7.0 Water Monitoring

7.1 Drinking Water Systems

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Eight DOE-owned, contractor-operated, public water systems supply drinking water to DOE facilities on the Hanford Site (Table 7.1). MSA operates six of the public water systems and CHPRC operates two systems. The City of Richland supplies water to the 300 Area, Richland North Area, and HAMMER.

Table 7.1. Drinking Water Systems

Public Water System	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)	MSA
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. 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) used 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 2015. 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.

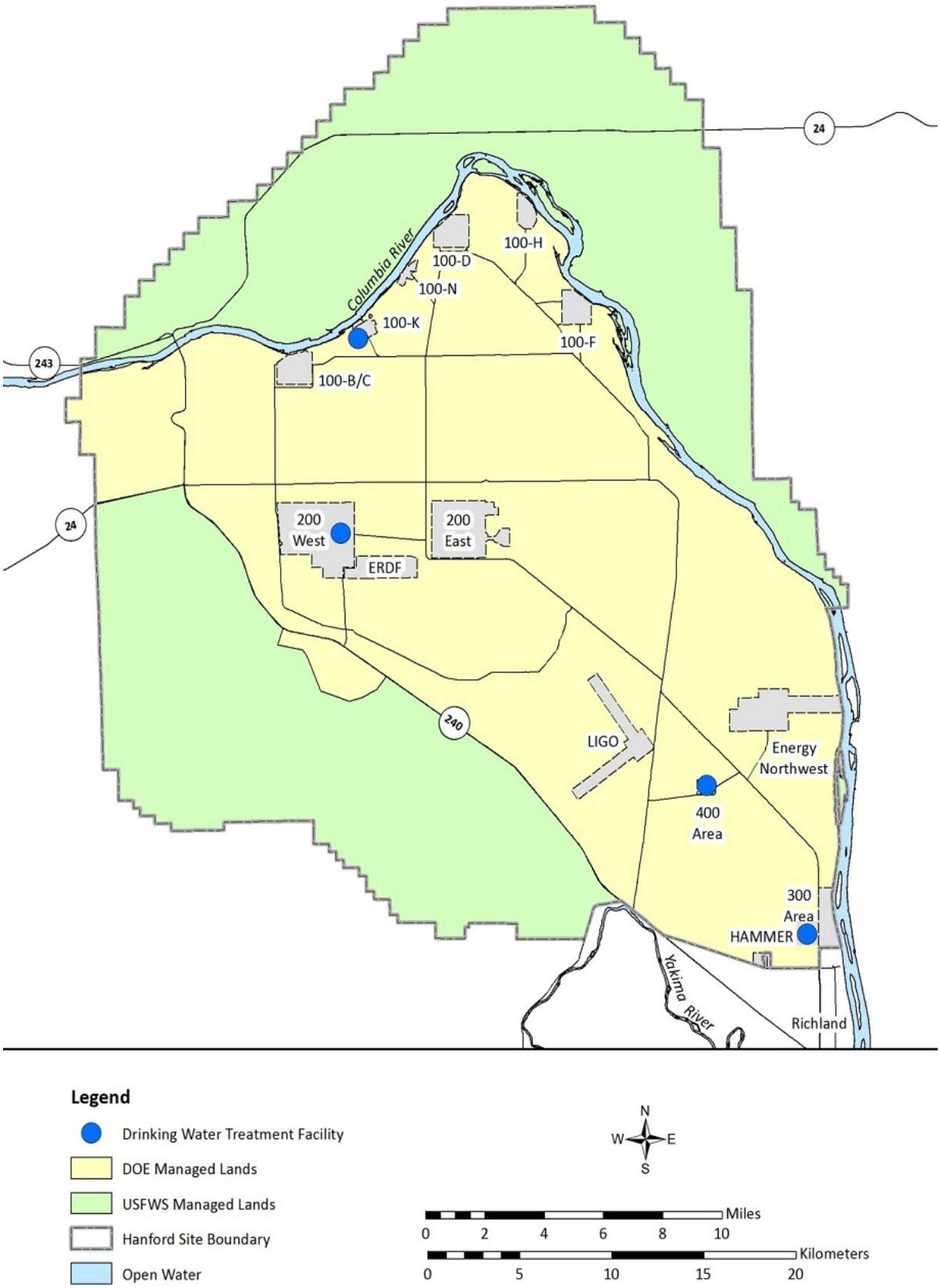

Figure 7.1. Drinking Water Treatment Facilities

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. DOE contractor personnel did not routinely monitor drinking water in the 300 Area, Richland North Area, and HAMMER for radiological contaminants. However, Public Safety and Resource Protection personnel 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 report monitoring results annually and characterize 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 and is available on the City of Richland website at https://www.ci.richland.wa.us/Home/ShowDocument?id=2106.

7.1.3 Radiological Results

Scientists conducted radiological monitoring of drinking water at one DOE-owned pump and three water treatment facilities. In addition, routine chemical, physical, and microbiological monitoring of Hanford Site drinking water was performed. Individual water systems operated by MSA and CHPRC (Table 7.1) 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. The contractor responsible for operating the water system provides process-monitoring reports directly to the state each month. Chemical, physical, and microbiological data are reported to the state directly by the state-accredited laboratory performing the analyses to MSA; however, the reports are not published.

All DOE-owned Hanford Site drinking water systems were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels during 2015. Contaminant concentrations measured during the year were similar to those observed in recent years as described in the annual Hanford Site environmental reports for 2013 (DOE/RL-2013-47) and 2014 (DOE/RL-2014-52).

Environmental Assessment personnel collected drinking water samples for radiological analysis, which were analyzed for gross alpha, gross beta, tritium, and strontium-90 (Table 7.2). The maximum amount of beta-gamma radiation from manmade radionuclides allowed in drinking water by Washington State and EPA is an annual average concentration that will not produce an annual dose equivalent to the whole body or any internal organ greater than 4 mrem (0.04 mSv). 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 mSv) 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 mSv).

Annual average concentrations of all monitored radionuclides in Hanford Site drinking water in 2015 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 2015 was well 499-S1-8J (P-16). Gross beta and tritium were found in all 400 Area water samples, but were 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* (pCi/L)†	Standard
Gross alpha‡	100-K Area	4§	–0.059 ± 3.019	15**, ††
	200 West Area	4§	0.085 ± 0.812	
	400 Area	4§	–0.155 ± 3.060	
Gross beta‡	100-K Area	4§	1.061 ± 2.381	50††
	200 West Area	4§	0.031 ± 1.686	
	400 Area	4	6.960 ± 2.512	
Tritium‡‡	100-K Area	1§	123 ± 327	20,000††
	200 West Area	1§	–51 ± 312	
	400 Area	4	1275 ± 217	
Strontium-90‡‡	100-K Area	1§	0.186 ± 0.746	8**, ††
	200 West Area	1§	–0.241 ± 0.544	
	400 Area	1§	–0.347 ± 0.663	

*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.
†Multiply pCi/L by 0.037 to convert to Bq/L.
‡Gross alpha samples were collected and analyzed quarterly. Gross beta samples were collected monthly, composited, and analyzed quarterly.
§Analytical results are below the minimum detectable concentration.
**WAC 246-290
††40 CFR 141
‡‡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.

Soil and Groundwater Remediation Project personnel collected and analyzed raw (untreated) water samples from all three 400 Area drinking water wells (one primary well and two backup wells). A tritium plume originating in the 200-East Area and extending under the 400 Area historically has affected tritium concentrations in all the 400 Area drinking water wells (Figure 7.2; Table 7.3). In addition, Environmental Assessment personnel collected raw (untreated) water samples from 400 Area drinking water backup well 499-S0-8 (P-14). Samples were collected quarterly, composited for a single annual tritium analysis (13,000 ± 2,480 pCi/L), and fell below the 20,000-pCi/L (740-Bq/L) federal and state annual average drinking water standards.

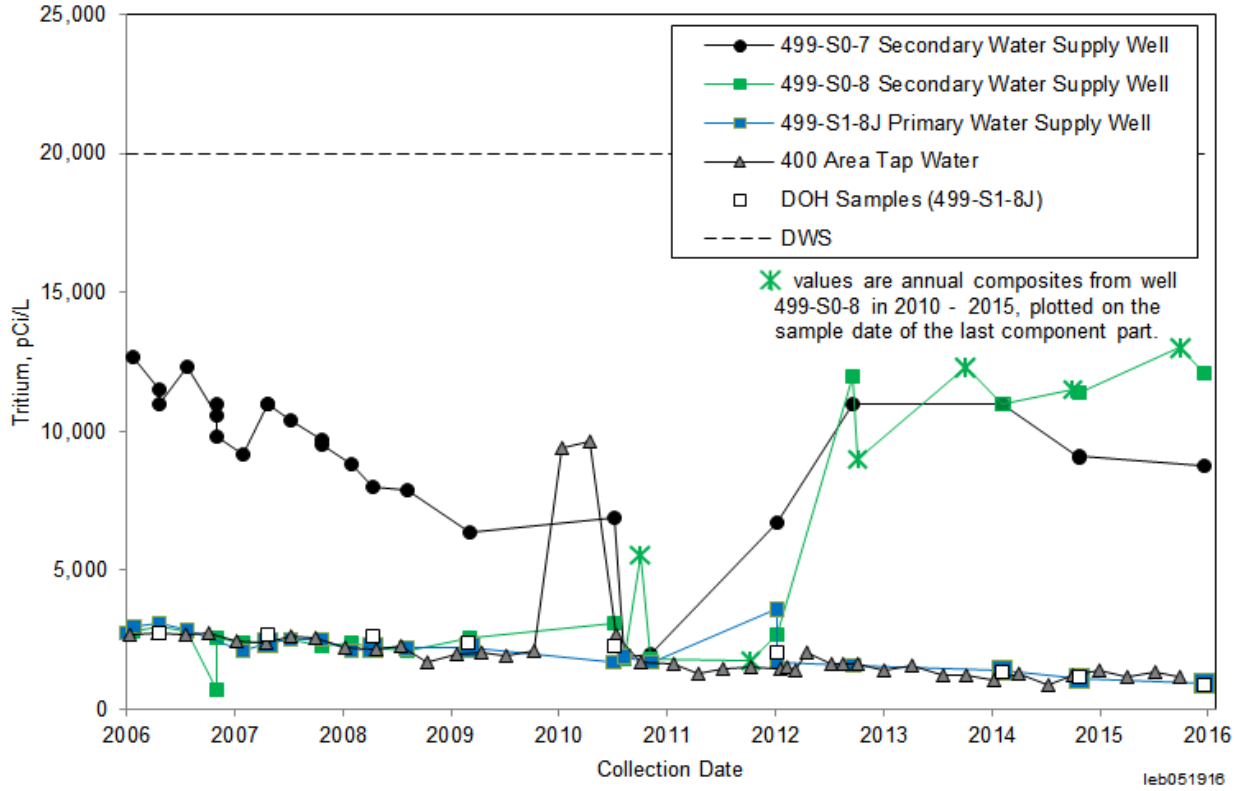

Figure 7.2. 400 Area Tritium Concentrations in Drinking Water
multiply pCi/L by 0.037 to convert to Bq/L

Table 7.3. Tritium Concentrations in Hanford Site 400 Area Drinking Water Wells*

Sampling Date	Primary Drinking Water Well 499-S1-8J (P-16; pCi/L)†	Backup Drinking Water Well 499-S0-8 (P-14; pCi/L)†	Backup Drinking Water Well 499-S0-7 (P-15; pCi/L)†
December 29, 2015	942 ± 170	12,100 ± 2,360	8,740 ± 410

*Reported concentration ±2 total propagated analytical error.
†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 off-site irrigation sources (Figure 7.3). Aquatic sediment monitoring was conducted for the Columbia River and one Hanford Site pond. Tables 7.4 and 7.5 summarize the sampling locations, types, frequencies, and sample analyses included in surface-water and sediment monitoring. This section describes the monitoring efforts and summarizes the results for these aquatic environments.

