



3.2 Near-Facility Environmental Monitoring

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Near-facility (near-field) environmental monitoring is defined as routine monitoring near facilities that have potential to discharge, or have discharged, stored, or disposed of radioactive or hazardous contaminants. Monitoring locations are associated with nuclear facilities such as the Plutonium Finishing Plant, Canister Storage Building, and the K Basins; inactive nuclear facilities such as N Reactor and the Plutonium-Uranium Extraction Plant; and active and inactive waste storage or disposal facilities such as burial grounds, cribs, ditches, ponds, waste tank farms, and trenches.

Much of the monitoring program consists of collecting and analyzing environmental samples and conducting radiological surveys in areas near facilities. The program also is designed to evaluate and report analytical data, determine the effectiveness of facility effluent monitoring and controls, measure the adequacy of containment at waste disposal units, and detect and monitor unusual conditions. The program implements applicable portions of DOE Orders 435.1, 5400.1, 5400.5, and 5484.1; 10 CFR 835 and 40 CFR 61; and WAC 246-247.

Near Hanford Site facilities, several types of environmental media are sampled, and various radiological and non-radiological measurements are taken to monitor the effectiveness of effluent

treatment and control practices, diffuse source emissions, and contamination control in waste management and restoration activities. These sample types and measurements include air, spring water, surface contamination, soil and vegetation, external radiation measurements, and investigative sampling. Samples are collected from known or expected effluent pathways. These pathways are generally downwind of potential or actual airborne releases and downgradient of liquid discharges.

Active and inactive waste disposal sites and the terrain surrounding them are surveyed to detect and characterize radioactive surface contamination. Routine radiological survey locations include cribs, trenches, retention basin perimeters, pond perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the site operational areas.

Sampling and analysis information and analytical results for 2000 are summarized in the following sections. Additional data may be found in *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2000* (PNNL-13487, APP. 2). Near-facility monitoring in 2000 is summarized in Table 3.2.1, which shows the type, quantity, and general location of samples collected.

3.2.1 Air Monitoring

A special section addressing near-facility air monitoring results related to the June 2000 wildfire is provided in Section 5.0.

In 2000, routine monitoring for radioactivity in air near Hanford Site facilities used a network of

continuously operating samplers at 85 locations (Table 3.2.2) (sampling locations illustrated in PNNL-13487, APP. 2). Air samplers were located primarily at or within ~500 meters (1,500 feet) of sites and/or facilities having the potential for, or



Table 3.2.1. Near-Facility Routine Environmental Monitoring Samples and Locations, 2000

Sample Type	Number of Sample Locations	Operational Area							ERDF ^(a)	200/600	300/400
		100-B/C	100-D/DR	100-K	100-F	100-H	100-N				
Air	85	0	11	8	6	6	4	3	41 ^(b)	6	
Water	14	0	0	0	0	0	14	0	0	0	
Soil	91	0	2	0	2	2	9	1	57	18	
Vegetation	75	0	0	0	0	0	8	0	52	15	
External radiation	148	5	5	15 ^(c)	5	3	14	3	77 ^(d)	21	

(a) Environmental Restoration Disposal Facility in the 200-West Area.

(b) Includes one station at the Wye Barricade, 19 in the 200-East Area, and 21 in the 200-West Area.

(c) Includes 4 locations at the Cold Vacuum Drying Facility.

(d) Includes 66 locations in the 200 Areas, 10 at the Tank Waste Remediation System located east of the 200-East Area, and one at the 212-R facility in the 200-West Area.

history of, environmental releases and are predominantly located in the prevailing downwind direction. To avoid duplication of sampling, air data for the 300 and 400 Areas, some onsite remediation projects, and some offsite distant locations were obtained from Pacific Northwest National Laboratory.

Samples were collected according to a schedule established before the 2000 monitoring year. Airborne particles were sampled at each sampling location by drawing air through a glass-fiber filter. The filters were collected biweekly, field surveyed for gross radioactivity, held for at least 7 days, and then analyzed for gross alpha and beta activity. The 7-day holding period was necessary to allow for the decay of naturally occurring, short-lived radionuclides that would otherwise obscure detection of longer-lived radionuclides associated with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the near-facility environment.

For most specific radionuclide analyses, the amount of radioactive material collected on a single filter during a 2-week period was too small to be measured accurately. To increase the accuracy of the analysis, the samples were combined into either quarterly or semiannual samples for each location.

Figure 3.2.1 shows the average concentrations of selected radionuclides in the 100 and 200/600 Areas compared to DOE derived concentration guides and air concentrations measured in distant communities. The DOE derived concentration guides (DOE Order 5400.5) are reference values that are used as indexes of performance. The data indicate a large degree of variability. Air samples collected from areas located at or directly adjacent to Hanford Site facilities had higher concentrations than did those samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which is much less than DOE derived concentration guides but greater than those measured off the site. In all areas, the data also show that concentrations of certain radionuclides were higher within different operational areas. Table 3.2.3 shows the annual average and maximum concentrations of radionuclides in near-facility air samples during 2000.

The 2000 analytical results for the remedial action projects at 100-D, 100-F, and 100-H Areas generally indicated that for most radionuclides, concentrations were greater than levels measured off the site. At the 100-D site, ambient air monitoring locations included eight samplers. Remedial action activities for fiscal year 2000 were completed

Table 3.2.2. Near-Facility Air Sampling Locations and Analyses, 2000

Site	Number of Samplers	EDP Code ^(a)	Analyses	
			Biweekly	Composite
100-D remedial action project	8	N467, N468, N469, N470, N512, N513, N514, N515	Gross alpha, gross beta	GEA, ^(b) Sr-90, Pu-iso, ^(c) U-iso ^(d)
105-D interim safe storage project	1	N523	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
105-DR interim safe storage project	2	N492, N493	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
105-F interim safe storage project	2	N494, N495	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
105-H interim safe storage project	2	N524, N525	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-H remedial action project	4	N507, N508, N509, N510	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-F remedial action project	4	N519, N520, N521, N522	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-K spent nuclear fuels	8	N401, N402, N403, N404, N476, N477, N478, N479	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso, Pu-241, Am-241
100-N surveillance, maintenance and transition/remedial action	4	N102, N103, N105, N106	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
200-East Area	17	N019, N158, N498, N499, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984, N985, N999	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
Canister Storage Building, 200-East Area	2	N480, N481	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso, Pu-241, Am-241
200-West Area	21	N155, N161, N165, N168, N200, N304, N433, N441, N442, N449, N456, N457, N956, N963, N964, N965, N966, N974, N975, N987, N994	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
300-FF-1 remedial action project (300 Area)	6	N130, N485, N486, N487, N488, N489	Gross alpha, gross beta	GEA, U-iso
600 Area (Wye Barricade)	1	N981	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
Environmental Restoration Disposal Facility	3	N482, N483/N517, N484/N518	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso

(a) EDP Code = Sampler location code. See PNNL-13487, APP. 2.

(b) GEA = Gamma energy analysis.

(c) Isotopic plutonium-238 and -239/240.

(d) Isotopic uranium-234, -235, and -238.



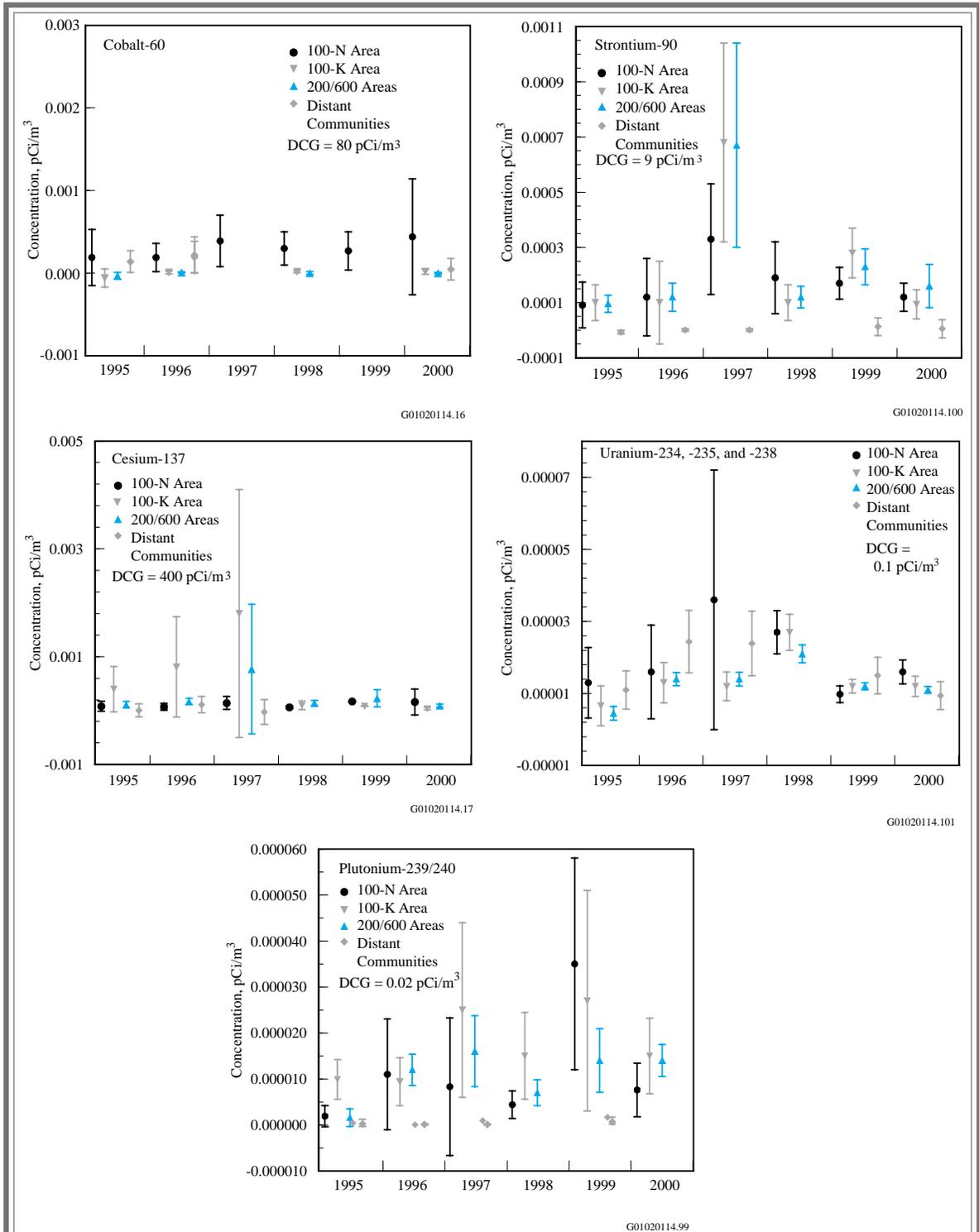


Figure 3.2.1. Average Concentrations (± 2 standard error of the mean) of Selected Radionuclides in Near-Facility Air Samples Compared to Those in Distant Communities, 1995 through 2000. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. Cobalt-60 was not detected in the 100-K or 200/600 Areas in 1999. DCG = Derived concentration guide (DOE Order 5400.5).

