4.6 Soil and Vegetation Surveillance

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Soil surveillance provides information on long-term contamination trends and baseline environmental radionuclide activities at undisturbed locations (DOE/RL-91-50, Rev. 2). Surveillance of perennial vegetation provides information on atmospheric deposition of radioactive materials in uncultivated areas and at onsite locations adjacent to potential sources of man-made radioactivity. Accordingly, radionuclide activities in soil and perennial vegetation provide a baseline against which unplanned releases can be compared.

Soil and perennial vegetation samples have been collected on and around the Hanford Site for >50 yr. Consequently, a large database exists that thoroughly documents onsite and offsite activities of man-made radionuclides in soil and natural vegetation at specific locations. Because the current site mission includes environmental restoration and cleanup and because routine plutonium production operations at the site have ceased, the need for annual soil and perennial vegetation surveillance has diminished. There are several additional reasons for the reduced need for soil and perennial vegetation sampling. Man-made radionuclides with short half-lives have decayed to stable isotopes and are no longer present. Moreover, radionuclide releases from the Hanford Site in recent years have been small, and, therefore, baseline radionuclide activities have not changed appreciably for a number of years. Because only radionuclides with relatively long half-lives presently are found in soil and vegetation, sitewide environmental surveillance sampling of soil and vegetation can be less frequent. Radiological surveillance of soil and vegetation was last conducted in 1994 (Section 4.6 in PNNL-10574). In 1998, routine sampling of soil and perennial vegetation was conducted at 15 locations on site and 5 locations off site (Figure 4.6.1). Additionally, special sampling of Columbia River shoreline mulberry trees at the 100-N Area was conducted in October 1998 to verify the results of samples collected and analyzed by an external stakeholder group. Fruit and leaves from trees located near the 100-F Area and the Old Hanford Townsite were also sampled and analyzed.

Other soil and vegetation sampling by Fluor Daniel Hanford, Inc. was conducted near active facility release points and waste sites. Results are discussed in Section 3.2, "Near-Facility Environmental Monitoring."

4.6.1 Soil Sampling

Soil samples were collected at 20 locations on and around the Hanford Site in 1998 (see Figure 4.6.1). Soil samples were organized into three distinct groups: 1) onsite, 2) offsite (combined perimeter and one distant upwind location at Sunnyside), and 3) the Fitzner-Eberhardt Arid Lands Ecology Reserve site (formerly grouped with perimeter locations). Onsite sample locations are selected in areas around industrial development on the site. The offsite perimeter locations sampled in 1998 were Ringold, Byers Landing, Sagemoor, and Riverview. These four locations lie in a generally downwind location east and southeast of the site. Soil was collected from two sites on the Fitzner-Eberhardt Arid Lands Ecology Reserve.

Soil samples consisted of five plugs, 2.54 cm (1 in.) deep and 10.2 cm (4 in.) in diameter, that were