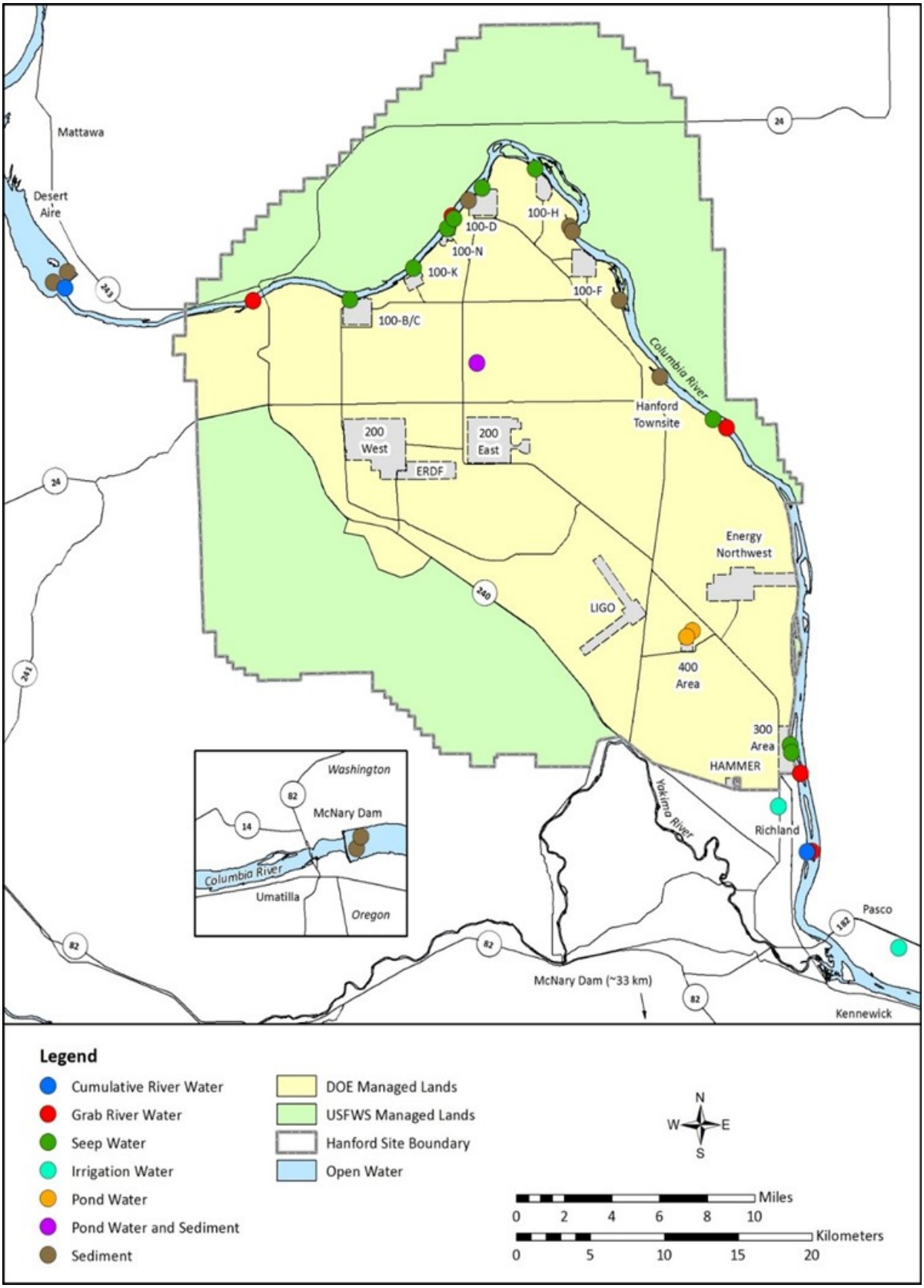

Figure 7.3. Surface-Water and Sediment Sampling Locations

Table 7.4. Surface Water Surveillance

Location	Sample Type	Frequency	Analyses
Columbia River – Radiological			
Priest Rapids Dam and Richland Pump House	Cumulative	M Comp*	Low tritium†, strontium-90, technetium-99, isotopic uranium‡
	Particulate (filter)	M Cont§	Gamma energy analyses, isotopic plutonium**
	Soluble (resin)	M Cont§	Gamma energy analyses, isotopic plutonium**
Vernita Bridge	Grab (transects)	Semi-annual	Gamma energy analyses, low tritium†, strontium-90, isotopic uranium‡, isotopic plutonium**, technicium-99
Richland	Grab (transects)	Semi-annual	Gamma energy analyses, low tritium†, strontium-90, isotopic uranium‡, isotopic plutonium**, technicium-99
100-N, 300 Areas and Hanford Townsite (HTS)	Grab (transects)	Annually	Gamma energy analyses, low tritium†, strontium-90, isotopic uranium‡
Columbia River – Inorganics and Organics			
Vernita Bridge	Grab (transects)	Annually	Anions, mercury, metals (filtered and unfiltered)
	Grab (transects)	Annually	Volatile organic compounds
Richland	Grab (transects)	Annually	Anions, mercury, metals (filtered and unfiltered)
	Grab (transects)	Annually	Volatile organic compounds
100-N, 300 Areas and Hanford Townsite (HTS)	Grab (transects)	Annually	Anions, metals (filtered and unfiltered)
On-site Ponds			
West Lake Seep	Grab	Annually	Tritium, isotopic uranium‡
West Lake Water	Grab	Annually	Tritium, isotopic uranium‡
Off-site Irrigation Water			
Riverview Irrigation Canal	Grab	3/year	Alpha, beta, low tritium†, strontium-90, gamma energy analyses
Horn Rapids	Grab	3/year	Alpha, beta, low tritium†, strontium-90, gamma energy analyses

Comp=composite, Cont=continuous, M=monthly
*M Comp indicates river water was collected at set intervals and composited monthly for analyses.
†Low tritium = Low-level tritium analysis (10-pCi/L detection limit).
‡Includes uranium-234, -235, and -238
§M Cont=River water was sampled for 2 weeks by continuous flow through a filter and resin column. Multiple samples were composited monthly for analyses.
**Includes plutonium-238 and plutonium-239/-240

Table 7.5. Columbia River Sediment

Location	Frequency	Analyses
McNary Dam (two nearby locations)	Annually	Anions, Cr+6, gamma energy analyses, isotopic uranium†, isotopic plutonium‡, metals, mercury, strontium-90, and total organic carbon
Hanford Reach§	Annually	Anions, Cr+6, gamma energy analyses, isotopic uranium†, isotopic plutonium‡, metals, mercury, strontium-90, and total organic carbon
Priest Rapids Dam (two nearby locations)	Annually	Anions, Cr+6, gamma energy analyses, isotopic uranium†, isotopic plutonium‡, metals, mercury, strontium-90, and total organic carbon
Contiguous Hanford Reach Islands (Locke and Savage)	Annually	Anions, Cr+6, gamma energy analyses, isotopic uranium†, isotopic plutonium‡, metals, mercury, and strontium-90

*Refer to Figure 7.3
†Uranium-234, -235, and -238
‡Plutonium-238 and plutonium-239/-240
§Hanford Reach consists of sediment collected in the 100D Spring 102-1 and 100K 63-1 Shoreline Seep areas and 100F, Hanford, and White Bluffs sloughs

The Columbia River is one of the largest rivers in the continental U.S. 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 of the Hanford Site. Water removed from the river immediately downstream of the Hanford Site also is used for irrigation in Benton and Franklin counties. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including boating, fishing, hunting, scuba diving, snorkeling, swimming, wakeboarding, and waterskiing.

Originating in the Rocky Mountains of eastern British Columbia, the Columbia River and its tributaries drain an area of approximately 260,000 m^2 (670,000 km^2) before discharging to the Pacific Ocean. Three dams in Canada and 11 dams in the United States regulate the flow of the river; four dams are downstream of the Hanford Site. Priest Rapids Dam is the nearest upstream dam, and McNary Dam is the nearest downstream dam in relation 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. The Hanford Reach is the last free-flowing stretch of the Columbia River. River flow through the Hanford Reach is controlled primarily by operations at upstream dams, which over the course of the year cause water levels to fluctuate significantly. Figure 7.4 shows the maximum, average, and minimum flow rates of the Columbia River at Priest Rapids Dam for 2015. The annual average flow of the Columbia River downstream of Priest Rapids Dam was approximately 111,669 ft^3 (3,162 m^3)/sec, slightly below the most recent 10-year average annual flow rate of 115,831 ft^3 (3,280 m^3)/sec (U.S. Geological Survey [USGS] 2013). The highest monthly average flow rate occurred during February (160,182 ft^3 [4,554 m^3]/sec; Figure 7.4). The lowest monthly average flow rate occurred during September (65,397 ft^3 [1,852 m^3]/sec) based on mean daily flows. Daily average flow rates varied from 38,000 to 188,321 ft^3 (1,076 to 5,333 m^3)/sec in 2015. 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 ft (3 m) 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 vary from approximately 980 to 3,300 ft (300 to 1,000 m) as it passes through the Hanford Site.

