4.2 Surface Water and Sediment Surveillance

G. W. Patton

Samples of surface water and sediment on and near the Hanford Site were collected and analyzed to determine the potential impact to the public and to the aquatic environment from Hanford-originated radiological and chemical contaminants. Surface-water bodies included in routine surveillance were the Columbia River and associated riverbank springs, onsite ponds, and irrigation sources (Figure 4.2.1). Sediment surveillance was conducted for the Columbia River and riverbank springs. Tables 4.2.1 and 4.2.2 summarize the sampling locations, types, frequencies, and analyses included in surface water and sediment surveillance during 2001. This section describes the surveillance efforts and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-13910, APP. 1.

4.2.1 Columbia River Water

The Columbia River is the second largest river in the continental United States in terms of total flow and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production and processing was based, in part, on the abundant water supply offered by the river. The river flows through the northern edge of the site and forms part of the site's eastern boundary. The river is used as a source of drinking water for onsite facilities and communities located downstream from the Hanford Site. Water from the river downstream of the site also is used for crop irrigation. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water-skiing, and swimming.

Originating in the mountains of eastern British Columbia, the Columbia River and its tributaries drain an area of ~670,000 square kilometers (260,000 square miles) en route to the Pacific Ocean. The flow of the river is regulated by three dams in Canada and eleven dams in the United States, seven upstream and four downstream of the Hanford Site. Priest Rapids Dam is the nearest upstream dam and McNary Dam is the nearest downstream dam from the site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam) near Richland, Washington. The Hanford Reach is the last stretch of the Columbia River in the United States above Bonneville Dam that remains unimpounded.

River flow through the Hanford Reach fluctuates significantly and is controlled primarily by operations at Priest Rapids Dam. Annual average flows of the Columbia River below Priest Rapids Dam are usually around 3,400 cubic meters (120,000 cubic feet) per second (WA-94-1). In 2001, however, the Columbia River had below normal flows; the average daily flow rate below Priest Rapids Dam was 2,140 cubic meters (75,700 cubic feet) per second. The peak monthly average flow rate occurred during January (3,820 cubic meters [135,000 cubic feet] per second) (Figure 4.2.2). The lowest monthly average flow rate occurred during July (1,600 cubic meters [56,600 cubic feet] per second). Daily flow rates varied from 1,040 to 3,820 cubic meters (36,800 to 135,000 cubic feet) per second during 2001. As a result of fluctuations in discharges, the depth of the river varies significantly over time. River stage (surface level) may change along the Hanford Reach by up to 3 meters (10 feet) within a few hours (Section 3.3.7 in PNL-10698). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are approximately half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (PNL-8580) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from ~300 to 1,000 meters (~980 to 3,300 feet) through the Hanford Site.

Hanford pollutants, both radiological and chemical, enter the Columbia River along the Hanford Reach. In

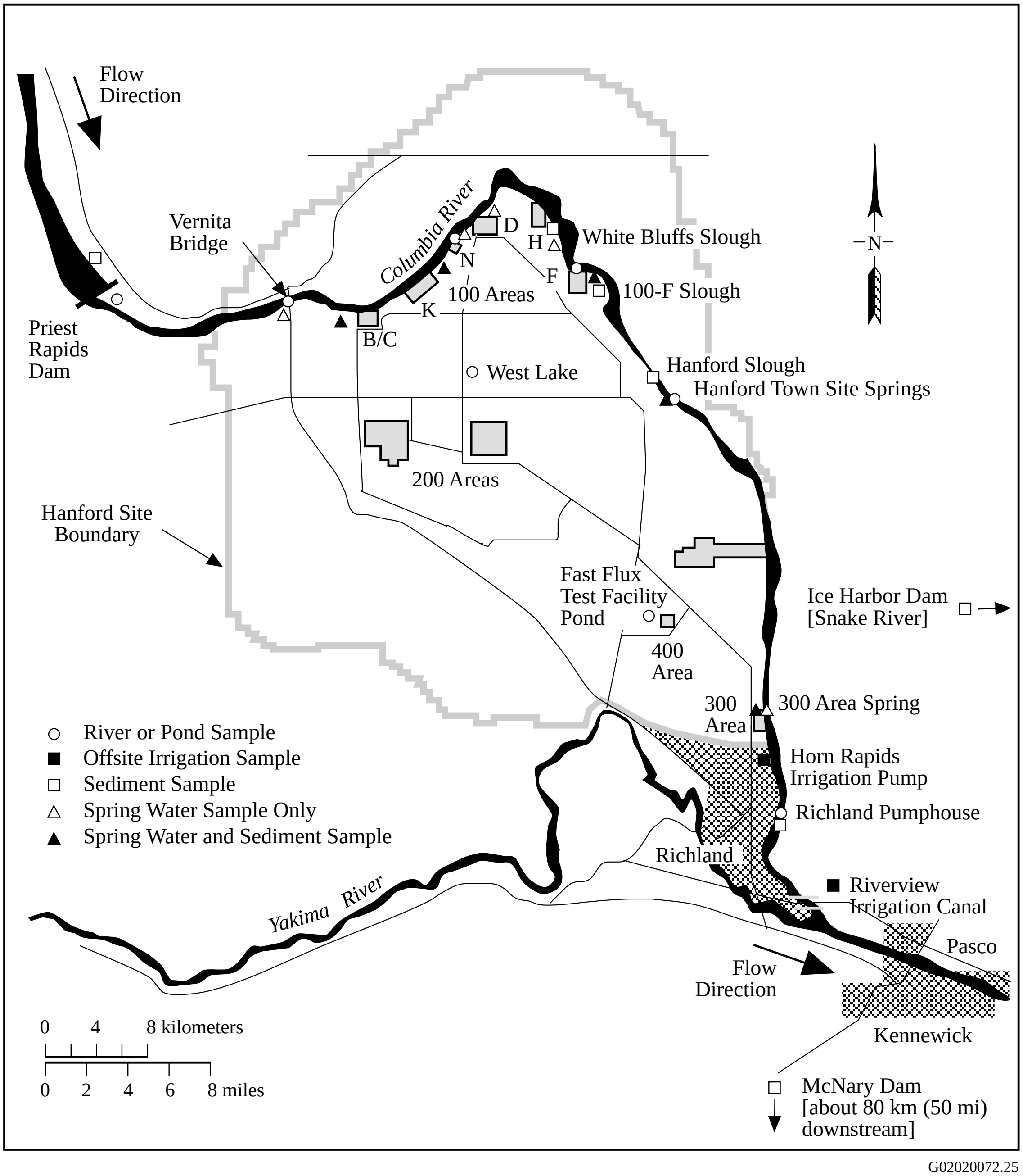

Figure 4.2.1. Sampling Locations for Water and Sediment, 2001

addition to permitted direct discharges of liquid effluents from Hanford facilities, contaminants in groundwater from past operational discharges to the ground seep into the river (DOE/RL-92-12; PNL-5289; PNL-7500; WHC-SD-EN-TI-006). Effluents from each direct discharge point are monitored routinely and reported by the responsible operating contractor (see Section 3.1). Direct discharges are identified and regulated for non-radiological constituents under the National Pollutant Discharge Elimination System in compliance with the *Clean Water Act*. The discharges permitted at the Hanford Site by National Pollutant Discharge Elimination System are summarized in Section 2.2.8.

Washington State has classified the stretch of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (WAC 173-201A). Water quality criteria and water use guidelines have been established in conjunction with this designation and are provided in Appendix D (Table D.1).

Table 4.2.1. Surface Water Surveillance, 2001

Location	Sample Type	Frequency[a]	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland Pumphouse	Cumulative	M Comp[b] Q Comp[e]	Alpha, beta, lo ^{3}H,[c] ^{90}Sr, ^{99}Tc, U[d] ^{129}I
	Particulate (filter)	M Cont[f] Q Cont[g]	Gamma energy analysis Pu[h]
	Soluble (resin)	M Cont Q Cont	Gamma energy analysis Pu
Vernita Bridge and Richland Pumphouse	Grab (transects)	Q	lo ^{3}H, ^{90}Sr, U
100-F, 100-N, 300, and Hanford town site	Grab (transects)	A	lo ^{3}H, ^{90}Sr, U
Columbia River - Non-Radiological			
Vernita Bridge and Richland Pumphouse[i]	Grab	Q	NASQAN, temperature, dissolved oxygen, turbidity, pH, alkalinity, anions, suspended solids, dissolved solids, specific conductance, hardness (as $CaCO_3$), Ca, P, Cr, Mg, N-Kjeldahl, Fe, NH_3, NO_3 + NO_2
	Grab (transects)	Q	ICP[j] metals, anions
	Grab (transects)	A	VOA[k]
100-F, 100-N, 300, and Hanford town site	Grab (transects)	A	ICP metals, anions
Onsite Ponds			
West Lake	Grab	Q	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma energy analysis
Fast Flux Test Facility pond	Grab	Q	Alpha, beta, ^{3}H, gamma energy analysis
Offsite Irrigation Water			
Riverview irrigation canal	Grab	3/year	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma energy analysis
Horn Rapids	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma energy analysis
Riverbank Springs			
100-H Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma energy analysis, ICP metals, anions
100-F Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma energy analysis, ICP metals, anions, VOA
100-B Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, gamma energy analysis, ICP metals, anions, VOA
100-D, 100-K, and 100-N Areas	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, gamma energy analysis, ICP metals, anions, VOA (100-K Area only)
Hanford town site	Grab	A	Alpha, beta, ^{3}H, ^{129}I, ^{90}Sr, ^{99}Tc, U, gamma energy analysis, ICP metals, anions
300 Area	Grab	A	Alpha, beta, ^{3}H, ^{129}I, ^{90}Sr, gamma energy analysis, ICP metals, anions, VOA

(a) A = Annually; M = Monthly; Q = Quarterly; Comp = Composite.
(b) M Comp indicates river water was collected hourly and composited monthly for analysis.
(c) lo ^{3}H = Low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.
(d) U = Isotopic uranium-234, -235, and -238.
(e) Collected weekly and composited for quarterly analysis.
(f) M Cont = River water was sampled for 2 wk by continuous flow through a filter and resin column and multiple samples were composited monthly for analysis.
(g) Q Cont = River water was sampled for 2 wk by continuous flow through a filter and resin column and multiple samples were composited quarterly for analysis.
(h) Pu = Isotopic plutonium-238 and -239/240.
(i) Numerous water quality analyses are performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network (NASQAN) Program.
(j) ICP = Inductively coupled plasma analysis method.
(k) VOA = Volatile organic compounds.

Table 4.2.2. Sediment Surveillance, 2001

Location[a]	Frequency	Analyses
River		All river sediment analyses included gamma energy analysis, ^{90}Sr, U[b], Pu[c], ICP[d] metals
Priest Rapids Dam: 2 locations near the dam	A[e]	
White Bluffs Slough	A	
100-F Slough	A	
Hanford Slough	A	
Richland	A	
McNary Dam: 2 locations near the dam	A	
Ice Harbor Dam: 3 locations near Levy Landing	A	
Springs[f]		All springs sediment analyses included gamma energy analysis, ^{90}Sr, U, ICP metals
100-B Area	A	
100-K Area	A	
100-N Area	A	
100-F Area	A	
Hanford town site springs	A	
300 Area	A	

(a) See Figure 4.2.1.
(b) U = Uranium-235 and -238 analyzed by low-energy photon analysis.
(c) Pu = Isotopic plutonium-238 and -239/240.
(d) ICP = Inductively coupled plasma analysis method.
(e) A = Annually.
(f) Sediment is collected when available.

4.2.1.1 Collection of River-Water Samples and Analytes of Interest

Samples of Columbia River water were collected throughout 2001 at the locations shown in Figure 4.2.1. Samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse and from Columbia River transects and near-shore locations near the Vernita Bridge, 100-F Area, 100-N Area, Hanford town site, 300 Area, and Richland Pumphouse. Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and Vernita Bridge to provide background data from locations unaffected by site operations. Samples were collected from all other locations to identify any increase in contaminant concentrations attributable to Hanford operations. The Richland Pumphouse is the first downstream point of Columbia River water withdrawal for a municipal drinking water supply.

The fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse consisted of both an automated sampler and a continuous flow system. Using the automated sampler, unfiltered samples of Columbia River water (cumulative samples) were obtained hourly and collected weekly. Weekly samples were combined into monthly composite samples for radiological analyses (see Table 4.2.1). Using the continuous flow system, particulate and soluble constituents in Columbia River water were collected by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in detail in DOE/RL-91-50.

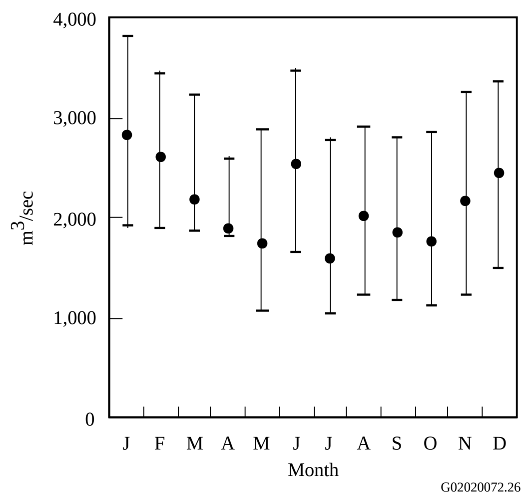

Figure 4.2.2. Mean, Maximum, and Minimum Monthly Columbia River Flow Rates at Priest Rapids Dam, 2001

Radionuclides of interest were selected for analysis based on

- their presence in effluents discharged from site facilities or in near-river groundwater underlying the Hanford Site
- their importance in determining water quality, verifying effluent control and monitoring systems, and determining compliance with applicable standards.

Analytes of interest in water samples collected from Priest Rapids Dam and the Richland Pumphouse included gross alpha, gross beta, selected gamma emitters, tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, -238, plutonium-238, and plutonium-239/240. Gross alpha and beta measurements are indicators of the general radiological quality of the river and provide a timely indication of change. Gamma energy analysis provides the ability to detect numerous specific radionuclides (see Appendix F). Sensitive radiochemical analyses were used to determine the concentrations of tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, -238, plutonium-238, and plutonium-239/240 in river water during the year. Analytical detection levels for all radionuclides were less than 12% of their respective water quality criteria levels (see Appendix D, Tables D.1 and D.2).

Transect sampling (multiple samples collected along a line across the Columbia River) was initiated as a result of findings of a special study conducted during 1987 and 1988 (PNL-8531). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed when sampled at routine monitoring stations located downriver. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point, sampling system at the Richland Pumphouse. In 1999, the transect sampling strategy was modified, with some of the mid-river sampling points shifted to near-shore locations in the vicinity of the transect. For example, at the 100-N Area instead of collecting ten evenly-spaced cross-river transect samples, only six cross-river samples were collected, and the other four samples were obtained at near-shore locations. This sampling pattern allows the cross-river concentration profile to be determined and provides information over a larger portion of the Hanford shoreline where the highest contaminant concentrations would be expected. The Vernita Bridge and the Richland Pumphouse transects and near-shore locations were sampled quarterly during 2001. Annual transect and near-shore sampling was conducted at the 100-F Area, 100-N Area, Hanford town site, and 300 Area locations in late summer when river flows were low.

Columbia River transect water samples collected in 2001 were analyzed for both radiological and chemical contaminants (see Table 4.2.1). Metals and anions were selected for analysis following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67; PNL-8073; PNL-8654; PNL-10400; PNL-10535). All radiological and chemical analyses of transect samples were performed on grab samples of unfiltered water, except for metals analyses, which were performed on both filtered and unfiltered samples.

In addition to radiological monitoring conducted, non-radiological water quality monitoring was performed by the U.S. Geological Survey. Samples were collected along Columbia River transects quarterly at the Vernita Bridge and the Richland Pumphouse (see Appendix B, Table B.5). Sample analyses were performed at the U.S. Geological Survey laboratory in Denver, Colorado for numerous physical parameters and chemical constituents.

4.2.1.2 Radiological Results for River-Water Samples

Fixed Location Sampling. Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the Richland Pumphouse during 2001 are reported in PNNL-13910, APP. 1 and summarized in Appendix B (Tables B.1 and B.2). These tables also list the maximum and mean concentrations of selected radionuclides detected in Columbia River water in 2001 and during the previous 5 years. All radiological contaminant concentrations measured in Columbia River water in 2001 were less than DOE derived concentration guides (DOE Order 5400.5) and Washington State ambient surface-water quality criteria (WAC 173-201A and 40 CFR 141; see Appendix D, Tables D.5, D.3, and D.2). Significant results are discussed in the following paragraphs, and comparisons to previous years are provided.

Radionuclide concentrations monitored in Columbia River water were low throughout the year. During 2001, the radionuclides consistently detected in river water greater than two times their associated total propagated analytical uncertainty included tritium, strontium-90, iodine-129, uranium-234, -238, plutonium-239/240, and naturally occurring beryllium-7 and potassium-40. The concentrations of all other radionuclides were typically below detection limits. Tritium, strontium-90, iodine-129, and plutonium-239/240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford Site effluents.

Figures 4.2.3 and 4.2.4 illustrate the average annual gross alpha and gross beta concentrations, respectively, at Priest Rapids Dam and the Richland Pumphouse during the past 6 years. The 2001 average gross alpha and gross beta concentrations were similar

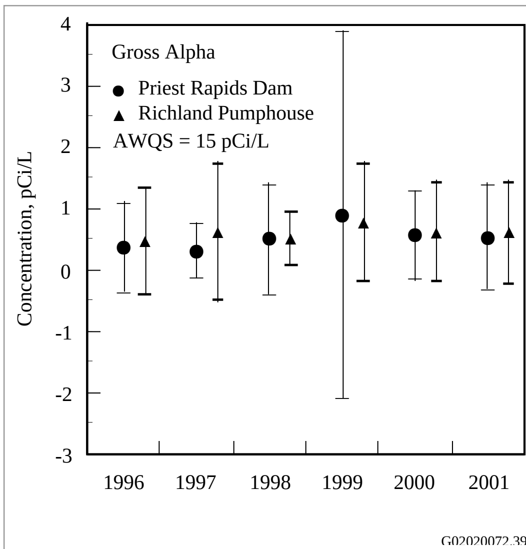

Figure 4.2.3. Annual Average Gross Alpha Concentrations (±2 standard deviations) in Columbia River Water, 1996 through 2001 (AWQS = ambient water quality standard)

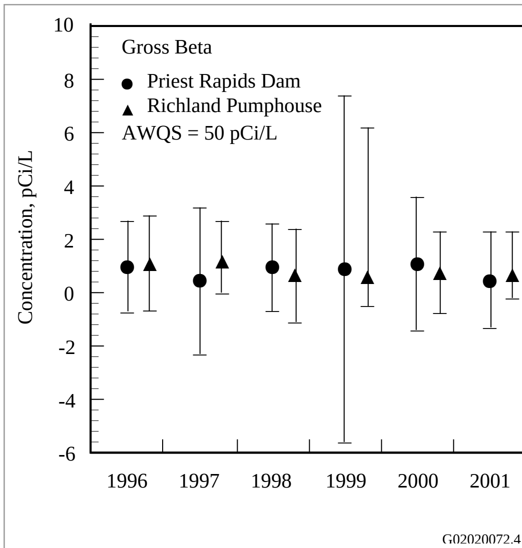

Figure 4.2.4. Annual Average Gross Beta Concentrations (±2 standard deviations) in Columbia River Water, 1996 through 2001 (AWQS = ambient water quality standard)

to those observed during recent years. Monthly measurements at the Richland Pumphouse in 2001 were not statistically higher than those measured at Priest Rapids Dam. Unless otherwise noted in this section, the statistical tests for differences are paired sample comparisons and two-tailed t-tests, 5% significance level. The average alpha concentration in Columbia River water at the Richland Pumphouse in 2001 was less than the state ambient surface-water quality criteria level of 15 pCi/L (0.56 Bq/L).

Figure 4.2.5 compares the annual average tritium concentrations at Priest Rapids Dam and Richland Pumphouse from 1996 through 2001. Statistical analysis indicated that monthly tritium concentrations in river water samples at the Richland Pumphouse were higher than concentrations in samples from Priest Rapids Dam. However, 2001 average tritium concentrations in Columbia River water collected at the Richland Pumphouse were only 0.4% of the state ambient surface-water quality criteria level of 20,000 pCi/L (740 Bq/L). Onsite sources of tritium entering the river include groundwater seepage and direct discharge from permitted outfalls located in the 100 Areas (see Sections 3.1 and 7.1). Tritium concentrations measured at the Richland Pumphouse, while representative of river water used by the city of Richland for drinking water, tend to overestimate the average tritium concentrations across the river at this location (PNL-8531). This bias is attributable to the contaminated 200 Areas' groundwater plume entering the river along the portion of shoreline

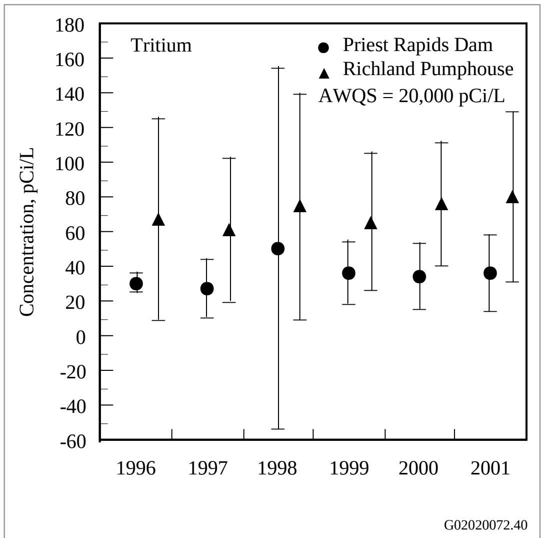

Figure 4.2.5. Annual Average Tritium Concentrations (±2 standard deviations) in Columbia River Water, 1996 through 2001 (AWQS = ambient water quality standard)

extending from the Hanford town site to below the 300 Area, which is relatively close to the Richland Pumphouse sample intake. This plume is not completely mixed within the river at the Richland Pumphouse. Sampling along cross-river transects at the pumphouse during 2001 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken from the Richland Pumphouse 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.

The annual average strontium-90 concentrations in Columbia River water collected from Priest Rapids Dam and the Richland Pumphouse from 1996 through 2001 are presented in Figure 4.2.6. Levels observed in 2001 were similar to those reported previously. Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas (see Section 6.1.6.1). Some of the highest strontium-90 levels that have been found in onsite groundwater are the result of past discharges to the 100-N Area liquid waste disposal facilities. Despite the Hanford Site source, there was no statistical difference between monthly strontium-90 concentrations at Priest Rapids Dam and the Richland Pumphouse in 2001. Average strontium-90 concentrations in Columbia River water at the Richland Pumphouse were less than 0.8% of the 8-pCi/L (0.30-Bq/L) state ambient surface-water quality criteria level.