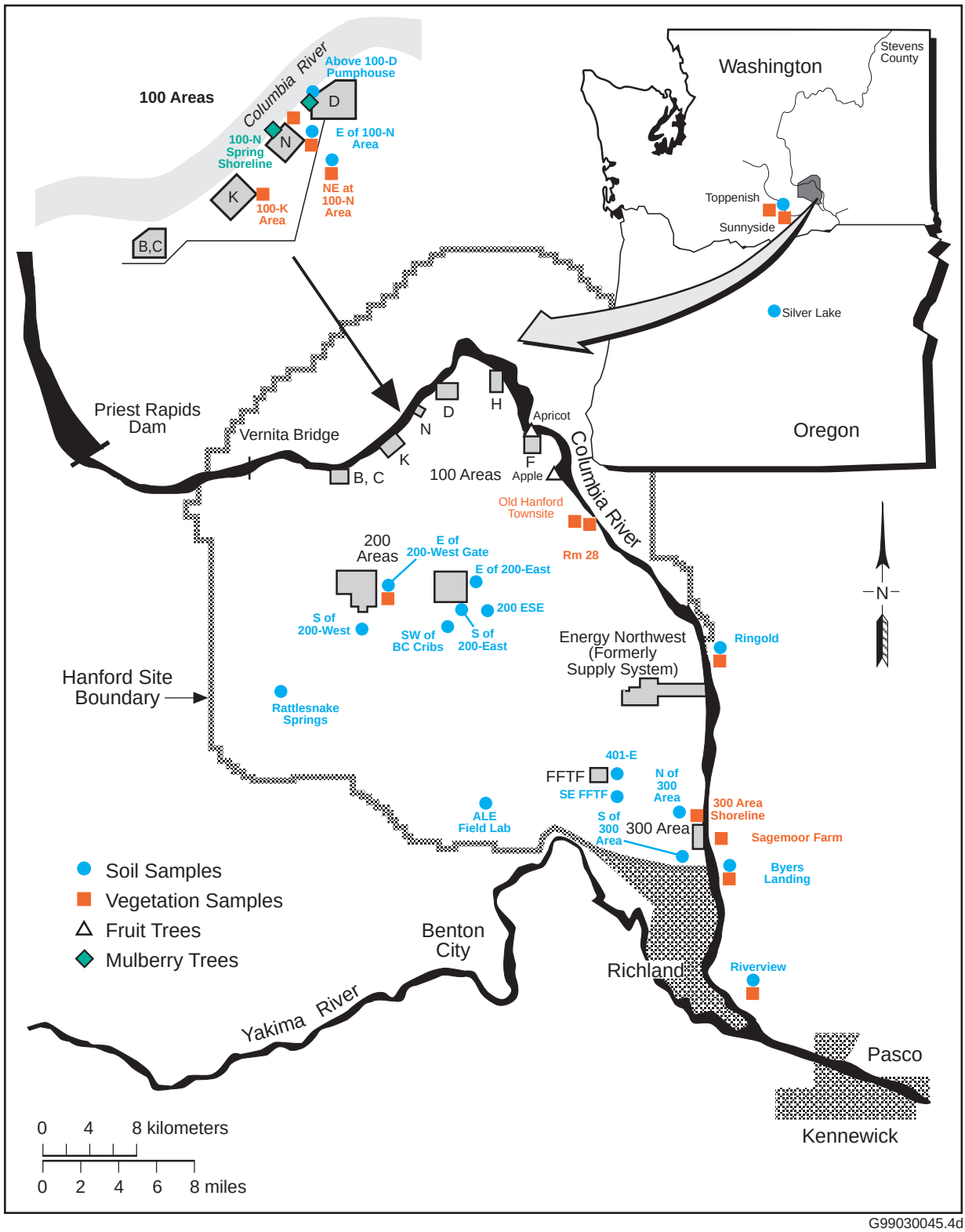

Figure 4.6.1. Soil and Vegetation Sampling Locations, 1998

collected within 10 m (33 ft) of one another and combined into one bulk sample. Soil samples were dried to remove residual moisture and sieved at the laboratory prior to analysis to remove rocks and plant debris.

In 1998, soil samples were analyzed for gamma-emitting radionuclides, strontium-90, uranium-234, -235, -238, plutonium-238, plutonium-239,240, and, in selected samples, americium-241 (Table 4.6.1). The 1998 results were compared to those from 1992 through 1997 (see Appendix A, Table A.8) and from soil samples collected from mountainous regions as part of special studies (Table 4.6.2). In 1996, results of an assessment of Hanford background radionuclide activities in soils were published (DOE/RL-96-12). These assessment results provide comparison values (median and 95th percentile[a] activities) for radionuclides that are routinely monitored on the Hanford Site.

In 1998, observed strontium-90 and cesium-137 activities in all soil samples were near detection limits. Median activities of strontium-90, cesium-137, and plutonium-239,240 collected from onsite locations were no different than those found at perimeter locations in 1998 and the preceding sampling years (1992 through 1994) (Figure 4.6.2). Maximum activities of strontium-90, cesium-137, and plutonium-239,240 in samples collected on the site were higher than the maximums measured at offsite locations because some of the locations on the site were selected to monitor specifically for past industrial releases. The East of 200-West Gate soil

Table 4.6.1. Routine Soil and Vegetation Samples Collected and Analyzed, 1998

Location	No. of Samples	Frequency	Analytes
Soil			
Onsite[a]	13	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}[b], Pu,[c] ^{241}Am
Distant	1	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}, Pu, ^{241}Am
Downwind perimeter[a]	4	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}, Pu, ^{241}Am
ALE[d]	2	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}, Pu, ^{241}Am
Vegetation			
Onsite	5	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}, Pu
Distant	2	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}, Pu
Perimeter	4	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}, Pu
Shoreline	3	Annual to once every 5 yr	Gamma, ^{90}Sr, U_{iso}, Pu

(a) Not all analytes are analyzed for at each location.
(b) U_{iso} is a method of analyzing for uranium by detecting alpha particles.
(c) Plutonium-238 and plutonium-239,240.
(d) Fitzner-Eberhardt Arid Lands Ecology Reserve.

