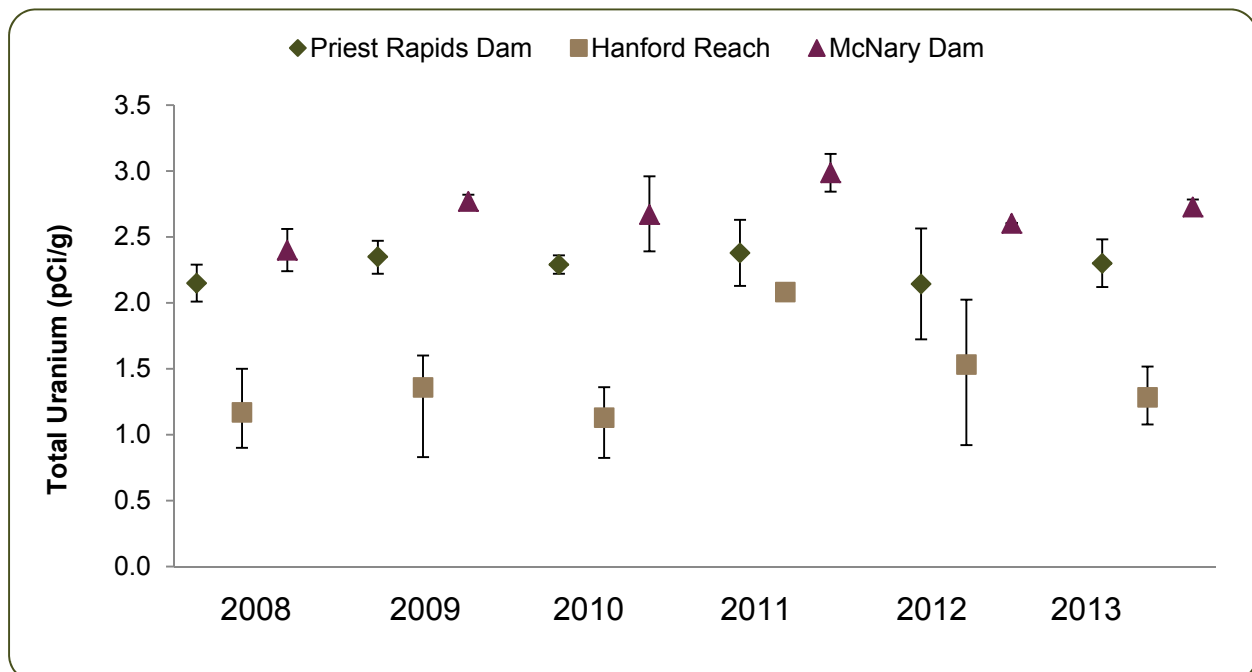
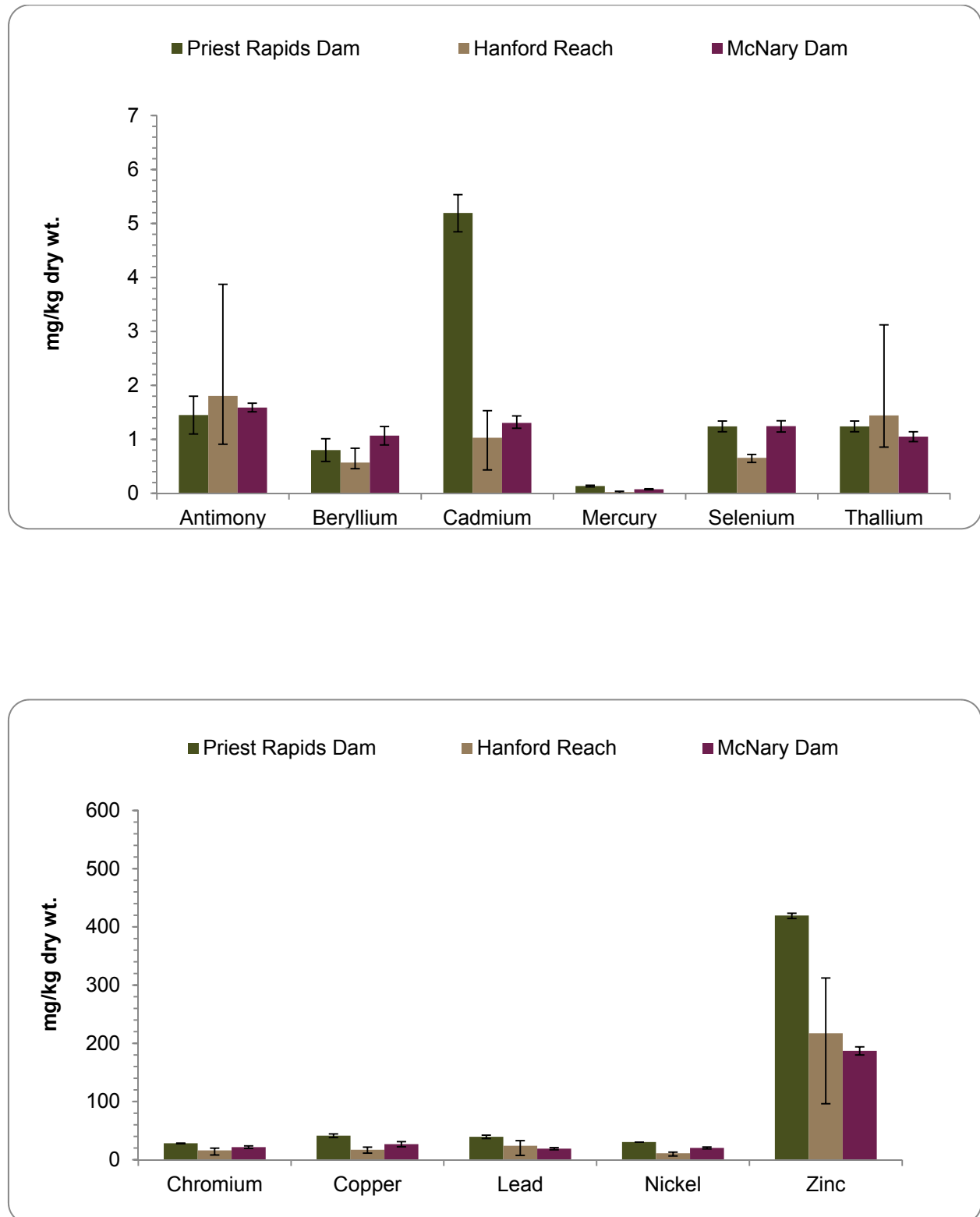


Figure 7.15. Selected Metals Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (Washington and Oregon)

(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 Seep Water

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Samples of Columbia River 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, inorganic, and organic 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

Columbia River 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*).

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 (via leaching) 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 through surface and subsurface discharge. Discharge zones, located above the water level of the river, are identified in this report as Columbia River seeps. Routine monitoring of riverbank seeps offers the opportunity to characterize the quality of groundwater being discharged to the river and to assess the potential human and ecological risk associated with the 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 Strontium-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*).

During the early 1980s, researchers walked a 41-mile (66-kilometer) stretch of the Benton County shoreline of the Hanford Reach and identified 115 seeps ([PNL-5289](#)). These researchers reported that the predominant areas of riverbank seeps at that time were in the vicinity of the 100-N Area, Hanford townsite, and the 300 Area.

In recent years, it has become increasingly difficult to locate riverbank seeps in the 100-N Area and other locations along the Hanford Reach. Declining water table elevations, a consequence of the end of N Reactor operations and other ongoing site remediation, have reduced discharges from the seeps in and around the 100-N Area. The presence of Columbia River seeps also vary 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 levels fluctuate, groundwater levels change, which cause the presence of seeps in the Hanford Reach to vary. At the 300 Area, the river stage is also influenced by the elevation of the McNary Dam pool.

Columbia River water moves into the Hanford Site aquifer as the river stage rises (bank storage) and then discharges from the aquifer in the form of 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, seeps are most readily identified immediately following a decline in river stage.

Bank storage of river water affects the contaminant concentration of the seeps. Columbia River 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 a seep water discharge increases over time following a drop in the river stage. Measuring conductivity of the seep water discharge provides an indicator of the extent of bank storage. Hanford Site groundwater has higher conductivity readings than Columbia River water. The conductivity of river water typically ranges between approximately 130 and 150 micro-Siemens per centimeter ($\mu\text{S}/\text{cm}$).

The effect of bank storage on groundwater discharges and contaminant concentration variations in aquifer thickness, porosity, and plume concentrations make it difficult to accurately estimate the proportion of contaminated groundwater discharging via seeps 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 seeps had localized effects on Columbia River contaminant concentrations only. Beginning in 2011, river-stage specified local quality control guidelines were administered for the PSRP seep monitoring efforts following the process and findings described in [WCH-380](#). These guidelines help precision and accuracy of the PSRP seep monitoring efforts by reducing variability across space and time associated with fluctuating river stages and the influence of bank storage.

7.4.2 Monitoring Results

Routine monitoring of selected Columbia River seeps was initiated in 1988. Currently, seep water samples are collected for contaminant monitoring and to support groundwater operable unit investigations ([DOE/RL-91-50](#)). Table 7.5 summarizes the sampling locations and frequencies, as well as sample types and analyses included in Columbia River seep monitoring during 2013. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Analytes of interest for samples from seeps were selected based on the 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 late summer to early fall to help minimize the effect of bank storage.

All samples collected 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 7.5).

Table 7.5. Columbia River Seep Water Monitoring

Location ^a	Sample Type	Sampling Frequency	Analyses
100-B Area	Grab	Annually	Anions, metals (filtered and unfiltered), strontium-90, tritium
100-D Area	Grab	Annually	Alpha, anions, beta, metals (filtered and unfiltered), strontium-90, technitium-99, uranium-234, -235, -238
100-F Area	Grab	Annually	Anions, metals (filtered and unfiltered), strontium-90, tritium
100-H Area	Grab	Annually	Alpha, anions, beta, metals (filtered and unfiltered), strontium-90, technitium-99, tritium
100-K Area	Grab	Annually	Alpha, anions, beta, carbon-14, metals (filtered and unfiltered), strontium-90, technitium-99, tritium, VOA
100-N Area	Grab	Annually	Alpha, anions, beta, metals (filtered and unfiltered), strontium-90, TPH, tritium
300 Area	Grab	Annually	Alpha, anions, beta, tritium, uranium-234, -235, -238, VOA
Hanford Townsite	Grab	Annually	Alpha, anions, beta, iodine-129, tritium

^a Refer to Figure 7.3.

TPH = Total petroleum hydrocarbons

VOA = Volatile organic analyses

7.4.2.1 Radiological Results

Contaminants of Hanford Site origin continued to be detected in 2013 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.

Carbon-14 levels measured in a 100-K Area riverbank seep were elevated in comparison to those measured in 2012 and was supported by higher conductivity readings in initial measurements recorded and throughout the sample collection process (averaged approximately 190 $\mu\text{S}/\text{cm}$ in 2012 and approximately 323 $\mu\text{S}/\text{cm}$ in 2013). As a result, conditions will continue to be monitored throughout the 2014 calendar year.

Gross alpha results for the 300 Area DR 42-2 riverbank seep had a detection (101 ± 8.2 pCi/L) that exceeded both DOE-derived standards (30 pCi/L) and the Washington State ambient water quality criteria (15 pCi/L) ([DOE O 458.1](#)).

Gross beta concentrations in all riverbank seep water at locations were elevated compared to maximum gross beta concentrations in Columbia River water at Priest Rapids Dam and the city of Richland fixed-station locations, but were below the Washington State ambient water quality criterion. The highest gross beta concentration was measured in the 300 Area DR 42-2 riverbank seep (42 ± 3.7 pCi/L [1.6 ± 0.14 Bq/L]), which was 84 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 townsite ($22,100 \pm 4,300$ pCi/L [818 ± 159 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 results at the Hanford townsite did not exceed DOE-derived standards for riparian life (265,000,000 pCi/L respectively). Tritium concentrations in most riverbank seep water samples were equivalent when compared to maximum concentrations in 2013 Columbia River fixed-station locations at Priest Rapids Dam and the city of Richland.

All water samples from riverbank seeps were analyzed for strontium-90. The highest strontium-90 concentration detected in shoreline spring water was in the 100-N Area (44 ± 0.43 pCi/L).

[1.6 ± 0.016 Bq/L]), which was approximately 4 percent of the DOE-derived concentration standards/guidelines ([DOE O 5400.5](#), *Radiation Protection of the Public and the Environment*) of 1,000 pCi/L (37 Bq/L). Historically, groundwater in the 100-N Area has had the highest strontium-90 levels and concentrations reported there during 2013 were within typical ranges for this area.

A water sample from a riverbank seep in the Hanford townsite area was collected in 2013 and submitted to a laboratory for iodine-129 analysis using an ultra-trace method. The concentration measured in the water sampled during 2013 from the Hanford townsite riverbank seep measured 0.067 ± 0.49 pCi/L which falls well below the Washington State surface water quality criterion of 1 pCi/L (0.037 Bq/L) (Appendix D) and DOE-biota concentration guide standards for aquatic and riparian life (1,000,000 pCi/L and 38,400 pCi/L). From 2007 to 2010, riverbank seep water samples were analyzed 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 DR 42-2 riverbank seep down gradient from the retired 300 Area Process Trenches. The total uranium concentration in this seep water sample was just over twice the EPA DWS limit of 30 μ g/L (approximately 20 pCi/L [0.74 Bq/L]). Maximum and average concentrations of uranium-234, uranium-235, and uranium-238 were slightly higher in 2013 than they were during 2008 to 2012. 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.

7.4.2.2 Inorganic and Organic Chemical Results

Inorganic and organic 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, was detected in the 300 Area DR 42-2 riverbank seep. Trichloroethene has been consistently detected at trace concentrations in 300 Area riverbank seep water, which is a result of contaminated groundwater in the shallowest part of the unconfined aquifer near the Columbia River.

Table 7.6 presents concentration ranges of selected metals and anions measured in riverbank seep water during 2008 through 2013. For most locations, the 2013 sample results were similar to those previously reported ([PNL-14687](#), *Hanford Site Environmental Report for Calendar Year 2003*). Nitrate concentrations for 2008 through 2013 were highest in seep water samples from the 100-F Area. Dissolved chromium concentrations in riverbank seeps for 2008 through 2013 were highest in the 100-K Area. Hanford Site groundwater monitoring results for 2013 indicated similar contaminant concentrations at shoreline areas near the discharge locations for the seeps (see Section 8, 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 USGS were used. Concentrations of most metals measured in water collected from seeps along the Hanford Site shoreline during 2008 through 2013, were below the Washington State ambient surface water chronic toxicity levels ([WAC 173-201A](#)). However, for 2008 through 2013, the maximum concentrations of dissolved chromium in riverbank seep water from the 100-B, 100-D, 100-F, 100-H, and 100-K Areas were above the Washington State ambient surface water chronic and acute toxicity levels ([WAC 173-201A](#)); concentrations from the 100-B Area were the only samples collected having results above the Washington State ambient surface water chronic toxicity levels. All other dissolved chromium results for 2013 were below the Washington State ambient surface water acute and 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 (0.01 mg/L) is 19,000 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.

7.4.3 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 townsite 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 was added. However, Hanford Site releases in these areas are best monitored using seep water samples as compared to sediment samples. As such, only one sediment sample was collected from a riverbank seep in the 100-D Area (100-D Spring 102-1) in 2013.

Table 7.6. Columbia River Seeps Concentration Ranges for Selected Metals and Anions in Water Monitoring Samples, Hanford Site

2008 – 2013 Analyte	Ambient-Water Quality Criterion	Sample Location							
	Level ^a	100-B Area	100-D Area	100-F Area	100-H Area	100-K Area	100-N Area	Hanford townsite	300 Area
Dissolved Metals (µG/L) ^e									
Antimony	NA	0.118 – 0.23	0.136 – 2.72	0.0988 – 0.128	0.188 – 0.392	0.0179 – 0.238	0.165 – 0.201	0.168 – 0.341	0.149 – 0.447
Arsenic	190	0.563 – 1.24	0.486 – 7.44	1.93 – 2.74	0.342 – 3.15	0.385 – 7.11	1.92 – 26.9	1.89 – 4.01	1.15 – 6.27
Cadmium	0.59	0.00396 – 0.109	0.0105 – 0.0191	0.0074 – 0.0275	0.00513 – 0.0375	0.00827 – 0.0254	0.009 – 0.0246	0.00726 – 0.0248	0.0129 – 0.0316
Chromium	10 ^b	3.97 – 14.9	1.51 – 35.4	5.88 – 15.5	3.08 – 33.7	0.787 – 63.4	4.0 – 8.26	0.524 – 2.42	0.47 – 3.3
Copper	6	0.203 – 1.57	0.344 – 1.46	0.23 – 0.583	0.396 – 1.47	0.332 – 1.25	0.244 – 1.61	0.404 – 0.701	0.309 – 0.678
Lead	1.1	0.174 – 1.41	0.00869 – 0.421	0.0508 – 0.224	0.118 – 0.179	0.118 – 0.361	0.0896 – 0.269	0.0762 – 0.217	0.0999 – 0.376
Nickel	83	0.342 – 2.1	0.295 – 3.82	0.118 – 2.61	0.231 – 2.66	0.244 – 2.61	0.934 – 2.75	0.216 – 0.915	0.167 – 3.03
Thallium	NA	0.00283 – 0.024	0.00983 – 0.023	0.001 – 0.45	0.00582 – 0.0121	0.00615 – 0.0158	0.00276 – 0.00699	0.00316 – 0.0157	0.00616 – 0.0185
Zinc	55	0.433 – 16.7	1.46 – 8.91	1.02 – 1.56	0.68 – 4.86	1.09 – 3.8	1.16 – 54.9	0.734 – 1.89	1.06 – 3.47
Number of Detects		9	9	4	9	7	7	9	12
Total Recoverable Metals (µG/L) ^e									
Chromium	96 ^c	2.22 – 253	1.53 – 35.5	10.5 – 58.8	3.22 – 37.9	1.01 – 64.6	2.16 – 9.9	0.686 – 6.83	0.655 – 9.14
Mercury	0.012	0.00022 – 0.00676 ^f	0.00074 8 – 0.0422	0.00217 – 0.0601 ^g	0.00052 4 – 0.0317 ^h	0.00043 6 – 0.0124 ⁱ	0.00076 6 – 0.00528 ^j	0.00057 1 – 0.00686	0.00091 6 – 0.0215
Selenium	5	0.671 – 1.26	0.208 – 2.04	1.46 – 1.96	0.339 – 1.31	0.795 – 1.38	0.754 – 0.913	0.383 – 1.65	0.423 – 3.91
Number of Detects		11	9	4	9	7	9	9	12
Anions (mg/L) ^e									
Nitrate	45 ^d	3.22 – 6.77	0.726 – 26.1	23.8 – 38.5	2.47 – 16.5	0.775 – 23.7	1.81 – 16.7	4.83 – 21.7	11.6 – 26.9
Number of Detects		10	9	4	9	7	8	11	19

Table 7.6. Columbia River Seeps Concentration Ranges for Selected Metals and Anions in Water Monitoring Samples, Hanford Site^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).^e Values shown are minimum concentrations minus maximum reported concentrations.^f 7 samples analyzed.^g 3 samples analyzed.^h 7 samples analyzed.ⁱ 5 samples analyzed.^j 4 samples analyzed.

NA = Not available.

7.4.3.1 Radiological Results

Results for 2013 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.10 compares radionuclide and total organic carbon concentrations in Columbia River sediment near the Hanford Site collected during 2008 through 2013.

7.4.3.2 Metals Results

Concentrations of metals in shoreline seep sediment samples collected in 2013 were similar to concentrations in Columbia River sediment samples with the exception of chromium. Concentrations reported in 2013 for shoreline sediment collected from the 100-D Spring 102-1 had levels almost four times higher than concentrations measured in Columbia River sediment samples. Appendix C, Table C.11 compares metal concentrations in sediment samples collected in 2013. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

7.4.3.3 Hexavalent Chromium Results

The 100-D Spring 102-1 area also had the highest levels of hexavalent chromium, as concentrations were six times higher than the average of all other sediment results. This is likely due to historical energy conversion when sodium dichromate was used in reactors to produce fluoride for the enrichment of uranium. The 100-D Area has two separate hexavalent chromium plumes that have been recorded and surrounding soil and water sampling have shown elevated concentrations ([BHI-01747](#), *Results of Hexavalent Chromium Sampling Near 100-D Area Sodium Dichromate Transfer Station Railroad Tracks*). All hexavalent chromium concentrations reported are listed in Appendix C, Table C.12.

7.5 Pond Water and Sediment

ME Hoefer

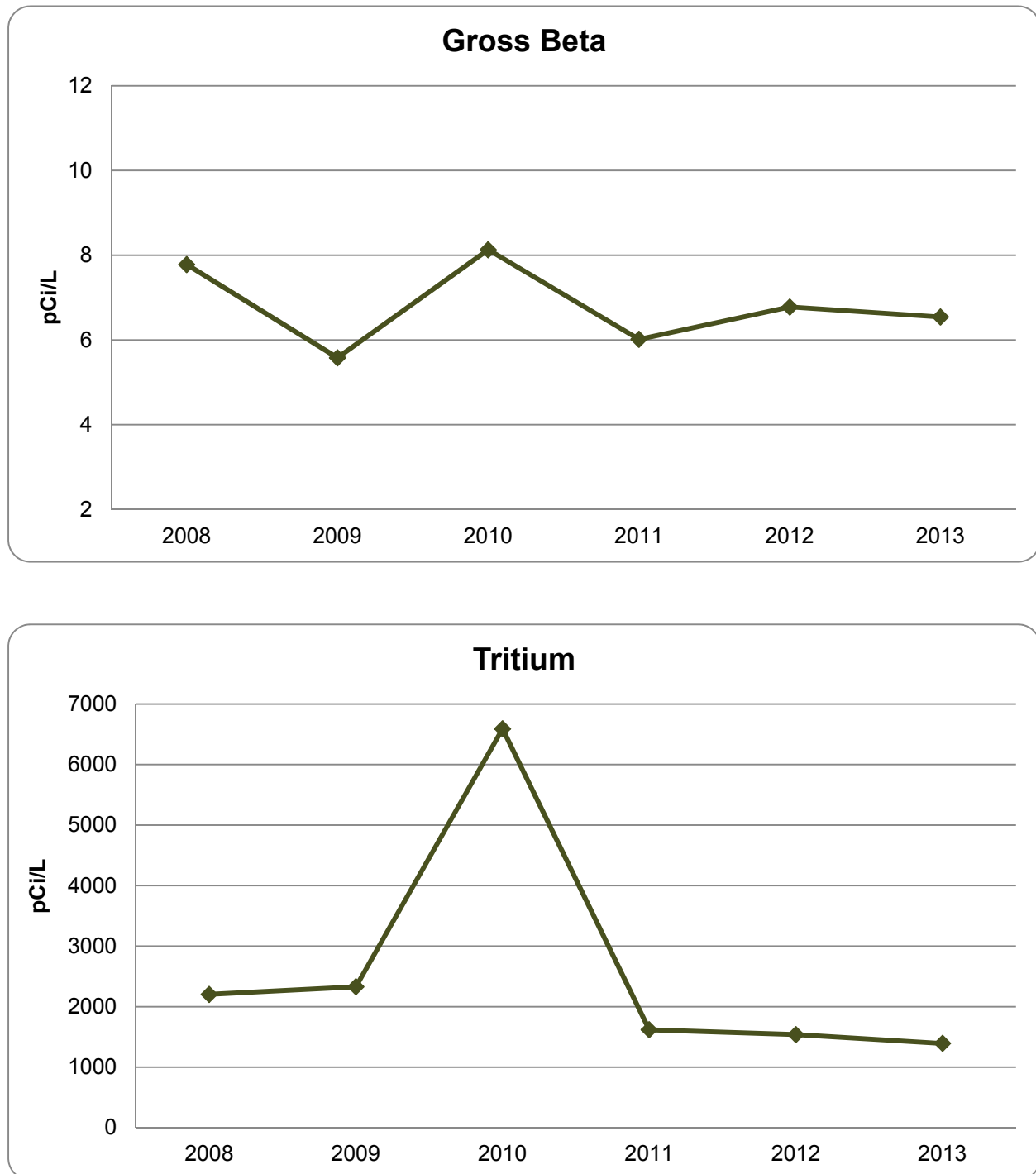
Two Hanford Site ponds, FFTF Pond and the West Lake Pond (Figure 7.3), were sampled periodically during 2013. The ponds are accessible to migratory waterfowl, deer, and other wildlife, creating a potential biological pathway for the dispersion of contaminants. The FFTF Pond is a disposal site for process water, primarily cooling water drawn from 400 Area groundwater wells. West Lake, the only naturally occurring pond on the Hanford 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 2013 from the FFTF Pond water access weir box. All water samples collected from the FFTF Pond were analyzed for gross alpha, gross beta, and gamma-emitting radionuclides.

Figure 7.16 shows the annual average gross beta and tritium concentrations in FFTF Pond water from 2008 through 2013. All samples had non-detects on gross alpha concentrations while average gross beta levels decreased slightly during 2013 when compared to 2012. Tritium concentrations in FFTF Pond water were slightly lower in 2013 than they were in 2012. The sources of contaminants in the pond water are historical groundwater contaminant plumes from the 200 Areas that have migrated to wells in the 400 Area which supplied water to facility operations. The weir box/pond area also serves as retention for surrounding storm water runoff. Radionuclide concentrations in FFTF Pond water samples collected during 2013 and in the previous 5 years are shown in Appendix C, Table C.1.

Figure 7.16. Gross Beta and Tritium in Pond Water Samples from the Fast Flux Test Facility Pond



7.5.2 West Lake Water

Water monitoring continued at West Lake in 2013 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 load to increase. West Lake seep and surface water samples collected from 2002 through 2010 were not analyzed for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, or 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, analyses of West Lake water samples for uranium-234, uranium-235, and uranium-238 were resumed in 2011.

During the first quarter of 2013, a grab sample of standing seep water was collected for analysis of 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](#)).

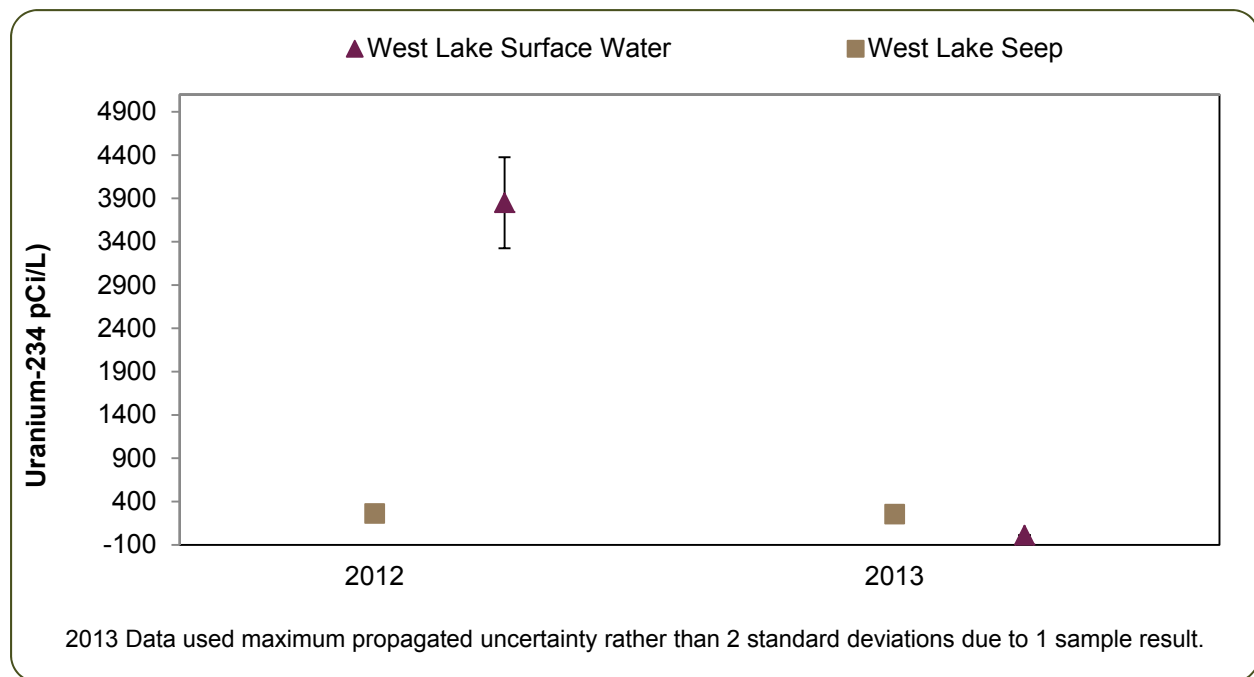
A grab sample of surface water was collected for analysis during the second quarter of 2013 when the lake was almost dry. The surface water collected within the footprint of West Lake was analyzed for tritium, uranium-234, uranium-235, and uranium-238. Tritium concentrations in surface water collected from West Lake in 2013 were below the laboratory-reported required detection limit. Figure 7.17 shows the annual average concentrations of uranium-234 in West Lake surface water and West Lake seep water from 2012 and 2013. Radionuclide concentrations in the West Lake seep and surface water samples collected during 2013 and in the previous 2 years are shown in Appendix C, Tables C.3 and C.4.

7.5.3 West Lake Sediment

One sediment sample was collected from West Lake during the second quarter of 2013. The West Lake sediment sample was analyzed for gross alpha, gross beta, cesium-137, strontium-90, uranium-234, uranium-235, uranium-238, and other 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 2013 and a summary of those collected during the previous 5 years are shown in Appendix C, Table C.2.

Figure 7.17. Uranium in West Lake Water Samples



7.6 Offsite Irrigation Water

ME Hoefler

As a result of public concern about the potential for Hanford Site-associated contaminants in offsite water, sampling was conducted in 2013 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, MEI and any other member of the public (Section 4.2.1).

Offsite Irrigation Water Monitoring. Water samples were collected in 2013 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 2013 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, strontium-90, and tritium.

Sample Results. Most radionuclide concentrations measured in irrigation water in 2013 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. Alpha results from both areas were lower than levels detected in upstream river transect samples. Beta results from the Horn Rapids and Riverview areas were slightly higher than levels detected in the Columbia River. Strontium-90 results had a similar juxtaposition between Horn Rapids and Riverview irrigation results, although levels were lower than those recorded in 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](#); [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 2013 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 (the most recently published being [HNF-EP-0527-22](#), *Environmental Releases Report for Calendar Year 2012*). 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 2013 is the 616-A Crib, also known as the State-Approved Land Disposal Site. Table 7.7 summarizes the analysis results on this effluent discharge point for 2013.

Table 7.7. 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	11.0

^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 synopsis of the state waste discharge permits.

8.0 Groundwater Monitoring

MJ Hartman

The Hanford Site, part of DOE's nuclear weapons complex, encompasses ~1,500 square kilometers along the Columbia River in southeastern Washington State. In 1943, the federal government took possession of the Site to build the world's first large-scale plutonium production reactor, which was used to make plutonium for the Trinity Test and the "Fat Man" bomb that was dropped on Nagasaki, Japan in 1945. During the Cold War period (1945 to 1991), the government built a total of nine reactors 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, mostly in the 200 East Area, 200 West Area, 300 Areas, 1100 Area, and reactor areas along the river (e.g., 100-BC, 100-K) (Figure 8.1). Since the 1990s, DOE has worked to remediate this contamination. DOE developed a plan to address groundwater and vadose 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.

Groundwater occurs in an unconfined aquifer within unconsolidated gravel and sand units. Groundwater in the unconfined aquifer 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. Maximum concentrations of key groundwater contaminants are presented in Tables 8.1 and 8.2; time series of cumulative plume areas for selected contaminants in Hanford groundwater are shown in Figure 8.3.

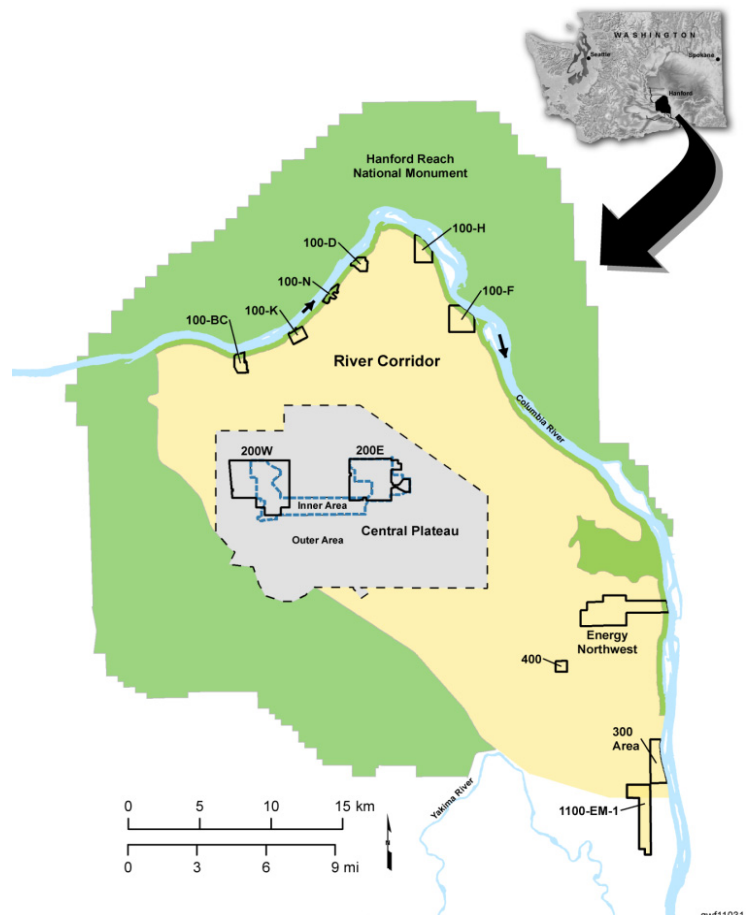
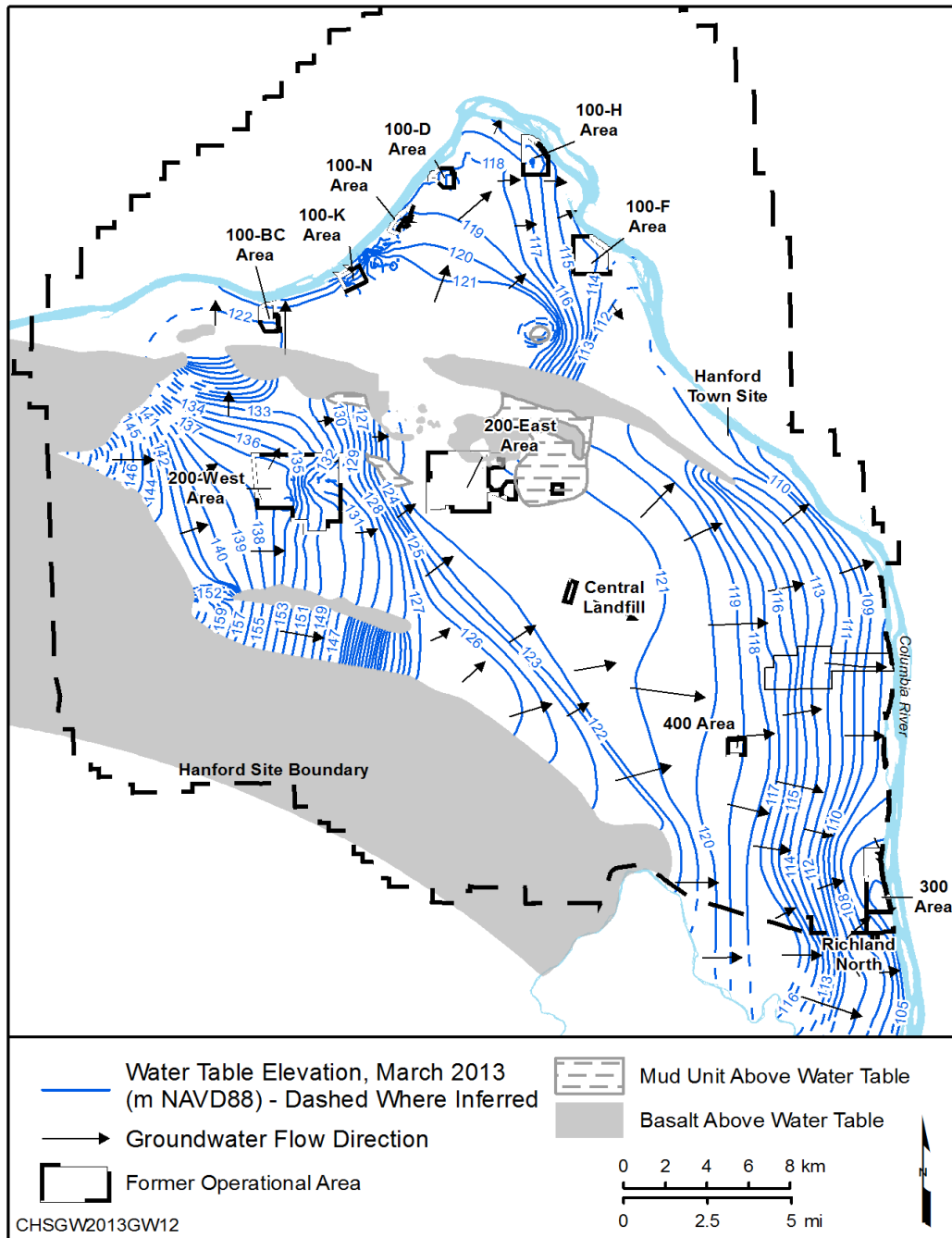


Figure 8.1. Regions of the Hanford Site

Figure 8.2. Hanford Site Water Table and Directions of Groundwater Flow



DOE has taken the following actions to protect the Columbia River from contaminated groundwater:

- Ceasing discharge of all unpermitted liquids in the central Hanford Site.
- Remediating former waste sites in the 100 and 300 Areas to reduce the potential for future groundwater contamination.
- Containing groundwater plumes and reducing the mass of primary contaminants through remedial actions such as pump-and-treat (P&T).

Table 8.1. Overview of the River Corridor Groundwater Interest Areas Contaminant Concentrations

Interest Area	Primary Operations	Status of Waste Site Cleanup ^(a)	Groundwater Interim Remedial Action	Groundwater Contamination: Maximum Concentration and Plume Area						
				Carbon-14 (pCi/L)	Hex. Chromium (µg/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Trichloroethene (µg/L)	Tritium (pCi/L)	Uranium (µg/L)
100-BC	Reactor operations -- B Reactor 1944-69; C Reactor 1952-69	92% complete	None	N	62.5	<DWS	53	<DWS	<DWS	<DWS
100-KR	Reactor operations -- KE Reactor 1955-71; KW Reactor 1955-70	59% complete	Cr(VI) -- P&T 1997 - present	39,500 ^b	3,280	64	13,200 ^b	8.3	76,000	<DWS
100-NR	Reactor operations -- N Reactor 1963-87	79% complete	Sr-90 -- P&T: 1995-2006; Apatite barrier: 2006 - present	<DWS	(c)	168	14,000	<DWS	120,000	<DWS
100-HR	Reactor operations -- D Reactor 1944-67; DR Reactor 1950-64; H Reactor 1949-65	77% complete	Cr(VI) -- P&T 1997 - present; ISRM: 2000-present	<DWS	5,392	70	31	<DWS	≤DWS	<DWS
100-FR	F Reactor 1945-65; Biological experiments until 1976	98% complete	None	N	25.5	189	180	15	<DWS	<DWS
300-FF	Nuclear fuel fabrication and research -- 1940s-1960s	90% complete	Final ROD: Uranium & others -- enhanced attenuation & MNA	N	N	(d)	<DWS	430 ^e	1,000,000	462
1100-EM	Vehicle maintenance, 1954-85; solid waste landfill --1950s-1970	100% (final ROD)	Final ROD:TCE - MNA, 1996-present	N	N	(d)	N	<DWS	<DWS	(d)
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 2013				Height of bar indicates plume area above standard (km ²)						
<div><div>≥1000 x standard</div><div>≥100 x standard and <1000 x standard</div><div>≥10 x standard and <100 x standard</div><div>≥Standard and <10 x standard</div></div>				<div><div>>10</div><div>>1 and ≤ 10</div><div>>0.1 and ≤ 1</div><div>>0, ≤0.1</div></div>						
NOTES										
(a) Percentage by number of sites classified as closed, interim closed, no action, rejected, or not accepted (end of 2013).										
(b) Based on extrapolated concentrations. Detected concentrations lower.										
(c) Chromium plume in 100-NR originates in 100-KR so plume area not shown										
(d) Contaminants from offsite sources excluded										
(e) TCE only exceeds the DWS in deep aquifer tubes; no plume map constructed										
ABBREVIATIONS										
DWS Drinking water standard			ISRM In situ redox manipulation							
N Not detected or not analyzed			ROD Record of decision			TCE Trichloroethene				
CHSGW/2013/GW/3										

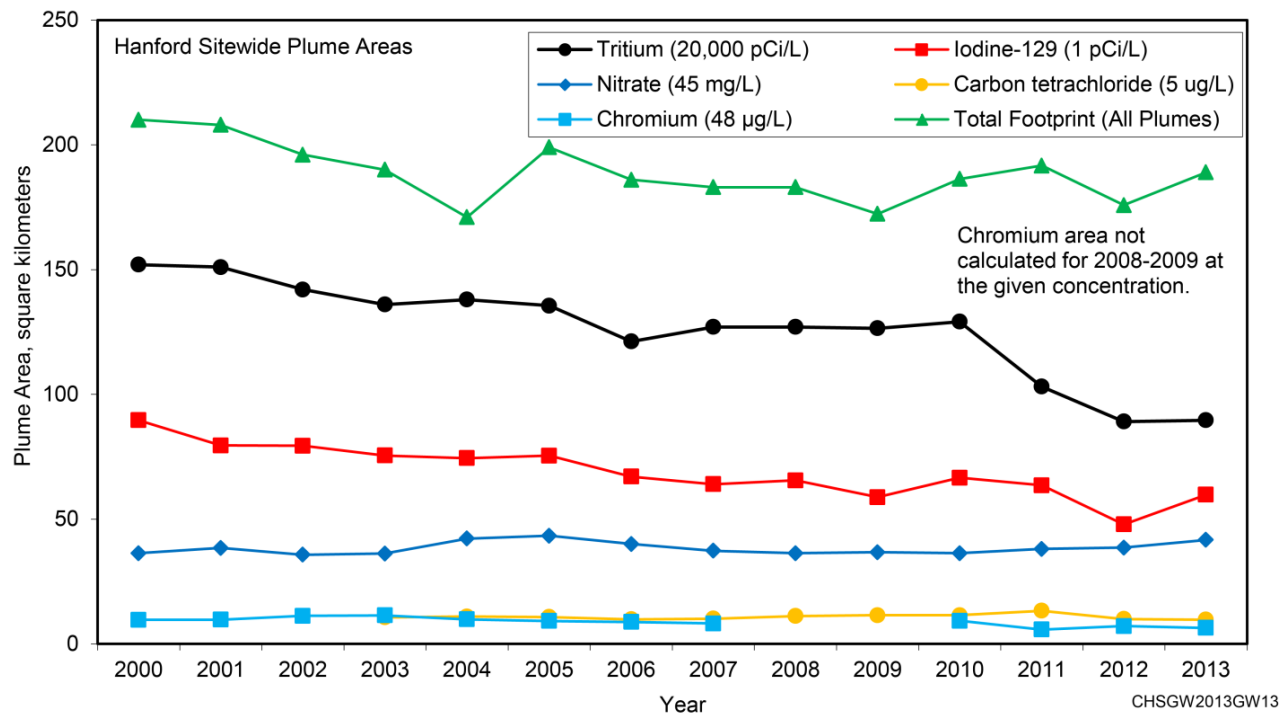
CHSGW2013GW32

Table 8.2. Overview of Central Plateau Groundwater Interest Areas Contaminant Concentrations

Interest Area	Primary Operations	Status of Groundwater ROD	Groundwater Remedial Action	Groundwater Contamination: Maximum Concentration and Plume Area									
				Carbon Tetrachloride (µg/L)	Chromium (µg/L)	Cyanide (µg/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Trichloroethene (µg/L)	Technetium-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)
200-ZP	T Plant (Pu separation) 1944-1956; Pu Finishing Plant: 1949-1989	Signed 2008 (final)	Carbon tet. & others: P&T & MNA: 1995-present; Soil vapor extraction 1991-present	2,600	186	<DWS	3.6	846	<DWS	9.8	8,600	140,000	<DWS
200-UP	REDOX Plant (Pu separation) 1952-1967; U Plant (U recovery) 1952-1957	Signed 2012 (interim)	U plant P&T Tc-99 & U: 1994-2011; S-SX P&T 2012-present	See 200-ZP	907	N	9.14	3,210	<DWS	7.2	62,000	310,000	298
200-BP	B Plant Pu separation: 1945-1952; B Plant Sr and Cs recovery: 1967-1985	Expected 2016	Perched aquifer P&T test: 2011-2013	<DWS	53.9	1,520	7.54	1,680	980	<DWS	36,000	42,000	3,300
200-PO	PUREX Plant Pu separation: 1956-1972 and 1983-1989	Expected 2016	Vadose zone desiccation test: 2011	<DWS	<DWS	N	9.09	126	15	<DWS	4,200	490,000	58.8
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 2013				Height of bar indicates plume area above standard (km ²)									
<div><div></div> ≥100 x standard and <1000 x standard</div>				<div><div></div> >10</div>									
<div><div></div> ≥10 x standard and <100 x standard</div>				<div><div></div> >1, ≤10</div>									
<div><div></div> ≥Standard and <10 x standard</div>				<div><div></div> >0.1, ≤1</div>									
				<div><div></div> >0, ≤0.1</div>									
ABBREVIATIONS													
DWS Drinking water standard				P&T Pump and treat system									
N Not detected or not analyzed				ROD Record of decision									
CHSGW2013GW03													

CHSGW2013GW33

Figure 8.3. Hanford Site Plume Areas



This report is organized by geographic regions known as “groundwater interest areas” that include the River Corridor (100 and 300 Areas) and the Central Plateau (200 Areas). Highlights of 2013 groundwater monitoring include the following:

River Corridor

- More than 85 percent 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 most immediate threat to the Columbia River.
- **100-BC.** New wells and sampling points were installed in 2013 to provide data that will support final decisions about groundwater cleanup in 2016. This includes ongoing, intensive sampling of water in the shallow riverbed.
- **100-KR.** Three P&T systems continued to operate under an interim ROD. In 2013 over 5 million gallons (2 billion liters) of groundwater was pumped from 36 extraction wells. A total of 3,631 pounds (1,647 kilograms) of hexavalent chromium have been removed from groundwater to date. The plume area ($>20 \mu\text{g/L}$) was estimated to be 0.4 square mile (1.0 square kilometer) in 2013, about the same as in 2012. Since 2007 the plume area has decreased by approximately two-thirds. Final cleanup decisions are expected after 2015; additional P&T is proposed.
- **100-NR.** Under an interim ROD, a permeable reactive barrier is in place along the shoreline to reduce the amount of strontium-90 migrating from groundwater into the river. A draft RI/FS report was submitted to the lead regulatory agency in 2013 for review. Final cleanup decisions are expected in 2015.
- **100-HR.** Two P&T systems continued to operate under an interim ROD. In 2013, 6.4 million gallons (2.4 billion liters) of groundwater were pumped from 72 extraction wells. A total of 4,496 pounds (2,039 kilograms) of hexavalent chromium have been removed from groundwater to date. The plume area ($>20 \mu\text{g/L}$) was estimated to be 1.6 square miles (4.0 square kilometers) in

2013 about the same as in 2012. Since 2005, the plume has shrunk by approximately 50 percent. Final cleanup decisions are expected in 2015; additional P&T is proposed.

- **100-FR.** Decision documents are being finalized and final cleanup decisions are expected in 2014. Groundwater contaminants are present at relatively low concentrations and do not appear to be impacting the river. Monitored natural attenuation (MNA) of contaminants is proposed.
- **300-FF.** The final ROD was signed in 2013 and remedial action of groundwater includes enhanced attenuation of uranium using sequestration by phosphate application. MNA is the remedy of choice for other contaminants of concern.

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.
- **200-ZP.** The final remedy for groundwater includes an expanded P&T system that continued operating in 2013. Together with the previous, interim P&T system and a soil vapor extraction system, nearly 216,090 pounds (98,000 kilograms) of carbon tetrachloride has been removed from the ground. In 2013, 18 extraction wells and 16 injection wells were in use, and the treatment plant was operating at a flow rate of 5,300 liters per minute (60 percent of its design capacity), about the same as in 2012. Additional wells were installed in 2013 that will be used to expand the extraction network in the future. Other contaminants of concern being removed by the P&T system include trichloroethene, total chromium, hexavalent chromium, nitrate, technetium-99, iodine-129, and tritium.
- **200-UP.** Groundwater is being remediated under an interim ROD that was signed in 2012. It includes a P&T near the S-SX single-shell tanks, where high concentrations of technetium-99 and other contaminants are present in groundwater. In 2013, 0.81 curies of technetium-99 were removed by the system. An additional P&T for uranium and technetium-99 in the U Plant area is currently being designed.
- **200-BP.** In recent years, high-concentration portions of contaminant plumes have been growing in one portion of this OU. These plumes include the highest concentrations of uranium in Hanford Site groundwater. Concentrations are even higher in a zone of perched water that lies above the water table. In 2013, water continued to be extracted from this perched zone to prevent uranium and other contaminants from continuing to drain to the water table. A remedial investigation has been completed; however, final cleanup decisions are yet to be made.
- **200-PO.** This OU includes the largest contaminant plumes on the Hanford Site, tritium, and iodine-129. The tritium plume had an estimated area of 35.9 square miles (89.8 square kilometers) in 2013. Although there is currently no practical treatment technology for tritium, concentrations and plume area have been declining due to radioactive decay and dispersion. The size of the tritium plume has decreased by one-third since 1980 and the maximum concentration has declined 90 percent. A remedial investigation has been completed.

8.1 Groundwater Monitoring Regulations

This document describes 2013 monitoring results for RCRA TSD units; for CERCLA groundwater OUs; and for the *Atomic Energy Act of 1954* (AEA), as required by DOE orders. DOE publishes details on CERCLA remediation activities (for example, P&T operations) in separate reports that are summarized and referenced in this report.

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 Washington State's dangerous waste regulations ([WAC 173-303-645](#)). The RCRA units not currently incorporated into a permit require interim status monitoring.

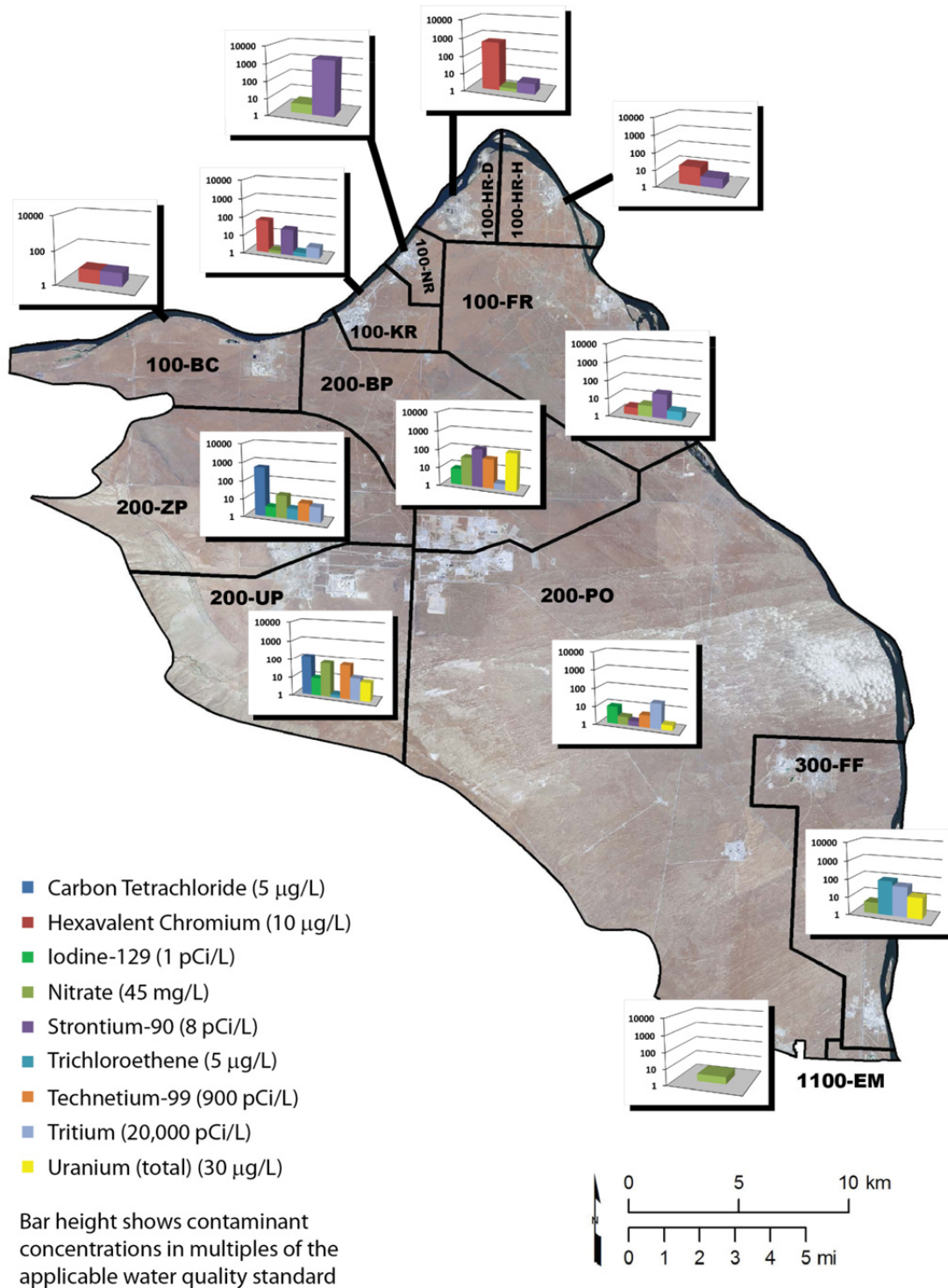
RCRA groundwater monitoring is conducted under one of three possible phases: (1) contaminant indicator evaluation (or detection) monitoring, (2) groundwater quality assessment (or compliance) monitoring, or (3) corrective action monitoring. In the interim-status contaminant indicator evaluation monitoring, four indicator parameters (pH, specific conductance, 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.

