2019 Highlight

Effluent Releases
Liquid effluent releases were below permit limits and applicable standards.

Onsite Drinking Water
Routine radiological, chemical, physical, and microbiological monitoring of Hanford Site drinking water is performed regularly as mandated by the U.S. Environmental Protection Agency's (EPA) Community Water System requirements. All of the U.S. Department of Energy-owned Hanford Site systems were in compliance with drinking water standards for 2019.

Columbia River Surface Water
Concentrations of most radionuclides in samples collected at the City of Richland intake facility were comparable with samples collected upstream at Priest Rapids Dam. Radionuclide concentrations measured in cross-river, transect samples were, with one exception, similar to levels measured upstream at Priest Rapids Dam. The tritium concentration measured at the Hanford Townsite transect was higher than at Priest Rapids Dam or at any other transect. Strontium-90 concentrations measured in transect samples collected upstream and downstream of the Hanford Site during 2019 were below analytical detection limits. Uranium concentrations in all transect samples were below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]).

Columbia River Sediment
Analytical results for 2019 were comparable to previous years with cesium-137 and uranium isotopes consistently detected at most sediment collection locations.

Columbia River Shoreline Seep Water
In 2019 sample collections, tritium concentrations were slightly elevated in a sample collected near the Hanford Townsite when compared to all other shoreline seep results.

Hanford Site Pond Water and Sediment
The 2019 West Lake water and sediment samples were collected and analyzed for radiological contaminants; concentrations were similar to results shown in previous years.

Offsite Irrigation Water
Tritium concentrations from fixed-station locations at the City of Richland intake facility and Priest Rapids Dam were similar to irrigation levels in 2019.

7.0 Water Monitoring

7.1 Drinking Water Systems

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Eight U.S. Department of Energy (DOE)-owned, contractor-operated public water systems supply drinking water to DOE facilities on the Hanford Site (Table 7-1). Mission Support Alliance operates five

of the public water systems, CH2M Plateau Remediation Contractor (CHPRC) operates two systems, and Pacific Northwest National Laboratory (PNNL) operates one system. The City of Richland supplies water to the 300 Area, Richland North Area, and Hazardous Materials Management and Emergency Response facility.

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)	PNNL
400 Area	400 Area Groundwater Wells	CHPRC
609 Fire Station	Trucked Water from Water Treatment Plant 283-W	MSA

CHPRC = CH2M Plateau Remediation Contractor
PNNL = Pacific Northwest National Laboratory
MSA = Mission Support Alliance

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 establish adequate disinfection prior to distribution. The Columbia River was the source of supply water for the 100-K Area and 200-West Area facilities. 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) encountered an equipment malfunction in October 2016; therefore, backup well 499-S0-07 (P-15) was the source of drinking water for 2019. Emergency backup well 499-S0-8 (P-14) did not supply water to 400 Area consumers during the reporting period.

7.1.2 Monitoring

Samples at the 100-K, 200-West, and 400 Areas drinking water treatment facilities were collected monthly and analyzed quarterly or annually for radiological contaminants (Table 7-2). 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 the Volpentest Hazardous Materials Management and Emergency Response (HAMMER) Federal Training Center 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 C.

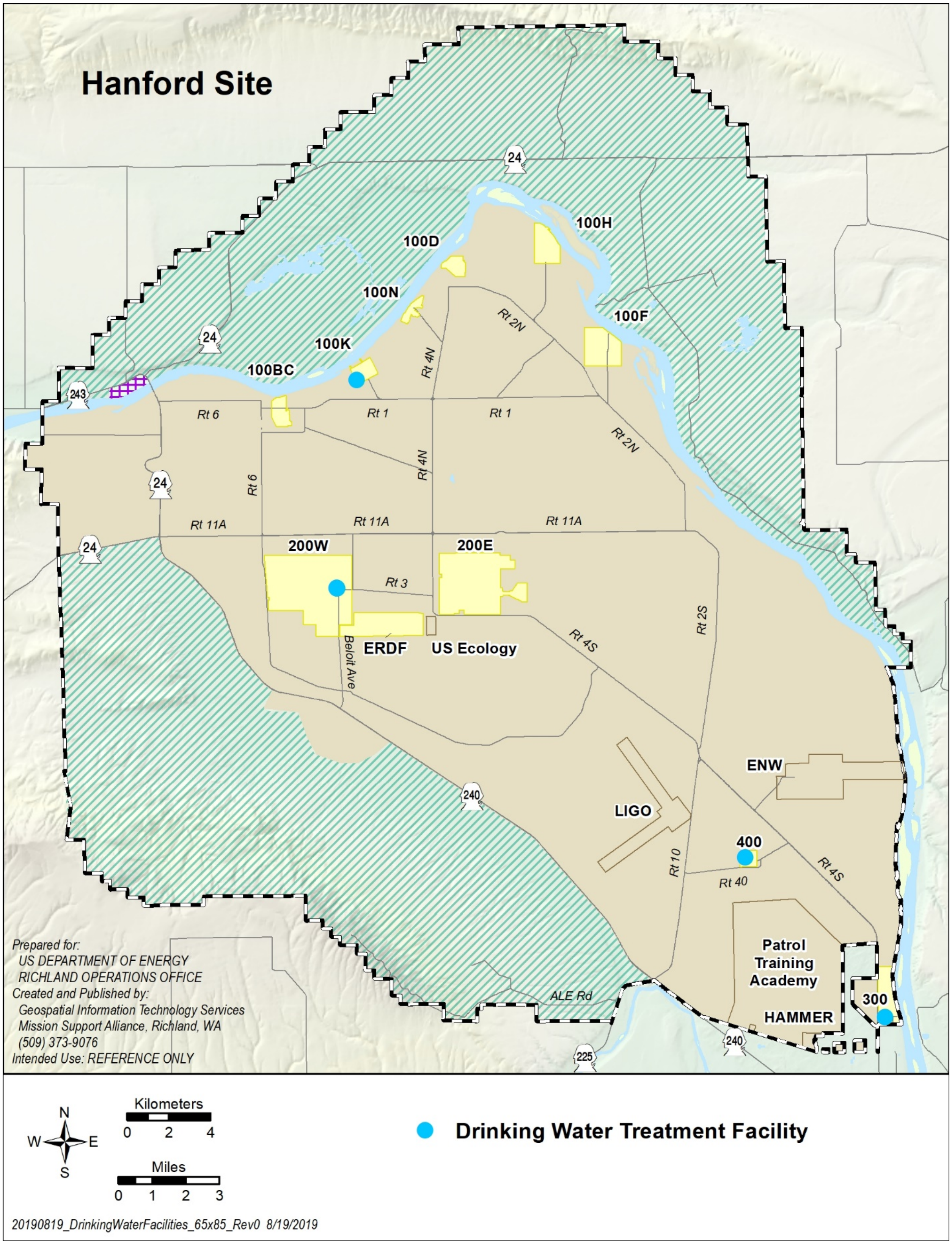

Figure 7-1. Drinking Water Treatment Facilities.

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=11039.

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 Mission Support Alliance, CHPRC, and PNNL (Table 7-1) performed monitoring (including chemical, physical, and microbiological sampling) at the water treatment plants and distribution systems to determine compliance with applicable regulations.

WAC 246-290, "Group A Public Water Supplies," requires that all drinking water analytical results be reported routinely to the Washington State Department of Health. Radiological results for Hanford Site drinking water samples are reported to the state through this annual environmental report. Chemical, physical, and microbiological data are reported to the state directly by the state-accredited laboratory performing the analyses, however, the reports are not published but analytical results are available online via the Washington State Department of Health Sentry system.

All of the DOE-owned Hanford Site drinking water systems were in compliance with drinking water standards for radiological, chemical, physical, and microbiological contaminant levels during 2019. Contaminant concentrations measured during the year were similar to those observed in recent years as described in the annual Hanford Site environmental reports for 2017 (DOE/RL-2018-32) and 2018 (DOE/RL-2019-33).

PNNL Environmental Sampling 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 the U.S. Environmental Protection Agency (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 [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 2019 were below state and federal maximum allowable contaminant levels (Table 7-2). The gross alpha 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), as was gross beta results for seven of the eight water samples analyzed and tritium for one of the two water samples analyzed.

The 400 Area source of supply was backup well 499-S0-7 (P-15). Gross beta and tritium were found in all 400 Area water samples; the tritium annual average was slightly elevated in comparison to historical data where the 400 Area primary well (499-S1-8J) was the main water source but were still below the maximum allowable contaminant level. Gross alpha and strontium-90 were not detected in 400 Area water samples.

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). In 2019, PNNL Environmental Sampling 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 (3,700 ± 885 pCi/L), and fell below the 20,000-pCi/L (740-Bq/L) federal and state annual average drinking water standards. CHPRC Soil and Groundwater Remediation Project personnel collected and analyzed raw (untreated) water samples from two of the three 400 Area drinking water wells. The primary well suffered a malfunction in October 2016 and the two backup wells were sampled and analyzed for tritium (Figure 7-2; Table 7-3).

Table 7-2. Drinking Water Annual Average Concentrations of Selected Radiological Constituents. (2 Pages)

Constituent	System	Frequency	Sample From	Samples Analyzed at Each Location	Annual Average (pCi/L)[a, b]			Standard
Gross alpha	100-K Area	Quarterly	Tap	4 [c]	0.79	±	1.15	15 [d, e]
	200-West Area	Quarterly	Tap	4 [c]	0.64	±	1.32	
	400 Area	Quarterly	Tap	4 [c]	1.28	±	1.23	
	400 Area Well P-14	Quarterly	Well	4 [c]	0.91	±	1.45	
Gross beta	100-K Area	Q Comp [f]	Tap	4 [c]	0.84	±	4.85	50 [e]
	200-West Area	Q Comp [f]	Tap	4 [c]	1.17	±	1.33	
	400 Area	Q Comp [f]	Tap	4	8.39	±	2.25	
	400 Area Well P-14	Q Comp [f]	Well	4	8.67	±	1.03	
Tritium	100-K Area	A Comp [g]	Tap	1 [c]	176	±	300	20,000 [e]
	200-West Area	A Comp [g]	Tap	1 [c]	962	±	409	
	400 Area	Quarterly	Tap	4	4597.50	±	291.38	
	400 Area Well P-14	A Comp [g]	Well	1	3700	±	885	
Strontium-90	100-K Area	A Comp [g]	Tap	1 [c]	0.28	±	0.71	8 [d, e]

Table 7-2. Drinking Water Annual Average Concentrations of Selected Radiological Constituents. (2 Pages)

Constituent	System	Frequency	Sample From	Samples Analyzed at Each Location	Annual Average (pCi/L)[a, b]			Standard
	200-West Area	A Comp[g]	Tap	1[c]	0.52	±	1.05	
	400 Area	A Comp[g]	Tap	1[c]	1.39	±	1.10	
	400 Area Well P-14	A Comp[g]	Well	1[c]	0.02	±	0.78	

[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] Analytical results are below the minimum detectable concentration.
[d] WAC 246-290.
[e] 40 CFR 141.
[f] Samples were collected monthly and composited quarterly for analyses.
[g] Samples were collected quarterly and composited annually for analyses.

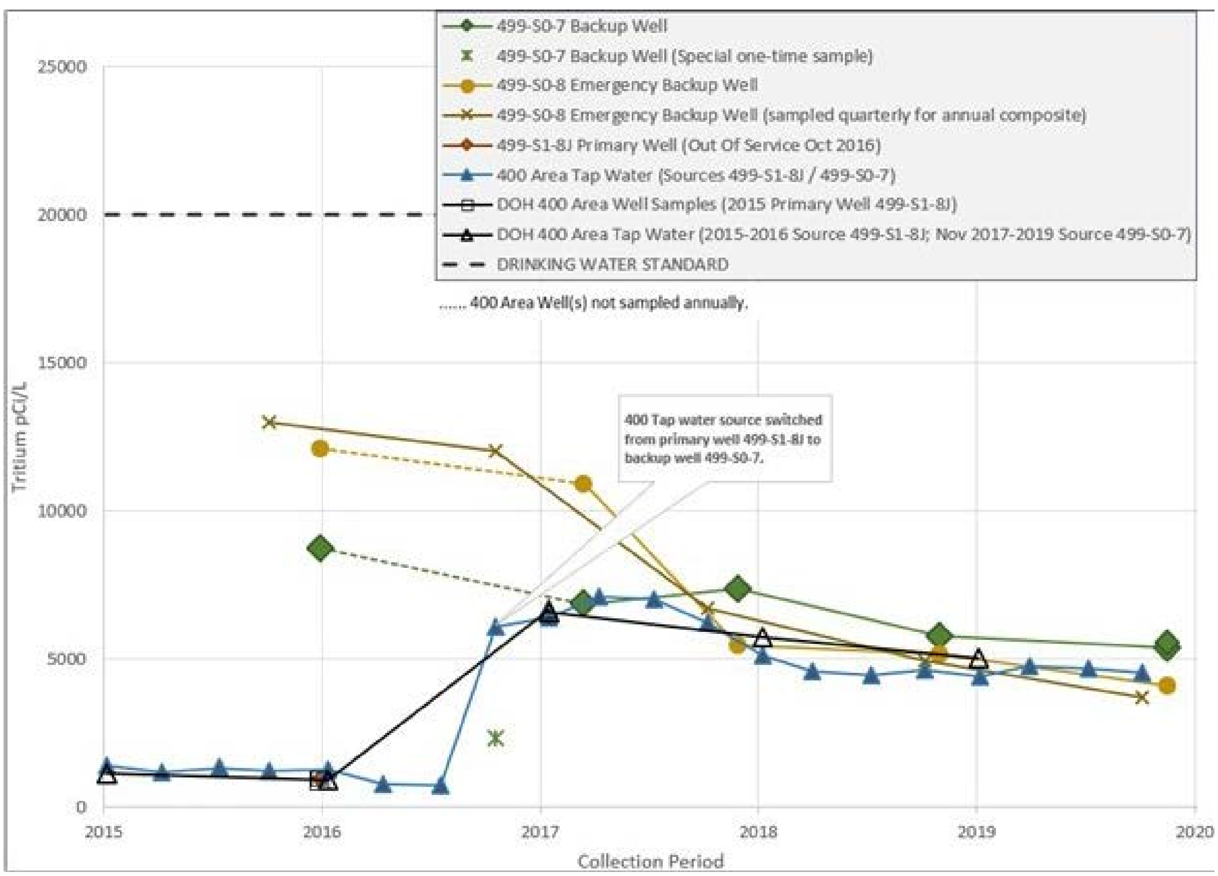

Figure 7-2. 400 Area Tritium Concentrations in Drinking Water (2014-2019) (multiply pCi/L by 0.037 to convert to Bq/L).