Table 3.2.3. Annual Average and Maximum Concentrations ($\alpha\text{Ci}/\text{m}^3$) of Radionuclides in Near-Facility Air Samples, 2000

Cobalt-60				Uranium-234			
Site	Average^(a)	Maximum^(b)	EDP Code^(c)	Site	Average^(a)	Maximum^(b)	EDP Code^(c)
100-D RA ^(d)	7.0 ± 35	170 ± 360	N468	100-D RA ^(d)	55 ± 40	260 ± 86	N468
100-H RA	3.8 ± 29	59 ± 83	N510	100-H RA	9.5 ± 2.6	16 ± 7.7	N509
100-F RA	6.5 ± 30	63 ± 110	N520	100-F RA	16 ± 7.3	38 ± 14	N519
105-DR/F/D/H				105-DR/F/D/H			
ISS ^(e)	-74 ± 323	1,000 ± 1,700	N525	ISS ^(e)	34 ± 8.2	82 ± 37	N493
100-K	18 ± 30	110 ± 110	N479	100-K	18 ± 5.3	47 ± 13	N477
100-N	442 ± 704	2,900 ± 350	N105	100-N	20 ± 5.2	33 ± 11	N106
200-East	4.2 ± 13	71 ± 110	N967	200-East	16 ± 1.9	29 ± 12	N977
200-West	-2.2 ± 12	120 ± 90	N433	200-West	16 ± 1.8	38 ± 12	N974
300-FF-1 ^(f)	26 ± 75	380 ± 1,200	N489	300-FF-1 ^(f)	48 ± 16	86 ± 63	N489
ERDF ^(g)	-22 ± 29	29 ± 93	N484	ERDF ^(g)	17 ± 6.8	32 ± 11	N484
Distant community ^(h)	48 ± 128	411 ± 950		Distant community ^(h)	15 ± 6.2	28 ± 19	
DCG ⁽ⁱ⁾		80,000,000		DCG ⁽ⁱ⁾		90,000	
Strontium-90				Uranium-235			
Site	Average^(a)	Maximum^(b)	EDP Code^(c)	Site	Average^(a)	Maximum^(b)	EDP Code^(c)
100-D RA ^(d)	121 ± 60	340 ± 310	N512	100-D RA ^(d)	31 ± 31	230 ± 83	N468
100-H RA	90 ± 50	160 ± 88	N507	100-H RA	4.1 ± 1.9	9.2 ± 6.1	N508
100-F RA	105 ± 96	340 ± 140	N519	100-F RA	7.3 ± 4.8	22 ± 11	N519
105-DR/F/D/H				105-DR/F/D/H			
ISS ^(e)	761 ± 907	8,400 ± 4,600	N523	ISS ^(e)	21 ± 9.4	88 ± 180	N523
100-K	94 ± 53	270 ± 95	N477	100-K	7.4 ± 4.3	32 ± 9.9	N477
100-N	120 ± 51	240 ± 84	N102	100-N	13 ± 6.1	27 ± 10	N103
200-East	221 ± 165	3,200 ± 640	N984	200-East	4.8 ± 1.0	13 ± 6.2	N968
200-West	114 ± 26	330 ± 130	N975	200-West	4.6 ± 1.3	24 ± 9.1	N974
ERDF ^(g)	111 ± 76	210 ± 86	N483	300-FF-1 ^(f)	14 ± 6.2	35 ± 63	N489
Distant community ^(h)	5.5 ± 33	63 ± 63		ERDF ^(g)	7.3 ± 6.7	22 ± 8.8	N484
DCG ⁽ⁱ⁾		9,000,000		Distant community ^(h)	0.5 ± 1.9	7.0 ± 9.3	
				DCG ⁽ⁱ⁾		100,000	
Cesium-137				Uranium-238			
Site	Average^(a)	Maximum^(b)	EDP Code^(c)	Site	Average^(a)	Maximum^(b)	EDP Code^(c)
100-D RA ^(d)	29 ± 45	120 ± 170	N467	100-D RA ^(d)	36 ± 24	160 ± 62	N468
100-H RA	22 ± 23	69 ± 83	N507	100-H RA	9.2 ± 2.1	14 ± 7.1	N509
100-F RA	67 ± 42	190 ± 140	N519	100-F RA	11 ± 4.6	19 ± 9.3	N521
105-DR/F/D/H				105-DR/F/D/H			
ISS ^(e)	296 ± 470	4,400 ± 3,600	N523	ISS ^(e)	37 ± 17	160 ± 190	N523
100-K	37 ± 25	160 ± 100	N403	100-K	12 ± 3.9	36 ± 11	N477
100-N	161 ± 239	990 ± 260	N105	100-N	15 ± 5.3	30 ± 11	N103
200-East	68 ± 28	470 ± 180	N985	200-East	13 ± 1.6	23 ± 11	N999
200-West	113 ± 45	890 ± 250	N155	200-West	13 ± 1.8	31 ± 10	N974
300-FF-1 ^(f)	0.8 ± 56	91 ± 210	N485	300-FF-1 ^(f)	47 ± 20	130 ± 84	N489
ERDF ^(g)	41 ± 48	96 ± 69	N482	ERDF ^(g)	12 ± 3.3	19 ± 9.1	N517
Distant community ^(h)	-43 ± 186	371 ± 440		Distant community ^(h)	13 ± 6.3	28 ± 10	
DCG ⁽ⁱ⁾		400,000,000		DCG ⁽ⁱ⁾		100,000	

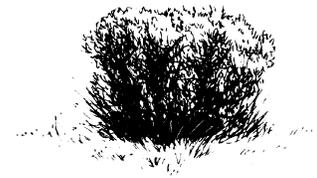




Table 3.2.3. (contd)

Plutonium-238				Plutonium-241			
Site	Average^(a)	Maximum^(b)	EDP Code^(c)	Site	Average^(a)	Maximum^(b)	EDP Code^(c)
100-D RA ^(d)	-4.9 ± 16	59 ± 59	N470	100-K	214 ± 215	1,300 ± 390	N401
100-H RA	3.5 ± 3.9	11 ± 14	N507	200-East	-270 ± 883	530 ± 160	N481
100-F RA	9.3 ± 8.7	31 ± 16	N520	Distant community ^(h)		Not reported	
105-DR/F/D/H				DCG ⁽ⁱ⁾		1,000,000	
ISS ^(e)	25 ± 41	390 ± 860	N523				
100-K	5.3 ± 5.5	33 ± 26	N479				
100-N	-5.0 ± 12	13 ± 13	N105				
200-East	2.9 ± 3.3	33 ± 36	N481				
200-West	1.5 ± 1.7	15 ± 20	N964				
ERDF ^(g)	-1.0 ± 5.5	7.6 ± 11	N483				
Distant community ^(h)	-0.4 ± 0.3	0.3 ± 1.8					
DCG ⁽ⁱ⁾		30,000					
Plutonium-239/240				Americium-241			
Site	Average^(a)	Maximum^(b)	EDP Code^(c)	Site	Average^(a)	Maximum^(b)	EDP Code^(c)
100-D RA ^(d)	12 ± 4.5	28 ± 10	N469	100-K	14 ± 6.5	36 ± 17	N476
100-H RA	6.0 ± 2.2	9.5 ± 5.7	N510	200-East	16 ± 17	33 ± 17	N481
100-F RA	8.0 ± 11	44 ± 17	N520	Distant community ^(h)		Not reported	
105-DR/F/D/H				DCG ⁽ⁱ⁾		20,000	
ISS ^(e)	40 ± 44	420 ± 320	N523				
100-K	15 ± 8.2	58 ± 23	N401				
100-N	7.6 ± 5.8	26 ± 19	N105				
200-East	12 ± 5.8	88 ± 22	N499				
200-West	16 ± 4.1	70 ± 19	N956				
ERDF ^(g)	14 ± 18	58 ± 17	N483				
Distant community ^(h)	-0.1 ± 0.5	0.6 ± 1.6					
DCG ⁽ⁱ⁾		20,000					

- (a) ±2 standard error of the mean.
- (b) ± total analytical uncertainty.
- (c) See PNNL-13487, APP. 2.
- (d) RA = Remedial Action project.
- (e) ISS = Interim Safe Storage project.
- (f) 300 Area.
- (g) ERDF = Environmental Restoration Disposal Facility.
- (h) See Section 4.1.
- (i) DOE Derived Concentration Guide.

at the 100-D site, and air monitoring ended in September. At the 100-F site, ambient air monitoring began in March at four locations and continued throughout the rest of the year. At the 100-H Area, ambient air monitoring locations included four project-specific samplers, one upwind and three downwind. Strontium-90 and uranium-234 and -238 were consistently detected at the 100-H monitoring locations. Plutonium-239/240 was occasionally detected.

In 2000, two samplers operated at each of the 105-DR and 105-F interim safe storage projects. The quarterly analytical results from these air samples were generally similar to the results seen over the past 2 years (sampling began in November 1998). Third quarter uranium results were slightly higher than previous levels but returned to typical levels during the fourth quarter.