[Executive Order 12580](#) assigns DOE the responsibility and authority (under CERCLA Section 104) to conduct cleanup of contamination at the Hanford Site, and CERCLA Section 120 gives EPA an oversight role at Hanford and other Federal facilities placed on the CERCLA National Priorities List. 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 P&T 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 8.4 compares maximum concentrations of the major groundwater contaminants in various parts of the Site in 2013. These contaminants are discussed further in the sections that follow.

Figure 8.4. Exceedance Ratios of Groundwater Contaminants

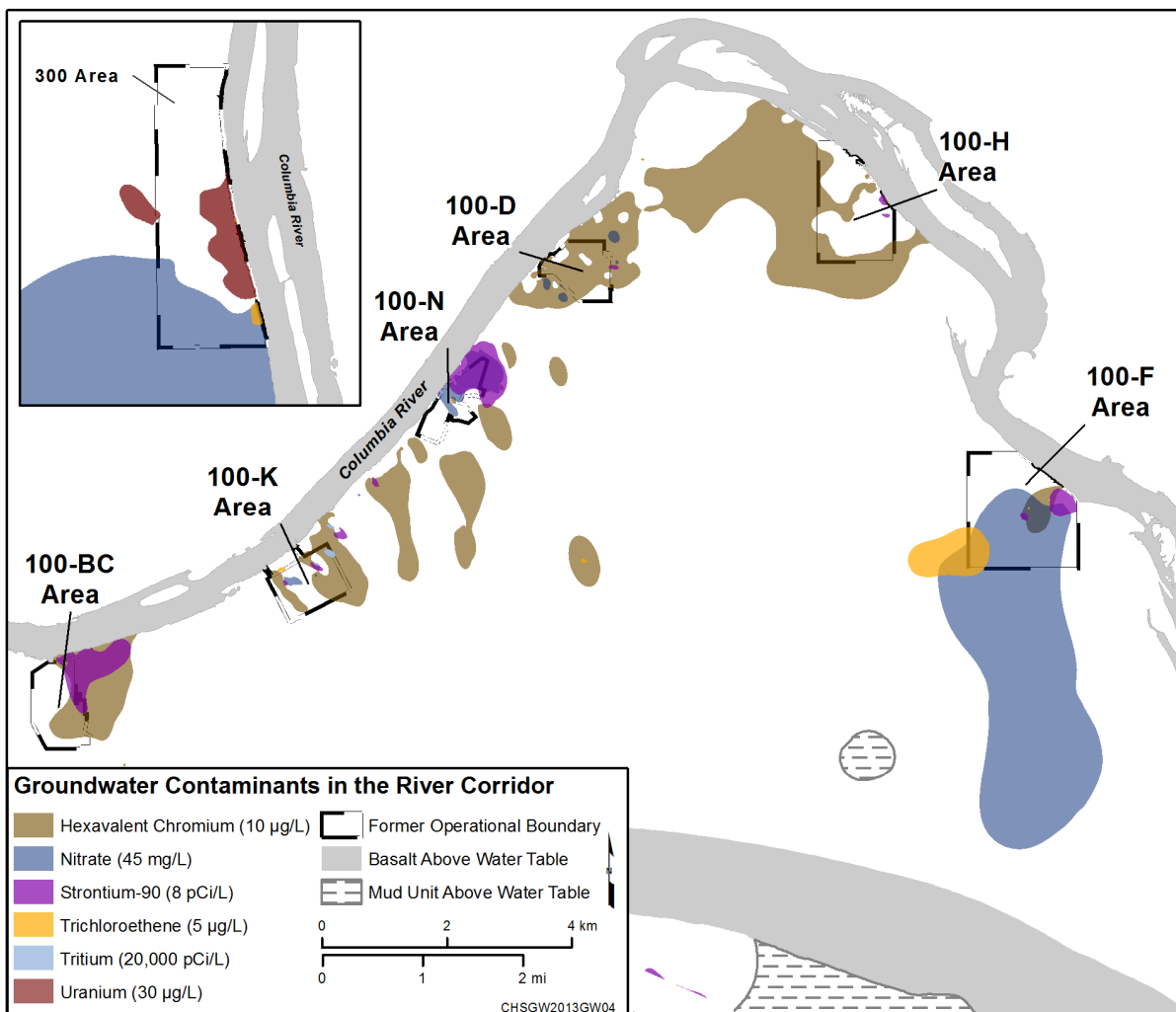


This map shows the maximum concentrations of groundwater contaminants in each groundwater interest area in 2013. The heights of the bars represent multiples of the applicable water quality standards. For example, if the maximum strontium-90 concentration was 80 pCi/L, the bar is 10 units high because the DWS is 8 pCi/L.

8.2 River Corridor

The River Corridor comprises the region of the Hanford Site along the shoreline of the Columbia River, which includes the 100, 300, and 1100 Areas. In the 100 Area, groundwater contamination is related to past disposal of waste associated with water-cooled nuclear reactors. The primary groundwater contaminants are hexavalent chromium, strontium-90, nitrate, and tritium (Figure 8.5). Sources of hexavalent chromium contamination included 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. In the 300-FF-5 OU uranium and tritium are the primary groundwater contaminants. Table 8.1 provides a summary of the River Corridor groundwater interest areas and associated contamination plumes.

Figure 8.5. Groundwater Contaminants in the River Corridor



Since the 1990s, DOE has been remediating waste sites and groundwater in the River Corridor under interim RODs. Removal of contaminated soil has reduced the potential for future groundwater contamination and, by the end of 2013; more than 85 percent of the waste sites near the river had been remediated or classified as not requiring remediation. Cleanup of the remaining sites is underway. 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. Interim cleanup of the River

Corridor has achieved a considerable level of cleanup and final remedies are being developed. EPA and DOE signed a final ROD for 300-FF-5 waste sites and groundwater in 2013, and final RODs for the other portions of the River Corridor are expected to be developed in the next few years.

8.2.1 100-BC-5 Operable Unit

Groundwater contaminants in 100-BC-5 include hexavalent chromium and strontium-90. Tritium concentrations declined below the DWS in 2013. Former waste sites in 100-BC-5 have been remediated under an interim action ROD, so contaminant levels in groundwater are expected to continue to decline.

DOE began conducting additional studies in 100-BC-5 in 2013 to reduce uncertainties relating to (1) the completion of waste site remediation; (2) short-term changes in groundwater contaminants related to waste site remediation; (3) modeling results predicting that it will take a long time for the hexavalent chromium plume to attenuate; and (4) the level of risk associated with variable contaminant concentrations in Columbia River pore water. In 2013, DOE installed and began monitoring 18 shallow aquifer tubes in the Columbia River. Eight new monitoring wells were installed in late 2013 and early 2014.

8.2.2 100-KR-4 Operable Unit

The principal groundwater activities for 100-KR-4 are cleaning up hexavalent chromium in the groundwater, tracking contaminant plumes, and monitoring groundwater near the former KE Fuel Storage Basins and the KW Fuel Storage Basins. The concrete KE and KW 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.

The KE Basin was demolished, but some contaminated soil remains. The KW Basin has been emptied of fuel rods but remains a depository for contaminated sludge from the KE and KW Basins. The KW Basin and the 116-KW-2 Crib are scheduled for removal. Groundwater monitoring in 2013 did not show new groundwater impacts from the basins. Remediation of waste sites continued in 2013.

Groundwater contaminant plumes in 100-KR-4 are decreasing in size due to remediation and natural processes including dispersion, discharge to the Columbia River in areas without hydraulic containment, degradation, and radioactive decay.

Hexavalent chromium is the primary contaminant of concern for groundwater. Three P&T systems operate as interim actions to remove hexavalent chromium from the groundwater. Changes in the hexavalent chromium plume over time are shown in Figure 8.6. Between 1997 and 2013, 1,647 pounds (747 kilograms) of hexavalent chromium have been removed. Smaller plumes of carbon-14, tritium, strontium-90, nitrate, and trichloroethene also are present in 100-KR-4 groundwater. Cleanup actions for these other contaminants will be defined in the ROD.

The CERCLA process is underway to make final cleanup decisions for 100-KR-4. DOE has proposed P&T for hexavalent chromium as part of a preferred alternative for groundwater remediation. The draft RI/FS and Proposed Plan underwent review in 2012 and DOE will incorporate the results of supplemental source characterization activities.

Figure 8.6. 100-KR-4 Hexavalent Chromium Plume in 1996 (Before Interim Action) Compared to 2013 (During Interim Action)



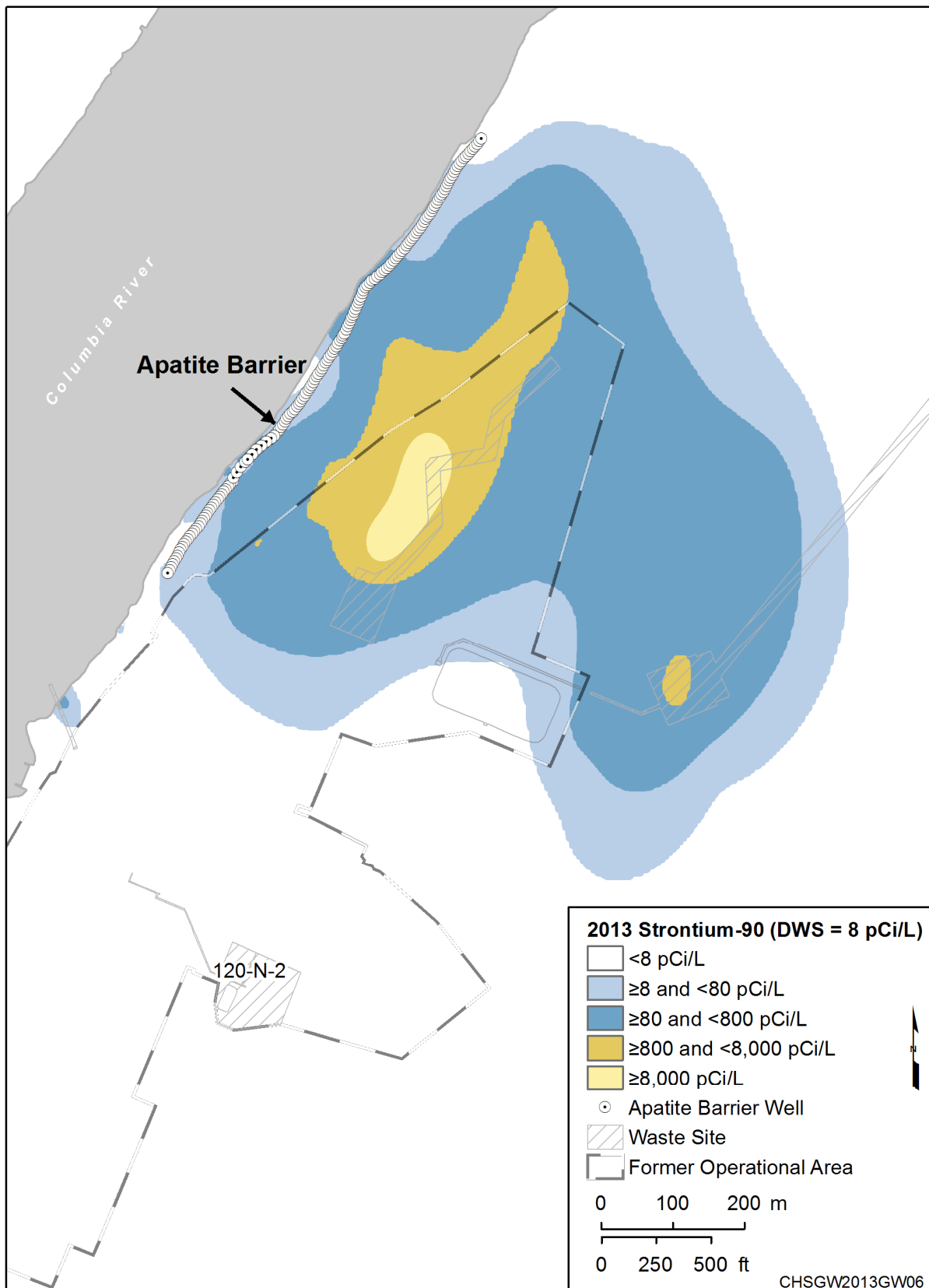
8.2.3 100-NR-2 Operable Unit

Principal groundwater activities for 100-NR-2 include RCRA monitoring and remediation of strontium-90 and total petroleum hydrocarbons. The major liquid waste disposal 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. Because strontium-90 binds to sediment the shape and size of the plume (Figure 8.7) has not changed significantly since 1996. P&T technology was found to be ineffective in cleaning up strontium-90, so DOE is now applying an in situ technology remedy called strontium-90 sequestration, using an apatite chemical solution. 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 chemicals were injected into a line of wells along the river shoreline several times between 2006 and 2011. As the injected chemicals reacted with the aquifer and sediments, strontium-90 levels temporarily increased in groundwater wells and aquifer tubes between the apatite barrier and the river. Subsequently, strontium-90 and gross beta concentrations declined, as predicted.

In 2013, RCRA monitoring continued under final status detection programs at the 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.

Figure 8.7. 100-NR Strontium-90 Plume



DOE submitted a draft RI/FS and Proposed Plan to Ecology for review in 2013. The RI/FS and Proposed Plan will be used to develop a ROD, documenting decisions for remediation of waste sites and groundwater in the coming year.

8.2.4 100-HR-3 Operable Unit

The 100-HR-3 groundwater OU in the northern Hanford Site includes the 100-HR-D and 100-HR-H groundwater interest areas. Remediation of waste sites continued in 2013. Hexavalent chromium is the primary contaminant of concern for groundwater, and is the target of two groundwater P&T systems. Hexavalent chromium also was detected at relatively high levels within the Ringold upper mud unit beneath portions of 100-HR-3, unlike elsewhere in the 100 Areas. Additional groundwater contaminants include strontium-90 and nitrate (Figure 8.8).

P&T systems remove hexavalent chromium contamination from the groundwater as part of an interim action. Between 1997 and 2013, these systems removed 4,494 pounds (2,038 kilograms) of hexavalent chromium. Investigation of groundwater conditions at 100-HR-3 greatly changed the understanding of the extent of chromium contamination during this time, primarily because many more wells were installed. In 1997, 95 wells were sampled, and in 2013, over 300 wells were sampled. The added wells identified areas of higher chromium concentrations at 100-D and in the Horn. Even with areas of high levels of contamination being identified, the overall aerial extent of the plume has decreased as a result of remediation (Figure 8.8).

The CERCLA process is underway to make final cleanup decisions for 100-HR-3. DOE submitted Draft A of an RI/FS and Proposed Plan in 2012. Starting in 2013 and continuing in 2014, DOE and Ecology have been working through the comment resolution process. After comments are incorporated, the document will undergo a public comment period and then a ROD will be issued that identifies the final remedial alternatives. DOE has proposed ongoing P&T as the preferred alternative for remediating hexavalent chromium in groundwater. The P&T system will capture the other contaminants of concern.

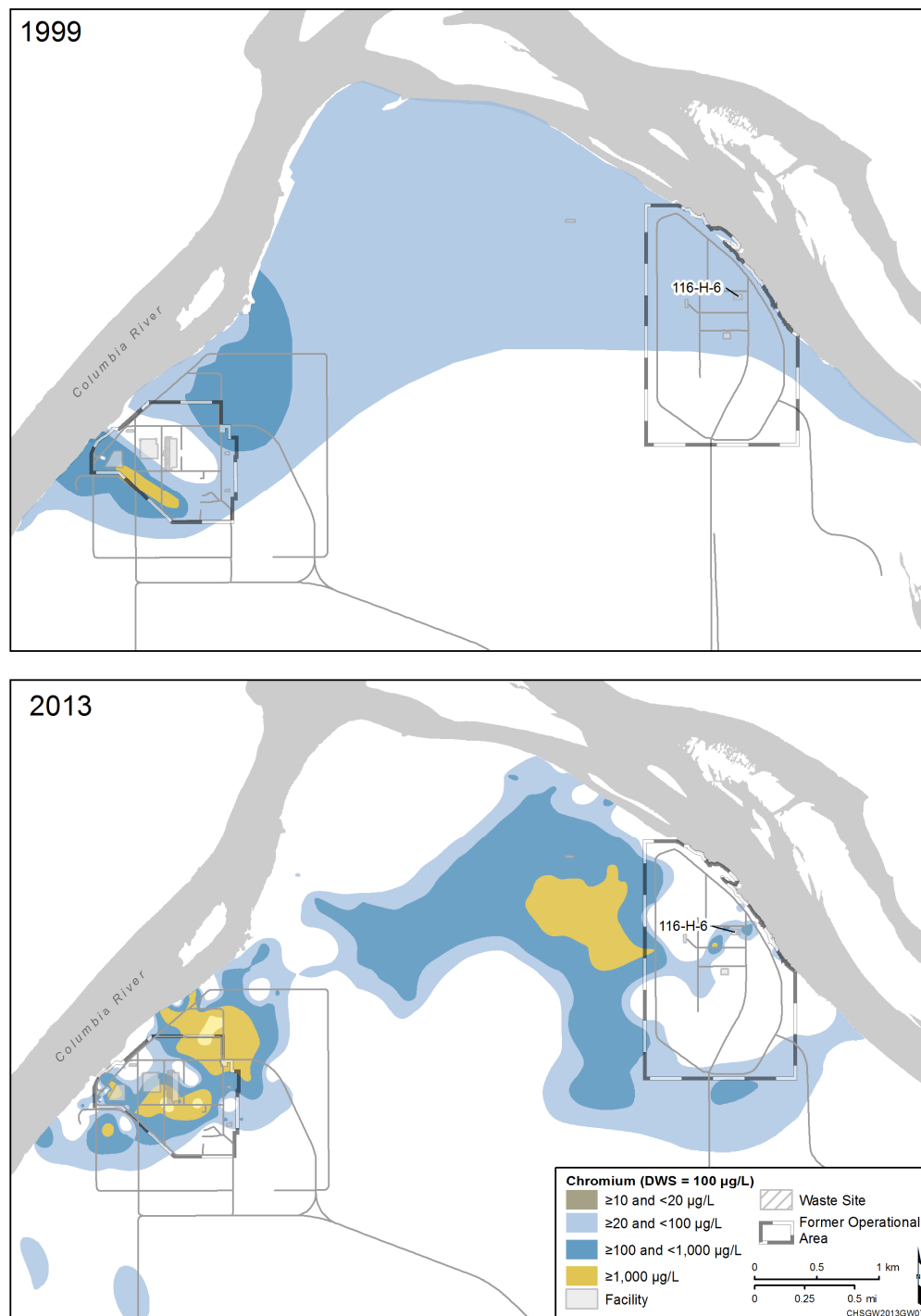
The former 183-H solar evaporation basins (waste site 116-H-6) constitute the only RCRA site in 100-HR-3. The site is monitored in accordance with RCRA corrective action requirements during the post-closure period to track contaminant trends during operation of the CERCLA interim action for chromium. Monitoring well 199-H4-3 was decommissioned in April 2013 due to ongoing CERCLA remediation activities and replaced in the permit by well 199-H4-84.

8.2.5 100-FR-3 Operable Unit

Groundwater contamination in 100-FR-3 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 the plume extends southward approximately 3 miles (5 kilometers). Smaller plumes of hexavalent chromium, strontium-90, and trichloroethene are present. Contaminant concentrations are below applicable standards near the river and are declining overall.

Former waste sites have been excavated and backfilled under a ROD for interim action. In 2013 DOE incorporated EPA's review comments into a draft RI/FS and Proposed Plan. In 2014 the Proposed Plan will undergo a public comment period and then a ROD will be issued that identifies the final remedial alternatives. DOE has proposed MNA as the preferred alternative for groundwater remediation.

Figure 8.8. 100-HR-3 Hexavalent Chromium Plume in 1999 (Early in Interim Action Period) Compared to 2013 (During Interim Action)



The changes in plume delineation and concentrations in 100-D and 100-H reflect the addition of new wells over time, which identified areas of higher concentration.

8.2.6 300-FF-5 Operable Unit

Three geographic regions comprise 300-FF-5: 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 classified as not requiring remediation under an interim ROD.

EPA and DOE signed a ROD for the 300-FF-5 groundwater OU in 2013. The contaminants of concern are uranium, gross alpha, trichloroethene, and cis-1,2-dichloroethene at the 300 Area Industrial Complex and tritium and nitrate at the 618-11 Burial Ground.

Uranium concentrations remain above the cleanup level (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 from 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. The contamination migrates toward the Columbia River and merges with the uranium plume in the 300 Area Industrial Complex.

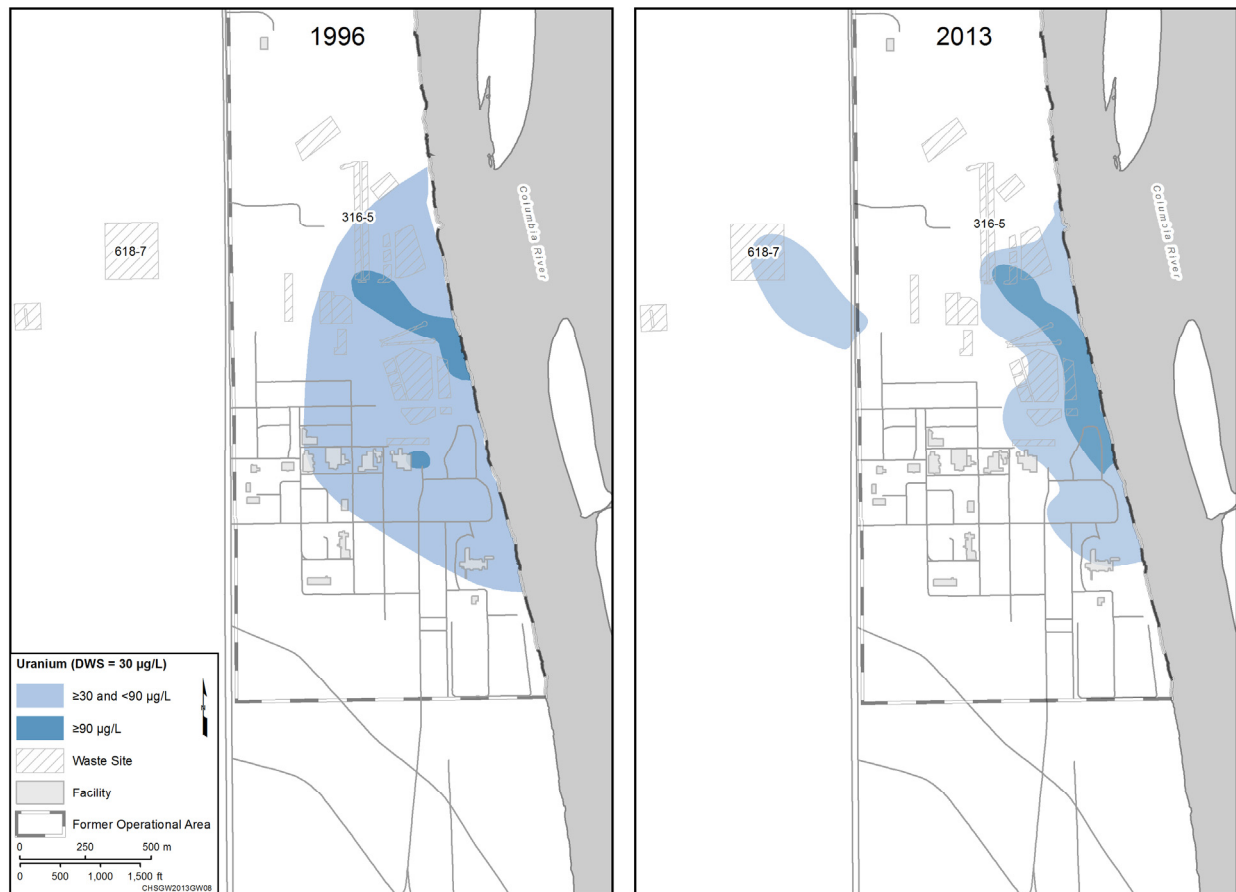
Trichloroethene concentrations did not exceed the cleanup level (4 µg/L) in any 300-FF-5 monitoring wells in 2013. Trichloroethene was detected at concentrations above the cleanup level at some aquifer tubes that are screened proximal to, or within, a finer-grained interval of Ringold Unit E sediment.

Groundwater associated with the 618-11 Burial Ground contains a high-concentration tritium plume originating from irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from a peak value of 8,140,000 pCi/L in January 2000 to a level concentration of 900,000 from 2007 to 2013, and the plume has maintained its basic shape since its discovery in 1999. Relatively constant tritium concentrations immediately adjacent to the site suggest that buried materials are providing an ongoing source of tritium to groundwater. However, 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 near the 618-11 Burial Ground continue to exceed the cleanup level (45 mg/L). Concentrations of nitrate above 45 mg/L are also present in groundwater beneath part of the 300 Area Industrial Complex, from sources off the Hanford Site.

RCRA groundwater monitoring continued at the 300 Area Process Trenches (waste site 316-5). The unit is monitored in accordance with post-closure corrective action requirements (WAC 173-303-645[11]). Uranium and cis-1,2-dichloroethene continued to exceed permit limits in 2013. Site remediation will be coordinated under the 300-FF-5 Groundwater OU as part of the Remedial Design (RD)/Remedial Action (RA) work plan.

Figure 8.9. 300-FF-5 Uranium Plume in 1996 Compared to 2013



8.2.7 1100-EM-1 Operable Unit and Richland North

The 1100-EM-1 Groundwater OU was removed from the “National Priorities List” ([40 CFR 300](#), Appendix B) in 1996. The selected remedy was MNA 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 in the vicinity of DOE’s inactive Horn Rapids Landfill have increased gradually since 1996, exceeding the DWS in 2012 and dropping slightly below the standard in January 2014. The presence of uranium at these locations is likely associated with the plume moving northeast from an offsite facility.

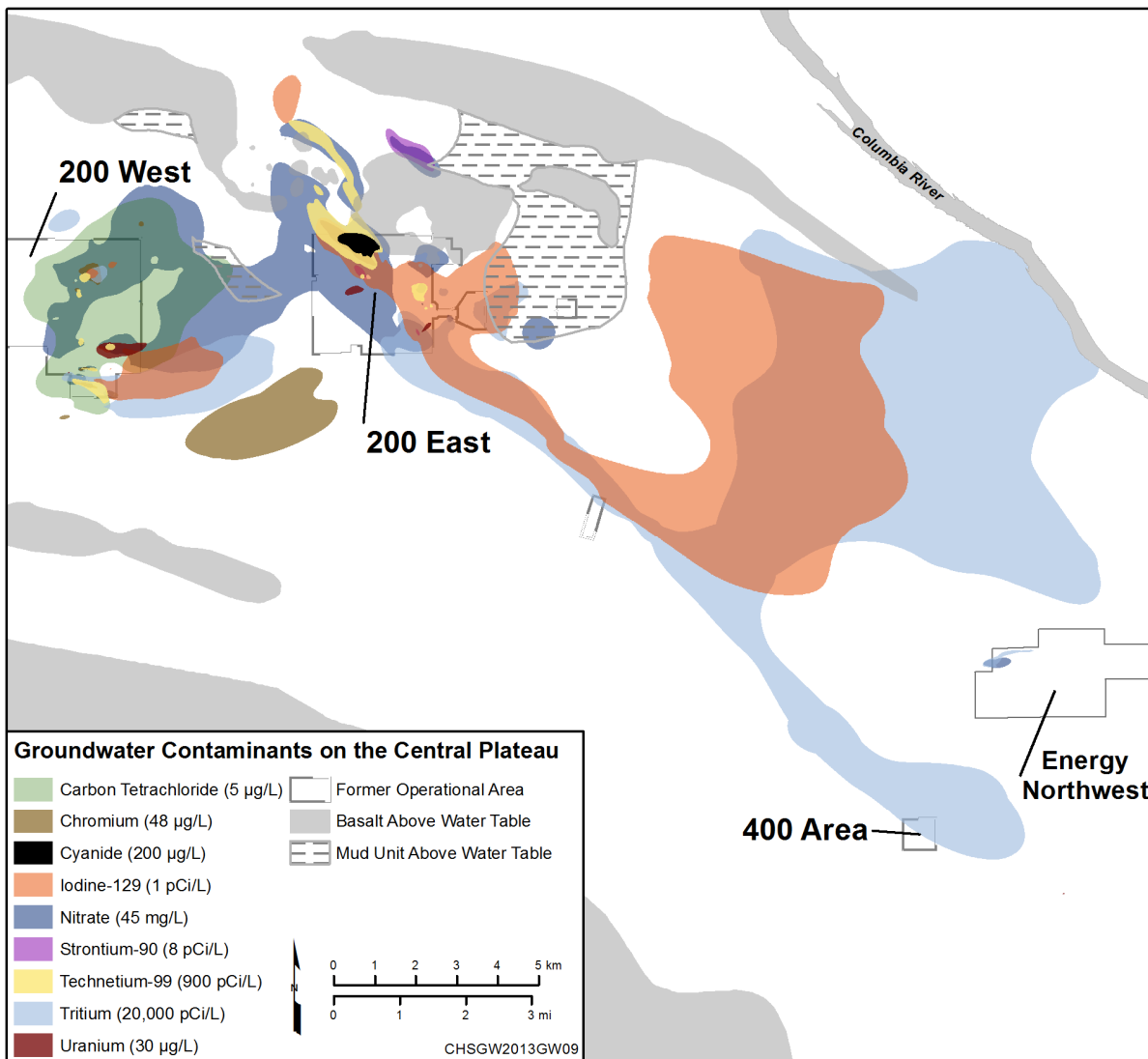
8.3 Central Plateau

When the Hanford Site was operating as a plutonium production facility, 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 Site. Ponds, cribs, and ditches used for disposal of liquid waste were primary sources of groundwater contamination. There are also seven single-shell tank waste management areas (WMAs) in the 200 Area. Some of these tanks have leaked, contaminating the vadose zone and groundwater beneath the tanks. Remediation of the Central Plateau waste sites is expected to accelerate

after River Corridor remediation is complete. Currently, cleanup activities on the Central Plateau focus on completing decision documents, remediating groundwater plumes, and decontaminating and decommissioning facilities.

Groundwater contaminant plumes of tritium, nitrate, 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. The tritium and nitrate plumes have decreased in area over the years as a result of dispersion and radioactive decay (tritium only); the area of iodine-129 has remained stable. A large carbon tetrachloride plume originated in the 200 West Area. Other groundwater contaminants in the Central Plateau include technetium-99, uranium, strontium-90, trichloroethene, cyanide, and other dangerous waste constituents (Table 8.2 and Figure 8.10).

Figure 8.10. Groundwater Contaminants in the Central Plateau

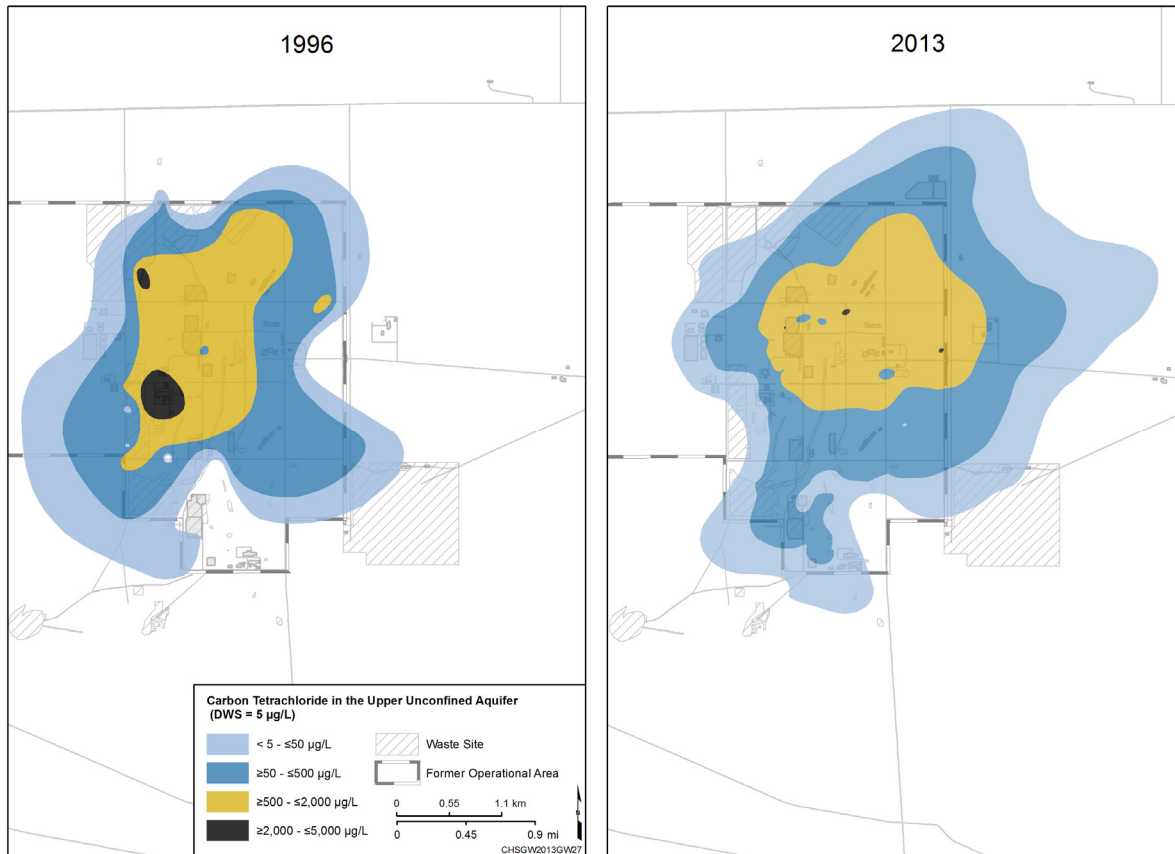


8.3.1 200-ZP-1 Operable Unit

Contaminant sources in 200-ZP-1, located in the 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. This plume is expanding at the edges but is currently contained within the 200 West area and vicinity. A P&T system has reduced the high-concentration core area (Figure 8.11).

Other contaminants of concern are trichloroethene, iodine-129, technetium-99, nitrate, chromium, and tritium.

Figure 8.11. 200-West Carbon Tetrachloride Plume in 1996 (Upper Part of Unconfined Aquifer) Compared to 2013 (Including Available Vertical Interval Data)

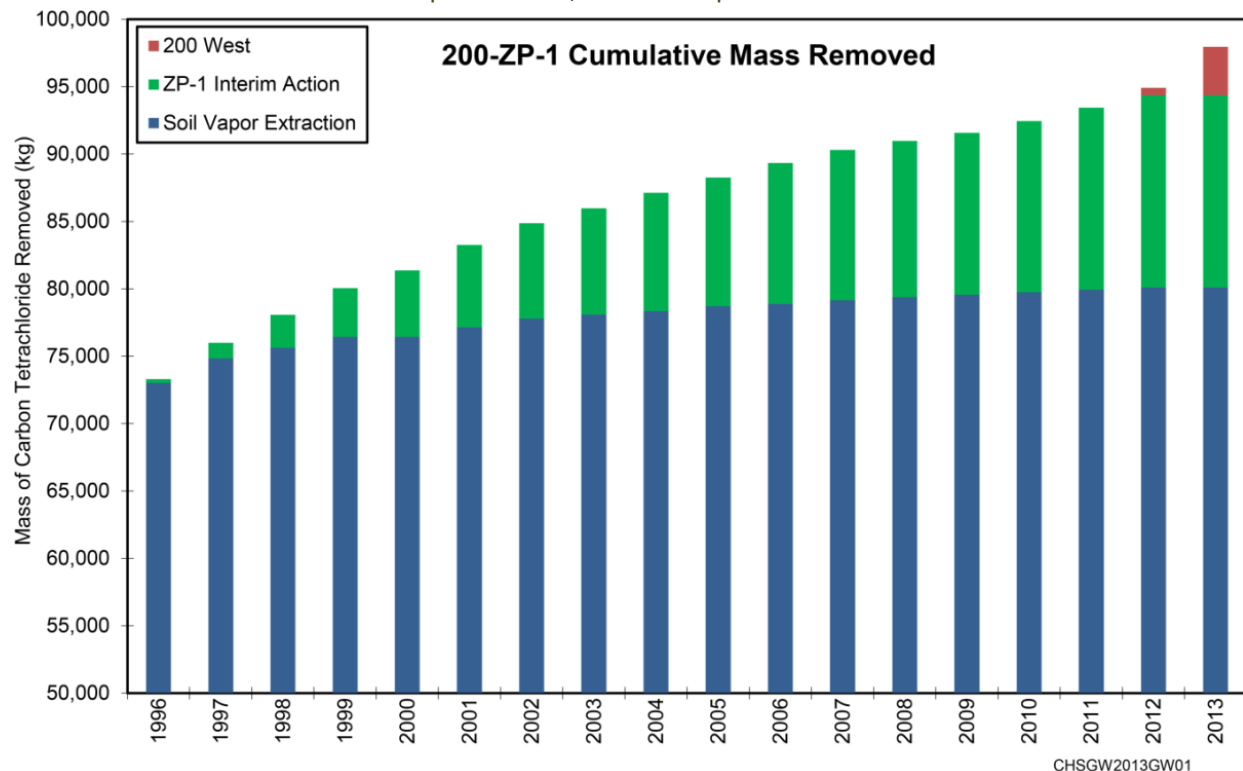


In July 2012, DOE began to operate a large, final action P&T system to remediate the entire thickness of the unconfined aquifer. In 2013, the system processed 197 million gallons (747 million liters) of groundwater and removed 6,723 pounds (3,049 kilograms) of carbon tetrachloride, 430,087 pounds (195,051 kilograms) of nitrate, and other contaminants from groundwater. Combined, the final action system and the interim action system, which operated from 1996 through 2012, has removed a total of 38,567 pounds (17,491 kilograms) of carbon tetrachloride from groundwater. In addition, a final-action soil vapor extraction system and the interim action system that operated from 1992 through 2011 removed a total of 176,635,935 pounds (80,107,000 kilograms) of carbon tetrachloride from the vadose zone. Figure 8.12 illustrates the total mass removed from the subsurface.

Two Low-Level Waste Management Areas (LLWMA-3 and LLWMA-4) in 200-ZP are monitored under RCRA interim-status, contaminant indicator parameter programs. 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 CERCLA remediation activities (operation of the 200 West P&T system) near WMA T, chromium concentrations are declining and the plume extents at both WMAs are shrinking.

Figure 8.12. 200-ZP Carbon Tetrachloride Mass Removed by Final Pump-and-Treat, Interim Pump-and-Treat, and Soil Vapor Extraction



The State-Approved Land Disposal Site (SALDS) receives treated water from the Hanford Site's Effluent Treatment Facility. It is regulated under a state waste discharge permit and has created a local tritium plume. All groundwater sampling results from the SALDS proximal wells were within permit compliance limits during 2013.

8.3.2 200-UP-1 Operable Unit

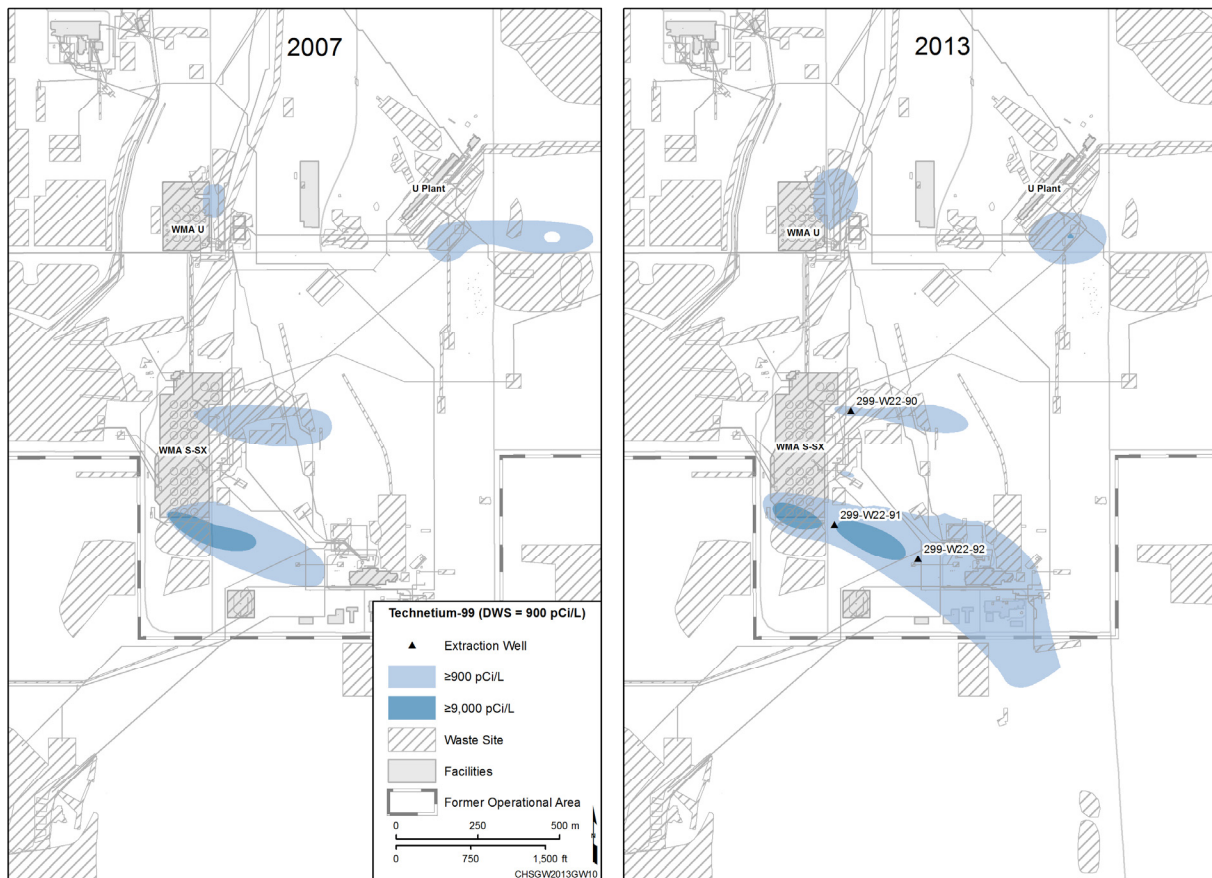
The southern portion of the 200 West Area and adjacent areas to the east and south comprise 200-UP-1. Contaminant sources included cribs, ponds, and single-shell tanks. Carbon tetrachloride, technetium-99, uranium, tritium, iodine-129, nitrate, and chromium plumes are present in groundwater. Carbon tetrachloride in this region originated from sources in 200-ZP-1.

An interim action ROD addressing all of the major contaminant plumes within the 200-UP-1 OU was published in 2012. The selected remedy in the ROD consists of a combination of P&T, MNA, hydraulic containment, and institutional controls.

A work plan released during September 2013 addressed the approach to be used to design P&T systems for uranium and technetium-99 near U Plant, a P&T system for the chromium plume southeast of 200 West Area, and an injection well system for hydraulic control of the iodine-129 plume while treatment technologies are investigated. The work plan also addressed continued operation of the groundwater extraction system at WMA S-SX.

Wells near WMA S-SX continued to show the highest technetium-99 concentrations on the Hanford Site in 2013. The plume has grown in recent years (Figure 8.13) and a P&T system began operating in July 2012 to remove contamination. In 2012 and 2013, the system removed a total of 1.03 curie of technetium-99; 21,080 pounds (9,560 kilograms) of nitrate; 39.5 pounds (17.9 kilograms) of chromium; and 267 pounds (121 kilograms) of carbon tetrachloride from groundwater.

Figure 8.13. WMA S-SX Technetium-99 Plume



The 200 West P&T system (discussed in the 200-ZP-1 section) is affecting groundwater flow in the northern part of 200-UP-1 near U Plant. Contaminant concentrations have declined in some wells and increased in other wells because of changing directions of groundwater flow. A groundwater extraction system to remediate the uranium and technetium-99 plumes in the U Plant area is currently being designed.

RCRA monitoring in 200-UP-1 includes 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. WMA S-SX has contaminated groundwater with chromium and nitrate. Water levels have declined at WMA S-SX due to groundwater extraction. Two monitoring wells went dry in 2013, two new wells were installed, and an additional replacement well is planned. Sources within WMA U have contaminated groundwater with nitrate and chromium. The groundwater beneath this tank farm is within the capture zone of a nearby extraction well. Indicator parameters did not exceed statistical comparison values at the 216-S-10 Pond and Ditch during 2013.

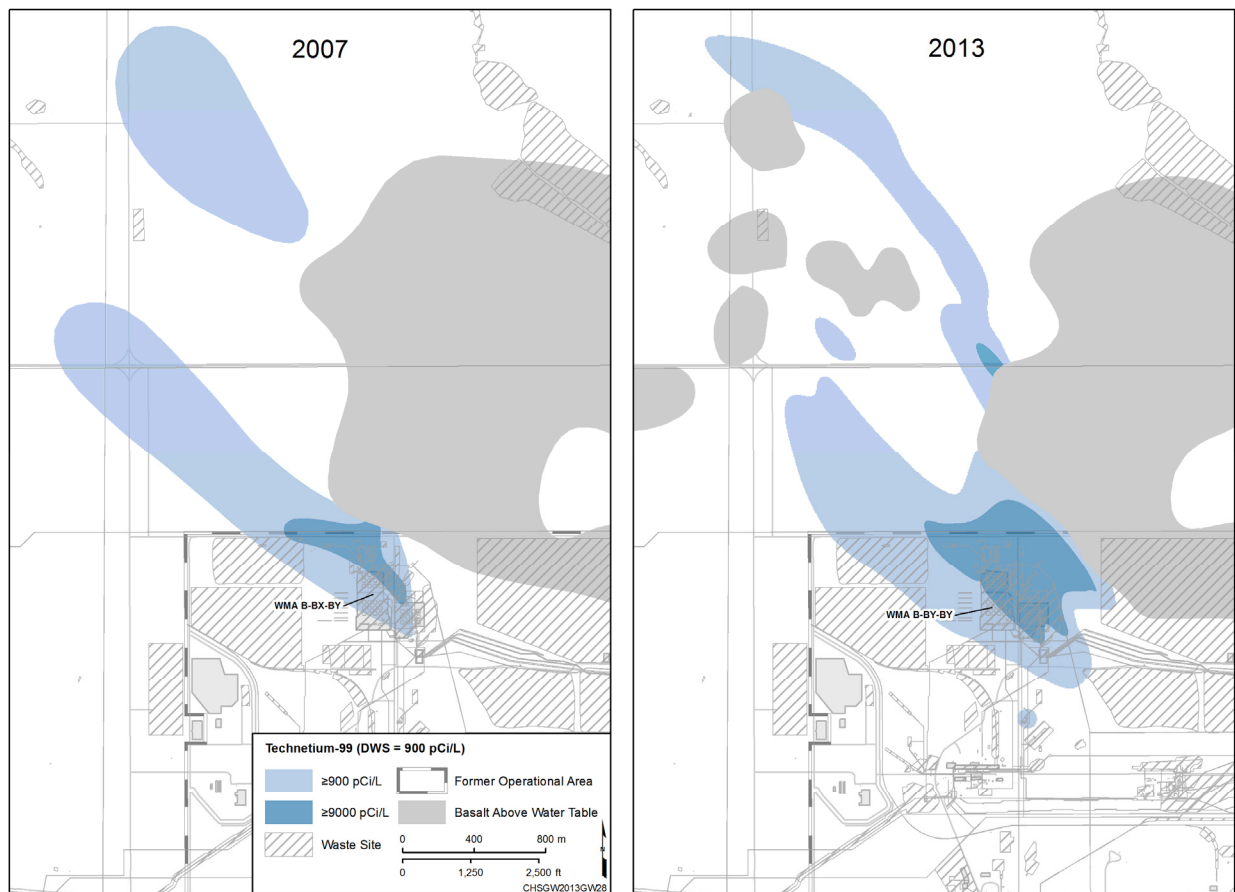
ERDF is a CERCLA disposal facility used for disposal of low-level radioactive mixed waste generated by remedial actions on the Hanford Site. The results of groundwater monitoring in 2013 continued to indicate that the facility has not adversely affected groundwater quality.

8.3.3 200-BP-5 Operable Unit

The 200-BP-5 groundwater interest area 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 200-BP-5 are yet to be made.

Nitrate, iodine-129, and technetium-99 form the largest contaminant plumes in 200-BP-5. These mobile contaminants have migrated to the northwest as a result of past groundwater flow. The high-concentration cores of these plumes have grown in size since 2007 due to continued drainage of contaminated water from the vadose zone into the aquifer (Figure 8.14). 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.

Figure 8.14. 200-BP-5 Technetium-99 Plume in 2007 Compared to 2013



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 through 2013, DOE operated a pumping test to remove this perched water before it reached groundwater. Approximately 71 pounds (32 kilograms) of uranium were removed through the end of 2013. DOE has proposed continuing the extraction of contaminated perched water as a non-time-critical removal action under CERCLA.

Six RCRA sites with groundwater monitoring requirements are located in 200-BP-5. 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. Because of the continued migration of this dangerous waste constituent, an additional well is planned to be installed at WMA B-BX-BY in 2014 to provide monitoring control. RCRA contamination indicator parameter monitoring continued at the 216-B-63 Trench, LLWMA-1, and LLWMA-2 in 2013. Results continued to show that these units have not adversely affected groundwater quality. DOE monitors LERF under a RCRA final-status detection program. Results showed no indication that the site has affected groundwater. In 2013, DOE prepared a class 2 modification of the permit including a new groundwater monitoring plan. This plan is going through public comment in early 2014 and may be implemented in late 2014.

8.3.4 200-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 200-PO-1. 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 in area by one-third since 1980 (Figure 8.15) and the maximum concentration has declined 90 percent. 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 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 include strontium-90, technetium-99, and uranium in smaller areas near their sources.

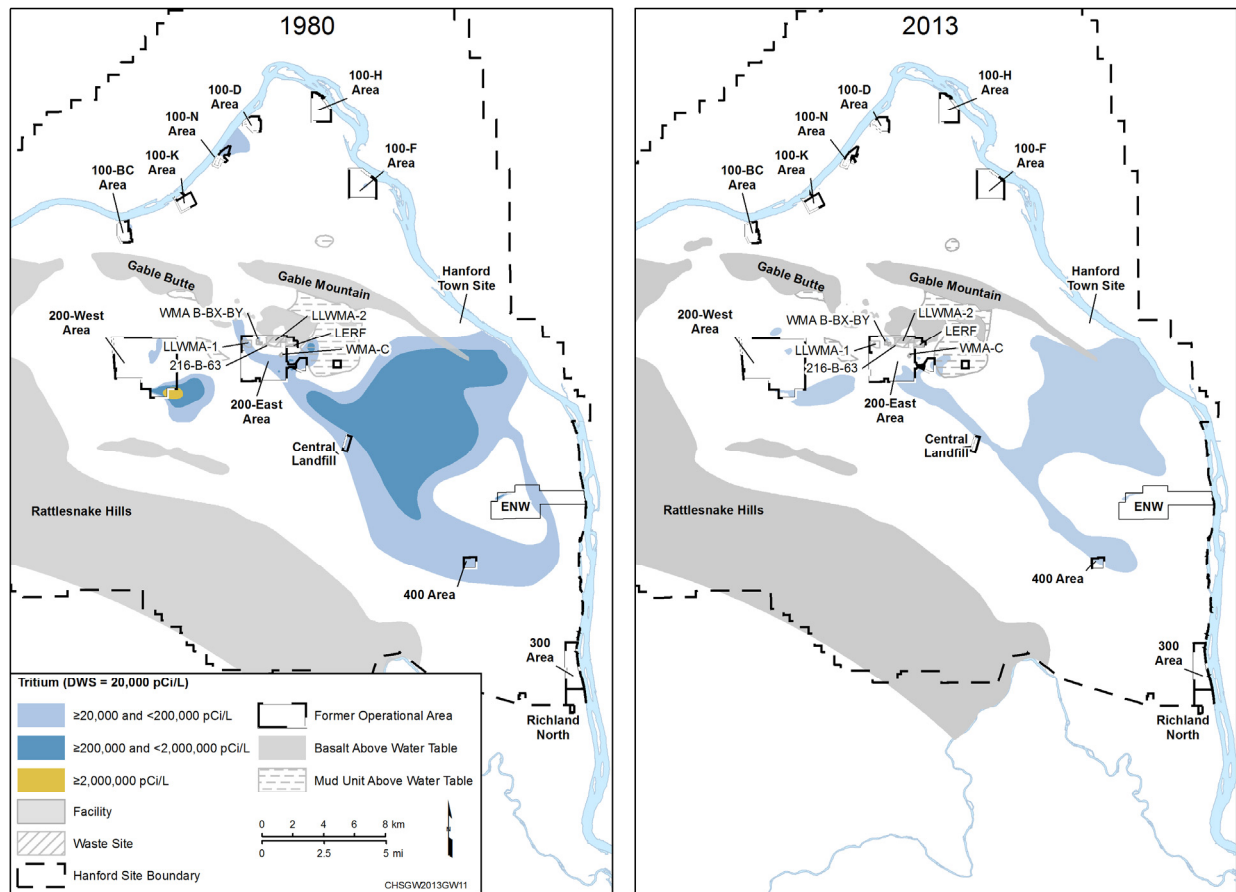
DOE conducted a CERCLA RI for 200-PO-1 in 2008 and 2009 and submitted an RI report to Ecology in 2012. In 2013, an RI report supplement was started to update the risk assessment using additional data collected since the RI report was completed. The report recommended that the next step in the CERCLA process should be an FS to develop remedies to address the groundwater contamination associated with the OU.