(a) The percentile is a statistical grouping of values, 95% of all values fall below the 95th percentile; hence, the 95th percentile is used as an estimate of the upper bounds of uranium activities in soil.

Table 4.6.2. Comparison of Strontium-90, Cesium-137, and Plutonium-239,240 Activities (pCi/g dry wt.) in Soils at Remote Locations with Site Background Observed Onsite and Offsite Concentrations

Location[a]	Year	Radionuclide	Minimum[b]	Median (50th Percentile)	Maximum[b] (95th Percentile)	Number
Silver Lake lowland	1994	Strontium-90	0.14 ± 0.03	0.18 ± 0.04	0.23 ± 0.04	3
		Cesium-137	0.29 ± 0.05	0.33 ± 0.05	0.43 ± 0.07	
Silver Lake mountain	1994	Strontium-90	0.54 ± 0.10	0.67 ± 0.13	0.69 ± 0.13	3
		Cesium-137	1.67 ± 0.21	1.70 ± 0.20	1.72 ± 0.20	
Stevens County	1994	Strontium-90	NR[c]	NR	0.39 ± 0.07	1
		Cesium-137	NR	NR	0.82 ± 0.09	
Hanford Site background[d]	1985 to 1992	Strontium-90	NR	0.06	0.21	73
		Cesium-137	NR	0.31	1.08	149
		Plutonium-239,240	NR	0.0077	0.026	128
Hanford Site perimeter	1998	Strontium-90	0.043 ± 0.010	0.054 ± 0.008[e]	0.060 ± 0.012	4
		Cesium-137	0.16 ± 0.02	0.20 ± 0.03	0.32 ± 0.04	
		Plutonium-239,240	0.0066 ± 0.0010	0.0088 ± 0.0015	0.012 ± 0.0015	
On the Hanford Site	1998	Strontium-90	0.014 ± 0.004	0.065 ± 0.015	0.38 ± 0.069	13
		Cesium-137	0.005 ± 0.009	0.14 ± 0.021	1.8 ± 0.18	
		Plutonium-239,240	0.0004 ± 0.0002	0.0052 ± 0.0009	0.53 ± 0.058	

(a) See Figure 4.6.1 for locations.
(b) ±2 sigma total analytical error.
(c) NR = Not reported.
(d) Estimated values based on samples collected on and around the Hanford Site (see Table 3-5 in DOE/RL-95-55).
(e) 2-sigma error of highest activity used to calculate the median.

sampling location (see Figure 4.6.1) has consistently had the highest activities of these radionuclides.

In the past, soil sites on the Fitzner-Eberhardt Arid Lands Ecology Reserve were included in the perimeter grouping. Because of the transfer of management of this reserve to the U.S. Fish and Wildlife Service in 1997, results from the Rattlesnake Springs and Arid Lands Ecology Field Laboratory stations are reported separately. Results for these locations for 1998 were similar to 1993 (see Appendix A, Table A.9) and fall within the range of activities observed at other onsite or offsite locations (see Figure 4.6.2).

Uranium is a natural radionuclide that is present in all soils. Uranium activities in soil on and near the Hanford Site were analyzed in 1998 by acid leaching and alpha spectrometry of the extracted residue. In prior years, soil samples were analyzed by both alpha spectrometry and low-energy photon spectrometry.