Air monitoring at the 105-H and 105-D interim safe storage projects began in November 2000 and, at the projects' request, the air samplers (two at 105-H; one at 105-D) were operated only while actual decontamination and decommissioning work was being done (i.e., one work shift on weekdays). This led to sample volumes that were significantly lower for these three samplers than for all other near-facility air samplers. The overall effect of reduced sample volume was radionuclide concentrations that appeared to be higher than those measured at the other site samplers. Air sample concentrations are mathematically calculated by dividing the concentration (picocuries) measured in the laboratory by the sample volume (cubic meters of air that passed through the filter). Environmental air sample concentrations are typically very low (at or near background levels) and when divided by a small sample volume, the resulting concentration will appear to be higher than the calculated concentration obtained from an air sample with a higher (normal) sample volume. Given the small number of samples and the abnormal monitoring regime, it is difficult to derive definitive conclusions about these air sampling results.

The airborne contaminant levels in the 100-K Area were similar to those measured over the previous 5 years. Facility emissions in the 100-K Area decreased substantially in 1996 and subsequent radionuclide concentrations in the ambient air samples have been near detection limits. The radionuclides uranium-234 and -238 were detected consistently. Occasionally the radionuclides strontium-90, uranium-235, plutonium-239/240, and americium-241 were detected also.

Analytical results for ambient air samples from the 100-N Area in 2000 were similar to those measured in the previous 5 years. The radionuclides strontium-90, uranium-234, -235, -238, and plutonium-239/240 were detected consistently.

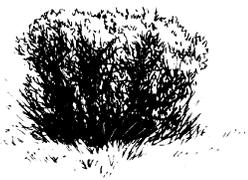
Radionuclide levels measured in 2000 in the 200-East Area were generally similar to those

measured in the previous 5 years. The radionuclides strontium-90 and uranium-234 and -238 were detected consistently. Occasionally the radionuclides cesium-137, uranium-235, and plutonium-239/240 were detected. Strontium-90 and plutonium-239/240 concentrations were slightly higher than the 1999 levels.

Radionuclide levels measured in the 200-West Area were also similar to results for previous years. The radionuclides strontium-90, uranium-234 and -238, and plutonium-239/240 were detected consistently. Cesium-137 and uranium-235 were occasionally detected.

Ambient air monitoring at the 300-FF-1 operable unit remedial action project in the 300 Area included eight samplers: one near-facility monitoring upwind sampler, located at the nearby 300 Area Treated Effluent Disposal Facility; two Pacific Northwest National Laboratory upwind samplers in the 300 Area (stations #14 "300 Trench" and #15 "300 NE;" see Section 4.1); and five downwind, project-specific air samplers. Remedial action activities for fiscal year 2000 were completed at this site and air monitoring was discontinued in September. Analytical results indicated that radionuclide concentrations in air samples collected at this site were much less than DOE derived concentration guides and were slightly lower than those measured since 1997 when the project began. Uranium-234, -235, and -238 were the only radionuclides that were detected consistently.

The air sampling network at the Environmental Restoration Disposal Facility (200-West Area) is made up of six samplers: two existing Hanford Site samplers for upwind monitoring (one near-facility sampler, "N-963;" one Pacific Northwest National Laboratory sampler, station #13 "200 W SE" [see Section 4.1]) and three air samplers at the facility that provided downwind coverage. Disposal activities expanded during 2000, and two of the existing facility air samplers (N-483 and N-484) were retired





and replaced with two new stations (N-517 and N-518, respectively) to provide technically appropriate sampling locations. The 2000 analytical results indicated that the strontium-90 and uranium-234, -235, and -238 levels were slightly lower than 1999 levels. Consistently detectable radionuclides were strontium-90, uranium-234, -235, and -238, and plutonium-239/240.

The remedial action, interim safe storage, and surveillance and maintenance/transition projects discussed above are described in more detail in Section 2.3.11. A complete listing of the 2000 near-facility ambient air monitoring results can be found in PNNL-13487, APP. 2. Results for selected Pacific Northwest National Laboratory air samples are also reported in PNNL-13487, APP. 2, as well as in Section 4.1.

3.2.2 Spring Water Monitoring

In the past, radioactive effluent streams were sent to the 1301-N and 1325-N Liquid Waste Disposal Facilities in the 100-N Area. This waste migrated with the groundwater and contributed to the release of radionuclides to the Columbia River. Radionuclides from these facilities enter the Columbia River along the riverbank region sometimes called N Springs. Groundwater springs and/or shoreline seepage wells at the N Springs are sampled annually to verify that the reported radionuclide releases to the Columbia River are conservative (i.e., not underreported). The amount of radionuclides entering the Columbia River at these springs (i.e., release) is calculated based on analyses of monthly samples collected from monitoring well 199-N-46 located near the shoreline. Analytical results and discussion of these releases may be found in Section 3.1 and in HNF-EP-0527-10.

collected using a bailer carefully lowered into the water column of each well to avoid sediment suspension, and a 4-liter (1-gallon) sample was obtained. Analyses of these samples detected tritium, strontium-90, and gamma-emitting radionuclides.

In 2000, the levels of strontium-90 detected in samples from riverbank springs were highest in N Springs wells Y303 and Y304, which are nearest well 199-N-46. None of the concentrations exceeded the DOE derived concentration guide value of 1,000 pCi/L. The highest tritium level was measured ~60 meters (200 feet) upstream of well 199-N-46 at well Y301. Tritium concentrations at all sampling locations were well below the 2 million pCi/L derived concentration guide. Nearly all gamma-emitting radionuclide concentrations were below analytical detection limits in 2000. Tritium and strontium-90 data from 2000 riverbank springs sampling are summarized in Table 3.2.4.

In October 2000, samples were collected from all 13 100-N Area shoreline wells. The samples were

3.2.3 Radiological Surveys of Surface Contamination

Radiological surveys are used to monitor and detect contamination on the Hanford Site. The main types of contaminated areas are underground radioactive materials areas, contamination areas, soil contamination areas, and high contamination areas.

soil surface. These areas are typically stabilized cribs, burial grounds, covered ponds, trenches, and ditches. Barriers over the contamination sources are used to inhibit radionuclide transport to the surface environs. These areas are surveyed at least annually to document the current radiological status.

Underground radioactive materials areas are areas that have contamination contained below the

Table 3.2.4. Radionuclide Concentrations (pCi/L) in 100-N Area Riverbank Springs, 2000

Radionuclide	Facility Effluent Monitoring Well	Shoreline Springs		DCG ^(c)
	199-N-46 (average) ^(a)	Maximum ^(b)	Average ^(a)	
Tritium	7,000 ± 3,100	1,300 ± 330	390 ± 190	2,000,000
Strontium-90	13,000 ± 3,900	180 ± 27	44 ± 35	1,000

(a) ±2 standard error of the mean.

(b) ± total analytical uncertainty.

(c) DCG = DOE derived concentration guide (DOE Order 5400.5).

Contamination/soil contamination areas may or may not be associated with an underground structure containing radioactive material. A breach in the barrier of a contaminated underground area may result in the growth of contaminated vegetation. Insects or animals may burrow into the soil and bring contamination to the surface. Vent pipes or risers from an underground structure may be a source of speck contamination (particles with a diameter less than 0.6 centimeter [0.25 inch]). Areas of contamination not related to subsurface structures can include sites contaminated with fallout from effluent stacks and sites that are the result of unplanned releases (e.g., contaminated tumbleweeds, animal feces). All contaminated areas may be susceptible to contamination migration and are surveyed at least annually to document the current radiological status (locations of contaminated areas are illustrated in PNNL-13487, APP. 2).

In 2000, the Hanford Site had ~3,628 hectares (8,965 acres) of posted outdoor contamination areas (all types) and 664 hectares (1,641 acres) of posted underground radioactive materials areas not including active facilities. It was estimated that the external dose rate at 80% of the outdoor contaminated areas was less than 1 mrem/h, though direct dose rate

readings from isolated radioactive specks could have been higher. Table 3.2.5 lists the contaminated areas and underground radioactive materials areas. Vehicles equipped with radiation detection devices and a global positioning system were again used in 2000 to measure more accurately the extent of the contamination. Area measurements are entered into the Hanford Geographical Information System, a computer database maintained by Bechtel Hanford, Inc.

The number and size of contaminated areas vary from year to year because of efforts to cleanup, stabilize, and remediate areas of known contamination. New areas of contamination also are being identified, though no areas of significance were added in 2000. Table 3.2.6 indicates the changes resulting from stabilization activities during 2000. Approximately 2.9 hectares (7.2 acres) were reclassified from contamination/soil contamination areas to underground radioactive materials areas. In addition, 5.9 hectares (14.6 acres) were posted as contamination areas. Newly identified areas are generally the result of either contaminant migration or an increased effort to investigate outdoor areas for radiological contamination.

3.2.4 Soil and Vegetation Monitoring

Soil and vegetation samples were collected on or adjacent to waste disposal units and from locations downwind and near or within the boundaries

of operating facilities and remedial action activity sites. Samples were collected to evaluate long-term





Table 3.2.5. Outdoor Contamination Status, 2000

Area	Contamination		Underground Radioactive Materials	
	Areas, ^(a) ha (acres)		Areas, ^(b) ha (acres)	
100-B/C	8	(20)	39	(96)
100-D/DR	0	(0)	39	(96)
100-F	0	(0)	34	(84)
100-H	0	(0)	14	(35)
100-K	6	(15)	65	(161)
100-N	29	(72)	12	(30)
200-East ^(c)	67	(165)	141	(348)
200-West ^(c)	30	(74)	224	(554)
300	11	(27)	41	(101)
400	0	(0)	0	(0)
600 ^(d)	3,477	(8,592)	55	(136)
Totals	3,628	(8,965)	664	(1,641)

- (a) Includes areas posted as contamination/soil contamination or as radiologically controlled and areas that had both underground radioactive material and surface contamination/soil contamination.
- (b) Includes areas with only underground contamination. Does not include areas that had surface contamination/soil contamination as well as underground radioactive material.
- (c) Includes tank farms.
- (d) Includes BC controlled area and waste disposal facilities outside the 200-East Area boundary that received waste from 200-East Area facilities (e.g., 216-A-25, 216-B-3) and waste disposal facilities outside the 200-West Area boundary that received waste from 200-West Area facilities (e.g., 216-S-19, 216-U-11). The first cell of the Environmental Restoration Disposal Facility was added during 1997.

trends in environmental accumulation of radioactivity and to detect potential migration and deposition of facility effluents. Special samples also were collected where potential physical or biological pathway problems were identified. Contaminant movement can occur as the result of resuspension from radioactively contaminated surface areas, absorption of radionuclides by the roots of vegetation growing on or near underground and surface-water disposal units, or animal activities at the waste site. The sampling methods and locations used are discussed in detail in WMTS-OEM-001. Radiological analyses of soil and vegetation samples included strontium-90, isotopic uranium, isotopic plutonium, and gamma-emitting radionuclides.