In 2013, RCRA assessment monitoring continued at WMA A-AX and interim-status indicator parameter programs continued at the 216-A-36B Crib, 216-A-37-1 Crib, 216-A-29 Ditch, 216-B-3 Pond, and Nonradioactive Dangerous Waste Landfill (NRDWL). One monitoring well with casing corrosion associated with WMA A/AX was decommissioned in 2013 and is scheduled to be replaced. Monitoring results provided no indication of releases from these facilities to groundwater. The Integrated Disposal Facility 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 Solid Waste Landfill is regulated under Washington State solid waste handling regulations. As in previous years, some of the monitoring wells showed higher concentrations of regulated constituents than the statistically calculated background threshold values. Background threshold values exceeded during 2013 included specific conductance, nitrite, sulfate, and total organic carbon. One monitoring well went dry in 2013.

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 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, where tritium concentrations are lower than at the top of the aquifer.

Figure 8.15. Hanford Site Tritium Plumes in 1980 Compared to 2013



8.4 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 (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 farther to the east and/or southeast.

In the northern Hanford Site, fine-grained sedimentary units, informally called the Ringold upper mud, confine deeper sediments in the Ringold Formation. In some parts of 100-HR-3 this unit is contaminated with hexavalent chromium at concentrations up to 133 µg/L.

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.

8.5 Wells

Over the lifetime of the Hanford Site, DOE has installed thousands of wells to monitor and remediate groundwater and provide geologic data. Figure 8.16 illustrates the number of wells installed during the past 10 years. During 2013, DOE installed 16 new wells and 18 new aquifer tubes (Table 8.3).

DOE identifies wells, boreholes, or other subsurface installations for decommissioning when they are no longer needed. In 2013, eight wells were physically decommissioned. This involved sealing the wells in compliance with Washington State groundwater protection laws ([WAC 173-160](#)).

Figure 8.16. New Wells Installed on the Hanford Site, 2004 to 2013
(Note: 2013 value is calendar year total)

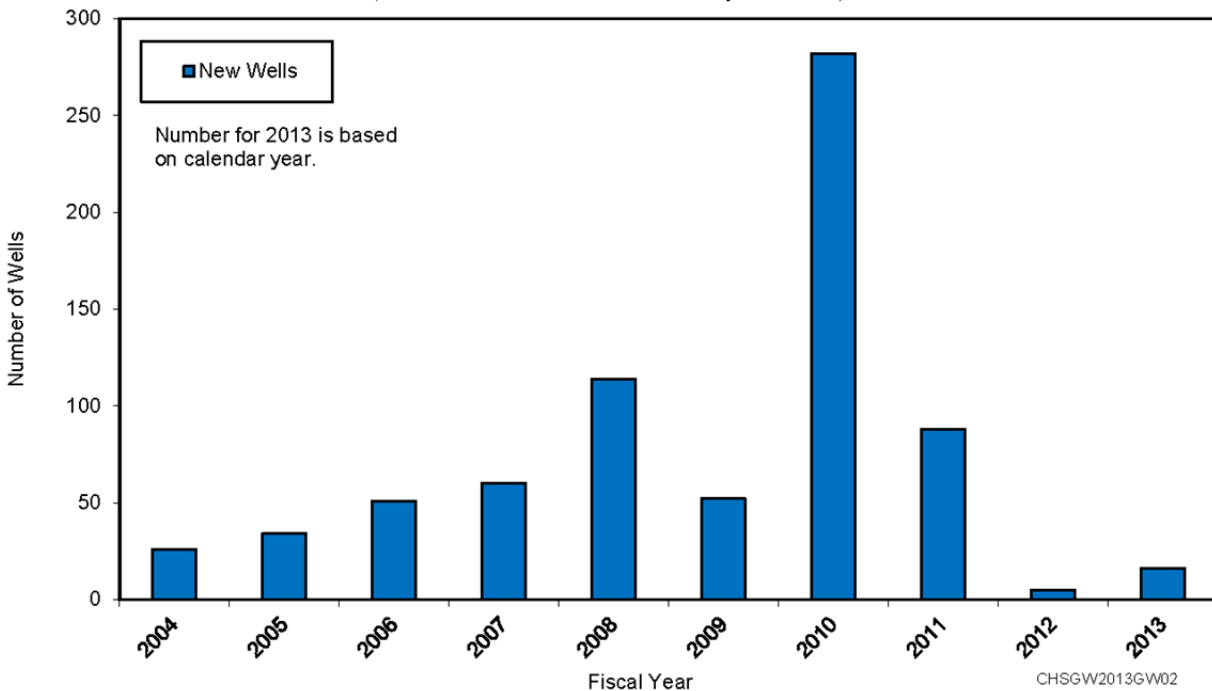


Table 8.3. New Wells and Aquifer Tubes Completed in 2013

Groundwater Interest Area	Wells	Aquifer Tubes
100-BC	0	18
100-HR-D	6	0
100-HR-H	4	0
200-UP	2	0
200-ZP	4	0
Total	16	18

8.6 Additional Information

The data presented in this report—and information on monitoring well locations, construction details, and screened intervals—can be found through the DOE Environmental Dashboard Application at <http://environet.hanford.gov/eda/>, in the interactive version of this document, or on the PHOENIX website at <http://phoenix.pnnl.gov>.

9.0 Soil Monitoring

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 onsite soil samples is used as a qualitative indicator and verification of ambient air sampling results per [FF-01](#).

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 that unplanned releases are compared. 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 2013 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

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 groundwater or 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 within the boundaries of operating facilities and remedial action sites. The number and locations of soil samples collected during 2013 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 ^{1,2}
	100-K	200 East ¹	200 West ¹	600 ¹	300 ¹	400	ERDF	
49	2	8	9	6	7	1	1	15

¹ Number of samples includes one or more replicate samples.

² 63 individual soil samples from the 200 and 600 Areas were combined into 15 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 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. Now that concentrations have leveled and are comparable to those samples collected offsite in previous years, the distant communities' comparison is no longer applicable to reporting figures as trends are variable yet stable at this point in time.

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 2013 were higher than the concentrations in samples collected farther away. The data also shows, as expected, that concentrations of certain radionuclides in 2013 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-239/240, and uranium were detected consistently in the 2013 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 2013 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 2013, as well as sampling location maps, are available upon request.

Soil samples collected in 2013 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 Areas. 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 detected in a number of soil samples in the 200, 300, and 600 Areas. Uranium isotopes were elevated in a small number of samples from the 200 and 600 Areas.

All areas, with the exception of ERDF, had samples with detections of cesium-137. These levels were below historical levels in the 200, 400 and 600 Areas, but slightly higher in the 300 Area. One sample from the 200 Areas had elevated concentrations in comparison to other samples collected. The levels were still five times lower than historical concentrations shown in that location. This particular sampling site also had slightly elevated levels of plutonium 239/240 and uranium when compared to historical data so the site was inspected and it appeared as though it had been remediated recently with evidence of discing. Ongoing remediation and traffic from disposal vehicles adjacent to and generally upwind of the sampling site may have led to the elevated concentration.

Strontium-90 was detected in the ERDF, 200, and 600 Area samples but levels fell well below historical concentrations. The ERDF soil sample collected also showed slightly elevated concentrations of

uranium; however, detections were comparable to levels observed in previous years at other near-facility sampling locations on the Hanford Site. Table 9.4 provides a summary of selected analytical results for samples from these sites.

Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides
(2009 through 2013)

*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.*

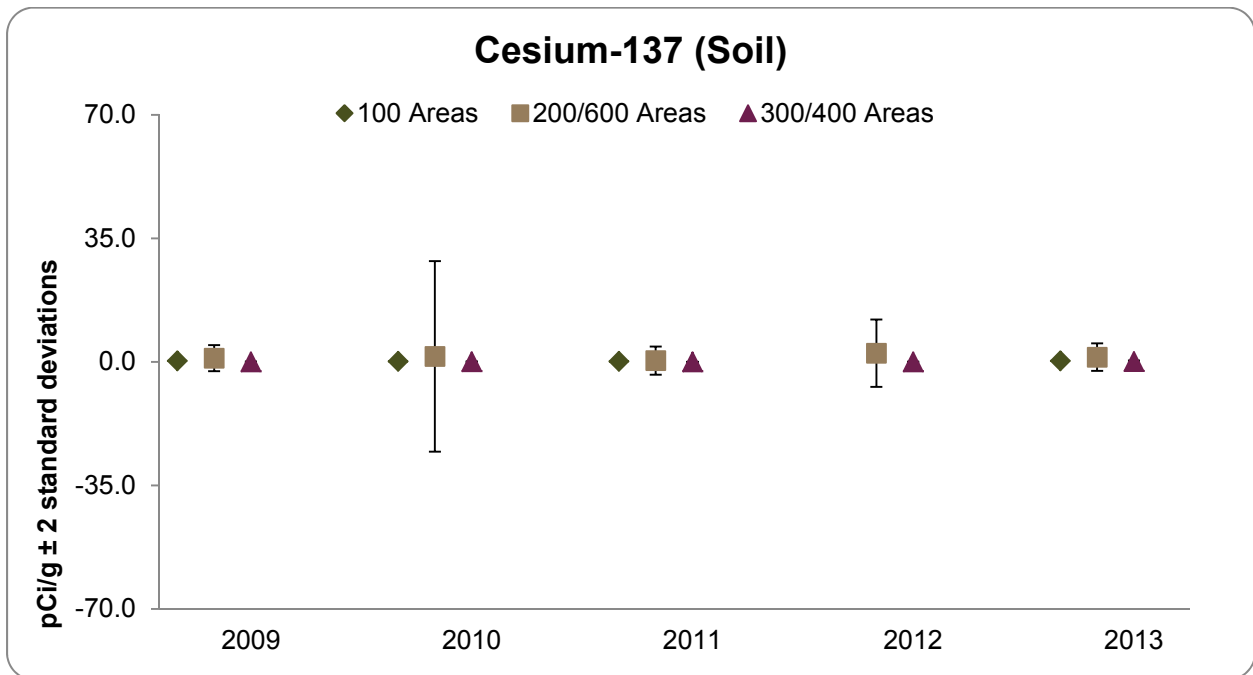


Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides (Cont.)
(2009 through 2013)

*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.*

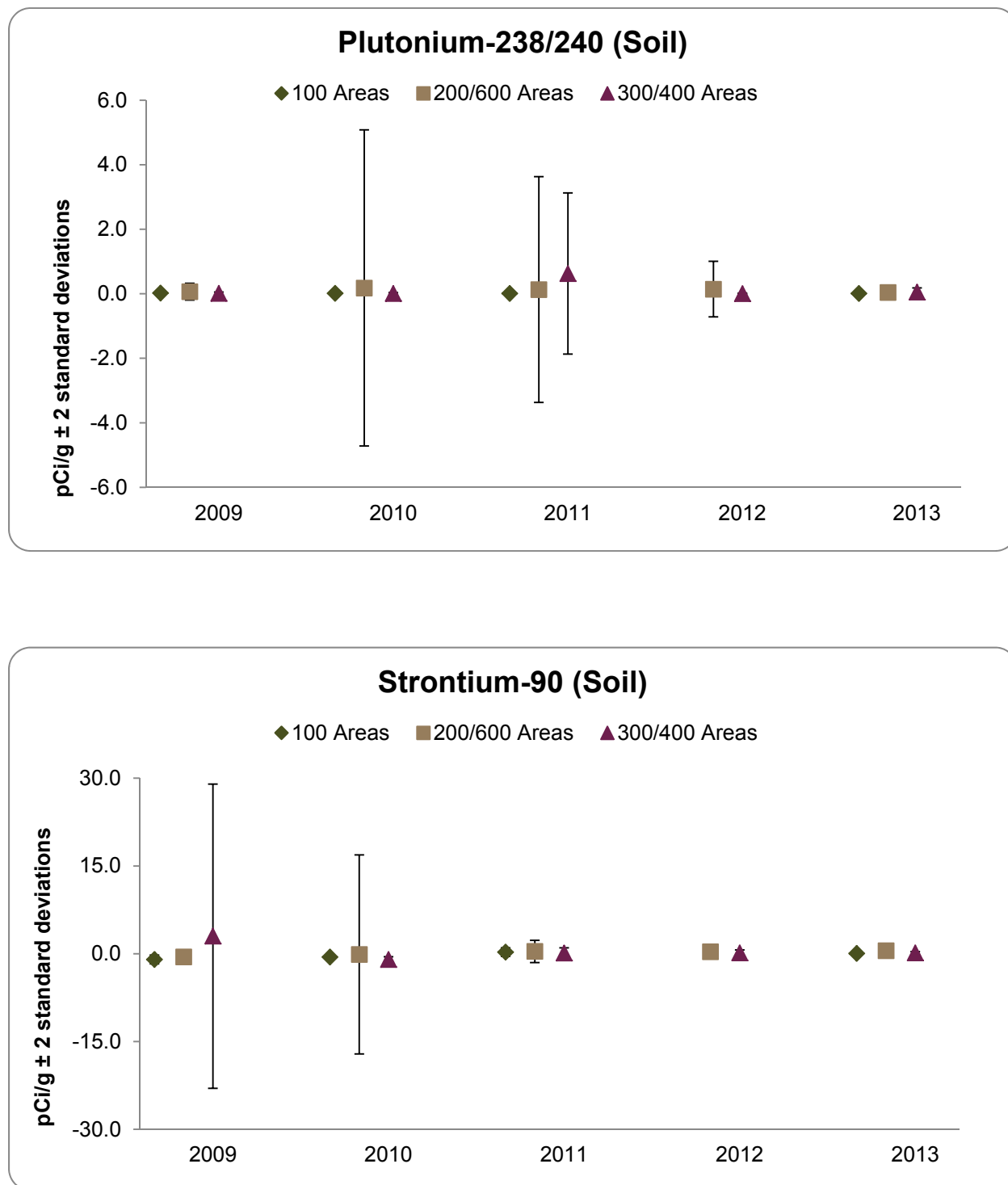


Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides (Cont.)
(2009 through 2013)

*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.*

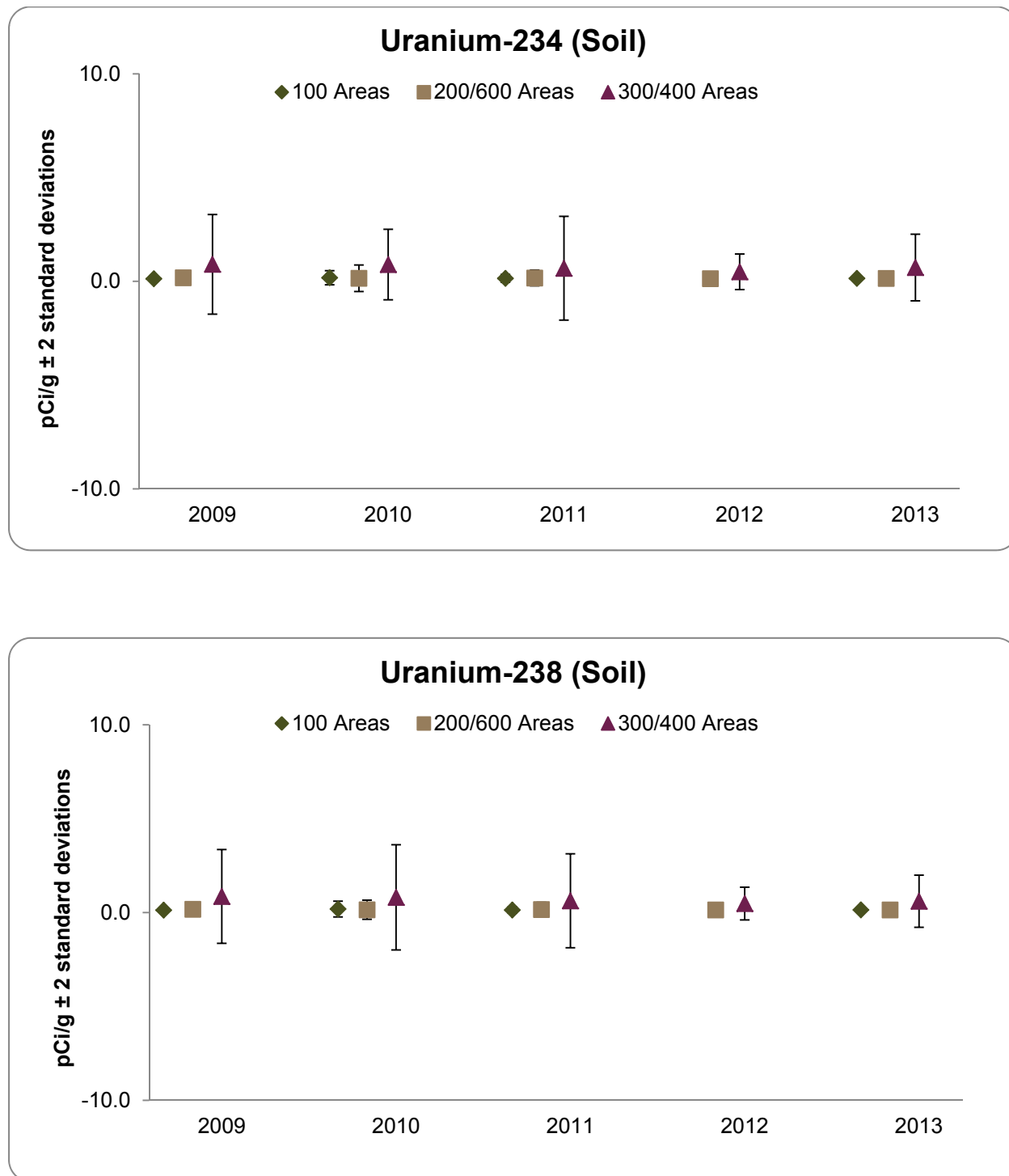


Table 9.3. Concentrations of Selected Radionuclides in Hanford Site Soil Samples
(pCi/g)
(2013 compared to previous years)

Isotope	Hanford Area	2013		Maximum ^(b) (pCi/gm)	2008 to 2012		Maximum ^(b) (pCi/gm)
		Number of Samples	Detects	Average ^(a,d) (pCi/gm)	Number of Samples	Detects	Average(a) (pCi/gm)
Cobalt 60	100	2	0	1.2E-02 ± 2.4E-03	41	4	6.5E-03 ± 4.0E-02
	200-E	8	0	-6.6E-04 ± 1.0E-02	67	0	-1.1E-03 ± 9.0E-03
	200-W	10	0	8.3E-04 ± 9.5E-03	120	1	-2.9E-05 ± 9.2E-03
	300	7	0	-1.2E-03 ± 8.1E-03	73	0	-4.0E-04 ± 7.2E-03
	400	1	0	–	5	0	-1.1E-03 ± 9.1E-03
	600	6	0	7.8E-04 ± 1.2E-02	76	0	-1.7E-02 ± 2.9E-01
Cesium 137	100	2	2	3.0E-01 ± 1.8E-01	41	40	2.0E-01 ± 3.7E-01
	200-E	8	8	2.5E+00 ± 5.6E+00	67	67	2.2E+00 ± 7.9E+00
	200-W	10	9	9.5E-01 ± 1.7E+00	120	119	1.2E+00 ± 2.7E+00
	300	7	4	8.7E-02 ± 3.0E-01	73	57	4.8E-02 ± 8.6E-02
	400	1	1	–	5	5	5.0E-02 ± 8.0E-02
	600	6	6	5.1E-01 ± 7.7E-01	76	74	2.0E+00 ± 2.2E+01
Plutonium 238	100	2	0	1.0E-03 ± 6.0E-03	41	1	1.9E-03 ± 3.3E-02
	200-E	8	0	1.3E-03 ± 2.8E-03	67	3	1.7E-03 ± 4.4E-02
	200-W	10	2	8.1E-03 ± 3.1E-02	120	10	9.8E-03 ± 5.9E-02
	300	7	0	1.6E-03 ± 5.7E-03	73	2	-5.6E-05 ± 2.5E-02
	400	1	0	–	5	0	-1.1E-02 ± 4.6E-02
	600	6	0	-2.3E-03 ± 4.2E-03	76	4	8.2E-03 ± 8.6E-02
Plutonium 239/240	100	2	1	9.0E-03 ± 1.4E-02	41	13	1.2E-02 ± 1.6E-02
	200-E	8	6	1.7E-02 ± 3.6E-02	67	24	6.6E-02 ± 8.4E-01
	200-W	10	8	5.6E-02 ± 8.5E-02	120	91	1.6E-01 ± 7.5E-01
	300	7	2	1.9E-02 ± 7.0E-01	73	19	9.4E-03 ± 2.6E-02
	400	1	0	–	5	1	7.8E-03 ± 2.1E-02
	600	6	4	2.0E-02 ± 3.4E-02	76	36	1.0E-01 ± 1.1E+00

Table 9.3. Concentrations of Selected Radionuclides in Hanford Site Soil Samples
(pCi/g)
(2013 compared to previous years)

Isotope	Hanford Area	2013		Maximum ^(b) (pCi/gm)	2008 to 2012		Maximum ^(b) (pCi/gm)
		Number of Samples	Detected	Average ^(a,d) (pCi/gm)	Number of Samples	Detected	Average(a) (pCi/gm)
Strontium 90	100	2	0	3.6E-02 ± 8.5E-02	41	1	-4.1E-01 ± 1.0E+00
	200-E	8	6	4.1E-01 ± 6.1E-01	67	11	2.2E-02 ± 4.4E+00
	200-W	10	6	4.2E-01 ± 7.2E-01	120	20	-1.2E-01 ± 2.6E+00
	300	7	0	1.5E-01 ± 2.3E-01	73	5	5.4E-01 ± 1.3E+01
	400	1	0	–	5	0	-2.9E-01 ± 1.3E+00
	600	6	3	2.7E-01 ± 2.8E-01	76	10	-1.9E-01 ± 1.0E+00
Uranium 234	100	2	2	1.4E-01 ± 1.7E-02	41	41	1.5E-01 ± 1.2E-01
	200-E	8	8	1.3E-01 ± 6.6E-02	67	66	1.5E-01 ± 8.3E-02
	200-W	10	10	1.6E-01 ± 1.2E-01	120	115	1.6E-01 ± 1.1E-01
	300	7	7	7.5E-01 ± 1.7E+00	73	73	6.8E-01 ± 1.7E+00
	400	1	1	–	5	5	2.9E-01 ± 4.5E-01
	600	6	6	1.3E-01 ± 4.7E-02	76	75	1.7E-01 ± 1.5E-01
Uranium 235	100	2	2	1.4E-02 ± 9.4E-03	41	20	1.2E-02 ± 1.5E-02
	200-E	8	2	4.1E-03 ± 1.1E-02	67	37	1.3E-02 ± 1.3E-02
	200-W	10	3	1.0E-02 ± 9.5E-03	113	63	1.5E-02 ± 2.0E-02
	300	7	7	5.7E-02 ± 1.4E-01	73	54	4.5E-02 ± 1.0E-01
	400	1	1	–	5	4	2.6E-02 ± 3.5E-02
	600	6	1	7.2E-03 ± 6.7E-03	66	37	1.5E-02 ± 1.8E-02
Uranium 238	100	2	2	1.5E-01 ± 5.4E-02	41	41	1.5E-01 ± 1.2E-01
	200-E	8	8	1.3E-01 ± 5.7E-02	67	66	1.6E-01 ± 7.8E-02
	200-W	10	10	1.6E-01 ± 1.4E-01	120	115	1.6E-01 ± 1.1E-01
	300	7	7	6.8E-01 ± 1.44E+00	73	72	6.8E-01 ± 1.7E+00
	400	1	1	–	5	5	3.2E-01 ± 6.1E-01
	600	6	6	1.3E-01 ± 3.8E-02	76	75	1.7E-01 ± 1.2E-01

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.

9.3 Radiological Contamination Investigations

JW Wilde

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 Areas were strontium-90, cesium-137, and plutonium-239/240. Uranium-234, uranium-235, and uranium-238 was routinely found in 300 Area samples.

There were 21 instances of radiological contamination in soil samples collected in 2013 during site investigations. Of the 21, 13 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 2013 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 2013, and provides the number of contamination incidents investigated from 2000 through 2013.

Table 9.5. Soil Contamination Incidents Investigated

Location	2013 Incidents	Year	Incidents
100 Area	0	2000	25
200 East Area		2001	20
Tank farms	0	2002	22
Burial grounds	2	2003	30
Cribs, ponds, and ditches	0	2004	19
Fence lines	0	2005	20
Roads and railroads	0	2006	25
Unplanned release sites	0	2007	17
Underground pipelines	2	2008	16
LERF/ETF	8	2009	28
Miscellaneous	2	2010	22
200 West Area		2011	10
Tank farms	1	2012	10
Burial grounds	0	2013	21
Cribs, ponds, and ditches	0		
Fence lines	0		
Roads and railroads	0		
Unplanned release sites	0		
Underground pipelines	0		
Miscellaneous	1		
Cross-site transfer line	0		
200-BC cribs and trenches	0		
200-North Area	0		
300 Area	2		
400 Area	0		
600 Area	3		
TOTAL	21		

10.0 Biota Monitoring

10.1 Agricultural Monitoring

ME Hoefler

Food and farm products (alfalfa, grapes, leafy vegetables, milk, potatoes, tomatoes, and wine) were collected in 2013 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 2013 were below levels that could be detected by analytical laboratories; however, some contaminants that could have potentially originated from the Hanford Site (e.g., tritium and beryllium) were found at low levels in some samples. These findings are presented in the following sections. Data for potassium-40 is 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 were 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-mrem (10-microSievert) dose per year ([DOE/RL-91-50](#)).

Agricultural products sampled in 2013 are listed in Table 10.1, and described in the following sections.

Figure 10.1. Agricultural Monitoring Locations

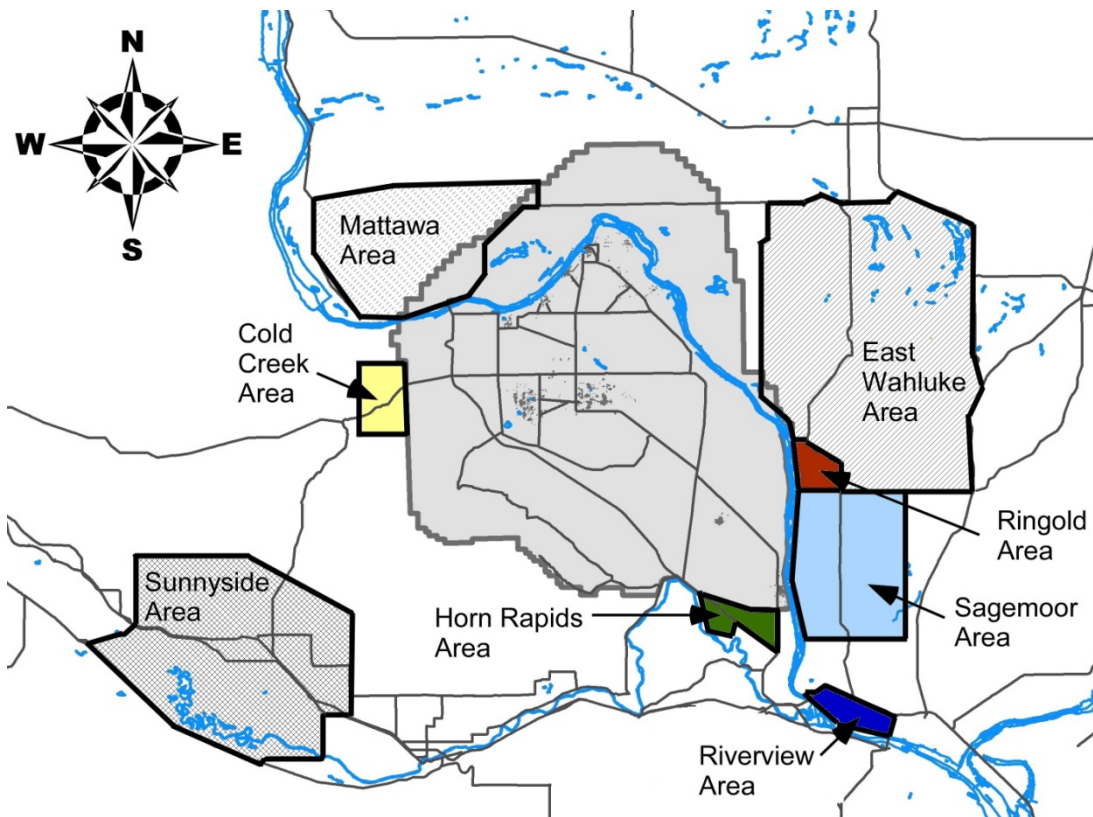


Table 10.1. Agricultural Monitoring Locations

Product	Sampling Locations	Analytes
Alfalfa	Horn Rapids, Riverview, Sagemoor, and Sunnyside	Gamma, Strontium-90
Grapes	Mattawa, Sagemoor, and Sunnyside	Gamma, Strontium-90
Leafy Vegetables	Riverview, Sagemoor, and Sunnyside	Gamma, Strontium-90
Milk	East Wahuake, Sagemoor, and Sunnyside	Gamma, Strontium-90, Tritium
Potatoes	East Wahuake, Horn Rapids, Riverview, and Sunnyside	Gamma, Strontium-90
Tomatoes	Riverview and Sunnyside	Gamma, Strontium-90, Tritium
Wine	Columbia Basin, Mattawa, and Yakima Valley	Gamma, Tritium

10.1.1 Milk

Milk samples were obtained quarterly in 2013 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 could potentially 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 2013. Concentrations ranged from a maximum of 58 pCi/L (2.2 Bq/L) in a Sagemoor area sample to 20 pCi/L (0.74 Bq/L) in a Sunnyside area sample. Annual average concentrations for the three sampling areas were 39 pCi/L (1.4 Bq/L) for Sagemoor (n = 5); 32 pCi/L (1.2 Bq/L) for East Wahluke (n = 4); and 43 pCi/L (1.6 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 2013.

Cesium-137 – No synthetic gamma emitters were detected in milk samples collected and analyzed in 2013.

Potassium-40 – Naturally occurring potassium-40 was detected in all milk samples collected in 2013. Concentrations ranged from a maximum of 1,570 pCi/L (58 Bq/L) in a Sunnyside sample to a minimum of 1,320 pCi/L (49 Bq/L) in a Sagemoor sample. The East Wahluke area had a maximum of 1,520 pCi/L (56 Bq/L) and there was an overall average of 1,349 pCi/L (50 Bq/L) for all results.

10.1.2 Fruit and Vegetables

Alfalfa, grapes, leafy vegetable (e.g., lettuce), potato, tomato, and wine samples were collected from upwind and downwind sampling areas during the 2013 growing season (Figure 10.1). All samples were analyzed for gamma-emitting radionuclides and strontium-90. Tomato samples also were monitored for tritium (Table 10.1). Alfalfa collections (all locations) and a single leafy vegetable sample (Riverview area) had slightly elevated concentrations of beryllium-7; however, these concentrations were within historical range and follow typical result patterns. All fruit and vegetable concentrations of cesium-137, cobalt-60, strontium-90, and tritium were reported as non-detects and were well within historical range.

All alfalfa, grape, leafy vegetable, potato, tomato, and wine samples had detectable concentration levels of naturally occurring potassium-40. Wine samples also had detections of tritium but all concentrations fell below historical levels.

10.2 Animal Monitoring

JW Wilde

The fish and wildlife species sampled and analyzed for Hanford Site operations-produced contaminants included mountain whitefish (*Prosopium williamsoni*), Nuttall's cottontail (*Sylvilagus nuttallii*), and Canada Goose (*Branta Canadensis*). 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 at least every 5 years.

Table 10.2. Animal Monitoring Analysis

Biota	Offsite		Gamma	Strontium-90	Trace Metals
	Locations	Onsite Locations			
Fish (mountain whitefish)	1	2	8	8	2
Mammals (cottontail rabbit)	1	1	3	3	0
Waterfowl (Canada Goose)	0	2	6	6	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).

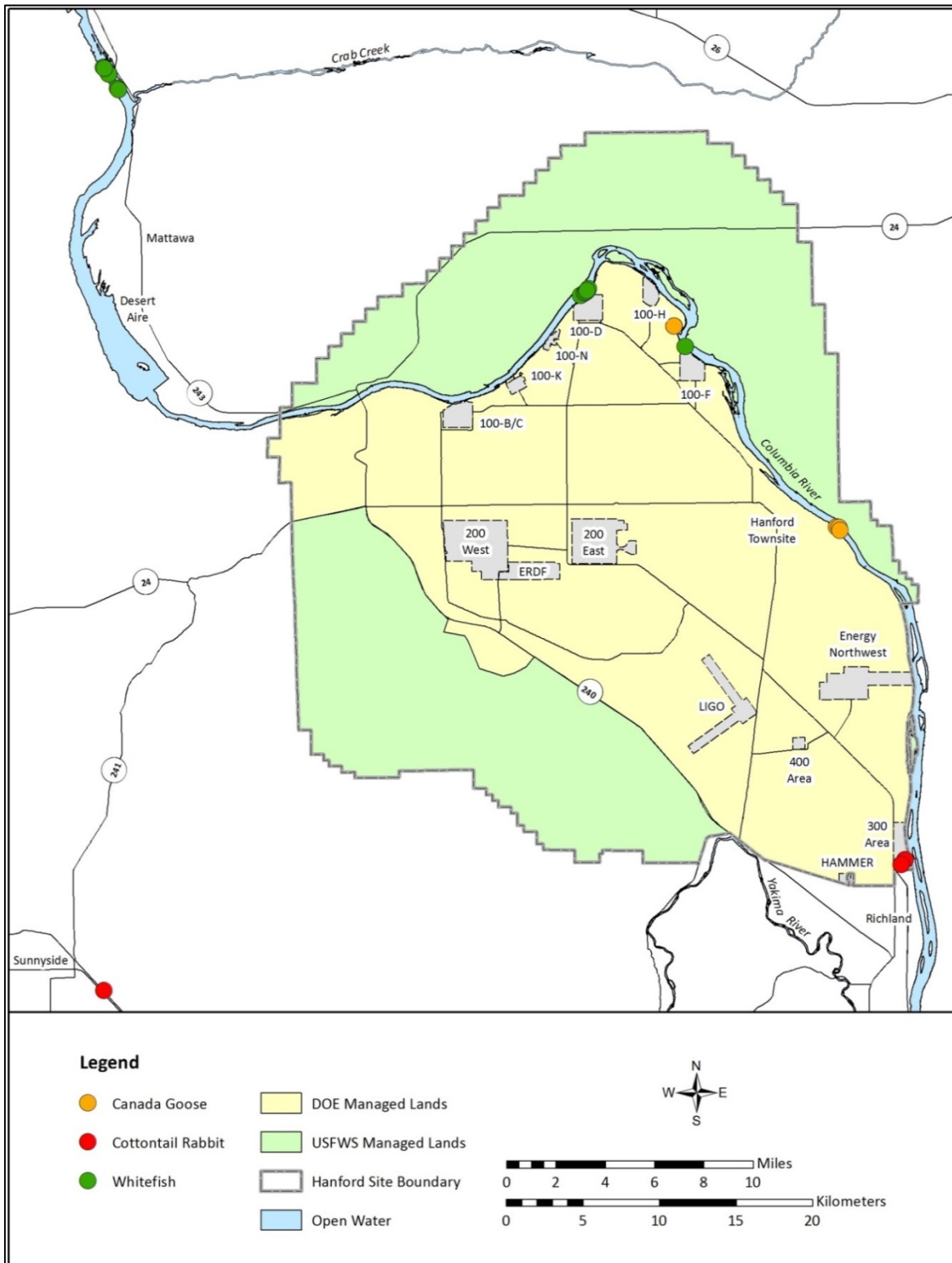
Cesium-137 is present in Hanford Site environments because of past Hanford Site operations, waste disposal practices, and from historical worldwide fallout resulting from nuclear weapons testing. Cesium-137 is particularly important to the human food chain because cesium-137 is chemically similar to 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. 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 Mountain Whitefish

Mountain whitefish were sampled and analyzed for radiological contaminants, because whitefish are sometimes harvested for food along the Hanford Reach of the Columbia River, whitefish 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.

Sixteen mountain whitefish were collected from three locations along the Hanford Reach, including a reference location (two collected between 100-H and 100-F areas, six collected along the 100-D shoreline, and eight collected reference locations at Priest Rapids Lake above the Priest Rapids Dam). One fish from the 100 Area and one fish from the reference area were sent to the WDOH. Two composite samples were used to achieve sample mass for larger suite of analyses including trace metals. Four fish from the 100 Area created one composite and four fish from the reference area made up the other. The following are the radiological results for the eight mountain whitefish samples analyzed:

Cesium-137. Synthetic 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 whitefish samples collected from the reference area and the two Hanford Reach locations.

Trace Metals. Two whitefish samples were analyzed for 17 different trace metal concentrations. Only aluminum, copper, manganese, and zinc were detected above the analytical detection limit at any location. Table 10.3 provides a summary of the metal analyses for the whitefish 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 described 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. Mountain Whitefish Metals Analyses

Isotope	Samples	Detects	Isotope	Samples	Detects
Aluminum	2	0	Manganese	2	0
Antimony	2	0	Mercury	2	2
Arsenic	2	0	Nickel	2	0
Beryllium	2	0	Selenium	2	2
Cadmium	2	0	Silver	2	0
Chromium	2	0	Thallium	2	0
Copper	2	0	Thorium	2	2
Lead	2	0	Uranium	2	0
			Zinc	2	2

10.2.2 Cottontail Rabbits

Nuttall's cottontails were sampled from the 300 Area. Cottontail rabbits are useful for detecting localized radioactive contamination because they have relatively small home ranges, forage or live in potentially contaminated soil, and can enter fenced restricted areas that contain radioactive waste materials.

Cottontail rabbits also may be useful as sentinel organisms both on and off the Hanford Site. Public access to cottontails exposed to Hanford Site environs is limited due to the range size of the animal. The 300 Area poses the largest probability for public contact with rabbits from Hanford Site environs.

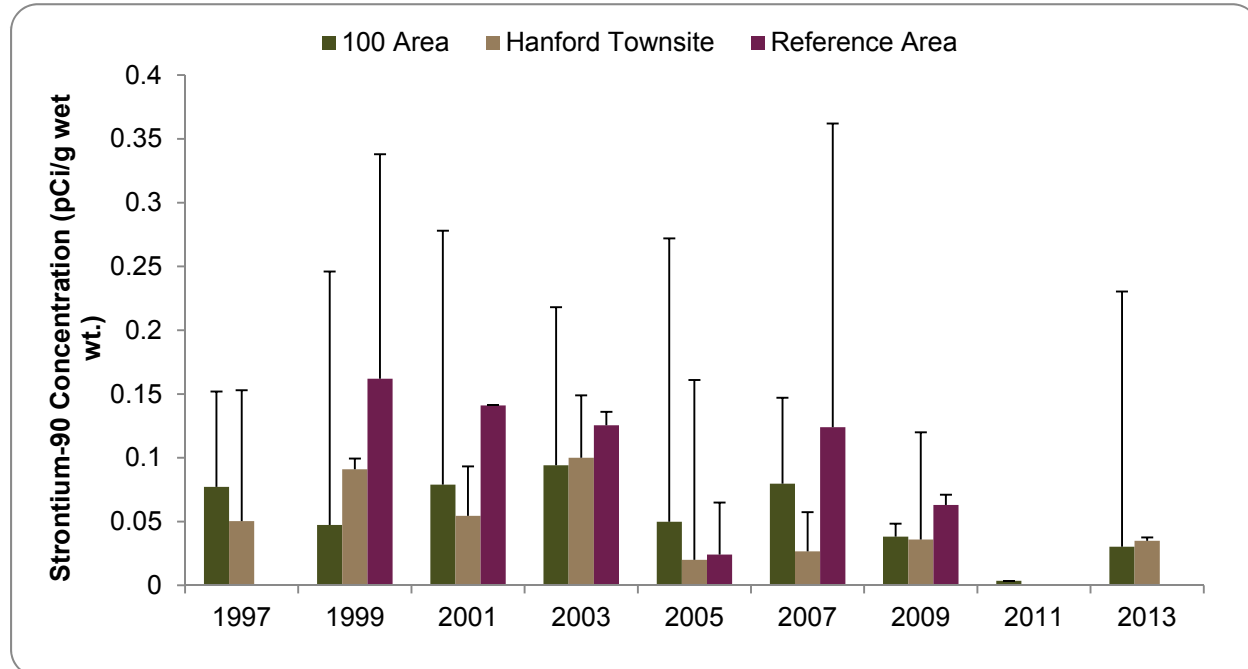
Five cottontail rabbits were collected for analysis, four from the 300 Area and one from the reference location (one rabbit from the 300 Area was sent to the WDOH). Results from the four remaining rabbits collected were compared to samples collected over the last 12 years. The data from these analyses is provided below.

Cesium-137. Cesium-137 was not found above detection limits (0.03 pCi/g [0.001 Bq/g] wet weight) in cottontail rabbit samples submitted for analysis in 2013. These results are consistent with a decline in cesium-137 levels in wildlife examined from the preceding 10 years.

Strontium-90. Only a single sample detected concentrations of strontium-90 in rabbit bone samples collected at the Hanford Site. The single detect was at 0.146 pCi/g (0.0054 Bq/g) wet weight.

Figure 10.3 shows the historical median and maximum strontium-90 concentrations (pCi/g wet weight) in rabbit bone samples collected near the Hanford Site and from reference locations from 2 of the past 10 sampling events.

Figure 10.3. Cottontail Bone Strontium-90 Concentrations
Maximum concentrations are represented by the upper bar.



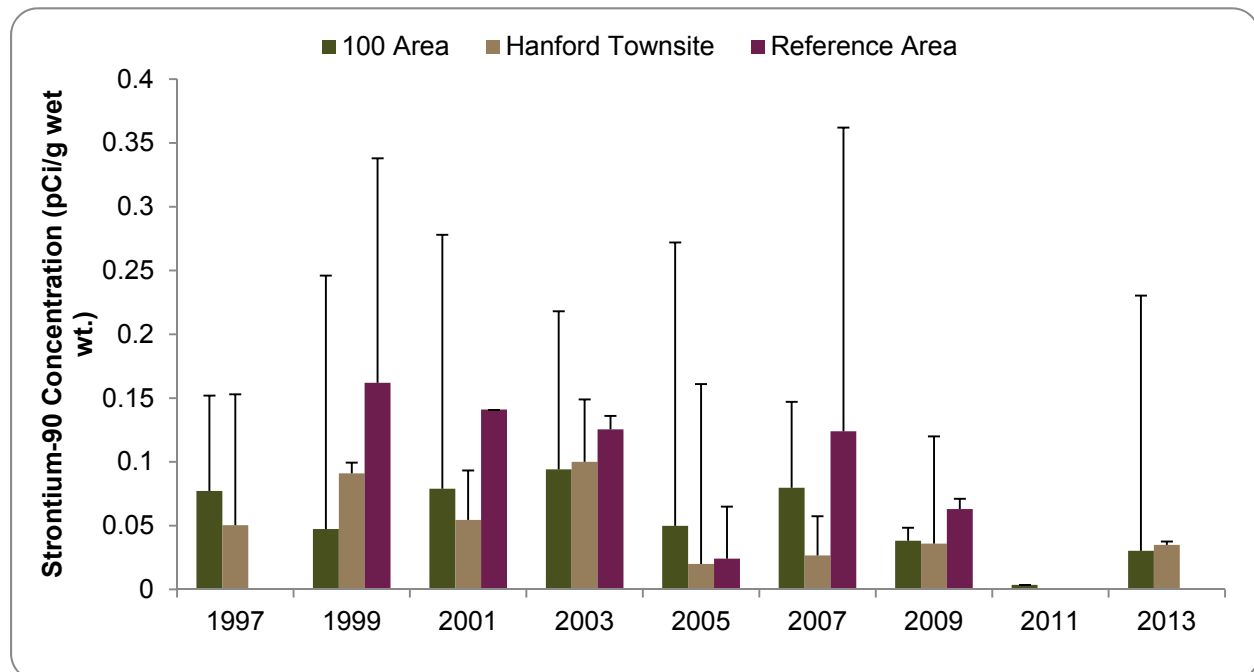
10.2.3 Waterfowl

Six Canada geese were collected along the Hanford Reach of the Columbia River, three between the Hanford town site and the 300 Area, three in the vicinity of the 100 Area, and attempts to collect a reference sample from the Priest Rapids lake area were unsuccessful. Sampling efforts focused on young birds, whose entire lifecycle before collection would have occurred on the Hanford Site. In addition, all six geese were monitored for cesium-137 in muscle and strontium-90 in bone. Radionuclide levels found in muscle and bone samples analyzed during 2013 were compared to levels measured in waterfowl samples collected at the Hanford Site over the past eight sample evolutions, and to samples collected from reference locations when available.

Cesium-137. Synthetic gamma-emitting radionuclides, including cesium-137, were below the detection limit (0.03 pCi/g [0.001 Bq/g] wet weight) for all Canada goose muscle samples analyzed. 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 Canada goose bone samples collected. Comparisons of the maximum and median strontium-90 concentrations reported for waterfowl bone samples collected at the Hanford Site since 1997 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 waterfowl samples for 2013 compared to previous years.

Figure 10.4. Canadian Goose Bone Strontium-90 Concentrations
Maximum concentrations are represented by the upper bar.



10.3 Vegetation Monitoring

ME Hoefer

Vegetation monitoring conducted on and around the Hanford Site in 2013 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 historical offsite vegetation samples are analyzed for information about atmospheric deposition of contaminants in and around operational areas onsite and in uncultivated areas offsite. 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 10.3 or [DOE/RL-91-50](#).

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 synthetic radionuclides in vegetation at specific locations. This database contains baseline data against 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 2013 are summarized in Table 10.4. Only those radionuclides with concentrations consistently above analytical detection limits are discussed in this section. Data obtained from onsite vegetation samples is used as a qualitative indicator and verification of ambient air sampling results per [FF-01](#). Vegetation samples from offsite locations were last collected in 2008 ([PNNL-18427](#)).

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, samples may consist 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 ^{a,b}
	100-N	200 East	200 West ^a	300 ^a	400	600 ^a	
41	2	7	7	1	1	6	13

^a Number of samples include one or more Replicate Samples.

^b 28-individual vegetation samples from the 200 and 600 Areas were combined into 13 composite samples using a multi-incremental approach.

10.3.1.1 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 2013 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 Areas and 600 Area, and uranium in the 300 Area and 400 Area.

Uranium-234 and uranium-238 were detected consistently in the 2013 samples. Individual samples of vegetation showed detectable concentrations of cesium-134, plutonium-238, and ruthenium-106, but remained within historical range. Five 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 average concentration of selected radionuclides for vegetation samples. (Note: Distant community vegetation samples were not collected in 2013.)

Table 10.5 provides a summary of selected radionuclides detected in vegetation samples collected and analyzed in 2013 and in previous years. The average and maximum results are reported for the six primary waste facility/operational areas of interest, including comparative data for the preceding 5 years. Vegetation samples collected in 2013 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 two vegetation samples in the 200 West Area. Eleven vegetation samples from the 200 Areas 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 10.5. Hanford Site Vegetation Average Concentration of Selected Radionuclides

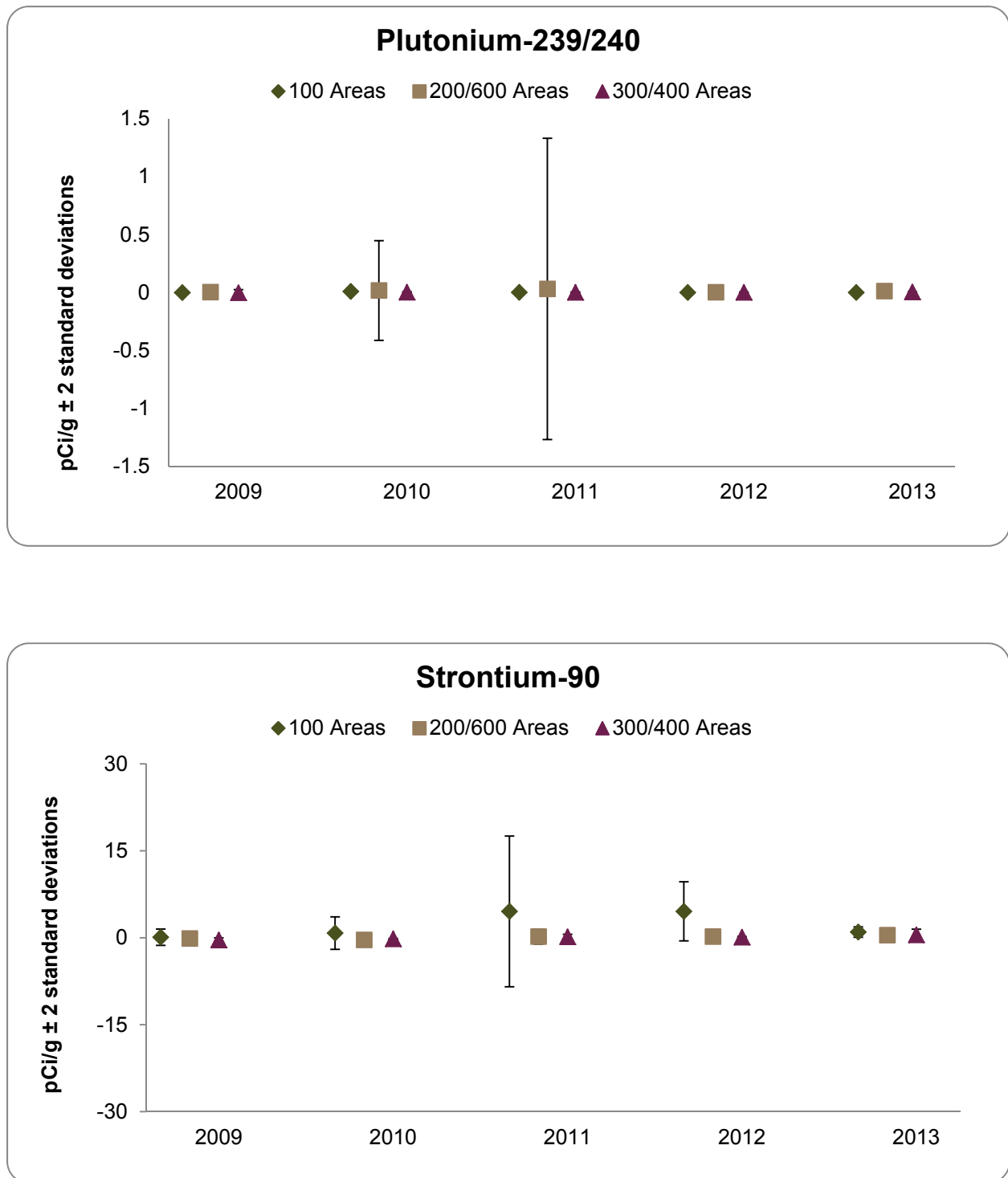


Figure 10.6. Average Concentration of Selected Radionuclides in Vegetation Samples from the Hanford Site (cont.)