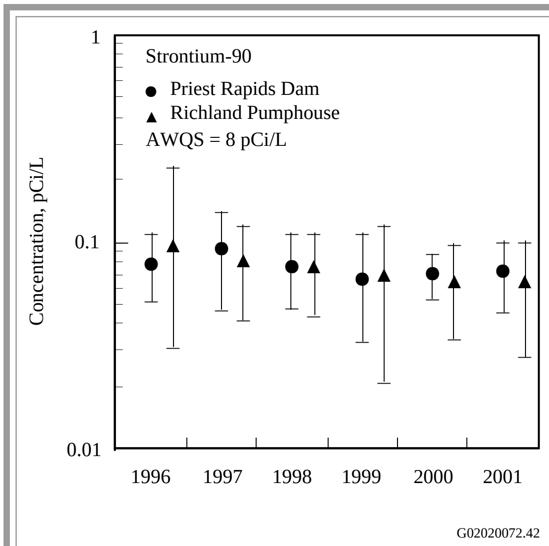

Figure 4.2.6. Annual Average Strontium-90 Concentrations (±2 standard deviations) in Columbia River Water, 1996 through 2001 (AWQS = ambient water quality standard)

Annual average total uranium concentrations (i.e., the sum of uranium-234, -235, -238) at Priest Rapids Dam and the Richland Pumphouse for 1996 through 2001 are shown in Figure 4.2.7. Total uranium concentrations observed in 2001 were similar to those observed during recent years. Monthly total uranium concentrations measured at the Richland Pumphouse in 2001 were statistically higher than those measured at

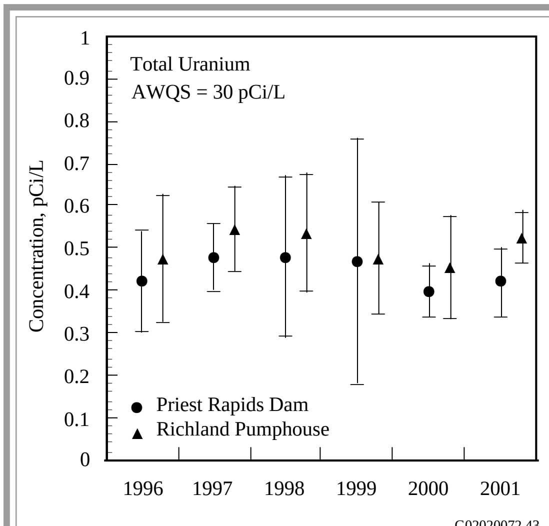

Figure 4.2.7. Annual Average Total Uranium Concentrations (±2 standard deviations) in Columbia River Water, 1996 through 2001 (AWQS = ambient water quality standard)

Priest Rapids Dam. Although there is no direct process discharge of uranium to the river, uranium is present in the groundwater beneath the 300 Area as a result of past Hanford operations (see Section 6.1). Hanford groundwater discharges to the Columbia River and groundwater contaminants have been detected at elevated levels in riverbank springs at the 300 Area (see Section 4.2.3). Naturally occurring uranium is also known to enter the river across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500). There are no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium levels in the river during 2001 were well below the EPA drinking water standard of 30 µg/L (~27 pCi/L [1.0 Bq/L], Appendix D, Table D.2).

The annual average iodine-129 concentrations at Priest Rapids Dam and the Richland Pumphouse for 1996 through 2001 are presented in Figure 4.2.8. The average iodine-129 concentration in Columbia River water at the Richland Pumphouse was extremely low during 2001 (0.012% of the state ambient surface-water quality criteria level of 1 pCi/L [1 million aCi/L {0.037 Bq/L}]) and similar to levels observed during recent years. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Hanford town site (see Section 6.1). The iodine-129 plume originated in the 200 Areas from past waste disposal practices. Quarterly iodine-129 concentrations in Columbia River water at the Richland Pumphouse were statistically higher than those at Priest Rapids Dam.

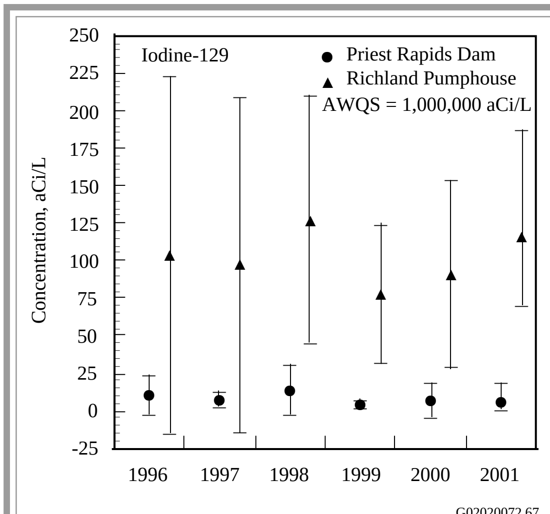

Figure 4.2.8. Annual Average Iodine-129 Concentrations (±2 standard deviations) in Columbia River Water, 1996 through 2001 (AWQS = ambient water quality standard)

Plutonium-239/240 concentrations were at or near the detection limits for some filter (particulate) and most resin (dissolved) components. Average plutonium-239/240 concentrations on filter samples at Priest Rapids Dam and the Richland Pumphouse were 0.00099 ± 0.0030 pCi/L (0.000037 ± 0.00011 Bq/L) and 0.000033 ± 0.000058 pCi/L (0.0000012 ± 0.000002 Bq/L), respectively. With the exception of one sample each at Priest Rapids Dam and the Richland Pumphouse, plutonium was only detected for the particulate fraction of the continuous water sample (i.e., detected on the filters but not detected on the resin column). No state ambient surface-water quality criteria level exists for plutonium-239/240. However, if the DOE derived concentration guides (see Appendix D, Table D.5), which are based on a 100-mrem dose standard, are converted to the 4-mrem dose equivalent used to develop the drinking water standard and ambient surface-water quality criteria level, 1.2 pCi/L (0.044 Bq/L) would be the relevant guideline for plutonium-239/240. There were no statistical differences in plutonium-239/240 concentrations for filter samples collected at Priest Rapids Dam and the Richland Pumphouse. Statistical comparisons for dissolved plutonium concentrations at Priest Rapids Dam and the Richland Pumphouse were not performed because the majority of the concentrations were below the detection limit.

River Transect and Near-Shore Sampling. Radiological results from samples collected along Columbia River transects and at near-shore locations near the Vernita Bridge, 100-F Area, 100-N Area, Hanford town site, 300 Area, and Richland Pumphouse during 2001 are presented in Appendix B (Tables B.3 and B.4) and PNNL-13910, APP. 1. Sampling locations were documented using a global positioning system. Constituents consistently detected at concentrations greater than two times their associated total propagated analytical uncertainty included tritium, strontium-90, uranium-234, and uranium-238. All measured concentrations of these radionuclides were less than applicable state ambient surface-water quality criteria levels.

Tritium concentrations measured along Columbia River transects during September 2001 are depicted in Figure 4.2.9. The results are displayed such that the observer's view is upstream from the Richland Pumphouse. Vernita Bridge is the most upstream transect. Stations 1 and 10 are located along the Benton County and Franklin/Grant Counties shorelines, respectively. The 100-N Area, Hanford town site, 300 Area, and Richland Pumphouse transects have higher tritium concentrations at the Hanford shore compared to the opposite shore. The presence of a tritium concentration gradient in the Columbia River at the Richland

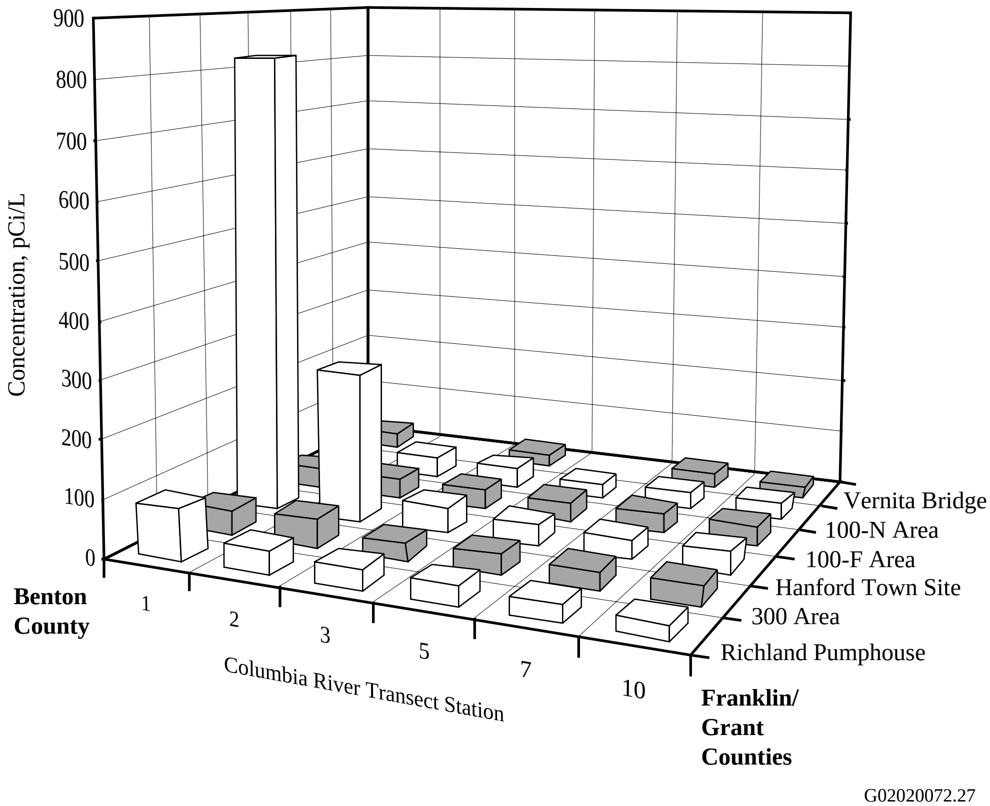

Figure 4.2.9. Tritium Concentrations in Water Samples from Columbia River Transects, September 2001

Pumphouse supports previous conclusions made in HW-73672 and PNL-8531 that contaminants in the 200 Areas' groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed at the Richland Pumphouse. The gradient is most pronounced during periods of relatively low river flow. Since transect sampling began in 1987, the mean tritium concentration measured along the Richland Pumphouse transect was less than that measured in monthly composited samples from the pumphouse, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station. The highest tritium concentration detected in 2001 samples of cross river transect water was 820 ± 73 pCi/L (30 ± 2.7 Bq/L) (see Appendix B, Table B.3), which was detected along the shoreline of the Hanford town site. This is a location where groundwater containing tritium levels over 20,000 pCi/L (740 Bq/L) is known to discharge to the river (see Section 6.1.6.1).

Tritium concentrations for near-shore water samples collected at the Hanford (Benton County) shoreline during September 2001 are shown in Figure 4.2.10. The near-shore sampling locations are identified according to Hanford river markers, which are a series of signpost markers (~1.6 kilometers [~1 mile] apart) that originate at Vernita Bridge (Hanford river marker #0) and end just upriver from the Richland Pumphouse (Hanford river marker #46). The concentrations of tritium in near-shore water samples collected at the 100-N Area, Hanford town site, and 300 Area were elevated compared to concentrations in samples collected near the Vernita Bridge. There was a wide range of tritium concentrations measured for the shoreline samples with the concentrations increasing near discharge points for the groundwater tritium plume (see Section 6.0, Figures 6.1.11, 6.1.12, and 6.1.19). The tritium concentrations in near-shore samples collected from the Richland shore were only slightly higher that those measured at Vernita Bridge. In 2001, the highest tritium concentration observed in near-shore water samples was 5,100 ± 440 pCi/L (189 ± 16 Bq/L) (see Appendix B, Table B.4), which was detected along the shoreline of the Hanford town site.

In 2001, strontium-90 concentrations in Hanford Reach river water for both transect and near-shore samples were similar to background concentrations for all locations, except for the 100-N Area. The 100-N Area had elevated strontium-90 concentrations in some samples obtained at near-shore locations. The mean strontium-90 concentration found during transect

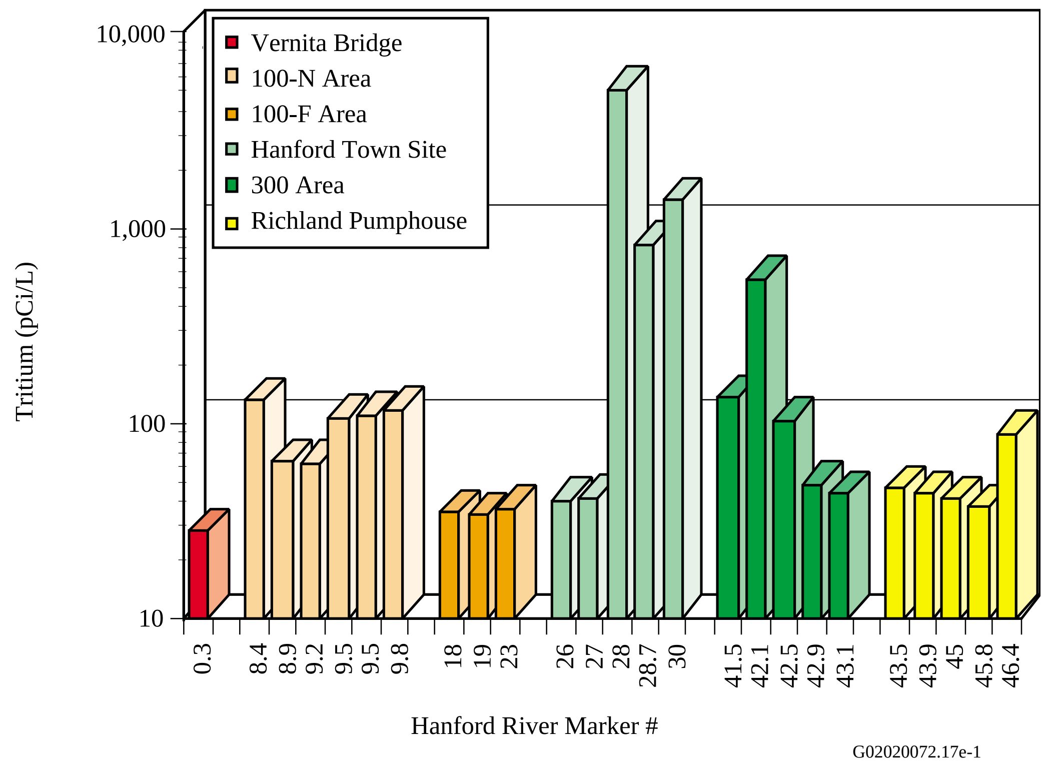

Figure 4.2.10. Tritium Concentrations in Columbia River Water Collected at the Hanford Shoreline, September 2001. The Hanford river markers (HRMs) are a set of signposts on the Hanford shore that are roughly a mile apart. Vernita Bridge is HRM #0 and Ferry Street in Richland is HRM #46. Samples collected between markers are assigned a decimal (e.g., halfway between HRM #12 and HRM #13 is HRM #12.5).

sampling at the Richland Pumphouse was similar to that measured in monthly composite samples from the pumphouse, indicating that strontium-90 levels in water collected from the fixed-location monitoring station are representative of the average strontium-90 concentrations in the river at this location.