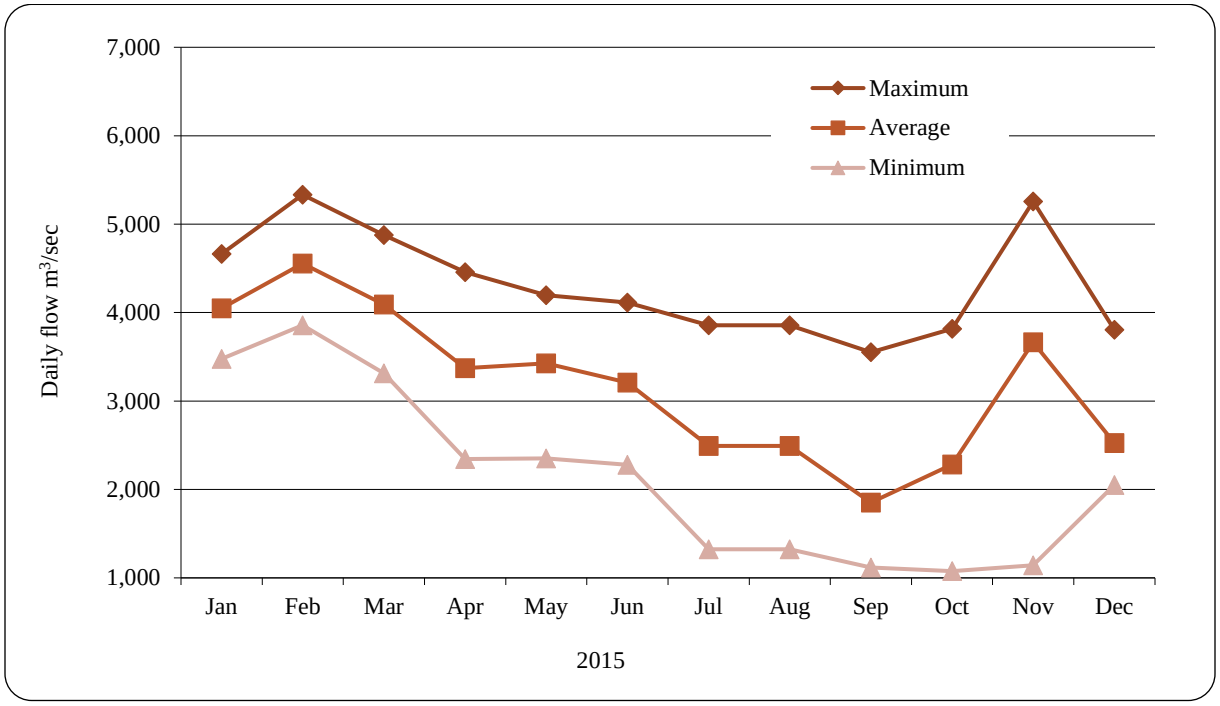

Figure 7.4. Columbia River Flow Rates at Priest Rapids Dam
multiply m^3/sec by 35.31 to obtain ft^3/sec

7.2.1 Monitoring

In 2015, Columbia River water samples were collected and analyzed for radionuclides from fixed-location monitoring stations at Priest Rapids Dam and at the City of Richland raw water intake facility. Cross-river transects near Vernita Bridge, 100-N Area, Hanford Townsite, 300 Area, and the City of Richland were analyzed for radionuclides, metals, and inorganic and organic compounds (Figure 7.3). Samples were collected upstream of 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. Irrigation water systems sampling is discussed in Section 7.6.

The fixed-location monitoring stations at Priest Rapids Dam and the City of Richland raw water intake facility 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 hr) and set incremental volumes (e.g., 55 mL). These bi-weekly samples were combined into monthly composite samples for radiological analyses (Table 7.4). The continuous flow system was used to collect particulate and soluble constituents in Columbia River water by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into monthly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in the latest revision of DOE/RL-91-50.

Radionuclides of interest were selected for analyses based on the following criteria:

- presence in historical effluent discharges from Hanford Site facilities or in groundwater underlying the Hanford Site near the Columbia River
- importance in determining water quality, and in determining compliance with applicable water quality standards
- importance in key pathway-specific exposure dose assumption calculations based on 95th percentile of drinking water ingestion rate of 3.1 L/day for 350 days/yr (EPA 2011, Table ES-1).

Constituents of interest in Columbia River water samples collected at Priest Rapids Dam and the City of Richland raw water intake facility included gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/-240. 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% 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% significance level.

National primary and secondary drinking water standards were used to compare detections at Vernita and Richland Pumphouse in 2015 (filtered metals), and observations determined concentrations were slightly exceeding some guidelines; however, similar concentrations were observed from both the upstream (Vernita) and downstream (Richland Pumphouse) locations. Drinking water is consumed, but it travels through the water treatment plant operated by the City of Richland before it is available for public use.

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 (PNL-8531, *Columbia River Monitoring: Distribution of Tritium in Columbia River Water at the Richland Pumphouse*). The 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 conservative bias in the data generated using the routine, single-point sampling system at the City of Richland drinking water intake. Transect sampling allows cross-river concentration profiles to be determined to provide information over a larger portion of the Hanford Site shoreline where the highest contaminant concentrations of concern would be expected.

In 2015, four to five evenly spaced cross-river transect samples were obtained. The Richland Pumphouse and Vernita Bridge transects are collected semi-annually (typically spring/summer). The 100-N Area, Hanford Townsite, and 300 Area locations were all sampled annually in 2015 during late summer when river flows were low, which provides the highest probability of detecting Hanford Site contaminants carried by groundwater to the Columbia River.

Columbia River transect water samples collected during 2015 were analyzed for radiological, inorganic, and organic contaminants (Table 7.4). 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 (recoverable) and filtered (dissolved) 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 raw water intake facility in 2015, and for the previous 5 years, are summarized in Appendix C, Table C.7. Individual radiological contaminant concentrations measured in Columbia River water during 2015 were less than 1/25 of the DOE-derived concentrations (Appendix D). The DOE-derived concentrations are based on a 100 mrem (1 mSv) per year standard; dividing by 25 allows for more direct comparison to the 4 mrem (0.04 mSv) per year drinking water standards 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 2015. 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 minimum detectable values. All other radionuclides were typically less than the minimum detectable concentrations.

The 2015 annual average tritium concentrations measured upstream and downstream of the Hanford Site were similar to concentrations measured in recent years (Figure 7.5). Statistical analyses indicated that monthly tritium concentrations in river water samples at the City of Richland raw water intake facility were slightly higher than concentrations in samples from Priest Rapids Dam. Average tritium concentrations in Columbia River water collected at the City of Richland were 0.15% of the Washington State ambient surface-water quality criterion of 20,000 Ci/L (740 Bq/L).

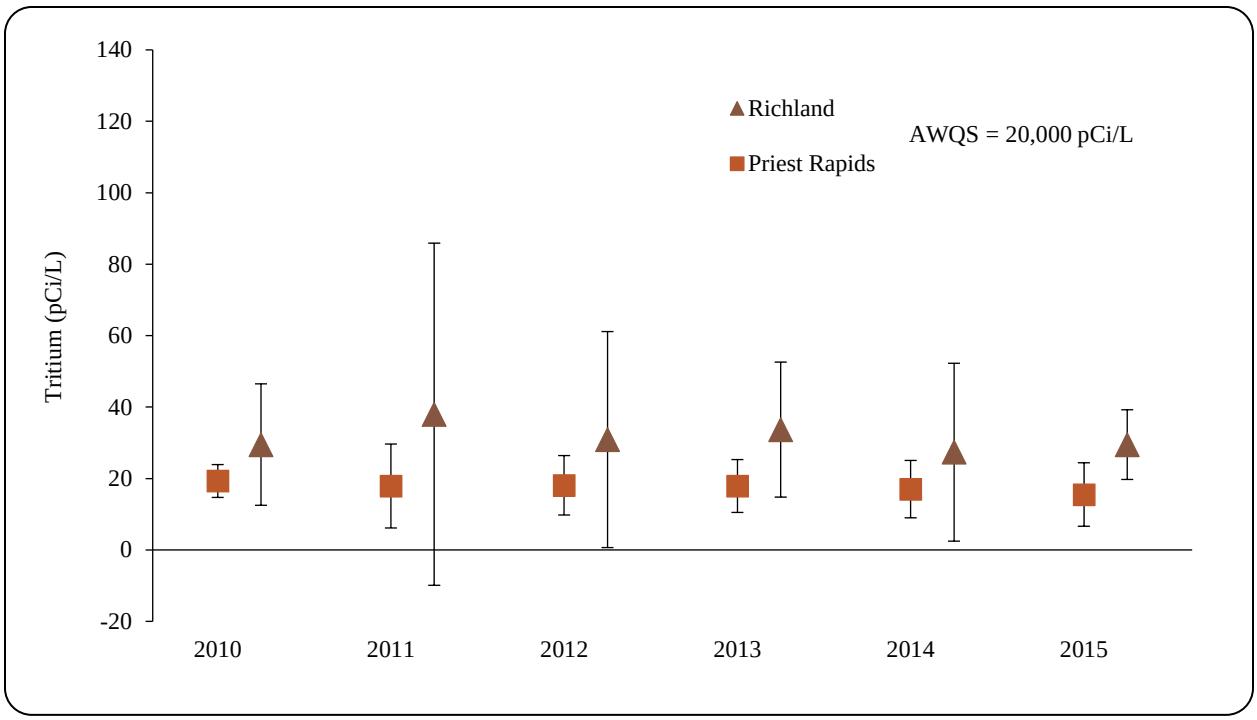

Figure 7.5. Tritium Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site

±X standard deviations, AWQS=ambient water quality standard; Washington State AWQS for tritium is 20,000 pCi/L (740 Bq/L)

The Hanford Site source of tritium entering the river is from groundwater upwelling 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 historical 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 shoreline extending from the Hanford Townsite downstream to the 300 Area. The plume is not completely mixed within the Columbia River because of the close proximity to the City of Richland's water intake structure. Sampling along cross-river transects at the City of Richland during 2015 confirmed the existence of a concentration gradient in the river under certain flow conditions discussed in this section. The extent to which samples taken at the City of Richland drinking water intake overestimate the average tritium concentrations in the Columbia River at this location is variable and appears to be related to the flow rate of the river just before and during sample collection.

Average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2015 were similar to those reported in previous years (Figure 7.6). 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 below minimum detection limits (0.06 pCi/L), low levels were still statistically compared to show differences. Priest Rapids Dam had a maximum concentration of 0.033 pCi/L (0.0012 Bq/L), and the City of Richland intake had a maximum concentration of 0.034 pCi/L (0.0013 Bq/L). Average strontium-90 concentrations in Columbia River water at the City of Richland were less than 0.4% of the Washington State ambient surface-water quality criterion (8 pCi/L [0.30 Bq/L]) while those at Priest Rapids measured 0% due to negative strontium-90 concentrations.