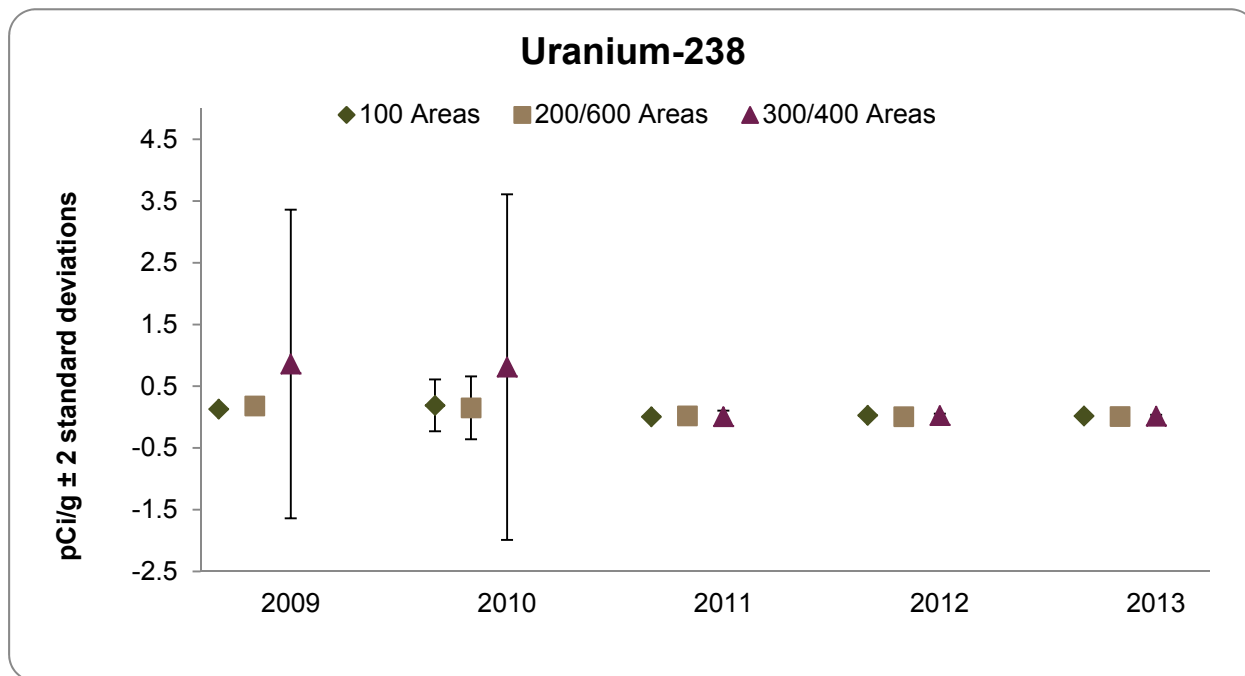
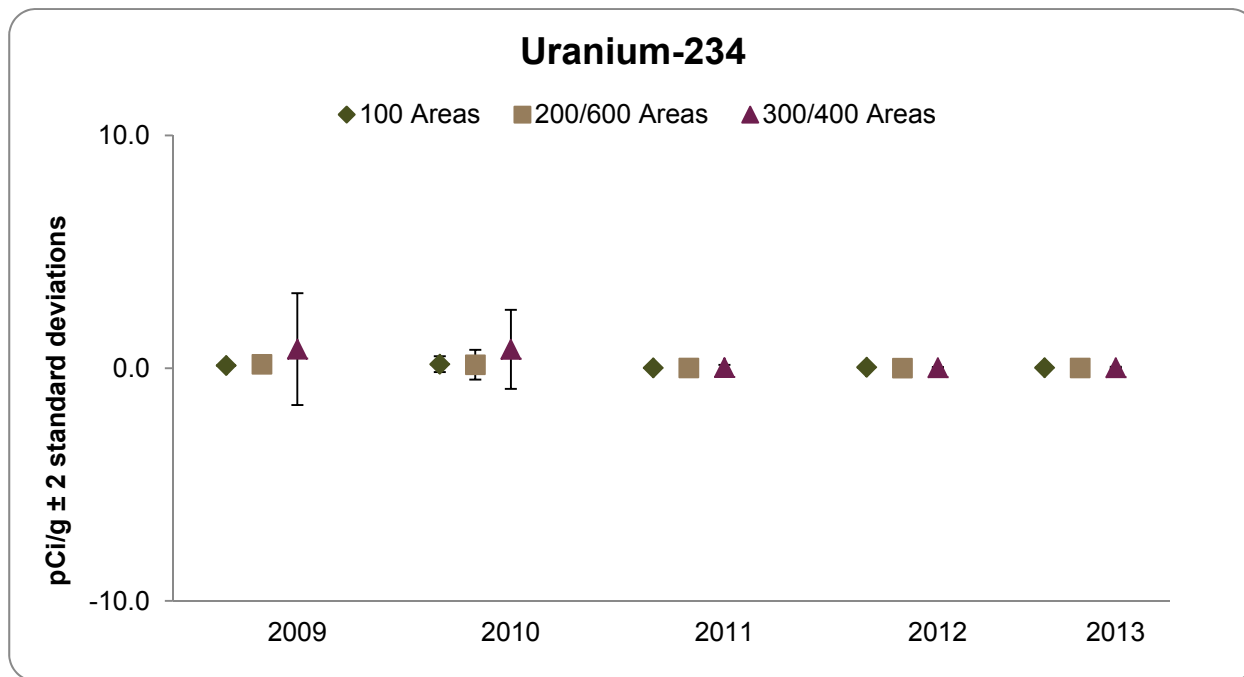


Table 10.5. Hanford Site Vegetation Concentrations of Selected Radionuclides

(pCi/g)

Isotope	Hanford Area	2013				2008-2012			
		Number of		Average ^(a, d)	Maximum ^(b)	Number of		Average ^(a)	Maximum ^(b)
		Samples	Detects	(pCi/gm)	(pCi/gm)	Samples	Detects	(pCi/gm)	(pCi/gm)
Cobalt 60	100	2	0	-1.0E-02 ± 1.4E-02	-2.9E-03 ± 2.9E-02 ^(c)	14	0	1.1E-02 ± 4.6E-02	3.6E-02 ± 8.8E-02 ^(c)
	200-E	7	0	1.9E-03 ± 2.2E-02	1.4E-02 ± 1.8E-02 ^(c)	45	0	-4.8E-03 ± 6.2E-02	5.4E-02 ± 1.1E-01 ^(c)
	200-W	7	0	4.6E-03 ± 2.1E-02	2.9E-02 ± 3.2E-02 ^(c)	98	0	-7.7E-03 ± 6.3E-02	1.1E-01 ± 9.5E-02 ^(c)
	300	1	0	—	1.6E-02 ± 2.8E-02 ^(c)	3	0	2.0E-02 ± 5.8E-02	5.6E-02 ± 5.7E-02 ^(c)
	400	1	0	—	-5.0E-03 ± 1.4E-02 ^(c)	4	0	-8.6E-03 ± 5.1E-02	2.5E-02 ± 3.8E-02 ^(c)
	600	6	0	3.8E-03 ± 1.7E-02	1.9E-02 ± 1.7E-02 ^(c)	68	1	4.1E-03 ± 8.9E-02	2.6E-01 ± 1.3E-01
Cesium 137	100	2	0	1.1E-02 ± 4.6E-02	3.4E-02 ± 3.7E-02 ^(c)	14	1	1.3E-02 ± 6.6E-02	8.7E-02 ± 8.5E-02 ^(c)
	200-E	7	5	5.7E-02 ± 5.8E-02	1.1E-01 ± 4.8E-02	45	8	5.5E-02 ± 1.4E-01	3.3E-01 ± 1.4E-01
	200-W	7	3	4.6E-02 ± 7.5E-02	1.3E-01 ± 3.4E-02	98	22	6.7E-02 ± 1.3E-01	3.2E-01 ± 1.2E-01
	300	1	0	—	1.5E-02 ± 2.9E-02 ^(c)	3	0	3.6E-02 ± 5.0E-02	5.9E-02 ± 5.9E-02 ^(c)
	400	1	0	—	1.8E-03 ± 1.3E-02 ^(c)	4	0	1.4E-03 ± 5.9E-02	2.8E-02 ± 3.8E-02 ^(c)
	600	6	0	1.0E-02 ± 1.7E-02	2.1E-02 ± 1.6E-02 ^(c)	68	12	3.8E-02 ± 1.4E-01	2.0E-01 ± 8.6E-02
Plutonium 138	100	2	0	-2.4E-03 ± 3.0E-05	-2.4E-03 ± 6.8E-03 ^(c)	14	0	-2.4E-03 ± 2.0E-02	6.4E-03 ± 1.4E-02 ^(c)
	200-E	7	0	1.2E-03 ± 3.8E-03	3.3E-03 ± 5.8E-03 ^(c)	45	3	2.2E-03 ± 1.8E-02	3.5E-02 ± 1.4E-02
	200-W	7	0	-1.6E-06 ± 2.8E-03	1.4E-03 ± 8.1E-03 ^(c)	98	4	9.9E-04 ± 1.4E-02	2.7E-02 ± 1.2E-02
	300	1	0	—	1.1E-03 ± 3.9E-03 ^(c)	3	0	3.2E-05 ± 2.4E-03	9.3E-04 ± 9.3E-03 ^(c)
	400	1	0	—	-9.3E-04 ± 3.2E-03 ^(c)	4	0	4.1E-03 ± 1.4E-02	1.3E-02 ± 1.8E-02 ^(c)
	600	5	0	-6.0E-04 ± 5.1E-03	2.6E-03 ± 2.6E-02 ^(c)	68	1	2.8E-03 ± 1.7E-02	3.2E-02 ± 2.3E-02 ^(c)
Plutonium 239/240	100	2	0	-7.0E-04 ± 3.4E-03	1.0E-03 ± 1.0E-02 ^(c)	14	2	1.6E-03 ± 8.4E-03	9.2E-03 ± 7.3E-03
	200-E	7	0	2.3E-03 ± 2.7E-03	5.2E-03 ± 5.2E-02 ^(c)	45	1	2.4E-03 ± 1.7E-02	5.9E-02 ± 2.2E-02
	200-W	7	2	5.8E-03 ± 8.3E-03	1.3E-02 ± 9.1E-03	98	40	3.1E-02 ± 2.8E-01	1.3E+00 ± 2.8E-01
	300	1	0	—	4.4E-03 ± 5.5E-03 ^(c)	3	1	1.3E-03 ± 6.0E-03	4.2E-03 ± 3.9E-03
	400	1	0	—	3.7E-03 ± 4.3E-03 ^(c)	4	0	9.6E-04 ± 3.7E-03	2.8E-03 ± 4.2E-03 ^(c)
	600	6	0	3.8E-04 ± 5.5E-03	3.0E-03 ± 3.0E-02 ^(c)	68	10	3.3E-03 ± 1.3E-02	3.6E-02 ± 1.6E-02

Table 10.5. Hanford Site Vegetation Concentrations of Selected Radionuclides

(pCi/g)

Isotope	Hanford Area	2013				2008-2012			
		Number of		Average ^(a, d)	Maximum ^(b)	Number of		Average ^(a)	Maximum ^(b)
		Samples	Detects	(pCi/gm)	(pCi/gm)	Samples	Detects	(pCi/gm)	(pCi/gm)
Strontium 90	100	2	2	9.7E-01 ± 6.0E-01	1.3E+00 ± 3.2E-01	14	8	1.9E+00 ± 7.4E+00	1.3E+01 ± 1.7E+00
	200-E	7	4	4.1E-01 ± 4.9E-01	8.2E-01 ± 1.8E-01	45	14	-1.8E-02 ± 1.2E+00	1.0E+00 ± 2.8E-01
	200-W	7	3	2.8E-01 ± 3.0E-01	5.3E-01 ± 2.0E-01	98	8	-1.2E-01 ± 7.2E-01	7.4E-01 ± 2.0E-01
	300	1	1	—	8.4E-01 ± 1.9E-01	3	0	-1.9E-01 ± 6.2E-01	1.7E-01 ± 1.5E-01 ^(c)
	400	1	0	—	1.5E-01 ± 1.7E-01 ^(c)	4	0	-1.4E-01 ± 2.9E-01	1.0E-02 ± 1.0E-01 ^(c)
	600	6	4	2.4E-01 ± 3.0E-01	4.2E-01 ± 1.8E-01	68	3	-8.1E-02 ± 7.8E-01	1.3E+00 ± 3.4E-01
Uranium 234	100	2	2	2.2E-02 ± 1.0E-02	2.8E-02 ± 1.2E-02	14	11	1.5E-02 ± 2.7E-02	6.2E-02 ± 2.2E-02
	200-E	7	3	7.7E-03 ± 9.7E-03	1.5E-02 ± 8.8E-03	45	40	1.3E-02 ± 9.6E-03	2.6E-02 ± 1.2E-02
	200-W	7	6	1.3E-02 ± 6.5E-03	1.7E-02 ± 1.0E-02	98	92	1.7E-02 ± 2.3E-02	1.1E-01 ± 3.5E-02
	300	1	1	—	3.4E-02 ± 1.4E-02	3	2	2.7E-02 ± 3.8E-02	5.4E-02 ± 2.0E-02
	400	1	1	—	8.6E-03 ± 6.4E-03	4	3	1.7E-02 ± 7.1E-03	2.0E-02 ± 1.0E-02
	600	6	4	9.1E-03 ± 8.4E-03	1.8E-02 ± 9.6E-03	68	51	1.4E-02 ± 2.1E-02	8.4E-02 ± 2.8E-02
Uranium 235	100	2	0	3.0E-03 ± 3.1E-04	3.1E-03 ± 3.7E-03 ^(c)	14	4	4.3E-03 ± 6.0E-03	1.0E-02 ± 7.5E-03
	200-E	7	2	2.7E-03 ± 2.9E-03	5.1E-03 ± 4.8E-03	45	4	2.5E-02 ± 2.9E-01	1.0E+00 ± 0.0E ^(c)
	200-W	7	1	3.6E-03 ± 3.1E-03	7.1E-03 ± 5.7E-03	98	26	3.4E-03 ± 5.0E-03	1.3E-02 ± 7.9E-03
	300	1	0	—	2.9E-03 ± 4.4E-03 ^(c)	3	1	2.8E-03 ± 2.8E-03	4.4E-03 ± 4.1E-03
	400	1	1	—	3.8E-03 ± 3.9E-03	4	1	4.0E-03 ± 2.8E-03	6.1E-03 ± 5.2E-03
	600	6	1	2.4E-03 ± 3.0E-03	4.7E-03 ± 4.4E-03	67	13	3.3E-03 ± 4.4E-03	1.1E-02 ± 7.7E-03
Uranium 238	100	2	2	1.9E-02 ± 7.2E-03	2.3E-02 ± 1.1E-02	14	11	1.0E-02 ± 2.2E-02	4.9E-02 ± 1.8E-02
	200-E	7	2	7.3E-03 ± 7.8E-03	1.5E-02 ± 8.4E-03	45	35	9.4E-03 ± 8.4E-03	1.8E-02 ± 9.5E-03
	200-W	7	5	9.6E-03 ± 7.3E-03	1.5E-02 ± 8.4E-03	98	83	1.4E-02 ± 2.9E-02	1.4E-01 ± 4.3E-02
	300	1	1	—	2.3E-02 ± 1.2E-02	3	3	2.2E-02 ± 3.3E-02	4.6E-02 ± 1.8E-02
	400	1	1	—	7.7E-03 ± 5.5E-03	4	4	1.0E-02 ± 6.6E-03	1.4E-02 ± 9.2E-03
	600	6	3	5.9E-03 ± 7.6E-03	1.4E-02 ± 8.1E-03	68	55	1.1E-02 ± 1.6E-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.

10.3.1.2 Radiological Contamination*JW Wilde 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 35 vegetation samples surveyed during the 2013 investigations. Twenty-six of the samples were Russian thistle (*Salsola kali*) or fragments and nine samples were broadleaf cattail (*Typha latifolia*). No samples were analyzed for specific radionuclides, and all samples were disposed at a licensed facility.

Section 10.3.1 provided 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 2000 through 2013.

Table 10.6. Hanford Site Vegetation Contamination Incidents Investigated

Year	Incidents	Year	Incidents	Location
2000	66	2013		200 East Area
2001	31		2	Tank Farms
2002	16		8	Burial grounds
2003	32		0	Cribs, ponds, and ditches
2004	60		1	Fence lines
2005	66		0	Roads and railroads
2006	75		0	Unplanned release sites
2007	62		0	Underground pipelines
2008	127		9	LERF/ETF
2009	109		2	Miscellaneous
2010	36			200 West Area
2011	29		4	Tank Farms
2012	18		0	Burial grounds
2013	35		0	Cribs, ponds, and ditches
			1	Fence lines
			0	Roads and railroads
			0	Unplanned release sites
			0	Underground pipelines
			5	Miscellaneous
			0	Cross-site transfer line
			0	200-BC Cribs and trenches
			0	200-North Area
			0	100 Areas
			0	300 Area
			0	400 Area
			3	600 Area
			0	1100 Area
			35	Total

10.3.2 Vegetation Control

JM Rodriguez and RC Roos

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 of plants in contaminated or potentially contaminated areas, and monitoring, controlling, and removing unwanted (noxious) plant species.

Approximately 2,218 acres (898 hectares) were treated with herbicides in 2013 on radiological waste sites, around operations areas, and along roadways to keep 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 more than one herbicide application.

10.3.2.1 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. Only 5 acres (2 hectares) of noxious weeds on the Hanford Site were treated with herbicides in 2013 along roadways. Budget limitations together with an unresolved procedure for NEPA compliance prevented treatment off road, and limited treatment on roads to the most critical areas. In 2012, the *Environmental Assessment, Integrated Vegetation Management on the Hanford Site, Richland, Washington* ([DOE/EA-1728-F](#)) was completed in 2012. The FONSI clears the way to develop an appropriate process for NEPA clearance of noxious weed control. As the process is clarified, control of noxious weeds will resume.

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 2013 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 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 2013 consisted of hand pulling individual plants as they were identified. The number and size of yellow starthistle populations in 2013 were greater than could be effectively controlled by hand pulling. However, seed production was substantially reduced by hand pulling plants before seed could be spread.

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.

As the population of yellow starthistle plants is reduced, it can no longer sustain a robust population of the biological control organisms. As the population of bio controls fails, greater emphasis needs to be placed on effective monitoring and control to continue toward eradication of the species at Hanford.

Rush Skeletonweed (*Chondrilla juncea*). Rush skeletonweed is scattered over large areas of the Hanford Site. 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 destroyed 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 2013 while NEPA authorization was being finalized. Active control of babysbreath in 2013 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 is found near Energy Northwest on 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. Budget reductions and NEPA compliance limited control of diffuse knapweed to hand pulling in a few critical areas. 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 2013. 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, widely fluctuating water levels along the Columbia River destroy the biological control organisms as they attempt to over-winter in the soil at the base of the plants. Winter mortality prevents an effective population of control agents from developing. No control measures were applied in 2013 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 continue to be treated with herbicide and will be monitored until they are eradicated; however, no active control measures were performed in 2013.

Spotted Knapweed (*Centaurea maculosa*). Spotted knapweed at the Hanford Site has been controlled so that sprouts or seedlings are rare. In 2013, 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 cross over to control spotted knapweed. Most biological controls for diffuse knapweed also are effective for spotted knapweed.

10.4 Waste Site Remediation and Revegetation

RC Roos and JM Rodriguez

Approximately 8.5 acres (3.4 hectares) 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 waste sites and to repair damage from ground-disturbing maintenance operations. An unusually dry fall prevented good seed germination, and discouraged further 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 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 lifecycle, 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 feet (0.6 to 1.2 meters) 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.

11.0 Resource Protection

11.1 Ecological Protection

JW Wilde, JJ Nugent, and JA Pottmeyer

Ecological monitoring is performed on the Hanford Site to collect and track data needed to ensure compliance with an array of environmental laws, regulations, and policies governing DOE activities. Ecological monitoring data provide baseline information about the plants, animals, and habitat under RL stewardship at Hanford that is required for decision-making under NEPA and CERCLA.

The CLUP-EIS ([DOE/EIS-0222-F](#)) evaluated the impacts associated with future land-use planning at the Hanford Site. The purpose of this land-use plan and its implementing procedures is to facilitate decision-making about the site's uses and facilities over at least the next 50 years. The DOE decision to adopt the CLUP seeks to balance continuing land-use needs at Hanford with the preservation of important ecological and cultural values of the site and future economic development in the area (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement").

The BRMP ([DOE/RL-96-32](#)) is identified by the CLUP as the primary implementation control for managing and protecting natural resources on the Hanford Site. According to the CLUP, the BRMP:

“provides a mechanism for ensuring compliance with laws protecting biological resources; provides a framework for ensuring that appropriate biological resource goals, objectives, and tools are in place to make DOE an effective steward of the Hanford biological resources; and implements an ecosystem management approach for biological resources on the Site. The BRMP provides a comprehensive direction that specifies DOE biological resource policies, goals, and objectives.”

RL places priority on monitoring those plant and animal species or habitats with specific regulatory protections or requirements; that are rare and/or declining (federal or state listed endangered, threatened, or sensitive species); or are of significant interest to federal, state, or tribal governments or the public. The BRMP ranks wildlife species and habitats (Levels 0-5), providing a graded approach to monitoring biological resources based on the level of concern for each resource.

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 acts [16 USC 1531](#), [16 USC 668-668c](#), and [16 USC 703](#), as well as compliance with executive orders, DOE orders, and 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.

Hanford Site ecological monitoring activities 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. Population level surveys are conducted to monitor fish, wildlife, and plants and are used to develop baseline information and monitor any changes resulting from Hanford Site operations. Population data collection and analysis are integrated with data from environmental surveillance monitoring of biotic and abiotic media, and analytical results are used to characterize any potential risk or impact to the biota.

11.1.1 Rare Plants

Plant populations monitored at the Hanford Site include taxa classified by the Washington Natural Heritage Program (WNHP) ([WNHP 2012](#)) 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). In 2013, monitoring efforts were focused on population status assessments of a subset of the known populations of Columbia yellowcress (*Rorippa columbiae*) and spot-surveys for other rare riparian species.

Columbian yellowcress, also called persistent sepal yellowcress, 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 WNHP. 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. Over 91,000 individual ramets were counted at these sites over the 2-year period.

Management of the river flow from upstream dams regularly inundates the species' habitat on a daily cycle for extended periods during the summer. These daily fluctuations have likely shifted the growing season into the late summer and fall when the habitat is more reliably and continuously exposed. More recently, the growing season has been abruptly curtailed in mid-October due to Reverse Load Factoring. Reverse Load Factoring is defined by the Hanford Reach Fall Chinook Protection Program ([HRFCPP 2004](#)) as "the intentional reduction of power generation during daylight hours and the corresponding increase in power generation during hours of darkness for the purpose of influencing the location of redds on Vernita Bar, during which the habitat is flooded on a daily cycle to influence placement of redds by fall Chinook salmon." This results in low flows during daylight periods and high flows during the night, the "reverse" of a typical flow regime driven by power demand.

Photo-documentation of the diurnal inundation due to reverse load factoring was obtained by installing a wildlife trail-camera overlooking one of the larger Columbia yellowcress populations, which was located near 100-H Area. After the start of reverse load factoring, which began on October 15, the typical daily pattern was very high water levels at dawn that clearly inundated the population, followed by a quick lowering of the water level, so that relatively low, stable water levels were observed from mid-morning until dusk. The flow regime observed has shifted and truncated the growing season so that fruits of Columbia yellowcress seldom have a long enough and/or warm enough season to develop, and mature fruits are now rarely observed under this management strategy.

The number of ramets (stems) in a population can fluctuate widely from year to year. In 2013, 35 previously identified Columbia yellowcress populations were revisited. Populations in 2013 ranged from as few as 6 ramets to over 2,100 ramets and covered areas ranging from 1 to 239 square yards (1 to 200 square meters). The overall ramet count decreased compared to previous years for most of the populations, and no ramets were seen at two populations; however, several populations more than doubled in size. About half of the populations increased in area and half decreased in area covered. Stem density decreased by 25 to 75 percent for most populations. The decrease in stem count and density may be due to changes in seasonal river flow, differences in temperature patterns over the compared years, or other undetermined factors. Populations of Columbia yellowcress are known to fluctuate widely, thus a 1-year decrease in overall stem count is not necessarily significant. Populations should continue to be monitored annually to identify long-term trends in population size and density.

Although Columbia yellowcress continues to occupy 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 reproduction and recruitment are causes for concern. In 2013, as noted in previous years, the

number of ramets with flowers and buds was very low to virtually non-existent, and no mature fruits were observed. The surveys in 2012 and 2013 were conducted late in the growing season, and the absence of mature fruits indicates that the species may not be able to reproduce via seed under the regulated flow conditions present on the Hanford Reach. While the pre-dam river flow regime during summer was characterized by sustained low river levels, current management of the river typically inundates and exposes the species' habitat repeatedly, often daily, during the period when flower and fruit production should occur. Regular inundation reduces the plants ability to photosynthesize, increases the potential for fungal infection, and can result in fine sediments covering the leaves. This management regime has shifted the primary growing period into the fall and has limited, if not halted, reproduction by seed.

The riparian zone adjacent to the Columbia River also provides habitat for numerous rare or unusual plant species. Focused riparian surveys were conducted at five locations along the Columbia River in late September 2013. Three species listed as threatened or sensitive by the WNHP were observed during the 2013 riparian surveys. These species included lowland toothcup (*Rotala ramosior*), Canadian St. John's wort (*Hypericum majus*), and awned half-chaff sedge (*Lipocarpa aristulata*). Additional details from the 2013 survey are available in HNF-56799, *Hanford Site Rare Plant Monitoring Report*, which is available 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 2013, and presents this information in context with historical data and trend information.

Historically, four fish and wildlife species on the Hanford Site have been monitored annually: 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 with the exception of mule deer, were monitored in 2013. Monitoring consisted of estimating numbers of fall Chinook salmon redds, surveying for steelhead redds, and assessing bald eagle nesting and night roosting activity. 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 in 2013 were aimed at nesting raptors, migratory birds, burrowing owls, bats, ground squirrels, mussels, anurans, jackrabbits, and snake hibernacula.

The sections below provide summaries of the 2013 monitoring results; the detailed monitoring reports are available 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, Netboy 1958). 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).

Since 1948, aerial counts of Chinook salmon redds have been conducted at Hanford to provide an index of relative abundance among spawning areas and years. The counts have been useful to document the onset of spawning, to locate spawning areas, and to determine intervals of peak spawning activity. Prior to 2011, the Hanford Reach was divided into 11 sections, which have been maintained in the current sampling campaign. In 2011, eight additional sections (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F, Dunes, 300 Area) were defined to better monitor the abundance and distribution of fall Chinook redds in areas of potential upwelling of contaminated groundwater. The original 11 sections and the newer 8 sections are not mutually exclusive areas; they simply represent different divisions of the Hanford Reach area.

In 2013, three aerial surveys were completed along the length of the Hanford Reach (October 20, November 10, and November 21). Table 11.1 summarizes the results of visual aerial surveys for fall Chinook salmon redds in the originally defined 11 sections. The results for the same surveys, organized into the eight operational areas are shown in Table 11-2. The peak annual visual redd count for 2013 (17,398) was almost double compared to the 2012 (8,368) count, and exceeded the all-time high count of 9,465 (2003), and the previous 10 year average (7,271). Viewing conditions were good to excellent during the three surveys, which contributed to the high number of redds counted in 2013.

In addition to the visual counts made, the flight conducted on November 21, 2013, also included aerial photography of the entire Hanford Reach. The photographs taken during 2013 were intended to capture 100 percent of the Hanford Reach from Priest Rapids Dam to the I-182 Bridge, so that all visible redds could be enumerated using a Geographic Information System (GIS). With the use of aerial photography, a higher number of redds could be identified, and 26,193 redds were estimated for the Hanford Reach, which is 1.5 times the visual redd count for 2013.

The primary driving factor for the extremely high number of redds observed in 2013 was the record escapement of adult fall Chinook to the Hanford Reach for 2013, which totaled 157,484 (Hoffarth 2014, *2013 District 4 Fish Management Annual Report*). This is 68,184 higher than the previous 2003 high of 89,300.

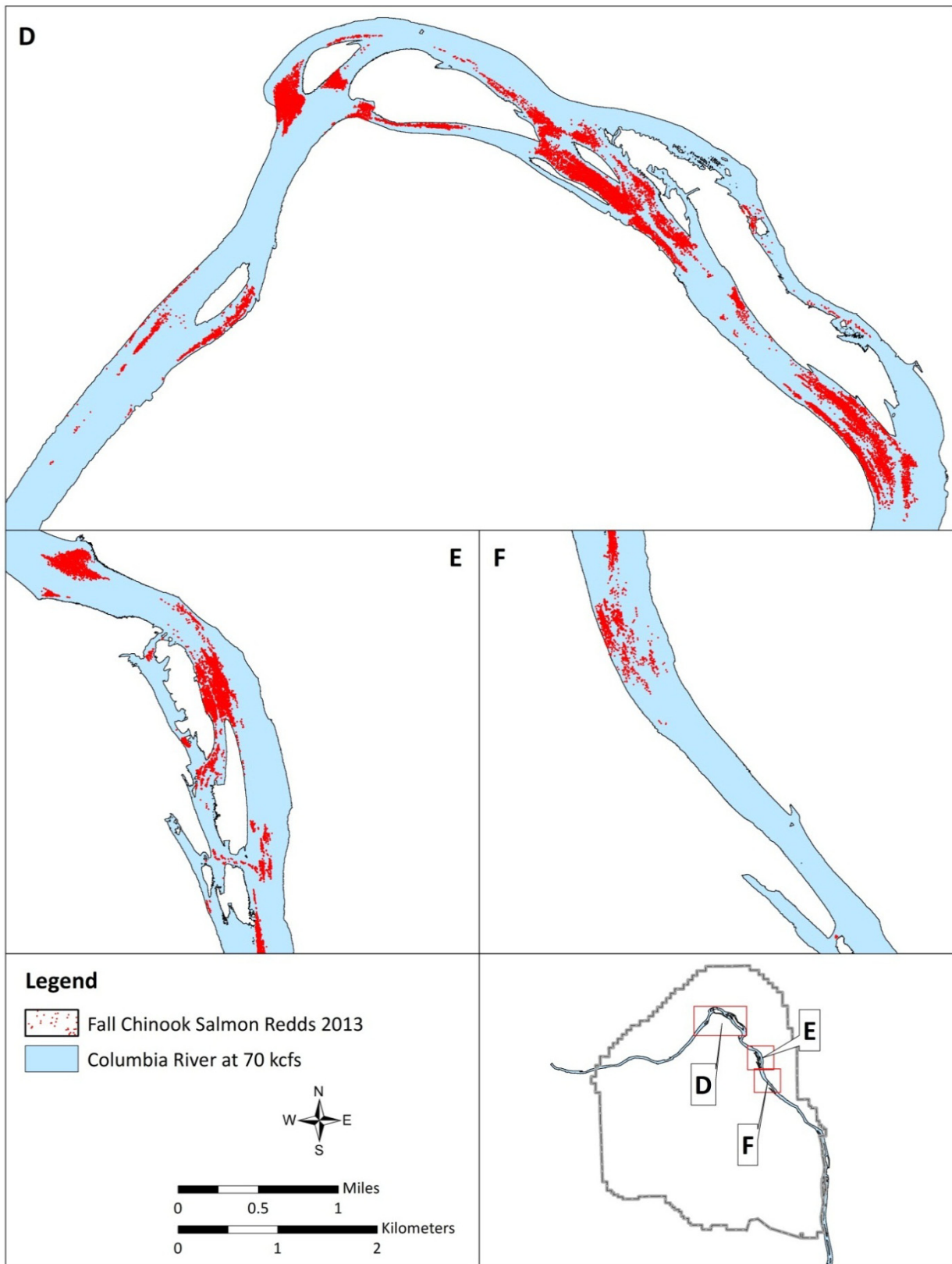
Overall, photograph quality and redd visibility was outstanding for the entire 2013 dataset. The use of aerial photography was effective for recording the abundance of fall Chinook salmon redds along the Hanford Reach of the Columbia River. Figure 11.1 is a digitized image of the redd locations for the Middle Hanford Reach, which provides a record of the location of all spawning activity that occurred in the Hanford Reach in 2013. As a result of the record escapement that occurred for the Hanford Reach, this dataset likely represents most or all of the locations that are used by fall Chinook for spawning in this section of the Columbia River. This map will be extremely useful to analyze and avoid impacts to these spawning areas from Hanford Site activities and to document changes that may occur due to slumping along the Grant/Franklin County shoreline of the Columbia River.

Additional information detailing the 2013 monitoring effort is available in HNF-56707, *Hanford Reach Fall Chinook Redd Monitoring Report for Calendar Year 2013*, which is located at <http://www.hanford.gov/files.cfm/ecologicalmonitoring>.

Table 11.1. Summary of the Aerial Surveys for Fall Chinook Salmon Redd Counts in the Hanford Reach, Columbia River

Area	Description	10/20/13	11/10/13	11/21/13	Maximum Count
0	Islands 17-21 (Richland)	0	0	0	0
1	Islands 11-16	1	708	798	798
1a	Savage Island/Hanford Slough	0	0	0	0
2	Islands 8-10	27	1,835	2,200	2,200
3	Near Island 7	0	471	655	655
4	Island 6 (lower half)	3	2,338	3,340	3,340
5	Island 4, 5 and upper 6	4	2,560	2,650	2,650
6	Near Island 3	2	800	1,000	1,000
7	Near Island 2	13	1,320	1,700	1,700
8	Near Island 1	0	680	900	900
8a	Upstream of Island 1 to Coyote Rapids	0	0	0	0
9	Near Coyote Rapids	0	463	520	520
9a	Upstream of Coyote Rapids to China Bar	0	0	0	0
China Bar	China Bar/Midway	2	80	100	100
10	Near Vernita Bar	11	2,630	3,505	3,505
11	Near Priest Rapids Dam	0	24	30	30
TOTAL		63	13,909	17,398	17,398

Figure 11.1. Fall Chinook Salmon Redd Locations



11.1.2.2 Steelhead

Steelhead use the Hanford Reach for rearing as juveniles, as a migratory corridor for juveniles and adults, and for spawning as adults. Upper Columbia Summer-run Steelhead are currently listed as threatened in [16 USC 1531](#). Because of their listing status and importance to recreational and tribal fisheries, steelhead was 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 mainstream rivers, such as the Columbia, where suitable habitat exists. If suitable conditions occurred within the Hanford reach, spawning 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*; [DOE/RL-2000-27](#)).

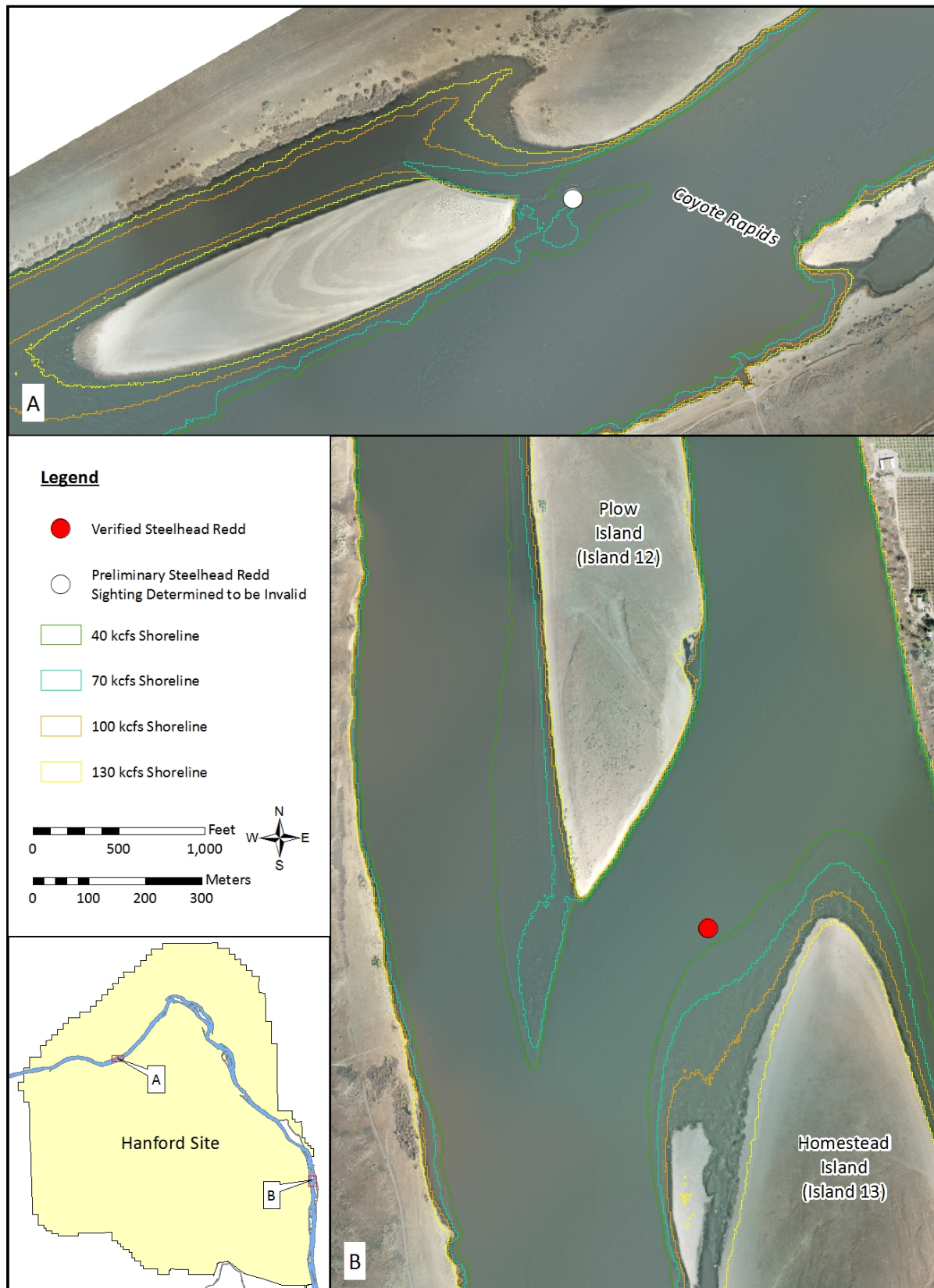
Aerial surveys for steelhead redds are conducted on Hanford Reach in the spring of each year to identify potential spawning areas and timing as well as to provide an annual index of relative abundance among spawning areas. Although few redds have been counted in recent years, the surveys document any change in the status of steelhead spawning in the Hanford Reach and could help plan project activities to avoid redds, if any are 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 sub-sections (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F, the dunes, 300 Area) were added in 2011 to monitor the abundance and distribution of steelhead redds in areas of potential upwelling of contaminated groundwater. The original 11 sections and the newer 8 sections are not mutually exclusive areas; they simply represent different divisions of the Hanford Reach area.

Survey flight altitudes ranged from approximately 244 to 366 m (800 to 1,200 ft) with air speeds of 120 to 161 km (75 to 100 miles) per hour. Redds, when observed, were counted individually. Flight cancellation could occasionally be necessary due to either adverse weather conditions (i.e., wind, fog, or low clouds) or excessively high river flows. Excessively high flows resulting from spring runoff can flood areas typically characterized by terrestrial vegetation and lacking steelhead-spawning habitat, and leave previously usable habitat with flows too swift for spawning and too deep to be observed from the air. Sustained flows in excess of 160 thousand cubic feet per second (ft^3/s) (4,531 thousand cubic liters/second [L^3/s]) were considered too high to survey.

Steelhead redd count surveys began near Richland at Nelson Island and ended at Priest Rapids Dam, and any redds observed were documented by survey area on large format printed maps. When redds were identified during aerial surveys, follow-up surveys were conducted from a boat to confirm their presence. The suspected steelhead redds identified from the air were also located from a boat to confirm their status as newly formed steelhead redds.

Two aerial surveys were completed along the length of the Hanford Reach for the 2013 survey season. The first survey was performed on March 28, 2013, and the second was completed on May 12, 2013. Higher than average river flows prevailed through the first half of April and much of May, which hampered the survey effort. Figure 11.2 shows the steelhead redd locations (preliminary and verified) for 2013. There were 2 suspected redd clusters containing a total of 6 redds (2 near Coyote Rapids and 4 near the top of Homestead Island) were identified on the first survey on March 28, 2013. During the follow-up boat survey on March 29, 2013, the 4 redds at Homestead Island were validated, while the 2 redds at Coyote Rapids were rejected. No redds were observed on the May 12, 2014 flight. Additional information detailing the 2013 monitoring effort is available in [HNF-56705](#), *Steelhead Redd Monitoring Report for Calendar Year 2013*.

Figure 11.2. Steelhead Redd Locations



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 [16 USC 668-668c](#) and [16 USC 703](#) 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 m) 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 maintain current biological information about bald eagle abundance and distribution on the Hanford Site, ensure compliance with protection regulations, and inform future protection and management efforts and decisions. During the 2013-2014 season (as of March 26, 2014), 34 night roost surveys, 3 boat surveys, 5 nest surveys, and 28 days of camera surveys were conducted. 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 two nights and during more than one year.” Night roost surveys were conducted between half an hour before and half an hour after sunset. On four separate days between early December 2013 and late February 2014, 34 roost surveys were conducted at nine locations.

The entire Hanford Reach was surveyed by boat three times during the 2013-2014 season (mid-December, mid-January, and late February). Boat surveys are used to determine the number, age class, and distribution of eagles present on the Hanford Reach. Boat surveys also are used to identify additional potential night roosts and nest sites and to identify the primary foraging areas along the Hanford Reach. During the February 24, 2014 boat survey, an adult eagle was observed sitting on the nest at the Upstream of Wooded Island location successfully used by a pair of eagles in 2013.

Nest site surveys were conducted in two locations (White Bluffs Peninsula and Upstream of Wooded Island). Nest sites were monitored for nesting activities (e.g., a pair defending the nest from other eagles, nest tending, pair bonding behaviors, etc.). As of March 24, 2014, eagles do not appear to be using the White Bluffs Peninsula nest; however, nesting activity continues at the Upstream of Wooded Island location. The area is posted with a nest protection sign to ensure that no vehicular traffic approaches the nest within 436 yards (400 meters), as required by [DOE/RL-94-150](#). MSA staff will continue to monitor the nest to determine the outcome of the nesting attempt.

Camera surveys were conducted at two night roost locations (100-H Upstream and Upstream White Bluffs) for 28 consecutive days from December 19, 2013 to January 15, 2014 to assess their possible value in documenting night roost use by eagles. The cameras were set to capture photos of the night roosts every 5 minutes beginning 1 hour prior to sunrise/sunset and finishing 1 hour after sunrise/sunset. Each photo was time and date stamped. Cameras were retrieved and the photos were downloaded and reviewed for eagle activity.

Additional information detailing the 2013 monitoring effort is available in [HNF-55187](#), *Hanford Site Bald Eagle Monitoring Report for Calendar Year 2013*.

11.1.2.4 Raptor Nest Monitoring

The Hanford Site supports a large and diverse community of raptorial birds ([Fitzner et al. 1991](#)), 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. Several of these species are on state and federal threatened and endangered species lists ([WDFW 2013](#)). 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. In addition to the Ferruginous hawks and Bald Eagles, the Burrowing Owl (*Athene cunicularia*) is a Washington State candidate species. 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 RL documents nest locations 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, and although they are not considered raptors, they perform a similar ecological role.

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.

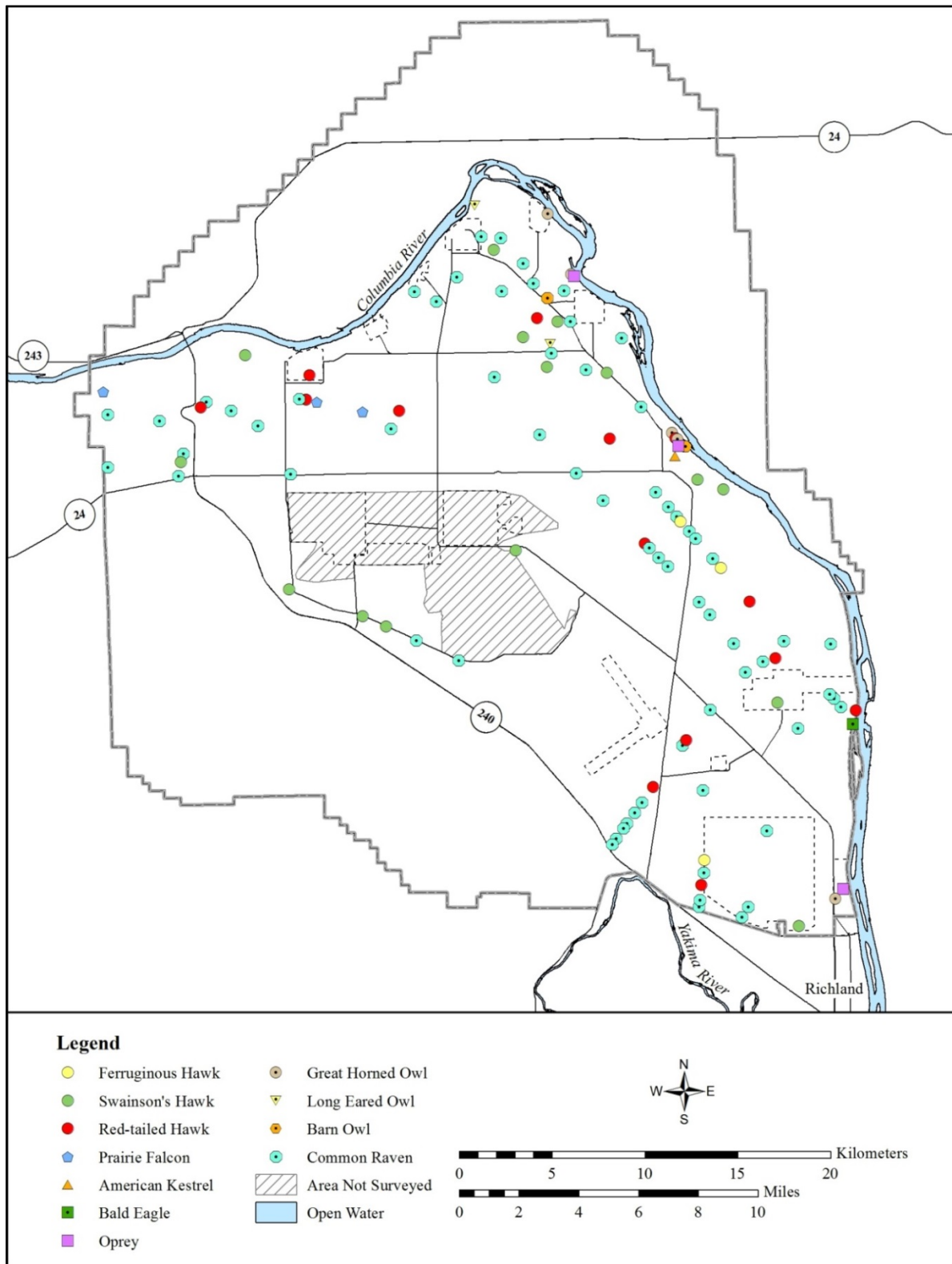
A total of 115 nest sites were recorded in 2013 including 3-Ferruginous Hawks, 15-Swainson's Hawks, 14-Red-tailed Hawks, 3-Prairie Falcons, 1-American Kestrel, 3-Ospreys, 5-Great Horned Owls, 2-Barn Owls, 2-Long-eared Owls, 1-Bald Eagle, and 66-Common Ravens. Nest substrates used by raptors and ravens on RL-managed lands are provided in Table 11.3, and their locations are shown in Figure 11.3. Approximately 7 percent of the raptor and raven nests located were on naturally occurring substrates such as cliffs and non-planted trees along the Columbia River.

Table 11.2. Nest Substrates Used by Raptors and Ravens

Species	Tree	Cliff	Transmission Tower	Utility pole	Nest platform	Instrument Tower	Communication Tower	Building	Total
Ferruginous Hawk			3						3
Swainson's Hawk	14			1					15
Red-tailed Hawk	3	2	8					1	14
Prairie Falcon		3							3
American Kestrel	1								1
Bald Eagle	1								1
Osprey					3				3
Great Horned Owl	4						1		5
Long-eared Owl	2								2
Barn Owl								2	2
Common Raven ¹	12	1	44	8		1			66
Total	37	6	55	9	3	1	1	3	115

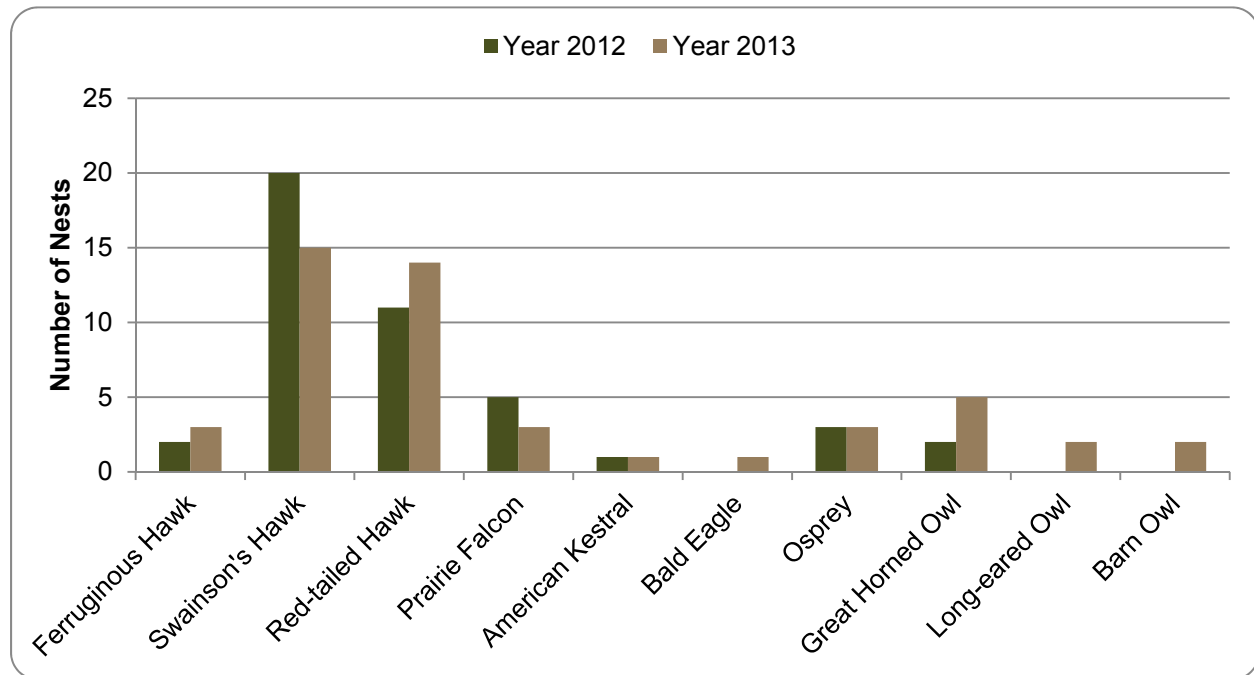
¹ Common Ravens are not technically raptors but occupy a similar ecological niche.

Figure 11.3. Raptor and Common Raven Nests Located



Survey methods used in 2013 were consistent with the methods used in 2012 ([HNF-53073](#), *Raptor Nest Monitoring Report for Calendar Year 2012*). Nests of 10 raptor species (Ferruginous Hawks, Swainson's Hawks, Red-tailed Hawks, Prairie Falcons, American Kestrel, Bald Eagles, Ospreys, Great Horned Owls, Long-eared Owls, and Barn Owls), as well as Common Ravens, were located in 2013. Nests of three additional species of raptors (Bald Eagle, Long-eared Owls, and Barn Owls) were detected in 2013 over that detected in 2012. The number of nest sites of raptor species located on RL-managed lands of the Hanford Site in 2012 and 2013 was similar (Figure 11.4). The number of Common Raven nest sites was comparable with 63 nests observed in 2012 and 66 nests observed in 2013.

Figure 11.4. Number of Nest Sites of Raptor Species



A Bald Eagle nest was documented on the Hanford Site for the first time in 2013. A pair of eagles was observed constructing a nest in a grove of trees on the Hanford shoreline near the upstream end of Wooded Island on January 25, 2013. Nest surveys continued at the location regularly and two young were observed in the nest. The two young fledged and were seen alive in the general area in mid-June. Additional details from this research are available in the *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2013* ([HNF-56769](#)), which is available at <http://www.hanford.gov/page.cfm/ecologicalmonitoring>.

11.1.3 Hanford Bird Surveys

The Hanford Site contains a wide expanse of bird habitats including basalt outcrops, riparian streams and springs, shrub-steppe on slopes and on plains, sand dunes and blowouts, and abandoned fields or disturbed areas. 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 ([TNC 1999](#), *Biodiversity Inventory and Analysis of the Hanford Site*). 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 urophasianu*), have been locally extirpated. Several sagebrush-steppe dependent species, such as the Sagebrush Sparrow

(*Artemisiospiza nevadensis*), Sage Thrasher (*Oreoscoptes montanus*), and Loggerhead Shrike (*Lanius ludovicianus*) are currently listed by the WDFW as “candidate species” and have the potential to be listed as threatened or endangered in the future ([WDFW 2013](#)). In addition, the Hanford Site and surrounding area provides refuge to potentially 18 state-listed species in addition to numerous state monitored species ([WDFW 2013](#)) that benefit from the large expanses of habitat. This list includes birds such as the Ferruginous Hawk, a state “threatened” species, the American White Pelican, a state “endangered” species, and the Bald Eagle, a state “sensitive” species ([WDFW 2013](#)).

Road surveys are a practical way to monitor changes in species richness and relative abundance of shrub-steppe birds over time and in response to various types of land-use changes.

Eleven roadside surveys, covering each of the four Hanford roadside routes three times (a single breeding bird survey covered two Hanford Routes), were completed.