The number and location of soil and vegetation samples collected in 2000 are shown in Table 3.2.1. A comprehensive presentation of the analytical data results can be found in PNNL-13487, APP. 2. Only those radionuclide concentrations above analytical detection limits are discussed in this section.

Table 3.2.6. Zone Status Change of Posted Contamination Areas, 2000^(a)

Areas	Zone Changes ^(b)	Area, ha (acres)	
100	CA to URM	0	(0)
200-East	CA to URM	0.8	(2.0)
200-East	None to CA	2.9	(7.2)
200-West	CA to URM	2.1	(5.2)
200-West	None to CA	3.0	(7.4)
300	CA to URM	0	(0)
400	CA to URM	0	(0)
600	CA to URM	0	(0)

- (a) Changes from stabilization activities, newly discovered sites, or resurveyed using a global positioning system.
- (b) CA = Contamination/soil contamination area.
URM = Underground radioactive materials area.

Each soil sample represents a composite of five plugs of soil 2.5 centimeters (1 inch) deep and 10 centimeters (4 inches) in diameter collected from each site. Each vegetation sample consists of new-growth leaf cuttings taken from the available species of interest at a sample location. Often, the vegetation sample consisted of a composite of several like members of the sampling site plant community to avoid decimation of any individual plant through overharvesting.

Early in the summer of each year, soil and vegetation samples are collected on the

Hanford Site and submitted for radioanalyses. The analyses include those for radionuclides expected to be found in the areas sampled (i.e., gamma-emitting radionuclides, strontium isotopes, uranium isotopes, and/or plutonium isotopes). The results are then compared to levels found at various offsite sample locations in Yakima, Benton, and Franklin Counties (PNL-10574; PNNL-11795). Comparison of the levels can be used to determine the difference between contributions from site operations and remedial action sites and contributions from natural causes and worldwide fallout.

Soil sampling results also are compared to the “accessible soil” concentrations (WHC-SD-EN-TI-070) developed specifically for use at the Hanford Site (see PNNL-13487, APP. 2 for complete listing). These radioactive limits were established to ensure that effective dose equivalents to the public do not exceed the established limits for any reasonable scenario, such as direct exposure, inadvertent ingestion, inhalation, and ingestion of food crops, including animal products. The accessible soil concentration values are based on a radiation dose estimate scenario where an individual would have to spend 100 hours per year in direct contact with the contaminated soil. The conservatism inherent in pathway modeling ensures that the required degrees of protection are in place (WHC-SD-EN-TI-070). These concentrations apply specifically to the Hanford Site with respect to onsite disposal operations, stabilization, cleanup, and decontamination and decommissioning operations.

In general, radionuclide concentrations in soil and vegetation samples collected from, or adjacent to, waste disposal facilities were higher than the concentrations in samples collected farther away and were significantly higher than concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides were higher within different operational areas when compared to concentrations measured in distant communities. Generally, the predominant radionuclides were activation and fission products in the

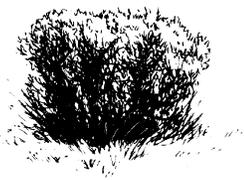
100-N Area, fission products in the 200 Areas, and uranium in the 300/400 Areas.

3.2.4.1 Radiological Results for Soil Samples

Of the radionuclide analyses performed, cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were detected consistently. The concentrations of these radionuclides in soil samples were elevated near and within facility boundaries when compared to historical concentrations measured off the site. Figure 3.2.2 shows average soil values for 2000 and the preceding 5 years. The levels show a large degree of variability.

Generally, the surface soil samples collected near the 1301-N Liquid Waste Disposal Facility exhibited higher radionuclide concentrations than those collected at the other soil sampling locations in the 100-N Area. Average radionuclide concentrations detected in the surface soil samples near the facility from 1995 through 2000 are presented in Table 3.2.7. Results were at or near historical levels measured on the Hanford Site, and the concentrations for most radionuclides were somewhat lower than the 1999 levels.

Average radionuclide concentrations detected in all of the surface soil samples collected in the 100-N Area from 1995 through 2000 are presented in Table 3.2.8. The average values for 100-N Area soil were down in 2000 for strontium-90, while the averages for cobalt-60, cesium-137, and plutonium-239/240 isotopes were slightly elevated over the 1999 sample results. The 2000 maximum, average, offsite average concentrations, and accessible soil concentrations are compared in Table 3.2.9. The maximum cobalt-60 concentration in soil of 11.0 pCi/g shown in Table 3.2.9 exceeds the accessible soil concentration of 7.1 pCi/g. Given the remoteness of this sample location, and the restrictions to access to the area by Hanford Security and the 100-N Operations, this is a highly unlikely situation, and considered not to be a problem.



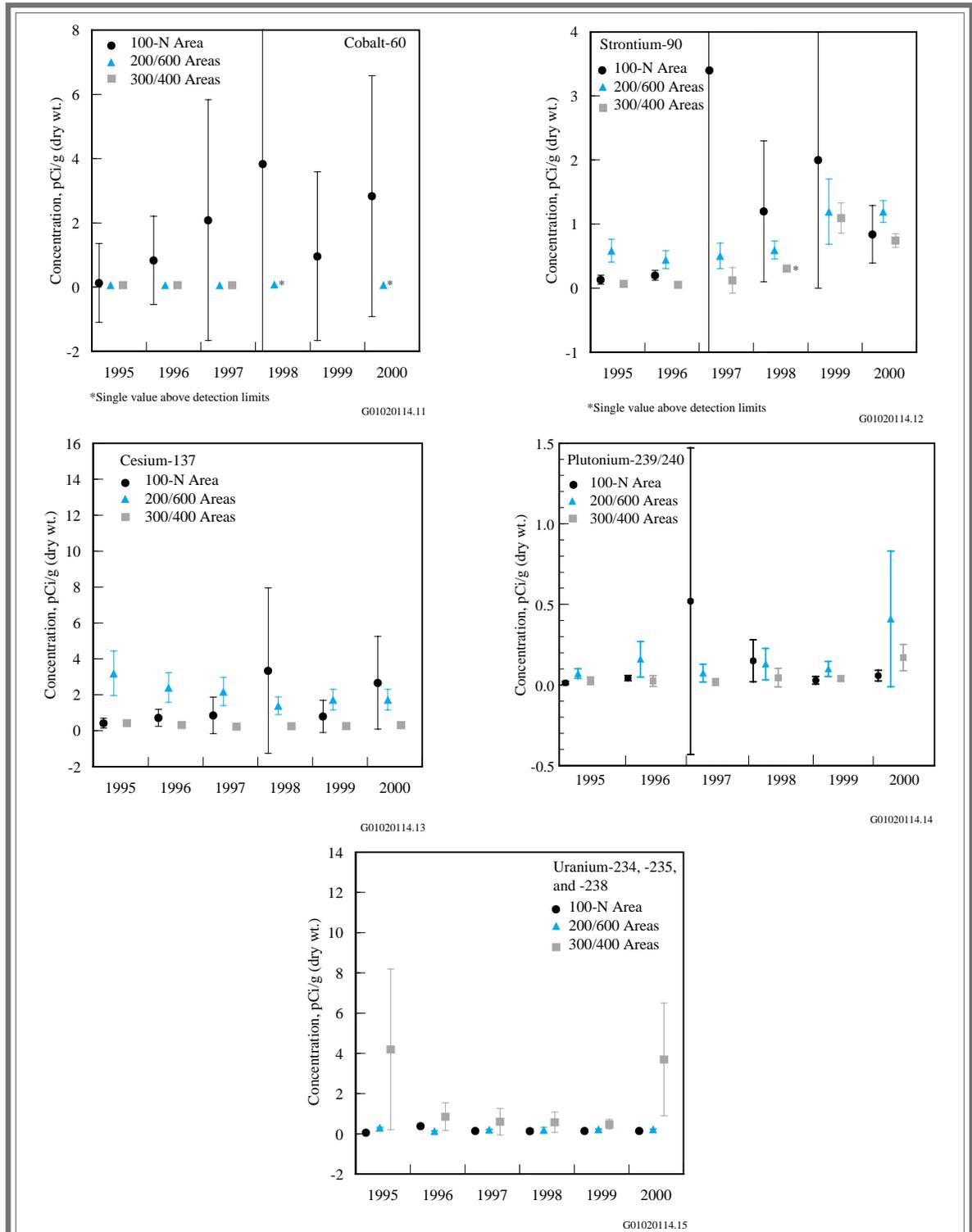


Figure 3.2.2. Average Concentrations (± 2 standard error of the mean) of Selected Radionuclides in Near-Facility Soil Samples, 1995 through 2000. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. Cobalt-60 was not detected in the 200/600 Areas in 1999 or in the 300/400 Areas in 1999 and 2000.

