21.0 Columbia River

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The Hanford Reach of the Columbia River begins upstream of the Hanford Site at Priest Rapids Dam and extends 82 kilometers downstream to the upper end of Lake Wallula, impounded by McNary Dam. Although flow volume and water levels are controlled by upstream dams, the Hanford Reach is essentially the only free-flowing stretch of the Columbia River in the United States.

The U.S. Department of Energy (DOE) is committed to protecting the Columbia River from the Hanford Site's contaminated groundwater. The *Hanford Integrated Groundwater and Vadose Zone Management Plan* (DOE/RL-2007-20) outlines the steps for addressing groundwater and vadose zone contamination. The DOE developed the plan in consultation with the U.S. Environmental Protection Agency and the Washington State Department of Ecology.

The DOE is committed to protecting the Columbia River from the Hanford Site's contaminated groundwater.

Many actions have already been taken to address principal threats to the Columbia River and groundwater. These actions include the following:

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

Near the Columbia River, the rise and fall of the river stage create a dynamic zone of interaction between groundwater and the river, influencing flow patterns, contaminant concentrations, and in some instances, contaminant mobility (PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River*). The zone of interaction is monitored via near-shore groundwater wells and aquifer tubes (discussed in previous sections of this report), riverbank seeps (springs), and near-shore river water (discussed below).

The DOE conducts water quality monitoring in the Columbia River environment as part of its Public Safety and Resource Protection Program, with the purpose of monitoring the offsite migration of contaminants of Hanford Site origin via multiple pathways (DOE/RL-91-50, *Environmental Monitoring Plan*). The Surface Environmental Surveillance Project at Pacific Northwest National Laboratory (PNNL) conducts monitoring related to contaminants that groundwater carries to the river. Hanford Site shoreline monitoring is further discussed in *Water Quality Sampling Locations Along the Shoreline of the Columbia River, Hanford Site, Washington* (PNNL-19052), which also includes detailed location maps for near-river monitoring.

The DOE is conducting a risk assessment and remedial investigation of contaminant releases to the Columbia River, which are summarized in this chapter.

21.1 Seep and River Monitoring

PNNL collects samples from seepage areas on the banks of the Columbia River in the fall when the river stage is low. Samples are analyzed for a variety of chemicals and radionuclides, and the results are published annually in the Hanford Site environmental report (e.g., PNNL-18427, *Hanford Site Environmental Report for Calendar Year 2008*). Table 21-1 lists concentrations of contaminants of interest for each of the shoreline segments.

PNNL monitors Columbia River water by collecting samples along several cross-river transects and at near-shore river locations adjacent to groundwater plumes, where humans and aquatic biota are potentially exposed to contaminants. This surveillance includes sampling Columbia River water and sediment, and riverbank springs, as well as other media (e.g., air, plants, and animals). The surveillance data provide a historical record of radionuclides and chemicals in the environment. The results of water quality monitoring along the shoreline and in the free-flowing river are presented annually in the Hanford Site environmental report (e.g., PNNL-18427).

The Hanford Site environmental report for 2008 is available at http://hanford-site.pnl.gov/envreport/2008/.

The river water sampling results (PNNL-18427) are summarized below for CY 2008, which were the most recent results available at the time that this report was prepared:

- Tritium, uranium-234, and uranium-238 were consistently detected in river water at low concentrations. Uranium enters the Hanford Reach via groundwater from beneath the Hanford Site's 300 Area and via irrigation wastewater from Franklin County (which contains naturally occurring uranium from minerals in agricultural fertilizer).
- Strontium-90, uranium-235, and plutonium-239/240 were occasionally detected, but all values were near detection limits. Concentrations of all other radionuclides were typically less than detection limits.
- Chloride, nitrate, and sulfate concentrations were elevated along both shorelines of the Hanford Reach. The highest concentrations of these anions are frequently observed along the Franklin County shoreline, with agricultural activities being the likely cause.
- All river water samples had total chromium concentrations (filtered) of less than 1 µg/L (which is far below the ambient water quality criterion for hexavalent chromium of 10 µg/L).

Concentrations of contaminants are generally lower as groundwater approaches the river, because of mixing with clean river water that intrudes into the aquifer. Table 21-2 and Figure 21-1 provide the maximum concentrations of selected contaminants in Hanford Site groundwater, aquifer tubes, riverbank springs, and river water.