Total uranium concentrations in Hanford Reach water in 2001 were elevated along the Franklin County shoreline in both the 300 Area and Richland Pumphouse transects. The highest total uranium concentration was measured near the Franklin County shoreline of the Richland Pumphouse transect and likely resulted from groundwater seepage and water from irrigation return canals on the Franklin County side of the river that contained naturally occurring uranium (PNL-7500). The mean concentration of total uranium across the Richland Pumphouse transect was similar to that measured in monthly composite samples from the pumphouse.

4.2.1.3 Chemical and Physical Results for River-Water Samples

The U.S. Geological Survey and Pacific Northwest National Laboratory compiled chemical and physical water quality data for the Columbia River during 2001. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford origin. Potential sources of pollutants not associated with Hanford include irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500).

U.S. Geological Survey. Figure 4.2.11 shows U.S. Geological Survey results for the Vernita Bridge and Richland Pumphouse for 1996 through 2001 (2001 results are preliminary) for several water quality parameters with respect to their applicable standards. The complete list of preliminary results obtained through the

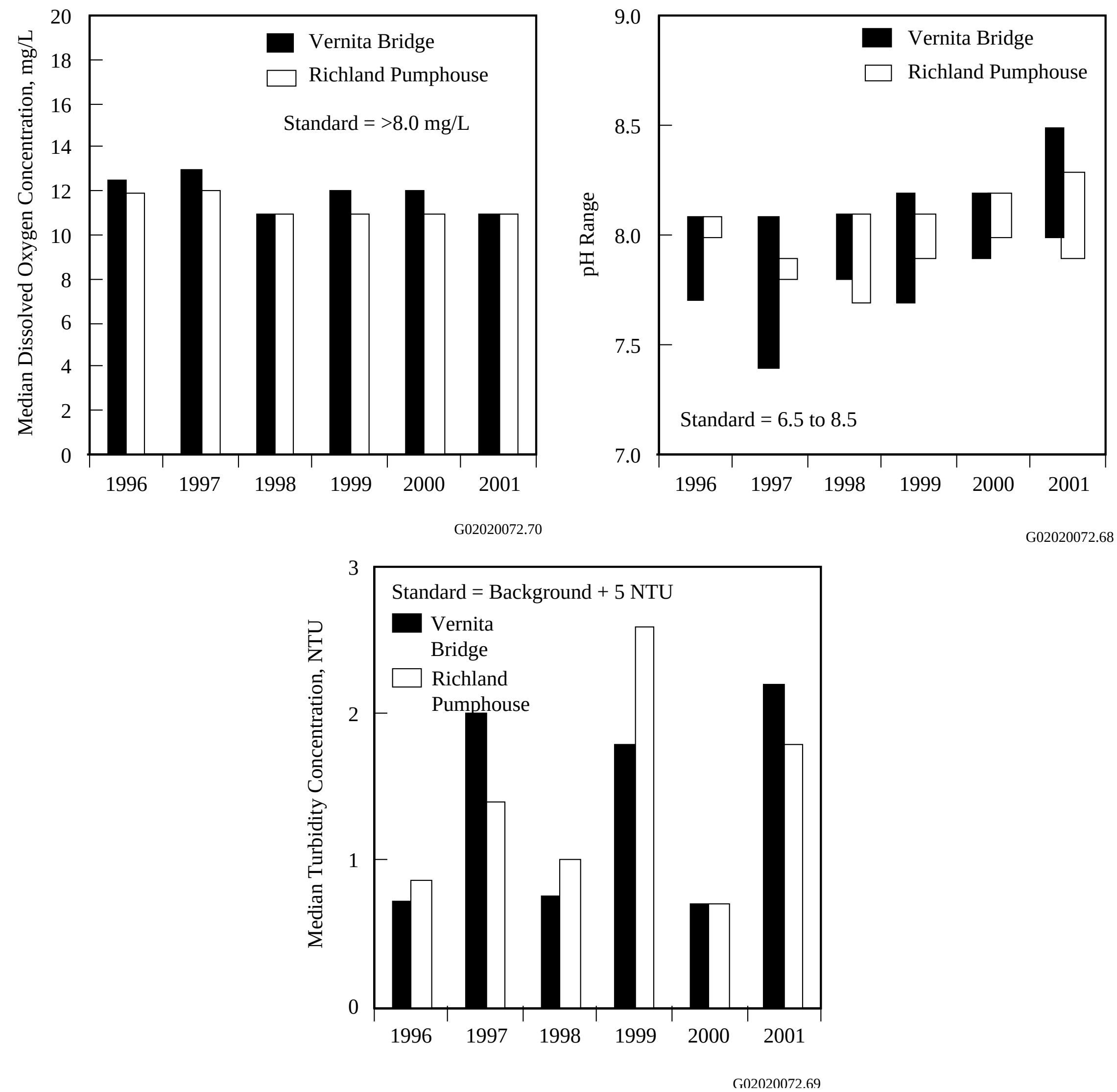

Figure 4.2.11. U.S. Geological Survey Columbia River Water Quality Measurements, 1996 through 2001 (2001 results are preliminary; NTU = nephelometric turbidity unit)

U.S. Geological Survey National Stream Quality Accounting Network program is documented in PNNL-13910, APP. 1 and is summarized in Appendix B (Table B.5). Final results are published annually by the U.S. Geological Survey (e.g., WA-99-1). The 2001 U.S. Geological Survey results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface-water body were met. During 2001, there was no indication of any deterioration of water quality resulting from site operations along the Hanford Reach of the Columbia River (see Appendix D, Table D.1).

River Transect and Near-Shore Samples. Results of chemical sampling conducted by Pacific Northwest National Laboratory along transect and near-shore locations of the Columbia River in 2001 at the Vernita Bridge, 100-F Area, 100-N Area, Hanford town site, 300 Area, and Richland Pumphouse are provided in PNNL-13910, APP. 1. The concentrations of metals and anions observed in river water in 2001 were similar to those observed in the past and remain below regulatory limits. Several metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, lead, nickel, thallium, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium, selenium, and silver were detected occasionally. Nitrate concentrations for water samples from the Benton County shoreline near the Richland Pumphouse were similar to mid-river samples. Nitrate, sulfate, and chloride concentrations were slightly elevated, compared to mid-river samples, along the Franklin County shoreline at the Richland Pumphouse transects and likely resulted from groundwater seepage associated with extensive irrigation north and east of the Columbia River. Nitrate contamination of some Franklin County groundwater has been documented by the U.S. Geological Survey (1995) and is associated with high fertilizer and water usage in agricultural areas. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141; USGS Circular 1144). Average nitrate and chloride results were slightly higher for quarterly concentrations at the Richland Pumphouse transect compared to the Vernita Bridge transect. Nitrate, chloride, and sulfate concentrations were slightly elevated, compared to mid-river, for the Franklin County shoreline at the 300 Area. There were no apparent concentration gradients near the Hanford shoreline for anions measured in transect samples collected at the Vernita Bridge, 100-N Area, 100-F Area, and Hanford town site.

Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix D, Table D.3). Criteria for Columbia River water were calculated using a total hardness of 47 mg/L as calcium carbonate, the limiting value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the Richland Pumphouse over the past years. The total hardness reported by the U.S. Geological Survey at those locations from 1992 through 2001 ranged from 47 to 77 mg/L as calcium carbonate. All metal and anion concentrations in river water were less than the state ambient surface-water quality criteria levels for the protection of aquatic life from both acute and chronic toxicity levels (see Appendix B, Table B.6 and Appendix D, Table D.3). Arsenic concentrations exceeded the EPA standard for the protection of human health for the consumption of water and organisms; however, this EPA value is >10,500 times lower than the state chronic toxicity value and similar concentrations were found at the Vernita Bridge and the Richland Pumphouse (see Appendix D, Table D.3). The concentrations of volatile organic compounds in Columbia River water samples (e.g., chlorinated solvents, benzene) were below detection limits in most samples, with no indication of a Hanford source.

4.2.2 Columbia River Sediment

Upon release to the Columbia River, radioactive and non-radioactive materials were dispersed rapidly, sorbed onto detritus and inorganic particles, incorporated into aquatic biota, deposited on the riverbed as sediment, or flushed out to sea. The concentrations of the radioactive material decreased as it underwent radioactive decay. Fluctuations in the river flow rate, as a result of the operation of hydroelectric dams, annual spring freshets, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the sediment (DOE/RL-91-50). Sediment in the Columbia River contains low concentrations of radionuclides and metals of Hanford Site origin as well as radionuclides from nuclear weapons testing fallout (Beasley et al. 1981; BNWL-2305; PNL-8148; PNL-10535). Potential public exposures are well below the level at which routine surveillance of Columbia River sediment is required (PNL-3127; Wells 1994). However, periodic sampling is necessary to confirm the low levels and to assure that no significant changes have occurred for this pathway. The accumulation of radioactive materials in sediment can lead to human exposure by ingestion of aquatic organisms, sediment resuspension into drinking water supplies, or as an external radiation source irradiating people who are fishing, wading, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T).

Since the shutdown of the last single-pass reactor at Hanford in 1971, the contaminant concentrations in the surface sediment have been decreasing as a result of radioactive decay and the subsequent deposition of uncontaminated material (Cushing et al. 1981). However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via permit-regulated liquid effluent discharges (see Section 3.1) and via contaminated groundwater seepage (see Section 4.2.3).

Several studies have been conducted on the Columbia River to investigate the difference in sediment grain-size composition and total organic carbon content at routine monitoring sites (Beasley et al. 1981; PNL-10535; PNNL-13417). Physical and chemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were generally collected from the pools near all the dams and from White Bluffs Slough.

4.2.2.1 Collection of Sediment Samples and Analytes of Interest

During 2001, samples of Columbia River surface sediment were collected at depths of 0 to 15 centimeters (0 to 6 inches) from six river locations that were permanently submerged and six riverbank springs that were periodically inundated (see Figure 4.2.1 and Table 4.2.2). Sediment sampling locations were documented using a global positioning system. In addition, sediment samples were collected behind Ice Harbor Dam on the Snake River.

Samples were collected upstream of Hanford Site facilities from the Priest Rapids Dam pool (the nearest upstream impoundment) to provide background 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 that found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns, irrigation water returns, and factories in these drainages also may contribute to the contaminant load found in McNary Dam sediment; thus, sediment samples are periodically taken at Ice Harbor Dam to assess Snake River inputs. Sediment samples also were collected along the Hanford Reach of the Columbia River from areas close to contaminant discharges (e.g., riverbank springs), from slackwater areas where fine-grained material is known to deposit (e.g., the White Bluffs, 100-F Area, and Hanford Sloughs), and from the publicly accessible Richland shoreline.