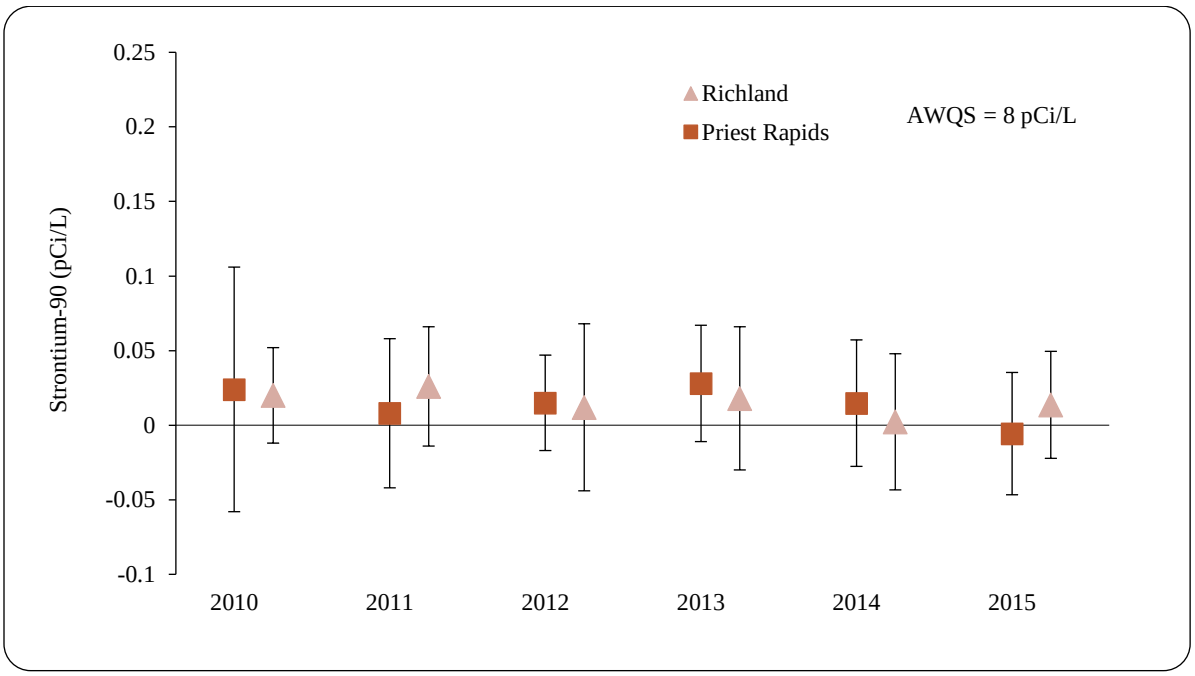

Figure 7.6. Strontium-90 Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site

±2 standard deviations, AWQS = ambient water quality standard

Annual average uranium-234 and uranium-238 concentrations measured in water samples collected upstream and downstream of the Hanford Site in 2015 were similar to those observed during recent years (Figure 7.7). Average monthly uranium concentrations measured at Priest Rapids Dam (0.47 pCi/L total uranium) in 2015 were slightly lower than those averages measured at the City of Richland (0.52 pCi/L total uranium). Uranium is present in the groundwater beneath the 300 Area as a result of past Hanford Site operations, and it has previously been detected at elevated levels in shoreline springs at the 300 Area (Section 7.4; PNNL-13692 and PNNL-16805). There is no Washington State ambient surface-water quality criterion directly applicable to uranium; however, total uranium levels in the river during 2015 were well below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]; Appendix D).

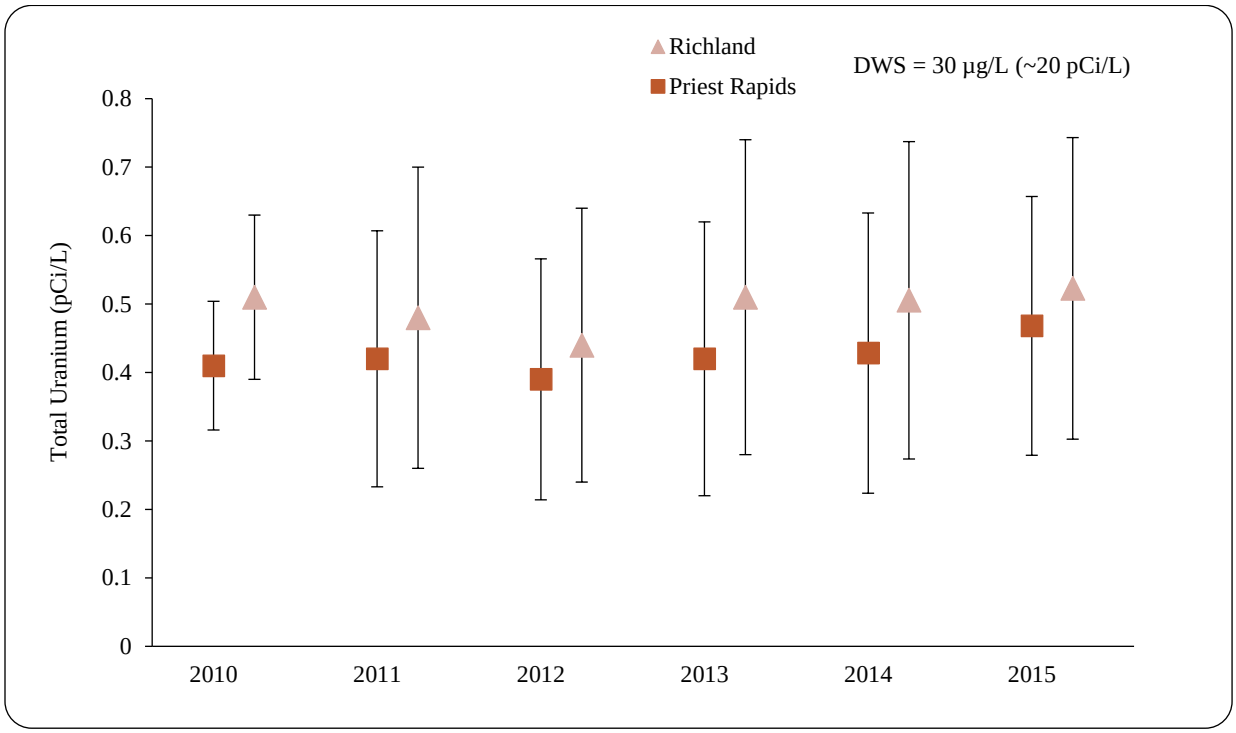

Figure 7.7. Uranium Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
(±2 standard deviations; DWS = drinking water standard)

Plutonium-238 and plutonium-239/-240 concentrations for river water samples at the City of Richland in 2015 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 required minimum detectable concentrations. However, the Priest Rapids Dam data did have a single plutonium-238 detection of 0.0005 pCi/L (0.000019 Bq/L) and a single plutonium-239/-240 detection of 0.0002 pCi/L (0.0000074 Bq/L).

Columbia River Transect Samples. Radiological results from samples collected along Columbia River transects near Vernita Bridge, 100-N Area, Hanford Townsite, 300 Area, and the City of Richland are presented in Appendix C, Table C.8. Sampling locations were documented using a hand-held or vessel-mounted GPS. Station1 at each transect is located along the Benton County shoreline, while the highest

station number for each transect is along the Grant-Franklin County shoreline. Radionuclides consistently measured at concentrations greater than minimum detectable activity included tritium, uranium-234, and uranium-238. Uranium-235 was detected occasionally, and most levels were near minimum detectable concentrations. All measured concentrations of these radionuclides were less than applicable Washington State ambient surface-water quality criteria and EPA drinking water standards.

Tritium concentrations measured along Columbia River transects at Vernita Bridge, 100-N Area, Hanford Townsite, 300 Area, and the City of Richland during 2015 are depicted in Figure 7.8. The Vernita Bridge transect is the most upstream location. The 100-N Area, Hanford Townsite, 300 Area, and 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. However, 2015 was somewhat of an anomaly, as the transect results had a maximum of 24.9 ± 6.67 pCi/L (0.92 ± 0.25 Bq/L) and the fixed monitoring station had a maximum result of 37.1 ± 14.1 pCi/L (1.37 ± 0.52 Bq/L). The highest tritium concentration measured in cross-river transect water was 79.5 ± 12.3 pCi/L (2.94 ± 0.46 Bq/L) at the Hanford Townsite.

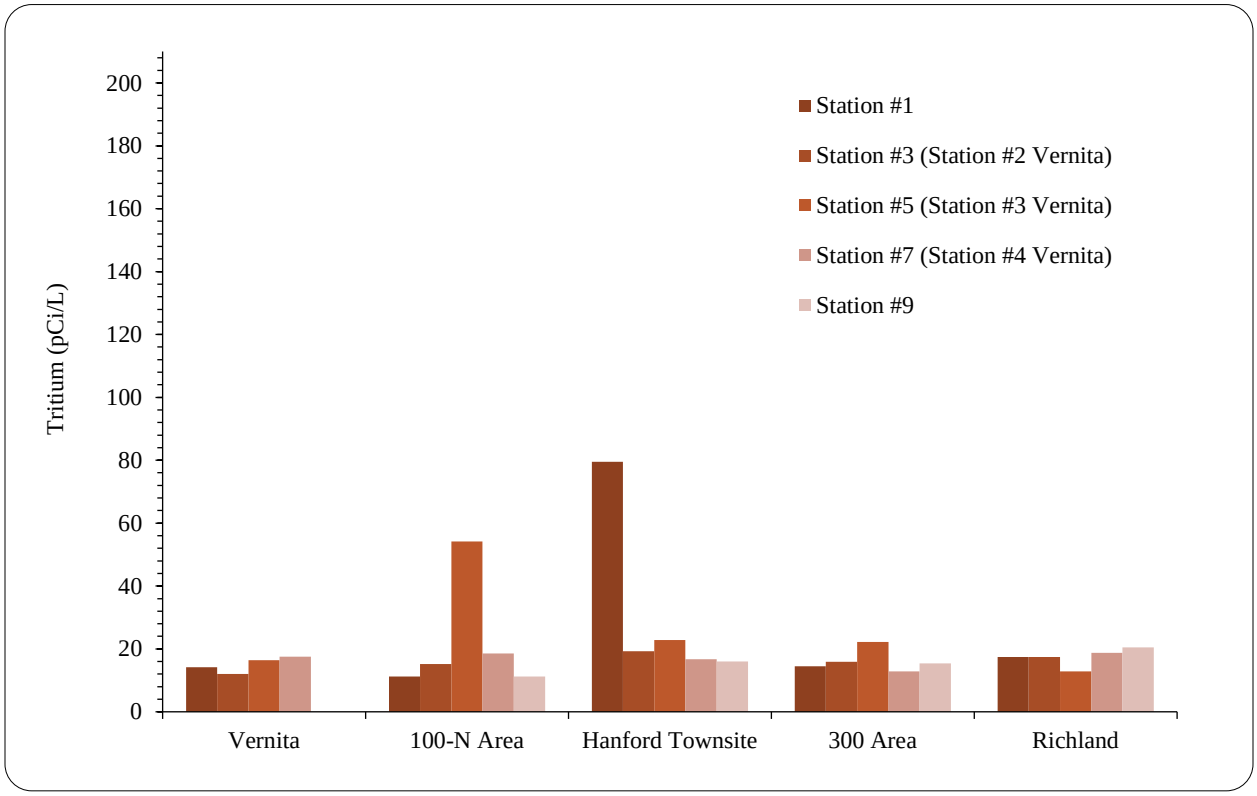

Figure 7.8. Tritium Concentrations in Cross-River Transect Water Samples (Hanford Reach, Columbia River)

Strontium-90 concentrations in Hanford Reach river water for transect samples collected in 2015 were similar to upstream reference concentrations for most locations. The maximum strontium-90 concentration was 0.045 ± 0.036 pCi/L (0.0017 ± 0.0013 Bq/L) from a sample collected along the Vernita Bridge transect. The average strontium-90 concentrations found during sampling at the City of Richland transect were less than those measured in monthly composite samples at the Richland Pumphouse and at Priest Rapids Dam.