21.2 River Corridor Baseline Risk Assessment

A critical step in developing final remedial action decisions for the portions of the Hanford Site along the Columbia River is the completion of a quantitative baseline risk assessment. Washington Closure Hanford is responsible for the River Corridor baseline risk assessment. The 100 and 300 Area component of the River Corridor baseline risk assessment addresses post-remediation, residual contaminant concentrations in the 100 and 300 Areas, as well as the Hanford and White Bluffs town sites. This assessment also investigates risks related to the potential transport of Hanford Site contaminants to Columbia River riparian and near-shore environments adjacent to the former operational areas.

Additional information about the River Corridor baseline risk assessment is available at (http://www.washingtonclosure.com/Projects/EndState/baseline_risk_assessment.html).

Recent documents associated with the River Corridor baseline risk assessment include the following:

- DOE/RL-2004-37, Rev. 2, *Risk Assessment Work Plan for the 100 Area and 300 Area Component of the RCBRA*

- DOE/RL-2005-42, Rev. 1, *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan*
- DOE/RL-2007-21, *Risk Assessment Report for the 100 Area and 300 Area Component of the RCBRA*.

21.3 Hanford Site Releases to the Columbia River

The DOE and Washington Closure Hanford are investigating Hanford Site contaminant releases to the Columbia River (DOE/RL-2008-11, *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River*). It is important to understand the contaminants that are present, their concentrations, and where they are located, because these contaminants may have undesirable health effects for humans, animals, and plants that use or live in the Columbia River. The information obtained from this investigation will ultimately be used to help make final cleanup decisions for Hanford Site contaminants that exist in and along the Columbia River.

A fact sheet about the remedial investigation work plan is available at http://www.washingtonclosure.com/projects/EndState/risk_library.html#investigation.

A significant amount of field work was completed during the reporting period to provide observations on the potential presence of Hanford Site contaminants in the river environment. Samples collected include riverbed porewater (i.e., river and possibly groundwater entrained in riverbed sediment), as well as sediment, river water, fish, and soil from the islands.

In 2008 through early 2010, Washington Closure Hanford conducted a study of groundwater upwelling and porewater in the Columbia River. The study areas included all six reactor areas, the Hanford town site, and the 300 Area. The results of the study are scheduled for publication in CY 2010.

The study employed the Trident[1] probe, which is a device that is driven into the river sediment, typically about 0.3 meters deep. Specific conductance and temperature were measured in situ in the porewater and simultaneously in the river. The probe was deployed from a boat, and a camera provided images of the river bottom at each sampling site. The probe also allowed for the collection of water samples.

Phase I of the study, completed in CY 2008, involved testing the applicability of the Trident probe technology for Hanford Reach conditions. After a few equipment modifications, the system was deployed in a variety of river substrates in most river current conditions along the Hanford Reach of the Columbia River.

Phase II of the study, conducted in winter of 2008-2009, was designed to delineate areas where groundwater was discharging (upwelling) to the Columbia River. Phase IIa included ~675 in situ measurements of specific conductance and temperature. Areas of upwelling were defined by (1) specific conductance greater than river water, and (2) temperature differential (i.e., in winter, the groundwater is warmer than river water). The results indicated areas of preferential upwelling in definable locations along the Hanford Site shoreline, the opposite shoreline, and in the deep river channel. Researchers used the results from Phase IIa to select sites for sampling in Phase IIb.

During Phase IIb of the study, researchers collected samples of porewater from a subset of Phase IIa locations and analyzed the samples for key Hanford Site contaminants (i.e., hexavalent chromium in the 100-B/C, 100-K, 100-D, 100-H, and 100-F Areas; strontium-90 and petroleum hydrocarbons in the 100-N Area; tritium at the Hanford town site; and uranium and organics in the 300 Area.).

1 Trident™ probe is a trademark of Environmental Sciences, San Diego, California.

Contaminants were detected in some of the porewater samples and, in a few cases, were detected at higher concentrations than anticipated. For example, hexavalent chromium at 112 µg/L was detected in a sample from the deep river channel at the 100-B/C Area (see Chapter 13.0 for further discussion).

Phase III of the study, conducted in early CY 2010, included additional sampling of approximately five locations in each study area. Samples of porewater, river sediment, and river water were analyzed for a comprehensive list of contaminants. Sampling sites were selected based on Phase II results. The results of Phase III were not available when this report was prepared.