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) [a]	Backup Drinking Water Well 499-S0-7 (P-15; pCi/L) [a]
November 19, 2019	No Sample	4,100 ± 865 [b]	5,465 ± 212 [c]

[a] Multiply pCi/L by 0.037 to convert to Bq/L. [b] Reported concentration ± 2 total propagated analytical error.
[c] Two samples collected 11/19/19, annual average ± 2 times the standard deviation.

7.2 Columbia River Surface Water

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Samples of Columbia River surface water were collected upstream and downstream of the Hanford Site, as well as from locations along the Hanford Reach. Tables 7-4 and 7-5 summarize the sampling locations, types, frequencies, and sample analyses included in surface water monitoring.

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 Columbia 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. River water is also used for irrigation purposes downstream of the Hanford Site as well as a variety of recreational activities. Water removed from the river immediately downstream of the Hanford Site is used to irrigate a small portion of agricultural crops in Benton and Franklin Counties. The majority of irrigation water utilized by Franklin County residents originates at Grand Coulee Dam and is provided through its extensive water delivery systems (i.e., canals). Likewise, Benton County relies heavily on the Yakima River for irrigation purposes. Originating in the Rocky Mountains of eastern British Columbia, the Columbia River and its tributaries drain an area of approximately 260,000 mi^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; 4 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 2019. The annual average flow of the Columbia River downstream of Priest Rapids Dam was approximately 94,505 ft^3 (2,676m^3)/sec, slightly below the most recent 10-year average annual flow rate of 115,831 ft^3 (3,280 m^3)/sec (USGS 2013). The highest monthly average flow rate occurred during May (147,154ft^3 [4,167m^3]/sec; Figure 7-4). The lowest monthly average flow rate occurred during September (56,918ft^3 [1,611m^3]/sec) based on mean daily flows. Daily average flow rates varied from 42,233 to 3,183,204 ft^3 (1,183 to 5,130 m^3)/sec in 2019. 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.

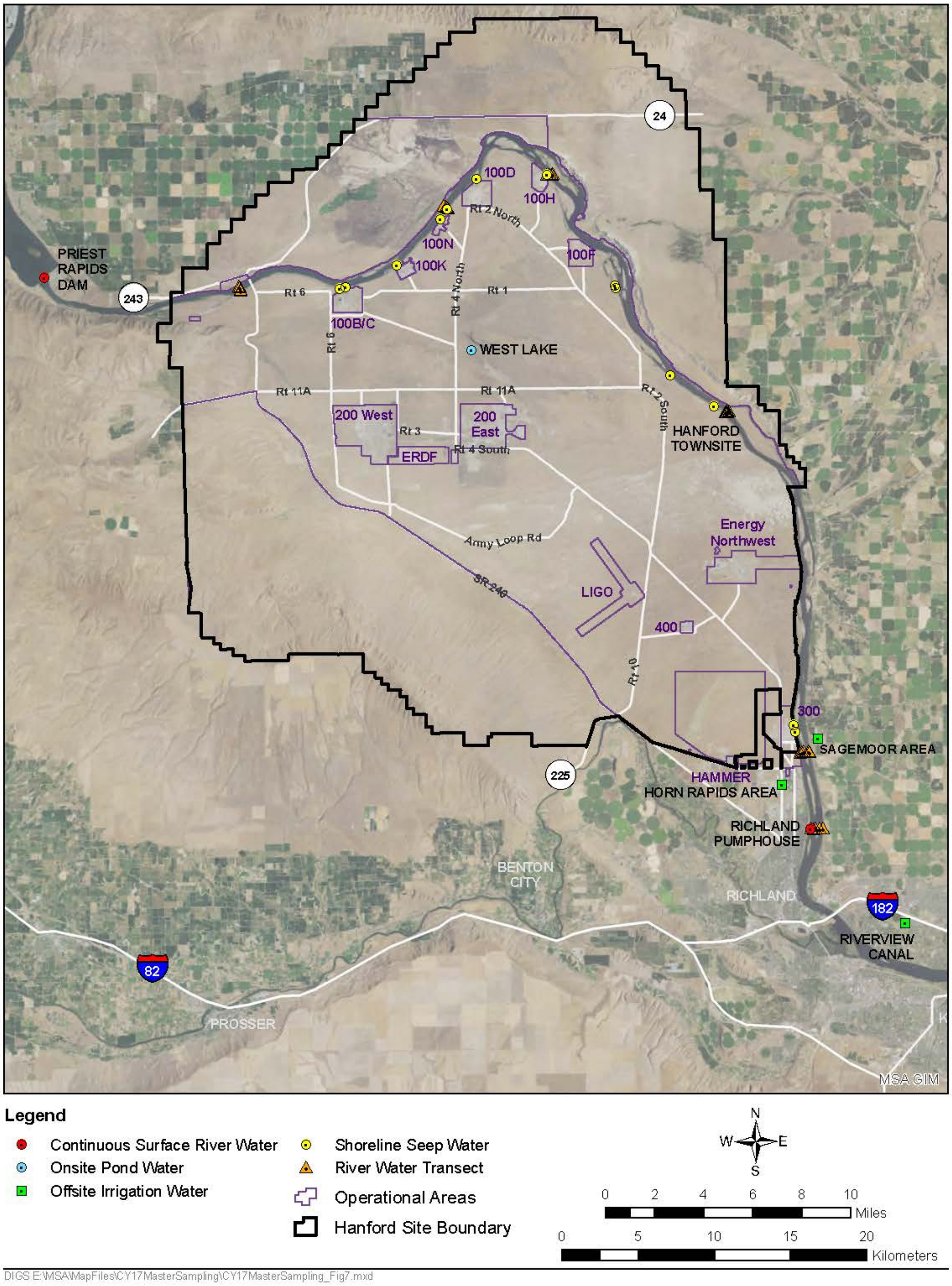

Figure 7-3. Surface Water and Sediment Sampling Locations.

Table 7-4. Surface Water Surveillance. (2 Pages)

Location	Sample Type	Frequency	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland Pump House	Cumulative	M Comp[a]	Low tritium[b], strontium-90, technetium-99, isotopic uranium[c]
	Particulate (filter)	M Cont[d]	Gamma energy analyses, isotopic plutonium[e]
	Soluble (resin)	M Cont[d]	Gamma energy analyses, isotopic plutonium[e]
	Grab	Quarterly	Anions
Vernita Bridge	Grab (transects)	Semi-annual	Gamma energy analyses, low tritium[b], strontium-90, isotopic uranium[c], isotopic plutonium[e], technetium-99
Richland	Grab (transects)	Semi-annual	Gamma energy analyses, low tritium[b], strontium-90, isotopic uranium[c], isotopic plutonium[e], technetium-99
100-H, 100-N, 300 Areas and Hanford Townsite	Grab (transects)	Annually	Gamma energy analyses, low tritium[b], strontium-90, isotopic uranium[c], uranium-236 (300 Areas only)
Columbia River - Inorganics and Organics			
Vernita Bridge	Grab (transects)	Semi-annual	Anions, mercury, metals (filtered and unfiltered)
	Grab (transects)	Semi-annual	Volatile organic compounds
Richland	Grab (transects)	Semi-annual	Anions, mercury, metals (filtered and unfiltered)
	Grab (transects)	Semi-annual	Volatile organic compounds
100-H, 100-N, 300 Area, and Hanford Townsite	Grab (transects)	Annually	Anions, metals (filtered and unfiltered), volatile organic compounds (300 Area only)
Onsite Ponds			
West Lake Seep	Grab	March	Tritium, technetium-99, isotopic uranium[(c)]
West Lake Water	Grab	May	Tritium, technetium-99, isotopic uranium[(c)]
Offsite Irrigation Water			
Riverview Irrigation Canal	Grab	3/year	Alpha, beta, gamma energy analyses, low tritium[(b)], strontium-90
Horn Rapids Battelle Sports Complex	Grab	3/year	Alpha, beta, gamma energy analyses, low tritium(b), strontium-90
Sagemoor Irrigation Canal	Grab	3/year	Alpha, beta, gamma energy analyses, low tritium(b), strontium-90

Table 7-4. Surface Water Surveillance. (2 Pages)

[a] M Comp indicates river water was collected at set intervals and composited monthly for analyses.
[b] Low tritium = Low-level tritium analysis (10-pCi/L detection limit).
[c] Includes uranium-234, uranium-235, and uranium-238.
[d] M Cont = River water was sampled for 2 weeks by continuous flow through a filter and resin column; Samples were composited monthly for analyses.
[e] Includes plutonium-238 and plutonium-239/240.
Comp = Composite
Cont = Continuous
M = Monthly

Table 7-5. Columbia River Sediment.

Location[a]	Frequency	Analyses
McNary Dam (Two locations near the dam)	Annually	Anions, Cr+6, gamma energy analyses, hexavalent chromium, isotopic uranium[b], isotopic plutonium[c], metals, mercury, strontium-90, and total organic carbon
Hanford Reach[d]	Annually	Anions, Cr+6, gamma energy analyses, hexavalent chromium, isotopic uranium[b], isotopic plutonium[c], metals, mercury, strontium-90, and total organic carbon
Priest Rapids Dam (Two locations near the dam)	Annually	Anions, Cr+6, gamma energy analyses, hexavalent chromium, isotopic uranium[b], isotopic plutonium[c], metals, mercury, strontium-90, and total organic carbon
Contiguous Hanford Reach Islands (Adjacent to Locke and Savage)	Annually	Anions, Cr+6, gamma energy analyses, hexavalent chromium, isotopic uranium[b], isotopic plutonium[c], metals, mercury, and strontium-90

[a] Refer to Figure 7-3
[b] Uranium-234, uranium-235, uranium-236 (300 Area only), and uranium-238
[c] Plutonium-238 and plutonium-239/240
[d] Hanford Reach consists of sediment collected in the following areas: 100-D Spring 102-1, 100-K Spring 63-1, 100-H Spring 145-1, 100-F Slough, Hanford Slough, White Bluffs Slough, and 300 Area Spring DR 42-2.

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 Area 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.

7.2.1 Monitoring

In 2019, 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 transect samples near Vernita Bridge, 100-N Area, 100-H Area, Hanford Townsite, 300 Area, and the City of Richland were also collected and 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 consists 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, *Hanford Site Environmental Monitoring Plan*.

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 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 (i.e., strontium-90, technetium-99, tritium, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238). 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 1% 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 guideline standards were used to compare concentrations of contaminants of concern at upstream (Vernita) and downstream (Richland Pumphouse) locations for 2019. At both locations, concentrations were similar and lower than the guideline standards. Drinking water supplied by the City of Richland travels through the water treatment plant before it is available for public use.

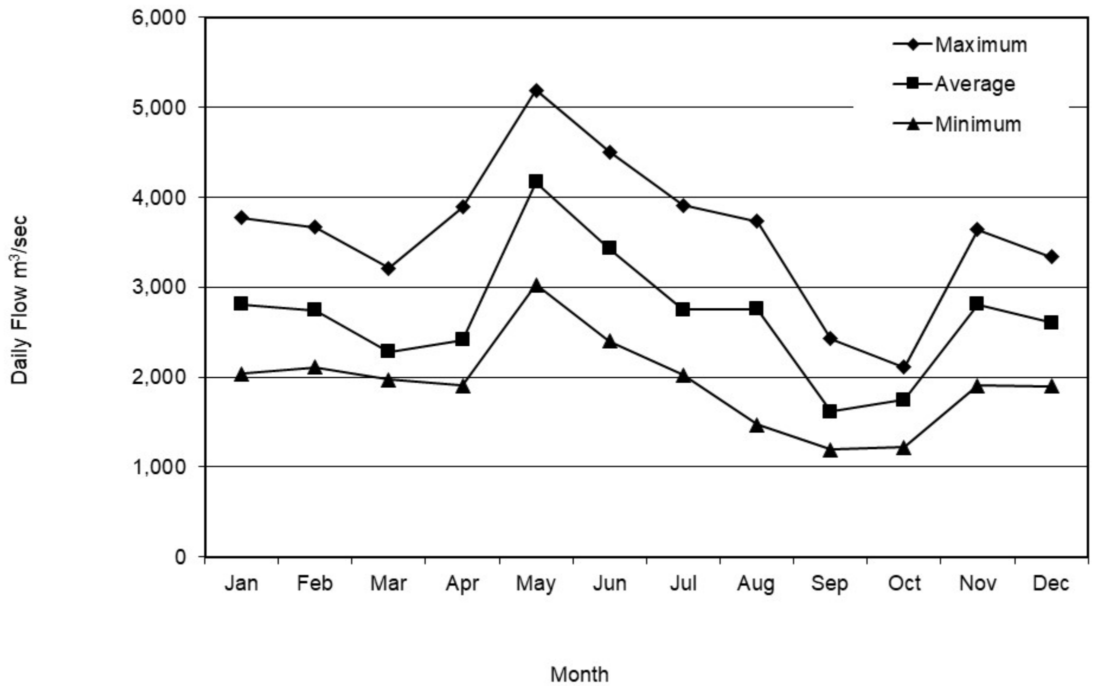

Figure 7-4. Columbia River Flow Rates at Priest Rapids Dam (multiply m³/sec by 35.31 to obtain ft³/sec).