Uranium concentrations in all transect samples collected during 2015 were below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]). The uranium-234 concentration was highest in the water sample collected near the Franklin County shoreline (300 Area–9 HRM 43.1), which measured 0.45 µg/L (0.30 pCi/L). The maximum uranium-238 concentration was reported along the City of Richland shoreline (Richland Pumphouse-1 HRM 46.4), which measured 0.36 µg/L (0.24 pCi/L).

Uranium isotopes measured in the 300 Area riverbank seep water samples were higher than those reported at the 300 Area-9 HRM 43.1 and other transect location 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.

Average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2015 were similar to those reported in previous years (Figure 7.6). Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Area. Some of the highest strontium-90 levels 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 below minimum detection limits (0.06 pCi/L), low levels were still statistically compared to show differences. Priest Rapids Dam had a maximum concentration of 0.033 pCi/L (0.0012 Bq/L) and the City of Richland intake had a maximum concentration of 0.034 pCi/L (0.0013 Bq/L), respectively. Average strontium-90 concentrations in Columbia River water at the City of Richland and Priest Rapids were less than the Washington State ambient surface-water quality criterion (8 pCi/L [0.30 Bq/L]).

7.2.3 Inorganic and Organic Chemical Results

Inorganic and organic water quality data were compiled in 2015 for the Columbia River. A number of the parameters measured have no regulatory limits but are useful 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.

Metal and anion concentrations observed in river water were similar to those previously observed and remain below regulatory limits. Metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Aluminum, copper, magnesium, sodium, uranium, and zinc were detected in most 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.9).

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 66 mg/L as calcium carbonate, the lowest value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge (USGS 2007) 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 and sulfate were slightly elevated near the 300 Area compared to other transect locations (Figure 7.9). 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 *Nitrate Concentrations in Ground Water of the Central Columbia Plateau* (USGS 1995) and is associated with high fertilizer and water usage in agricultural areas. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141; *Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992-95* [USGS 1998]). Average annual concentrations of chloride were similar at the City of Richland transect when compared with Vernita Bridge transect results. The highest concentrations of nitrates were measured at the Richland Pumphouse-9 HRM 46.4 transect; however, the 100-N, 300 Area, Hanford Townsite, and Vernita Bridge transects also had detections of nitrate in 2015. Additional anion analysis of fluoride in Columbia River transect collections resulted in reportable concentrations (>33 µg/L) of fluoride in all samples; however, these results were less than required detection limits (500 µg/L) per DOE guidelines. When compared to concentrations since 2010, the overall average has dropped from 109 µg/L to 77 µg/L in 2015 transect samples.

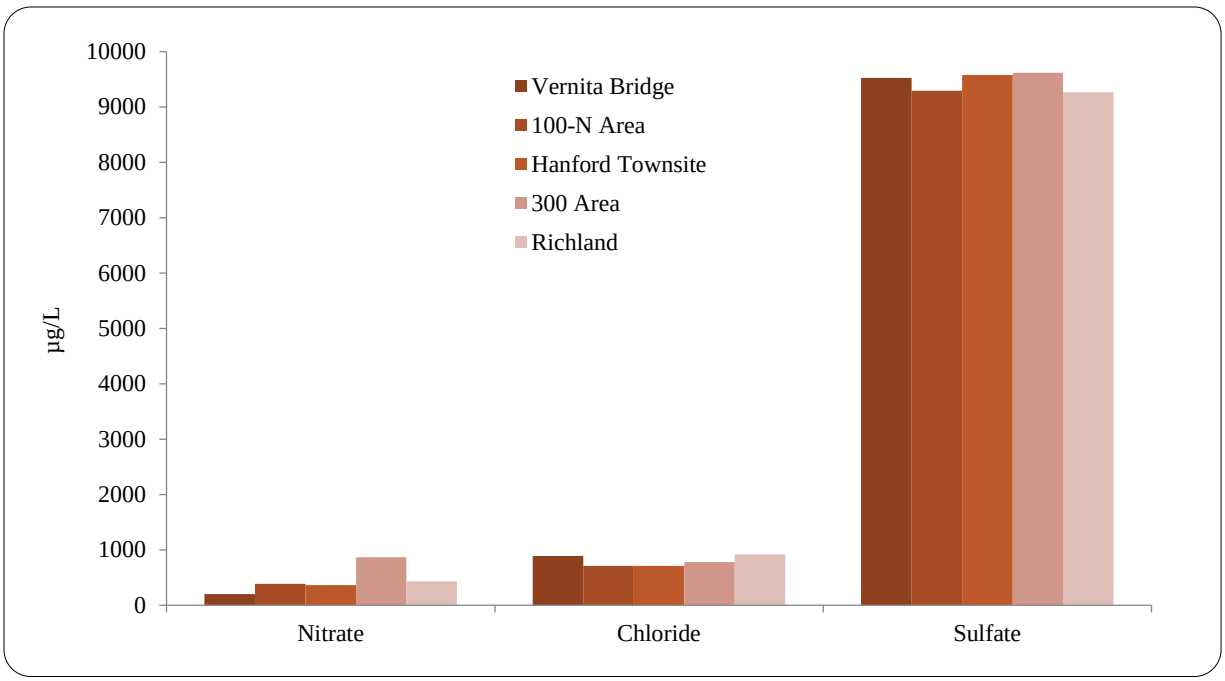

Figure 7.9. Selected Anion Concentrations in Columbia River Transect Samples

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 2014 had chromium concentrations below the minimum detectable concentration.

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 reservoirs behind the dams located downstream of the Hanford Site. The majority of short-lived radioactive constituents have decayed, but some longer-lived radionuclides such as isotopes of cesium, plutonium, strontium, and uranium are still detectable. Fluctuations in the river flow from upriver hydroelectric dam operations, 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 worldwide 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* and 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 sediment or re-suspension into drinking water supplies. Sediment with accumulated radioactive materials can be an external radiation source, irradiating people fishing, wading, swimming, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T). Sediment contaminant concentrations are also used to model potential pathway exposures to riparian (e.g., raccoon, coyote) and aquatic receptors (e.g., fish, benthic organisms) and to establish DOE guidelines for organisms within the Hanford Reach.

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, 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 at depths of 0 to 6.3 in. (0 to 16 cm) from 10 river locations that were predominantly submerged (some Hanford Reach sampling locations may not be submerged during an extremely low-river stage). Sampling locations were documented using a vessel or handheld GPS. 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 in. (0.723 cm)/yr for Priest Rapids Dam and 0.89 in. (2.25 cm)/yr for McNary Dam (*An Investigation of the Origin of ^{152Eu} in Columbia River Sediments* [Gibbons 2000]). Assuming a maximum sediment sampling depth of 6.3 in. (16 cm) with the Ponar dredge, 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 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 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 may also contribute to the contaminant load found in McNary Dam sediment. Sediment samples were also 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 100-D Spring (seep) 102-1 and an additional from 100-F Slough. The White Bluffs Slough monitoring site consisted of two sampling locations in previous years; however, only one sampling location was sampled successfully in 2015 due to rock and aquatic vegetation inclusions in the collection process during both the 2013 and 2014 attempts. One sample was collected at a location in Hanford Slough and two additional samples from locations adjacent to the islands.

7.3.2 Radiological Results

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. No federal or state freshwater sediment criteria are available to assess the sediment quality of the Columbia River. Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during 2015 included 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 required 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. Uranium isotopes occur naturally in the environment and have been present in past releases of Hanford Site effluent. Analytical results for 2015 showed similar concentrations of cesium-137 at Priest Rapids and McNary dams sediment collection locations. These concentrations were slightly elevated when compared to Hanford Reach sediment collection location results (Figure 7.10). Plutonium-239/-240 sediment results mirrored cesium-137 data as Priest Rapids and McNary dam locations had higher concentrations reported than sediment results along the Hanford Reach (Figure 7.11). Note that for both Figures 7.10 and 7.11, the upper and lower bars represent maximum and minimum values, which may be similar to the average and may not be visible.