21.4 Research Activities Involving Discharge of Groundwater to the Columbia River

During the reporting period, DOE's Office of Science supported several research investigations at the Hanford Site involving the movement of groundwater near and beneath the Columbia River. The methods employed are shallow geophysical survey tools and an innovative application of fiber optic cables along the 300 Area shoreline (see Section 18.3.5). The initial results suggest that the survey methods are useful for identifying areas of preferential discharge of groundwater through the riverbed.

Hanford Reach National Monument

The Hanford Reach of the Columbia River, the last free-flowing stretch of this river in the United States, is part of the Hanford Reach National Monument. The monument also includes the Saddle Mountains Wildlife Refuge north of the river, and the Fitzner-Eberhardt Arid Lands Ecology Reserve in the southwestern Hanford Site. The 195,000-acre monument contains a wealth of wildlife and remnants of human history spanning more than 10,000 years.

The monument was established by Presidential decree in 2000 and is administered by the U.S. Fish and Wildlife Service.

For more information, see http://www.fws.gov/hanfordreach/.

Table 21-1. Hanford Site Contaminants in Columbia River Seeps (Springs), Calendar Year 2008.

Shoreline Segment	Constituent	Maximum Concentration
100-B/C	Chromium (filtered)	12.4 µg/L
	Nitrate	6.6 mg/L
	Strontium-90	2.16 pCi/L
	Tritium	2,680 pCi/L
100-K	Chromium (filtered)	62.6 µg/L
	Nitrate	6.6 mg/L
	Strontium-90	Undetected
	Trichloroethene	4.18 µg/L
	Tritium	3,250 pCi/L
100-N	Chromium (filtered)	7.7 µg/L
	Nitrate	14.7 mg/L
	Strontium-90	Undetected
	Tritium	5,800 pCi/L
100-D	Chromium (filtered)	11.3 µg/L
	Nitrate	4.2 mg/L
	Strontium-90	0.107 pCi/L
	Tritium	Undetected
100-H	Chromium (filtered)	33.7 µg/L
	Nitrate	15.7
	Strontium-90	6.76 pCi/L
	Tritium	2,110 pCi/L
100-F	Chromium (filtered)	15.5 µg/L
	Nitrate	31.5 mg/L
	Strontium-90	Undetected
	Tritium	1,160 pCi/L
Hanford town site	Chromium (filtered)	0.738 µg/L
	Iodine-129	Undetected
	Nitrate	6.2 mg/L
	Tritium	14,300 pCi/L
300 Area	Nitrate	26.5 mg/L
	Trichloroethene	1.45 µg/L
	Tritium	9,060 pCi/L
	Uranium	143 µg/L

Source: PNNL-18427, *Hanford Site Environmental Report for Calendar Year 2008*, Appendix 1.
Notes:
Nitrate as N converted to nitrate as NO_3.
Total uranium converted from pCi/L to µg/L.