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). 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 were 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 2019, the Richland Pumphouse and Vernita Bridge transects were collected twice (spring and late summer). The 100-N Area, 100-H Area, Hanford Townsite, and 300 Area locations were all sampled once in 2019 during late summer when river flows were low. Low river flows provide the highest probability of detecting Hanford Site contaminants carried by groundwater to the Columbia River. Transect stations at the Richland Pumphouse, 300 Area, Hanford Townsite, 100-H Area, and 100-N Area were comprised of five locations. The Vernita Bridge station is made up of four locations due to safety concerns associated with an inability to anchor at the midstream location because of the smooth riverbed and high flow rates.

Columbia River transect water samples collected during 2019 were analyzed for radiological, inorganic, and organic contaminants (Table 7.4). The contaminants of concern (specifically hexavalent chromium [filtered and unfiltered], metals [filtered and unfiltered], anions, and radionuclides that were selected for analyses) were based upon previous studies of groundwater plume migration, reviews of existing

surface water and groundwater upwelling/discharge data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67; WCH-380). Metals analyses included both unfiltered (recoverable) and filtered (dissolved) samples.

7.2.2 Radiological Results

7.2.2.1 Fixed-location Samples.

Individual radiological contaminant concentrations measured in Columbia River water during 2019 were well below the DOE-derived concentration standards. The DOE-derived concentrations are based on a 100 mrem/yr (1 mSv/yr) standard; dividing by 25 allows for more direct comparison to the 4 mrem/yr (0.04 mSv/yr) drinking water standards and Washington State ambient surface water quality criteria (40 CFR 141; WAC 173-201A). Results of radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the City of Richland raw water intake facility in 2019, and for the previous 5 years, are summarized in Appendix C, Tables C-7 and C-8.

Due to operational issues with the Richland Pumphouse sampling system during the first half of calendar year (CY) 2019, grab samples were obtained from the Columbia River directly adjacent to the pumphouse structure every 2 weeks to maintain sample scheduling and analyses.

Radionuclide concentrations in Columbia River water were low throughout 2019. Tritium, uranium-234, and uranium-238 were consistently detected at both locations. Uranium-234 and uranium-238 results were measured at less than 10% of their respective DOE-derived concentration standards. One up-gradient sample from Priest Rapids had detectable plutonium-239/240 results and two down-gradient samples from the Richland Pumphouse had detectable concentrations of technetium-99. All other radionuclides were below minimum detectable concentrations.

The 2019 annual average tritium concentrations measured upstream and downstream of the Hanford Site were similar to concentrations measured in recent years (Figure 7-5). Tritium concentrations in river water samples at the City of Richland raw water intake facility were slightly higher than in samples from Priest Rapids Dam. The maximum concentration detected at the Richland Pumphouse was 45.5 pCi/L (1.7 Bq/L), while Priest Rapids Dam had a maximum concentration of 21.5 pCi/L (0.8 Bq/L). Average tritium concentrations in Columbia River water samples collected at the City of Richland raw water intake facility were well below the Washington State ambient surface water quality criterion of 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 tritium 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 and at shoreline seep locations during 2019 confirmed the existence of a concentration gradient in the river under certain flow conditions discussed in this section.

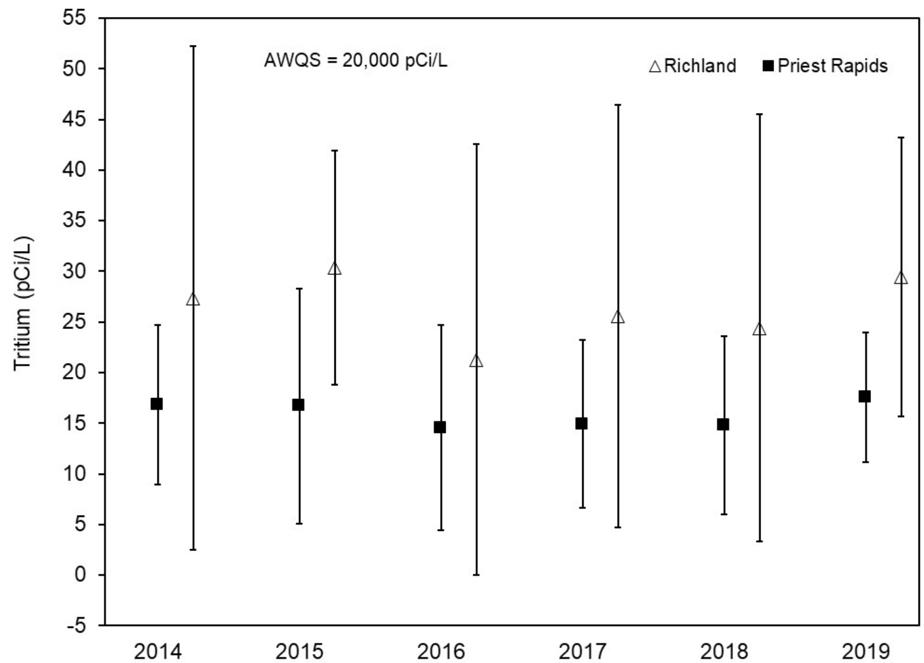

Figure 7-5. 2019 Annual Tritium Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site (±2X standard deviations, AWQS=ambient water quality standard; Washington State AWQS for tritium is 20,000 pCi/L [740 Bq/L]).

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 2019, were similar to those reported in previous years (Figure 7-6). Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Area.

Historically speaking, 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 concentrations of strontium-90 remained elevated until the mid-1990s, the levels seen both upstream and downstream today are very similar. Strontium-90 concentrations at Priest Rapids Dam and the City of Richland were below minimum detection limits (0.06 pCi/L). Priest Rapids Dam and the City of Richland intake had similar maximum concentrations of 0.04 pCi/L (0.0015 Bq/L). Low concentrations are likely attributable to a number of reasons, but the decline is likely due to radioactive decay, and to a permeable reactive barrier within the groundwater that was put into place by DOE. The barrier essentially locks up most of the groundwater strontium entering the Columbia River.

Annual averages of total uranium concentrations measured in water samples collected upstream and downstream of the Hanford Site in 2019 were similar to those observed during recent years (Figure 7-7). Average monthly uranium concentrations measured at Priest Rapids Dam (0.52 pCi/L total uranium) in 2019 were slightly lower than those averages measured at the City of Richland (0.58 pCi/L total uranium).

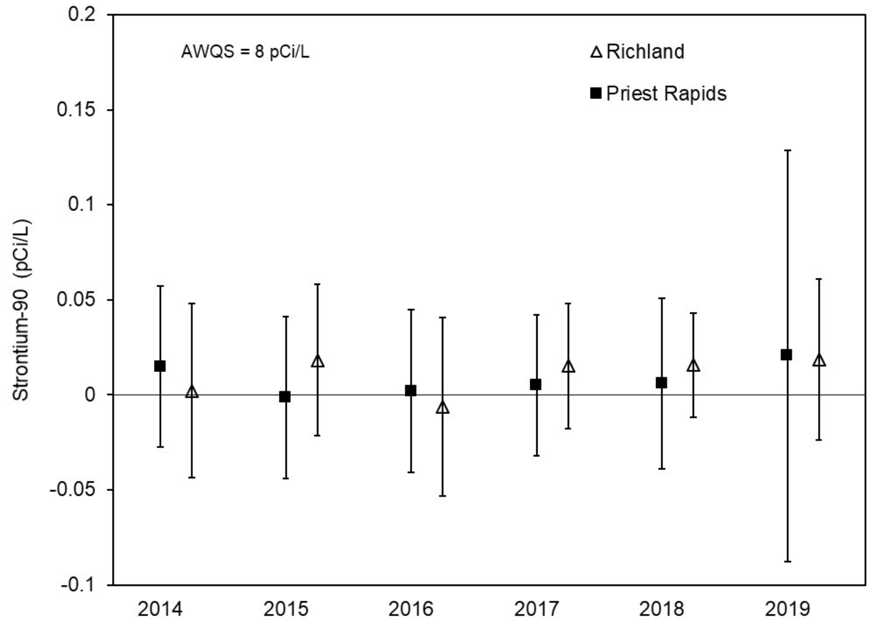

Figure 7-6. 2019 Annual Strontium-90 Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site (±2 standard deviations, AWQS = ambient water quality standard).

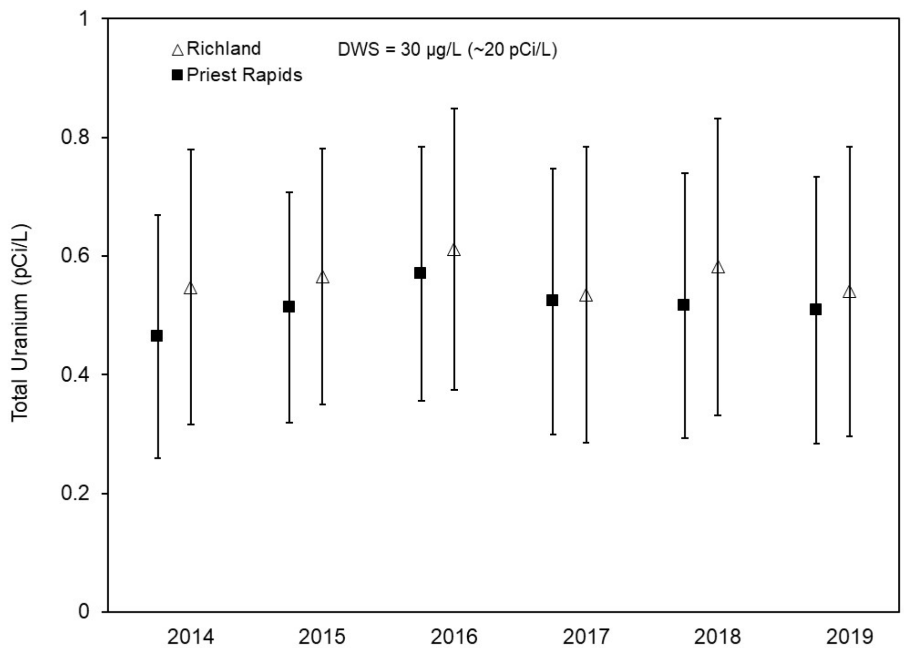

Figure 7-7. 2019 Annual Uranium Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site (±2 standard deviations; DWS = drinking water standard).

Uranium is present in the groundwater beneath the 300 Area as a result of past Hanford Site operations, it has also been previously detected at elevated levels in shoreline springs at the 300 Area (Section 7.4; PNNL-13692; PNNL-16805).

There is no Washington State ambient surface water quality criterion directly applicable to uranium; however, total uranium levels in the river during 2019 were well below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]).

Plutonium-238 and plutonium-239/240 concentrations in river water samples collected at the City of Richland in 2019 were below analytical detection limits. One sample collected upstream at Priest Rapids Dam did show plutonium-239/240 at an extremely low concentration.

7.2.2.2 Columbia River Transect Samples.

Radiological results from samples collected along Columbia River transects near Vernita Bridge, 100-N Area, 100-H Area, Hanford Townsite, 300 Area, and the City of Richland are presented in Appendix C, Table C-9. Station 1 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 detected included tritium, uranium-234, uranium-235, and uranium-238. There were no detections of strontium-90 in 2019 Columbia River transect samples. All measured concentrations of radionuclides consistently detected 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, 100-H Area, Hanford Townsite, 300 Area, and the City of Richland during 2019 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. Incomplete mixing of river water and groundwater is likely a result of differing water temperatures as well. All of these factors affect the tritium concentration in this area.

Average concentrations of tritium in a sample collected from the City of Richland fixed-station were comparable to levels observed in the Benton County shoreline transect sample (Richland Pumphouse Hanford River Mile [HRM] 46.4 station-1). The highest tritium concentration measured in a cross-river transect water was at the Hanford Townsite at a concentration less than 1% of the Washington State Drinking Water Quality Standard of 20,000 pCi/L.