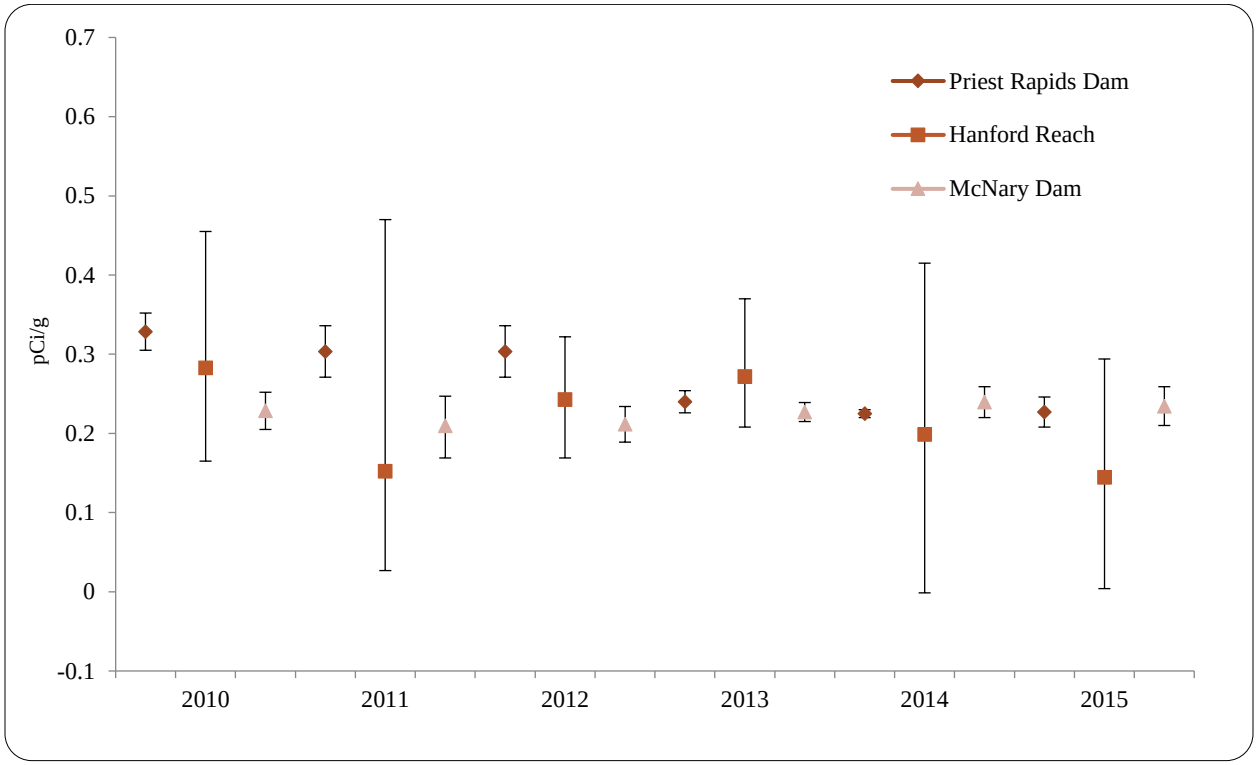


Figure 7.10. Cesium-137 Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

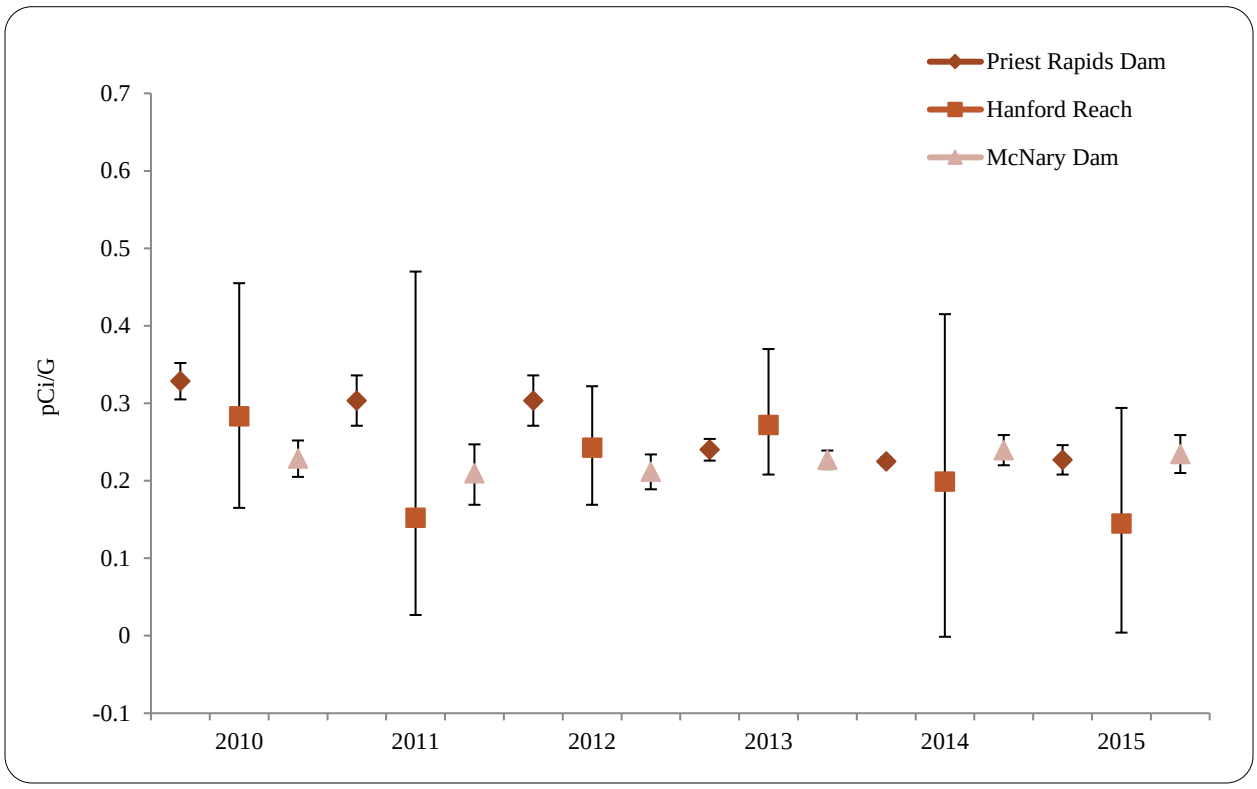


Figure 7.11. Plutonium-239/-240 Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

Uranium-234 concentrations were slightly elevated in the Hanford Reach sediment location adjacent to Locke Island when compared to other sediment collected from the Hanford Reach, McNary Dam, and Priest Rapids Dam samples in 2015. Other radionuclide concentrations in river sediment were similar to those reported for previous years, and there were no obvious differences between locations.

Priest Rapids and McNary dams sediment also had elevated total uranium results compared to Hanford Reach locations in 2015. Hanford Reach averaged 1.7 pCi/g, while Priest Rapids and McNary dams concentrations averaged 2.5 pCi/g and 2.6 pCi/g, respectively (Figure 7.12; note that upper and lower bars represent maximum and minimum values, which may be similar to the average and may not be visible).

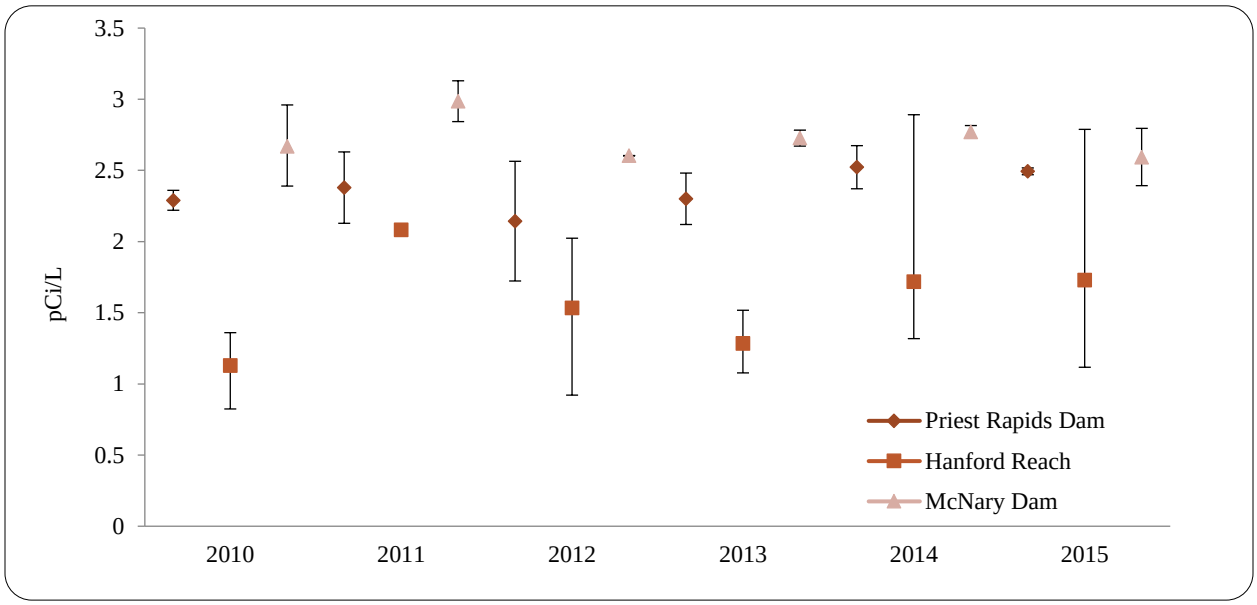
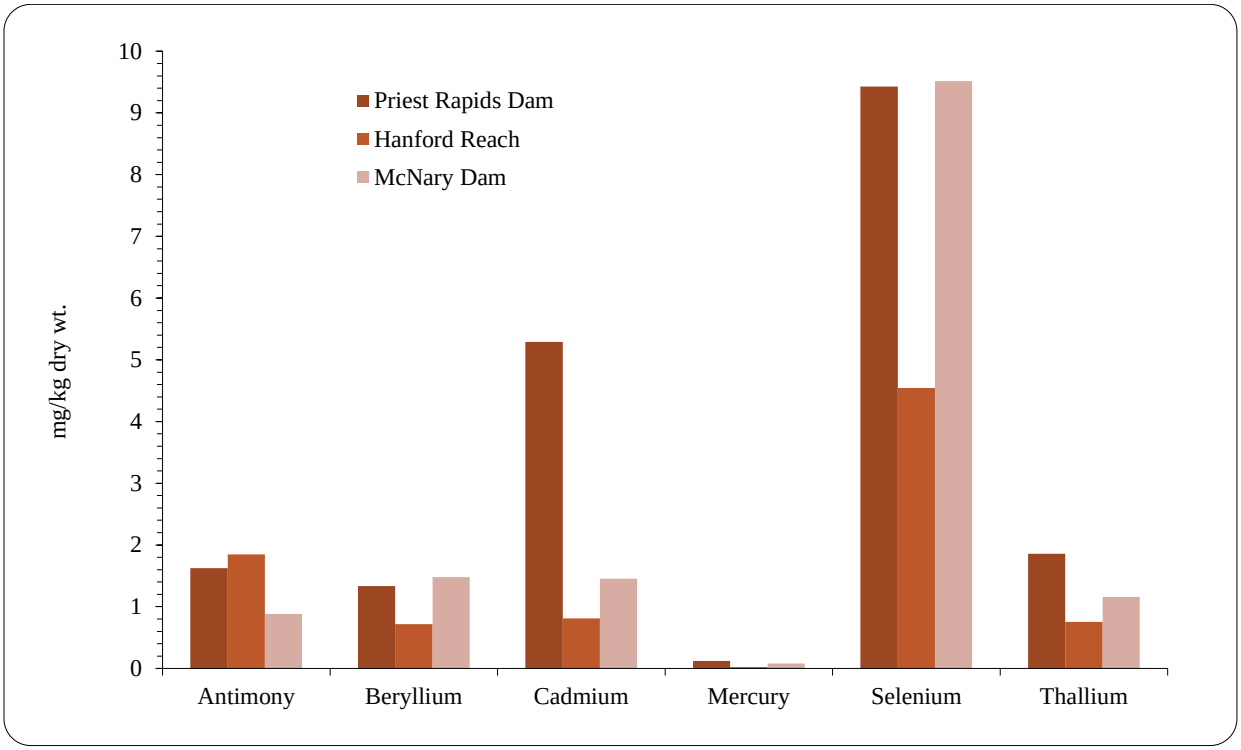


Figure 7.12. Uranium Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

The values for cesium-137 in the White Bluffs Slough location of the Hanford Reach were slightly elevated compared to other Hanford Reach sample locations, Priest Rapids and McNary dams and all other sediment collection locations. 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 (2010 to 2015) are presented in Figures 7.10, 7.11, and 7.12.

7.3.3 Chemical Results

Detectable amounts of most metals were found in all river sediment samples (Figure 7.13; note that upper and lower bars represent maximum and minimum values, which may be similar to the average and may not be visible). Maximum and average concentrations of cadmium, chromium, copper, lead, mercury, nickel, thallium, and zinc were higher for sediment collected in the reservoir upstream of Priest Rapids Dam than in sediment from either the Hanford Reach or McNary Dam. Lead concentrations were detected at higher rates in White Bluffs sediment in comparison to all other sediment collection locations. Variations in stream hydraulics and associated sediment depositional zones for differing locations were likely attributable to increased concentrations in areas such as White Bluffs. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.