Monitoring sites at McNary and Priest Rapids Dams consisted of two stations spaced equidistant (approximately) on a transect line crossing the Columbia River; the samples were collected near the boat exclusion buoys at each dam. On the Snake River, sediment samples were collected at three locations at Levy Landing, which is a public park located upriver from Ice Harbor Dam. All other monitoring sites consisted of a single sampling location. Samples of permanently inundated river sediment were collected using a clam-shell style sediment dredge. Samples of periodically inundated river sediment, (riverbank springs sediment) were collected using a large plastic spoon, immediately following the collection of riverbank springs water samples. Sampling methods are discussed in detail in DOE/RL-91-50. All sediment samples were analyzed for gamma emitting radionuclides (see Appendix F), strontium-90, uranium-234, uranium-235, uranium-238, and metals (DOE/RL-91-50). Selected river sediment samples were also analyzed for plutonium-238, and plutonium-239/240. The specific analytes selected for sediment samples were based on findings of previous Columbia and Snake River sediment investigations, reviews of past and present effluents discharged from site facilities, and reviews of contaminant concentrations observed in groundwater monitoring wells near the river.

4.2.2.2 Radiological Results for Samples from River Sediment

Results of the radiological analyses on river sediment samples collected during 2001 are reported in PNNL-13910, APP. 1 and summarized in Appendix B (Table B.7). Radionuclides consistently detected in river sediment adjacent and downstream of the Hanford Site during 2001 included potassium-40, cesium-137, uranium-238, plutonium-238, and plutonium-239/240. The concentrations of all other radionuclides were below detection limits for most samples. Cesium-137 and plutonium isotopes exist in worldwide fallout, as well as in effluents from Hanford Site facilities. Uranium occurs naturally in the environment in addition to being present in Hanford Site effluents. Comparisons of contaminant levels between sediment sampling locations are made below. Because of variations in the bioavailability of contaminants in various sediment, no federal or state freshwater sediment criteria are available to assess the sediment quality of the Columbia River (EPA 822-R-96-001).

Radionuclide concentrations reported in river sediment in 2001 were similar to those reported for previous years (see Appendix B, Table B.7). Median, maximum, and minimum concentrations of selected radionuclides measured in Columbia (1995 through 2000) and Snake River sediment from 1996 through 2001 are presented in Figure 4.2.12. Sampling areas include stations at Priest Rapids, McNary, and Ice Harbor Dams as well as the Hanford Reach stations (White Bluffs, 100-F Area and Hanford Sloughs, and the Richland Pumphouse).

4.2.2.3 Radiological Results for Sediment Samples from Riverbank Springs

Sampling of sediment from riverbank springs began in 1993 at the Hanford town site and the 300 Area. Sampling of the riverbank springs in the 100-B, 100-F,

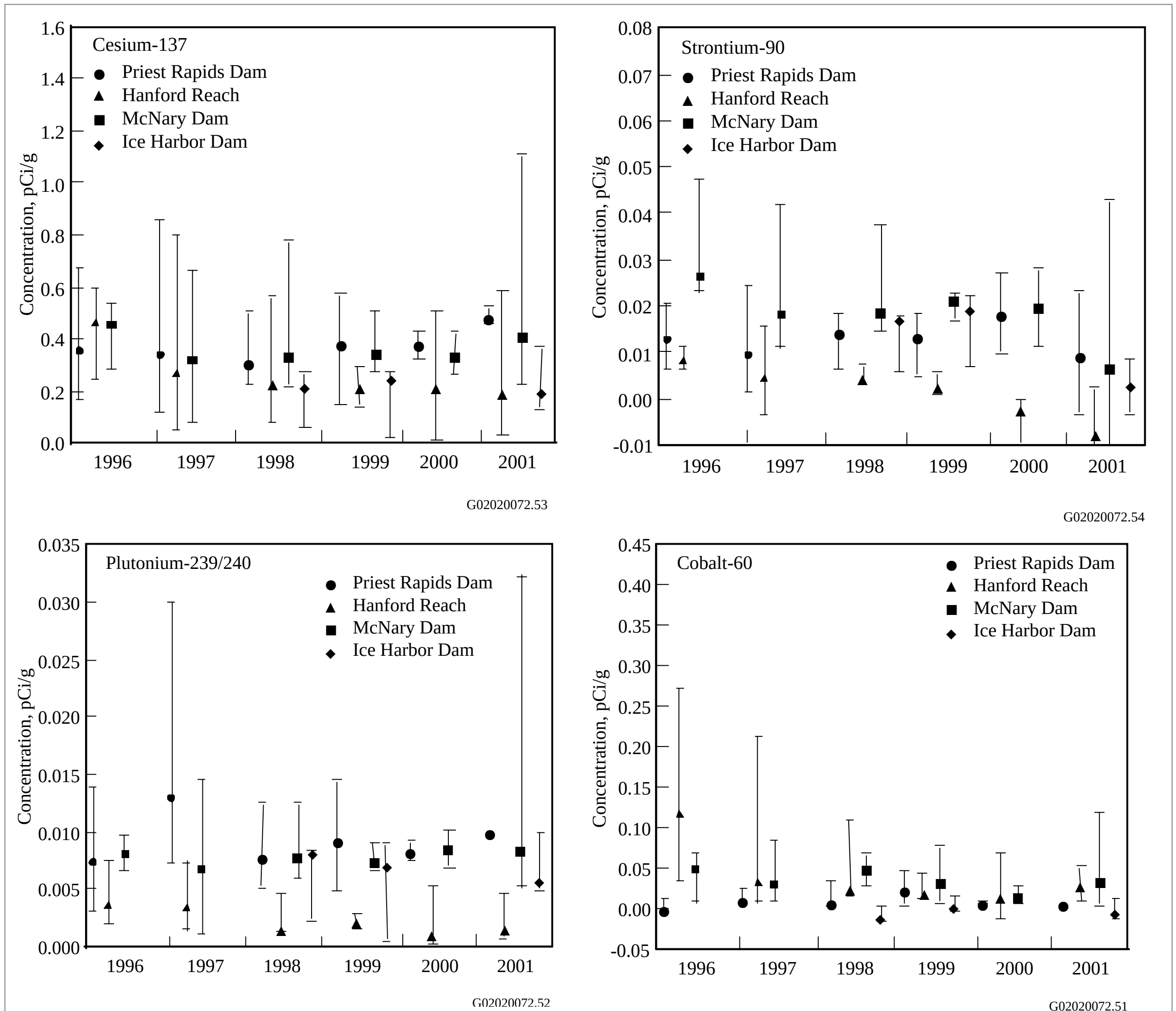

Figure 4.2.12. Median, Maximum, and Minimum Concentrations of Selected Radionuclides Measured in Columbia and Snake River Sediment, 1996 through 2001

and 100-K Areas began in 1995. Substrates at all other riverbank springs sampling locations consist of predominantly large cobble and are unsuitable for sample collection.

Radiological results for sediment collected from riverbank springs in 2001 are presented in PNNL-13910, APP. 1 and are summarized in Appendix B (Table B.7). Results were similar to those observed for previous years. In 2001, sediment samples were collected at riverbank springs in the 100-B, 100-F, and 300 Areas. There was no sediment available for sampling at the 100-K and 100-N Area locations. In 2001, radionuclide concentrations in riverbank spring sediment were similar to those observed in river sediment.

4.2.2.4 Chemical Results for Sediment Samples from the Columbia River and from Riverbank Springs

Metal concentrations (total metals, reported on a dry weight basis) observed in Columbia River sediment in 2001 are reported in PNNL-13910, APP. 1 and are summarized in Appendix B (Table B.8). Detectable amounts of most metals were found in all river sediment samples (Figure 4.2.13). Maximum and median concentrations of most metals were higher for sediment collected at Priest Rapids Dam compared to either

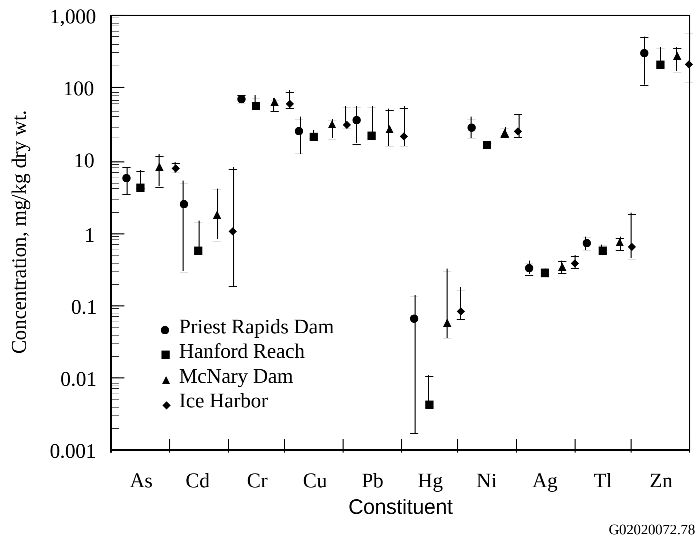

Figure 4.2.13. Median, Maximum, and Minimum Concentrations of Selected Metals Measured in Columbia and Snake River Sediment, 2001

Hanford Reach or McNary Dam sediment. The concentrations of cadmium, chromium, lead, nickel, thallium, and zinc had the largest differences between locations. Metal concentrations in riverbank spring sediment samples in 2001 were similar to concentrations in Hanford Reach sediment samples. Currently, there are no Washington State freshwater sediment quality criteria for comparison to the measured values.

4.2.3 Riverbank Spring Water

The Columbia River is the primary discharge area for the unconfined aquifer underlying the Hanford Site (see Section 6.1.2). Groundwater provides a means for transporting Hanford-associated contaminants, which have leached into groundwater 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 via surface and subsurface discharge. Discharge zones located above the water level of the river are identified in this report as riverbank springs. Routine monitoring of riverbank springs offers the opportunity to characterize the quality of groundwater being discharged to the river and to assess the potential human and ecological risk associated with the spring water.

The seepage of groundwater into the Columbia River has occurred for many years. Riverbank springs were documented along the Hanford Reach long before Hanford Site operations began during World War II (Jenkins 1922). In the early 1980s, researchers walked the 66-kilometer (41-mile) stretch of Benton County shoreline of the Hanford Reach and identified 115 springs (PNL-5289). They reported that the predominant areas of groundwater discharge at that time were in the vicinity of the 100-N Area, Hanford town site, and 300 Area. The predominance of the 100-N Area may no longer be valid because of declining water-table elevations in response to the cessation of liquid waste discharges to the ground from Hanford Site operations and pump-and-treat operations at the 100-N Area. In recent years, it has become increasingly difficult to locate riverbank springs in the 100-N Area.

The presence of riverbank springs also varies with river stage. Groundwater levels in the 100 and 300 Areas are heavily influenced by river stage fluctuations (see Section 6.1). Water levels in the Columbia River fluctuate greatly on annual and even daily cycles and are controlled by the operation of Priest Rapids Dam upstream of the site. Water flows into the aquifer (as bank storage) as the river stage rises and then flows in the opposite direction as the river stage falls. Following an extended period of low river flow, groundwater discharge zones located above the water level of the river may cease to exist once the level of the groundwater comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage. Bank storage of river water also affects the contaminant concentration of the springs.

Spring water discharge immediately following a river stage decline generally consists of river water or a river/groundwater mix. The percentage of groundwater in the spring water discharge is believed to increase over time following a drop in river stage. Measuring the specific conductivity of the spring water discharge provides an indicator of the extent of bank storage because the Hanford Site groundwater has higher specific conductivity than the Columbia River.

Because of the effect of bank storage on groundwater discharge and contaminant concentration, it is difficult to estimate the volume of contaminated groundwater discharged to the Columbia River within the Hanford Reach. The estimated total groundwater discharge from the upstream end of the 100 Areas to south of the 300 Area is ~66,500 cubic meters (2.35 million cubic feet) per day.[a] This represents only 0.02% of the long-term average daily flow rate of the Columbia River, which illustrates the tremendous dilution potential afforded by the river. Studies of riverbank springs conducted in 1983 (PNL-5289), in 1988 (PNL-7500), and a near-shore study (PNNL-11933) also noted that discharges from the springs had a localized effect on river contaminant concentrations. These studies reported that the volume of groundwater entering the river at these locations was very small compared to the flow of the river and that the impact of groundwater discharges to the river was minimal.