Table 3.2.7. Average Radionuclide Concentrations (pCi/g dry wt.)^(a) Detected in Surface Soil Samples near the 1301-N Liquid Waste Disposal Facility, 1995 through 2000

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁵ U	²³⁸ U	^{239/240} Pu
1995	2.1 ± 2.2	0.15 ± 0.17	0.77 ± 0.53	0.078 ± 0.015	0.003 ± 0.001	0.081 ± 0.012	0.010 ± 0.013
1996	2.5 ± 1.5	0.23 ± 0.11	0.98 ± 0.57	0.568 ± 0.142	0.025 ± 0.023	0.563 ± 0.222	0.048 ± 0.026
1997	4.3 ± 5.2	5.8 ± 10.8	1.5 ± 1.5	0.22 ± 0.07	0.020 ± 0.004	0.218 ± 0.057	0.98 ± 1.79
1998	8.5 ± 14.4	1.6 ± 1.2	5.2 ± 7.4	0.223 ± 0.112	0.039 ± 0.007	0.160 ± 0.041	0.19 ± 0.19
1999	2.6 ± 3.5	2.9 ± 3.4	1.3 ± 1.3	0.210 ± 0.061	0.014 ± 0.004	0.190 ± 0.053	0.03 ± 0.04
2000	1.6 ± 1.3	0.8 ± 0.5	2.7 ± 3.2	0.20 ± 0.04	0.010 ± 0.004	0.22 ± 0.05	0.07 ± 0.04

(a) ±2 standard error of the mean.

Table 3.2.8. Average Radionuclide Concentrations (pCi/g dry wt.)^(a) Detected in 100-N Area Surface Soil Samples, 1995 through 2000

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁵ U	²³⁸ U	^{239/240} Pu
1995	0.94 ± 0.98	0.13 ± 0.07	0.51 ± 0.24	0.091 ± 0.012	0.004 ± 0.001	0.097 ± 0.014	0.014 ± 0.009
1996	1.5 ± 1.1	0.20 ± 0.08	0.077 ± 0.042	0.567 ± 0.082	0.038 ± 0.021	0.566 ± 0.125	0.043 ± 0.016
1997	2.5 ± 3.0	3.9 ± 7.2	0.89 ± 0.90	0.21 ± 0.04	0.020 ± 0.002	0.207 ± 0.036	0.91 ± 1.79
1998	4.9 ± 8.4	1.2 ± 1.2	3.1 ± 4.4	0.214 ± 0.063	0.033 ± 0.008	0.166 ± 0.026	0.15 ± 0.14
1999	1.6 ± 2.1	2.0 ± 2.0	0.84 ± 0.80	0.220 ± 0.037	0.016 ± 0.004	0.200 ± 0.033	0.029 ± 0.023
2000	3.1 ± 3.0	0.84 ± 0.45	2.5 ± 2.3	0.220 ± 0.087	0.018 ± 0.007	0.220 ± 0.032	0.058 ± 0.033

(a) ±2 standard error of the mean.

Table 3.2.9. Concentrations of Selected Radionuclides (pCi/g dry wt.) in 100-N Area Soil, 2000

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁵ U	²³⁸ U	^{239/240} Pu
Maximum ^(a)	11.0 ± 0.9	1.5 ± 0.3	7.6 ± 1.1	0.26 ± 0.06	0.024 ± 0.015	0.26 ± 0.07	0.12 ± 0.04
Average ^(b)	3.1 ± 3.0	0.84 ± 0.45	2.5 ± 2.3	0.220 ± 0.087	0.018 ± 0.007	0.220 ± 0.032	0.058 ± 0.033
Offsite average ^(b,c)	NR ^(d)	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil concentration (WHC-SD-EN-TI-070) ^(e)	7.1	2,800	30	630	170	370	190

(a) ± total analytical uncertainty.

(b) ±2 standard error of the mean.

(c) PNL-10574 and PNNL-11795.

(d) NR = Not reported.

(e) Hanford soils that are not behind security fences.





Offsite averages for isotopic uranium, strontium-90, and cesium-137 are from PNNL-11795 and offsite values for plutonium-239/240 are contained in PNL-10574. Complete listings of radionuclide concentrations and sample location maps are provided in PNNL-13487, APP. 2.

Soil samples from 57 of 111 sampling locations in the 200/600 Areas were collected in 2000. A follow-up sampling location (D146) was again included this year from the southern end of the Environmental Restoration Disposal Facility (200-West Area) and is now sampled on an annual basis. The 2000 maximum, average, offsite average, and accessible soil concentrations are compared in Table 3.2.10. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-13487, APP. 2.

Analytical results from soil samples taken from the 200/600 Areas showed generally level trends for the average values for all of the radionuclides measured in 2000, with the exception of plutonium-239/240, which was slightly higher than the value reported in 1999.

Soil samples from 18 sampling locations in the 300/400 Areas were collected in 2000: 17 from the

300 Area and 1 from the 400 Area. The 2000 maximum, average, offsite average concentrations, and accessible soil concentrations are compared in Table 3.2.11. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-13487, APP. 2. For the samples collected in 2000, average values were higher for the uranium isotopes and plutonium-239/240 than in 1999. However, uranium concentrations were expected to be higher in the 300 Area samples than at other site locations because uranium was used during past fuel fabrication operations in the 300 Area.

In 2000, two soil samples each were collected at the remedial action locations in the 100-D, 100-F, and 100-H Areas, and three samples were collected from the 100-N Area. A single sample was collected from the Environmental Restoration Disposal Facility (200-West Area) to determine the effectiveness of contamination controls. The samples collected from these locations provide baseline samples to be compared with future samples. Table 3.2.12 provides a summary of the analytical data for selected radionuclides. All of the 2000 data are provided in PNNL-13487, APP. 2.

Table 3.2.10. Concentrations of Selected Radionuclides (pCi/g dry wt.) in 200/600 Areas Soil, 2000

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁵ U	²³⁸ U	^{239/240} Pu
Maximum ^(a)	0.006 ^(b)	3.3 ± 0.7	9.0 ± 1.2	1.0 ± 0.2	0.086 ± 0.033	1.0 ± 0.2	8.5 ± 1.6
Average ^(c)	--	1.1 ± 0.2	1.4 ± 0.5	0.23 ± 0.03	0.027 ± 0.004	0.23 ± 0.03	0.41 ± 0.42
Offsite average ^(c,d)	NR ^(e)	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil concentration limits (WHC-SD-EN-TI-070) ^(f)	7.1	2,800	30	630	170	370	190

- (a) ± total analytical uncertainty.
- (b) Single value above detection limit.
- (c) ±2 standard error of the mean.
- (d) PNL-10574 and PNNL-11795.
- (e) NR = Not reported.
- (f) Hanford soils that are not behind security fences.

Table 3.2.11. Concentrations of Selected Radionuclides (pCi/g dry wt.) in 300/400 Areas Soil, 2000

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁵ U	²³⁸ U	^{239/240} Pu
Maximum ^(a)	ND ^(b)	1.0 ± 0.3	0.41 ± 0.07	43.0 ± 8.2	2.4 ± 0.5	44.0 ± 8.4	0.33 ± 0.08
Average ^(c)	ND	0.59 ± 0.18	0.14 ± 0.06	5.4 ± 5.6	0.37 ± 0.36	5.4 ± 5.7	0.17 ± 0.08
Offsite average ^(c,d)	NR ^(e)	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil concentration limits (WHC-SD-EN-TI-070) ^(f)	7.1	2,800	30	630	170	370	190

- (a) ± total analytical uncertainty.
 (b) ND = Not detected.
 (c) ±2 standard error of the mean.
 (d) PNL-10574 and PNNL-11795.
 (e) NR = Not reported.
 (f) Hanford soils that are not behind security fences.

Table 3.2.12. Radionuclide Concentrations (pCi/g dry wt. ± total analytical uncertainty) in Environmental Restoration Contractor Projects' Soil Samples, 2000

Site	Sample Location ^(a)	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁵ U	²³⁸ U	^{239/240} Pu
ERDF ^(b)	D146	ND ^(c)	0.36 ± 0.23	ND	0.15 ± 0.05	0.016 ± 0.012	0.13 ± 0.04	0.064 ± 0.026
100-D	D147	0.011 ± 0.006	0.48 ± 0.22	0.2 ± 0.03	0.20 ± 0.06	0.032 ± 0.019	0.20 ± 0.06	ND
100-D	D148	0.03 ± 0.01	0.66 ± 0.026	0.43 ± 0.06	0.16 ± 0.05	0.023 ± 0.017	0.15 ± 0.05	0.051 ± 0.023
100-H	D151	ND	0.30 ± 0.21	0.74 ± 0.1	0.20 ± 0.06	0.033 ± 0.019	0.13 ± 0.04	0.041 ± 0.02
100-H	D152	0.015 ± 0.008	0.81 ± 0.28	0.23 ± 0.04	0.14 ± 0.05	0.021 ± 0.025	0.17 ± 0.05	ND
100-F	D154	ND	0.55 ± 0.3	0.06 ± 0.02	0.18 ± 0.07	0.018 ± 0.014	0.17 ± 0.06	ND
100-F	D155	0.018 ± 0.007	0.43 ± 0.24	0.37 ± 0.05	0.18 ± 0.07	0.001 ± 0.001	0.16 ± 0.06	0.028 ± 0.018
100-N	D156	0.047 ± 0.009	0.59 ± 0.21	0.07 ± 0.02	0.21 ± 0.08	0.03 ± 0.029	0.16 ± 0.07	ND
100-N	D157	0.096 ± 0.013	0.72 ± 0.25	0.13 ± 0.03	0.20 ± 0.05	0.021 ± 0.013	0.19 ± 0.05	ND
100-N	D158	0.036 ± 0.009	0.50 ± 0.21	0.05 ± 0.01	0.35 ± 0.08	0.02 ± 0.013	0.28 ± 0.07	ND
Offsite Average ^(d,e)		NR ^(f)	0.06 ± 0.052	0.3 ± 0.3	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.1	0.011 ± 0.001
Accessible Soil Concentration ^(g)		7.1	2,800	30	630	170	370	190

- (a) Sampling location code. See PNNL-13487, APP. 2.
 (b) ERDF = Environmental Restoration Disposal Facility.
 (c) ND = Not detected.
 (d) ±2 standard error of the mean.
 (e) PNL-10574 and PNNL-11795.
 (f) NR = Not reported.
 (g) Hanford soils that are not behind security fences.





3.2.4.2 Radiological Results for Vegetation Samples

Of the radionuclide analyses performed, cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were consistently detected. Concentrations of these radionuclides in vegetation were elevated near and within facility boundaries compared to the concentrations measured off the site. Figure 3.2.3 shows average vegetation values for 2000 and the preceding 5 years. The results show a high degree of variability.