Hanford Reach transect samples collected in 2019 were similar to upstream reference concentrations for most locations with no detections of strontium-90. The maximum strontium-90 concentration was from a sample collected at the Vernita transect HRM 0.3 station-3. Average strontium-90 concentrations at the Priest Rapids Dam fixed-location monitoring station were greater than those measured at the Richland Pumphouse and in all Richland Pumphouse (RPH)-HRM 46.4 transect samples.

Uranium concentrations in all transect samples collected during 2019 were below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]). The highest uranium-234 concentration was measured in a sample collected near the Franklin County shoreline (RPH-HRM 46.4 station-9). Uranium-236 concentrations from the 300 Area transects were below analytical detection limits.

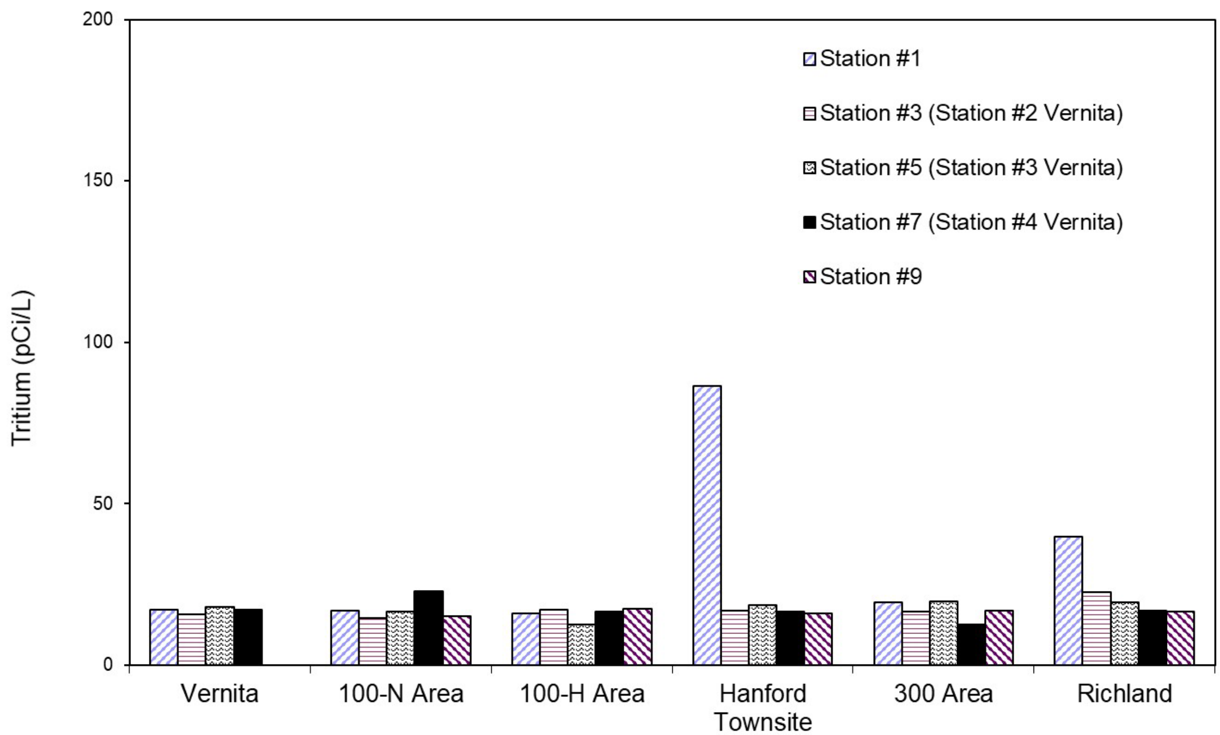

Figure 7-8. 2019 Tritium Concentrations in Cross-River Transect Water Samples (Hanford Reach, Columbia River).

7.2.3 Inorganic and Organic Chemical Results

Inorganic and organic water quality data were compiled in 2019 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. Analytical results showed detections of arsenic, copper, thallium, uranium, and zinc. All dissolved metal concentrations in river water were well below the Washington State ambient surface water quality criteria for the protection of aquatic life (Appendix C, Table C-10).

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 in recent years based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge (USGS 2007) and the City of Richland.

The Richland Pumphouse HRM 46.4 station-9 (Franklin County shoreline) had a maximum nitrate concentration of 1,380 µg/L, which was slightly higher than the next highest transect result found at RPH-HRM 46.4 station-1 (Benton County Shoreline), which measured 1,300 µg/L. All other samples collected throughout the Hanford Reach had average concentrations that were approximately 20% of those measured at the RPH-HRM 46.4 station-1 location. Concentrations of chloride were slightly elevated at RPH-HRM 46.4 station-9 when compared to other transect locations (Figure 7-9) found throughout the Hanford Reach. RPH-HRM 46.4 concentrations of sulfate were also slightly elevated when compared to transect samples collected throughout the Hanford Reach. Sulfate and chloride levels found at Vernita Bridge HRM 0.3 stations were comparable to the 300 Area HRM 43.1 stations.

In some cases, the highest anion concentrations were found in samples collected along the Grant-Franklin County shoreline. These elevated results are likely attributable to 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 10 mg/L, the EPA maximum contaminant level measured as nitrate nitrogen (40 CFR 141; USGS 1998).

Annual average concentrations of chloride measured downstream at the City of Richland and upstream at the Vernita Bridge transect locations were similar. All other transect locations had detectable levels of nitrates as well. Anion analysis of Columbia River transect samples showed detectable levels of fluoride at very low concentrations in all samples. The overall average concentration of fluoride in transect samples has dropped from 109 µg/L in 2010 to 97 µg/L in 2019.

Concentrations of chromium in the Hanford Reach are of interest because groundwater contaminated with chromium above the ambient water quality criterion intersects the Columbia River at several Hanford Site locations. All filtered river water samples for 2019 had chromium concentrations below the minimum detectable concentration.

Results from organic analyses of water samples are voluminous and not all results are included in this report. A complete listing may be found in the Hanford Environmental Information System database. The two major organic contaminants monitored in 2019 were trichloroethane and dichloroethane, compounds used during past reactor fuel fabrication in the 300 Area. These contaminants were measured in transect water collected upstream and downstream of the Hanford Site and in the vicinity of the 300 Area. Analytical results for these samples showed concentrations below their respective EPA Drinking Water Standards (Appendix C, Table C-11).

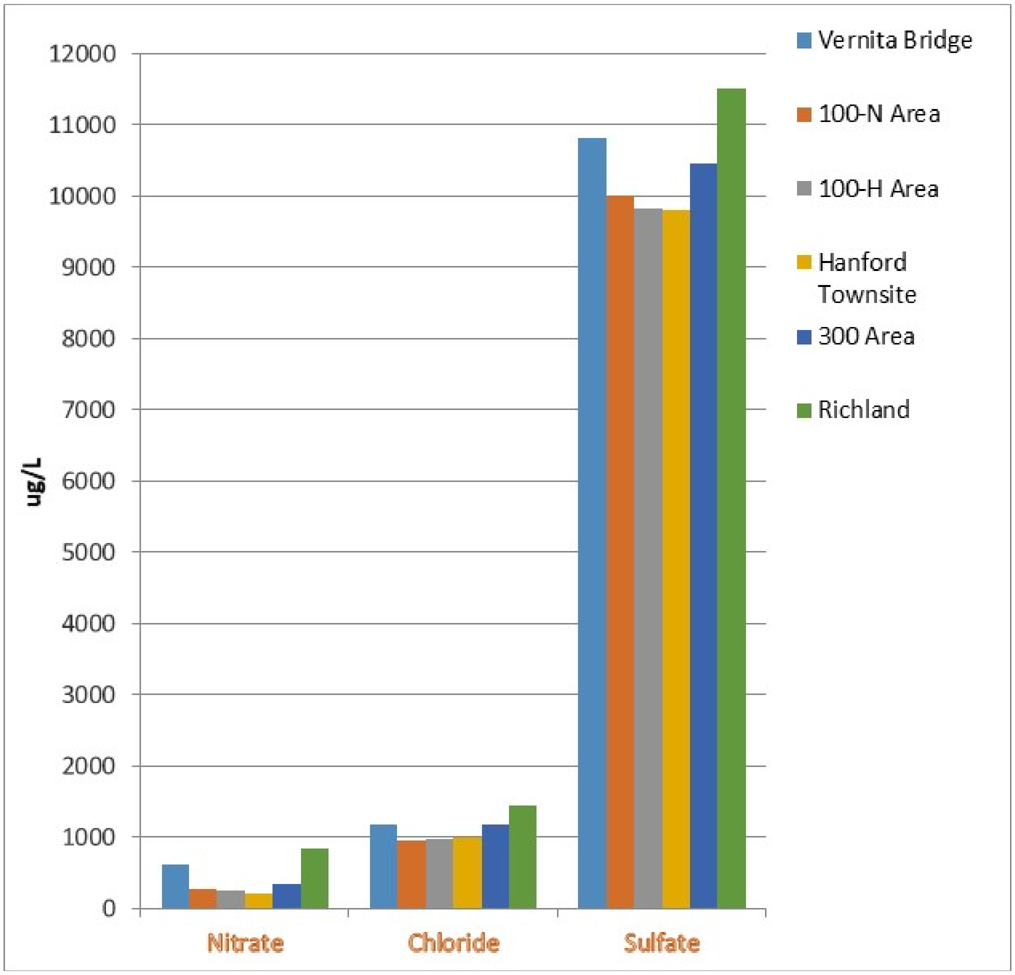

Figure 7-9. 2019 Selected Anion Concentrations in Columbia River Transect Samples (micrograms/liter).

7.3 Columbia River Sediment

During peak operating years at the Hanford Site, large volumes 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 (e.g., 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; PNNL-16990). Periodic sediment sampling confirms that concentrations are low and that no significant changes in concentrations have occurred. The accumulation of radioactive materials in sediment can lead to human exposure from ingestion of aquatic organisms associated with 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 Hanford Site, the 100-K Spring 63-1 shoreline sediment location, White Bluffs and Hanford Sloughs on the Hanford Reach, and downstream of the Hanford Site in the reservoir pool located above McNary Dam.

7.3.1 Monitoring

In 2019, samples of the surface layer of Columbia River sediment were collected at depths of 0 to 6.3 in. (0 to 16 cm) from 13 river locations that were predominantly submerged (some Hanford Reach sampling locations may not be submerged during an extremely low-river stage) during late summer/early fall (Figure 7-13). Sediment was collected using a clamshell-style sediment dredge sampler (Petite Ponar), capturing several years of sediment deposits. Estimated average sediment deposition rates are 0.28 in. (0.723 cm)/yr for Priest Rapids Dam and 0.89 in. (2.25 cm)/yr for McNary Dam (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. Deposition rates have not been estimated for shoreline or slough sediment collection 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 Hanford 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, 100-H Spring 145-1, Hanford Slough, 100-K Spring 63-1, 300 Area DR 42-2, White Bluffs Slough, and locations adjacent to Locke and Savage Islands (locations, analyses, frequency, and contaminant results are presented in Table 7-5, Table 7-7, and Appendix C). The majority of these sites are located along the Hanford Reach of the Columbia River in slack-water areas where fine-grained material is known to deposit or in shoreline spring areas known to contain groundwater contaminated by past Hanford Site practices.

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.

7.3.2 Radiological Results

All sediment samples were analyzed for gamma-emitting radionuclides, anions, hexavalent chromium, strontium-90, plutonium-238, plutonium-239/240, uranium-234, uranium-235, uranium-238, metals, mercury, and total organic carbon. 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 2019 included cesium-137, uranium-234, uranium-235, uranium-238, and decay products from naturally-occurring radionuclides. The concentrations of all other radionuclides 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, are present in many agricultural fertilizers, and have been present in past releases of Hanford Site effluent. Analytical results for 2019 showed similar concentrations of cesium-137 at Priest Rapids and McNary Dam sediment collection locations. Average concentrations were slightly elevated when compared to Hanford Reach sediment collection location results (Figure 7-10). Plutonium-239/240 sediment results at McNary Dam had higher concentrations than those seen along the Hanford Reach (Figure 7-11). Note: both Figures 7-10 and 7-11 have upper and lower bars that represent maximum and minimum values, which may be similar to the average and, therefore, not visible.

Uranium-234 concentrations were slightly elevated at the 300 Area Spring DR 42-2 location compared to other sediment samples collected from the Hanford Reach, McNary, and Priest Rapids Dam samples in 2019. All other sediment detections were comparable to historic values. Other radionuclide detections and concentrations found in Hanford Reach river sediment were similar to those reported in previous years; there were no significant glaring differences between locations.

Total uranium averaged 1.7 pCi/g for the Hanford Reach, while Priest Rapids and McNary Dam concentrations averaged 2.6 pCi/g and 2.7 pCi/g, respectively (Figure 7-12). Note: upper and lower bars represent maximum and minimum values, which may be similar to the average and may not be visible.

The value for cesium-137 in the Hanford Slough of the Hanford Reach was slightly elevated (0.28 pCi/g concentration) compared to other Hanford Reach sample locations (0.08 pCi/g average concentration). McNary Dam had a slightly lower cesium-137 average concentration compared to Priest Rapids Dam sediment results (0.19 pCi/g and 0.22 pCi/g, respectively). The average, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (2014 to 2019) are presented in Figures 7-10, 7-11, and 7-12.