The 3,421 birds documented were similar to the 3,565 individuals counted in 2012. There were 73 different bird species made up the species list for 2013, up from the 53 species in 2012. The Western Meadowlark (*Sturnella neglecta*) was the most abundant species documented. Surveys documented 712 meadowlark individuals, which constituted approximately 20.81 percent of all individuals counted. Following very closely was the Horned Lark (*Eremophila alpestris*) with 708 individuals, 20.70 percent of surveyed individuals. The Western Meadowlark was counted on 239 survey points (79.67 percent), while the Horned Lark was documented on 221 survey points (73.67 percent). These two species were clearly the most counted species in 2013; they were counted at nearly three times as many survey points and almost twice as many individuals as any other species were documented.

Six locations were surveyed in addition to the historical roadside routes: three with a point counts protocol and three with a walking transects protocol. All six surveys took place on September 9, 2013. Point counts were conducted for 20 minutes at each location, while transects ranged from 30 minutes to 1 hour and 10 minutes to complete. The effort yielded nine species (12.3 percent addition) of birds that had not been documented in the 12 Hanford roadside route surveys during 2013 including Dark-eyed Junco (*Junco hyemalis*), Western Wood-pewee (*Contopus sordidulus*), Black-chinned Hummingbird (*Archilochus alexandria*), Golden-crowned Kinglet (*Regulus satrapa*), Gray Flycatcher (*Empidonax wrightii*), Hammond’s Flycatcher (*Empidonax hammondi*), Spotted Towhee (*Pipilo maculatus*), Yellow Warbler (*Setophaga petechia*), and House Sparrow (*Passer domesticus*).

The bird-monitoring program documents the presence, abundance, and distribution of species of concern on the Hanford Site. Both the USFWS and the WDFW maintain lists of species that are of management concern because populations or habitat availability are limited. In the State of Washington, those listings include (in order of least to greatest concern) State Candidate, State Sensitive, State Threatened, and State Endangered. Washington also maintains a list of State Monitor species, a group of birds that are not considered “species of concern”, but for whom status and distribution data are maintained by the WDFW. There are currently no avian species listed as federally threatened or endangered on the Hanford Site, although several are considered federal “species of concern” in Eastern Washington; all of these species also have Washington state listings. Seven state-listed species were recorded on the Hanford Site in the 2013 surveys: Common Loon (*Gavia immer*) - Sensitive, American White Pelican (*Pelecanus erythrorhynchos*) - Endangered, Bald Eagle (*Haliaeetus leucocephalus*) - Sensitive, Ferruginous Hawk (*Buteo regalis*) - Threatened, Loggerhead Shrike (*Lanius ludovicianus*) - Candidate, Sagebrush Sparrow (*Artemisiospiza nevadensis*) - Candidate, and Western Grebe (*Aechmophorus occidentalis*) - Candidate.

Additional information detailing migratory bird monitoring efforts is available at <http://www.hanford.gov/files.cfm/ecologicalmonitoring>.

Figure 11.5 Roadside Bird Survey Routes

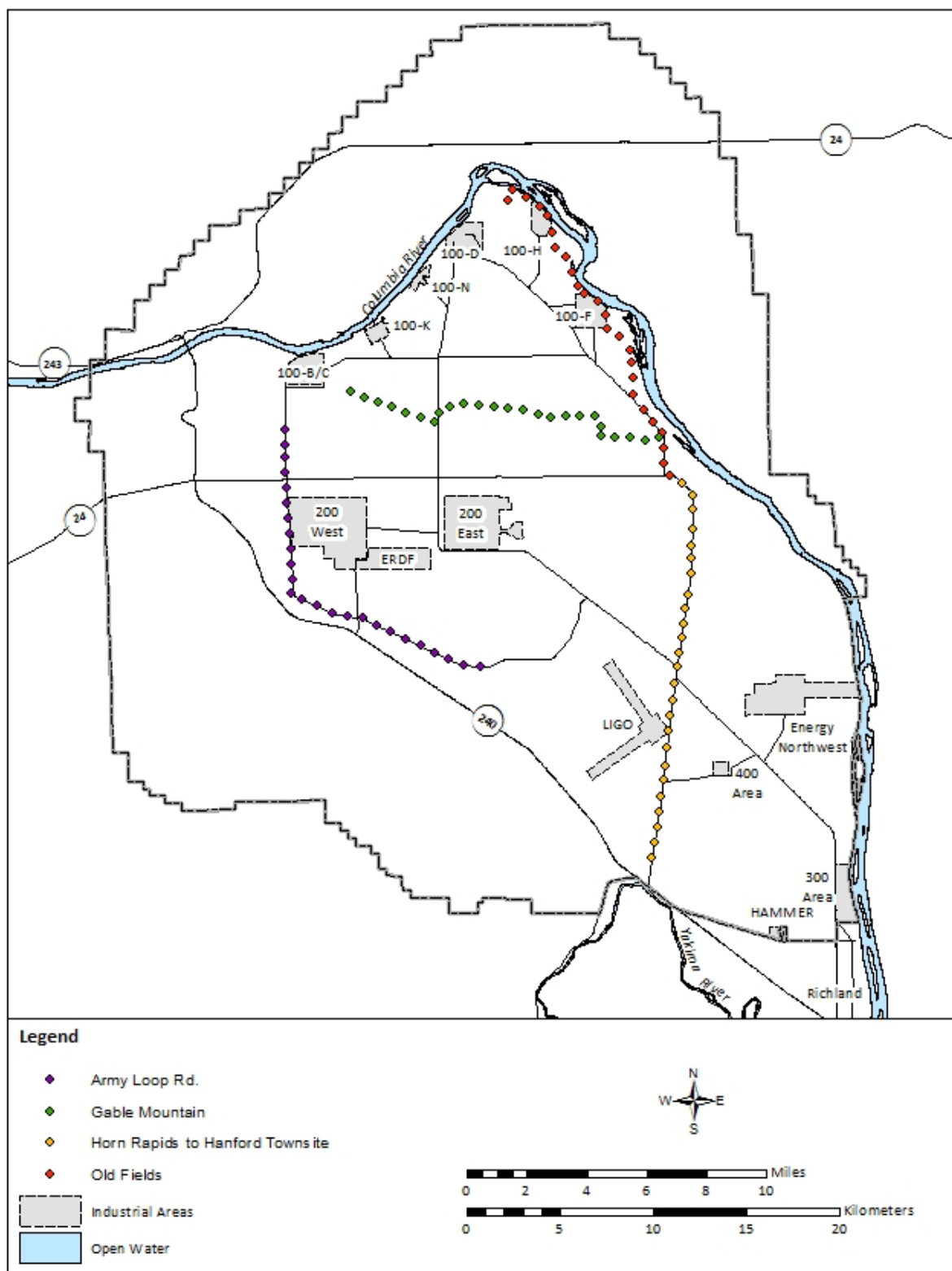
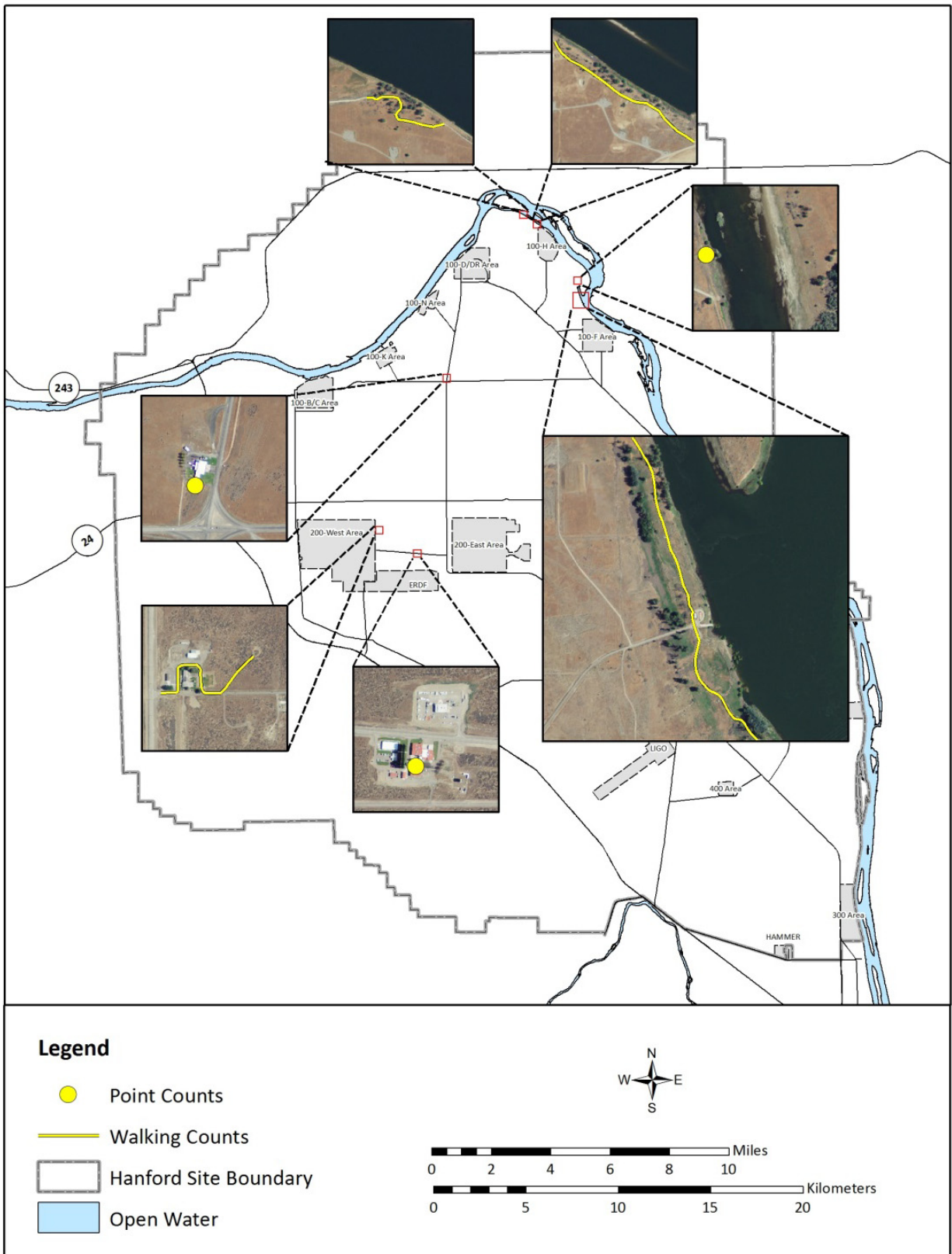


Figure 11.6. Roadside Bird Survey Walking Routes



11.1.3.1 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 ([16 USC 703](#)). 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 2013](#)), 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.

Prior to the spring arrival of migrating owls in 2013, maintenance was performed on all artificial burrows on the Hanford Site, with the exception of three burrows where owls were present on the associated perches and the burrows installed and currently maintained by WCH. All artificial burrows were maintained regardless of historical activity levels. Burrow entrances were cleared of obstructions, and heavy vegetation impeding the burrow function was removed. A heavy bristled duster with an extending handle was placed down the entrance opening to remove obstructions including spider webs, vegetation, soil, and other debris. Soil was managed around the burrow entrances by recreating original mounds over and around the pipe entrance. A total of 52 artificial burrows had maintenance performed in 2013.

In 2013, a systematic approach was designed to locate new or previously undocumented burrows on the Hanford Site. Transects were developed to locate new burrows in the vicinity of natural burrows that were determined to be active in 2012. Each transect was an Archimedean spiral that originated at the known active burrow or centroid of a cluster of active burrows, and spiraled out approximately 1,640 feet (500 meters) from outermost active known burrow in cluster. The successive turns of the spiral had a separation distance of approximately 656 feet (200 meters). Transects were walked with three staff members who walked approximately 100 feet (30 meters) apart. Surveyors walked with a Global Positioning Unit along the predetermined transect line while being paced by additional personnel on both sides. Figure 11.8 shows the 2013 survey locations for the burrowing owl nests on the Hanford Site. A total of 8 spirals were surveyed, resulting in the discovery of 14 new burrows. Nine of these burrows were located in structures of anthropogenic origin while the other five were of mammalian origin. The location of the survey spirals also allowed staff to document the status of the burrows that were active in 2012. Not all burrows active in 2012 remained active during the 2013 season. From 2012 into the 2013 year, 15 of the 23 burrows remained active, for a total of 29 active natural burrows on the Hanford Site in 2013.

USFWS contacted Public Safety and Resource Protection about using this increase of successful artificial burrows at the HAMMER as an opportunity to trap owls to recover geolocators used in their owl migration study. In an effort led by the USFWS team, 12 traps were placed in front of the burrow openings to trap owls returning to or exiting from the burrow. There were nine owls captured and banded; however, no geolocators were recovered. Six owls were found to be hatch-year birds, and the other three were after hatch year. The three after hatch year owls consisted of a male and two females, one with a wrinkled brood patch and the other with a recovering brood patch. The differing maturity of brood patches on the female owls highlights timing of brood hatching, with the recovering brood patch further along in the rearing process than the wrinkled patch owl. All captured owls were banded, on the left leg for hatch-year and on the right leg for after-hatch year, and released with USFWS band numbers.

Additional information detailing the 2013 monitoring effort is available in HNF-56531, *Hanford Site Burrowing Owl Monitoring Report for Calendar Year 2013*, which is located at <http://www.hanford.gov/files.cfm/ecologicalmonitoring>.

Figure 11.7. Burrowing Owl Nest Survey Locations

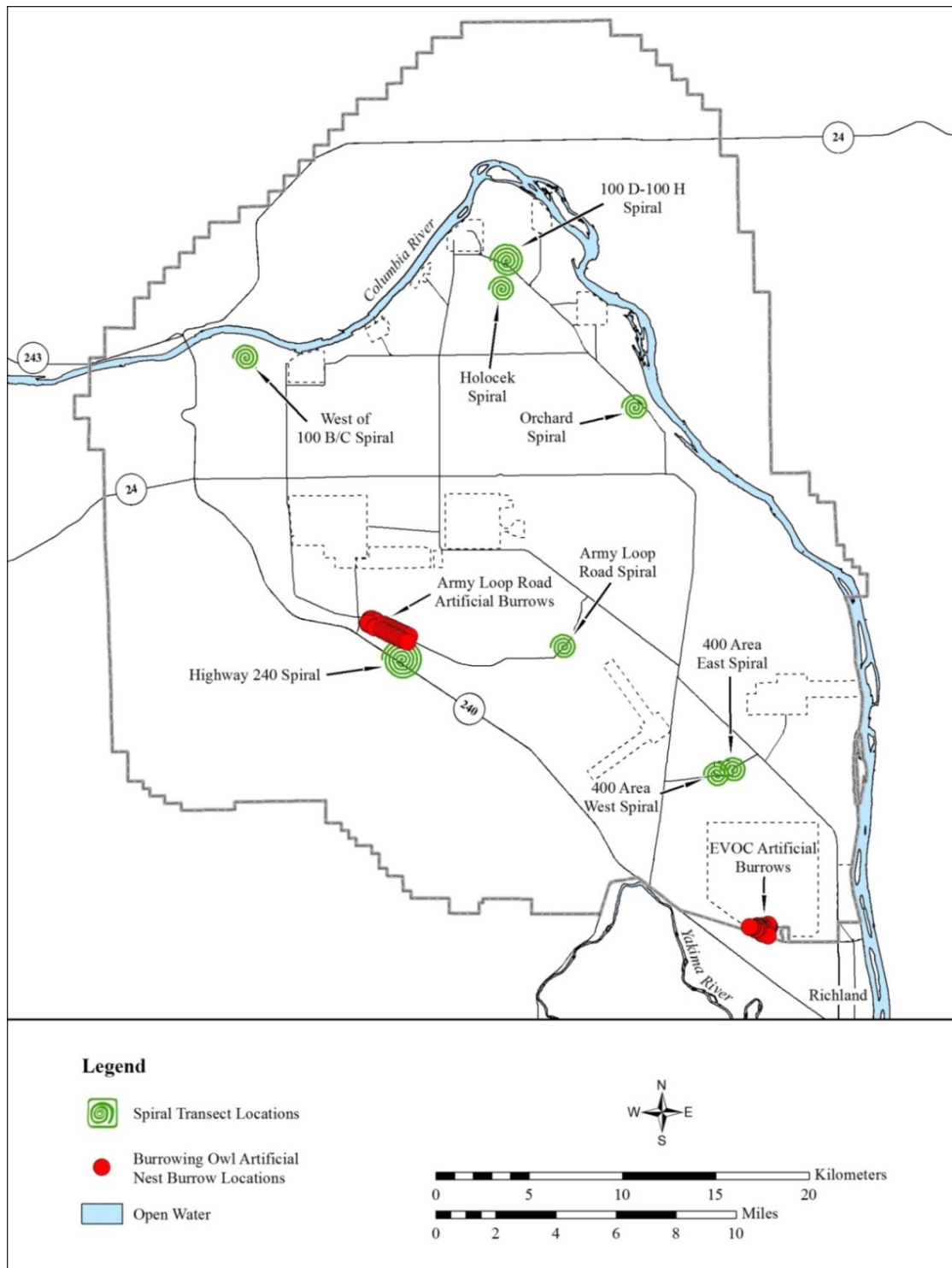
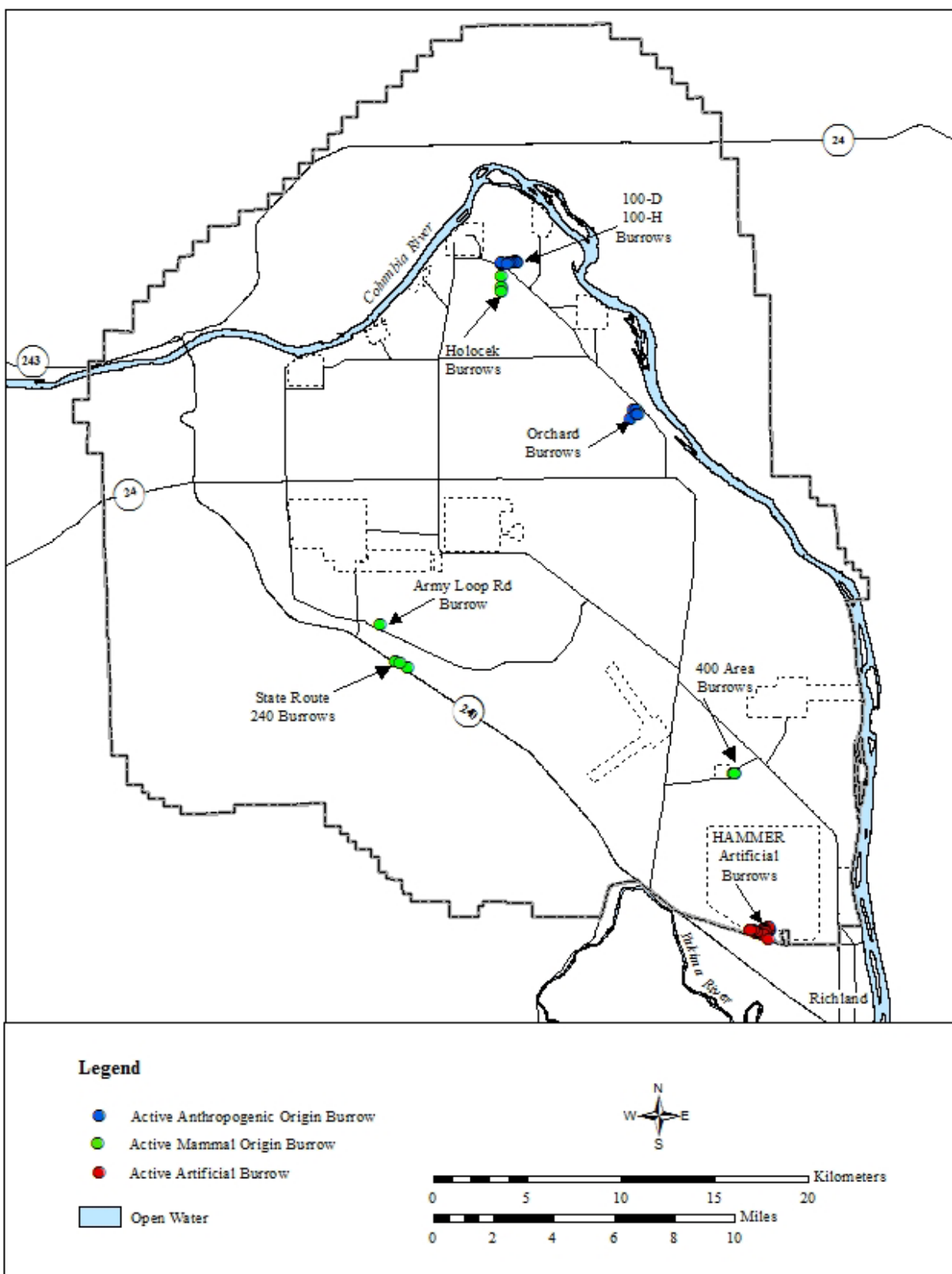


Figure 11.8. Active Burrowing Owl Burrow Locations



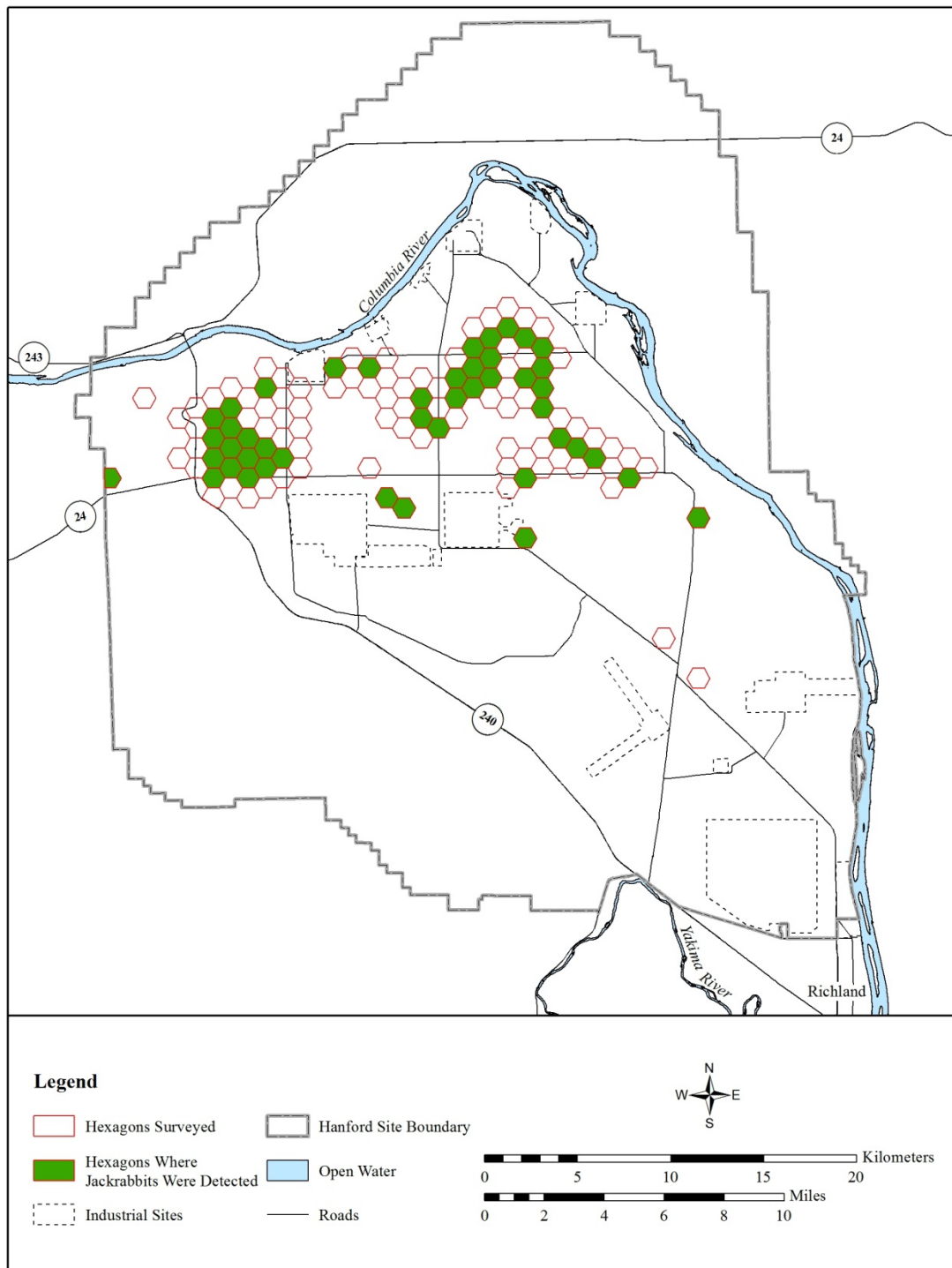
11.1.3.2 Black-Tailed Jackrabbit Monitoring

Jackrabbit populations are declining across Washington State due to the loss and fragmentation of the shrub-steppe habitat. The WDFW currently list both the black-tailed (*Lepus californicus*) and white-tailed jackrabbits (*L. townsendii*) as ‘Candidates’ for listing as Threatened or Endangered ([WDFW 2012](#)). Jackrabbits are infrequently sighted on the Hanford Site, potentially indicating population declines, while other factors such as natural population cycles may be contributing. To understand the extent and causes of this possible decline, and to implement means to protect the species, it is imperative to collect population status and distribution data before jackrabbits disappear completely from the Hanford Site.

Monitoring for FY2013 focused on the black-tailed jackrabbit on the RL-managed portion of the Hanford Site using motion-activated trail cameras. Traditional traps are labor intensive and intrusive to the animals, but trail cameras can be used as camera-traps. The cameras capture photos of jackrabbits, confirming occupancy without interfering with the animal’s normal behavior.

The entire central Hanford Site was divided into a mesh of 820 hexagonal survey areas measuring 0.39 square mile (1 square kilometer) using a GIS. Surveying every hexagon would have been prohibitively time consuming, so initial camera setup locations were determined based on the presence of a black-tailed jackrabbit activity center, termed a “core area”. These core areas are defined as areas with high levels of visibly detectable jackrabbit activity such as active trails and fresh scat. Jackrabbits were confirmed at core areas using the cameras, and then all adjacent hexagons were monitored using the camera setup. If any of the hexagons adjacent to the original core areas were found to contain jackrabbits, based on camera-trap observations, then the search area was expanded to include all hexagons adjacent to the newly discovered active hexagon. Monitoring with trail cameras began on February 2, 2013, and the last 2013 camera trap was retrieved on December 31, 2013. There were 124 hexagons completed in 2013 (Figure 11.9), and Jackrabbits were detected within 45 of the hexagons surveyed. Between three and five cameras were deployed for the majority of the survey period with 981 camera trap-nights recorded.

Figure 11.9. Black-Tailed Jackrabbits Survey Locations



The status of the black-tailed jackrabbit population on the Hanford Site was largely unknown at the start of the 2013 survey. The monitoring effort documents the continued presence of the black-tailed jackrabbit and their primary habitats on the Hanford Site, and is helping to establish a population distribution map for this State Candidate species. Additional information detailing the 2013 monitoring effort is available in HNF-56710, *Hanford Site Black-tailed Jackrabbit Monitoring Report for Calendar Year 2013*, which is located at <http://www.hanford.gov/files.cfm/ecologicalmonitoring>.

11.1.3.3 Bat Roost Monitoring

A survey conducted by MSA during the summer of 2012 documented nine species of bats on the Hanford Site ([HNF-53759](#), *Summer Bat Monitoring Report for Calendar Year 2012*) (Table 11.4). Of these species, pallid bats, western small-footed myotis, and canyon bats are listed as WDFW State Monitor Species ([WDFW 2013](#)). In addition, roosting concentrations of big-brown bats, 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. Bats are sensitive to disturbance, especially while pregnant and lactating, and early identification of roost areas can help avoid impacts to these sensitive species.

Table 11.3. Bat Species Detected on the Hanford Site

Common Name	Scientific Name	Abbreviation
Pallid Bat	<i>Antrozous pallidus</i>	ANPA
Big Brown Bat	<i>Eptesicus fuscus</i>	EPFU
Silver-Haired Bat	<i>Lasionycteris noctivagans</i>	LANO
Hoary Bat	<i>Lasiurus cinereus</i>	LACI
California Myotis	<i>Myotis californicus</i>	MYCA
Western Small-Footed Myotis	<i>Myotis ciliolabrum</i>	MYCI
Little Brown Myotis	<i>Myotis lucifugus</i>	MYLU
Yuma Myotis	<i>Myotis yumanensis</i>	MYYU
Canyon Bat	<i>Parastrellus hesperus</i>	PAHE

During 2013, acoustic surveys were used to identify potential summer and winter bat roosting areas within the RL-managed portion of the Hanford Site. Acoustic bat detectors record the echolocation calls of bats, and these recordings can be used to identify species and determine the relative level of bat activity. The summer acoustic bat surveys began on May 6 and continued through August 26 of 2013, and included 11 locations (Figure 11.10). The acoustic detector was deployed for 42 nights during this monitoring period. There were 38 nights where the weather conditions were considered suitable, and 2,193 bat passes were documented during these nights.

A summary of the findings from selected sites monitored during the summer of 2013 are provided below; additional information can be found in HNF-56359, *Hanford Site Summer Bat Monitoring Report for Calendar Year 2013*, which is available at <http://www.hanford.gov/page.cfm/ecologicalmonitoring>.

Cornelius Pumphouse: The Cornelius Pumphouse appears to function as a night roost for pallid bats. Pallid bats were detected at this location, but not during emergence time, indicating that the building does not function as a day roost. The Cornelius Pumphouse is also very active for other bat species such as little brown bats and Yuma Myotis, but additional information is needed to determine the type of roost that exists. Bat passes totaled 140 per suitable recording night at this location.

Gable Butte West: The Gable Butte West location serves as a natural funnel between large cliff faces along the south side of Gable Butte. Bats recorded at this location are likely roosting in the cliffs and using the natural flyway to access the Columbia River to the North. An extremely high number of little brown bat recordings were made, including many calls during the emergence period near dusk, indicating a maternity colony potentially exists in the cliffs adjacent to the Gable Butte West location.

Umtanum Cliffs 2: Umtanum Cliffs 2 is located along the Umtanum Ridge cliff complex, and is 984 feet (300 meters) from the Midway Substation. Although not confirmed, a colony of bats was thought to be present in the Midway Substation. The Umtanum Cliffs 2 location had the highest level of bat activity recorded during 2013, with 399 bat passes recorded during the single suitable recording night. The large number of little brown bat recordings made during the single recording night, including many calls during

the emergence period near dusk, indicates that a colony of little brown bats may be present in the Midway Substation.

Little brown bats were the most recorded bat species during the summers of 2012 and 2013. Little brown bats appear to be the most abundant bat in cliff areas, which have been the primary focus over the two MSA survey years at the Hanford Site. Yuma myotis and pallid bats are the most detected bat species in the 100-Areas of the Hanford Site near abandoned buildings, but they are rarely detected elsewhere. These two species have benefited greatly from the presence of anthropogenic habitats on the Hanford Site. Hoary bats and silver-haired bats were recorded frequently during 2012 and 2013, even in areas far from trees, which are their typical roosting habitat.

Figure 11.10. Bat Survey Summer Locations

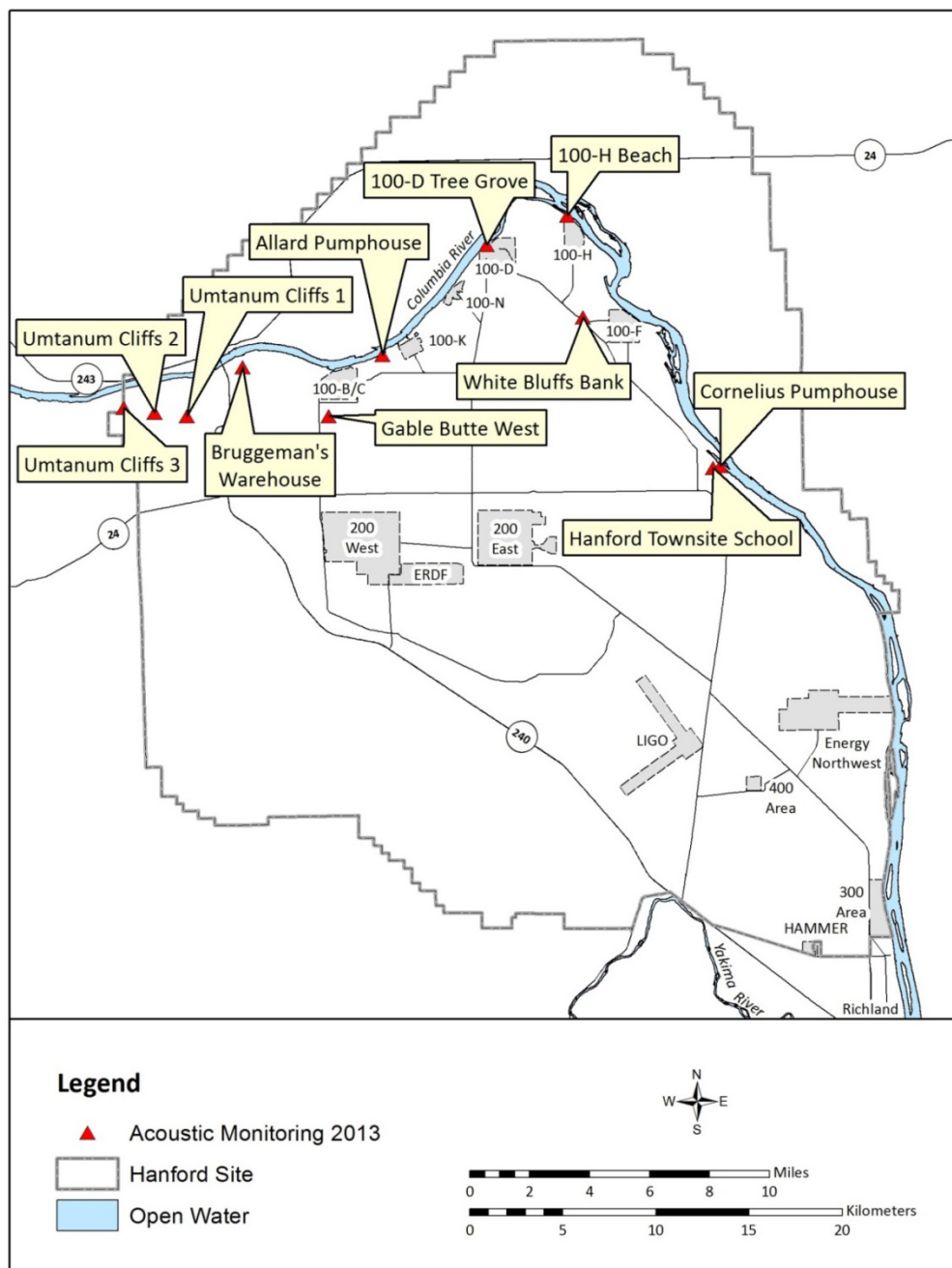
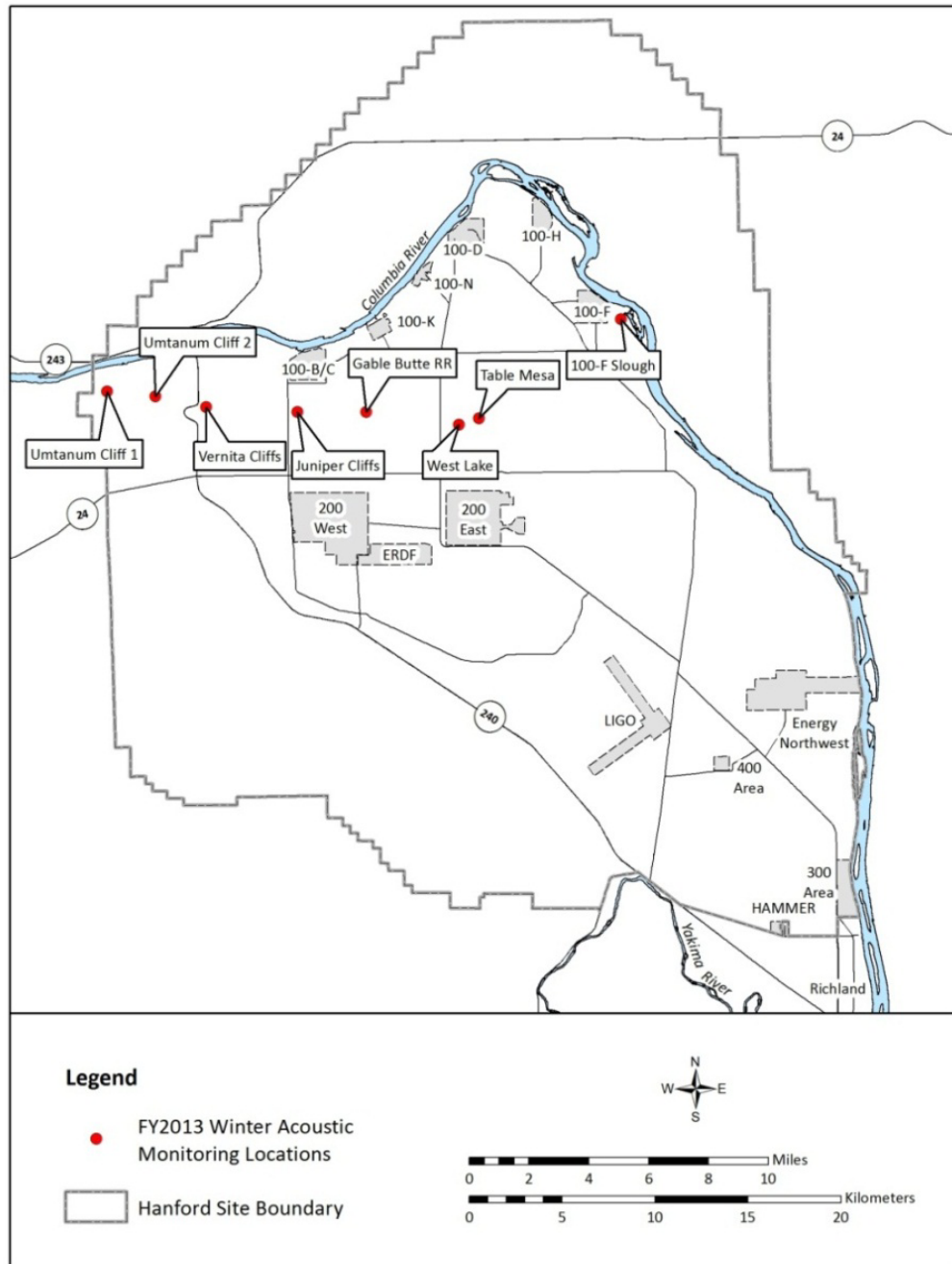


Figure 11.11. Bat Survey Winter Locations



Due to cold temperatures and lack of available food (insects), bats must use winter roosts to survive. Winter roosts are selected for cold and constant temperatures so that bats can down-regulate their body temperature, slowing their metabolism and conserving energy, to survive through the winter. Bats select all communal roost types for very specific conditions, which may not be otherwise available in the same area, potentially making roost availability population limiting. Eight sites were identified and surveyed during the winter of FY2013 (Figure 11.11).

There were five bat passes (little brown bats) recorded during FY2013 winter monitoring period conducted between January 9, 2013 and February 28, 2013. The data collected indicate that little brown bats are using the Hanford Site for winter roosting, and while it is not possible to determine the precise

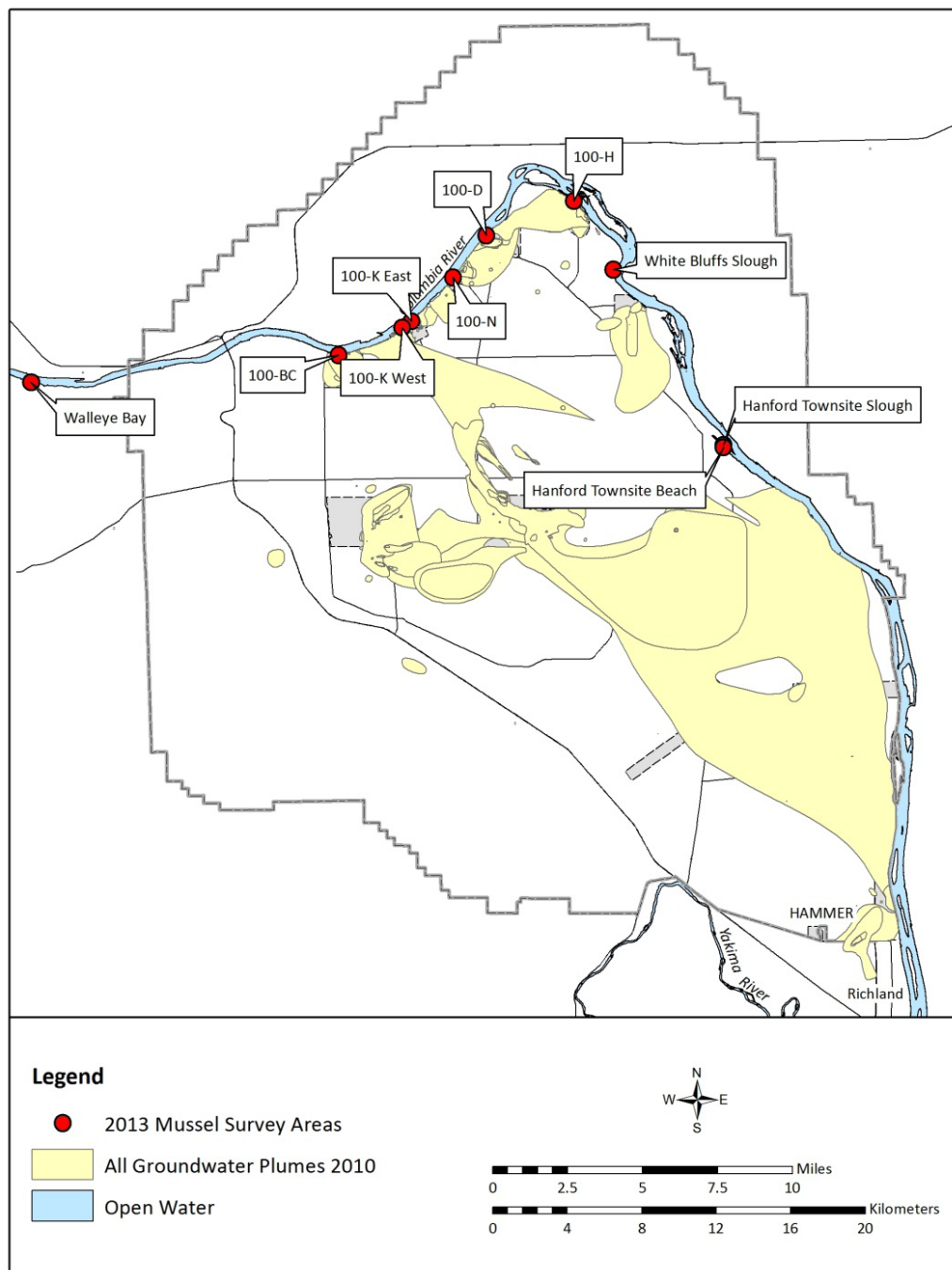
number of bats based on the number of acoustic detections, it appears the usage of the areas monitored during FY2013 is low. Four of the seven sites monitored during the winter roosting period had no detections, and three sites had only five bat passes among them. One of the sites where bats were detected (100-F Slough) is adjacent to the Columbia River and may indicate that bats were seeking hydration during their arousal periods. The two remaining detection sites were both on Umtanum Cliffs, which likely represent the most suitable winter roosting habitat on the RL-managed portion of the Hanford Site. The Umtanum Cliffs are characterized by tall (>50 feet [15 meters]), north facing basalt cliff faces. The Umtanum Cliffs stretch for over 3 miles (5 kilometers) and thus present a vast area for potential winter roosting. Additional details about bat monitoring in the winter of 2013 can be found in HNF-55280, *Hanford Site Winter Bat Monitoring Report for Fiscal Year 2013*.

11.1.3.4 Freshwater Mussels

Freshwater mussels are one of the most imperiled groups of organisms on the planet, including those species potentially occurring in the stretch of the Columbia River along the Hanford Site known as the Hanford Reach ([Nedean et al. 2009](#), *Freshwater Mussels of the Pacific Northwest*). Freshwater mussels have long lifespans, are relatively immobile, and are relatively sensitive to changing environmental conditions, making them ideal sentinel/indicator species for environmental impacts such as contamination. Freshwater mussels were selected for monitoring in FY2013 because of their listing status, sensitivity to changing environmental conditions, and their utility as sentinel/indicator species. The 2013 survey focused on mussels in the genus *Anodonta*.

Self-contained underwater breathing apparatus was used to perform the 2013 surveys. Survey areas were selected based on the presence of fine-grained sediment, which is a preferred habitat of *Anodonta*. Survey areas adjacent to groundwater contamination plumes included the 100-B/C, 100-KW, 100-KE, 100-N, 100-D, and 100-H survey areas. Figure 11.12 shows the 2013 mussel survey areas and all groundwater plumes from 2010; sites away from groundwater contamination plumes included Walleye Bay, White Bluffs Slough, Hanford town site Slough, and Hanford town site Beach.

Figure 11.12. Mussel Survey Areas with Groundwater Plumes



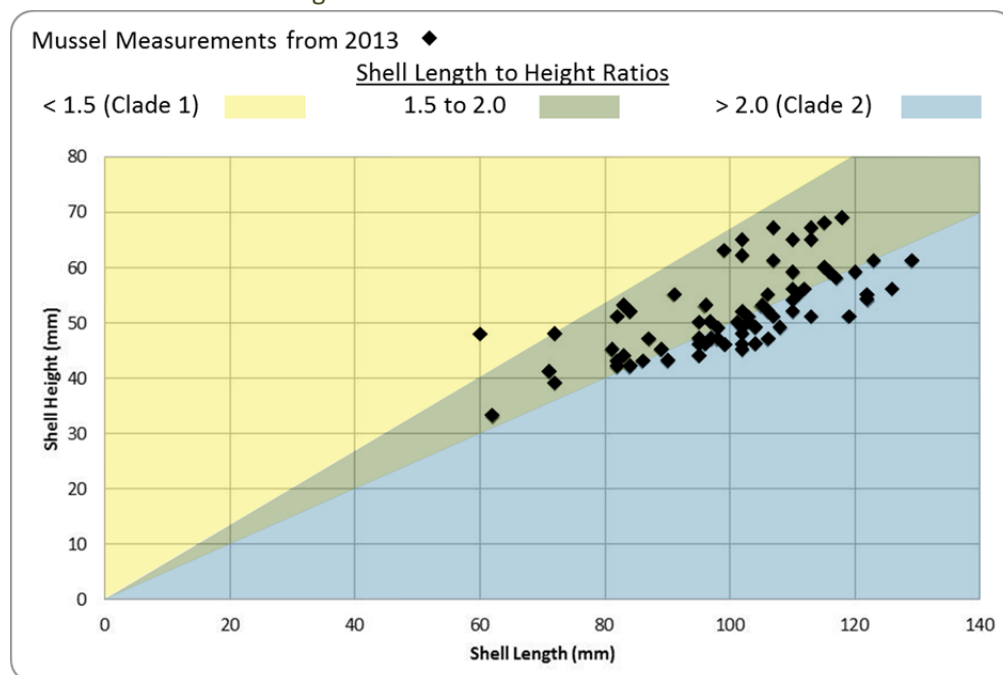
Once sediment areas were defined, each survey area was divided into grids. A 13-foot (4-meter) radius, circular sample plot was centered on each of the chosen grid cells. Two surveyors each surveyed a circular, 7-foot (2-meters) wide swath of the river bottom within each selected grid cell.

Mussel surveys began on August 27, 2013 and concluded on September 5, 2013. There were 50 sample plots examined across the 10 selected survey areas. Survey depths ranged from 3 to 30 feet (1 to 9 meters). Surveyors located 75 mussels, all from the genus *Anodonta*. These mussels ranged in length from 2.4 to 5.1 inches (60 to 129 millimeters). The total number of mussels within a single survey plot ranged from 0 to 12 individuals. The calculated number of mussels per 1,076 square feet (100 square

meters) within a survey area ranged from 0 to 9 individuals, with an average density across all surveys of 2.9 mussels per 1,076 square feet (100 square meters).

[Nedea et al.](#) (2009) described the method for determining whether an individual belongs to Clade 1 (California Floater/Winged Floater) or Clade 2 (Oregon Floater/Western Floater), with Clade 1 having a shell length to height ratio “usually less than 1.5” and Clade 2 having a length to height ratio “close to or exceeding 2.0”. The data collected during 2013 indicated a continuum of shell length to height ratios between 1.3 and 2.3. Therefore, using the methods described by [Nedea et al.](#) (2009), a large proportion of the mussels collected during 2013 fell outside of either clade description. Only two individuals had a shell length to height ratio of less than or equal to 1.5, and 40 had a ratio equal or greater than 2. This left 33 mussels with a shell length to height ratio between 1.5 and 2. Figure 11.13 shows mussel measurements including shell length and height data from 2013 with corresponding length to height ratios.

Figure 11.13. Mussel Measurements



Mussel density (mussels per 1,076 square feet [100 square meters]) was compared between areas that are adjacent to contaminated groundwater plumes ($M = 1.4$, $SD = 2.2$) and areas away from contaminated groundwater plumes ($M = 3.8$, $SD = 4.8$). The areas surveyed away from known contaminant plumes had significantly higher mussel density, $t(-2.3)$, $df = 45$, $p = 0.03$. In addition to the presence of adjacent groundwater contamination plumes, many factors such as substrate characteristics could potentially influence mussel occupancy rates.

The 2013 data showed a population curve similar to the 2004 data collected by PNNL ([PNNL-19933](#), *Assessment of the Species Composition, Densities, and Distribution of Native Freshwater Mussels along the Benton County Shoreline of the Hanford Reach, Columbia River*), indicating population stability over the 9-year timeframe between the surveys despite the lack of small age-class individuals in either dataset. Although questions remain, the comparison of the 2013 dataset to the data collected in 2004 indicates that the population of *Anodonta* present along the Hanford Site appears to be relatively stable. This may not be the case for the other mussel species, the western pearlshell and western-ridged mussels, potentially occurring on the Hanford Reach. These species were not detected alive during the 2004 or 2013 surveys but were historically present in the Hanford Reach ([PNNL-19933](#), [WCH-29](#), *Radionuclides, Trace*

Metals, and Organic Compounds in Shells of Native Freshwater Mussels Along the Hanford Reach of the Columbia River: 6000 Years Before Present to Current Times). Additional information about the 2013 surveys and results can be found in HNF-56238, *Hanford Site Freshwater Mussel Monitoring Report for Calendar Year 2013*, which is available at <http://www.hanford.gov/page.cfm/ecologicalmonitoring>.

11.1.3.5 Townsend Ground Squirrels

The WDFW lists the Townsend's ground squirrel (*Urocitellus townsendii*) as a "State Candidate" (WDFW 2014). Monitoring of Townsend's ground squirrel colonies, and surveys to identify new colonies, are necessary to collect the baseline data needed to manage and prevent impacts to this sensitive species. The crucial window to observe and monitor these ground squirrels is between late January, after hibernation, and before late May when estivation begins. Ground squirrels breed and rear young during this time, and age determination is easier at this time of year because juvenile ground squirrels are smaller. Protective maternal alarm calls are also used at this time, maximizing the likelihood of detecting colonies.

At the onset of the 2013 monitoring season, eight Townsend's ground squirrel colonies were known on the Hanford Site. Figure 11.14 shows the active Townsend's ground squirrel colonies on the RL-managed portion of Hanford Site. Two of these sites were known prior to 2012 (Public Safety and Resource Protection Database), while the other six were documented during the 2012 monitoring season (HNF-53075, *Ground Squirrel Monitoring Report for Calendar Year 2012*). The goals of the 2013 monitoring project were to document the status of previously known colonies and to survey for new colonies across the RL-managed portion of the Hanford Site.

Previously identified ground squirrel colonies were monitored for activity such as fresh burrowing and audible distress calls. The only Townsend's ground squirrel colony known prior to the 2012 survey that remains active on the Hanford Site today is the 300 Area Colony. The HAMMER Colony was no longer active during 2013, although it was marked as active at a very low level in 2012 (HNF-53075).

Transect surveys were conducted to identify new colonies across the central portion of the Hanford Site. These transects are the same methods performed by MSA in 2012, squares with 3,281 feet (1,000 meter) sides and rounded corners. A total of 34.8 miles (56 kilometers) were walked during transects completed in 2013, covering approximately 830 acres (336 hectares). When combined with the surveys from 2012, a total of 108 miles (173 kilometers), covering 2,565 acres (1,038 hectares) have been surveyed for ground squirrels. These combined surveys have covered approximately 1.3 percent of the RL-managed portion of the Hanford Site. No new ground squirrel colonies were found during the 2012 or 2013 diamond transect surveys. The lack of ground squirrel detections using this survey method is likely due to the low density of ground squirrels present on the Hanford Site.

Figure 11.14 shows active Townsend's ground squirrel colonies on the RL managed portion of Hanford Site in 2013. Field personnel discovered a new Townsend's ground squirrel colony on May 8, 2013, which surveyors named 'Scurf Pea', due to the prevalence of (*Psoralea lanceolata*) at the location. There are eight known active Townsend's ground squirrel colonies on the RL-managed portion of the Hanford Site, including a single new colony in 2013, six locations identified in 2012, and the 300 Area Colony.