Average radionuclide concentrations detected in the vegetation samples near the retired 1301-N Liquid Waste Disposal Facility from 1995 through 2000 are presented in Table 3.2.13. In 2000, these samples had non-detectable concentrations of cobalt-60 and plutonium-239/240 and significantly lower concentrations of strontium-90 and cesium-137 (see PNNL-13487, APP. 2) when compared to 1999 levels. This same trend occurred at 1301-N in 1996 with elevated concentrations being reported for cobalt-60, strontium-90, and cesium-137. This was followed in 1997 by a significant reduction in the concentrations of these same radionuclides (see Table 3.2.13). The elevated values were due to vegetation collected from sample location Y705 in 1996 and 1999. However, vegetation samples from this site were not available in 1997 and 2000 due to either construction activities or limited access.

Average radionuclide concentrations detected in all of the vegetation samples collected in the 100-N Area from 1995 through 2000 are presented in Table 3.2.14. These concentrations were also significantly lower than concentrations measured in 1999.

Vegetation samples collected along the 100-N Area shoreline (N Springs) contain radionuclides that were not completely retained in the soil columns beneath the retired 1301-N and 1325-N Liquid Waste Disposal Facilities. Values for all of the radionuclides analyzed were about the same in

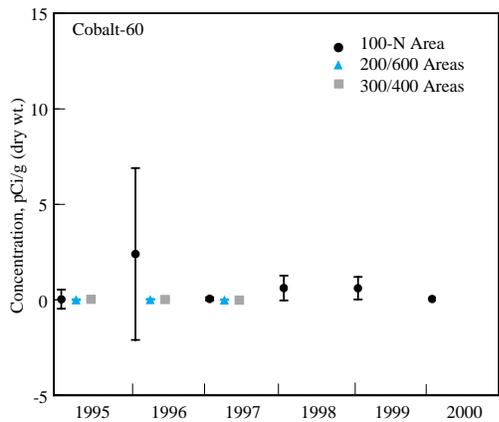
2000, with the exception of strontium-90. The data presented in Table 3.2.15 show the average radionuclide concentrations detected in the vegetation samples collected along N Springs in 2000 were higher than 1999 results, but only plutonium-239/240 was above detection limits.

The 2000 analytical results for vegetation samples collected at the 100-N Area are compared to offsite averages in Table 3.2.16. A complete list of radionuclide concentrations and sampling location maps are provided in PNNL-13487, APP. 2. In 2000, analytical results from vegetation samples collected from the 100-N Area were generally less than those observed in 1999. The radionuclide levels measured in 100-N Area vegetation were greater than those measured off the Hanford Site.

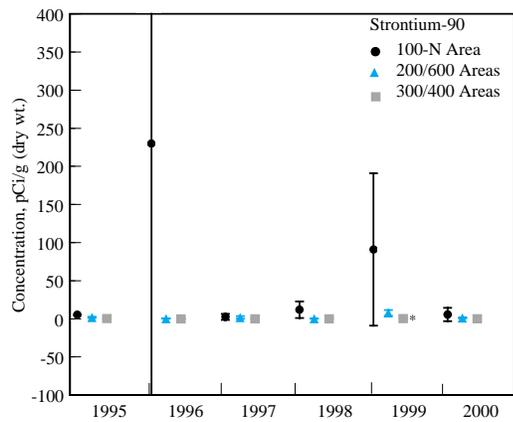
In 2000, 47 vegetation samples were collected from the 200/600 Areas. The 2000 maximum, average, and offsite average are compared in Table 3.2.17. A complete list of radionuclide concentrations and sampling location maps is provided in PNNL-13487, APP. 2. Analytical results from vegetation samples taken in 2000 from the 200/600 Areas were comparable to those observed in previous years. Radionuclide levels for strontium-90, cesium-137, and plutonium-239/240 were greater than those measured off the Hanford Site. The levels of cesium-137 and strontium-90 at the 200/600 Areas was higher than found in the 100 and 300/400 Areas.

This was the ninth year of sampling at locations established to more directly monitor facilities and active/inactive waste sites in the 300 and 400 Areas. The 2000 maximum, average, offsite average, and accessible soil limits for 300/400 Areas samples are listed in Table 3.2.18. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-13487, APP. 2.

The levels of most radionuclides measured in the 300 Area were greater than those measured off the Hanford Site, and uranium levels were higher than levels measured in the 100 and 200 Areas. The

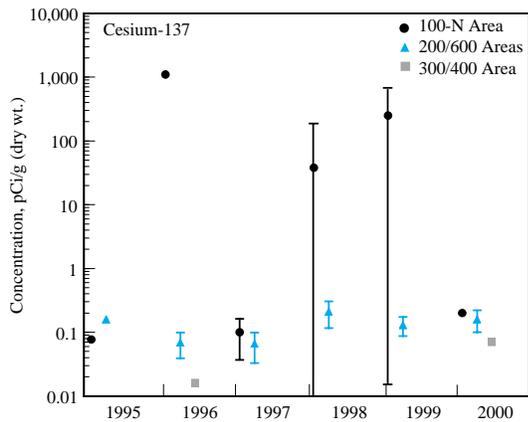


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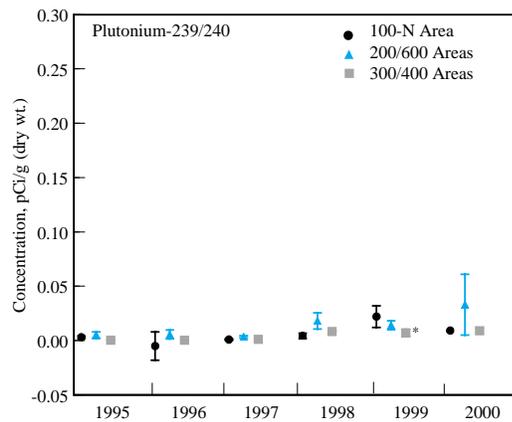


*Single value above detection limits

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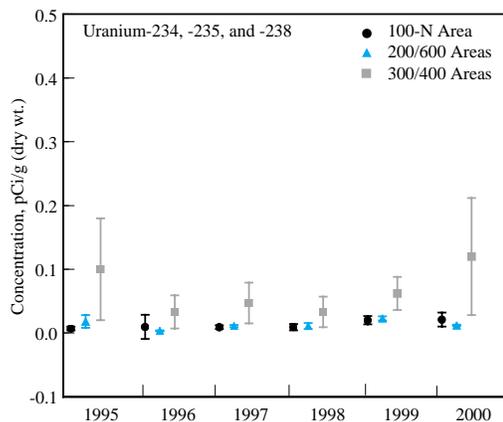


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*Single value above detection limits

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G01020114.10

Figure 3.2.3. Average Concentrations (± 2 standard error of the mean) of Selected Radionuclides in Near-Facility Vegetation Samples, 1995 through 2000. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. The 1997 cesium-137 data point for the 300/400 Areas is less than zero and cannot be plotted on a log scale. Cobalt-60 was not detected in the 200/600 or 300/400 Areas since 1997. Cesium-137 was not detected in the 300/400 Areas in 1995 and 1997 through 1999.

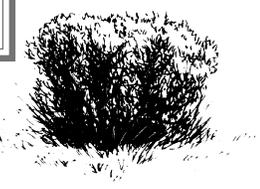




Table 3.2.13. Average Radionuclide Concentrations (pCi/g dry wt.)^(a) Detected in Vegetation Samples Collected near the 1301-N Liquid Waste Disposal Facility, 1995 through 2000

<u>Year</u>	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>^{239/240}Pu</u>
1995	0.054 ± 0.10	0.064 ± 0.019	0.12 ± 0.14	0.008 ± 0.003
1996	6.1 ± 11.9	575 ± 1,150	2,750 ± 5,500	-0.013 ± 0.38 ^(b)
1997	0.42 ^(c)	0.49 ^(c)	0.14 ± 0.06	ND ^(d)
1998	0.54 ± 0.93	13.6 ± 26.4	50.1 ± 99.8	0.0071 ^(c)
1999	0.99 ± 0.97	205 ± 201	505 ± 410	0.009 ± 0.010
2000	ND	0.06 ± 0.06	0.2 ^(c)	ND

- (a) ±2 standard error of the mean.
 (b) Negative value indicates results at or below background levels of radioactivity.
 (c) Single value above detection limit.
 (d) ND = Not detected.

Table 3.2.14. Average Radionuclide Concentrations (pCi/g dry wt.)^(a) Detected in 100-N Area Vegetation Samples, 1995 through 2000

<u>Year</u>	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>^{239/240}Pu</u>
1995	0.03 ± 0.05	5.4 ± 4.8	0.081 ± 0.044	0.0033 ± 0.0016
1996	2.4 ± 4.5	230 ± 430	1,100 ± 2,000	-0.0051 ± 0.013 ^(b)
1997	0.42 ± 0.05	3.6 ± 5.3	0.16 ± 0.008	ND ^(c)
1998	0.62 ± 0.73	11.7 ± 11.1	37.6 ± 74.9	0.0042 ± 0.0029
1999	0.61 ± 0.59	91 ± 100	250 ± 250	0.022 ± 0.010
2000	0.05 ^(d)	5.7 ± 8.7	0.2 ^(d)	0.009 ^(d)

- (a) ±2 standard error of the mean.
 (b) Negative value indicates results at or below background levels of radioactivity.
 (c) ND = Not detected.
 (d) Single value above detection limit.

higher uranium levels were expected because uranium was released during past fuel fabrication operations in the 300 Area. In the 400 Area, the

levels recorded for most radionuclides were higher than those measured off the site in previous years.

3.2.5 External Radiation

In 2000, there were 148 locations collecting external radiation information. At 78 locations, the dosimeter results showed a decrease in external radiation from 1999 levels. At one location (312-R), there was a 3% increase in radiation detected. At 66 locations in the 200/600 Areas, there was no change in the external radiation detected.