4.2.3.1 Collection of Water Samples from Riverbank Springs and Analytes of Interest

Routine monitoring of selected riverbank springs was initiated in 1988. Currently, riverbank spring water samples are collected for environmental surveillance and to support groundwater operable unit investigations. The locations of all riverbank springs sampled in 2001 are identified in Figure 4.2.1. Sample collection methods are described in DOE/RL-91-50. Analytes of interest for samples from riverbank springs were selected based on findings of previous investigations, reviews of contaminant concentrations observed in nearby groundwater monitoring wells, and results of preliminary risk assessments. Sampling is conducted annually when river flows are low, typically in late summer or early fall.

The below normal flows on the Columbia River in 2001 allowed samples of water from riverbank springs to be collected in the spring and fall of 2001. All samples collected during 2001 were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, iodine-129, and uranium-234, -235, and -238. All samples were analyzed for metals and anions, with volatile organic compounds analyzed at selected locations. All analyses were conducted on unfiltered samples, except for metals analyses, which were conducted for both filtered and unfiltered samples.

Hanford-origin contaminants continued to be detected in water from riverbank springs entering the Columbia River along the Hanford Site during 2001. The locations and extent of contaminated discharges were consistent with recent groundwater surveys. Tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, and -238, metals, and anions (chloride, fluoride, nitrate, and sulfate) were detected in spring water. Volatile organic compounds were near or below the detection limits for most samples. The contaminant concentrations in water from riverbank springs are typically lower than those found in near-shore groundwater wells because of bank storage effects.

Results of radiological and chemical analyses conducted on samples from riverbank springs in 2001 are documented in PNNL-13910, APP. 1. Radiological results obtained in 2001 are summarized in Appendix B (Table B.9) and compared to those reported in 1996 through 2000. In the following discussion, radiological and chemical results are addressed separately. Contaminant concentration trends are illustrated for selected locations.

4.2.3.2 Radiological Results for Water Samples from Riverbank Springs

All radiological contaminant concentrations measured in riverbank springs in 2001 were less than the DOE derived concentration guides (DOE Order 5400.5; see Appendix D, Table D.5). However, the spring near well 199-N-8T at the 100-N Area that has historically exceeded the DOE derived concentration guide for strontium-90 only had observed flow during one (1997) sampling attempt in the last 6 years; thus, an alternative spring was sampled in the 100-N Area. Tritium concentrations in water samples collected in 2001 from riverbank springs at the Hanford town site exceeded the state ambient surface-water quality criteria level

(a) Personal communication from S. P. Luttrell to G. W. Patton, Pacific Northwest National Laboratory, Richland, Washington, January 1995.

of 20,000 pCi/L (740 Bq/L) (WAC 173-201A; 40 CFR 141). The maximum tritium concentration in riverbank spring water collected in 2001 at the 100-N Area was 17,000 pCi/L (630 Bq/L), which was 86% of the state ambient surface water criteria level (WAC 173-201A; 40 CFR 141). At the 300 Area, the maximum tritium levels was 12,000 pCi/L (440 Bq/L), which was 60% of the criteria. The strontium-90 concentration in riverbank spring water was greater than the criteria level at the 100-H Area location. Total uranium concentrations exceeded the EPA drinking water standard (EPA 822-R-96-001) in the 300 Area (see Appendix D, Table D.2). The gross alpha concentration exceeded the ambient surface-water quality criteria level (15 pCi/L [0.56 Bq], Appendix D, Table D.2) in riverbank spring water at the 300 Area, which is consistent with the elevated uranium levels. All other radionuclide concentrations in 300 Area springs water were less than the state ambient surface-water quality criteria levels. Gross beta concentrations in riverbank spring water at the 100-B Area, 100-H Area, Hanford town site, and 300 Area were elevated compared to other riverbank spring water locations. Concentrations of selected radionuclides in riverbank spring water near the Hanford town site (spring 28-2) from 1996 through 2001 are provided in Figure 4.2.14. Several of the radionuclides show what appear to be increasing trends since 1995; however, radionuclide concentrations measured in the early 1990s were similar to the 2001 concentrations (see Figure 4.2.13 in PNNL-11472). Annual fluctuations in these values may reflect the influence of bank storage during the sampling period.

Figure 4.2.15 depicts concentrations of selected radionuclides in the 300 Area riverbank spring water (spring 42-2) from 1996 through 2001. Results in 2001 were slightly higher than those observed previously and were probably influenced by the below average Columbia River flows in 2001. The elevated tritium levels measured in the 300 Area riverbank springs are indicators of the contaminated groundwater plume from the 200 Areas (Section 5.9 in PNL-10698). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of the former uranium fuel fabrication facilities and inactive waste sites. The gross alpha and gross beta concentrations in 300 Area riverbank springs water from 1996 through 2001 parallel uranium and are likely associated with its presence.

Tritium concentrations varied widely with location. The highest tritium concentration detected in riverbank springs was at the Hanford town site (110,000 ± 4,100 pCi/L [4,070 ± 152 Bq/L]), followed by the 100-N Area (17,000 ± 800 pCi/L [629 ± 30 Bq/L]), and 300 Area (12,000 ± 580 pCi/L [444 ± 21 Bq/L]). The state ambient surface-water quality criteria level for tritium is 20,000 pCi/L (740 Bq/L). Tritium concentrations in all riverbank spring samples were elevated compared to the 2001 average Columbia River concentration at Priest Rapids Dam (37 ± 22 pCi/L [1.4 ± 0.81 Bq/L]).

Samples from riverbank springs in the 100-B, 100-H, 100-K, and 300 Areas and the Hanford town site were analyzed for technetium-99. All results were below the EPA drinking water standard (see Appendix D, Table D.2). The highest technetium-99 concentration was found in riverbank spring water from the Hanford town site (110 ± 75 pCi/L [4.1 ± 2.8 Bq/L]), which was higher than the observed gross beta concentrations (36 ± 5.8 pCi/L [1.3 ± 0.21 Bq/L]).

Samples from riverbank springs at the Hanford town site and 300 Area were analyzed for iodine-129. The highest concentration was measured in a water sample from the Hanford town site spring (0.25 ± 0.022 pCi/L [0.0093 ± 0.00081 Bq/L]). This value was elevated compared to the 2001 average measured at Priest Rapids Dam (0.0000025 ± 0.000017 pCi/L [0.000000092 ± 0.00000063 Bq/L]) but was below the 1-pCi/L (0.037-Bq/L) surface-water quality criteria level (see Appendix D, Table D.2).

Uranium was sampled in riverbank spring water in the 100-H Area, 100-F Area, Hanford town site, and 300 Area in 2001. The highest level was found in 300 Area spring water (100 ± 19 pCi/L [3.7 ± 0.70 Bq/L]), which was collected from a spring located downgradient from the retired 300 Area process trenches. The 300 Area spring had elevated gross alpha concentration (87 ± 8.7 pCi/L [3.2 ± 0.32 Bq/L], which paralleled that of uranium.

Samples from riverbank springs were analyzed for strontium-90 in the 100-B, 100-D, 100-F, 100-H, 100-K, and 100-N Areas. The highest strontium-90 concentration detected in riverbank spring water was at the 100-H Area (14 ± 3.2 pCi/L [0.52 ± 0.12 Bq/L]). This value was above the ambient surface water quality criteria of 8 pCi/L (0.30 Bq/L).

Historically, riverbank seepage in the 100-N Area has been monitored for contaminants by sampling from well 199-N-8T, which is located close to the river; well 199-N-46 (caisson), which is slightly inland from well 199-N-8T (PNNL-11795, Figure 3.2.4); or riverbank springs. Since 1993, 100-N Area seepage samples for the Surface Environmental Surveillance Project have been collected only from riverbank springs. The Near-Facility Environmental Monitoring Program (see

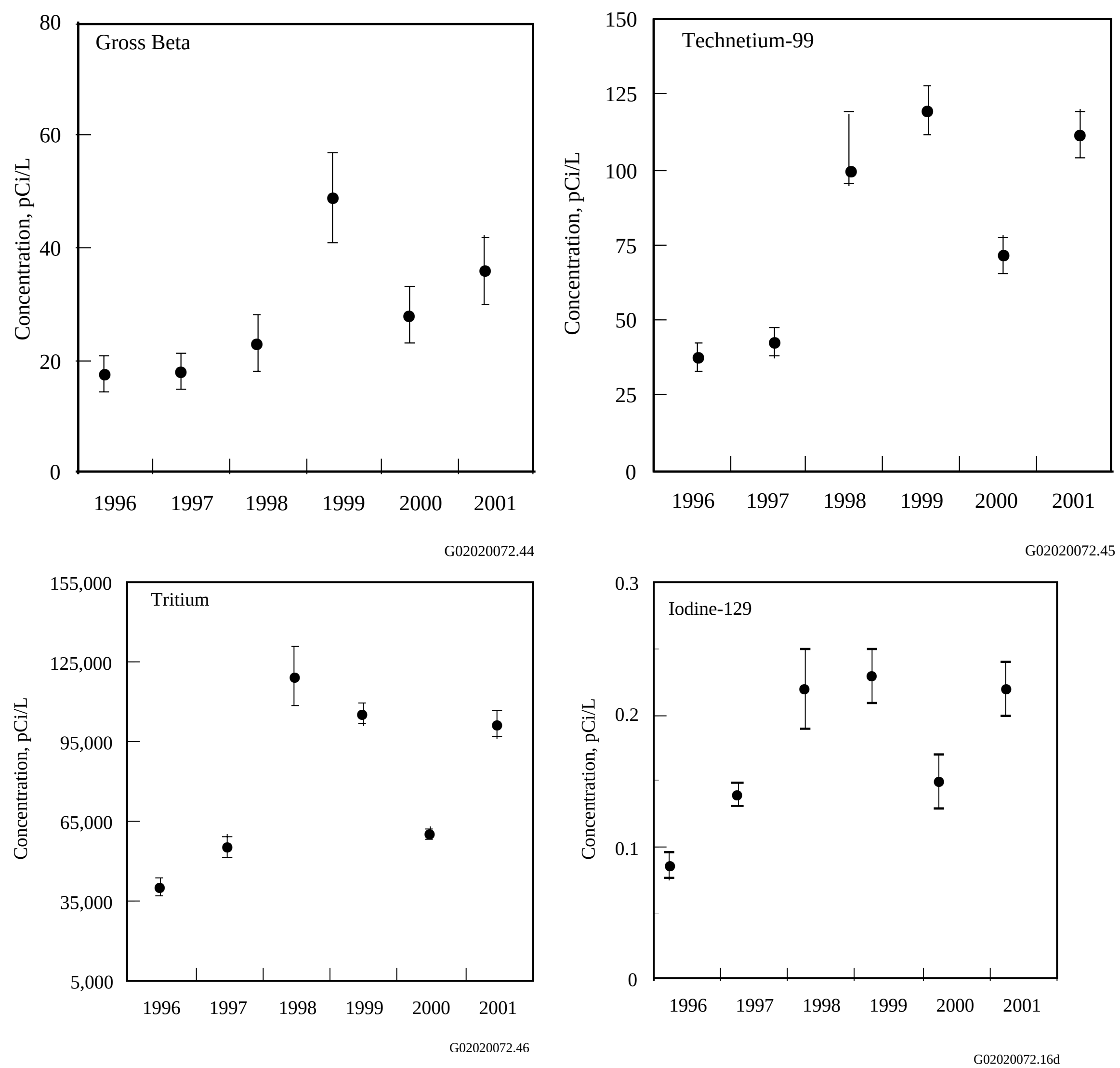

Figure 4.2.14. Concentrations (results ±2 total propagated analytical uncertainty) of Constituents of Interest in Columbia River Riverbank Spring Water at the Hanford Town Site (Spring 28-2), 1996 through 2001. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Section 3.2.2) also collects water samples along the 100-N shoreline at monitoring well 199-N-46 and at shoreline seepage wells. The Near-Facility Environmental Monitoring Program reported all strontium-90 concentrations in calendar year 2001 samples were below the 1,000 pCi/L (37 Bq/L) DOE derived concentration guide for shoreline seepage wells near monitoring well 199-N-46 (see Table 3.2.4). For 1993 to 2001, there were no visible riverbank springs directly adjacent to wells 199-N-8T or 199-N-46 during the Surface Environmental Surveillance Project sampling periods; with the exception of one sample collected in 1997. The samples from 100-N Area riverbank springs were, therefore, collected from a downstream riverbank spring. Contaminant concentrations measured in the water from the two riverbank springs locations sampled in previous years were distinctly different from each other (Table 4.2.3). Historically, the concentrations of strontium-90 and gross beta were considerably higher in the riverbank spring directly adjacent to well 199-N-8T than for the downstream spring. Tritium levels in water from riverbank springs are typically elevated at both locations, and the 2001 tritium result for the 100-N riverbank spring was similar to those found in previous years (see Table 4.2.3). Tritium was the only specific radionuclide detected at the 100-N Area riverbank spring in 2001.