Additional information detailing the 2013 monitoring effort is available in HNF-56374, *Hanford Site Ground Squirrel Monitoring Report for Calendar Year 2013*, which is located at <http://www.hanford.gov/files.cfm/ecologicalmonitoring>.

11.1.3.6 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. Finding and protecting snake hibernacula is critical to maintaining Hanford Site populations of

both common and sensitive species. The striped whipsnake (*Masticophis taeniatus*), the night snake (*Hypsiglena torquata*), and racers (*Coluber constrictor*) are three species of snakes documented on the Hanford Site that are considered rare by the WDFW. The WDFW considers the striped whipsnake a State Candidate species and could potentially be listed as threatened or endangered if habitat degradation continues. The striped whipsnake is known to den with other species including western rattlesnakes (*Crotalus viridis*), racers, and gopher snakes (*Pituophis melanoleucus*) ([Larsen 1997](#), *Management Recommendations for Washington's Priority Species*, Volume III: Amphibians and Reptiles). The Department of Natural Resources considers hibernacula destruction a key threat to this species ([Hallock 2005](#), *Washington Herb Atlas*). The night snake and racers are on the WDFW State Monitor list. These three rare species could be sharing hibernacula with other snakes that are known to be present on the Hanford Site, including gopher snakes, common garter snakes (*Thamnophis sirtalis*), western terrestrial garter snakes (*Thamnophis elegans*), and western rattlesnakes.

On the Hanford Site, snakes typically seek out hibernacula in mid-October, and remain there until April. During early to mid-April, western rattlesnakes will typically spend 2 to 3 weeks moving into and out of the hibernacula locations prior to dispersing to feeding ranges. Some species may remain nearby the hibernaculum longer for breeding and egg laying ([Larsen 1997](#)). Hibernacula locations used by western rattlesnakes are readily identifiable during the emergence period, due to the presence of snakes at the openings. A thorough investigation into the locations of snake hibernacula across the Hanford Site was initiated by MSA in 2012 and continued in 2013. Prior to 2012, only three hibernacula were known on the Hanford Site. In 2012, six additional hibernacula were located, bringing the total number of known snake hibernacula on the Hanford Site to nine ([HNF-53026](#), *Snake Hibernacula Monitoring Report for Calendar Year 2012*).

Due to the limited timeframe when snakes are present at hibernacula openings before dispersal to their home range, there is only a short period of time to document if the potential hibernaculum is an active den or not. In 2013, surveyors documented snake activity near hibernacula on March 28 and no activity by April 30. During this time period personnel conducted five days of surveys and located an additional 14 hibernacula increasing the total number of known snake hibernacula on the Hanford Site to 23 (Figure 11.15). Additional details from this investigation are available in the monitoring report [HNF-56087](#), *Hanford Site Snake Hibernacula Monitoring Report for Calendar Year 2013*.

Figure 11.14. Active Townsend's Ground Squirrel Colonies

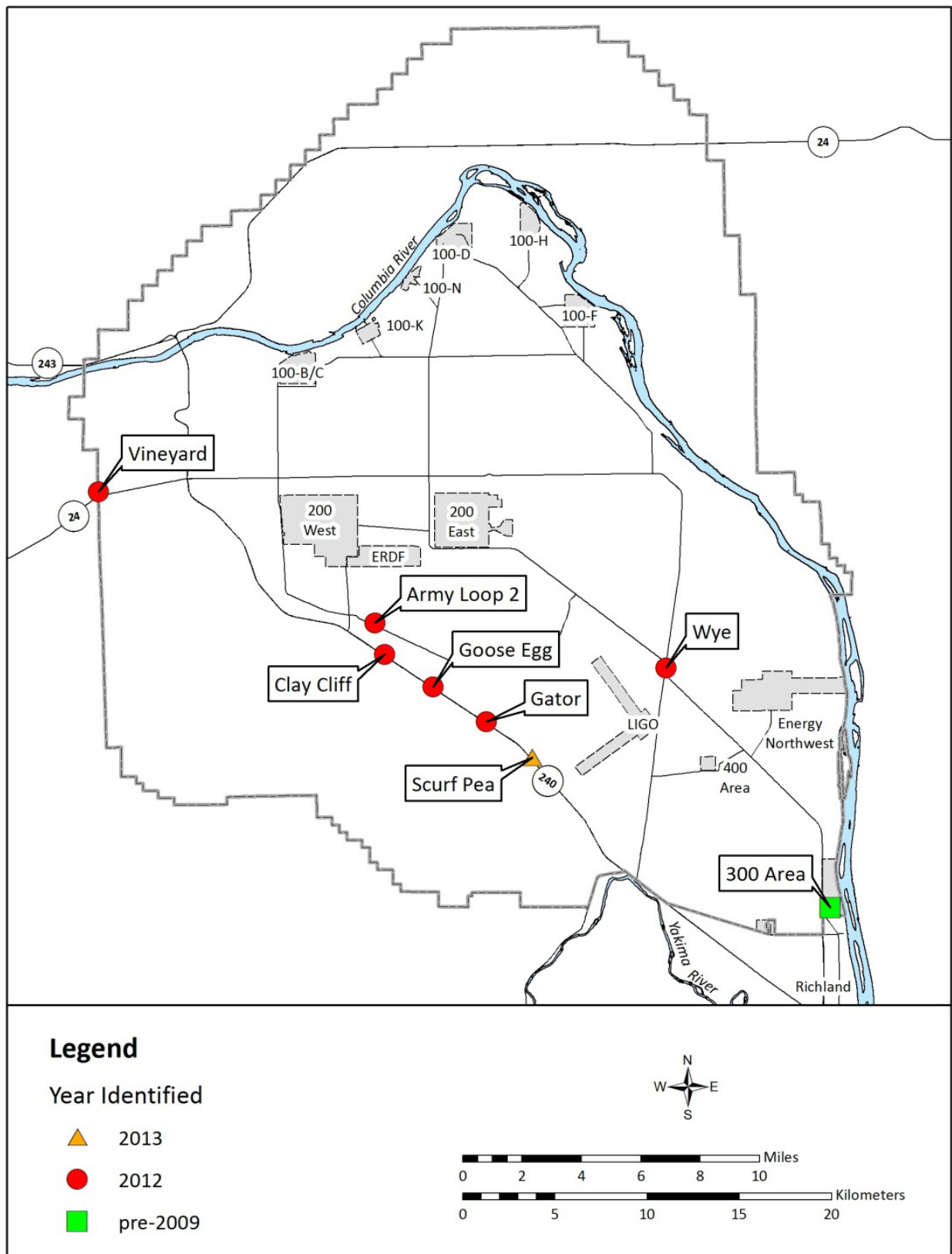
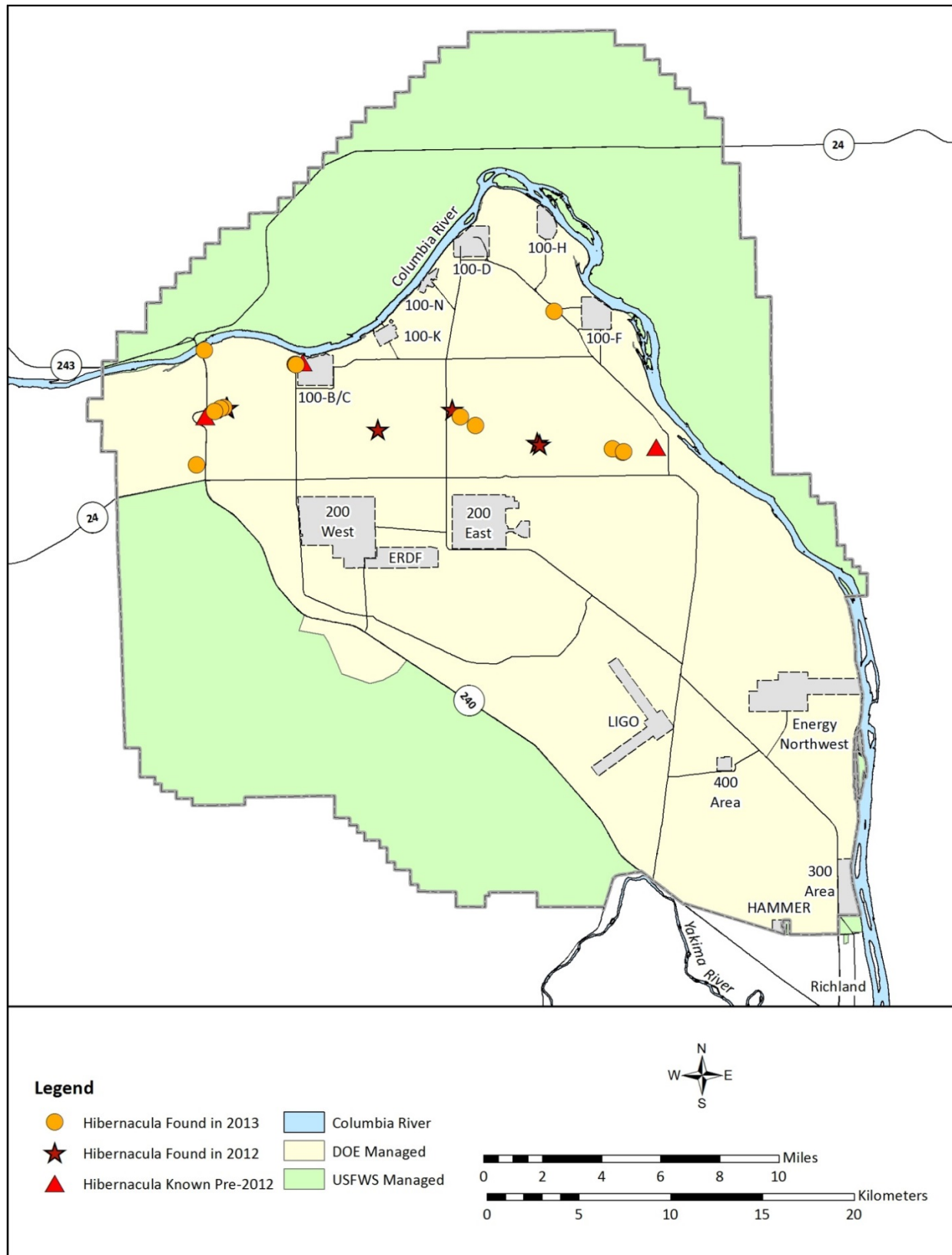


Figure 11.15. Active Snake Hibernacula on the Central Hanford Site



11.1.3.7 Anuran Monitoring

The order Anura, within the class Amphibia, includes the frogs and toads. Monitoring of the anuran populations is an important piece of the comprehensive ecological monitoring of the Hanford Site. This importance is heightened with the outbreak of chytridiomycosis in anuran populations around the globe. This disease, caused by the chytrid fungus (*Batrachochytrium dendrobatidis*), is implicated in the widespread decline of anurans. The fungus and disease has been documented within the Columbia Basin ([Hayes et al. 2009](#), *Amphibian Chytridiomycosis in the Oregon Spotted Frog (Rana pretiosa) in Washington State, USA*). This disease has caused many species to be listed as threatened or endangered; monitoring done to document the locations and relative abundance of sensitive species and their habitats can be used to help protect the species from adverse impacts and to determine if any significant population or distribution changes should be investigated.

Three species of anurans are documented on the Hanford Site: two native species, the Woodhouse toad (Washington State Monitor species) and the Great Basin spadefoot toad (*Spea intermontana*), and one introduced species the American bullfrog (*Lithobates catesbeianus*). Other anurans that have been recorded on the Hanford Site are the Western toad (*Anaxyrus boreas*) and Pacific chorus frog (*Pseudacris regilla*) ([TNC 1999](#)), although more recent work has not documented these species ([Miller 2010](#), *Anuran Utilization of a Semi-Arid Regulated River Environment, The Hanford Reach of the Columbia River*). The anurans on the Hanford Site live and breed in the ephemeral pools and sloughs adjacent to the Columbia River.

In 2003, there were 15 ephemeral pools, and riverbank/backwater slough sites identified as potential anuran breeding habitats by PNNL ([Becker 2011](#), *Hanford National Environmental Research Park*). Anuran population characteristics/habitat-use data have not been collected on the Hanford Site since 2008. Since the transition of the Public Safety and Resource Protection program to MSA in 2011, current breeding status of these sites is unknown. The presence or absence of suitable habitat at these sites is dependent on river level fluctuations and monitoring these areas provides a better understanding of the breeding success and population distribution of anurans on the Hanford Site. Loss of these habitats would be detrimental to their survival. Hanford Site anurans are sentinel species and serve as fundamental indicators of ecological health, and as receptor species in ecological assessments. Anuran monitoring provides a status of the riparian ecosystem on the Hanford Site and documents valuable ecological resources for protection and information for effective natural resource management.

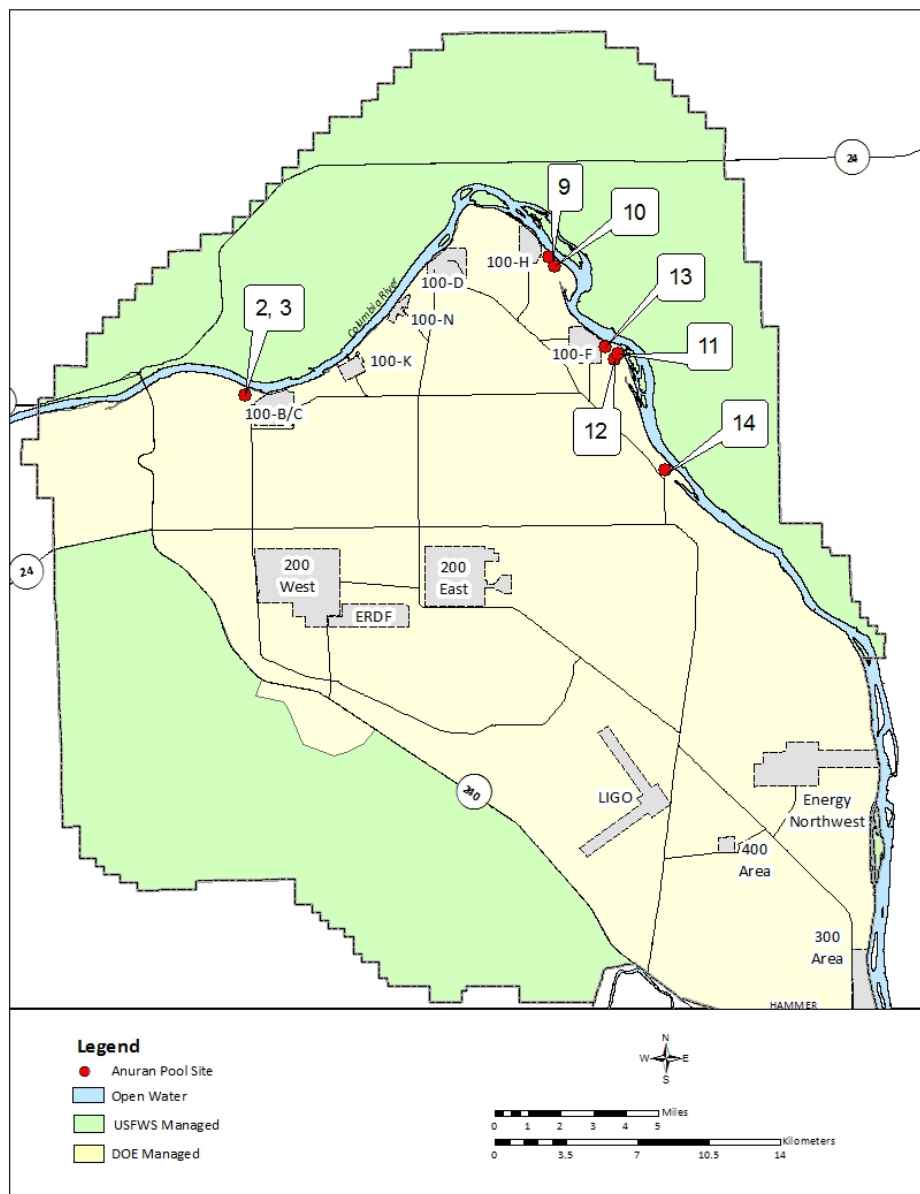
Flow data were gathered from the USGS National Water Information System for station *USGS 12472800 Columbia River below Priest Rapids Dam, WA* ([USGS 2013](#)). These data were compared to existing shoreline maps with 10 kcfs flow band intervals to determine the flow level at which each pool was filled or isolated. Because attenuation of low fluctuations increases with greater distance from the upstream dam, pools were only considered filled or isolated if flows exceeded the respective trigger level for 4 hours. An individual pool was initially created when it was first inundated by flows greater than the 'filled' level, then isolated from the main river channel by flows lower than the 'isolated' level. That pool was then considered a viable breeding habitat until it was inundated again by increasing flows.

Larval development (hatching to the emergence of the first forelimb) is completed in about 47 days in spadefoot toad and about 56 days in Woodhouse's Toad ([Lannoo 2005](#), *Amphibian Declines: The Conservation Status of United States Species*). A viable breeding pool would need to be filled and isolated for approximately 50 days for complete larval development to occur. Once pools were created, surveys were conducted to count and document species with chorus surveys. Chorus surveys were performed by a minimum of two staff at locations near the edge of the pool where species, number of individuals and displacement from the surveyors could be determined. Surveys were performed during hours of darkness starting no sooner than civil twilight.

Eight of the fifteen pools previously identified as suitable anuran breeding sites were surveyed during the 2013 monitoring season (Figure 11.16). Staff performed chorus surveys two dates corresponding to an early breeding season and late breeding season survey. Because of the fluctuations in the river surface level, not all pools were isolated on those nights; however, all that were isolated were surveyed. Although breeding habits are being influenced by river fluctuations, some successful reproduction appears to be occurring; however, no pools remained fully isolated between April and July for the duration required for complete larval development. It is apparent that the modified flow regime is impacting anuran breeding on the Hanford Reach, but the extent of the impact is unknown. Further analysis is needed to understand fully how chorus initiation and larval maturation is impacted by changing pool conditions.

Additional information detailing the 2013 monitoring effort is available in [HNF-56676](#), *Hanford Site Anuran Monitoring Report for Calendar Year 2013*.

Figure 11.16. Anuran Pool Locations Surveyed



11.2 Endangered and Threatened Species

MR Sackschewsky, and JA Pottmeyer

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.” [WNHP 2012](#) and [WDFW 2013](#) maintain state lists.

The purposes of [16 USC 1531](#), 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. The National Oceanic and Atmospheric Administration’s (NOAA) National Marine Fisheries Service ([NOAA 2013](#), *Endangered and Threatened Marine Species*) 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 federal Endangered Species Act in April 2013 ([78 FR 23984](#), “Endangered and Threatened Wildlife and Plants”); the rule was reaffirmed late in 2013 and was effective as of December 20, 2013 ([78 FR 76995](#), “Endangered and Threatened Wildlife and Plants”). 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 (Washington Ground Squirrel) and one bird species (Greater Sage Grouse) are currently candidates for federal listing (Table 11.5). In addition, 12 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 animals and 18 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 24 watch or review list plant species (Table 11.7).

Table 11.4. Federal and State Endangered, Threatened, Sensitive, and Candidate Species

Common Name	Scientific Name	Federal Status ¹	State Status ¹
Plants			
Annual Sandwort	<i>Minuartia pusilla</i> var. <i>pusilla</i>		Sensitive
Awned Halfchaff Sedge	<i>Lipocarpha</i> (<i>Hemicarpha</i>) <i>aristulata</i>		Threatened
Beaked Spike-Rush	<i>Eleocharis rostellata</i>		Sensitive
Canadian St. John's Wort	<i>Hypericum majus</i>		Sensitive
Columbia Milkvetch	<i>Astragalus columbianus</i>	Species of concern	Sensitive
Columbia Yellowcress	<i>Rorippa columbiae</i>	Species of concern	Threatened
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 cespitosa</i> ssp. <i>cespitosa</i>		Sensitive
Dwarf Evening Primrose	<i>Eremothera</i> (<i>Camissonia</i>) <i>pygmaea</i>		Sensitive
Fuzzytongue Penstemon	<i>Penstemon eriantherus</i> var. <i>whitedii</i>		Sensitive
Geyer's Milkvetch	<i>Astragalus geyeri</i> var. <i>geyeri</i>		Threatened
Grand Redstem	<i>Ammannia robusta</i>		Threatened
Gray Cryptantha	<i>Cryptantha leucophaea</i>	Species of concern	Sensitive
Great Basin Gilia	<i>Aliciella</i> (<i>Gilia</i>) <i>leptomeria</i>		Threatened
Hairy Bugseed	<i>Corispermum villosum</i>		Sensitive
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>		Threatened
Lowland Toothcup	<i>Rotala ramosior</i>		Threatened
Piper's Daisy	<i>Erigeron piperianus</i>		Sensitive
Rosy Pussypaws	<i>Cistanthe</i> (<i>Calyptridium</i>) <i>rosea</i>		Threatened
Small-Flowered Evening-Primrose	<i>Eremothera</i> (<i>Camissonia</i>) <i>minor</i>		Sensitive
Snake River Cryptantha	<i>Cryptantha spiculifera</i> (<i>C. interrupta</i>)		Sensitive
Suksdorf's Monkey Flower	<i>Erythranthe</i> (<i>Mimulus</i>) <i>suksdorfii</i>		Sensitive
Thompson's Sandwort	<i>Eremogone</i> (<i>Arenaria</i>) <i>franklinii</i> var. <i>thompsonii</i>		Sensitive
Umtanum Desert Buckwheat	<i>Eriogonum codium</i>	Threatened	Endangered
White Bluffs Bladderpod	<i>Physaria</i> (<i>Lesquerella</i>) <i>douglasii</i> ssp. <i>tuplashensis</i>	Threatened	Threatened
White Eatonella	<i>Eatonella nivea</i>		Threatened
Mollusks			
California Floater	<i>Anodonta californiensis</i>		Candidate
Columbia Pebblesnail	<i>Fluminicola columbiana</i>		Candidate
Giant Columbia River Limpet	<i>Fisherola nuttalli</i>		Candidate
Insects			
Columbia Clutail (Dragonfly)	<i>Gomphus lynnae</i>		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
Chinook Salmon (Upper Columbia Spring-Run)	<i>Oncorhynchus tshawytscha</i>	Endangered	Candidate
Steelhead (Upper Columbia)	<i>Oncorhynchus mykiss</i>	Threatened	Candidate

Table 11.4. Federal and State Endangered, Threatened, Sensitive, and Candidate Species

Common Name	Scientific Name	Federal Status ¹	State Status ¹
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>		Candidate
Clark's Grebe	<i>Aechmophorus clarkii</i>		Candidate
Common Loon	<i>Gavia immer</i>		Sensitive
Ferruginous Hawk	<i>Buteo regalis</i>		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>		Candidate
Northern Goshawk ³	<i>Accipiter gentilis</i>	Species of concern	Candidate
Peregrine Falcon	<i>Falco peregrinus</i>	Species of concern	Sensitive
Sagebrush Sparrow	<i>Artemisiospiza nevadensis (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
Amphibians and Reptiles			
Sagebrush Lizard	<i>Sceloporus graciosus</i>		Candidate
Striped Whipsnake	<i>Masticophis taeniatus</i>		Candidate
Western Toad	<i>Bufo boreas</i>		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 townsendii</i>		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 USFWS regions.

² Probable, but not observed, on the Hanford Site.

³ Reported, but seldom observed, on the Hanford Site.

Table 11.5. 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>	Paiute 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>
Gyr Falcon 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			
Juba Skipper	<i>Hesperia juba</i>		
Nevada Skipper	<i>Hesperia nevada</i>		
Pasco Pearl Crescent	<i>Phyciodes tharos 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			
American 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>Lemmyscus curtatus</i>		
Western Small-Footed Myotis ²	<i>Myotis ciliolabrum</i>		

¹ Reported, but seldom observed on the Hanford Site.² Federal species of concern.

Table 11.6. 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
Basalt Milkvetch	<i>Astragalus conjunctus</i> var. <i>rickardii</i>	Watch List
Bristly Combseed	<i>Pectocarya setosa</i>	Watch List
Chaffweed	<i>Anagallis (Centunculus) minima</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
Kittitas Larkspur	<i>Delphinium multiplex</i>	Watch List
Medic Milkvetch	<i>Astragalus speirocarpus</i>	Watch List
Pigmy-Weed	<i>Crassula aquatica</i>	Watch List
Porcupine Sedge	<i>Carex hystericina</i>	Watch List
Robinson's Onion	<i>Allium robinsonii</i>	Watch List
Rosy Balsamroot	<i>Balsamorhiza rosea</i>	Watch List
Scilla Onion	<i>Allium scilloides</i>	Watch List
Shining Flatsedge	<i>Cyperus bipartitus (C. rivularis)</i>	Watch List
Shy Gilly-flower	<i>Gilia inconspicua</i>	Review Group
Small-flowered Nama	<i>Nama densum</i> var. <i>parviflorum</i>	Watch List
Smooth Cliffbrake	<i>Pellaea glabella</i> var. <i>simplex</i>	Watch List
Smooth Willowherb	<i>Epilobium pygmaeum</i>	Review Group
Southern Mudwort	<i>Limosella acaulis</i>	Watch List
Stalked-pod Milkvetch	<i>Astragalus sclerocarpus</i>	Watch List
Vanilla Grass	<i>Anthoxanthum hirtum (Hierchloe odorata)</i>	Review Group
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

JL Mendez and TE Marceau

Cultural and historic resources protection on the portions of the Hanford Site managed by RL is conducted under the auspices of the RL Cultural Resources Program to ensure site compliance with federal cultural resources laws and regulations (Section 2.5). Program activities in 2013 included the following:

- Performed Cultural Resource Reviews (CRRs) for federal undertakings conducted at the Hanford Site in accordance with Section 106 of the NHPA ([16 USC 470](#)) and NEPA
- Monitored site conditions to ensure important cultural 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.

RL's Cultural Resources Program personnel oversee all cultural resource activities at the Hanford Site. NHPA Section 106 compliance work scope in 2013 was performed for RL by staff archaeologists from MSA and WCH.

The RL 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

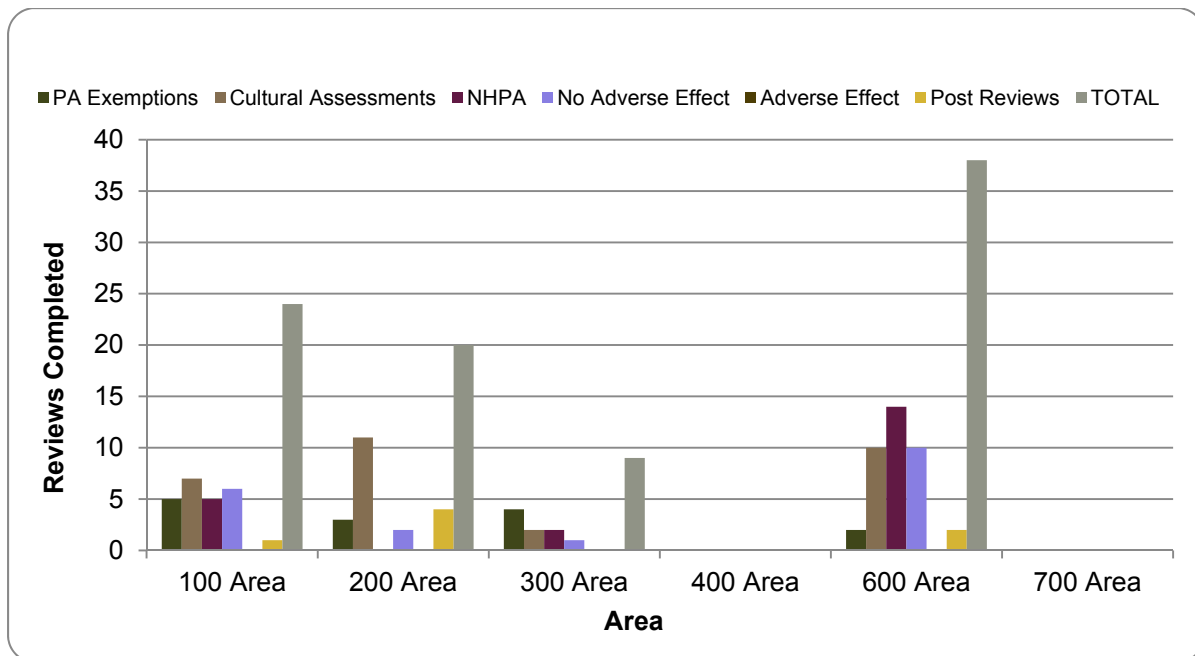
Pursuant to NEPA and Section 106 of the NHPA, RL conducts CRRs of federal undertakings at the Hanford Site. NHPA Section 106 CRRs ensure that important cultural resources are identified and effects to those resources are evaluated prior to project initiation so that mitigation measures can be conducted, if necessary.

Hanford Site archaeologists completed 97 NHPA Section 106 CRRs, including 50 proposed projects that did not involve ground disturbance. These projects were determined exempt by Hanford Site archaeologists after meeting the RL-approved Historic Buildings Programmatic Agreement exemption criteria (PA Exemptions) following an initial review, or had satisfied the requirements of NHPA Section 106 under a prior review (Cultural Assessments). Hanford Site archaeologists reviewed and completed seven projects under an emergency declaration (Post Reviews) in accordance with Section 5.1.1 of [DOE/RL-98-10](#). Most projects cleared under these expedited reviews occurred in the 200 Areas of the Hanford Site (Figure 11.17).

Hanford Site archaeologists also reviewed 40 undertakings in 2013 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 measures, if necessary¹. Of the 40 undertakings, 21 were identified as *No Historic Properties Affected*, while 19 were determined to have *No Adverse Effects* to historic properties. No project was identified as having *Adverse Effects* (Figure 11.17). Approximately 6,085 acres (2,463 hectares) of new ground was surveyed for cultural resources, because of the 40 undertakings that had the potential to affect physically cultural resources. In addition, some undertakings required National Register of Historic Places (NRHP) ([36 CFR 60](#)) eligibility evaluations, including sub-surface archaeological testing.

¹ This number does not reflect all full cultural resources reviews initiated in 2013. Additional reviews were initiated in 2013, but completed in 2014, and are not included in this report.

Figure 11.17. National Historic Preservation Act Section 106 Reviews



11.3.2 Cultural Resources Protections

To ensure protection of the cultural and historic resources located on the Hanford Site, monitoring activities are conducted to comply with Section 110 of the NHPA ([36 CFR 60](#)), [16 USC 470](#), and the *Native American Graves Protection and Repatriation Act of 1990* ([16 USC 3001](#)). A monitoring program has been in place since 1989 to assess the effects of weathering and erosion and/or unauthorized excavation and collection of significant cultural resources on the Hanford Site. Activities include onsite inspections to monitor site conditions, assess impacts, and identify protective measures, if necessary.

There were 31 pre-contact archaeological sites were monitored. Site visits are conducted with the participation of Tribal cultural resources personnel. In addition, information from the last 9 years of monitoring was analyzed to define a path forward for the program that would increase efficiency in fieldwork and maximize the value of collecting this information. Archaeological site condition assessment considers two factors: first, the artifacts, sediments, and features that comprise the site (i.e., the “data”); and second, the physical integrity of the site (i.e., how close to “pristine” the site remains). Impacts to archaeological sites are cumulative and permanently destroy both the site’s data and integrity. To assess the condition of a site, variables such as the spatial extent of damage (if any), degree of effect, potential threat, and severity of threat are evaluated. Based on all current and previously recorded impacts, a numeric value is assigned to the site. Sites are then classified using the National Park Service (NPS) definitions of “Good” (0 to 1.9), “Fair” (2 to 2.9), “Poor” (3 to 3.9), and “Destroyed” (4 or higher). Of the 105 sites monitored in the last 9 years, 35 sites are in Good condition, 23 sites are in Fair condition, 39 sites are in Poor condition, and 8 are possibly Destroyed.

Changes in “site condition” over time, as recorded by periodic site monitoring, are used to measure the second factor; i.e., the physical integrity or stability of the site. This is determined by looking at the NPS condition ranking (described above) through time. Three determinations are possible: the site is deteriorating through increases in destructive activity; stabilizing by decreasing destructive activity; or experiencing no increase or decrease in destructive activity. Of the 31 sites monitored in 2013, only 12 sites had enough cumulative information from the previous 9 years to draw any meaningful

conclusions. Within this limited sample, the condition of six sites was deteriorating, three sites were stabilizing, and three sites were not experiencing any change.

Impacts to archaeological site 45BN162, a National Register eligible site, were reported in 2012 due to vehicle traffic, exposing cultural materials in the roadway on the west edge of the site. The area was cordoned off to avert vehicle traffic around the exposed cultural material. Consultation with local Native American Tribes in 2013 led to the stabilization of the site in September with the use of landscape fabric and gravel. Once the gravel was added, the existing barricade was left in place to deter additional vehicle traffic over the exposed area. The stabilization efforts have deterred additional deterioration and erosion of these cultural materials. Additional cultural resources monitoring activities in the area will ensure that the stabilization measures in place are sufficient to protect the site.

This reporting year, RL completed the NHPA Section 106 work for the stabilization and rehabilitation of one of its historic structures, the White Bluffs Bank. The White Bluffs Bank was constructed in 1907 and incorporated in 1909. It was also known as the First National Bank of White Bluffs and the First Bank of White Bluffs, and is a historically significant building on the Hanford Site. The building has been determined eligible for listing in the NRHP ([36 CFR 60](#)) and is considered a contributing component to the White Bluffs Historic District, which encompasses the historic, pre-Hanford town of White Bluffs. As part of the NHPA Section 106 process, RL worked with an architectural engineering firm, in consultation with the Washington State Historic Preservation Office (SHPO), to identify stabilization efforts/techniques consistent with the *Secretary of the Interior's Standards for the Treatment of Historic Properties* to implement during Phase I of the project. RL will continue to work with the architectural/engineering professionals on the development of a rehabilitation plan for the Bank in FY2014.

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*. There were 13 new archaeological sites or isolated finds recorded (Table 11.8). *National Register of Historic Places* evaluations were completed on eight newly discovered sites; only one was determined eligible for listing in the National Register. Three new sites were not evaluated. Archaeological site forms for two previously recorded archaeological sites were updated, and each was re-evaluated for National Register eligibility; both were determined not eligible for listing. Isolates generally are not evaluated for National Register eligibility. Two Historic Property Inventory Forms (HPIF) were completed during the reporting period for components of Hanford's built environment including historic Route 6 and the 183-B Clearwells.

Table 11.7. Sites and Isolates Recorded or Updated

	Eligible	Not Eligible	Unevaluated	Total
Site Updates	0	2	0	2
New Sites	1	7	3	11
New Isolates	0	0	2	2
Historic Property Inventory Form	0	0	2	2
Total	1	9	7	17

As part of cultural resource identification under Section 110 of the NHPA ([16 USC 470](#)), a 320-acre (130-hectare) survey was completed in the Wautoma Area of the Hanford Site to identify any previously unrecorded archaeological sites. In addition to the pedestrian survey, a sub-surface investigation (nine shovel probes) also was completed to identify any potential sub-surface resources. While no new archaeological sites were identified during these survey efforts, geological information was collected from shovel probe data to add to our knowledge on soil formation processes and paleo-environments in

this particular area of the Hanford Site. This information will prove useful in understanding archaeological resources found in this area of the site, and will aid in determining the probability of cultural sites being located in the Wautoma Area of the Hanford Site. The results of these efforts will be documented in a technical report that will be shared with the SHPO and consulting parties in FY2014.

This reporting year, NHPA Section 106 work for proposed radiological and chemical characterization sampling of sediments at two large waste sites on the Columbia River floodplain of the Hanford Site was completed by WCH Cultural Resources staff. These waste sites were associated with discharged water from the cooling of the 100-K Area reactor cores during Hanford Site operations. These waste sites overlapped with areas of both significance and importance to area Tribes and “National Register of Historic Places” (36 CFR 60) eligible properties. RL, along with several other state and federal agencies (including the Ecology and the EPA), and Tribal leaders, worked together to incorporate Tribal preference in soil sampling techniques into the protocols to be implemented in these culturally sensitive areas. Soil characterization sampling activities would generally include invasive and extensive excavations using heavy machinery; however, in consultation with area Tribes, the working group was able to design minimally invasive sampling techniques to recover characterization samples from these waste sites. Specifically, characterization samples were collected from shovel test units excavated using archaeological excavation techniques with the assistance of Tribal monitors and elders. Artifacts encountered in the test units were documented and analyzed in the field and reburied. Archaeological information collected during these field efforts is being compiled into a technical report, which will be shared with consulting parties and maintained in the records of both RL and the Washington SHPO. Performing the work in this way, with the archaeological testing and characterization sampling completed in tandem, ensured that data on the sites of cultural and religious significance were appropriately documented for future use, while also ensuring that soil for characterization was collected with minimum impacts to this culturally sensitive area.

11.3.2.2 Data and Artifact Collections Management

MSA staff maintains the Hanford Site NHPA 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 CRRs conducted on the Hanford Site. Data entry into the NHPA Section 106 database includes the tracking of important dates, actions, letters, and results of the CRRs. Once a project is complete, it is closed out in the database and accessioned into the MSA paper archives for use by all Hanford Site Cultural Resource contractors and other interested researchers. In addition to a MSA contractual obligation, management and maintenance of these files is essential to the completion of all cultural resource compliance activities conducted on the Hanford Site. As part of ongoing records management, 104 new projects were opened, with pertinent information entered as acquired into the Hanford Site NHPA Section 106 database, and 109 projects were closed out after data entry was complete, with a hard copy of the project documentation added to the MSA paper archive.

MSA staff also updates and maintains the Cultural Resources 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 NHPA Section 106 work, newly recorded and updated archaeological site locations, and contextual information describing the survey or site. All Hanford Site contractors for literature reviews use the GIS database, cultural resource compliance reporting, and documentation, and research by RL approved users.

As part of ongoing database management, a total of 26 polygons delineating completed archaeological surveys were added to the Hanford Site Survey Master shapefiles (map file), and 13 new archaeological sites/isolates, together with associated spatial and contextual information, were added to the GIS Archaeological Site and Isolate Database. Spatial and contextual information for four archaeological sites/isolates were updated in the GIS Archaeological Site and Isolate Database based on information gathered during recent re-visits to these locations.

Largely as a result of excavations conducted as mitigation for adverse effects on archaeological sites, MSA staff manages a collection of artifacts relating to the Native American settlement of the area within the mid-Columbia Basin that would become the Hanford Site. Similarly, MSA maintains a small collection of artifacts that mark the pre-1943 Euro-American settlement of the Priest Rapids Valley, later designated as the Hanford Site. The forms and reports that document the excavations and interpret these sites also are held by MSA. During 2013, archaeological test excavations were conducted to support soil characterization sampling on the Columbia River floodplain outside the 100-K Area. Nearly half of the 56 shovel test units contained lithic, shell or bone material; however, all artifacts encountered through these excavations were analyzed in the field and returned to the ground. No new artifacts were added to either the prehistoric or pre-Hanford collections.

The MSA staff also manages the Hanford Site Manhattan Project and Cold War Era artifact collection, known as the Hanford Collection. Efforts to generate additional items for the collection are conducted as stipulated in the *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* ([DOE/RL-96-77](#)), which directs RL personnel to assess the contents of site historic buildings and structures prior to commencement of D4 activities. Assessments identify and preserve any artifacts that may have value as interpretive or educational exhibits within national, state, or local museums. Artifact assessments were conducted for the last 20 buildings in 2013. The walkthrough conducted on December 11, 2013, closed out a 17-year effort (i.e., 1997 through 2013) that had evaluated the contents of 293 buildings, identifying 743 items for potential collection as representative artifacts of the Hanford Site during the Manhattan Project and Cold War Era.

11.3.3 Cultural Resources Consultations and Public Involvement

RL conducts formal consultations with the Washington SHPO, Native American Tribes, and other interested parties for CRRs to comply with Section 106 of the NHPA and NEPA (Section 2.1.4). RL consulted with the Washington SHPO and Native American Tribes on all 40 projects that required a full review because of their potential to affect cultural resources within the project area.

RL Cultural Resources Program staff held nine meetings in 2013 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 CRRs both completed and initiated in 2013; proposed undertakings within Traditional Cultural Property (TCP) boundaries and view sheds; and approaches to protecting threatened archaeological sites and places containing Native American human remains.

Consultation with local Tribes took place for one of Hanford's TCPs between July 2012 and March 2013. RL worked closely with area Tribes and the Washington SHPO to revise the boundary for this important property, and update the NRHP ([36 CFR 60](#)) form to reflect Tribal input and importance. In an effort to facilitate discussions with area Tribes and the SHPO, RL set up several workshops as a forum to discuss the TCP and complete the NRHP form. Information gained from the TCP workshops, as well as background research and fieldwork, was combined into the final version of the NRHP form for the TCP. This form was transmitted to SHPO and consulting parties in August of 2013.

12.0 Quality Assurance

SJ Johnson

Quality assurance (QA) and quality control (QC) practices encompass all aspects of Hanford Site environmental monitoring and surveillance activities. Hanford Site contractors, subcontractors, and multiple DOE organizations are involved in and conduct environmental monitoring and surveillance activities independently – each driven by different missions and regulatory requirements, but with the same goal in mind. This section is representative of the Environmental Surveillance Program, managed by the MSA Public Safety and Resource Protection Program. The program is responsible for a portion of the environmental monitoring and surveillance activities both on the Hanford Site and offsite. The program produces multi-media environmental monitoring to assess Hanford Site and offsite human health exposures to radionuclides and chemicals and to evaluate the impact of Hanford Site operations on the environment. This section provides information on specific measures taken in 2013 to ensure quality and defensibility in project management, sample collection, and analytical results.

The Environmental Surveillance Program comprehensively includes Hanford Site and offsite environmental surveillance and monitoring across multiple media types and are described in this section. Due to the complexity of the groundwater program, QA/QC specifications for groundwater sampling and program management are reported independently in the [Hanford Site Groundwater Monitoring Report for 2013](#) (Appendix D) and are not discussed in this section.

Quality assurances and controls of the Hanford Site and offsite surveillance programs are documented through QA program plans and describe applicable QA elements (e.g., MSC-23333, *Environmental Quality Assurance Program Plan*). Sample analyses across all media types are performed by both on and offsite contracted laboratories, which are also required to meet these plan specifications. To ensure the highest quality of data is obtained, accredited offsite laboratories used were audited for equipment and services before the contract awards were made.

12.1 Program Management

Per federal requirements, environmental surveillance activities are subject to an overall QA program. This program satisfies the requirements for collecting and assessing environmental data in compliance with the following:

- [10 CFR 830](#), “Nuclear Safety Management, Subpart A, Quality Assurance Requirements”
- [DOE O 414.1D](#), *Quality Assurance*
- [DOE/RL-96-68](#), *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD)
- [EPA/240/B-01/003](#), *EPA Requirements for Quality Assurance Project Plans*
- Richland Requirements Document 008, *Quality Assurance Program Requirements*
- Project-specific QA plans and documentation are found in MSC-23333 and describe the QA/QC elements associated with the Environmental Surveillance Program.

DOE O 414.1D QA Program Requirements

- Management/QA Program
- Personnel Training and Qualification
- Quality Improvement
- Documents and Records
- Work Processes
- Design
- Procurement
- Inspection and Acceptance Testing
- Management Assessment
- Independent Assessment

12.1.1 Personnel Training and Qualifications

Hanford Site personnel are provided with the knowledge and skills necessary to perform specific jobs safely, effectively, and efficiently with minimal supervision. This capacity is accomplished by establishing and enforcing site-wide policies, procedures, and guidance through training programs that provide general and specialized training classes and also housing hands-on training facilities dedicated to ensuring personnel are qualified and confident to safely perform the task at hand. The training program includes the following principles and practices and is documented in MSC-23333:

- Development of training standards and procedures that meet valid requirements and regulations and are consistent with industry-proven “best management practices”
- Recognition of management’s responsibility to lead and coach their employees to ensure employees are trained and remain proficient to perform assigned tasks
- Conduct evaluations of employee training to ensure regulatory compliance, compliance with standards and instructions, and to improve the training process
- Instructional staff and subject matter experts who are qualified and maintain their instructional and subject area skills and knowledge
- Use a graded approach to develop training programs to ensure value and effectiveness.

12.2 Quality Control Samples

Several types of QC samples are collected during monitoring and sampling events. The QC samples are in place to help reduce data uncertainty and to collect the highest quality data possible. The tasks vary by monitoring and sampling event and QC procedures are followed in both the field and laboratory to ensure reliable data are obtained.

Field environmental QC samples are collected to evaluate the potential for cross-contamination and to provide information pertinent to field variability. Field QC samples require the collection of field duplicates, trip or field blanks, and equipment blanks.

Laboratory QC samples estimate the precision and accuracy of the analytical data and include method blanks, laboratory replicates, matrix spikes, and matrix spike duplicates. Table 12.1 summarizes the different types of QC samples administered.

A QC sample frequency goal of 5 percent, or 1 in 20 samples, where feasible, is set for environmental surveillance activities on the Hanford Site for the number of QC samples needed for environmental data collection and surveillance activities.

Blanks: A sample of the carrying agent (gas, liquid, or solid) normally used to measure selectively a material of interest that is subjected to the usual analytical process and associated procedures to establish a baseline or background value. This value is then used to adjust or correct the routine analytical results.

Field Duplicate Samples: Two samples produced from material collected in the same location. The Parent sample and its Duplicate are each uniquely labeled and are used to provide information regarding the homogeneity of the matrix.

Laboratory Replicate Sample: A single sample aliquoted alternately into two sets of sample containers for duplicate analysis by the primary laboratory. Lab replicates are a measure of variation of aliquots analyzed from the same sample.

Spiked Sample: A normal sample of material (gas, liquid, or solid) to which a known amount of some substance of interest is added. Spiked samples are used to check on the accuracy of a routine analysis or the recovery efficiency of an analytical method. Spiked samples are exclusively used by the laboratory.

Table 82.1 Field and Laboratory Quality Control Sample Types, Characteristics, and Frequency

Sample Type	Primary Characteristics Evaluated	Frequency
Field QC Samples		
Field trip blank (FTB)	Volatile Organic Compound cross-contamination from other sources during transportation	1 per field trip
Equipment blank (EB)	Cross-contamination from non-dedicated equipment	1 per sampling method type per year for selected analytes
Duplicate	Reproducibility	1 per 20 samples, where feasible
Laboratory QC Samples		
Method blank	Laboratory contamination	^a
Laboratory replicate	Laboratory reproducibility	^a
Matrix spike	Matrix effect and laboratory accuracy	^a
Matrix spike duplicate	Laboratory reproducibility/accuracy	^a

^a As defined in the laboratory contract or QA plan, and/or analysis procedures

12.3 Sample Collection Quality Assurance and Quality Control

Environmental samples collected for air, surface water, biota (including wildlife and food and farm products), soil and vegetation, and sediment were collected by trained personnel in accordance with approved desk instructions and/or procedures. Established sampling locations were accurately identified with visible postings or plotting global positioning system readings and documented to ensure continuity of data. Environmental samples collected were submitted to the WSCF laboratory located in the 200 Area of the Hanford Site for radiochemical analyses, or to the General Engineering Laboratories, LLC, in Charleston, South Carolina, for chemical and radiochemical analyses (Table 12.2).

Table 19.2 Laboratories and Types of Environmental Surveillance Samples Analyzed

Analytical Laboratory	Environmental Monitoring and Surveillance Samples			
	Air	Water	Biota	Other
WSCF	X			X
General Engineering Laboratories, LLC	X	X	X	X

12.3.1 Field Sample Collection Quality Assurance

Personnel are trained to conduct sampling in accordance with approved schedules, instructions, and procedures. Field assessments are routinely performed by Media Task Leads and documented. Field duplicate samples are used to assess sampling and measurement precision, and continuity of all sampling location identities was maintained through careful documentation. Field duplicate samples collected and analyzed for offsite media included air, Columbia River water, Hanford Site pond water, milk, alfalfa, leafy vegetables, sediment, and seep samples (Table 12.3).

Table 12.10 Hanford Site Offsite Media Field Duplicate Samples and Locations

Media	Location	Number of Samples
Air	300 South Gate	12
Columbia River Water	Hanford Townsite - HRM 28.7	5
Columbia River Water	300 Area - HRM 43.1	5
Hanford Site Pond Water	Fast Flux Test Facility Pond	4
Milk	Sagemoor Area	2
Alfalfa	Sagemoor Area	1
Leafy Vegetables	East Wahluke Area	1
Sediment	Hanford Slough	1
Seep	300 Area Spring 42-2	8

HRM: Hanford River Mile

Field duplicates for Hanford Site samples and locations collected included air, soil, and natural vegetation (Table 12.4). Hanford Site air samples were collected and analyzed bi-weekly from two locations, then composited semiannually, by location, for isotopic analysis.

Table 12.11 Hanford Site Media Field Duplicate Samples, Locations, and Constituents Analyzed

Media	Location	Analyte
Air	200 West Area	Alpha (gross); Beta (gross); antimony-125; cesium-134, -137; cobalt-60; europium-152, -154, -155; plutonium-238, -239/240; ruthenium-106; strontium-90; uranium-234, -238, -235
Air	WYE Barricade	Alpha (gross); Beta (gross); americium-241; antimony-125, cesium-134, -137; cobalt-60; europium-152, -154, -155; plutonium-238, -239/240; potassium-40; ruthenium-106; strontium-90; uranium-234, -238, -235
Soil	316-2 Process Pond, South	antimony-125, cesium-134, -137; cobalt-60; europium-152, -154, -155; plutonium-238, -239/240; ruthenium-106; strontium-90; uranium-234, -238, -235
Soil	316-3 Process Pond, South	antimony-125, cesium-134, -137; cobalt-60; europium-152, -154, -155; plutonium-238, -239/240; ruthenium-106; strontium-90; uranium-234, -235, -238
Soil	U-Plant	antimony-125, cesium-134; cesium-137; cobalt-60; europium-152, -154, -155; plutonium-238; plutonium-239/240; ruthenium-106; strontium-90; uranium-234, -238, -235
Natural Vegetation	U-Plant	antimony-125; cesium-134; cesium-137; cobalt-60; europium-152, -154, -155; plutonium-238; plutonium-239/240; ruthenium-106; strontium-90; uranium-234, -238, -235

Analytical results for onsite and offsite parent and duplicate samples were reviewed against the criterion that the result must be greater than the minimum detectable activity value or the method detection limit to be evaluated (commonly known as a detect). To be considered an acceptable result (a result within the control limits); the relative percent difference (RPD) of the detected routine sample and its duplicate must also be less than 30 percent (MSC-SD-CP-QAPP-017, *Waste Sampling and Characterization Facility Quality Assurance Program Plan*). Of the 157 reported offsite media duplicate results evaluated, 131 of them were acceptable and within the control limits. Offsite media duplicate comparisons had an overall acceptance rate of 83.4 percent and are shown, by media and constituent, in Table 12.5.

Relative Percent Difference (RPD)

A measure of the precision of the measurement of a sample (S) and its duplicate (D). The formula is as follows:

$$RPD = \left(\frac{|S - D|}{\frac{(S + D)}{2}} \right) \times 100$$

Of the 136 reported Hanford Site media duplicates (air, soil, and natural vegetation), 133 comparison results were considered acceptable. Results of the Hanford Site duplicate sample comparisons had an overall 97.8 percent acceptance rate for detected results (see Table 12.6).

12.4 Media Audits and Comparisons

Selected sediment, surface water, food and farm products, wildlife, soil, and vegetation samples are provided to the WDOH for comparative analysis as part of the Public Safety and Resource QA program ([DOE/RL-91-50](#)). The Hanford Environmental Radiation Oversight Program of the WDOH independently verifies the quality of DOE monitoring programs at the Hanford Site. Since 1985, WDOH and DOE have collaboratively participated in the collection of environmental samples located on or in the surrounding areas of the Hanford Site ([WDOH 320-097](#), *Hanford Environmental Radiation Oversight Program 2011 Data Summary Report*). This includes, but not limited to, conducting split, collocated and independent sampling at locations which have the potential to release radionuclides to the environment or at locations which may be impacted by such releases. This program provides oversight to Hanford Site contractors to determine the impact of Hanford releases on the environment and the public and is not intended to completely characterize environmental radiation on the Hanford Site. More information can be found on the WDOH website at [DOH's Environmental Sciences](#). Media types analyzed by the WDOH included:

- Air Filters from 11 locations
- Alfalfa from 2 locations
- Leafy vegetables from 2 locations
- Potatoes from 3 locations
- Sediment from 5 locations
- Concord grapes from 2 locations
- Cottontail rabbits from 1 location
- Red and white wine from 3 locations
- Whitefish from 2 locations
- Columbia River surface water from 1 location
- Offsite irrigation water from 2 locations
- Columbia River shoreline springs (seeps) from 6 locations

No comparison data were available at the time this report was written; however, links to past data summary reports and other environmental science publications for the Hanford Environmental Radiation Oversight program are available online at <http://www.doh.wa.gov/communityandenvironment/radiation/publications/environmentalsciences.aspx>.

12.5 Laboratory Quality Assurance Programs

Contracted analytical laboratories are required to maintain internal QC programs and also participate in independent QC programs used to determine analytical precision and accuracy. These laboratories house chemical technologists who are qualified to perform these analyses through formal classroom education and on-the-job training. Internal QC programs for contracted laboratories involve 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. Examples of independent QC programs are the Mixed Analyte Performance Evaluation Program and the DOE Consolidated Audit Program and are described in the subsequent sections.