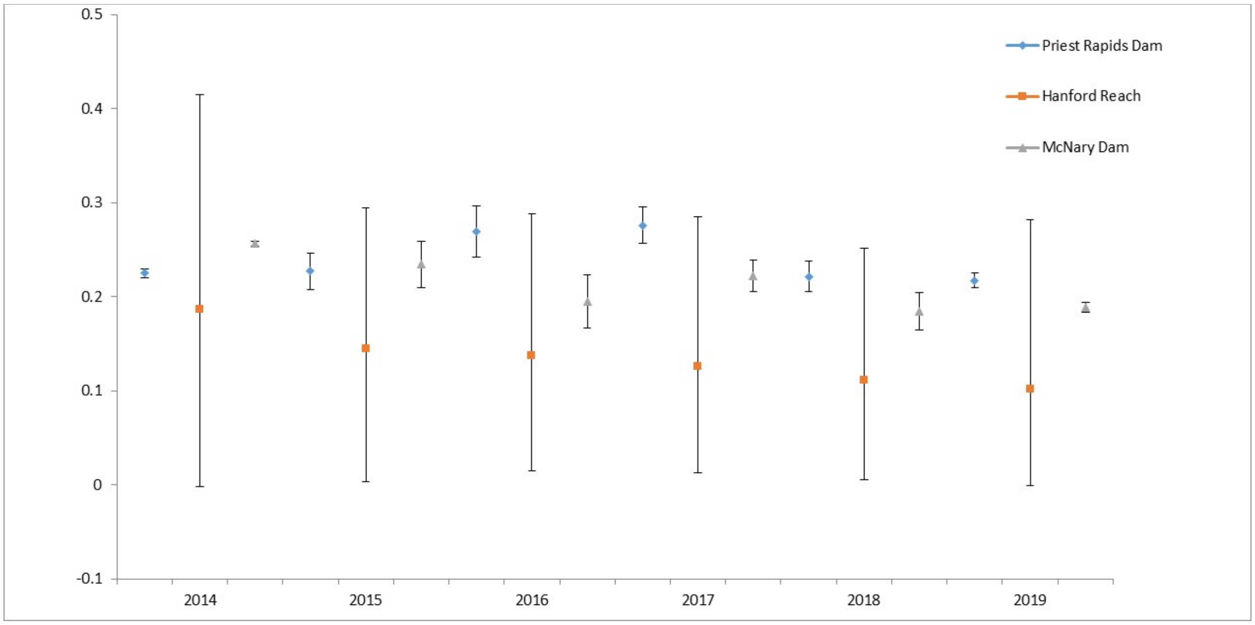

Figure 7-10. Cesium-137 Average, Maximum (top), and Minimum (bottom) Concentrations Measured in Columbia River Sediment (results shown are in pCi/g ±2 standard deviations).

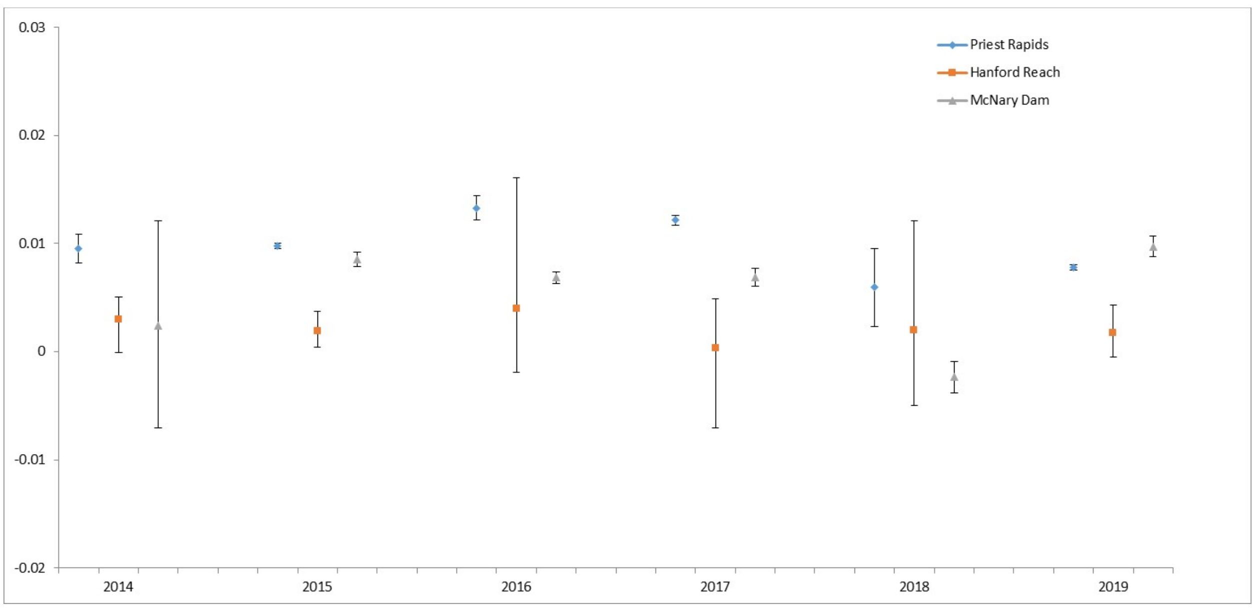

Figure 7-11. Plutonium-239/240 Average, Maximum (top), and Minimum (bottom) Concentrations Measured in Columbia River Sediment (results shown are in pCi/g ±2 standard deviations).

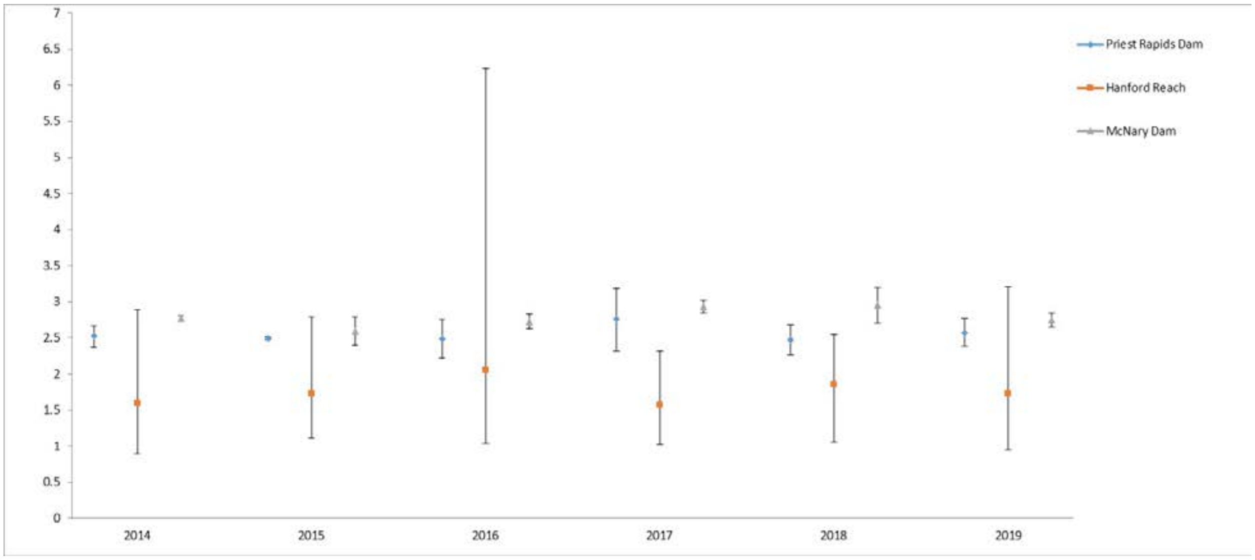

Figure 7-12. Uranium Average, Maximum (top), and Minimum (bottom) Concentrations Measured in Columbia River Sediment (results shown are in pCi/g ±2 standard deviations).

7.3.3 Chemical Results

Detectable amounts of most metals were found in all river sediment samples (Figure 7-13). Note: upper and lower bars represent maximum and minimum values, which may be similar to the average and may not be visible. Average concentrations of antimony, cadmium, chromium, copper, lead, mercury, nickel, 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. Maximum concentrations of antimony were higher for sediment collected in the Hanford Reach than in sediment collected at McNary Dam. Lead concentrations were detected at higher rates in the Hanford Slough 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 Hanford Slough.

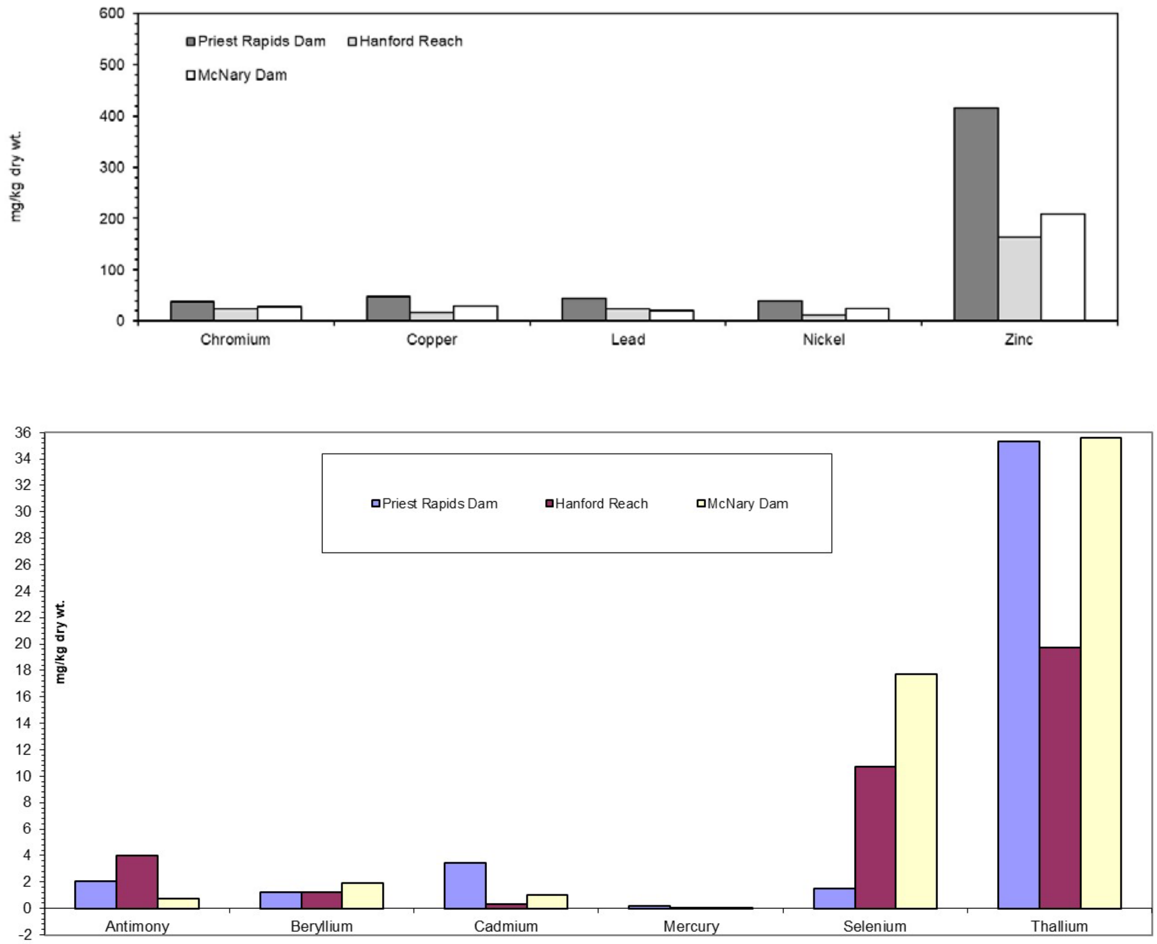

Figure 7-13. Selected Metals Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (Washington and Oregon), 2019.

7.4 Columbia River Seep Water

In 2019, samples of Columbia River seep water and three associated shoreline sediment samples were collected along the Hanford Reach (Figure 7-3). These samples were analyzed to determine the potential impact of radiological, inorganic, and organic contaminants from the Hanford Site on the public, aquatic, and riparian environment. Various radiological analyses were performed on selected seeps following reviews of existing surface water and groundwater data, multiple remedial investigation/feasibility study 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 7-5 and 7-6 and in Appendix C.

Table 7-6. Columbia River Seep Monitoring.

Location[a]	Sample Type	Sampling Frequency	Analyses
100-B Area	Grab	Annually	Alkalinity, anions, metals (filtered/unfiltered), strontium-90, tritium, VOA[c]
100-D Area	Grab	Annually	Alkalinity, alpha, anions, beta, metals (filtered/unfiltered), strontium-90, technetium-99, tritium, isotopic uranium[b]
100-F Area	Grab	Annually	Alkalinity, anions, metals (filtered/unfiltered), strontium-90, tritium, VOA[c]
100-K Area	Grab	Annually	Alkalinity, alpha, anions, beta, carbon-14, metals (filtered/unfiltered), strontium-90, technetium-99, tritium, VOA[c]
100-N Area	Grab	Annually	Alkalinity, alpha, anions, beta, metals (filtered and unfiltered), strontium-90, TPH, tritium
300 Area	Grab	Annually	Alkalinity, alpha, anions, beta, metals (filtered/unfiltered), tritium, isotopic uranium[(b)], uranium-236, VOA[c]
Hanford Townsite	Grab	Annually	Alkalinity, alpha, anions, beta, iodine-129, metals (filtered/unfiltered), strontium-90, technetium-99, tritium, VOA[c]

[a] Refer to Figure 7.3; Locations may contain multiple shoreline seeps with differing analyses.
[b] Uranium-234, uranium-235, and uranium-238
[c] 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. It is also a regional groundwater discharge zone that includes discharge from confined basalt aquifers. 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.