External radiation fields were monitored near facilities and waste handling, storage, and disposal sites to measure and assess the impact of operations. Thermoluminescent dosimeters are used at numerous fixed locations to gather dose rate information over longer periods of time. Thermoluminescent

Table 3.2.15. Average Radionuclide Concentrations (pCi/g dry wt.)^(a) Detected in N Springs Vegetation Samples, 1995 through 2000

<u>Year</u>	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>^{239/240}Pu</u>
1995	0.014 ± 0.045	13.4 ± 10.2	0.094 ± 0.059	0.0028 ± 0.0008
1996	0.01 ± 0.01	2.4 ± 4.2	0.038 ± 0.010	-0.0015 ± 0.002 ^(b)
1997	ND ^(c)	6.2 ± 9.9	0.18 ± 0.17	ND
1998	0.068 ^(d)	21.0 ± 19.0	ND	0.0028 ^(d)
1999	ND	0.98 ± 0.80	0.28 ± 0.49	ND
2000	ND	9.4 ± 15.6	ND	0.009 ^(d)

- (a) ±2 standard error of the mean.
 (b) Negative value indicates results at or below background levels of radioactivity.
 (c) ND = Not detected.
 (d) Single value above detection limit.

Table 3.2.16. Concentrations of Selected Radionuclides (pCi/g dry wt.) in 100-N Area Vegetation Samples, 2000

	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>²³⁴U</u>	<u>²³⁵U</u>	<u>²³⁸U</u>	<u>^{239/240}Pu</u>
Maximum ^(a)	0.048 ± 0.032 ^(b)	25.0 ± 3.8	0.2 ± 0.12 ^(b)	0.12 ± 0.09	0.016 ± 0.012	0.073 ± 0.066	0.009 ± 0.008 ^(b)
Average ^(c)		5.7 ± 8.7		0.033 ± 0.027	0.016 ± 0.00	0.024 ± 0.018	
Offsite average ^(c,d)	NR ^(e)	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND ^(f)	0.013 ± 0.004	0.00018 ± 0.00013

- (a) ± total analytical uncertainty.
 (b) Single value above detection limit.
 (c) ±2 standard error of the mean.
 (d) PNL-10574 and PNNL-11795.
 (e) NR = Not reported.
 (f) ND = Not detected.

Table 3.2.17. Concentrations of Selected Radionuclides (pCi/g dry wt.) in 200/600 Areas Vegetation Samples, 2000

	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>²³⁴U</u>	<u>²³⁵U</u>	<u>²³⁸U</u>	<u>^{239/240}Pu</u>
Maximum ^(a)	ND ^(b)	11.0 ± 1.6	0.52 ± 0.10	0.05 ± 0.02	0.015 ± 0.010	0.06 ± 0.03	0.22 ± 0.05
Average ^(c)	ND	1.3 ± 0.08	0.16 ± 0.06	0.02 ± 0.03	0.009 ± 0.001	0.014 ± 0.002	0.033 ± 0.028
Offsite averages ^(c,d)	NR ^(e)	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND	0.013 ± 0.004	0.00018 ± 0.00013

- (a) ± total analytical uncertainty.
 (b) ND = Not detected.
 (c) ±2 standard error of the mean.
 (d) PNL-10574 and PNNL-11795.
 (e) NR = Not reported.





Table 3.2.18. Concentrations of Selected Radionuclides (pCi/g dry wt.) in 300/400 Areas Vegetation Samples, 2000

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁵ U	²³⁸ U	^{239/240} Pu
Maximum ^(a)	ND ^(b)	0.24 ± 0.12	0.07 ^(c)	1.4 ± 0.3	0.075 ± 0.023	1.4 ± 0.3	0.013 ± 0.007
Average ^(d)	ND	0.21 ± 0.03		0.018 ± 0.019	0.018 ± 0.01	0.017 ± 0.019	0.0091 ± 0.0029
Offsite averages ^(d,e)	NR ^(f)	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND	0.013 ± 0.004	0.00018 ± 0.00013

- (a) ± total analytical uncertainty.
 (b) ND = Not detected.
 (c) Single value above detection limit.
 (d) ±2 standard error of the mean.
 (e) PNL-10574 and PNNL-11795.
 (f) NR = Not reported.

dosimeter results can be used individually or averaged to determine dose rates in a given area for a particular sampling period. A summary of the 1999 and 2000 thermoluminescent dosimeter results can be found in Table 3.2.19. Individual thermoluminescent dosimeter results and locations are provided in PNNL-13487, APP. 2. Specific information regarding external radiation sampling methods and locations can be found in WMTS-OEM-001. Dose rate

information for the Hanford perimeter locations can be found in Section 4.6.

Environmental thermoluminescent dosimeters measure dose rates from all types of external radiation sources. These sources include cosmic radiation, naturally occurring radioactivity in air and soil, and fallout from nuclear weapons testing, as well as any contribution from Hanford Site

Table 3.2.19. Thermoluminescent Dosimeter Results (mrem/yr) for Waste Handling Facilities, 1999 and 2000, based on 24 hours/day

Area	No. of Locations, 2000	1999		2000		% Change ^(a)
		Maximum	Mean	Maximum	Mean	
100-B/C	5	100	90	87	84	-7
100-D,DR	5	97	91	89	84	-8
100-F	5	NA ^(b)	NA	88	85	NA
100-H	3	99	95	90	88	-7
100-K	11	320	130	390	120	-8
100-N	14	6,500	1,400	4,700	1,100	-21
200/600	66	290	110	300	106	-4
212-R	1	1,980	1,940	2,500	2,000	3
300 TEDF ^(c)	6	90	87	85	83	-5
300	8	220	110	180	100	-9
400	7	93	85	81	80	-6
CVSF ^(d)	4	120	85	81	75	-12
ERDF ^(e)	3	94	91	93	89	-2
TWRS ^(f)	10	90	88	84	83	-6

- (a) Numbers indicate a decrease (-) or increase from the 1999 mean.
 (b) NA = Not applicable: comparisons cannot be made because monitoring locations were new in 2000.
 (c) TEDF = 300 Area Treated Effluent Disposal Facility.
 (d) CVDF = Cold Vacuum Drying Facility.
 (e) ERDF = Environmental Restoration Disposal Facility.
 (f) TWRS = Tank Waste Remediation System Phase I demonstration project.

activities. These outside radiation sources cause an estimated 20% deviation in thermoluminescent dosimeter results. The results are reported in units of millirems per year.

Near-facility monitoring uses the Harshaw thermoluminescent dosimeter system, which includes the Harshaw 8807 dosimeter and the Harshaw 8800 reader. The packaging, which uses an O-ring seal, protects the dosimeter from light, heat, moisture, and dirt. The thermoluminescent dosimeters were placed 1 meter (3.3 feet) above the ground near facilities, active and inactive surface-water disposal sites, and remedial action projects. The dosimeters were exchanged and analyzed each calendar quarter. The Radiological Calibrations Facility in the 318 Building (300 Area) calibrates the response of the chips; results are reported in terms of external dose.

To evaluate environmental restoration activities at the former 116-B-11 and 116-C-1 Liquid Waste Disposal Facilities (located in the 100-B/C Area), four thermoluminescent dosimeter monitoring sites were established during the fourth quarter of 1997. An additional dosimeter location, collocated with a Washington State Department of Health dosimeter, was established during the fourth quarter of 1999. Dose rates measured at these locations in 2000 were 7% lower compared to the data from 1999. The 2000 average dose rate was 84 mrem/yr, comparable to the Hanford perimeter 5-year average of 92 mrem/yr (PNNL-13230).

This was the fifth year that thermoluminescent dosimeters were placed in the 100-D/DR Area to evaluate cleanup activities at the former 116-D-7 and 116-DR-9 Liquid Waste Disposal Facilities. Dose rates measured at these locations were 8% lower than the results of 1999, with an average dose of 84 mrem/yr, comparable to the Hanford perimeter 5-year average of 92 mrem/yr.

To evaluate environmental restoration activities in the 100-F Area, five new thermoluminescent

dosimeter monitoring sites were established for the last three quarters of 2000. Because only three quarters of data were collected at these sites, the thermoluminescent dosimeter results were extrapolated to one year, resulting in an average of 85 mrem/yr, comparable to the Hanford perimeter 5-year average of 92 mrem/yr.

To evaluate environmental restoration activities in the 100-H Area, three thermoluminescent dosimeter monitoring sites were established in 1999. Dose rates in this area decreased 79% in 2000, with an average of 88 mrem/yr, which is comparable to the Hanford perimeter 5-year average of 92 mrem/yr.

The cleanup activities at the K Basins and adjacent retired reactor buildings in the 100-K Area continue to be monitored. Dose rates in this area in 2000 decreased 8% relative to 1999 values, with an average of 120 mrem/yr, because of the removal of radioactive waste stored in proximity to the three thermoluminescent dosimeter locations.

Four thermoluminescent dosimeter monitoring sites were established around the Cold Vacuum Drying Facility in 1999 to perform preoperational monitoring. Dose rates around this facility decreased 12% in 2000, with an average of 75 mrem/yr, which is comparable to the Hanford perimeter 5-year average of 92 mrem/yr.

The 2000 results for the 100-N Area indicate that direct radiation levels are highest near facilities that contained or received liquid effluent from N Reactor. These facilities primarily include the retired 1301-N and 1325-N Liquid Waste Disposal Facilities. The results for these two facilities were noticeably higher than those for other 100-N Area thermoluminescent dosimeter locations, but were 41% lower than dose levels measured at these locations in 1999. This reduction was directly attributable to the removal of source material at the 1325-N facility by the Environmental Restoration Contractor. Overall, the average dose rate measured in the 100-N Area in 2000 was ~13% lower than





that measured in 1998. Annual average thermoluminescent dosimeter results for the entire 100-N Area from 1987 through 2000 are presented in Figure 3.2.4.

Dose rates were measured at the N Springs shoreline to determine potential external radiation doses to the public as well as to onsite workers. Because of the “skyshine” effect (i.e., radiation reflected by the atmosphere back to the earth’s surface) from the retired 1301-N facility, annual dose rates at the N Springs shoreline were greater than 100 mrem/yr, which is the DOE annual external dose limit to members of the public. However, neither a member of the public nor a Hanford worker would conceivably spend an entire year at the N Springs; therefore, the values shown in Figure 3.2.5 are for comparison only.