12.6 Analytical Quality Assurance and Quality Control

Hanford Site environmental samples were sent to two laboratories in 2013 (Table 12.1) and included routine chemical and radiological analyses of air, water, soil and vegetation, sediment and biota. In 2013, these laboratories participated in independent QA and QC programs including the Mixed Analyte Performance Evaluation Program (MAPEP). 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, the validity, reliability, and defensibility of data from the contract laboratories.

General Engineering Laboratories, LLC, was audited by DOECAP in March 2013, participated in MAPEP Studies 28 and 29, and a number of Environmental Resource Associates proficiency studies for water, soil, air filter, and vegetation matrices.

WSCF maintains Ecology and American Industrial Hygiene Association accreditation and have implemented an internal QA program plan ([MSC-SD-QAPP-017](#)). In 2013, WSCF participated in laboratory performance evaluation programs: EPA studies (i.e., soil, water pollution, and water tritium), and DOE MAPEP Studies 28 and 29. These programs are briefly described in the sections below.

12.6.1 U.S. Department of Energy Consolidated Audit Program (DOECAP)

General Engineering Laboratories, LLC, was audited by DOECAP in March 2013. 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 follow approved and technically sound methods, and the handling of DOE samples and associated waste in a manner that protected human health and the environment.

12.6.2 Laboratory Performance Evaluation and Proficiency Testing

Participation of Hanford Site analytical laboratories in DOE and EPA laboratory performance evaluation programs serve to ensure data quality. Hanford Site environmental monitoring contract laboratories participated in MAPEP and/or in an EPA-sanctioned proficiency test provided by an independent laboratory; e.g., Environmental Resource Associates.

DOE's MAPEP provides critical QA testing for environmental analytical services. Radiological and non-radiological (organic and inorganic) constituents were evaluated by performing semiannual proficiency testing of the Hanford Site DOE laboratories, and other federal, state, commercial, 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. Results to past MAPEP studies can be found on the DOE's Mixed Analyte Performance Evaluation Program webpage at <http://www.id.energy.gov/resl/mapep/mapepreports.html>.

General Engineering Laboratories, LLC, MAPEP program results were 100 percent acceptable for Studies 28 and 29 in 2013 for air and water; however, radiological results for vegetation in Study 28 failed for uranium-234 and uranium-238 due to sensitivity evaluations. Radiological vegetation results for Study 29 were 100 percent acceptable. Results of MAPEP Studies 28 and 29 for General Engineering Laboratories, LLC, can be found in Table 12.7 or at the link provided in the paragraph above.

In 2013, WSCF completed MAPEP Studies 28 and 29 (including filter, soil, vegetation, and water matrices) and Environmental Resource Associates performance evaluation studies for tritium (semiannual) and for gamma energy analysis (annual). WSCF had an overall 94 percent acceptance rate with a total of 126 reported radiochemical performance evaluation results. The summary of the 2013 radiochemistry performance evaluation results for WSCF is presented in Table 12.8.

12.7 Data Recording and Data Management

Record keeping is a vital part of all environmental programs on the Hanford Site. Maintenance of environmental data is essential for QA, regulatory compliance, trend analysis, and optimization purposes. The Environmental Surveillance organization is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements that govern data management procedures. Project documentation includes environmental sample logbooks and processing forms, and as applicable, monthly, quarterly and annual occurrence reports. Several electronic data repositories are used to house the environmental data; all of which have their own internal QA and QC policies and procedures.

Table 12.12. Offsite Media¹ Field Duplicate Sample Results

Radionuclides Media	Detected Analytes	Number of Results Within Control Limits ²	Percent of Results within Control Limits
Air			
	Alpha (gross)	18 of 26	69.2
	Beta (gross)	19 of 26	73.1
	Americium-241	2 of 2	100
	Antimony-125	2 of 2	100
	Colbalt-60	2 of 2	100
	Cesium-134	2 of 2	100
	Cesium-137	2 of 2	100
	Europium-152	2 of 2	100
	Europium-154	2 of 2	100
	Europium-155	2 of 2	100
	Hydrogen-3 (tritium)	12 of 12	100
	Plutonium-238	2 of 2	100
	Plutonium-239/240	2 of 2	100
	Potassium-40	2 of 2	100
	Ruthenium-106	2 of 2	100
	Strontium-90	2 of 2	100
	Uranium-234	2 of 2	100
	Uranium-235	2 of 2	100
	Uranium-238	2 of 2	100
Food and Farm Products			
Milk	Hydrogen-3 (tritium)	1 of 1	100
Surface Water			
Pond	Beta (gross)	1 of 1	100
	Hydrogen-3 (tritium)	1 of 1	100
Columbia River	Cesium-137	0 of 1	0%
	Hydrogen-3 (tritium)	2 of 2	100%
	Uranium-234	2 of 2	100%
	Uranium-235	0 of 1	0%
	Uranium-238	1 of 2	50%
Seep			
	Gross α	1 of 1	100%
	Gross β	1 of 1	100%
	Hydrogen-3 (tritium)	1 of 1	100%
	Uranium-234	1 of 1	100%
	Uranium-235	1 of 1	100%
	Uranium-238	1 of 1	100%
Sediment			
	Cesium-134	0 of 1	0%
	Cesium-137	1 of 1	100%
	Uranium-234	0 of 1	0%
	Uranium-235	0 of 1	0%
	Uranium-238	0 of 1	0%

Table 12.12. Offsite Media¹ Field Duplicate Sample Results

Radionuclides Media	Detected Analytes	Number of Results Within Control Limits ²	Percent of Results within Control Limits
Anions			
Surface Water	Chloride	2 of 2	100%
	Fluoride	2 of 2	100%
	NO ₃ -N	1 of 2	50%
	Sulfate	2 of 2	100%
Seep	Chloride	1 of 1	100%
	Fluoride	1 of 1	100%
	NO ₃ -N	1 of 1	100%
	Sulfate	1 of 1	100%
Sediment	Chloride	1 of 1	100%
	Fluoride	1 of 1	100%
	Sulfate	0 of 1	0%
Inorganics			
Surface Water	Copper	4 of 4	100%
	Nickel	1 of 1	100%
	Uranium	4 of 4	100%
	Zinc	2 of 3	66.6%
Sediment	Antimony	1 of 1	100%
	Arsenic	1 of 1	100%
	Beryllium	1 of 1	100%
	Cadmium	1 of 1	100%
	Chromium	1 of 1	100%
	Copper	1 of 1	100%
	Hexavalent Chromium	0 of 1	0%
	Lead	1 of 1	100%
	Mercury	1 of 1	100%
	Nickel	1 of 1	100%
	Silver	1 of 1	100%
	Zinc	1 of 1	100%

¹ Media analyzed by General Engineering Laboratories, LLC, Charleston, South Carolina.² 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 12.13. Hanford Site Media¹ Field Duplicate Sample Results

Detected Analytes	Number of Results in Control Limits ²	Percentage of Results in Control Limits
Air Filters		
Alpha (gross)	26 of 26	100
Beta (gross)	25 of 26	96.2
Antimony-125	2 of 2	100
Cesium-134	2 of 2	100
Cesium-137	2 of 2	100
Cobalt-60	2 of 2	100
Europium-152	2 of 2	100
Europium-154	2 of 2	100
Europium-155	2 of 2	100
Plutonium-238	2 of 2	100
Plutonium-239/240	2 of 2	100
Ruthenium-106	2 of 2	100
Strontium-90	2 of 2	100
Uranium-234	2 of 2	100
Uranium-235	2 of 2	100
Uranium-238	2 of 2	100
Soil		
Antimony-125	3 of 3	100
Cesium-134	3 of 3	100
Cesium-137	3 of 3	100
Cobalt-60	3 of 3	100
Europium-152	3 of 3	100
Europium-154	3 of 3	100
Europium-155	3 of 3	100
Plutonium-238	3 of 3	100
Plutonium-239/240	3 of 3	100
Ruthenium-106	3 of 3	100
Strontium-90	2 of 3	66.6
Uranium-234	3 of 3	100
Uranium-235	3 of 3	100
Uranium-238	3 of 3	100
Natural Vegetation		
Antimony-125	1 of 1	100
Cesium-134	1 of 1	100
Cesium-137	0 of 1	0
Cobalt-60	1 of 1	100
Europium-152	1 of 1	100
Europium-154	1 of 1	100
Europium-155	1 of 1	100
Plutonium-238	1 of 1	100
Plutonium-239/240	1 of 1	100
Ruthenium-106	1 of 1	100
Strontium-90	1 of 1	100
Uranium-234	1 of 1	100
Uranium-235	1 of 1	100
Uranium-238	1 of 1	100

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 12.14. DOE Mixed Analyte Performance Evaluation Program Results for
General Engineering Laboratories, LLC

Environmental Sample Media and Analytes		MAPEP 28 Series March 2013 ¹	MAPEP 29 Series August 2013 ¹
Radionuclides			
Air Filters	Gross alpha, Gross beta, Americium-241, Cesium-134, Cesium-137, Cobalt-60, Plutonium-238, Plutonium-239/240, Strontium-90, Uranium-234/233, Uranium-238	100% Acceptable	100% Acceptable
Water	Gross alpha, Gross beta, Americium-241, Cesium-134, Cesium-137, Cobalt-60, Iodine-129, Plutonium-238, Plutonium-239/240, Potassium-40, Strontium-90, Technetium-99, Tritium, Uranium-234/233, Uranium-238	100% Acceptable	100% Acceptable
Vegetation	Cesium-134, Cesium-137, Cobalt-60, Plutonium-238, Plutonium-239/240, Strontium-90, Uranium-234/233, Uranium-238	Uranium-234/233 ² Uranium-238 ²	100% Acceptable
Soil	Cesium-134, Cesium-137, Cobalt-60, Plutonium-238, Plutonium-239/240, Strontium-90	100% Acceptable	100% Acceptable
Inorganic Compounds			
Water	Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Thallium, Zinc	100% Acceptable	100% Acceptable
Organic Compounds			
Water	1,4-Dichlorobenzene	100% Acceptable	100% Acceptable

¹ Performance results 100 percent acceptable for all analytes unless otherwise noted.² Result not acceptable, Bias > 30 percent due to the sensitivity evaluation of the radionuclide in the sample. No adverse effect on Hanford sample.

Table 12.15 Radiochemical Performance Evaluation Results from the
Waste Sampling and Characterization Facility¹

Media	Program	Radionuclide	Number of Results Reported	Number of Results within Control Limits
Air filters	MAPEP	Alpha (gross); beta (gross); americium-241; cesium-134, -137; cobalt-57, -60; manganese-54; plutonium-238, -239/240; strontium-90; uranium-233/234, -238; zinc-65	28	28
Soil	MAPEP	Americium-241; cesium-134, -137; cobalt-57, -60; manganese-54; plutonium-238, -239/240; potassium-40; strontium-90; technetium-99; uranium-233/234, -238; zinc-65	28	25 ²
Vegetation	MAPEP	Americium-241; cesium-134, -137; cobalt-57, -60; manganese-54; plutonium-238, -239/240, strontium-90; uranium-233/234, -238; zinc-65	24	23 ³
Water	MAPEP	Alpha (gross); beta (gross); americium-241; cesium-134, -137; cobalt-57, -60; manganese-54; plutonium-238, -239/240; potassium-40; strontium-90; technetium-99; uranium-233/234, -238; zinc-65;	32	32 ⁴
Water	RAD	Barium-133; cesium-134, -137; cobalt-60; radium-226, -228; tritium (hydrogen-3); uranium (total); zinc-65;	14	12 ⁵

¹ Hanford Site laboratory operated by MSA (RJ Lee Group, Inc.)

² Failed uranium-233/234 in Study 28 as well as uranium-233/234, -238 in Study 29 soil sample due to solubility of uranium used for MAPEP soil. Total dissolution is required to digest MAPEP soil sample to characterize isotopic uranium. Routine environmental sample analysis does not require total dissolution. Depleted uranium was used in Study 28 soil matrix. There is no impact on the Hanford Site sample. A make-up PE soil sample is in-house for uranium analysis.

³ Failed zinc-65 in vegetation of Study 29. MAPEP vegetation has different density. Detector used for routine vegetation counting was out for maintenance and was not used for counting MAPEP Study 29 vegetation sample. There is no impact on the Hanford sample.

⁴ Failed potassium-40 in MAPEP water matrix due to background interference.

⁵ Failed tritium and zinc-65. A make-up tritium PE sample was analyzed and was within acceptable range. Failure of zinc-65 was due to Bi-214 interference. A new software for data processing will have a better peak fitting and is in the process of testing for implementation. Zinc has 244 days of half-life. There is no impact on Hanford sample.

RAD = Radiochemistry Program provided by Environmental Resource Associates, Inc., a Waters Corporation.

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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 $g_{RPD} = \left(\frac{|S - D|}{\frac{S + D}{2}} \right) \times 100$ 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.

Appendix B**Useful Information**

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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 A.

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://www.platauremediation.hanford.gov/>
DOE: <http://www.hanford.gov/page.cfm/officialdocuments>
MSA: <http://msa.hanford.gov/page.cfm/enviroreports>
PNNL: <http://www.pnnl.gov/publications/results.asp>
WCH: <http://www.washingtonclosure.com/>
WRPS: <http://wrpstoc.com/>

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 B.1 summarizes and defines the terms and corresponding symbols (metric and non-metric). A conversion table is provided in Table B.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 B.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 B.4 includes selected conversions from curies to becquerels.

Table B.1. Units of Measure

Symbol	Name
Temperature	
°C	degree Celsius
°F	degree Fahrenheit
Time	
d	day
hr	hour
min	minute
sec	second
yr	year
Rate	
cfs (or ft ³ /sec)	cubic feet per second
cpm	counts per minute
gpm	gallon per minute
mph	mile per hour
mR/hr	milliroentgen per hour
mrem/yr	millirem per year
Volume	
cm ³	cubic centimeter
ft ³	cubic foot
gal	gallon
L	liter
m ³	cubic meter
mL	milliliter (1 × 10 ⁻³ L)
yd ³	cubic yard

Symbol	Name
Concentration	
ppb	parts per billion
ppm	parts per million
ppmv	parts per million by volume
Length	
cm	centimeter (1 × 10 ⁻² m)
ft	foot
in.	inch
km	kilometer (1 × 10 ³ m)
m	meter
mi	mile
mm	millimeter (1 × 10 ⁻³ m)
μm	micrometer (1 × 10 ⁻⁶ m)
Area	
ha	hectare (1 × 10 ⁴ m ²)
km ²	square kilometer
mi ²	square mile
ft ²	square foot
Mass	
g	gram
kg	kilogram (1 × 10 ³ g)
mg	milligram (1 × 10 ⁻³ g)
μg	microgram (1 × 10 ⁻⁶ g)
lb	pound

Table B.2. Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
cm	0.394	in.	in.	2.54	cm
m	3.28	ft	ft	0.305	m
km	0.621	mi	mi	1.61	km
kg	2.205	lb	lb	0.454	kg
L	0.2642	gal	gal	3.785	L
m ²	10.76	ft ²	ft ²	0.093	m ²
ha	2.47	acre	acre	0.405	ha
km ²	0.386	mi ²	mi ²	2.59	km ²
m ³	35.31	ft ³	ft ³	0.0283	m ³
m ³	1.308	yd ³	yd ³	0.7646	m ³
pCi	1,000	nCi	nCi	0.001	pCi
μCi/mL	109	pCi/L	pCi/L	10 ⁻⁹	μCi/mL
Ci/m ³	1012	pCi/m ³	pCi/m ³	10 ⁻¹²	Ci/m ³
mCi/cm ³	1015	pCi/m ³	pCi/m ³	10 ⁻¹⁵	mCi/cm ³
nCi/m ²	1.0	mCi/km ²	mCi/km ²	1.0	nCi/m ²
Ci	3.7×10^{10}	Bq	Bq	2.7×10^{-11}	Ci
pCi	0.037	Bq	Bq	27	pCi
rad	0.01	Gy	Gy	100	rad
rem	0.01	Sv	Sv	100	rem
ppm	1,000	ppb	ppb	0.001	ppm
°C	$(^{\circ}\text{C} \times 9/5) + 32$	°F	°F	$(^{\circ}\text{F} - 32) \div 9/5$	°C
oz	28.349	g	g	0.035	oz
ton	0.9078	tonne	tonne	1.1	ton

Table B.3. Radioactivity Unit Conversions

aCi	fCi	fCi	pCi	pCi	nCi	nCi	μCi	μCi	mCi	mCi	Ci	Ci	kCi
27	1	27	1	27	1	27	1	27	1	27	1	27	1
1	37	1	37	1	37	1	37	1	37	1	37	1	37
μBq	μBq	mBq	mBq	Bq	Bq	kBq	kBq	MBq	MBq	GBq	GBq	TBq	TBq

New unit of quantity = Becquerel (Bq) (formerly curie [Ci]) (1 Ci = 3.7×10^{10} dps).

1 Becquerel = 1 disintegrations/sec (dps).

Table B.4. Radioactivity Units

Symbol	Name	Symbol	Name
Ci	curie	Bq	becquerel (2.7×10^{-11} Ci)
mCi	millicurie (1×10^{-3} Ci)	mBq	millibecquerel (1×10^{-3} Bq)
μCi	microcurie (1×10^{-6} Ci)	kBq	kilobecquerel (1×10^3 Bq)
nCi	nanocurie (1×10^{-9} Ci)	MBq	megabecquerel (1×10^6 Bq)
pCi	picocurie (1×10^{-12} Ci)	GBq	gigabecquerel (1×10^9 Bq)
fCi	femtocurie (1×10^{-15} Ci)	TBq	terabecquerel (1×10^{12} Bq)
aCi	attocurie (1×10^{-18} Ci)		

B.6 Radiological Dose Limits

Regulatory dose limits, both public and occupational regulatory dose limits, are set by federal (i.e., U.S. Environmental Protection Agency [EPA], Nuclear Regulatory Commission [NRC], and U.S. Department

of Energy [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 B.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 B.5 also can be used to convert grays to rads.

Table B.5. Radiological Dose Units Conversions

μ Sv 0.01	μ Sv 0.1	μ Sv 1	μ Sv 10	μ Sv 100	mSv 1	mSv 10	mSv 100	Sv 1
1 μ rem	10 μ rem	100 μ rem	1 mrem	10 mrem	100 mrem	1 rem	10 rem	100 Rem

Unit of absorbed dose – Gray (Gy) (formerly rad).

Unit of dose equivalent – Sievert (Sv) (formerly rem).

Table also converts Gy to rad.

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 B.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 A. A list of the radionuclides discussed in this report, their symbols, and their half-lives are included in Table B.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)
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 B.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 also can 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 percent 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 percent 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 B.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.

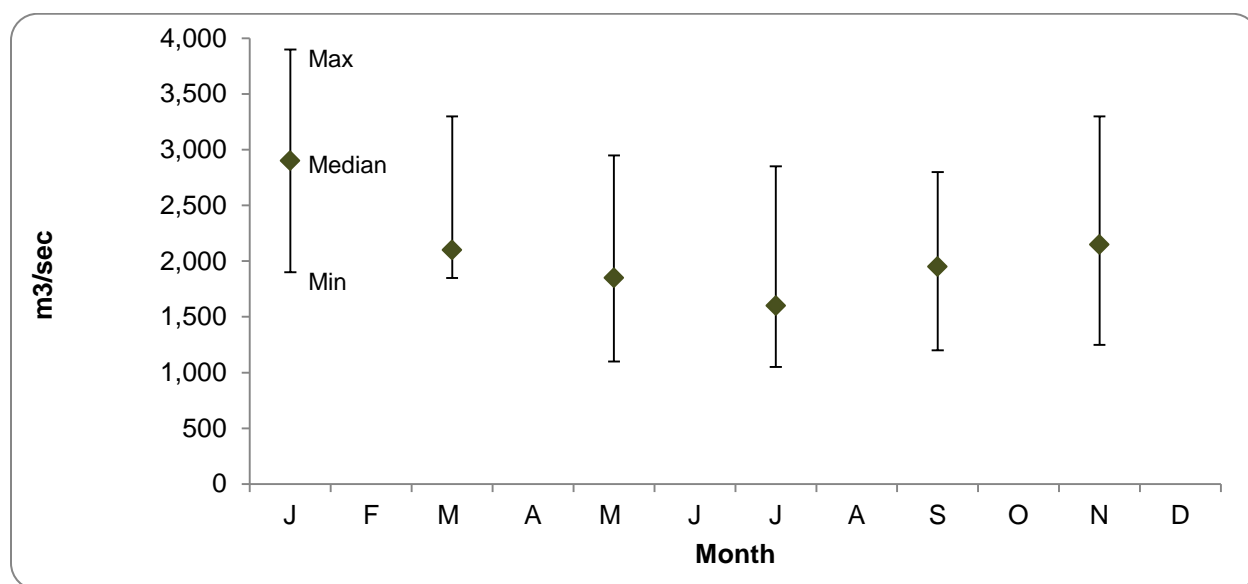
B.14 Negative Concentrations

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 (\leq or \geq) 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 B.2). A logarithmic plot of these same two numbers allows the reader to see both data points clearly (Figure B.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 B.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

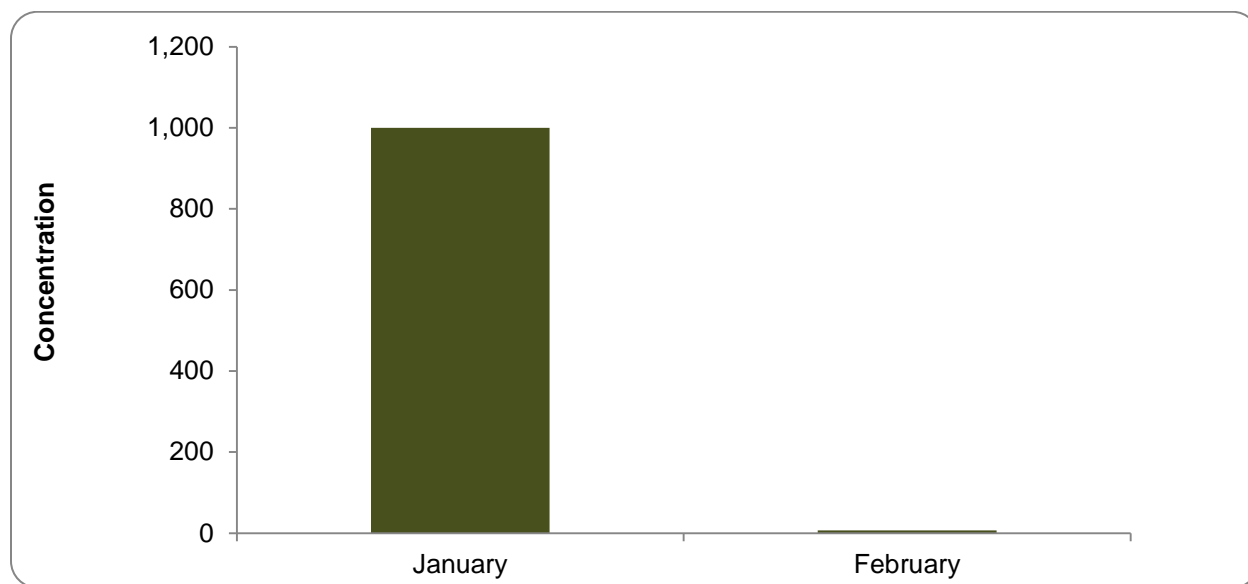


Figure B.3 Data Plotted Using a Logarithmic Scale

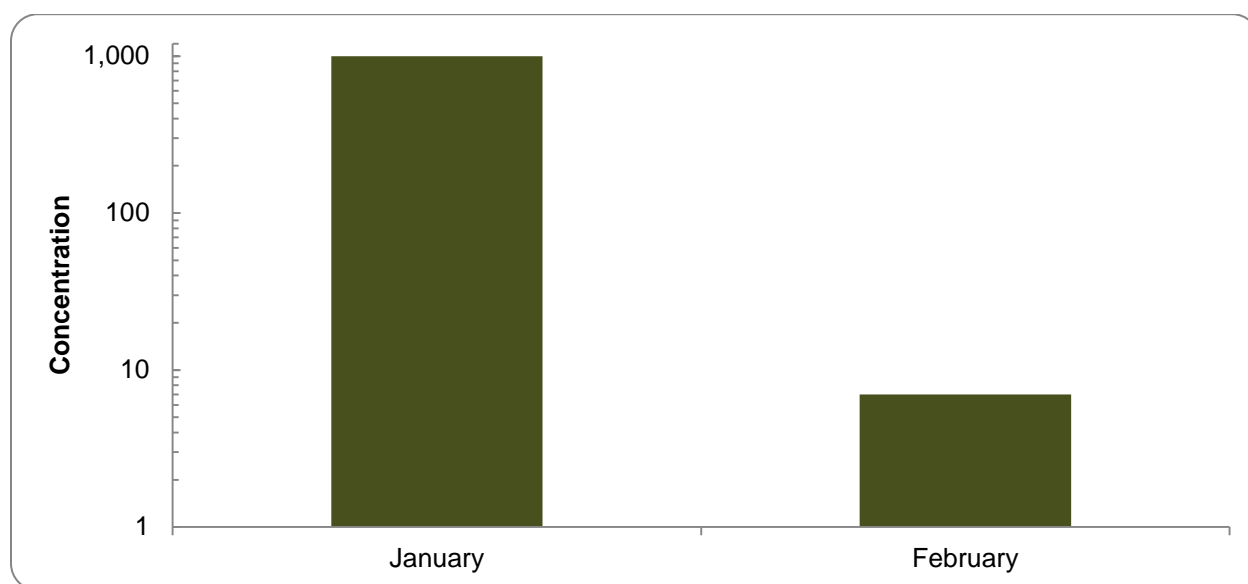
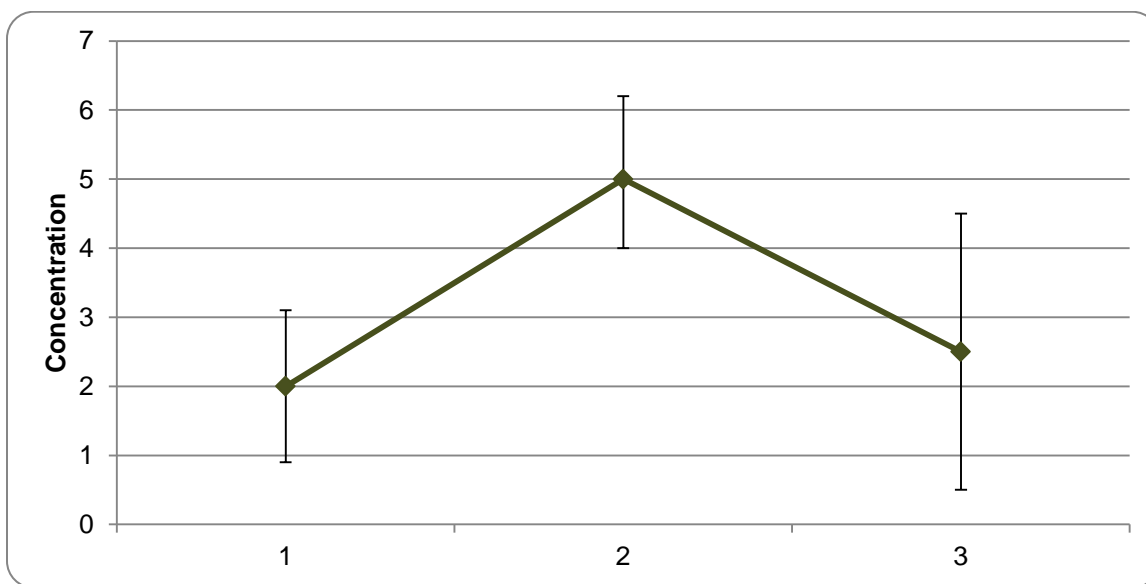


Figure B.4 Data with Error Bars Plotted Using a Linear Scale



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).

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C. Additional Monitoring Results

ME Hoefer and CJ Perkins

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	2013				2008 - 2012			
	No. of		Average ^a pCi/L	Maximum ^b pCi/L	No. of		Average ^a pCi/L	Maximum ^b pCi/L
	Samples	Detects			Samples	Detects		
Antimony-125 ^c	1	0	1.6E+00	1.6E+00 ± 6.0E+00	19	0	-9.5E-01 ± 6.0E+00	4.4E+00 ± 5.4E+00
Cesium-134 ^c	1	0	1.1E+00	1.1E+00 ± 2.7E+00	19	0	5.1E-01 ± 2.3E+00	3.0E+00 ± 3.0E+00
Cesium-137 ^c	1	0	2.9E+00	2.9E+00 ± 2.5E+00	19	0	-1.3E-01 ± 2.0E+00	1.2E+00 ± 2.3E+00
Cobalt-60 ^c	1	0	1.4E+00	1.4E+00 ± 2.6E+00	19	0	-3.3E-02 ± 1.8E+00	1.4E+00 ± 2.5E+00
Europium-152 ^c	1	0	2.0E+00	2.0E+00 ± 6.6E+00	19	0	5.5E-01 ± 5.2E+00	3.8E+00 ± 7.6E+00
Europium-154 ^c	1	0	6.7E+00	6.7E+00 ± 7.0E+00	19	0	-1.4E+00 ± 5.2E+00	2.0E+00 ± 6.2E+00
Europium-155 ^c	1	0	-3.2E+00	-3.2E+00 ± 1.1E+01	19	0	-1.2E+00 ± 9.2E+00	8.5E+00 ± 1.0E+01
Gross Alpha	1	0	3.7E-01	3.7E-01 ± 1.1E+00	19	1	7.0E-01 ± 1.6E+00	2.6E+00 ± 2.0E+00
Gross Beta	1	1	5.2E+00	5.2E+00 ± 2.5E+00	19	18	8.2E+00 ± 7.4E+00	1.9E+01 ± 3.3E+00
Tritium	1	1	1.5E+03	1.5E+03 ± 4.1E+02	19	19	2.9E+03 ± 5.5E+03	1.2E+04 ± 2.4E+03
Potassium-40 ^c	1	0	9.6E+00	9.6E+00 ± 3.7E+01	19	0	1.7E+00 ± 3.6E+01	5.0E+01 ± 5.0E+01
Ruthenium-106 ^c	1	0	1.1E+01	1.1E+01 ± 2.0E+01	19	0	1.4E+00 ± 1.2E+01	1.6E+01 ± 1.7E+01

^a Average ± two standard deviations.^b Maximum ± analytical uncertainty.^c Maximum value reported is a non-detect.

Table C.2 Radionuclide Concentrations in West Lake Sediment

Radionuclide	2013		2008-2012		
	No. of Samples	Concentration pCi/g^a Result ^b	No. of Samples	Concentration pCi/g^a	
				Average ^c	Maximum ^b
Antimony-125	1	-1.7E-02 ± 4.2E-02 ^d	6	1.5E-02 ± 3.0E-02 ^d	3.6E-02 ± 4.6E-02 ^d
Cesium-134	1	6.4E-02 ± 4.3E-02 ^d	6	4.7E-02 ± 5.4E-02	9.7E-02 ± 5.6E-02
Cesium-137	1	4.6E-01 ± 5.4E-02	6	1.1E+00 ± 8.2E-01	1.9E+00 ± 1.5E-01
Cobalt-60	1	5.3E-03 ± 1.8E-02 ^d	6	-2.7E-03 ± 1.1E-02 ^d	8.6E-03 ± 1.7E-02 ^d
Europium-152	1	2.5E-02 ± 5.8E-02 ^d	6	-2.2E-03 ± 1.7E-02 ^d	1.4E-02 ± 5.2E-02 ^d
Europium-154	1	-8.4E-03 ± 5.4E-02 ^d	6	-2.6E-02 ± 8.7E-02 ^d	4.7E-02 ± 6.0E-02 ^d
Europium-155	1	8.5E-02 ± 8.6E-02 ^d	6	4.8E-02 ± 3.3E-02	8.1E-02 ± 4.4E-02
Gross Alpha	1	8.9E-01 ± 1.1E+00 ^d	6	8.9E+00 ± 5.7E+00	1.2E+01 ± 4.8E+00
Gross Beta	1	9.7E+00 ± 2.2E+00	6	2.4E+01 ± 9.1E+00	3.1E+01 ± 5.4E+00
Potassium-40	1	1.8E+01 ± 2.0E+00	6	1.7E+01 ± 4.5E+00	1.9E+01 ± 1.9E+00
Ruthenium-106	1	3.1E-02 ± 1.4E-01 ^d	6	-2.7E-02 ± 1.5E-01 ^d	1.2E-01 ± 1.5E-01 ^d
Strontium-90	1	1.1E-01 ± 4.3E-02	6	2.9E-01 ± 1.6E-01	4.0E-01 ± 9.0E-02
Technetium-99	1	3.9E-02 ± 3.7E-01 ^d	6	-1.2E-01 ± 4.3E-01 ^d	1.4E-01 ± 4.7E-01 ^d
Uranium-234	1	7.7E-01 ± 2.4E-01	6	2.6E+00 ± 3.7E+00	6.4E+00 ± 8.7E-01
Uranium-235	1	8.6E-02 ± 8.4E-02	6	1.4E-01 ± 2.0E-01	3.6E-01 ± 6.8E-02
Uranium-238	1	7.5E-01 ± 2.3E-01	6	2.4E+00 ± 3.5E+00	6.1E+00 ± 8.3E-01

^a 1 pCi = 0.037 Bq.^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 Seep Water
(2013 and 2011, 2012)

Radionuclide	2013			2011 and 2012			DOE-Derived Concentration Guides/Standards	Washington State Ambient Surface Water Quality Standard ^d
	No. of Sample s	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	^f	6.9E+02 ± 2.1E+02	4	11.6E+01 ± 16.6E+01	22.0E+02 ± 17.2E+01	2,000,000	20,000 ^{d,e}
Uranium-234	1	^f	2.6E+02 ± 7.1E+01	4	13.6E+02 ± 32.4E+02	38.5E+02 ± 52.5E+01	500	—
Uranium-235	1	^f	1.4E+01 ± 4.3E+00	4	56.0E+00 ± 13.1E+01	14.7E+01 ± 4.7E+01	600	—
Uranium-238	1	^f	2.5E+02 ± 6.9E+01	4	13.0E+02 ± 32.9E+02	36.5E+01 ± 5.0E+02	600	—

^a 1 pCi = 0.037 Bq.^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 West Lake Surface Water
(2013 and 2011, 2012)

Radionuclide	2013			2011 and 2012			DOE-Derived Concentration Guides/Standards	Washington State Ambient Surface Water Quality Standard ^d
	No. of Samples	Concentration ^a		No. of Sample s	Concentration ^a			
		Average ^b pCi/L	Maximum ^c pCi/L		Average ^b pCi/L	Maximum ^c pCi/L		
Tritium	1	--- ^f	2.4E+01 ± 13.5E+01	4	11.6E+01 ± 16.6E+01	22.0E+02 ± 17.2E+01	2,000,000	20,000 ^{d,e}
Uranium-234	1	--- ^f	12.1E+00 ± 2.0E+00	4	13.6E+02 ± 34.7E+02	38.5E+02 ± 52.1E+01	500	—
Uranium-235	1	--- ^f	5.2E-01 ± 1.7E-01	4	5.6E+01 ± 13.1E+01	14.7E+01 ± 4.7E+01	600	—
Uranium-238	1	--- ^f	11.9E+00 ± 1.9E+00	4	13.0E+02 ± 32.9E+02	36.5E+02 ± 5.0E+02	600	—

^a 1 pCi = 0.037 Bq.^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.5. Radionuclide Concentrations in Onsite Air Samples

Radionuclide	Site	2013					2008 - 2012					EPA Table 2 ^{e,f}
		Number of		Average ^b	Maximum ^c	Sampler	Number of		Average ^b	Maximum ^c		
		Samples	Detects ^a	(pCi/m ³) ^d	(pCi/m ³) ^d		Samples	Detects ^(a)	(pCi/m ³) ^d	(pCi/m ³) ^d		
Gross Alpha	100-D FR	79	79	1.6E-02 ± 1.9E-02	4.2E-02 ± 3.4E-03	N468	524	524	1.7E-02 ± 1.9E-02	7.3E-02 ± 6.7E-03	9.0E+00	
	100-H FR	31	31	1.4E-02 ± 1.9E-02	4.0E-02 ± 3.2E-03	N509	427	425	1.8E-02 ± 2.0E-02	6.0E-02 ± 6.1E-03		
	100-K KBC	187	186	2.1E-02 ± 3.0E-02	8.4E-02 ± 6.5E-03	N900	1253	1253	2.4E-02 ± 1.1E-01	1.2E+00 ± 8.4E-02		
	100-N	69	69	1.8E-02 ± 3.0E-02	6.9E-02 ± 6.4E-03	N102	393	393	1.7E-02 ± 1.8E-02	5.4E-02 ± 5.5E-03		
	200-East	545	545	2.1E-02 ± 3.3E-02	1.2E-01 ± 9.0E-03	N984	2723	2723	1.7E-02 ± 1.8E-02	7.0E-02 ± 6.1E-03		
	200-West	587	587	1.9E-02 ± 3.1E-02	7.6E-02 ± 5.8E-03	N963	3137	3134	1.7E-02 ± 2.1E-02	1.7E-01 ± 2.0E-02		
	300 D4	52	52	2.0E-02 ± 3.1E-02	8.2E-02 ± 6.2E-03	N130	262	262	1.7E-02 ± 1.9E-02	5.0E-02 ± 4.6E-03		
	618-10 FR	104	104	2.2E-02 ± 3.6E-02	1.1E-01 ± 9.0E-03	N579	227	226	1.4E-02 ± 1.8E-02	9.0E-02 ± 9.0E-03		
ERDF	130	130	1.7E-02 ± 2.8E-02	7.6E-02 ± 5.8E-03	N963	653	651	1.5E-02 ± 1.8E-02	4.9E-02 ± 4.5E-03			
Gross Beta	100-D FR	79	79	9.2E-04 ± 9.2E-04	2.7E-03 ± 7.1E-04	N468	524	479	1.1E-03 ± 1.1E-03	4.6E-03 ± 1.2E-03	2.0E-02	
	100-H FR	31	31	8.1E-04 ± 7.1E-04	1.8E-03 ± 3.9E-04	N509	427	389	1.2E-03 ± 1.2E-03	3.6E-03 ± 8.3E-04		
	100-K KBC	187	183	1.1E-03 ± 1.3E-03	3.4E-03 ± 7.7E-04	N577	1253	1159	1.2E-03 ± 2.3E-03	2.0E-02 ± 2.5E-03		
	100-N	69	68	1.2E-03 ± 1.9E-03	5.5E-03 ± 1.4E-03	N102	393	368	1.2E-03 ± 1.4E-03	4.3E-03 ± 1.1E-03		
	200-East	545	544	1.2E-03 ± 1.6E-03	6.6E-03 ± 1.1E-03	N559	2723	2555	1.2E-03 ± 1.2E-03	4.8E-03 ± 1.5E-03		
	200-West	587	586	1.2E-03 ± 1.4E-03	4.7E-03 ± 7.4E-04	N974	3137	2903	1.3E-03 ± 1.6E-03	1.4E-02 ± 2.0E-03		
	300 D4	52	52	1.1E-03 ± 1.3E-03	2.9E-03 ± 5.3E-04	N130	262	243	1.1E-03 ± 1.0E-03	2.8E-03 ± 8.3E-04		
	618-10 FR	104	104	1.3E-03 ± 2.7E-03	9.9E-03 ± 1.1E-03	N580	227	200	1.1E-03 ± 2.4E-03	1.6E-02 ± 2.3E-03		
ERDF	130	129	9.8E-04 ± 1.2E-03	3.5E-03 ± 5.9E-04	N963	653	582	1.1E-03 ± 1.2E-03	5.1E-03 ± 1.1E-03			
Americium-241	100-D FR	4	0	-4.9E-07 ± 1.1E-06	1.2E-07 ± 1.2E-06	N515	40	19	6.5E-06 ± 8.3E-06	1.7E-05 ± 1.3E-05	1.9E-03	
	100-H FR	2	0	4.6E-06 ± 1.5E-05	1.2E-05 ± 2.8E-05	N574	26	10	8.3E-06 ± 9.9E-06	2.5E-05 ± 1.4E-05		
	100-K KBC	15	0	-6.2E-06 ± 9.7E-05	7.1E-05 ± 7.1E-04	N900	104	61	5.8E-05 ± 5.4E-04	1.2E-03 ± 4.4E-04		
	100-N	6	0	-1.2E-06 ± 3.8E-06	1.5E-06 ± 6.3E-06	N106	33	21	1.1E-05 ± 1.7E-05	3.9E-05 ± 1.7E-05		
	200-East	4	0	3.0E-06 ± 4.3E-06	5.8E-06 ± 8.3E-06	N481	20	5	4.0E-06 ± 7.1E-06	1.0E-05 ± 6.1E-06		
	200-West	2	2	2.3E-05 ± 4.6E-06	2.5E-05 ± 1.5E-05	N165	10	9	6.8E-05 ± 1.6E-04	3.1E-04 ± 1.1E-04		
	618-10 FR	8	5	1.3E-05 ± 2.9E-05	4.1E-05 ± 1.7E-05	N580	16	11	4.9E-05 ± 1.3E-04	2.4E-04 ± 9.4E-05		
	ERDF											
Cesium- 134	100-D FR	4	0	-1.0E-04 ± 3.4E-04	1.0E-04 ± 2.0E-04	N514	44	4	2.8E-05 ± 2.3E-04	4.0E-04 ± 3.8E-04	2.7E-02	
	100-H FR	2	0	-4.0E-04 ± 7.9E-04	-1.6E-06 ± 1.6E-05	N509	34	3	5.3E-06 ± 2.5E-04	3.1E-04 ± 6.6E-04		
	100-K KBC	15	0	-8.1E-05 ± 5.7E-04	1.5E-04 ± 3.3E-04	N900	120	7	2.6E-05 ± 2.5E-04	3.9E-04 ± 5.3E-04		
	100-N	6	0	-1.8E-04 ± 2.5E-04	4.5E-06 ± 4.5E-05	N102	33	3	1.4E-05 ± 2.2E-04	3.3E-04 ± 1.5E-04		
	200-East	42	0	-6.4E-05 ± 2.8E-04	1.9E-04 ± 2.6E-04	N499	212	19	1.8E-05 ± 2.4E-04	5.2E-04 ± 2.1E-04		
	200-West	46	0	-6.3E-05 ± 2.6E-04	3.2E-04 ± 1.8E-04	N554	247	23	2.7E-06 ± 2.9E-04	5.2E-04 ± 4.0E-04		
	300 D4	6	0	-5.8E-05 ± 1.8E-04	8.0E-05 ± 1.3E-04	N557	32	1	6.7E-05 ± 3.4E-04	4.8E-04 ± 1.5E-03		
	618-10 FR	8	0	-1.8E-05 ± 2.2E-04	1.5E-04 ± 2.4E-04	N548	24	3	-6.8E-05 ± 5.0E-04	6.8E-04 ± 2.3E-04		
	ERDF	10	0	-7.1E-05 ± 2.2E-04	1.2E-04 ± 2.6E-04	N482	53	2	3.3E-05 ± 2.6E-04	5.8E-04 ± 4.5E-04		

Table C.5. Radionuclide Concentrations in Onsite Air Samples

Radionuclide	Site	2013					2008 - 2012					EPA Table 2 ^{e,f}
		Number of		Average ^b	Maximum ^c	Sampler	Number of		Average ^b	Maximum ^c		
		Samples	Detects ^a	(pCi/m ³) ^d	(pCi/m ³) ^d		Samples	Detects ^(a)	(pCi/m ³) ^d	(pCi/m ³) ^d		
Cesium- 137	100-D FR	4	0	-4.8E-05 ± 1.7E-04	7.9E-05 ± 2.5E-04	N468	44	7	7.7E-05 ± 2.3E-04	4.5E-04 ± 1.9E-04	1.9E-02	
	100-H FR	2	0	-1.0E-04 ± 7.5E-05	-6.6E-05 ± 2.0E-04	N509	34	4	5.9E-05 ± 2.6E-04	5.1E-04 ± 2.5E-04		
	100-K KBC	15	0	-4.8E-05 ± 3.2E-04	1.4E-04 ± 3.0E-04	N900	120	50	4.5E-03 ± 3.4E-02	1.2E-01 ± 3.9E-02		
	100-N	6	0	1.3E-05 ± 2.1E-04	1.6E-04 ± 3.5E-04	N103	33	12	2.8E-04 ± 9.2E-04	1.9E-03 ± 6.5E-04		
	200-East	42	7	7.4E-04 ± 5.9E-03	1.9E-02 ± 6.2E-03	N984	212	45	1.2E-04 ± 5.5E-04	2.3E-03 ± 7.7E-04		
	200-West	46	1	3.7E-05 ± 3.4E-04	5.2E-04 ± 5.8E-04	N956	247	33	5.3E-05 ± 2.5E-04	7.6E-04 ± 3.8E-04		
	300 D4	6	0	2.7E-05 ± 1.6E-04	1.4E-04 ± 5.1E-04	N557	32	3	5.9E-05 ± 2.6E-04	5.3E-04 ± 2.7E-04		
	618-10 FR	8	0	-2.7E-05 ± 9.5E-05	3.9E-05 ± 3.6E-04	N549	24	4	1.2E-04 ± 5.7E-04	1.2E-03 ± 4.0E-04		
	ERDF	10	0	-4.2E-06 ± 1.7E-04	1.3E-04 ± 2.0E-04	N963	53	8	7.3E-05 ± 1.9E-04	3.8E-04 ± 1.5E-04		
Plutonium-238	100-D FR	4	0	2.5E-07 ± 2.2E-06	1.9E-06 ± 2.4E-06	N468	44	0	6.6E-07 ± 1.2E-05	1.8E-05 ± 1.6E-05	2.1E-03	
	100-H FR	2	0	4.1E-06 ± 9.4E-06	8.8E-06 ± 1.2E-05	N574	34	1	-7.3E-07 ± 8.5E-06	1.1E-05 ± 1.5E-05		
	100-K KBC	15	0	5.1E-07 ± 3.9E-06	4.4E-06 ± 4.4E-05	N577	117	11	8.9E-06 ± 5.1E-05	1.5E-04 ± 7.1E-05		
	100-N	6	0	8.7E-07 ± 4.5E-06	5.2E-06 ± 7.2E-06	N106	33	0	2.5E-06 ± 1.1E-05	1.9E-05 ± 1.8E-05		
	200-East	42	0	1.1E-06 ± 3.6E-06	7.6E-06 ± 9.6E-06	N481	211	5	2.2E-06 ± 2.8E-05	1.9E-04 ± 6.8E-05		
	200-West	46	0	1.8E-07 ± 4.9E-06	3.9E-06 ± 4.0E-06	N456	247	10	1.6E-06 ± 1.2E-05	3.7E-05 ± 1.9E-05		
	300 D4	6	0	2.4E-06 ± 1.2E-05	1.1E-05 ± 2.7E-05	N557	32	2	1.1E-06 ± 1.8E-05	2.3E-05 ± 2.8E-05		
	618-10 FR	8	0	1.1E-06 ± 3.0E-06	4.1E-06 ± 4.8E-06	N548	24	2	3.7E-06 ± 2.1E-05	4.6E-05 ± 2.2E-05		
	ERDF	10	0	7.1E-07 ± 3.7E-06	3.4E-06 ± 3.7E-06	N518	53	1	1.2E-06 ± 9.5E-06	1.6E-05 ± 8.3E-06		
Plutonium-239/240	100-D FR	4	2	4.5E-06 ± 6.1E-06	9.5E-06 ± 5.5E-06	N514	44	7	2.6E-06 ± 3.9E-06	1.0E-05 ± 6.2E-06	2.0E-03	
	100-H FR	2	0	3.2E-06 ± 5.3E-06	5.8E-06 ± 1.0E-05	N574	34	8	2.9E-06 ± 9.7E-06	2.6E-05 ± 1.3E-05		
	100-K KBC	15	0	2.6E-06 ± 4.0E-06	5.0E-06 ± 5.9E-06	N476	120	60	6.2E-05 ± 3.7E-04	1.2E-03 ± 4.7E-04		
	100-N	6	0	2.0E-06 ± 1.4E-06	2.9E-06 ± 3.0E-06	N103	33	15	7.7E-06 ± 1.8E-05	3.9E-05 ± 1.8E-05		
	200-East	42	7	2.2E-06 ± 5.1E-06	1.1E-05 ± 7.6E-06	N969	212	15	1.0E-05 ± 2.5E-04	1.8E-03 ± 6.5E-04		
	200-West	46	9	9.8E-06 ± 5.3E-05	1.6E-04 ± 6.1E-05	N165	247	95	2.1E-05 ± 1.3E-04	4.6E-04 ± 1.8E-04		
	300 D4	6	0	2.2E-06 ± 8.1E-06	8.4E-06 ± 1.5E-05	N557	32	2	3.3E-06 ± 1.5E-05	3.1E-05 ± 2.0E-05		
	618-10 FR	8	6	3.7E-05 ± 1.1E-04	1.7E-04 ± 6.0E-05	N580	24	10	7.0E-05 ± 3.0E-04	6.8E-04 ± 2.6E-04		
	ERDF	10	4	9.8E-06 ± 3.5E-05	6.1E-05 ± 2.4E-05	N963	53	20	5.3E-06 ± 1.3E-05	4.6E-05 ± 2.0E-05		
Plutonium-241	100-K KBC	13	0	2.0E-04 ± 6.9E-04	1.0E-03 ± 1.5E-03	N577	89	15	6.9E-04 ± 3.3E-03	9.2E-03 ± 2.9E-03	1.9E-03	
	200-East	4	0	1.8E-04 ± 6.9E-04	7.7E-04 ± 1.1E-03	N481	20	0	4.2E-05 ± 6.8E-04	7.7E-04 ± 8.4E-04		
	200-West	2	0	3.4E-04 ± 6.7E-04	6.8E-04 ± 4.6E-04	N165	10	3	6.6E-04 ± 1.3E-03	1.7E-03 ± 1.5E-03		
Strontium-90	100-D FR	4	2	1.3E-04 ± 2.1E-04	3.1E-04 ± 1.3E-04	N467	44	3	-4.8E-05 ± 3.6E-04	4.5E-04 ± 2.1E-04	1.9E-02	
	100-H FR	2	2	3.5E-04 ± 3.4E-04	5.2E-04 ± 3.2E-04	N574	34	0	-8.9E-05 ± 2.6E-04	2.3E-04 ± 2.4E-04		
	100-K KBC	15	2	6.1E-05 ± 1.1E-04	1.4E-04 ± 7.2E-05	N578	120	20	5.1E-04 ± 4.5E-03	1.5E-02 ± 4.4E-03		
	100-N	6	0	7.7E-05 ± 3.5E-05	1.0E-04 ± 7.5E-05	N106	33	4	-4.4E-05 ± 4.4E-04	5.7E-04 ± 2.3E-04		
	200-East	42	16	8.8E-05 ± 2.2E-04	6.9E-04 ± 2.2E-04	N999	212	22	-5.6E-05 ± 4.4E-04	1.7E-03 ± 5.7E-04		
	200-West	46	16	5.4E-05 ± 1.1E-04	2.4E-04 ± 1.1E-04	N165	246	9	-1.1E-04 ± 3.6E-04	5.0E-04 ± 3.9E-04		
	300 D4	6	2	4.3E-05 ± 2.0E-04	2.1E-04 ± 1.3E-04	N557	32	0	-1.9E-04 ± 5.0E-04	1.5E-04 ± 1.3E-04		
	618-10 FR	8	2	6.9E-05 ± 8.3E-05	1.4E-04 ± 7.6E-05	N548	24	2	-6.2E-05 ± 6.1E-04	3.7E-04 ± 3.2E-04		
	ERDF	10	3	5.6E-05 ± 1.1E-04	1.8E-04 ± 9.0E-05	N168	53	3	-7.8E-05 ± 3.6E-04	6.7E-04 ± 2.7E-04		