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 along the Hanford Reach. Water table elevations are declining as a result of decreased artificial groundwater mounding from the discharge of millions of gallons of effluent from the 1950s through the early 1980s. As the groundwater mound declines, the water levels will reach pre-Hanford water-level equilibrium, which result in the gradual disappearance of groundwater seeps.

Columbia River seeps also vary with river stage (river water surface elevation). The water table near the Hanford Reach is influenced strongly 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 while Hanford Site groundwater typically has readings greater than 180 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 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) 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. It is suspected that some seep samples collected may be a blend of groundwater and Columbia River 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, 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 2019. This section describes the monitoring efforts and summarizes results for these aquatic and riparian 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.

In 2019, 13 of 13 scheduled seeps samples were successfully sampled. All samples collected were analyzed for tritium. Some samples from selected seeps were analyzed for alkalinity, alpha, anions, beta, carbon-14, hexavalent chromium, metals, strontium-90, technetium-99, uranium-234, uranium-235, uranium-238, and volatile organic compounds. Unfiltered samples were analyzed except for hexavalent chromium and 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 2019 in water from riverbank seeps entering the Columbia River along the Hanford Site. A listing of the 2019 sampling results is provided in Appendix C, Table C-14.

Tritium concentrations varied widely with location. The highest tritium concentration measured in riverbank seeps was at the Hanford Townsite 28-2 riverbank seep (24,100 pCi/L ± 4,690 pCi/L [892 ± 174 Bq/L]), which was slightly above the Washington State ambient surface water quality criterion of 20,000 pCi/L (740 Bq/L) . No tritium results exceeded the Biota Concentration Guide (DOE/EH-0676) level for Riparian Animal receptors (265,000,000 pCi/L). Tritium concentrations in riverbank seep water samples were higher compared to maximum concentrations in 2019 Columbia River fixed-station location samples at Priest Rapids Dam and the City of Richland, as well as Columbia River transect samples. Overall, results in 2019 were comparable to the previous 5 years of concentrations reported in riverbank seeps.

Two water samples from riverbank seeps near the old Hanford Townsite area (Hanford Townsite 25-4; Hanford Spring 28-2) were collected in 2019 and submitted to a laboratory for iodine-129 analysis using an ultra-trace analytical method. Laboratory results showed the concentrations to be below analytical detection limits.

All water samples from riverbank seeps were analyzed for strontium-90 and the highest concentration was in the 100-N Area, at approximately 20% of the DOE-derived concentration standard for riparian animals. Historically, groundwater in the 100-N Area has had the highest strontium-90 levels measured at the Hanford Site.

Uranium isotopes' concentrations measured in the 300 Area riverbank seep water samples were higher than those at the 300 Area HRM 43.1 transect location as well as at all other transect locations. 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.

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 seep water collected at the 300-DR 42-2 riverbank seep site. This location is down gradient from the retired 300 Area process trenches. The maximum uranium concentration in this seep water sample was slightly lower (7.5 pCi/L ± 0.28 pCi/L uranium-234) than the EPA drinking water standard limit of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]). The 2019 concentrations of uranium-234, uranium-235, and uranium-238 were lower than those measured during 2014 through 2018.

During 2019 riverbank seep collections, three locations recorded detections of gross alpha. The 300 Area Spring 42-2, 300 Area Spring DR 42-2, and Hanford Townsite 25-4 riverbank seeps had detections. The

maximum concentration was recorded in at the 300 Area Spring DR 42-2 location (14.8 pCi/L ± 4.4 pCi/L) which fell just below the Washington State Ambient Water Quality criteria (15 pCi/L; DOE O 458.1).

During 2019, gross beta detections occurred in 100-K 63-1, 100-N 8-13, 100-N 89-1, 100-H 152-2, and Hanford Spring 25-4 Areas. Detectable concentrations in all riverbank seep water samples along the Hanford Spring Reach were elevated when compared to maximum gross beta concentrations in irrigation water collected from the Horn Rapids Battelle Sporting Complex (3.0 pCi/L ± 1.9 pCi/L) and Riverview (2.3 pCi/L ± 1.6 pCi/L) collection locations. The highest gross beta concentration was measured in the Hanford Townsite 28-2 riverbank seep (45 pCi/L ± 4.8 pCi/L [1.7 ± 0.18 Bq/L]), which was 90% of the Washington State ambient surface water quality criterion of 50 pCi/L (1.85 Bq/L; WAC 173-201A and 40 CFR 141).

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 (i.e., 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.

Nitrate concentrations were highest in a seep water sample from 100-F Spring 211-1 (31,300 µg/L). Dissolved chromium concentrations were highest in the 100-B Spring 39-2 Area (8.3 µg/L).

Concentrations of most metals measured in water collected from seeps along the Hanford Site shoreline during 2014 through 2019 were below the Washington State ambient surface water chronic toxicity levels (WAC 173-201A). All 2019 riverbank seep nitrate concentrations exceeded the Washington State drinking water standard of 10 µg/L (WAC 246-290). However, it is extremely unlikely that members of the public would ever consume riverbank seep water.

Results from organic analyses of water samples are voluminous and not all results are included in this report. A complete listing may be found in the Hanford Environmental Information System database. The two major organic contaminants monitored in 2019 were trichloroethane and dichloroethane, compounds used during past reactor fuel fabrication in the 300 Area. These contaminants were measured in transect and shoreline seep water collected upstream and downstream of the Hanford Site and in the vicinity of the 300 Area. Analytical results for these samples showed concentrations below their respective EPA Drinking Water Standards (Appendix C, Table C-12).

7.4.3 Sediment Monitoring

Beginning in the 1990s, periodic studies were conducted to collect and analyze sediments at riverbank seeps in the 100 and 300 Areas (DOE/RL-92-12; WHC-EP-0609; WHC-SD-EN-TI-125; WHC-SD-EN-TI-198). Routine sediment sampling began in 1993 at the Hanford Townsite and the 300 Area. Sampling in the 100-B, 100-K, and 100-F Areas began during 1995 and the 100-H Area was added in 2004.

Over the years, as a result of fluctuating groundwater shoreline discharge patterns, sediment collection locations have been moved, added, and/or abandoned. In 2019, sediment samples were collected from riverbank seep locations in the 100-D, 100-H, 100-K, and 300 Areas. (Table 7-7).

Table 7-7. Sediment Samples at Riverbank Seep Locations.

Location[a]	Sampling Frequency	Analyses
100-D Area	Annually	Anions, Cr+6, gamma energy analysis, isotopic uranium[b], isotopic plutonium[c], metals, mercury, strontium-90, and total organic carbon
100-H Area	Annually	Anions, Cr+6, gamma energy analysis, isotopic uranium[b], isotopic plutonium[c], metals, mercury, strontium-90, and total organic carbon
100-K Area	Annually	Anions, carbon-14, Cr+6, gamma energy analysis, isotopic uranium[b], isotopic plutonium[c], metals, mercury, strontium-90, and total organic carbon
300 Area	Annually	Anions, Cr+6, gamma energy analysis, isotopic uranium[b], isotopic plutonium[c], metals, mercury, strontium-90, total organic carbon, and uranium-236

[a] Refer to Figure 7-14
[b] Uranium-234, uranium-235, and uranium-238
[c] Plutonium-238 and plutonium 239/240

7.4.3.1 Radiological Results.

Radiological results for the 2019 shoreline seep sediment samples were similar to those measured in Columbia River sediment samples collected at Priest Rapids and McNary Dams. Cesium-137 and uranium isotopes were consistently detected at low levels at most sediment sample locations. Table C-13 in Appendix C shows radionuclide concentrations in Columbia River and shoreline seep location sediment samples from 2014 through 2019.

7.4.3.2 Metals Results.

Concentrations of metals in Hanford Reach sediment samples collected in 2019 were similar to concentrations found in McNary and Priest Rapids Dam sediment samples, with the exception of antimony, where higher average concentrations were seen. Shoreline sediment collected from the 100--H Spring 145-1 area had the highest level of arsenic (11.3 mg/kg) when compared to other Reach and Columbia River sediment samples. The highest concentrations of beryllium (2.1 mg/kg) and chromium (47.3 mg/kg) was measured in a sample from the 100-D Spring 102-1 location. Lead concentrations found in the Hanford Slough (54.9 mg/kg) topped all other 2019 sediment collections (Appendix C, Table C-16). Currently, there are no Washington State freshwater sediment quality criteria to compare against the measured values.

7.4.3.3 Hexavalent Chromium Results.

All 2019 sediment sample collections were recorded as non-detects. The McNary and Priest Rapids Dam sediment samples had the highest concentrations of hexavalent chromium when compared to all other sediment collection locations (Appendix C, Table C-17).

7.4.3.4 Total Organic Carbon Results.

All Columbia River sediment samples collected in 2019 had detections of Total Organic Carbon. Results were similar to those observed in previous years from the same locations. The highest result was found in a 2019 Priest Rapids Dam sample that mirrored historical observations (Appendix C, Table C-18).

7.5 Pond Water and Sediment

West Lake pond water and sediment (Figure 7-3) sampling was conducted twice (during early spring/late spring) during 2019. West Lake is accessible to migratory waterfowl, deer, and other wildlife, creating a potential biological pathway for the dispersion of contaminants.

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 Water

Water monitoring continued at West Lake in 2019 with sampling conducted twice during the year (early and late spring). Samples collected from West Lake were analyzed for tritium, uranium-234, uranium-235, uranium-238, and technetium-99. Technetium-99 and tritium concentrations were below the laboratory detection limits and were well below applicable DOE-Biota Concentration Guide levels (DOE/EH-0676) for aquatic animal receptors. Radionuclide concentrations from surface water samples collected during 2019 and in the previous 2 years are shown in Appendix C, Table C-2.

Isotopes of uranium were detected in all samples at varied concentrations, and all levels were within the historic range of sample results for this location (Figure 7-15).

7.5.2 West Lake Sediment

Biannual Sediment samples were collected during early and late spring from West Lake during 2019. The sediment sample was collected from upper-layer material near the pond shoreline.

The West Lake sediment samples were 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. There were detections for all analytes with the exception of technetium-99. Detections of all radionuclides during 2019 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 2019 and a summary of those collected during the previous 5 years are shown in Appendix C, Table C-1.

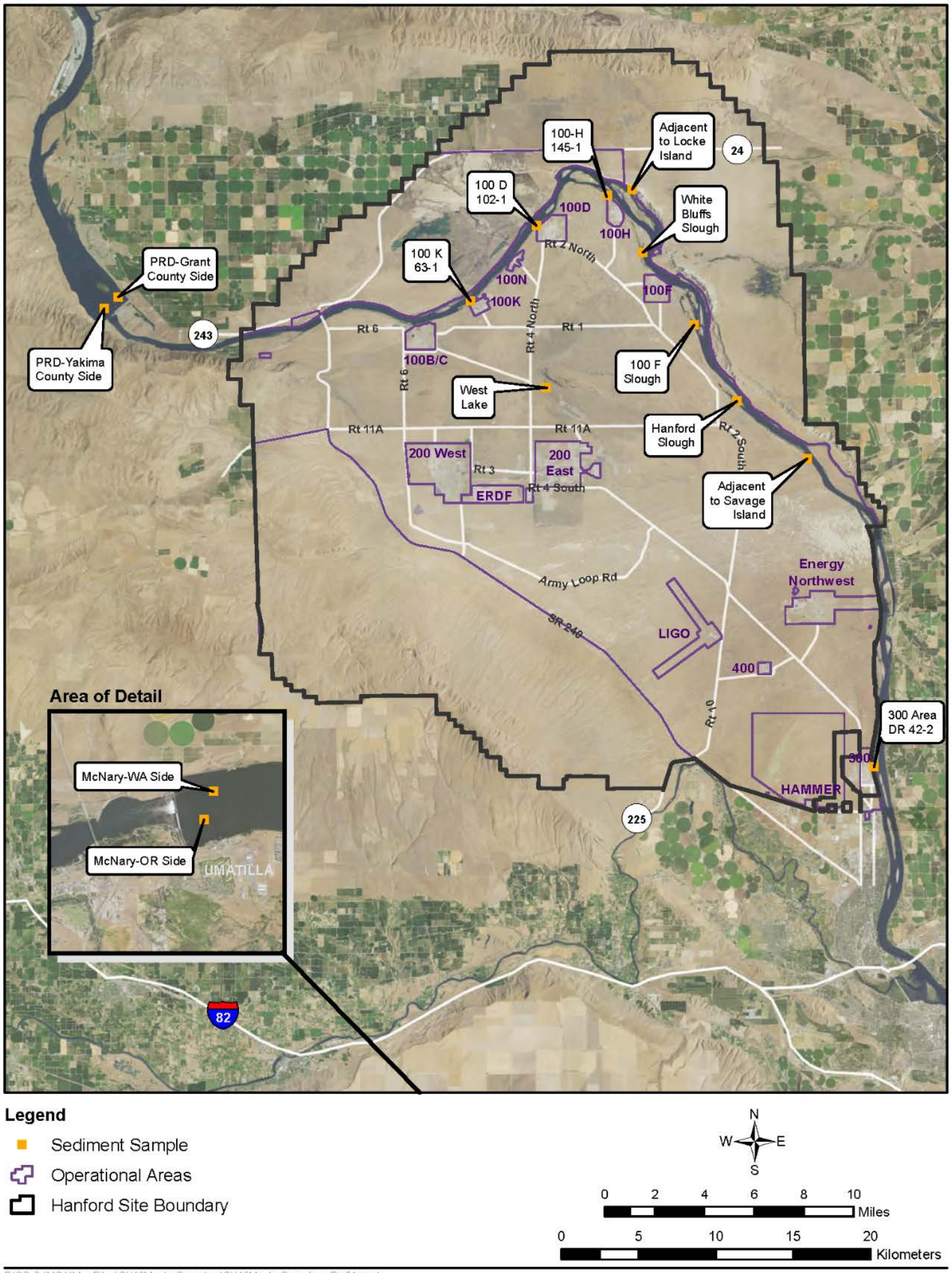

Figure 7-14. Sediment Collections Sampling Locations Collected in Fiscal Year 2019.