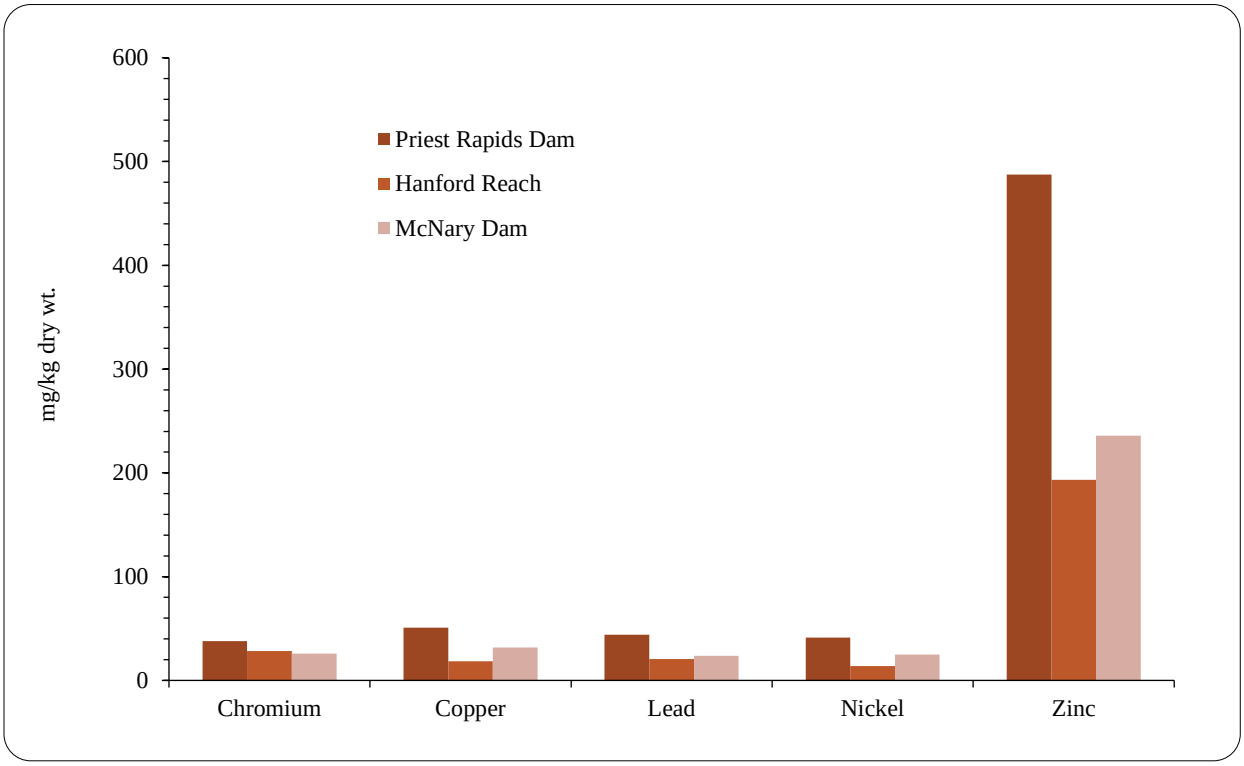


Figure 7.13. Selected Metals Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (WA and OR)

7.4 Columbia River Seep Water

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In 2015, 12 of 15 targeted samples of Columbia River seep water and two associated shoreline sediment samples 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 Table 7.6 and Appendix C.

Table 7.6. Columbia River Seep Monitoring

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

*Refer to Figure 7.3; Locations may contain multiple shoreline seeps with differing analyses.
†Uranium-234, uranium-235, and uranium-238 analyzed by alpha spectrometry (alpha energy analysis)
‡VOA=Volatile organic analyses

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). 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; PNL-5289; PNL-7500; WHC-SD-EN-TI-006). 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 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; PNNL-14444; PNNL-16805; PNNL-16894; SGW-41497).

During the early 1980s, researchers walked a 41-mi (66-km) 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 near 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. A consequence of the end of 100-N Reactor operations and other ongoing site remediation, declining water table elevations have reduced discharges from the seeps in and around the 100-N Area. 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 microsiemens (µS)/cm.

The effect of bank storage on groundwater discharges and contaminant concentration variations in aquifer thickness, porosity, and plume concentrations make it difficult to estimate accurately 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); and results of near-shore studies in 1997 (PNNL-11933) 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 seep monitoring efforts following the process and findings described in WCH-380. These guidelines help precision and accuracy of the 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 dose calculations and contaminant trends (DOE/RL-91-50). Table 7.6 summarizes the sampling locations and frequencies as well as sample types and analyses included in Columbia River seep monitoring during 2015. This section describes the monitoring efforts and summarizes 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, contaminant plume locations and movements throughout the Hanford site, 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 7.6).

7.4.2.1 Radiological Results

Contaminants of Hanford Site origin continued to be detected in 2015 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 decreased (maximum concentration measured 341 pCi/L) in comparison to those previously measured. In fall 2014, carbon-14 results exceeded DOE biota concentrations with approximately 2,200 pCi/L (609 pCi/L established RESRAD riparian guideline). As a result, conditions were monitored throughout CY 2015. Seep collections and surface water collections were collected quarterly as a result, and carbon-14 levels have shown an exponential decrease since fall 2014. A shoreline sediment sample was also collected in the 100-K area in 2015 as a result of those concentrations seen in fall 2014.

Gross alpha results for the 300 Area DR 42-2 riverbank seep had two detections (48 pCi/L ± 7.2 pCi/L and 37 pCi/L ± 6.4 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 detections occurred in 100-K, 100-D, 100-N, Hanford Spring 28-2, and 300 Area seeps during 2015. Detectable concentrations in riverbank seep water at those locations were elevated compared to maximum gross beta concentrations in irrigation water collected from the Horn Rapids Battelle Sporting Complex and Riverview collection locations. The highest gross beta concentration was measured in the 300 Area DR 42-2 riverbank seep (30 ± 4.3 pCi/L [1.1 ± 0.16 Bq/L]), which was 60% of the Washington State ambient surface water quality criterion of 50 pCi/L (1.85 Bq/L; WAC 173-201A and 40 CFR 141).

Tritium concentrations varied widely with location. The highest tritium concentration measured in riverbank seeps was at the 100-N Spring 8-13 location (5,840 ± 1,160 pCi/L [216 ± 43 Bq/L]), which was less than the Washington State ambient surface water quality criterion of 20,000 pCi/L (740 Bq/L) (WAC 173-201A; 40 CFR 141). No 2015 tritium results exceeded DOE-derived standards for riparian life (265,000,000 pCi/L). Tritium concentrations in riverbank seep water samples were higher when compared to maximum concentrations in 2015 Columbia River fixed-station locations at Priest Rapids Dam and the City of Richland and Columbia River transect station locations. Overall, results in 2015 were comparable to the previous 5 years of concentrations reported in riverbank seeps.

All water samples from riverbank seeps were analyzed for strontium-90, the highest concentration of which was detected in shoreline spring water was in the 100-N Area (17 ± 3 pCi/L [0.63 ±0.11 Bq/L]), approximately 1% of the DOE-Derived Concentration Guide (DOE O 458.1) of 1,000 pCi/L (37 Bq/L). Historically, groundwater in the 100-N Area has had the highest strontium-90 levels measured at Hanford. The 2015 seep water result at 100-N was slightly higher than the 2014 reported concentration and was within the typical range for this area.

A water sample from a riverbank seep in the Hanford Townsite area was collected in 2015 and submitted to a laboratory for iodine-129 analysis using an ultra-trace method. The water sampled during 2015 from the Hanford Townsite riverbank seep was a non-detect for iodine-129. The Washington State surface water quality criterion for I-129 is 1 pCi/L (0.037 Bq/L; Appendix D), and the DOE-biota concentration guide standards for aquatic and riparian life are 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. This location is down gradient from the retired 300 Area process trenches. The uranium concentrations in this seep water sample were slightly higher (30 pCi/L ± 5.1 pCi/L uranium-234) than the EPA DWS limit of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]). Maximum and average concentrations of uranium-234, uranium-235, and uranium-238 were slightly lower in 2015 than they were during 2010 to 2014. Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area near former uranium fuel fabrication facilities and inactive waste sites.

7.4.2.2 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.

Appendix C, Table C.14 presents concentration ranges of selected metals and anions measured in riverbank seep water during 2010 through 2015. For most locations, the 2015 sample results were similar to those previously reported (PNNL-19455). Nitrate concentrations for 2015 were highest in seep water samples from the 100-F Area. Dissolved chromium concentrations in riverbank seeps for 2015 were also highest in the 100-F Area. Hanford Site groundwater monitoring results associated with aquifer tube collections in 2015 indicated concentrations at shoreline areas near 100-N area seeps were greatest for the following contaminants: gross beta, nitrates, strontium-90, and tritium while the 300 Area had the highest uranium results (see Section 8).

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 66-mg/L calcium carbonate for 2006 and 2007 USGS-collected water samples near the Vernita Bridge were used. Concentrations of most metals measured in water collected from seeps along the Hanford Site shoreline during 2010 through 2015 were below the Washington State ambient surface water chronic toxicity levels (WAC 173-201A). However, for 2010 through 2015, 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 acute toxicity levels (WAC 173-201A). In 2015, concentrations from the 100-B and 100-F areas were the only samples collected having results above the Washington State ambient surface water chronic toxicity levels. All other dissolved chromium results for 2015 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. A sample collected in the 100-N area (9.7 µg/L or 0.0097 mg/L) was just under the EPA limit of 0.01 mg/L for the protection of human health for the consumption of water and organisms. This EPA value 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 drinking water standard 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 300 Area (DOE/RL-92-12; WHC-EP-0609; WHC-SD-EN-TI-125; WHC-SD-EN-TI-198). 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 the 100-H Area was added in 2004. However, Hanford Site releases in these areas are best monitored using seep water samples as compared to sediment samples. As such, only two sediment samples were collected from riverbank seep locations in the 100-D and 100-K areas (100-D Spring 102-1 and 100-K 63-1) in 2015 (Table 7.7).

Table 7.7. Columbia River Sediment Monitoring

Location*	Frequency	Analyses
100-D Area	Annually	Anions, Cr+6, gamma energy analysis, isotopic uranium†, isotopic plutonium‡, metals, mercury, strontium-90, and total organic carbon
100-K Area	Annually	Anions, carbon-14, Cr+6, gamma energy analysis, isotopic uranium†, isotopic plutonium‡, metals, mercury, strontium-90, and total organic carbon

*Refer to Figure 7.8
†Uranium-234, uranium-235, and uranium-238 analyzed by alpha spectrometry (alpha energy analysis)
‡Plutonium-289 and plutonium-239/-240

7.4.3.1 Radiological Results

Results for the 2015 shoreline seep sediment samples were similar to those observed in Columbia River sediment. Cesium-137 and uranium isotopes were the only radionuclides reported above the minimum detectable concentrations. Table C.10 in Appendix C compares radionuclide and total organic carbon concentrations in Columbia River sediment near the Hanford Site collected from 2010 through 2015.