The median background activity and the 95th percentile background activity of uranium-238 near and on the Hanford Site have been reported as 0.76 and 1.18 pCi/g, respectively (DOE/RL-95-55). These background activities are based primarily on low-energy photon spectrometry. Low-energy photon spectrometry results for uranium-238 are generally lower than alpha spectrometry results; however, the degree of difference varies, depending on the soil type and particle-size distribution. Maximum uranium-238 activities measured in soils on and around the

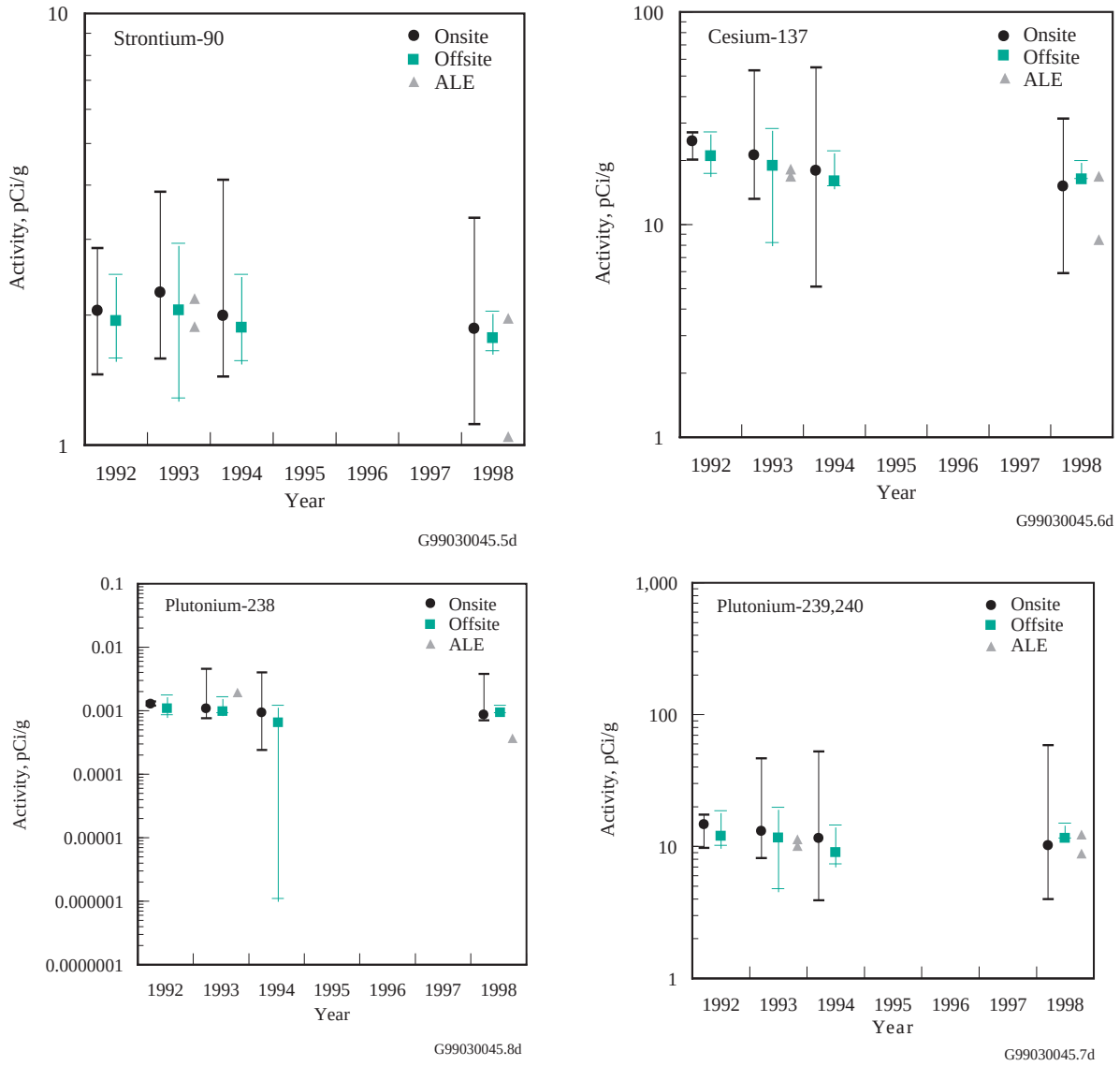

Figure 4.6.2. Median, Maximum, and Minimum Radionuclide Activities of Strontium-90, Cesium-137, Plutonium-238, and Plutonium-239,240 in Soil (pCi/g dry wt), 1992 Through 1998 (ALE = Fitzner-Eberhardt Arid Lands Ecology Reserve)

Hanford Site in 1998 by alpha spectrometry were below the reported median background.