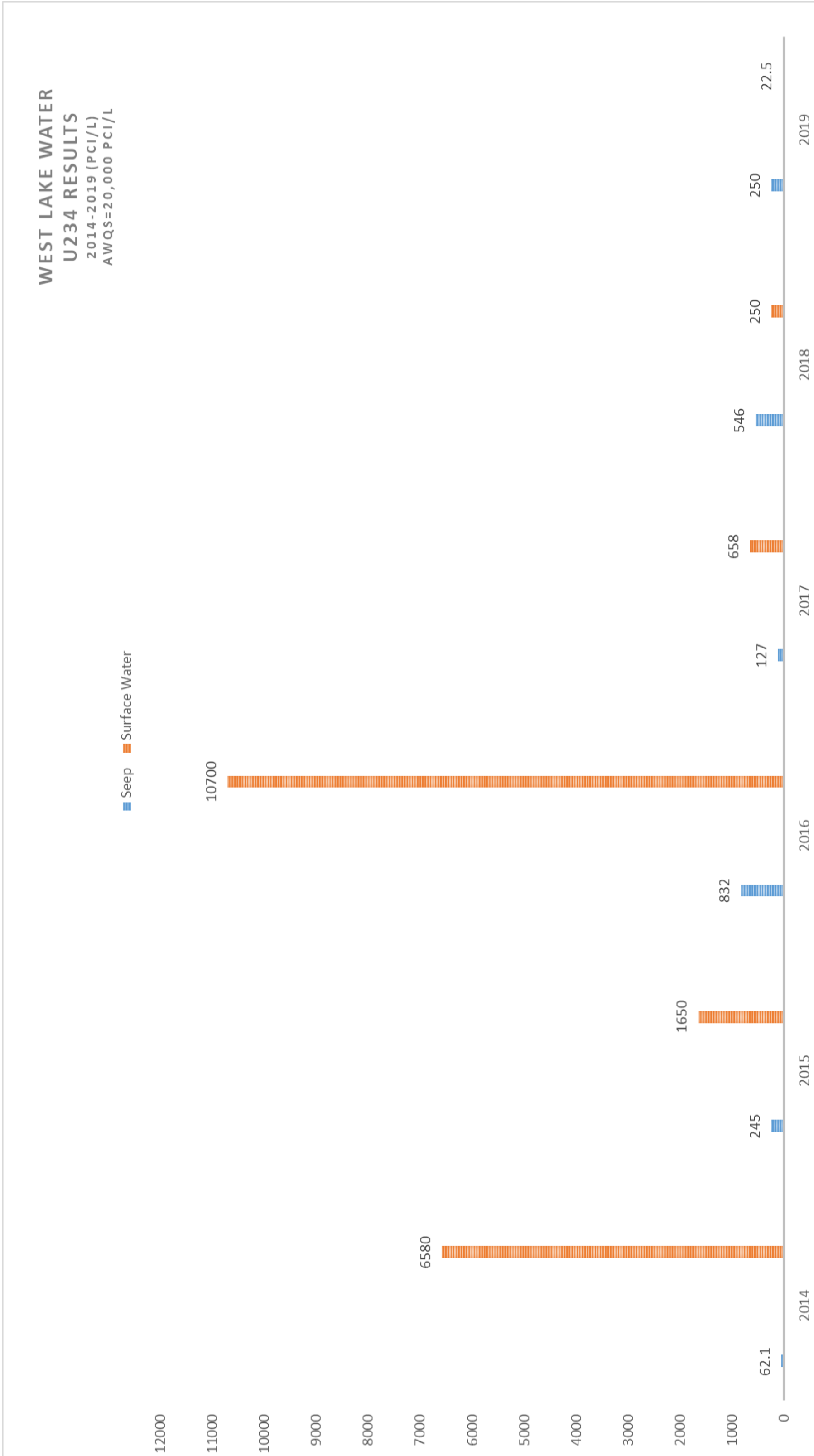

Figure 7-15. 2014 Through 2019 West Lake Uranium-234 Water Results.

7.6 Offsite Irrigation Water

Water extracted from the Columbia River immediately downstream of the Hanford Site is used to irrigate agricultural areas in Benton and Franklin Counties. The majority of irrigation water utilized in Franklin County originates at Grand Coulee Dam and is provided through its extensive water delivery systems (i.e., canals). Similarly, Benton County relies heavily on the Yakima River for irrigation.

Sampling of irrigation water is conducted to monitor for the presence of radionuclides. The consumption of food products (Section 10.1) irrigated with Columbia River water downstream of the Hanford Site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual and any other member of the public (Section 4.2.1).

7.6.1 Offsite Irrigation Water Monitoring

Irrigation water samples were collected in 2019 from a canal located on the east side (left bank) of the Columbia River downstream of the Hanford Site at Riverview (Road 68 in Pasco), from another irrigation line located on the west side (right bank) of the Columbia River just downstream of the 300 Area (Battelle Sporting Complex), and from an additional canal located in the Sagemoor area that is utilized as a reference location (water drawn from the potholes area). Samples from the Horn Rapids irrigation pumping station (Figure 7-3) were collected at the Battelle Sporting Complex. Each location was sampled three times during the irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, strontium-90, and tritium.

7.6.2 Sample Results

Radionuclide concentrations measured in irrigation water samples collected during 2019 were close to levels detected in Columbia River transect water samples collected upstream (Vernita Bridge HRM 0.3) and downstream (RPH-HRM 46.4) of the Hanford Site

Tritium was the only radionuclide detected in any of the samples collected during 2019. Maximum tritium levels from irrigation water collected in the Riverview (16.0 pCi/L; 0.59 Bq/L) and the Sagemoor area (18.7 pCi/L; 0.70 Bq/L) were comparable, while the Horn Rapids area (38.8 pCi/L; 1.4 Bq/L) had the highest concentrations reported. The 2019 Columbia River transect average tritium results from Vernita measured 17.1 pCi/L (0.63 Bq/L), while those at Richland had an average concentration of 23.1 p/Ci/L (0.85 Bq/L).

The 2019 irrigation results were also similar to concentrations reported in the fixed-station locations in Richland, Washington, and at Priest Rapids Dam. The Columbia River Priest Rapids Dam fixed-station water average tritium concentration was 17.5 pCi/L (0.65 Bq/L), while the Columbia River Richland Pumphouse fixed-station water had an annual average of 29.7 pCi/L (1.10 Bq/L). Radionuclide concentrations from irrigation water samples collected during 2019 and in the previous 5 years are shown in Appendix C, Tables C-19, C-20, and C-21.

7.7 Liquid Effluent

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During peak operating and production years at the Hanford Site from the 1940s through the 1990s, billions of gallons of effluent waste containing millions of kilograms of pollutants from reactor operations and chemical fuel processing were discharged to the Columbia River and soil column. Most of the discharges occurred in the 100 Reactor Areas along the river, 200-East Area, 200-West Area, and the 300 Area. As the mission of the Hanford Site shifted from production of nuclear materials to environmental cleanup, all discharges to the ground and Columbia River were ceased. Non permitted discharges to the ground stopped in the 1990s and the last permitted discharges to the Columbia River stopped in March 2011. In CY 2019, two permitted point sources discharged effluents to the ground and several permitted nonpoint sources also operated. Six groundwater pump–and-treat systems operated in the 200-West and 100 Areas discharging treated liquid effluents to the ground in CY 2019. See Section 8.0, Groundwater Monitoring, for more information on groundwater pump-and-treat systems.

7.7.1 Point Source Discharges

The EPA defines a point source of pollution in 40 CFR 122, "EPA administered Permit Programs: The National Pollutant Discharge Elimination System," as any discrete conveyance such as a pipe, ditch, channel, tunnel, conduit, well, discrete fissure, or container from which pollutants are or may be discharged. There are two liquid effluent point sources discharging liquids to the ground operated in CY 2019 on the Hanford Site: the Effluent Treatment Facility (ETF) and Treated Effluent Disposal Facility (TEDF).

7.7.1.1 200 Area Effluent Treatment Facility.

Hanford's ETF, in operation since 1995, is located in the 200-East Area and treats mixed radioactive and dangerous liquid waste. In 2019 the ETF treated and discharged approximately 4.7 million gal (17.8 million L) of liquid waste (Table 7-8). The ETF influent consists of multiple waste streams from Hanford facilities including process condensate from the 242-A Evaporator, leachate from land waste disposal sites, and water from the 100-K Basins. Most liquid waste streams are initially stored at the Liquid Effluent Retention Basin Facility, located near the ETF. The ETF waste treatment system removes toxic metals, radionuclides, and ammonia in addition to destroying organic compounds. After treatment, the liquid is not considered a dangerous waste per 40 CFR 261, Appendix IX, "Identification and Listing of Hazardous Waste." The liquid is stored in tanks, sampled, and analyzed for comparison with permit limits, then discharged in batches to the State-Approved Land Disposal Site (SALDS) located north of the 200-West Area (Figure 7-16) per the requirements of State Waste Discharge Permit Number ST0004500 (Ecology 2014).

The ETF waste treatment system does not remove tritium, a radioactive isotope of hydrogen, which cannot be easily or cost-effectively removed. The ST0004500 discharge permit does not include radionuclide limits as the EPA's definition of pollutant in 40 CFR 122 excludes radioactive materials regulated by DOE under the *Atomic Energy Act of 1954* (AEA). DOE O 458.1 requires the concentration of radioactive liquid discharges to be less than the derived concentration standard values established in DOE-STD-1196-2011, *Derived Concentration Technical Standard*. The location of SALDS was chosen because the long groundwater travel time required to migrate from this location to the Columbia River allows tritium concentrations to decrease to below the drinking water standard by dispersion and radiological decay. Hydrologic modeling, as well as analyses of groundwater, continues to demonstrate the disposal of tritium-containing water to SALDS is protective of the Columbia River.

Table 7-8 contains the volume of liquid discharged, curies of tritium released, average concentrations and fraction of the DOE derived concentration standard during CY 2019. See Appendix C, Table C-25 for a summary of ETF sample results. See Sections 5.2.11 for more information on ETF.

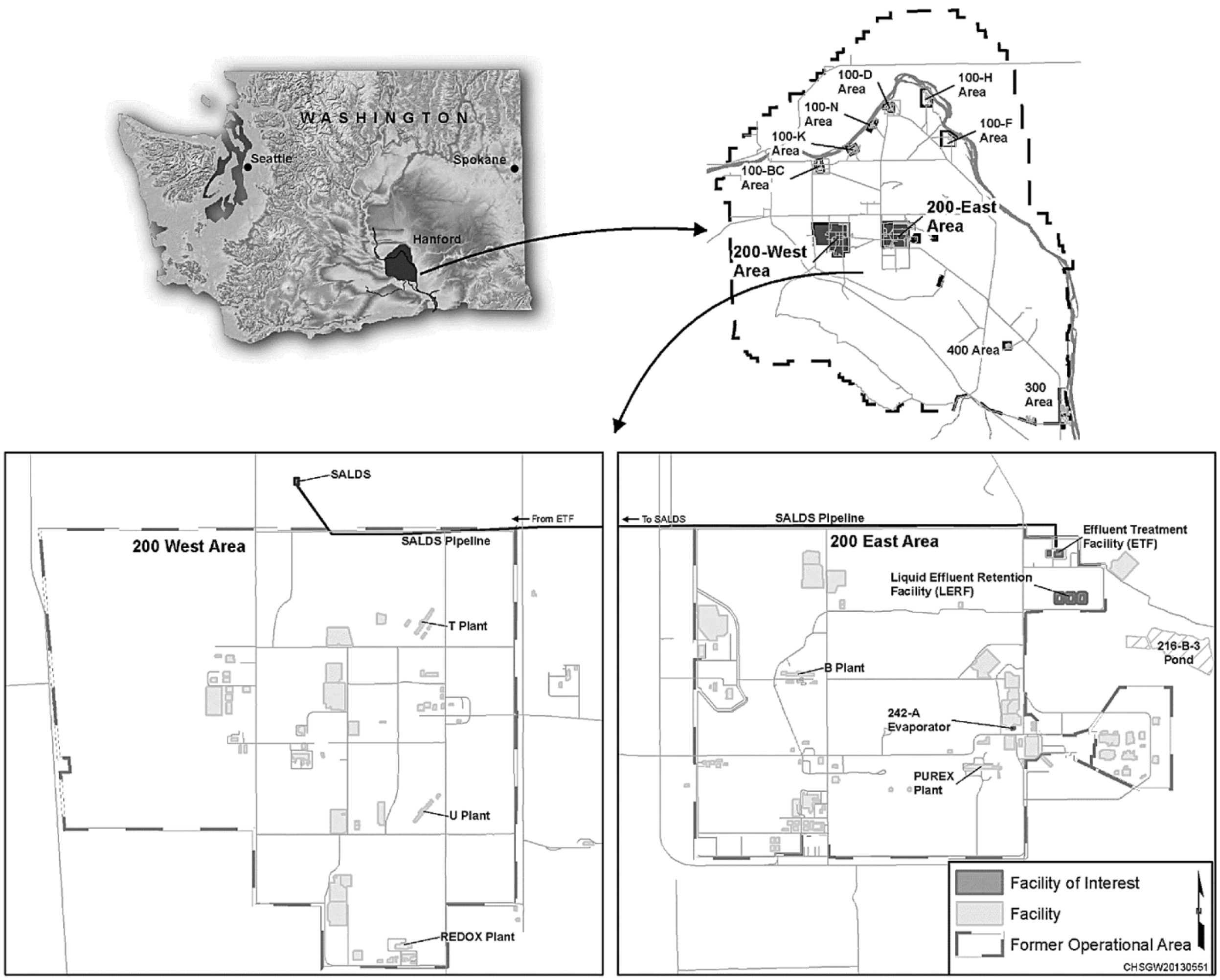

Figure 7-16. Location of Effluent Treatment Facility and State-Approved Land Disposal Site.