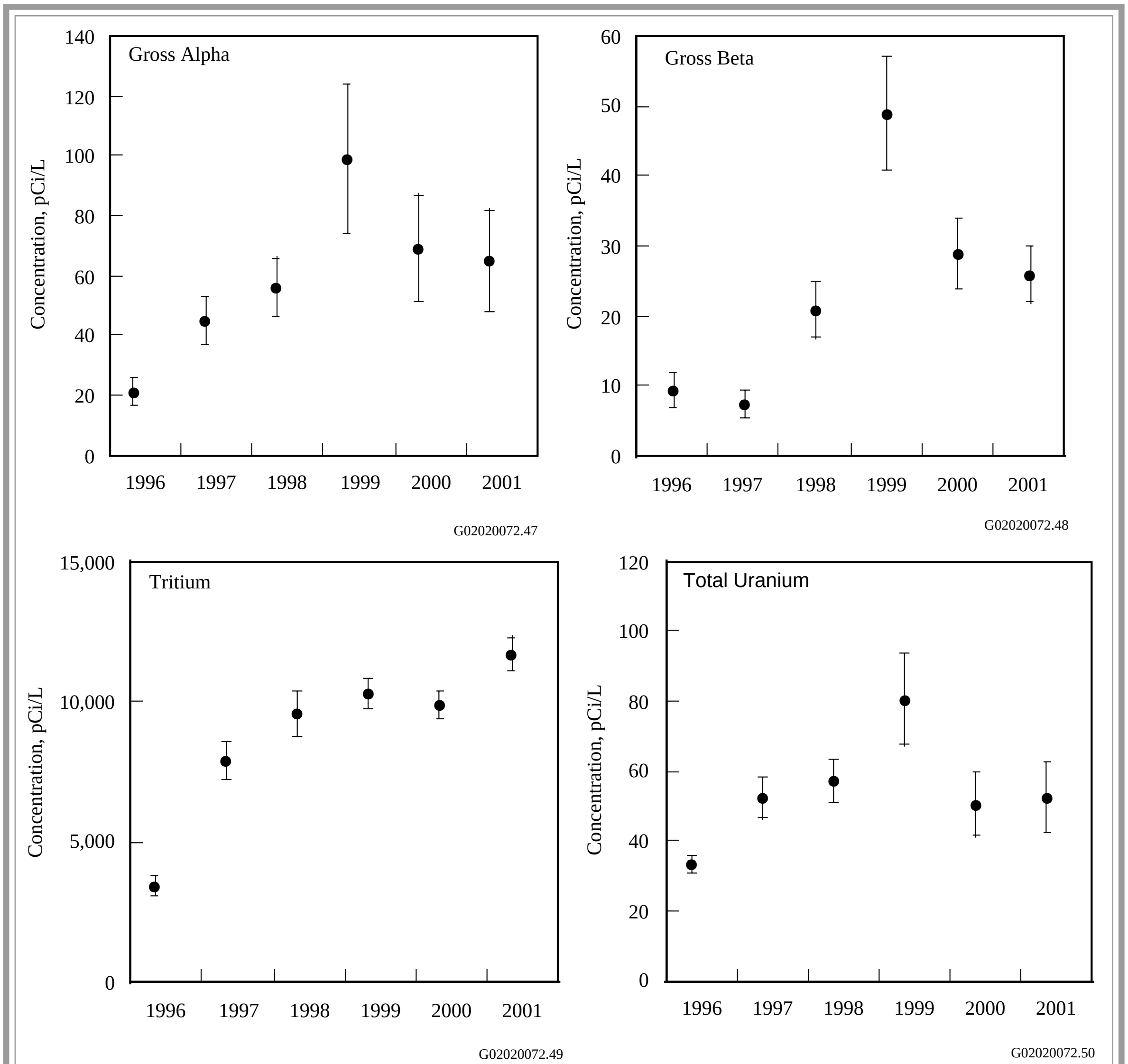

Figure 4.2.15. Concentrations (results ±2 total propagated analytical uncertainty) of Constituents of Interest in Water from a Columbia River Riverbank Spring near the 300 Area (Spring 42-2), 1996 through 2001. 2001 results are for the May 10, 2001 sampling event.

4.2.3.3 Chemical Results for Water Samples from Riverbank Springs

Concentration ranges of selected chemicals measured in riverbank springs water in 1999 through 2001 are presented in Table 4.2.4. For most locations, the 2001 chemical sample results were similar to those reported previously (PNNL-12088). Nitrate concentrations were highest in the 300 Area. Chromium concentrations were generally highest in the 100-D, 100-H, and 100-K Areas' riverbank springs. Hanford groundwater monitoring results for 2001 indicated similar contaminant concentrations in shoreline areas (see Section 6.1).

The ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix D, Table D.3). For comparison purposes, spring water criteria were calculated using the same 47-mg calcium carbonate per liter hardness given in Appendix D, Table D.3. Most metal concentrations measured in water from riverbank springs collected from the Hanford Site shoreline in 1999 through 2001 were below ambient surface-water acute toxicity levels (WAC 173-201A).

Table 4.2.3. Selected Radionuclide Concentrations in 100-N Area Riverbank Spring Water, 1996 through 2001

	Concentration, pCi/L[a]		
Year	**Tritium**	**Gross Beta**	**Strontium-90**
1996[b]	17,000 ± 1,300	4.5 ± 1.8	0.053 ± 0.048
1997[b]	19,000 ± 1,500	3.5 ± 1.6	0.59 ± 0.13
1997[c]	14,000 ± 1,100	16,000 ± 1,400	9,900 ± 1,800
1998[b]	24,000 ± 1,900	2.3 ± 2.1	[d]
1999[b]	14,000 ± 670	2.9 ± 1.7	0.026 ± 0.034
2000[b]	18,000 ± 800	5.9 ± 2.1	-0.0026 ± 0.037
2001[b]	17,000 ± 800	3.7 ± 1.8	0.013 ± 0.043
2001[b]	6,500 ± 430	5.5 ± 2.0	0.039 ± 0.044

(a) Concentrations are ±2 total propagated analytical uncertainty. To convert to international metric system, multiply pCi/L by 0.037 to obtain Bq/L.
(b) Sample collected from riverbank spring downstream of well 199-N-8T.
(c) Samples collected from spring below well 199-N-8T (100-N Area spring 8-13, see PNNL-11795, Figure 3.2.4).
(d) Sample was lost during processing at the analytical laboratory.

However, concentrations of chromium in 100-B, 100-K, 100-N, 100-D, 100-H, and 100-F, and 300 Areas spring water were above state ambient surface water acute toxicity levels (see Appendix D, Table D.3). Arsenic concentrations in riverbank spring water were well below state ambient surface water chronic toxicity levels, but all samples (including upriver Columbia River water samples) exceeded the federal limit for the protection of human health for the consumption of water and organisms; however, this EPA value is >10,500 times lower than the state chronic toxicity standard (40 CFR 141; see Appendix D, Table D.3). Nitrate concentrations at all spring water locations were below the drinking water standard (see Appendix D, Table D.2).

4.2.4 Onsite Pond Water

Two onsite ponds (see Figure 4.2.1), located near operational areas, were sampled periodically during 2001. The ponds are inaccessible to the public and, therefore, did not constitute a direct offsite environmental impact during 2001. However, they were accessible to migratory waterfowl, creating a potential biological pathway for the dispersion of contaminants (PNL-10174). The Fast Flux Test Facility pond is a disposal site for process water (primarily cooling water drawn from groundwater wells). West Lake, the only naturally occurring pond on the site, is located north of the 200-East Area (ARH-CD-775). West Lake has not received direct effluent discharges from Hanford Site facilities but is influenced by changing water-table elevation as a result of previous discharge of water to the ground in the 200 Areas.

4.2.4.1 Collection of Pond Water Samples and Analytes of Interest

In 2001, grab samples were collected quarterly from the Fast Flux Test Facility pond and from West Lake. Unfiltered aliquots of all samples were analyzed for gross alpha and gross beta concentrations, gamma-emitting radionuclides, and tritium. West Lake samples also were analyzed for technetium-99 and uranium-234, -235, and -238. Constituents were chosen for analysis based on their known presence in local groundwater or in effluents discharged to the pond and their potential to contribute to the overall radiation dose to the public.

4.2.4.2 Radiological Results for Pond Water Samples

Analytical results from pond water samples collected during 2001 are reported in PNNL-13910, APP. 1. With the exceptions of uranium-234 and uranium-238 concentrations in samples from West Lake, radionuclide concentrations in onsite pond water were less than the DOE derived concentration guides (DOE Order 5400.5; see Appendix D, Table D.5). The median gross alpha, and total uranium concentrations exceeded their ambient surface-water quality criteria in West Lake. The median concentrations of all other radionuclides were below state ambient surface-water quality criteria levels (WAC 173-201A; 40 CFR 141; see Appendix D, Tables D.1 and D.2).

Figure 4.2.16 shows the annual gross beta and tritium concentrations in Fast Flux Test Facility pond water

Table 4.2.4. Concentration Ranges for Selected Chemicals in Water from Columbia River Springs, 1999 through 2001

	Ambient Water Quality Criteria Level[a]	Concentration, µg/L							
		100-B Area	100-K Area	100-N Area	100-D Area	100-H Area	100-F Area	Hanford Town Site	300 Area
No. of Samples		5	6	4	5	11	4	4	6
Dissolved Metals (µg/L)									
Antimony	NA	0.081 - 0.28	0.14 - 0.24	0.19 - 0.24	0.18 - 0.22	0.23 - 0.42	0.12 - 0.23	0.13 - 0.39	0.20 - 0.36
Arsenic	190	0.93 - 1.6	0.32 - 2.1	1.4 - 3.4	0.66 - 1.3	0.30 - 3.0	1.5 - 2.6	2.6 - 4.8	0.95 - 2.9
Cadmium	0.59	0.010 - 0.021	0.0044 - 0.051	0.011 - 0.031	0.017 - 0.091	0.0044 - 0.034	0.0091 - 0.023	0.010 - 0.051	0.012 - 0.078
Chromium[b]	10	8.9 - 20	2.1 - 82	5.6 - 12	24 - 150	4.0 - 88	14 - 22	1.8 - 4.6	2.6 - 3.9
Copper	6	0.20 - 2.1	0.38 - 0.85	0.25 - 0.40	0.38 - 1.4	0.29 - 5.6	0.32 - 0.45	0.20 - 0.56	0.38 - 0.46
Lead	1.1	0.014 - 0.16	0.0078 - 0.016	0.0050 - 0.016	0.0073 - 0.017	0.0050 - 0.57	0.0078 - 0.033	0.0049 - 0.058	0.0050 - 0.034
Nickel	83	0.037 - 1.6	0.12 - 1.7	0.027 - 1.0	0.22 - 1.8	0.070 - 1.2	0.070 - 2.2	0.68 - 1.7	0.055 - 2.1
Silver[c]	0.94	0.0012 - 0.021	0.0012 - 0.021	0.0012 - 0.021	0.0043 - 0.021	0.0052 - 0.021	0.0012 - 0.042	0.0043 - 0.053	0.0049 - 0.021
Thallium	NA	0.0035 - 0.020	0.0035 - 0.021	0.010 - 0.016	0.026 - 0.098	0.0059 - 0.026	0.0035 - 0.011	0.013 - 0.020	0.013 - 0.028
Zinc	55	1.1 - 5.0	0.76 - 3.0	1.5 - 3.7	1.7 - 5.0	0.35 - 5.0	1.1 - 2.5	1.3 - 3.1	1.7 - 3.0
No. of Samples		6	6	4	5	10	4	8	6
Total Recoverable Metals (µg/L)									
Chromium[d]	96	8.1 - 20	2.2 - 93	7.6 - 14	24 - 170	4.0 - 99	17 - 33	1.8 - 5.4	2.9 - 24
Mercury	0.012	0.00098 - 0.0013[e]	0.00098 - 0.0013[f]	0.00044 - 0.0006[g]	0.00086 - 0.004[e]	0.00056 - 0.002[h]	0.0017 - 0.0038[g]	0.00089 - 0.0026[i]	0.00088 - 0.0047[e]
Selenium	5	1.2 - 2.2	0.11 - 2.2	0.41 - 0.96	0.67 - 2.7	0.39 - 2.9	0.94 - 2.3	1.2 - 2.3	2.3 - 4.1
No. of Samples		5	3	3	7[j,k]	6[k]	4[k]	6[k]	6
Anions (mg/L)									
Nitrate	45[l]	1.5 - 3.4	1.7 - 4.9	2.0 - 4.9	0.84 - 4.5	0.52 - 20	0.58 - 33	3.0 - 8.1	3.2 - 6.4