7.4.3.2 Metals Results

Concentrations of metals in shoreline seep sediment samples collected in 2015 were similar to concentrations in Columbia River sediment samples with the exception of chromium. Concentrations reported in 2015 for shoreline sediment collected from 100-D Spring 102-1 had levels that were more than twice as much as the next highest recorded concentration measured in Columbia River sediment samples. Appendix C, Table C.11 compares metal concentrations in sediment samples collected in 2015. 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 more than twice as much as the maximum 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). All hexavalent chromium concentrations are listed in Appendix C, Table C.14.

7.5 Pond Water and Sediment

ME Hoefer

West Lake Pond (Figure 7.3) was sampled quarterly during 2015; however, FFTF trends showed continual decreases in potential contaminants. The area had not received radioactive discharges for some time, so sampling was discontinued (Figure 7.14); only West Lake was sampled in 2015. West Lake is accessible to migratory waterfowl, deer, and other wildlife, creating a potential biological pathway for the dispersion of contaminants. The FFTF Pond is a retired disposal site that collected process water, primarily cooling water drawn from 400 Area groundwater wells. The only naturally occurring pond on the Hanford Site, West Lake is located north of the 200-East Area (ARH-CD-775). West Lake has not received direct effluent discharges from Hanford Site facilities, but it is influenced by precipitation and changing water table elevations. 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 West Lake Pond Water

Grab samples were collected quarterly from West Lake in 2015. All water samples collected from the West Lake were analyzed for tritium and uranium.

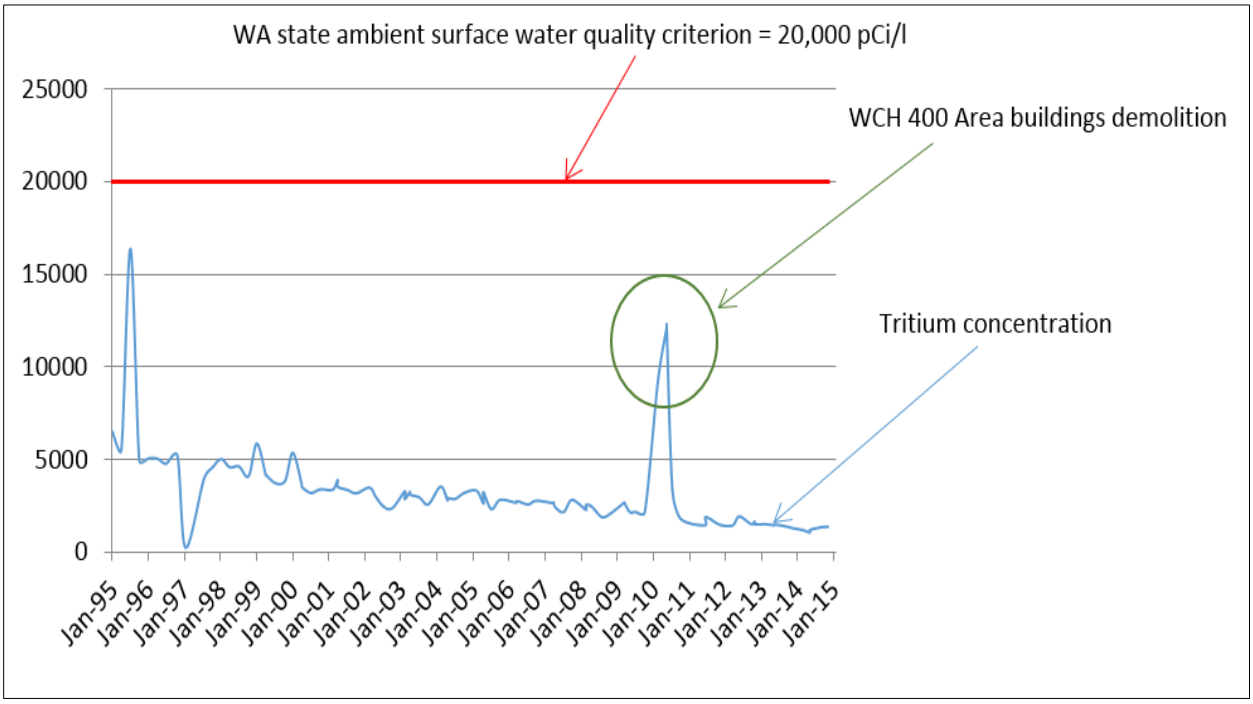

Figure 7.14. Fast Flux Test Facility Pond Water Tritium Concentration

7.5.2 West Lake Water

Water monitoring continued at West Lake in 2015 with sampling conducted quarterly as 2014 results showed uranium results that exceeded the established riparian concentration levels. The groundwater table in the 200-East Area dropped in recent years (Section 8.0), 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 year 2000 study (PNNL-13487) indicated that uranium was present in a soluble form in West Lake water; as a result, analyses of West Lake water for uranium-234, uranium-235, and uranium-238 were resumed in 2011.

During the first quarter of 2015, 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 results were above applicable DOE-derived concentration standards (DOE O 458.1).

A grab sample of surface water was attempted for analysis during the second quarter of 2015 when the lake was almost dry. A third quarter collection was attempted in late summer, but the lake was dry. West Lake surface water was collected again in the fourth quarter to monitor uranium levels more closely.

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 2015 were below the laboratory required detection limit. Figure 7.15 shows annual average concentrations of uranium-234 in West Lake surface water and West Lake seep water from 2013 to 2015. Radionuclide concentrations in the West Lake seep and surface water samples collected during 2015 and in the previous 2 years are shown in Appendix C (Tables C.2 and C.3).

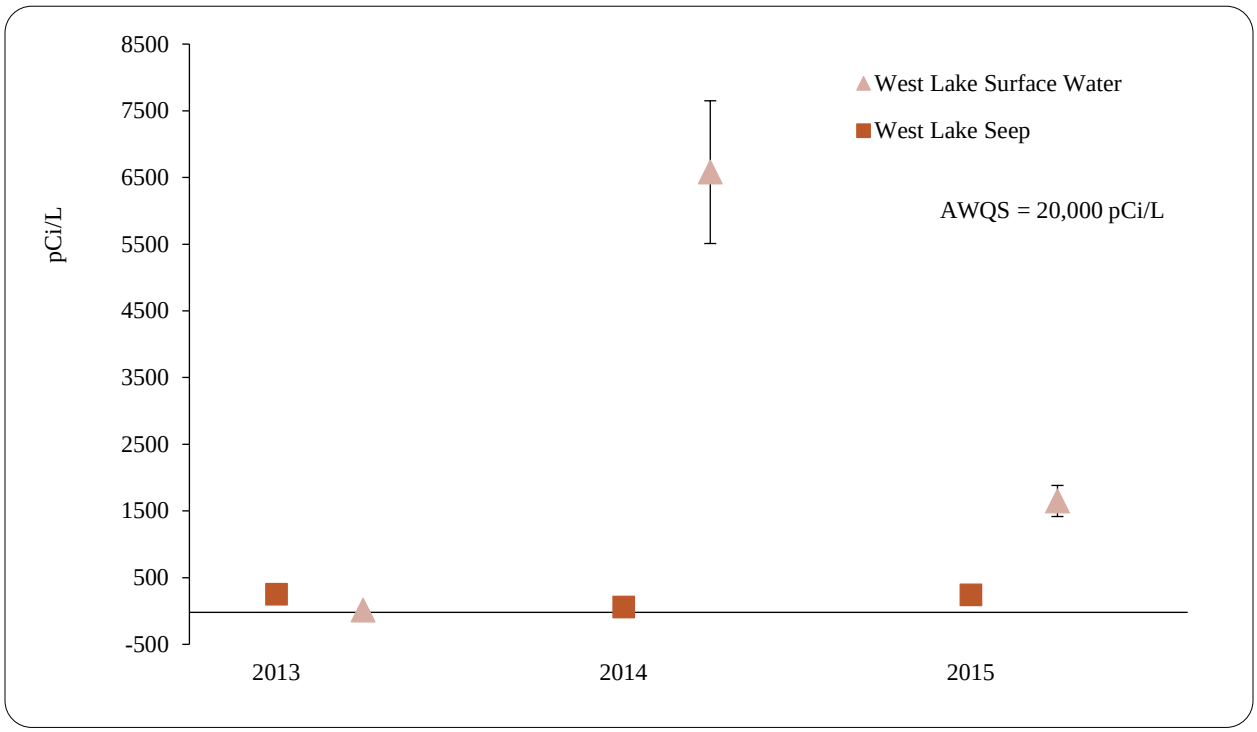

Figure 7.15. Uranium in West Lake Water Samples

7.5.3 West Lake Sediment

One sediment sample was collected from West Lake during the second quarter of 2015. The sediment sample was collected from upper-layer material near the pond shoreline.

The West Lake sediment sample was analyzed for gross alpha, gross beta, strontium-90, technetium-99, 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. Detections of all radionuclides during 2015 were similar to previous concentrations.

Uranium concentrations are most likely from naturally occurring uranium in the surrounding soil (BNWL-1979). Radionuclide levels from samples collected during 2015 and a summary of those collected during the previous 5 years are shown in Appendix C, Table C.1.

7.6 Off-site Irrigation Water

ME Hoefer

As a result of public concern about the potential for Hanford Site-associated contaminants in off-site water, sampling was conducted in 2015 to document the levels of radionuclides in water used by the public. The consumption of food products 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).

Off-site Irrigation Water Monitoring. Water samples were collected in 2015 from an irrigation canal located east of the Columbia River and 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 2015 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 2015 were at similar levels detected in Columbia River transect water samples collected upstream of the Hanford Site. At the Horn Rapids irrigation pumping station, the tritium results were slightly higher than water collected from the Riverview irrigation system. Strontium-90 was not detected, and results were similar to concentrations measured in historic Horn Rapids and Riverview irrigation samples. All radionuclide results were within the historical range and were less than their respective DOE-derived concentration standards and Washington state ambient surface-water quality criteria (DOE O 458.1; WAC 173-201A; 40 CFR 141).

7.7 Liquid Effluent

SJ Johnson

Liquid effluents are disposed of in a variety of ways at the Hanford Site, with each type of disposal governed by applicable regulations and permits. Primary disposal median for liquid effluents include the soil column and the City of Richland's sewer system. However, only one of those waste streams is permitted for radioactive constituents. Nonetheless, when discharges occur, all are sampled and analyzed for select radioactive parameters and nonradioactive hazardous materials.

Throughout each calendar year, discharge monitoring reports containing contaminant data from the analysis of liquid effluent samples are submitted to Ecology as regulated by WAC 173-216.

7.7.1 Radionuclide Results

The only permitted discharge point for radioactive liquid effluent to the ground in 2015 was the State-Approved Land Disposal Site.

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 four 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.