Table 7-8. Calendar Year 2019 Tritium Discharges to the State-Approved Land Disposal Site.

Month	Effluent Discharge (gal)	Tritium Released (Ci)	Average Concentration (µCi/mL)	Fraction of DCS (%)
January	0	0	0	0.0%
February	0	0	0	0.0%
March	0	0	0	0.0%
April	0	0	0	0.0%
May	899,344	2.90	8.5E-04	45%
June	625,256	0.98	4.1E-04	22%
July	633,043	0.75	3.1E-04	16%
August	1,251,293	1.49	3.1E-04	17%
September	535,711	0.54	2.6E-04	14%
October	537,269	0.61	3.0E-04	16%
November	0	0	0	0.0%
December	186,874	0.20	2.9E-04	15%
2019 TOTAL	4,668,790	7.45	4.2E-04	22%

Ci = curies
µCi/mL =micro-curies per milliliter
DCS =Derived Concentration Standard, ingested water for tritium = 1.9E-03 µCi/mL
SALDS =State Approved Land Disposal Site

7.7.1.2 200 Area Treated Effluent Disposal Facility.

The TEDF provides a collection, conveyance, and disposal system for treated effluent from buildings in the 200 Areas (Figure 7-17). It is located in the 200-East Area and consists of an 11 mi (17.7 km) long of buried pipelines connecting three pumping stations, the 6653 Building, and two 5-ac (2-ha) infiltration disposal ponds. The TEDF is a piped collection system that does not have any treatment or retention capacity. Wastewater generating processes include: cooling water, steam condensate, dryer condensate, air conditioning condensate, reverse osmosis unit brine, reverse osmosis permeate, potable water, raw water, rainwater, miscellaneous effluents, water softener regenerant, filter backwash, boiler blowdown, and cooling tower blowdown. The water from individual waste streams must be treated prior to transfer to TEDF. State Waste Discharge Permit Number ST0004502 (Ecology 2012a) provides the terms and conditions that regulate the discharge of this wastewater to the ground and ensures the discharges meet state standards in WAC 173-200, “Water Quality Standards.” The TEDF discharge is periodically sampled to verify permit compliance (Table C-25). The volume of non-radioactive, non-dangerous waste disposed to this facility in 2019 was approximately 75.7 million gal (287 million L). See Section 5.2.13 for more information on TEDF.

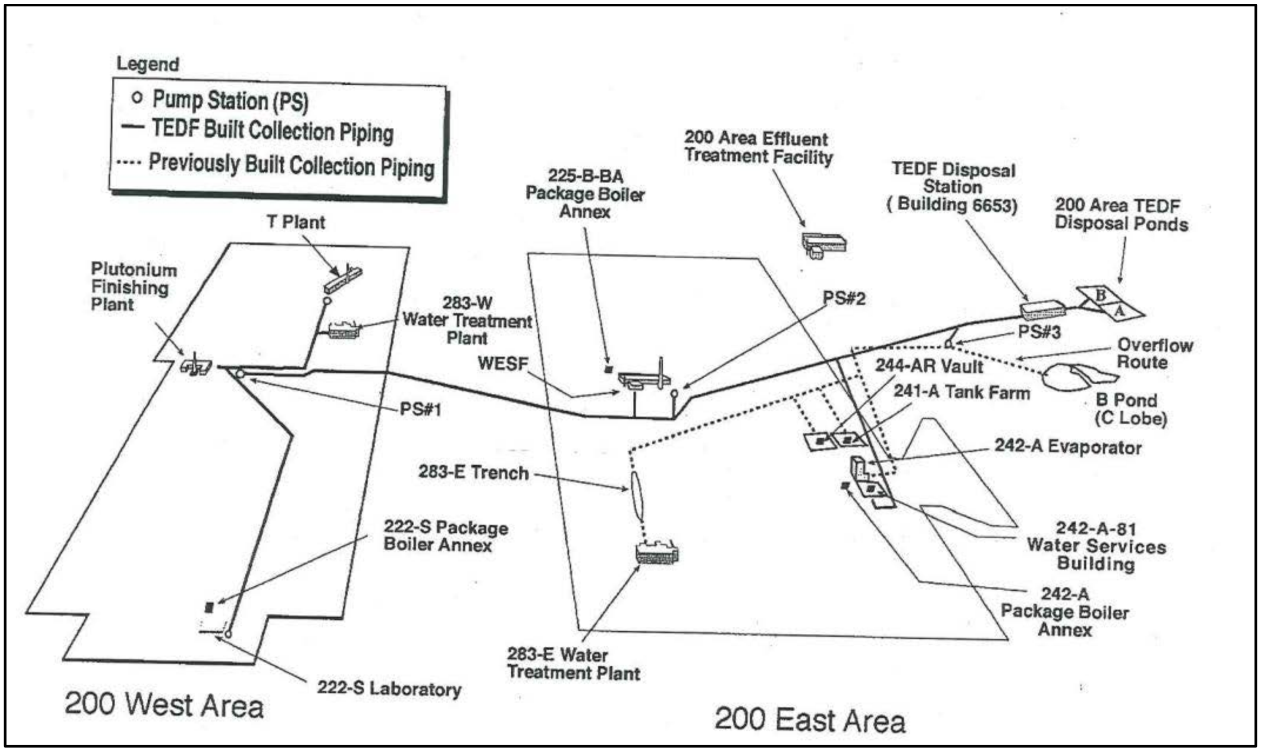

Figure 7-17. Location of the Treated Effluent Disposal Facility.

7.7.1.3 300 Area Discharges to the City of Richland Sewer.

The City of Richland regulates industrial wastewater discharges to its sewer collection system. DOE holds Permit No. CR-IU010, which allows discharges from contractor-operated facilities in the 300 Area.

7.7.2 Nonpoint Source Discharges

Nonpoint source discharges are effluents that occur over an area and are not easily attributed to a single point source. An example of a nonpoint source discharge is rain water or snowmelt runoff. Several permitted nonpoint discharges operated in CY 2019 on the Hanford Site.

7.7.2.1 Miscellaneous Wastewater Discharges.

The routine operations conducted at various locations on the Hanford Site periodically generate discharges of liquid waste streams. These types of miscellaneous wastewater discharges include hydrotesting water, construction, and maintenance wastewater; the discharge of cooling water and condensate; and the collection and the discharge of industrial stormwater. The terms and conditions regulating these wastewater discharges are included in a categorical State Waste Discharge Permit number ST0004511 (Ecology 2013).

7.7.2.2 Waste Treatment Plant.

The Hanford Tank Waste Treatment and Immobilization Plant (WTP) operates two state permitted sand and gravel locations. The concrete batch plant facility supports the construction of the WTP with the primary function of making concrete. The Pit 30 quarry also supports the construction of the WTP with the primary function of making gravel. The types of discharges include process water, storm water, and activities associated with sand and gravel operations and rock quarries. Permit conditions require the

permit holder to provide environmental protection through best management practices and wastewater treatment.

7.7.2.3 200-West Area Evaporative Sewage Lagoon.

The 200-West Area Evaporative Sewage Lagoon is a domestic wastewater treatment facility located northeast of the 200-West Area of the Hanford Site (Figure 7-18). The facility consists of double-lined evaporative lagoons and is designed and operated to have zero liquid discharge to the ground. The system provides domestic wastewater treatment for domestic wastewater transported from other locations within the Hanford Site. The DOE constructed the 200-West Area Evaporative Sewage Lagoon to replace the previously existing 100-N Sewage Lagoon, which was near the end of its service life. The majority of future Hanford Site cleanup activities are anticipated to be located in the vicinity of the 200 Areas and the siting of this treatment facility near 200-West better serves the cleanup mission over time. Although this facility is not permitted to discharge, except in the case of emergencies, State Waste Discharge Permit Number ST0045514 (Ecology 2012b) governs the operation and maintenance of this facility.

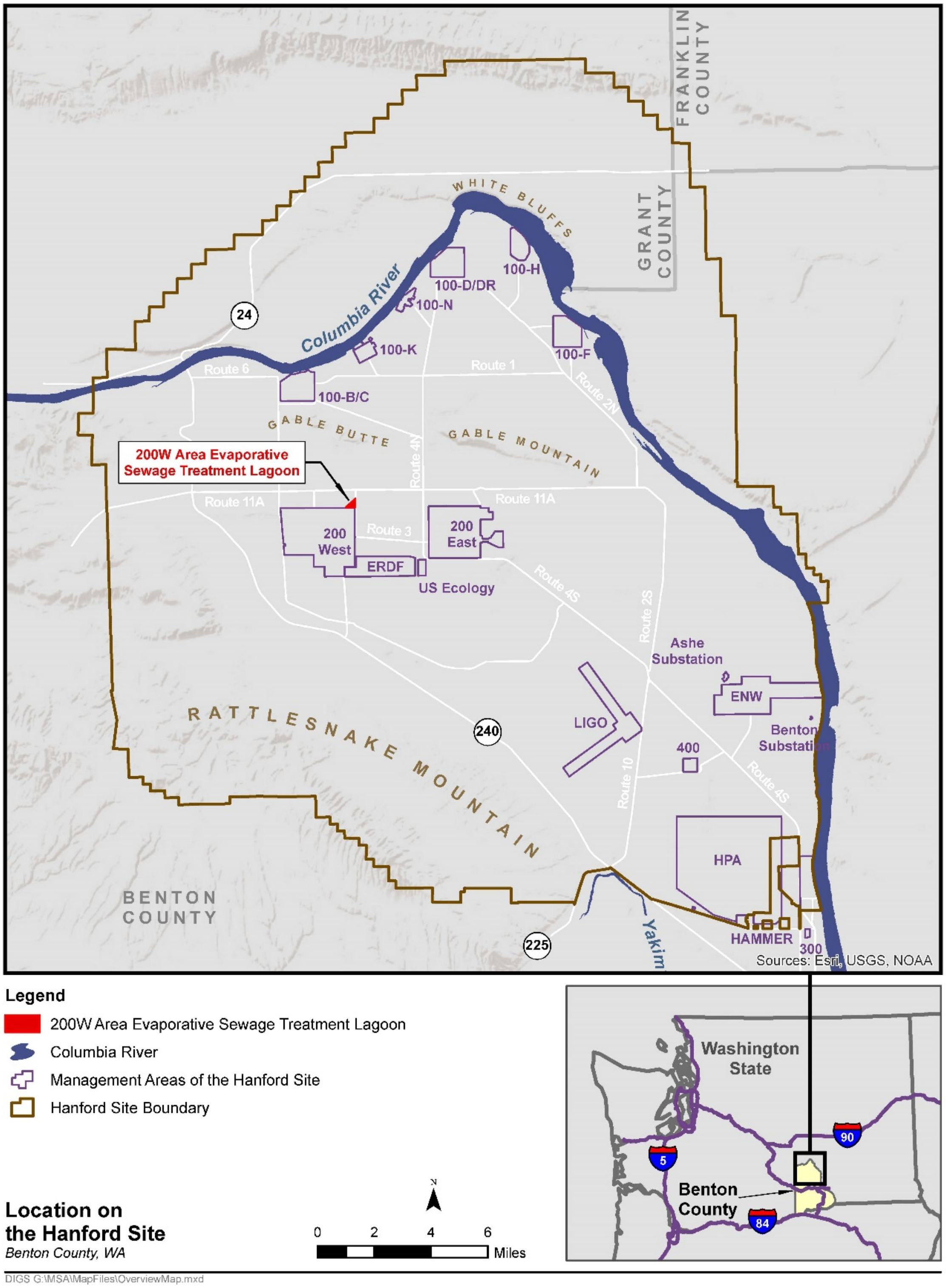

Figure 7-18. Location of the Evaporative Sewage Treatment Lagoon.

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