Onsite and offsite soil radionuclide activities from 1998 were also compared with the background values on and near the site (DOE/RL-95-55) and with the results from distant and remote sampling sites in Stevens County, Washington, and the two locations at Silver Lake, Oregon (Table 4.6.2). The remote samples provide some indication of the concentrations of fallout radionuclides that are found in other parts of the Pacific Northwest. Background fallout radionuclide activities generally increase with increased annual precipitation and altitude.

4.6.2 Vegetation Sampling

Vegetation samples were collected at 14 locations on and around the Hanford Site in 1998 (see Figure 4.6.1). Vegetation samples collected in 1998 were organized into four distinct groups: 1) onsite, 2) perimeter, 3) distant upwind locations, and 4) Columbia River shoreline samples (see Table 4.6.1). Onsite sample locations were generally selected in areas around industrial development on the site. The downwind perimeter locations were Ringold, Byers Landing, Sagemoor, and Riverview. These four locations lie generally downwind, east and southeast, of the site. They are expected to be in areas of highest offsite accumulation of contaminants from stack emissions. Special shoreline samples were collected at the Hanford Slough (in conjunction with apple tree sampling), at Hanford River mile marker 28, and at the 300 Area.

Perennial vegetation samples consist of the current year's growth of leaves, stems and new branches collected from sagebrush and rabbitbrush. Sample vegetation is dried before analyses, and analytical results are reported on a dry weight basis. Shoreline vegetation samples usually are taken from a predominant species at the sample location site. Samples of leaves and fruit collected from abandoned fruit trees were also analyzed for trace metals by inductively coupled plasma-mass spectrometry and by cold vapor atomic adsorption spectrometry (specifically for mercury). Metals results were reported on a dry weight basis.

Surveillance of perennial vegetation samples for radionuclides in 1998 generally confirmed observations of past sampling efforts. Activities of cesium-137, uranium-238, plutonium-238, and technetium-99 (in two samples of shoreline vegetation) were all below nominal detection limits (see Appendix A, Table A.10). Nominal detection limits for these radionuclides were 0.02, 0.02, 0.0002, and 0.4 pCi/g, respectively. Plutonium-239,240 was measured in one perennial vegetation sample (0.004 ± 0.001 pCi/g) collected at the East of the 200-West Gate sampling location (see Figure 4.6.1). All other plutonium-239,240 activities were below detection (0.0003 pCi/g).

Strontium-90 was found in 12 of 14 vegetation samples collected in 1998. There was no appreciable difference between the range of strontium-90 activities measured from 1992 through 1998 or between onsite, perimeter, and distant locations (Figure 4.6.3).

Special sampling involved the collection of leaves from willows along the Columbia River shoreline at the 300 Area and rough bugleweed along the river shoreline at Hanford River mile marker 28, near the Old Hanford Townsite. Samples collected near the river shoreline at the 100-N Area consisted of rabbitbrush. The rabbitbrush samples were not collected at the river shoreline. Instead, they were collected as near to the shoreline as possible because the shoreline area was covered with basalt. Consequently, the 100-N Area shoreline results were grouped and

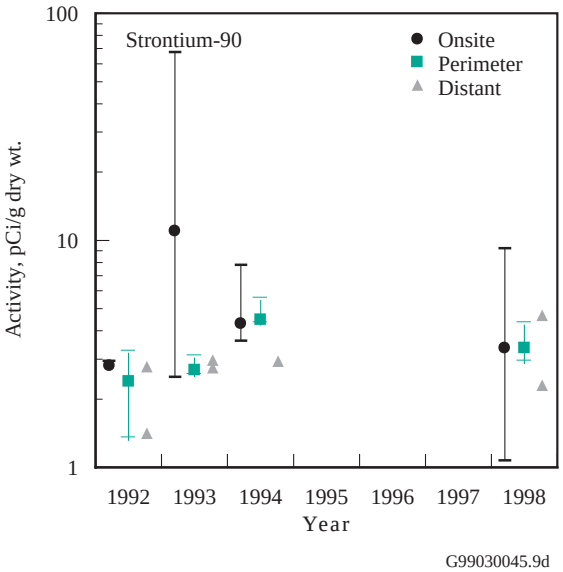

Figure 4.6.3. Median, Maximum, and Minimum Radionuclide Activities of Strontium-90 in Natural Vegetation, 1992 Through 1998

reported with other onsite (nonshoreline) perennial vegetation samples. Mulberry trees were sampled in October at two locations at the 100-N Area shoreline and approximately 1,600 m (1 mi) downstream of the radiological control area at the 100-N Area shoreline.