Table C.5. Radionuclide Concentrations in Onsite Air Samples

Radionuclide	Site	2013					2008 - 2012					EPA Table 2 ^{e,f}
		Number of		Average ^b	Maximum ^c	Sampler	Number of		Average ^b	Maximum ^c		
		Samples	Detects ^a	(pCi/m ³) ^d	(pCi/m ³) ^d		Samples	Detects ^(a)	(pCi/m ³) ^d	(pCi/m ³) ^d		
Uranium-234	100-D FR	4	4	7.1E-06 ± 6.0E-06	1.2E-05 ± 7.5E-06	N467	44	36	1.0E-05 ± 7.9E-06	2.0E-05 ± 1.2E-05	7.7E-03	
	100-H FR	2	1	6.7E-06 ± 9.8E-06	1.2E-05 ± 8.3E-06	N509	34	24	1.1E-05 ± 1.6E-05	4.0E-05 ± 2.1E-05		
	100-K KBC	13	10	9.2E-06 ± 4.6E-06	1.3E-05 ± 8.2E-06	N534	99	79	1.2E-05 ± 1.3E-05	4.7E-05 ± 3.0E-05		
	100-N	6	6	1.2E-05 ± 8.3E-06	1.9E-05 ± 1.2E-05	N103	33	28	1.0E-05 ± 1.2E-05	2.0E-05 ± 1.1E-05		
	200-East	42	29	9.4E-06 ± 8.4E-06	2.2E-05 ± 1.2E-05	N976	212	170	1.0E-05 ± 1.0E-05	4.4E-05 ± 2.0E-05		
	200-West	46	28	8.8E-06 ± 8.9E-06	2.8E-05 ± 2.4E-05	N956	247	206	2.5E-05 ± 2.8E-04	2.2E-03 ± 7.4E-04		
	300 D4	6	3	1.2E-05 ± 1.4E-05	2.2E-05 ± 1.5E-05	N557	32	24	1.7E-05 ± 1.9E-05	4.3E-05 ± 2.1E-05		
	618-10 FR	8	4	8.9E-06 ± 1.7E-05	3.0E-05 ± 1.5E-05	N579	24	17	1.5E-05 ± 1.4E-05	2.7E-05 ± 1.8E-05		
	ERDF	10	7	1.1E-05 ± 8.8E-06	1.7E-05 ± 9.8E-06	N517	53	48	2.9E-05 ± 1.2E-04	4.3E-04 ± 1.7E-04		
Uranium-235	100-D FR	4	0	1.1E-06 ± 2.8E-06	3.0E-06 ± 3.9E-06	N515	44	8	1.8E-06 ± 4.1E-06	6.8E-06 ± 5.2E-06	7.1E-03	
	100-H FR	2	0	-3.4E-07 ± 5.4E-06	2.4E-06 ± 2.9E-06	N509	34	4	2.1E-06 ± 4.5E-06	7.0E-06 ± 5.3E-06		
	100-K KBC	13	2	2.3E-06 ± 2.6E-06	4.0E-06 ± 3.8E-06	N578	98	11	2.2E-06 ± 7.1E-06	2.6E-05 ± 2.1E-05		
	100-N	6	1	3.7E-06 ± 3.8E-06	7.2E-06 ± 5.5E-06	N102	33	6	1.7E-06 ± 4.6E-06	6.0E-06 ± 4.8E-06		
	200-East	42	3	1.9E-06 ± 3.4E-06	7.3E-06 ± 7.4E-06	N498	212	24	1.9E-06 ± 3.7E-06	7.2E-06 ± 6.4E-06		
	200-West	46	6	2.2E-06 ± 4.5E-06	1.2E-05 ± 1.5E-05	N956	246	36	3.8E-06 ± 3.0E-05	2.1E-04 ± 7.8E-05		
	300 D4	6	0	3.2E-06 ± 2.6E-06	4.8E-06 ± 7.0E-06	N557	32	4	3.4E-06 ± 5.3E-06	1.0E-05 ± 7.0E-06		
	618-10 FR	8	0	1.3E-06 ± 5.3E-06	5.5E-06 ± 6.6E-06	N549	24	2	2.2E-06 ± 8.4E-06	1.0E-05 ± 1.1E-05		
	ERDF	10	2	2.1E-06 ± 3.1E-06	4.4E-06 ± 4.3E-06	N482	53	8	3.6E-06 ± 1.4E-05	5.3E-05 ± 2.3E-05		
Uranium-238	100-D FR	4	4	8.8E-06 ± 3.6E-06	1.2E-05 ± 7.3E-06	N515	44	36	8.0E-06 ± 5.8E-06	1.4E-05 ± 8.5E-06	8.3E-03	
	100-H FR	2	1	2.0E-07 ± 1.1E-05	5.8E-06 ± 4.6E-06	N509	34	24	9.2E-06 ± 9.4E-06	2.4E-05 ± 1.5E-05		
	100-K KBC	13	7	6.3E-06 ± 5.0E-06	1.0E-05 ± 6.8E-06	N476	99	73	9.1E-06 ± 1.0E-05	2.7E-05 ± 1.4E-05		
	100-N	6	6	9.1E-06 ± 3.7E-06	1.2E-05 ± 8.1E-06	N106	33	28	8.4E-06 ± 8.4E-06	1.7E-05 ± 9.2E-06		
	200-East	42	25	6.3E-06 ± 5.7E-06	1.4E-05 ± 8.7E-06	N559	212	170	8.2E-06 ± 7.4E-06	2.3E-05 ± 1.1E-05		
	200-West	46	26	5.7E-06 ± 5.8E-06	1.4E-05 ± 1.7E-05	N956	247	201	2.1E-05 ± 2.5E-04	1.9E-03 ± 6.6E-04		
	300 D4	6	3	9.1E-06 ± 1.2E-05	1.9E-05 ± 1.0E-05	N130	32	26	1.2E-05 ± 1.3E-05	3.3E-05 ± 1.8E-05		
	618-10 FR	8	6	1.6E-05 ± 2.5E-05	4.3E-05 ± 1.9E-05	N548	24	16	1.3E-05 ± 1.4E-05	2.7E-05 ± 1.6E-05		
	ERDF	10	7	9.7E-06 ± 9.9E-06	1.8E-05 ± 9.9E-06	N518	53	50	2.6E-05 ± 9.7E-05	3.7E-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.6. Radionuclide Concentrations in Offsite Air Samples

Radionuclide	Location	No. of Samples	No. of Detects ^(b)	2013	Maximum ^(d)	No. of Samples	No. of Detects ^(b)	2008 - 2012	Maximum ^(d)	EPA Table 2 ^(e,f)
				Average ^(c) pCi/m ³	pCi/m ³			Average ^(c) pCi/m ³	pCi/m ³	
Americium 241	Onsite	42	3	-2.9E-05 ± 1.6E-03	2.6E-03 ± 3.5E-03	162	0	-1.5E-04 ± 2.2E-03	3.0E-03 ± 6.0E-03	1.9E-03
	Perimeter	16	0	-7.2E-05 ± 2.2E-03	1.6E-03 ± 2.9E-03	118	0	-3.0E-04 ± 2.5E-03	3.3E-03 ± 4.1E-03	
	Nearby Communities	12	0	-6.0E-05 ± 1.5E-03	8.9E-04 ± 1.6E-03	90	0	-4.8E-04 ± 3.4E-03	5.1E-03 ± 5.3E-03	
	Distant Community	2	0	1.3E-03 ± 1.1E-03	1.8E-03 ± 2.1E-03	15	0	-1.2E-03 ± 2.7E-03	7.1E-04 ± 1.9E-03	
Cesium 137	Onsite	42	0	8.1E-05 ± 4.9E-04	8.0E-04 ± 6.4E-04	217	2	7.9E-05 ± 6.0E-04	1.2E-03 ± 1.0E-03	1.9E-02
	Perimeter	16	0	1.2E-04 ± 4.0E-04	4.6E-04 ± 5.2E-04	158	3	1.0E-04 ± 1.4E-03	6.9E-03 ± 2.0E-03	
	Nearby Communities	12	0	4.4E-05 ± 2.4E-04	2.6E-04 ± 3.7E-04	116	1	1.2E-04 ± 1.0E-03	2.7E-03 ± 2.5E-03	
	Distant Community	2	0	5.7E-06 ± 7.4E-05	4.2E-05 ± 4.3E-04	20	0	1.6E-04 ± 8.9E-04	1.3E-03 ± 1.3E-03	
Cobalt 60	Onsite	42	0	2.6E-05 ± 4.1E-04	4.3E-04 ± 6.0E-04	214	2	6.3E-06 ± 6.4E-04	1.2E-03 ± 1.6E-03	1.7E-02
	Perimeter	16	0	-5.7E-05 ± 4.2E-04	2.9E-04 ± 3.6E-04	156	0	2.0E-05 ± 8.3E-04	1.7E-03 ± 2.2E-03	
	Nearby Communities	12	0	-3.1E-05 ± 3.5E-04	2.1E-04 ± 2.5E-04	114	0	-1.1E-05 ± 1.2E-03	2.2E-03 ± 1.7E-03	
	Distant Community	2	0	1.1E-04 ± 1.9E-04	2.0E-04 ± 4.2E-04	20	0	9.1E-05 ± 5.4E-04	5.5E-04 ± 8.1E-04	
Gross Alpha	Onsite	558	500	8.7E-04 ± 1.6E-03	6.4E-03 ± 3.3E-03	2818	2507	7.7E-04 ± 1.2E-03	2.0E-02 ± 7.4E-03	2.0E-02
	Perimeter	206	189	8.6E-04 ± 1.5E-03	4.6E-03 ± 5.1E-04	1024	905	7.7E-04 ± 1.0E-03	8.2E-03 ± 1.6E-03	
	Nearby Communities	52	50	8.8E-04 ± 1.6E-03	3.6E-03 ± 4.5E-04	256	233	8.1E-04 ± 1.2E-03	4.8E-03 ± 1.3E-03	
	Distant Community	25	22	7.7E-04 ± 1.7E-03	3.6E-03 ± 7.9E-04	129	106	6.7E-04 ± 8.2E-04	2.0E-03 ± 6.2E-04	
Gross Beta	Onsite	558	558	2.4E-02 ± 3.9E-02	1.3E-01 ± 1.0E-02	2824	2824	1.9E-02 ± 3.0E-02	5.9E-01 ± 6.5E-02	9.0E+00
	Perimeter	206	206	2.3E-02 ± 3.7E-02	9.5E-02 ± 8.8E-03	1024	1024	1.8E-02 ± 2.0E-02	9.4E-02 ± 1.1E-02	
	Nearby Communities	153	153	2.4E-02 ± 3.9E-02	9.9E-02 ± 9.2E-03	727	727	1.8E-02 ± 1.9E-02	8.7E-02 ± 9.7E-03	
	Distant Community	25	25	2.1E-02 ± 3.9E-02	9.5E-02 ± 7.4E-03	129	129	1.6E-02 ± 1.6E-02	5.6E-02 ± 6.5E-03	
Plutonium 239/240	Onsite	40	1	4.5E-06 ± 5.0E-05	1.6E-04 ± 5.2E-05	189	28	1.1E-06 ± 5.8E-06	2.1E-05 ± 7.0E-06	2.0E-03
	Perimeter	11	0	4.0E-07 ± 1.4E-06	1.7E-06 ± 2.7E-06	107	9	1.0E-06 ± 1.1E-05	5.5E-05 ± 1.3E-05	
	Nearby Communities	6	0	1.8E-07 ± 1.7E-06	1.9E-06 ± 3.4E-06	53	7	7.9E-07 ± 5.5E-06	1.6E-05 ± 4.6E-06	
	Distant Community	2	0	1.4E-06 ± 2.5E-06	2.7E-06 ± 2.6E-06	18	0	1.4E-07 ± 2.0E-06	2.6E-06 ± 1.3E-05	
Tritium	Onsite	137	94	1.2E+01 ± 3.4E+01	1.1E+02 ± 1.1E+01	676	444	6.6E+00 ± 2.0E+01	8.4E+01 ± 1.2E+01	1.5E+03
	Perimeter	85	51	9.5E+00 ± 3.3E+01	9.4E+01 ± 8.9E+00	446	258	6.5E+00 ± 2.0E+01	7.6E+01 ± 1.1E+01	
	Nearby Communities	24	13	6.0E+00 ± 1.5E+01	3.5E+01 ± 7.3E+00	128	81	7.6E+00 ± 2.1E+01	6.2E+01 ± 1.0E+01	
	Distant Community	13	4	3.5E+00 ± 1.1E+01	1.7E+01 ± 3.9E+00	66	31	2.3E+00 ± 4.8E+01	7.1E+01 ± 1.2E+01	
Strontium 90	Onsite	34	0	5.2E-05 ± 2.5E-04	3.8E-04 ± 2.8E-04	140	2	1.1E-05 ± 7.2E-05	1.6E-04 ± 5.2E-05	1.9E-02
	Perimeter	12	0	1.6E-05 ± 2.3E-04	1.9E-04 ± 2.1E-04	121	4	1.5E-05 ± 1.4E-04	4.2E-04 ± 3.3E-04	
	Nearby Communities	4	0	4.1E-05 ± 1.5E-04	1.5E-04 ± 1.9E-04	44	1	3.8E-05 ± 3.0E-04	7.2E-04 ± 1.9E-04	
	Distant Community	2	0	1.7E-04 ± 2.2E-04	2.8E-04 ± 2.5E-04	19	0	3.7E-05 ± 3.1E-04	6.7E-04 ± 8.0E-04	
Uranium 234	Onsite	28	28	3.9E-05 ± 1.9E-05	6.2E-05 ± 2.7E-05	149	132	4.1E-05 ± 3.2E-05	8.8E-05 ± 2.1E-05	7.7E-03
	Perimeter	8	8	4.0E-05 ± 2.8E-05	7.2E-05 ± 3.1E-05	79	70	5.1E-05 ± 4.2E-05	9.4E-05 ± 3.1E-05	
	Nearby Communities	8	8	4.4E-05 ± 1.0E-05	5.3E-05 ± 2.4E-05	76	65	4.7E-05 ± 3.4E-05	1.0E-04 ± 3.0E-05	
	Distant Community	2	2	3.5E-05 ± 7.4E-06	3.9E-05 ± 2.0E-05	19	16	4.0E-05 ± 2.8E-05	7.2E-05 ± 3.5E-05	
Uranium 238	Onsite	28	28	3.6E-05 ± 1.8E-05	6.3E-05 ± 3.0E-05	149	139	4.4E-05 ± 2.7E-05	8.7E-05 ± 5.8E-05	8.3E-03
	Perimeter	8	8	5.0E-05 ± 4.4E-05	8.8E-05 ± 3.6E-05	79	75	5.3E-05 ± 3.7E-05	1.2E-04 ± 6.4E-05	
	Nearby Communities	8	8	4.0E-05 ± 9.4E-06	4.7E-05 ± 2.2E-05	76	73	5.2E-05 ± 2.9E-05	9.5E-05 ± 3.2E-05	
	Distant Community	2	2	3.4E-05 ± 1.8E-06	3.5E-05 ± 1.8E-05	19	17	4.3E-05 ± 2.1E-05	6.0E-05 ± 2.5E-05	

Table C.6. Radionuclide Concentrations in Offsite Air Samples

^a 1 pCi = 0.037 Bq.^b Number of samples with measurable concentrations of contaminant. Detection is defined as a value reported above the minimum detectable activity and above the total propagated analytical uncertainty.^c Average \pm two standard deviations of all samples analyzed.^d Maximum \pm analytical uncertainty.^e DOE derived concentration guides are shown for gross alpha and gross beta.^f EPA values are based on an effective dose equivalent of 10 mrem/year (40 CFR 61, Appendix E, Table 2).

Table C.7. Radionuclide Concentrations in Columbia River Water (Richland, Washington)

Radionuclide ^b	2013				2008-2012				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	4.8E+01 ± 1.4E+01	3.4E+01 ± 1.4E+01	61	59	1.4E+02 ± 3.2E+01	4.3E+01 ± 4.8E+01	20,000 ^d
Gross Alpha	1	0	1.2E+00 ± 1.3E+00	^h	61	11	3.6E+00 ± 1.9E+00	6.4E-01 ± 1.3E+00	15 ^{e, f}
Gross Beta	1	0	9.5E-01 ± 2.2E+00	^h	61	6	5.4E+00 ± 2.6E+00	1.8E+00 ± 2.8E+00	50
Strontium-90	12	0	5.0E-02 ± 3.7E-02	1.8E-02 ± 4.8E-02	61	61	8.1E-02 ± 2.9E-02	3.0E-02 ± 4.2E-02	8
Technetium-99	12	0	6.2E-01 ± 4.5E-01	-6.1E-02 ± 5.6E-01	60	17	8.1E-01 ± 3.9E-01	1.1E-01 ± 6.1E-01	900
Uranium-234	12	12	3.2E-01 ± 8.0E-02	2.7E-01 ± 5.8E-02	61	61	3.5E-01 ± 7.3E-02	2.6E-01 ± 6.8E-02	-- ^g
Uranium-235	12	2	3.4E-02 ± 4.6E-02	1.1E-02 ± 1.9E-02	59	4	4.5E-02 ± 4.5E-02	1.2E-02 ± 2.4E-02	-- ^g
Uranium-238	12	12	2.7E-01 ± 6.2E-02	2.2E-01 ± 6.3E-02	61	13	2.9E-01 ± 1.2E-01	2.1E-01 ± 7.0E-02	-- ^g
Cesium-137	P ^b	11	1.9E-03 ± 3.3E-03	2.4E-05 ± 3.0E-03	57	0	9.1E-03 ± 4.8E-03	3.4E-04 ± 3.2E-03	200 ^c
	D ^b	10	2.0E-03 ± 1.6E-03	2.9E-04 ± 1.2E-03	57	0	7.9E-03 ± 5.6E-03	6.5E-04 ± 5.5E-03	
Plutonium-238	P ^b	4	5.6E-05 ± 9.8E-05	2.2E-04 ± 4.8E-05	15	0	9.5E-05 ± 9.4E-05	8.7E-06 ± 6.7E-05	600 ^c
	D ^b	4	7.1E-12 ± 5.8E-05	-2.3E-06 ± 9.0E-06	18	2	3.3E-04 ± 9.6E-04	-6.4E-05 ± 4.8E-04	
Plutonium-239/240	P ^b	4	1.4E-04 ± 1.3E-04	5.5E-05 ± 4.8E-05	20	1	9.5E-05 ± 8.6E-05	-8.2E-06 ± 1.6E-04	
	D ^b	4	1.8E-05 ± 2.7E-05	1.2E-05 ± 8.6E-05	19	3	4.1E-04 ± 2.2E-04	6.1E-05 ± 4.8E-04	

^a Maximum values are \pm total propagated analytical uncertainty (2 sigma). Averages are \pm 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 1 pCi = 0.037 Bq.^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.^h Average values are not calculated when only one sample was analyzed.

WA = Washington State.

Table C.8. Radionuclide Concentrations in Columbia River Water (Priest Rapids Dam, Washington)

Radionuclide ^b	2013				2008-2012				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	1	0	1.2E+00 ± 1.4E+00	^h	61	3	2.3E+00 ± 1.6E+00	5.0E-01 ± 1.5E+00	15 ^{e, f}	
Gross Beta	1	0	7.7E-01 ± 2.1E+00	^h	60	8	9.4E+00 ± 2.6E+00	1.5E+00 ± 3.8E+00	50 ^{e, f}	
Strontium-90	12	0	5.4E-02 ± 3.7E-02	2.8E-02 ± 5.4E-02	61	6	1.3E-01 ± 5.0E-02	2.4E-02 ± 5.6E-02	8 ^{e, f}	
Technetium-99	12	0	3.8E-01 ± 3.8E-01	-1.8E-03 ± 5.3E-01	61	0	4.8E-01 ± 4.6E-01	-1.7E-02 ± 4.8E-01	900 ^d	
Tritium	12	12	2.5E+01 ± 7.1E+00	1.8E+01 ± 7.4E+00	63	59	4.8E+01 ± 1.9E+01	2.0E+01 ± 1.5E+01	20,000 ^d	
Uranium-234	12	12	2.3E-01 ± 6.4E-02	2.8E-01 ± 6.5E-02	61	61	3.0E-01 ± 1.0E-01	2.2E-01 ± 7.0E-01	-- ^g	
Uranium-235	12	1	2.9E-02 ± 2.2E-02	8.2E-03 ± 1.8E-02	60	14	3.1E-02 ± 3.3E-02	1.2E-02 ± 1.8E-02	-- ^g	
Uranium-238	12	12	2.3E-01 ± 5.1E-02	1.8E-01 ± 1.8E-02	61	61	2.7E-01 ± 7.2E-02	1.8E-01 ± 5.8E-02	-- ^g	
Continuous System										
Cesium-137	P ^b	11	0	3.8E-03± 4.0E-03	8.1E-04 ± 4.1E-03	52	0	7.8E-03 ± 7.0E-03	5.9E-04 ± 4.6E-03	200 ^c
	D ^b	11	0	9.7E-03 ± 1.8E-03	3.0E-04 ± 1.2E-03	52	1	2.8E-03 ± 2.0E-03	1.7E-04 ± 1.9E-03	
Plutonium-238	P ^b	4	0	3.7E-05 ± 1.2E-04	3.0E-05 ± 1.5E-05	18	4	2.1E-03 ± 6.0E-04	1.7E-04 ± 9.6E-04	-- ^g
	D ^b	4	0	4.5E-05 ± 7.4E-05	1.1E-05 ± 5.0E-05	18	1	7.3E-05 ± 2.0E-03	1.7E-04 ± 1.9E-03	
Plutonium-239/240	P ^b	4	0	3.5E-05 ± 1.1E-04	-4.7E-06 ± 7.2E-05	18	4	7.2E-04 ± 2.5E-04	8.3E-05 ± 3.8E-04	-- ^g
	D ^b	4	0	2.5E-05 ± 6.3E-05	1.3E-05 ± 2.8E-05	18	1	1.1E-04 ± 1.0E-04	1.6E-05 ± 7.0E-05	

^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 1 pCi = 0.037 Bq.^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.^h Average values are not calculated when only one sample was analyzed.

WA = Washington State.

Table C.9. Radionuclide Concentrations in Columbia River Water (Hanford Reach)

Transect/Radionuclide	No. of Detections	No. of Samples	Concentration ^b					
			Maximum <i>pCi/L</i> ^a			Minimum <i>pCi/L</i> ^a		
Vernita Bridge (HRM 0.3)								
Strontium-90	0	4	0.044	±	0.037	0.024	±	0.035
Tritium	4	4	19	±	7.2	15	±	6.4
Uranium-234	4	4	0.25	±	0.09	0.22	±	0.08
Uranium-235	0	4	0.025	±	0.028	-0.005	±	0.015
Uranium-238	4	4	0.29	±	0.09	0.19	±	0.07
100—N Area (HRM 9.5)								
Strontium-90	0	5	0.037	±	0.037	-0.029	±	0.029
Tritium	5	5	27	±	9.1	15	±	6.9
Uranium-234	5	5	0.28	±	0.074	0.25	±	0.068
Uranium-235	1	5	0.033	±	0.027	-0.004	±	0.018
Uranium-238	5	5	0.20	±	0.062	0.16	±	0.062
Hanford Townsite (HRM 28.7)								
Strontium-90	0	6	0.056	±	0.04	-0.005	±	0.03
Tritium	6	6	100	±	27	17	±	7.3
Uranium-234	6	6	0.25	±	0.08	0.18	±	0.06
Uranium-235	0	6	0.021	±	0.025	0.002	±	0.02
Uranium-238	6	6	0.24	±	0.07	0.12	±	0.05
300 Area (HRM 43.1)								
Strontium-90	0	6	0.043	±	0.037	-0.026	±	0.030
Tritium	6	6	43	±	27	17	±	7.3
Uranium-234	6	6	0.39	±	0.09	0.23	±	0.059
Uranium-235	3	6	0.032	±	0.026	0.013	±	0.018
Uranium-238	6	6	0.31	±	0.07	0.14	±	0.04
Richland (HRM 46.4)								
Strontium-90	0	5	0.049	±	0.038	-0.023	±	0.030
Tritium	5	5	23	±	8.4	17	±	7.7
Uranium-234	5	5	0.32	±	0.13	0.19	±	0.08
Uranium-235	1	5	0.023	±	0.04	0	±	0.02
Uranium-238	5	5	0.22	±	0.09	0.17	±	0.03

^a 1 pCi = 0.037 Bq.^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.10. Dissolved Metal Concentrations in Columbia River Transect Water Near Hanford Site

	No. of Samples	No. of Detections	Maximum (µg/L) ^a	Minimum (µg/L) ^a	Average (±2 SD) (µg/L) ^a		Minimum Detectable Concentrations	Washington State Ambient Surface Water Quality Chronic Toxicity Level ^b
Metal								
Vernita Bridge								
Antimony	4	0	—	—	—	—	1.0	—
Arsenic	4	3	3.2	1.7	3.7	1.3	1.7	190
Beryllium	4	0	—	—	—	—	0.2	—
Cadmium	4	0	—	—	—	—	0.11	—
Chromium	4	0	—	—	—	—	2	10
Copper	4	4	0.71	0.64	0.72	0.60	0.35	6
Lead	4	0	—	—	—	—	0.5	1.1
Nickel	4	3	0.75	0.50	0.92	0.44	0.5	83
Selenium	4	0	—	—	—	—	1.5	5
Silver	4	0	—	—	—	—	0.2	—
Thallium	4	0	—	—	—	—	0.45	—
Uranium	4	4	0.58	0.53	0.60	0.52	0.67	—
Zinc	4	4	4.5	3.5	4.8	3.0	3.5	55
100-N Area								
Antimony	5	0	—	—	—	—	1	—
Arsenic	5	3	2.2	1.7	2.2	1.5	1.7	190
Beryllium	5	0	—	—	—	—	0.2	—
Cadmium	5	0	—	—	—	—	0.11	—
Chromium	5	0	—	—	—	—	2	10
Copper	5	5	0.88	0.67	0.97	0.57	0.35	6
Lead	5	0	—	—	—	—	0.5	1.1
Nickel	5	4	0.86	0.50	0.98	0.46	0.5	83
Selenium	5	0	—	—	—	—	1.5	5
Silver	5	0	—	—	—	—	0.2	—
Thallium	5	0	—	—	—	—	0.45	—
Uranium	5	5	0.61	0.51	0.62	0.51	0.67	—
Zinc	5	5	6.1	3.7	6.5	2.5	3.5	55
Hanford Townsite								
Antimony	6	0	—	—	—	—	1.0	—
Arsenic	6	0	—	—	—	—	1.7	190
Beryllium	6	0	—	—	—	—	0.2	—
Cadmium	6	0	—	—	—	—	0.11	—
Chromium	6	0	—	—	—	—	2	10
Copper	6	6	0.77	0.68	0.76	0.64	0.35	6
Lead	6	0	—	—	—	—	0.5	1.1
Nickel	6	3	0.65	0.50	0.70	0.42	0.5	83
Selenium	6	0	—	—	—	—	1.5	5
Silver	6	0	—	—	—	—	0.2	—
Thallium	6	0	—	—	—	—	0.45	—
Uranium	6	6	0.52	0.50	0.53	0.49	0.67	—
Zinc	6	0	---	---	---	---	3.5	55

Table C.10. Dissolved Metal Concentrations in Columbia River Transect Water Near Hanford Site

	No. of Samples	No. of Detections	Maximum (µg/L) ^a	Minimum (µg/L) ^a	Average (±2 SD) (µg/L) ^a		Minimum Detectable Concentrations	Washington State Ambient Surface Water Quality Chronic Toxicity Level ^b
Metal								
300 Area								
Antimony	6	0	—	—	—	—	1	—
Arsenic	6	0	—	—	—	—	1.7	190
Beryllium	6	0	—	—	—	—	0.2	—
Cadmium	6	0	—	—	—	—	0.11	—
Chromium	6	0	—	—	—	—	2	10
Copper	6	6	0.75	0.66	0.78	0.62	0.35	6
Lead	6	0	—	—	—	—	0.5	1.1
Nickel	6	1	0.55	0.50	0.55	0.47	0.5	83
Selenium	6	0	—	—	—	—	1.5	5
Silver	6	0	—	—	—	—	0.2	—
Thallium	6	0	—	—	—	—	0.45	—
Uranium	6	6	0.98	0.56	1.1	0.3	0.67	—
Zinc	6	3	7.3	3.5	7.7	1.5	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	5	0.70	0.64	0.06	-0.02	0.35	6
Lead	5	0	—	—	—	—	0.5	1.1
Nickel	5	1	0.73	0.50	0.30	-0.10	0.5	83
Selenium	5	0	—	—	—	—	1.5	5
Silver	5	0	—	—	—	—	0.2	—
Thallium	5	0	—	—	—	—	0.45	—
Uranium	5	5	0.57	0.50	0.59	0.49	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 (µg/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.11. Radionuclide and Total Organic Carbon Concentrations in Columbia River Sediment (Near Hanford Site)

Location / 2013 Total Organic Carbon Concentration Value		2013		2008-2012			
Radionuclide	No. of Samples	Concentration, Ci/g ^a		No. of Samples	Concentration, Ci/g ^a		
		Average ^b	Maximum ^d		Average ^{bc}	Maximum ^d	
Priest Rapids Dam (14,700 – 25,400 mg/kg)	Cobalt-60	2	-0.00386 ± 0.004	-0.00241 ± 0.0184	10	-0.0033 ± 0.021	0.011 ± 0.016
	Strontium-90	2	0.008837 ± 0.024	0.0173 ± 0.0214	10	0.008 ± 0.021	0.043 ± 0.028
	Cesium-137	2	0.24 ± 0.0396	0.254 ± 0.0364	10	0.30 ± 0.063	0.35 ± 0.038
	Europium-152	2	-0.01218 ± 0.0544	0.00704 ± 0.0443	10	-0.012 ± 0.094	0.089 ± 0.136
	Europium-155	2	0.09735 ± 0.07	0.123 ± 0.0623	10	0.075 ± 0.046	0.114 ± 0.124
	Uranium-234	2	1.145 ± 0.0701	1.26 ± 0.209	12	1.2 ± 0.27	1.4 ± 0.25
	Uranium-235	2	0.07565 ± 0.041	0.09 ± 0.0397	10	0.062 ± 0.037	0.096 ± 0.026
	Uranium-238	2	1.08 ± 0.226	1.16 ± 0.197	11	1.1 ± 0.28	1.2 ± 0.23
	Plutonium-239/240	2	0.00928 ± 0.01856	0.00933 ± 0.00406	10	0.010 ± 0.004	0.013 ± 0.004
100-F Slough (1,430 mg/kg)	Cobalt-60	1		0.00525 ± 0.0115	4	0.015 ± 0.0062	0.019 ± 0.019
	Strontium-90	1		0.0166 ± 0.0278	4	0.0173 ± 0.0154	0.027 ± 0.025
	Cesium-137	1		0.208 ± 0.0298	4	0.227 ± 0.086	0.273 ± 0.0224
	Europium-152	1		0.0391 ± 0.035	4	0.032 ± 0.06	0.064 ± 0.033
	Europium-155	1		0.0787 ± 0.0558	4	0.031 ± 0.06	0.068 ± 0.045
	Uranium-234	1		0.587 ± 0.15	5	0.476 ± 0.226	0.658 ± 0.074
	Uranium-235	1		0.0533 ± 0.0475	4	0.043 ± 0.034	0.061 ± 0.021
	Uranium-238	1		0.437 ± 0.129	4	0.411 ± 0.036	0.433 ± 0.085
	Plutonium-239/240	1		0.00188 ± 0.00496	4	0.001 ± 0.001	0.002 ± 0.002
White Bluffs Slough (6,300 mg/kg)	Cobalt-60	1		-0.00557 ± 0.0131	6	0.011 ± 0.026	0.024 ± 0.026
	Strontium-90	1		-0.00049 ± 0.0255	6	0.0044 ± 0.04	0.04 ± 0.031
	Cesium-137	1		0.37 ± 0.0409	6	0.39 ± 0.19	0.47 ± 0.11
	Europium-152	1		0.0659 ± 0.0553	6	0.072 ± 0.10	0.145 ± 0.0766
	Europium-155	1		0.0564 ± 0.0536	6	0.068 ± 0.06	0.1 ± 0.068
	Uranium-234	1		0.813 ± 0.159	7	0.78 ± 0.32	1.01 ± 0.184
	Uranium-235	1		0.0444 ± 0.0349	6	0.045 ± 0.018	0.061 ± 0.02
	Uranium-238	1		0.66 ± 0.137	6	0.77 ± 0.40	1.03 ± 0.179
	Plutonium-239/240	1		0.00377 ± 0.0028	6	0.003 ± 0.003	0.006 ± 0.003
100-D Spring 102-1 (1,590 mg/kg)	Cobalt-60	1		0.0022 ± 0.0193	1		-0.00612 ± 0.0113
	Strontium-90	1		0.019 ± 0.0263	1		0.0148 ± 0.0272
	Cesium-137	1		0.104 ± 0.0316	1		0.209 ± 0.0238
	Europium-152	1		0.016 ± 0.0543	1		-0.0264 ± 0.0298
	Europium-155	1		0.0392 ± 0.054	1		0.0487 ± 0.0351
	Uranium-234	1		0.488 ± 0.106	1		0.516 ± 0.11
	Uranium-235	1		0.0567 ± 0.0365	1		0.0401 ± 0.0294
	Uranium-238	1		0.446 ± 0.1	1		0.49 ± 0.104
	Plutonium-239/240	1		-0.00092 ± 0.00269			

Table C.11. Radionuclide and Total Organic Carbon Concentrations in Columbia River Sediment (Near Hanford Site)

Location / 2013 Total Organic Carbon Concentration Value		2013		2008-2012		
Radionuclide	No. of Samples	Concentration, Ci/g ^a		No. of Samples	Concentration, Ci/g ^a	
		Average ^b	Maximum ^d		Average ^{bc}	Maximum ^d
Hanford Slough (5,290 – 6,740 mg/kg)	Cobalt-60	1	-0.00503 ± 0.0129	4	0.020 ± 0.039	0.038 ± 0.018
	Strontium-90	1	0.00591 ± 0.0253	4	0.006 ± 0.015	0.015 ± 0.014
	Cesium-137	1	0.215 ± 0.0349	4	0.16 ± 0.25	0.288 ± 0.036
	Europium-152	1	0.0299 ± 0.0376	4	0.037 ± 0.073	0.074 ± 0.058
	Europium-155	1	0.0786 ± 0.0696	4	0.071 ± 0.065	0.094 ± 0.045
	Uranium-234	1	4.09 ± 0.144	5	0.774 ± 0.260	0.925 ± 0.169
	Uranium-235	1	0.267 ± 0.0825	4	0.044 ± 0.048	0.079 ± 0.044
	Uranium-238	1	0.508 ± 0.112	4	0.077 ± 0.26	0.938 ± 0.169
	Plutonium-239/240	1	0.00255 ± 0.00273	4	0.002 ± 0.004	0.004 ± 0.0015
McNary Dam (4,450 – 11,400 mg/kg)	Cobalt-60	2	-0.021 ± 0.081	10	0.009 ± 0.015	0.02 ± 0.015
	Strontium-90	2	0.0163 ± 0.041	10	-0.0009 ± 0.03	0.021 ± 0.028
	Cesium-137	2	0.227 ± 0.033	10	0.24 ± 0.068	0.311 ± 0.032
	Europium-152	2	0.0594 ± 0.08	10	0.047 ± 0.096	0.116 ± 0.0472
	Europium-155	2	0.09735 ± 0.07	10	0.068 ± 0.052	0.101 ± 0.104
	Uranium-234	2	1.47 ± 0.16	12	1.4 ± 0.35	1.7 ± 0.31
	Uranium-235	2	0.0772 ± 0.12	10	0.078 ± 0.037	0.12 ± 0.03
	Uranium-238	2	1.185 ± 0.014	10	1.20 ± 0.24	1.4 ± 0.23
	Plutonium-239/240	2	0.00625 ± 0.00092	10	0.009 ± 0.009	0.021 ± 0.0061

^a 1 pCi = 0.037 Bq.^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.12. 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	1.1 – 1.8 ^c	0.72 – 3.7 ^c	1.5 – 1.7 ^c	4.4
Arsenic	7.5 – 7.6	2.9 – 6.6	5.3 – 8.6	6.3
Beryllium	0.78 – 0.82 ^c	0.43 – 0.81	0.90 – 1.2	0.74
Cadmium	4.9 – 5.5	0.59 – 1.7	1.2 – 1.4	1.3
Chromium	28 - 28	9.1 - 21	19 - 24	113
Copper	38 - 44	13 - 23	22 - 31	18.2
Lead	37 - 42	9.9 - 35	17 - 21	16.8
Mercury	0.07 – 0.08	0.008 – 0.04	0.07 – 0.08	0.009 ^c
Nickel	–30 - 30	6.9 - 14	19 - 22	9.2
Selenium	Not Detected	Not Detected	1.1 – 1.4 ^c	Not Detected
Silver	0.27 – 0.30 ^c	0.14 – 0.16 ^c	0.19 – 0.36 ^c	Not Detected
Thallium	Not Detected	Not Detected	Not Detected	3.1
Zinc	415 - 424	122-338	180 - 194	194
No. of Samples	2	3	2	1

^a 100-F Slough (n=1), Hanford Slough (n=1), White Bluffs Slough (n=1); where n = number of samples.^b 100-D Area at 100-D Spring 102-1 (n=1).^c Minimum detection limit met but fell below required detection limit.

Table C.13. Radionuclide Concentrations in Columbia River Shoreline Seep Water

Location/Radionuclide	2013				2008-2012				Washington State Ambient Surface Water Quality Standard pCi/L ^(a, b)
	No. of Samples	Concentration pCi/L ^(a)		No. of Samples	Concentration pCi/L ^(a)				
		Maximum ^(c)	Average ^(d)		Maximum ^(c)	Average ^(d)			
100-B Area (Spring 38-3)									
Strontium-90	1	0.00247 ± 0.03 ^e	NC	5	0.0547± 0.0377 ^e	0.0277± 0.052	8		
Tritium	1	1,000 ± 271	NC	5	2,680± 563	1,630± 1,226	20,000		
100-B Area (Spring 39-2)									
Alpha (gross)	1	0.929 ± 2.03 ^e	NC	3	6.57 ± 1.38	3.89 ± 5.01	15		
Beta (gross)	1	11 ± 2.94	NC	3	17.3 ± 3.64	13.4 ± 7.38	50		
Strontium-90	1	2.11 ± 0.373	NC	3	2.16 ± 0.371 ^e	1.87 ± 0.522 ^e	8		
Tritium	1	2,050 ± 445	NC	3	2,340 ± 498	2,083 ± 578.4	20,000		
100-D Area (Spring 110-1)									
Alpha (gross)	1	0.7 ± 1.2 ^e	NC	4	1.7 ± 1.6 ^e	0.89 ± 1.6 ^e	15		
Beta (gross)	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 (Spring 152-2)									
Strontium-90	1	275 ± 174	NC	0	Not Sampled		20,000		
Technetium-99	1	0.016 ± 0.034 ^e	NC	0	Not Sampled		8		
Tritium	1	0.42 ± 0.444	NC	0	Not Sampled		900 ^f		
100-K Area (Spring 63-1)									
Carbon-14	1	57 ± 27	NC	0	Not Sampled		2,000		
Tritium	1	2,890 ± 608	NC	4	Not Sampled		20,000		
100-N Area (Spring 8-13)									
Alpha (gross)	1	2.81 ± 2.45 ^e	NC	5	10.4 ± 3.96	6.35 ± 11.5	15		
Beta (gross)	1	5.43 ± 2.08	NC	5	17.5 ± 2.41	9.14 ± 14.6	50		
Strontium-90	1	0.0047 ± 0.033 ^e	NC	5	0.048 ± 0.032 ^e	0.019 ± 0.037 ^e	8		
Tritium	1	3,240 ± 671	NC	5	5,800 ± 1,160	3,046 ± 4,304	20,000		
100-N Area (Spring 89-1)									
Strontium-90	1	43.7 ± 6.9	NC	1	4.61 ± 0.747	NC	8		
Tritium	1	1,500 ± 348	NC	1	886 ± 289	NC	20,000		
Hanford Town site (Hanford Spring 28-2)									
Alpha (gross)	1	2.6 ± 2.4 ^e	NC	3	3.04 ± 2.2	1.8 ± 2.2	15		
Beta (gross)	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		

Table C.13. Radionuclide Concentrations in Columbia River Shoreline Seep Water

Location/Radionuclide	2013				2008-2012				Washington State Ambient Surface Water Quality Standard pCi/L ^(a, b)
	No. of Samples	Concentration pCi/L ^(a)			No. of Samples	Concentration pCi/L ^(a)			
		Maximum ^(c)	Average ^(d)			Maximum ^(c)	Average ^(d)		
300 Area (300 Area Spring 42-2 and 300 Area Spring DR 42-2)									
Alpha (gross)	3	101 ± 8.89	47.5 ± 92.6	13	86.3 ± 11	37.5 ± 52.7	15		
Beta (gross)	3	42.2 ± 3.66	23.2 ± 33.1	13	42.2 ± 5.04	25 ± 22.4	50		
Tritium	3	5,030 ± 1010	4,053 ± 1,702	13	9,060 ± 1,790	5,686 ± 3,899	20,000		
Uranium-234	3	48.7 ± 7.06	22.9 ± 44.6	13	48.3 ± 10.7	20.2 ± 32.5	^(f)		
Uranium-235	3	3.41 ± 0.559	1.58 ± 3.16	13	3.72 ± 1.07	1.56 ± 2.66	^(f)		
Uranium-238	3	46.9 ± 6.81	21.9 ± 43.4	13	46.8 ± 10.4	19.6 ± 31.4	^(f)		

^a 1 pCi = 0.037 Bq.^b WAC 246-290, 40 CFR 141, and Appendix D, Table D.4.^c Maximum values are ± total propagated analytical uncertainty.^d Averages are ± 2 standard deviations of the mean. Average values are not calculated (NC) when only one sample was analyzed.^e WAC 173-201A-250 and EPA-570/9-76-003.^f Dashes indicate no concentration guides available.

Table C.14. Radionuclide Concentrations in Columbia River Shoreline Sediment (100-D Seep)

Radionuclide	No. of Samples	Result, pCi/g a, b
Antimony-125 ^c	1	1.4E-02 ± 4.5E-02
Cobalt-60 ^c	1	2.2E-03 ± 1.9E-02
Cesium-134	1	4.9E-02 ± 4.3E-02
Cesium-137	1	1.0E-01 ± 3.2E-02
Europium-152 ^c	1	1.6E-02 ± 5.4E-02
Europium-154 ^c	1	-1.1E-02 ± 6.8E-02
Europium-155 ^c	1	3.9E-02 ± 5.4E-02
Potassium-40	1	1.3E+01 ± 1.3E+00
Plutonium-238 ^c	1	1.2E-03 ± 2.3E-03
Plutonium-239/240 ^c	1	-9.2E-04 ± 2.7E-03
Ruthenium-106 ^c	1	-6.3E-02 ± 1.6E-01
Strontium-90 ^c	1	1.9E-02 ± 2.6E-02
Uranium-234	1	4.9E-01 ± 1.1E-01
Uranium-235	1	5.7E-02 ± 3.7E-02
Uranium-238	1	4.5E-01 ± 1.0E-01

a International System of Units conversion (dry weight): multiply pCi/g by 0.037 to obtain Bq/g.

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

R Perona and RT Ryti

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 2013 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 summarized 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 also may 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 measureable amounts, it can be 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 points of release (stacks and vents). The water pathway dose calculations are based on the difference in 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 by irrigation or airborne depositions become possible sources of 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—

¹ 1 rem (0.01 sievert) = 1,000 millirem (10 millisievert).

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](#), *The Hanford Environmental Radiation Dosimetry Software System*), 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 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 (MEI) 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 2013* ([DOE/RL-2014-14](#)).

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 MEI
- Collective dose for members of the public should be calculated, and may be truncated by distance (e.g., 50 miles [80 kilometers])
- The representative person or MEI 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 location of the offsite MEI was identified, and information on modeling assumptions and inputs to the GENII computer code used to conduct the MEI dose calculations, is provided in Section D.1.1. Information supporting the calculation of collective offsite dose for members of the public using the GENII computer code is provided in Section D.1.2.

D.1.1 Maximally Exposed Individual Dose

The MEI is a hypothetical member of the public whose location and lifestyle makes it unlikely that any actual individuals would receive higher doses. The location of the MEI 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 MEI. Based on experience since 1990 from environmental transport modeling and environmental surveillance monitoring, several separate locations (Section 4, Figure 4.2) have been used to assess the location of the MEI. The distinguishing characteristics of these locations are described in the following paragraphs.

Riverview MEI. 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 MEI. 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 MEI, 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 MEI. 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; as a result, and the wells on the eastern side of the Columbia River are not impacted by radionuclides of Hanford Site origin. 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 been historically assigned to the Sagemoor area MEI. 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 MEI. Meteorological conditions in 2012 and 2013 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 slightly 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. 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 MEI. 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 two decades, the hypothetical MEI has been associated with air emissions from the 300 Area.

Because the hypothetical MEI 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 MEI 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 2013, air-pathways radiological dose calculations conducted using CAP-88PC in support of *Clean Air Act* requirements identified Horn Rapids Road as the location with the highest MEI dose, which is 0.25 mrem/yr. That dose consists of 0.13 mrem/yr from stack emissions, 0.055 mrem/yr from fugitive emissions, and 0.063 mrem/yr from radon ([DOE/RL-2014-14](#)). Air pathways calculations performed with the GENII computer code, which implements air dispersion calculations that differ slightly from CAP-88PC, indicate that Sagemoor and Horn Rapids Road doses are practically equivalent. Because the MEI at Horn Rapids Road also receives dose from the drinking water pathway, Horn Rapids Road was identified as the location of the hypothetical MEI in 2013 for the GENII calculations. Both Sagemoor and Horn Rapids Road MEI GENII results are shown in Section 4, Figure 4.4 for comparison.

The coordinates of the MEI 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 Areas. 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. GENII accepts inputs for environmental releases using dimensions of activity (e.g., Curie or Becquerel) per time for both water and air pathways.

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 2013. 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 Pumpouse, 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). Some radionuclides are measured in both filtered samples (in solution) and in samples that capture suspended particulates (adhered to resin). These data were evaluated both separately and summed.

One-tailed paired t-tests and nonparametric Wilcoxon Rank Sum (WRS) tests were 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. The WRS test has less power than the t-test when the data originate from a normal distribution, but the assumptions under which the statistical results are valid are not as restrictive. Both statistical tests identified tritium, uranium-234, and uranium-238 as potentially Hanford-related contaminants to include in the 2013 dose assessment. Because uranium-235 would be expected to co-occur with both uranium-234 and uranium-238, uranium-235 also was identified for inclusion in the water pathways dose assessment calculations. These liquid effluent releases were associated with the 200 Areas for reporting purposes. In addition to an evaluation of the 2013 Columbia River data, samples from 2002-2013 were evaluated to examine longer-term trends. Concentrations of tritium, uranium-234 and uranium-238 were clearly greater downstream compared to upstream for this longer period. In addition, concentrations of uranium-235 were marginally statistically significant ($p < 0.05$) downstream compared to upstream for the entire 2002 to 2013 period.

Table D.1, summarizes the mean annual differences in downstream and upstream concentrations, and calculated annual releases for the 2013 200 Areas GENII water pathways dose calculations.

Table D.1. 200 Area Liquid Effluent Radionuclide Releases for GENII Calculations

Radionuclide	Upstream	Downstream	Difference
Columbia River Annual-Average Radionuclide Concentrations (pCi/L)			
Tritium	1.8E+01	3.4E+01	1.6E+01
Uranium-234	2.3E-01	2.8E-01	5.0E-02
Uranium-235	8.2E-03	1.1E-02	2.5E-03
Uranium-238	1.8E-01	2.2E-01	3.4E-02
Calculated Radionuclide Releases (Ci/year)^a			
Tritium	NA	NA	1.7E+03
Uranium-234	NA	NA	5.4E+00
Uranium-235	NA	NA	2.6E-01
Thorium-231 ^b	NA	NA	2.6E-01
Uranium-238	NA	NA	3.7E+00
Thorium-234 ^c	NA	NA	3.7E+00
Protactinium-234m ^c	NA	NA	3.7E+00

a Calculated as the product of the difference in downstream and upstream radionuclide concentrations and the 2013 annual-average river flow rate of 3,429 m³/sec at Priest Rapids Dam and the number of seconds in a year.

b This short-lived progeny of uranium-235 was protectively assumed to be in secular equilibrium at the time of discharge.

c 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 of 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-hour 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-2014-14](#), 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 provide the values for the diet, residency, and river recreation parameters for MEIs 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 2013 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; Hanford Meteorological Station), 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 MEI 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 MEI 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 (elemental tritium)	NA	NA	57.1	NA
Hydrogen-3 (tritiated water vapor)	NA	NA	193	1.8E-03
Carbon-14	NA	NA	1.0E-06	NA
Sodium-22	NA	NA	NA	1.4E-09
Krypton-85	NA	NA	5.5E-03	NA
Stontium-90 ^b	1.6E-05	6.5E-04	7.8E-07	NA
Yttrium-90 ^{b, c}	2.4E-06	9.8E-05	1.2E-07	--
Technetium-99	NA	NA	1.6E-06	NA
Iodine-129	NA	7.4E-04	NA	NA
Cesium-137	3.4E-06	9.3E-05	6.7E-09	2.3E-06
Barium-137m ^c	3.4E-06	9.3E-05	6.7E-09	2.3E-06
Europium-152	NA	NA	1.3E-08	NA
Europium-154	2.4E-08	NA	2.6E-07	NA
Gadolinium-153	NA	NA	5.4E-11	NA
Radon-220	NA	NA	250	NA
Lead-212 ^c	--	--	3.5E-01	--
Bismuth-212 ^c	--	--	3.3E-01	--
Radium-226	NA	NA	2.3E-10	NA
Lead-214 ^c	--	--	2.3E-11	--
Bismuth-214 ^c	--	--	2.2E-11	--
Lead-210 ^c	NA	NA	5.6E-16	NA
Actinium-227	NA	NA	7.3E-11	NA
Uranium-232	NA	NA	2.9E-10	NA
Uranium-233	NA	NA	3.1E-09	NA
Neptunium-237	NA	NA	2.6E-10	NA
Plutonium-238	2.5E-07	9.5E-08	2.3E-10	NA
Plutonium-239/240 ^(d)	5.2E-06	4.7E-05	1.3E-07	1.9E-07
Plutonium-241	1.0E-05	5.2E-06	2.0E-07	NA
Americium-241	1.5E-06	3.6E-06	2.3E-10	NA
Americium-243	NA	NA	6.5E-08	NA
Neptunium-239 ^c	--	--	1.1E-08	--

^a Radionuclides in italic font are short-lived progeny of the parent listed above that may in grow 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-hour air dispersion time period to an exposure point within a 50-mile (80-kilometer) distance.

^d Includes additional activity reported as gross gamma activity for 100, 200, and 300 Areas.

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 hours 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 hours 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 MEI (Section D.1.1) were used to calculate doses to the offsite population. The primary difference between the MEI 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 an MEI.

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 in the Tri-Cities 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 33,000 pounds (15,000 kilograms) per year. It was protectively assumed that 100 percent of the annual catch was consumed by individuals in the Tri-Cities area. Population dose related to fish consumption was calculated as:

Population dose (person-rem) = MEI dose (mrem) × 0.001 rem/mrem × (annual catch [kg/year] / IR_fish [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>.

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)

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. Population files were created based on the number of individuals located in each of the 160 grid segments centered on the 100, 200, 300, and 400 Areas, 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 2013-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 100-K Area, Tier 3 calculations were implemented using the maximum media concentrations presented in Table D.7 as only a single sample result was obtained for this location. 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 1 100-K Area biota dose assessments were driven by the potential for dose from carbon-14 in water and the assumed potential for this isotope to accumulate in biota. The Tier 3 100-K Area biota dose calculations utilized more up-to-date literature information on bioaccumulation of carbon-14. 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 recent literature bioaccumulation information is from Hosseini et al. 2008, and the water carbon bioaccumulation factor for mammals is 1,927 gallons per pound (7,300 liters per kilogram)-fresh weight.

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
Tc-99	6.67E+05	Riparian animal	4.22E+04	Riparian animal	5
Cs-134	2.11E+01	Riparian animal	1.48E+03	Riparian animal	500
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

¹ Biota 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
Hydrogen-3	—	2050	935	3240	—	2950	566
Carbon-14	—	—	2150	—	—	—	—
Strontium-90	—	2.11	—	43.7	—	3.2	5.43
Tecnetium-99	—	—	20	—	—	—	1.91
Cesium-134	0.04	—	—	—	—	—	—
Cesium-137	0.25	—	—	—	0.10	—	—
Plutonium-239/240	0.009	—	—	—	—	—	—
Uranium-234	1.26	—	—	—	0.49	1.14	—
Uranium-235	0.09	—	—	—	0.06	0.05	—
Uranium-238	1.16	—	—	—	0.45	1.00	—

Radionuclide	Locke Island ¹	White Bluffs Slough ¹	100-F Slough ¹	100-F Spring ²	Hanford Slough ¹	Hanford Spring ²	Savage Island ¹
Hydrogen-3	—	—	—	414	—	22100	—
Carbon-14	—	—	—	—	—	—	—
Strontium-90	—	—	—	—	—	—	—
Tecnetium-99	—	—	—	—	—	—	—
Cesium-134	—	—	—	—	—	—	—
Cesium-137	—	0.37	0.21	—	0.24	—	0.04
Plutonium-239/240	—	0.004	—	—	—	—	—
Uranium-234	1.34	0.81	0.59	—	4.09	—	0.78
Uranium-235	0.09	0.04	0.05	—	0.27	—	0.06
Uranium-238	1.35	0.66	0.44	—	1.09	—	0.76

Radionuclide	300 Area Springs Seeps ²	McNary Dam Sediment ¹	West Lake Sediment ¹	West Lake Water ²
Hydrogen-3	5030	—	—	—
Carbon-14	—	—	—	—
Strontium-90	—	—	0.11	—
Tecnetium-99	—	—	—	—
Cesium-134	—	—	—	—
Cesium-137	—	0.24	0.46	—
Plutonium-239/240	—	0.007	—	—
Uranium-234	48.7	1.52	0.77	12.1
Uranium-235	3.41	0.08	0.09	0.52
Uranium-238	46.9	1.19	0.75	11.9

¹ pCi/g² pCi/L

— not detected or not measured.