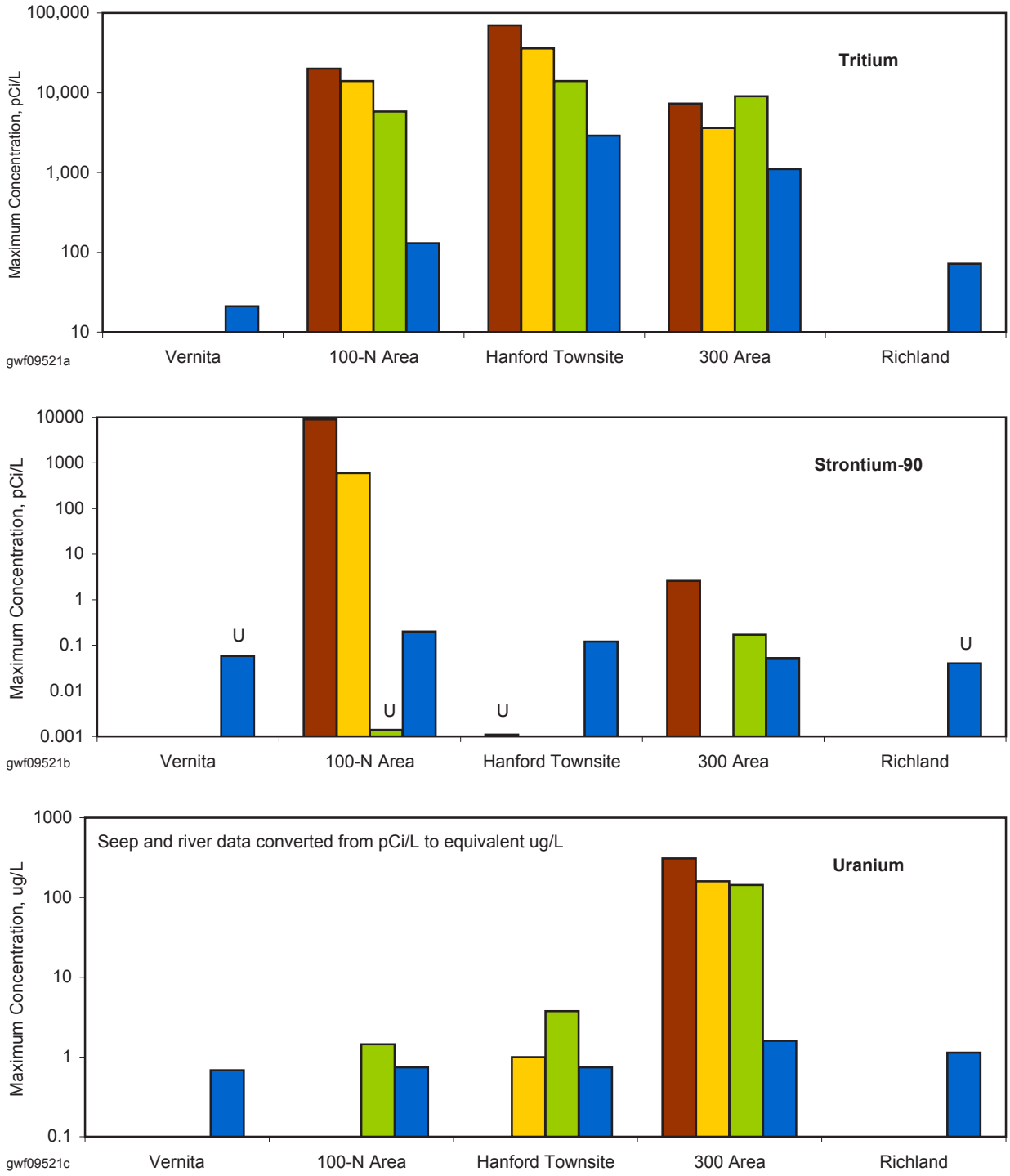
Table 21-2. Maximum Concentrations of Tritium, Strontium-90, and Uranium in Groundwater Wells, Aquifer Tubes, Riverbank Springs, and Near-Shore River Water.

Media	Vernita (Upstream)	100-N Area	Hanford Town Site	300 Area	Richland (Downstream)
Tritium, pCi/L					
Groundwater	--	20,000	70,000	7,300	--
Aquifer tube	--	14,000	36,000	3,600	--
Spring	--	5,800	14,000	9,060	--
River water	21	130	2,900	1,100	72
Strontium-90, pCi/L					
Groundwater	--	9,000	0.0011 (U)	2.6	--
Aquifer tube	--	600	--	--	--
Spring	--	0.0014 (U)	--	0.17	--
River water	0.058 (U)	0.2	0.12	0.052	0.04 (U)
Uranium, µg/L					
Groundwater	--	--	--	308	--
Aquifer tube	--	--	1	160	--
Spring*	--	1.44	3.75	143	--
River water*	0.68	0.74	0.74	1.59	1.13

Notes:
Groundwater and aquifer tube data from calendar year 2009.
Seep and near-shore river data for calendar year 2008 (from PNNL-18427, *Hanford Site Environmental Report for Calendar Year 2008*, Tables C.6 and C.10).
* Converted from pCi/L to µg/L, assuming natural abundances.

-- = no data
U = below detection limit

Figure 21-1. Maximum Concentrations of Tritium, Strontium-90, and Uranium in Groundwater Wells, Aquifer Tubes, Riverbank Springs, and Near-Shore River Water.



Groundwater
Aquifer Tube
Seep
River

Groundwater (well) and aquifer tube data for CY 2009.

Seep and near-shore river data for CY 2008 (from PNNL-18427, Tables C.6 and C.10).

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