Results of shoreline vegetation samples are summarized in Table 4.6.3 and are compared to a comprehensive survey of shoreline vegetation conducted from 1990 through 1992 (PNL-8797). Generally, strontium-90 activities were comparable to results from the 1990 to 1992 study, with the exception of the 100-N Area mulberry tree samples. The maximum strontium-90 measured in the 1998 mulberry leaf sample was >10 times lower than the maximum observed in 1990. While uranium-238 was approximately 10 times higher in 1998 bugleweed samples than in onions sampled from 1990 to 1992, the activities in the bugleweed were no different than the uranium-238 observed in historical perennial vegetation and shoreline plants (PNL-8797, PNL-10728).

4.6.3 Tree Sampling

Fruit trees growing on the site were sampled in 1998 to complement samples collected in 1997 (PNNL-11795). Fruit and leaves were collected from an apple tree at the Old Hanford Townsite and an apricot tree at the 100-F Area. Samples were analyzed for radiological constituents and trace metals. These trees are located on the Hanford Site and are not generally accessible to the public.

Concentrations of 13 trace metals were measured in leaf samples in 1997 and 1998. The metals were grouped into four distinct classifications based on the relationship of the concentrations in the samples to values from the literature that define natural background metal concentrations and concentrations of metals in vegetation associated with elevated and potentially toxic environmental

Table 4.6.3. Radionuclide Activities (pCi/g dry wt.) in Shoreline Vegetation, 1998 Compared to 1990-1992 (PNL-8797)

				Historic Maximum		
Species (1998)	Location	Radionuclide	1998 Activity[a]	Species	Activity[a]	Year
Willow	300 Area	Strontium-90	0.26 ± 0.05	Mulberry	0.17 ± 0.04	1990
		Cesium-137	0.07 ± 0.02	Mulberry	0.02 ± 0.01	1990
Bugleweed	HRM 28[b] (Old Hanford Townsite)	Technetium-99	0.66 ± 0.42	Mulberry	17 ± 2.3	1992
		Cesium-137	0.25 ± 0.03	Onion	0.15 ± 0.08	1992
		Uranium-238	0.64 ± 0.07	Onion	0.085 ± 0.012	1992
		Plutonium-239,240	0.006 ± 0.001	Asparagus	0.0006 ± 0.0004	1992
Mulberry tree	100-N Area Shoreline	Strontium-90	2.0 ± 0.37	Mulberry	437 ± 85	1990
		Strontium-90	28 ± 4.9	Mulberry	437 ± 85	1990
	1,600 m (1 mi) below 100-N Area shoreline	Strontium-90	0.20 ± 0.04	Mulberry	1.1 ± 0.21	1990

(a) ±2 sigma total analytical uncertainty.
(b) HRM = Hanford river mile, as measured from the Highway 24 Vernita Bridge.

exposures to metal contamination (Coughtrey and Thorne 1983, Coughtrey et al. 1983, Kabata-Pendias and Pendias 1984). The four classifications are all measured concentrations 1) less than the analytical detection limit, 2) less than or equal to the reported background concentrations, 3) less than the reported toxic concentration range, and 4) within the nominal toxic range of metal concentrations. The last classification may indicate that trees have been exposed to elevated concentrations of metals in their immediate habitat.

Based on this classification, all trace metal constituents measured in Hanford Site tree samples were below or within the concentration ranges associated with uncontaminated (i.e., background) habitat (Table 4.6.4). Chromium was measured in apricot leaves collected in 1997 from trees growing near the 100-D Reactor, within the bounds of known chromium groundwater plumes. Chromium was not detected in the tree samples collected at the Old Hanford Townsite or 100-F Area in either 1997 or 1998. The levels in the 100-D Area apricot leaf samples were well within the range of background vegetation concentrations and were below concentrations that are potentially harmful to vegetation. Metals concentrations in leaves are summarized in Appendix A, Table A.11.