(a) Ambient Water Quality Criteria Values (WAC 173-201A-040) for chronic toxicity unless otherwise noted.
(b) Value for hexavalent chromium.
(c) Value for acute toxicity; chronic value not available.
(d) Value for trivalent chromium.
(e) No 2001 result, n=4.
(f) No 2001 result, n=3.
(g) No 2001 result, n=2.
(h) Two 2001 results, n=6.
(i) No 2001 result, n=6.
(j) One nitrate result of 295 mg/L for riverbank spring (SD-110-2) on October 17, 2000 was not included in the range because it was considered an anomalously high value.
(k) No 2001 result.
(l) Drinking water standard (WAC 246-290).

from 1996 through 2001. Median levels of both constituents have remained stable in recent years. The median tritium concentration in Fast Flux Test Facility pond water during 2001 was 16% of the state ambient surface-water quality criteria.

The annual concentrations of selected radionuclides from 1996 through 2001 in West Lake water are shown in Figure 4.2.17. Median radionuclide concentrations in West Lake during 2001 were similar to those observed in the past. The gross alpha and gross beta levels in West Lake water are believed to result from high levels of naturally occurring uranium in the surrounding soil (BNWL-1979; PNL-7662). Annual median total uranium concentrations have remained stable over the last 6 years, but the range is large. The highest concentrations measured in 2001 were in the summer, when the water level in the pond was low. It is thought that the relatively large concentration of suspended sediment in the samples was causing the elevated results. Similar total uranium levels were reported in PNNL-7662 for West Lake samples that contained high concentrations of suspended sediment. Because of the high suspended sediment concentrations, strontium-90 analyses for West Lake water samples were not conducted in 2001. Declines in groundwater levels beneath the 200 Areas have been recorded since the decommissioning of the processing ponds and the shutdown of production facilities (see Section 6.1). As a result, the water level in West Lake has dropped. Median concentrations of tritium and technetium-99 in West Lake in 2001 were 0.57% and 39%, respectively, of the state ambient surface-water quality criteria levels and reflected local groundwater concentrations. The concentrations of all other measured radionuclides were below their detection limits, except for naturally occurring potassium-40.

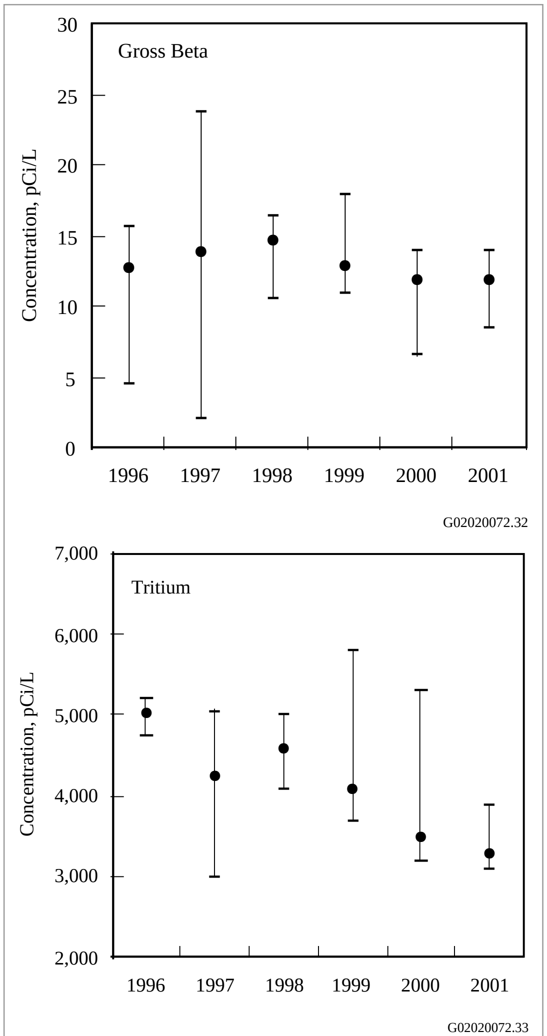

Figure 4.2.16. Median, Maximum, and Minimum Gross Beta and Tritium Concentrations in Fast Flux Test Facility Pond Water Samples, 1996 through 2001

4.2.5 Offsite Water

During 2001, water samples were collected from an irrigation canal located across the Columbia River and downstream from the Hanford Site at Riverview and from an irrigation water supply on the Benton County shoreline near the southern boundary of the Hanford Site (Horn Rapids irrigation pumping station). As a result of public concerns about the potential for Hanford-associated contaminants in offsite water, sampling was conducted to document the levels of radionuclides in water used by the public. Consumption of vegetation irrigated with Columbia River water downstream of the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual and any other member of the public (see Section 5.0).

Collection, Analysis, and Results for Irrigation Water

Water in the Riverview irrigation canal was sampled three times in 2001 during the irrigation season. Unfiltered samples of the canal water were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, and uranium-234, -235, and -238. Results are presented in PNNL-13910, APP. 1. In 2001,

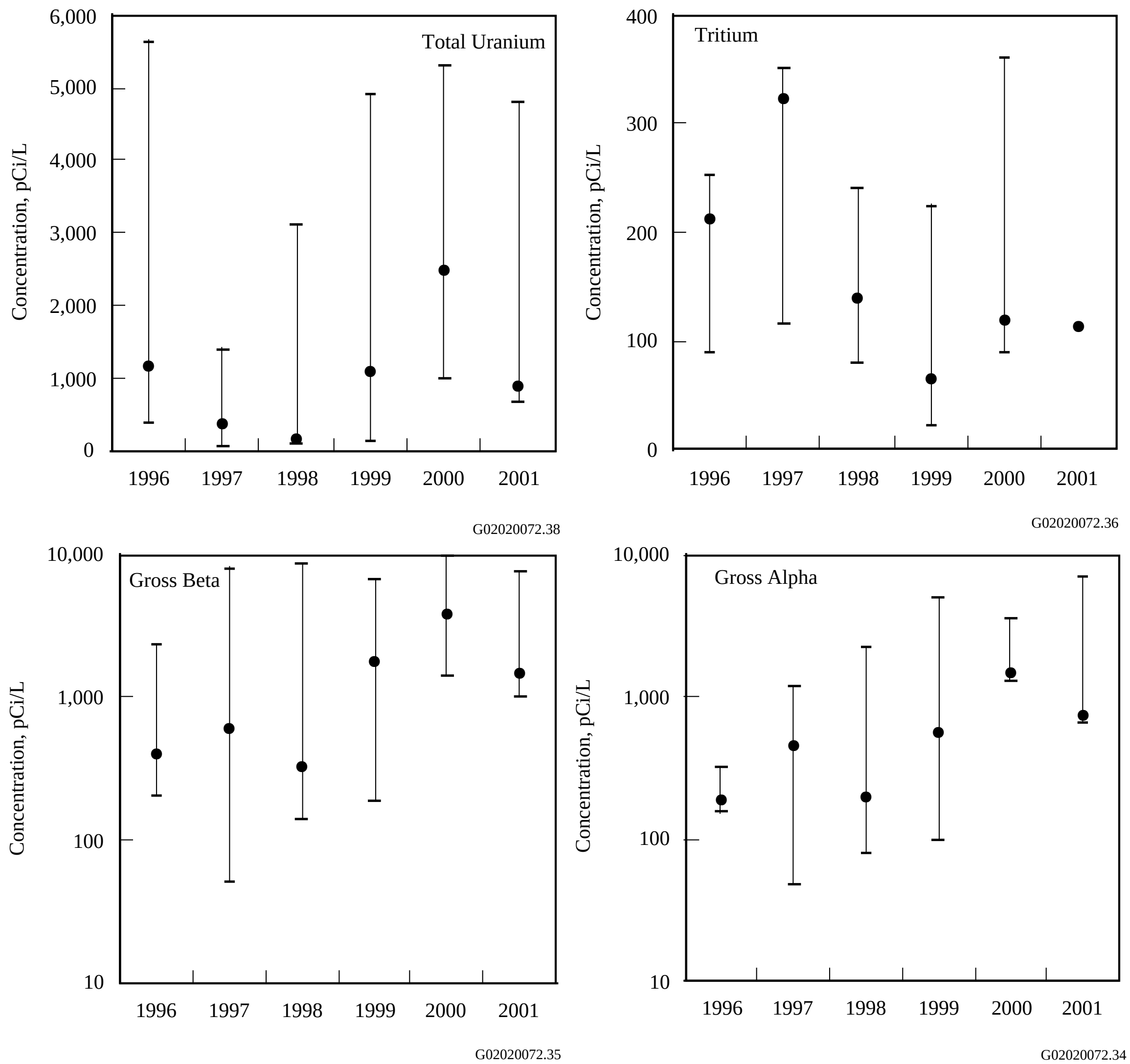

Figure 4.2.17. Median, Maximum, and Minimum Concentrations of Selected Radionuclides in West Lake Water Samples, 1996 through 2001

radionuclide concentrations measured in this canal's water were at the same levels detected in the Columbia River. All radionuclide concentrations were below the DOE derived concentration guides and state ambient surface-water quality criteria levels (DOE Order 5400.5; WAC 173-201A; 40 CFR 141). The strontium-90 levels in the irrigation water during 2001 ranged from 0.056 ± 0.028 to 0.082 ± 0.040 pCi/L (0.0021 ± 0.0010 to 0.0031 ± 0.0015 Bq/L) and were similar to those reported for the Columbia River at Priest Rapids Dam and the Richland Pumphouse (see Section 4.2.1).

The water sample from the Horn Rapids irrigation pumping station was analyzed for the same analytes as the Riverview irrigation canal water, except for tritium. All radionuclide concentrations were below both DOE derived concentration guides and state ambient surface-water quality criteria levels (DOE Order 5400.5; WAC 173-201A; 40 CFR 141) and were similar to Columbia River concentrations (see Section 4.2.1).

4.2.6 300 Area Near-Shore Contaminant Characterization

Pacific Northwest National Laboratory and the Washington State Department of Health conducted a contaminant characterization and biological and human dose/risk assessment for the near-shore of the Columbia River at the 300 Area. The objective of this study was to characterize the radiological and chemical conditions existing in the near-shore environment of the Columbia River by collecting water, biota, and sediment samples and measuring external radiation levels during a time period when the effects of riverbank spring discharges and groundwater upwelling into the river was likely to be maximized. Additionally, this study assessed the potential impact on resident ecological receptors and people that may visit this location. The study was conducted during August to October 2001 to coincide with expected low river stage. A number of contaminants are present in groundwater at the 300 Area and the near-shore environment can be exposed through riverbank springs and groundwater upwelling. Therefore, the sampling locations selected for this study were centered near historic riverbank spring discharges and the contaminants of concerns were primarily known groundwater contaminants (i.e., radionuclides, metals, anions, and volatile organics). This report is currently in production (PNNL-13692).