Table 4.6.4. Classification of Trace Metal Concentrations (μg/g dry wt.) in Onsite Fruit Tree Samples Collected in 1997 and 1998 Compared to Nominal Background and Nominal Toxic Reference Concentrations[a]

			Reference Concentrations[a]	
Classification of Metals	**Metal (Detection Limit)**	**Measured Concentration Range**	**Nominal Background Concentration Range**	**Nominal Toxic Range**
All measured concentrations <detection level	Antimony (0.02)	<0.02	7.0 to 50	≥150
	Beryllium (0.1)	<0.1	0.001 to 0.4	10 to 50
	Selenium (2.0)	<2.0	0.03 to 5.0	5.0 to 30
	Silver (0.45)	<0.45	0.07 to 1.4	5.0 to 10
	Thallium (0.01)	<0.01	0.008 to 0.125	≥20
Measured concentration ≤nominal background concentratiozn range	Arsenic (0.15)	<0.15 to 0.39	0.02 to 1.5	5.0 to 20
	Lead (0.01)	<0.01 to 0.25	1.0 to 15	30 to 300
	Zinc (1.0)	2.0 to 16.7	27 to 141	100 to 400
Measured concentration <nominal toxic range	Cadmium (0.04)	<0.04 to 0.2	0.05 to 0.2	5 to 30
	Chromium (1.0)	<1.0 to 0.31[b]	0.1 to 0.5	5 to 30
	Copper (0.8)	0.34 to 14.1	6.3 to 29	20 to 100
	Mercury (0.0016)	<0.0016 to 0.022	0.003 to 0.011	1 to 3
	Nickel (0.15)	0.15 to 1.1	0.1 to 5.0	10 to 100
Measured concentration = nominal toxic range	None	None	None	None

(a) Nominal concentrations were taken from Coughtrey and Thorne (1983), Coughtrey et al. (1983), and Kabata-Pendias and Pendias (1984).
(b) Detection limit for 1998 samples was <1.0 μg/g dry wt.; detection limit for 1997 samples was 0.2 μg/g dry wt.

Analyses of leaves and fruit from the apricot and apple trees were also performed for tritium, gamma emitters, and strontium-90. No man-made gamma emitters were detected in any fruit tree samples collected in 1997 or 1998. Tritium (as distillate from plant material) was found in fruit tree leaves and fruit in 1998 at activities slightly higher than levels found in fruit tree samples collected at the 100-F Area and Old Hanford Townsite in 1997 (Table 4.6.5). The tritium activities in 1998 samples were approximately a factor of 10 lower than those found in 100-D Area apricot tree samples in 1997.

Strontium-90 was not found in apricot or apple fruit samples collected on the site in 1998; however, strontium-90 was found in leaf samples from the apple and apricot trees (Table 4.6.6). Strontium-90 activities in leaf samples were comparable to those observed in perennial vegetation samples routinely collected on the site in 1998.

Table 4.6.5. Tritium (pCi/L of sample distillate) in Fruit Tree Samples Collected from the Hanford Site, 1997 and 1998

Sample	Location	Activity[(a)]
1997		
Quince leaves	Old Hanford Townsite	15.2 ± 7.40
Apricot leaves	100-D Area	618 ± 57.2
Apricot leaves	100-D Area	503 ± 47.4
Apricot leaves	100-F Area	12.1 ± 7.20
1998		
Apricot leaves	100-F Area	62.7 ± 15.1
Apricot fruit	100-F Area	39.0 ± 9.56
Apple leaves	Old Hanford Townsite	60.5 ± 15.2
Apple fruit	Old Hanford Townsite	67.4 ± 16.3

(a) ±2 sigma total analytical error.

Table 4.6.6. Strontium-90 Activities (pCi/g dry wt.) in Fruit Tree Samples Collected from the Hanford Site, 1997 and 1998

Sample	Location	Activity[a]
1997		
Apricot leaves	100-D Area	0.015 ± 0.005
Apricot leaves	100-D Area	0.011 ± 0.004
Apricot leaves	100-F Area	0.16 ± 0.013
Quince fruit	Old Hanford Townsite	0.004 ± 0.005
Quince leaves	Old Hanford Townsite	0.094 ± 0.017
1998		
Apricot fruit	100-F Area	0.018 ± 0.013
Apricot leaves	100-F Area	0.13 ± 0.026
Apple fruit	Old Hanford Townsite	0.008 ± 0.007
Apple leaves	Old Hanford Townsite	0.036 ± 0.024

(a) ±2 sigma total analytical error.