The highest dose rates in the 200 Areas were measured near waste handling facilities. The location within the 200 Areas exhibiting the highest dose rate was at tank farm A in the 200-East Area. The

average annual dose rate measured in 2000 in the 200 Areas (106 mrem/yr) was slightly lower than the average 1999 measurement. The annual average thermoluminescent dosimeter results from 1987 through 2000 are presented in Figure 3.2.6.

Ten thermoluminescent dosimeter locations were established around the perimeter of the Tank Waste Remediation System Phase I demonstration project during the fourth quarter of 1997 to collect pre-operational monitoring data. Dose rates measured at these locations in 2000 were 6% lower than the average 1999 measurements, with an average of 83 mrem/yr. This is comparable to the Hanford perimeter 5-year average background level.

This is the fifth year that thermoluminescent dosimeters have been placed at the Environmental Restoration Disposal Facility to evaluate dose rates during ongoing activities. Dose rates measured in 2000 were ~2% lower than the 1999 results, with an average of 89 mrem/yr, which is comparable to the Hanford perimeter 5-year average background level.

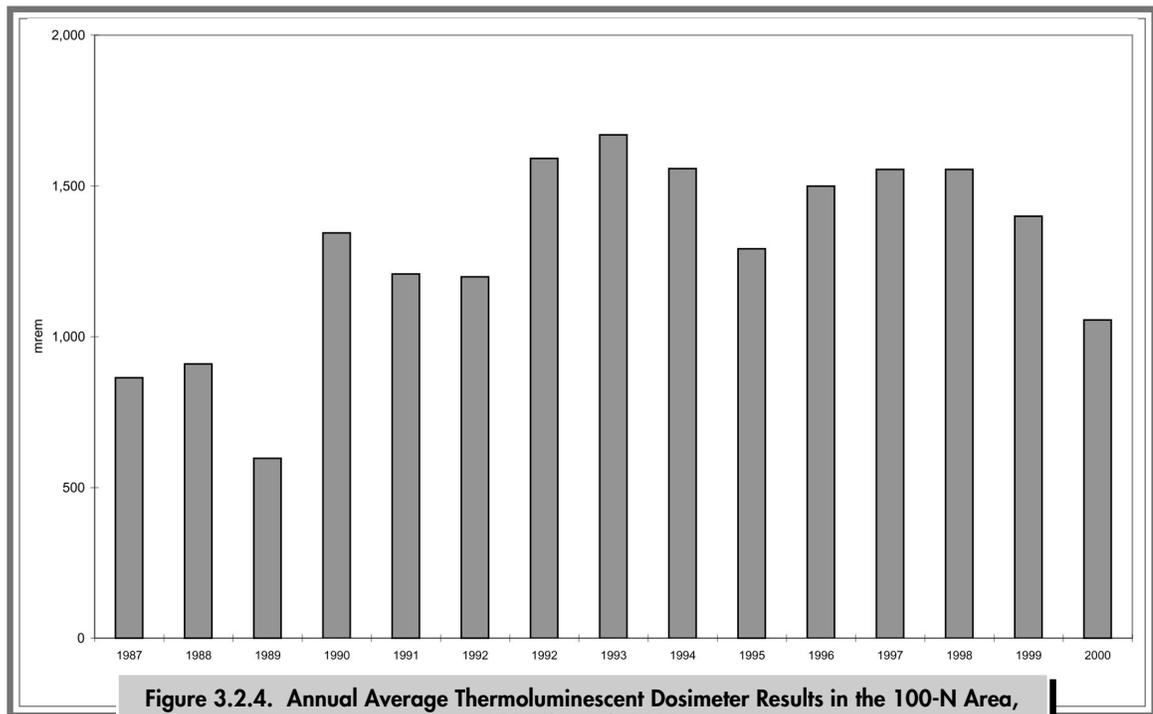
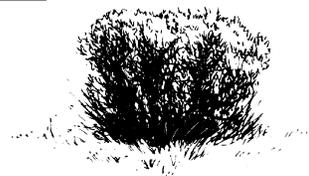
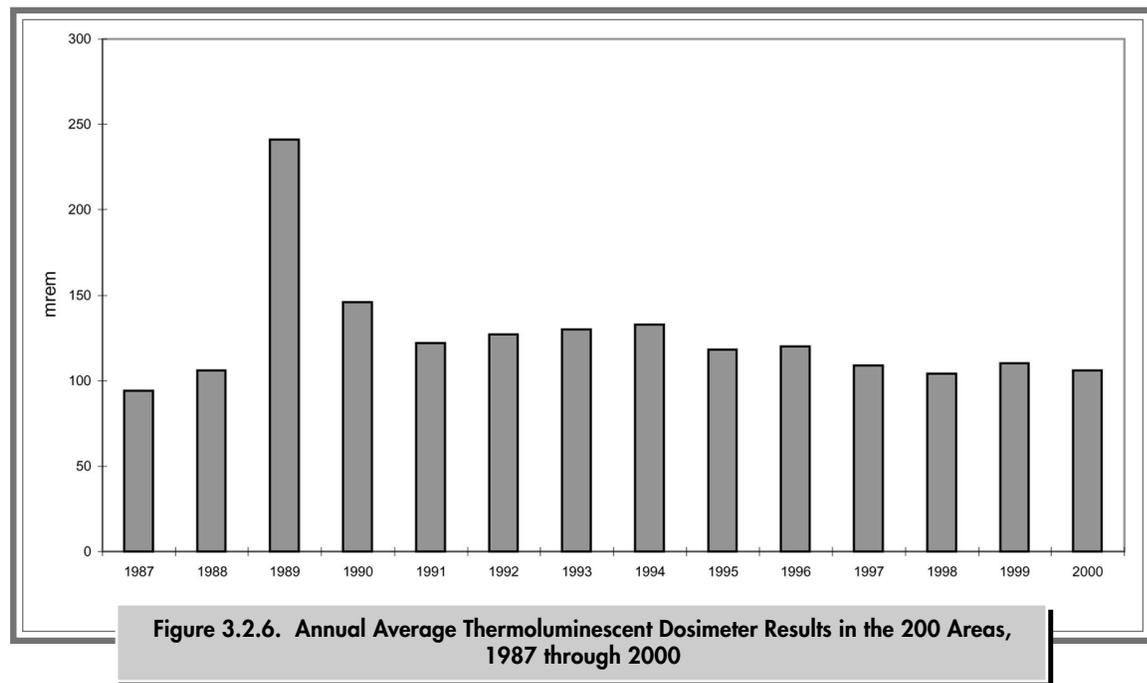
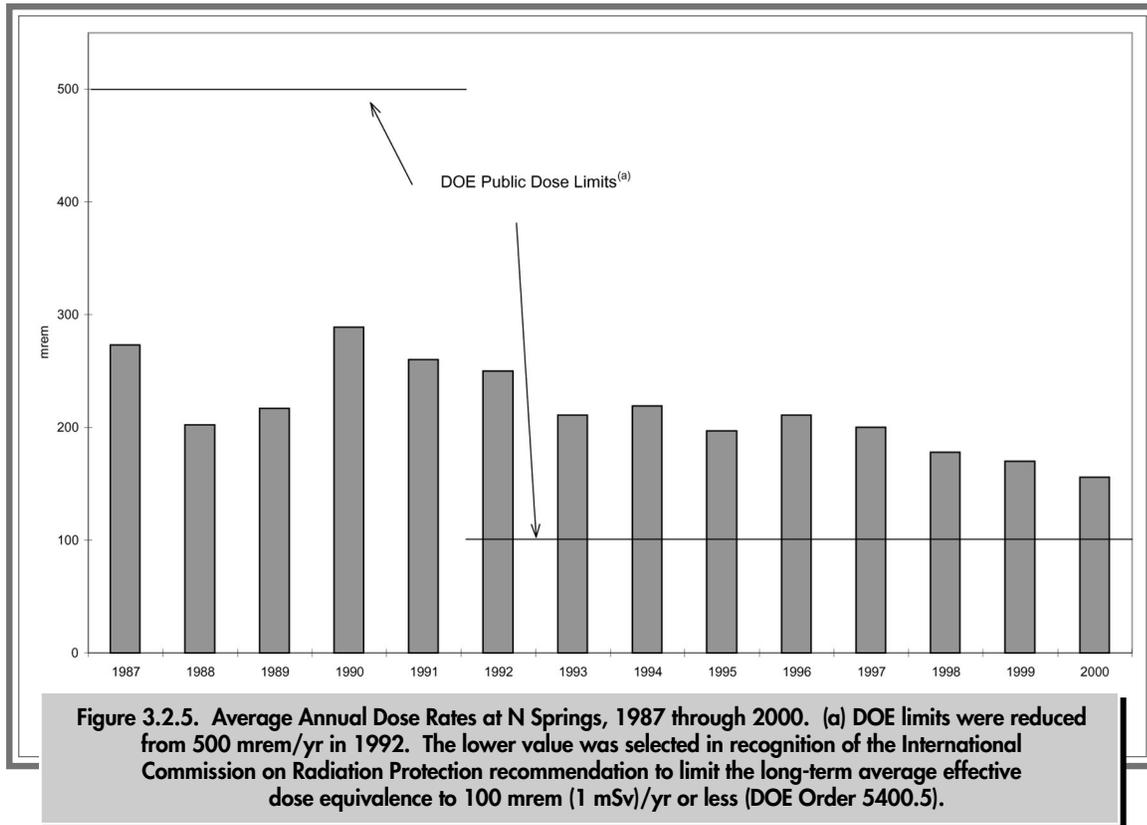


Figure 3.2.4. Annual Average Thermoluminescent Dosimeter Results in the 100-N Area, 1987 through 2000





The highest dose rates in the 300 Area in 2000 were measured near the 316-3 process trench. The average dose rate measured in the 300 Area in 2000 was 100 mrem/yr, which is 9% lower than the average dose rate measured in 1999. The average dose rate at the 300 Area Treated Effluent Disposal Facility in 2000 was 83 mrem/yr, which is a 5% decrease compared to the average dose rate of 80 mrem/yr measured in 1999. The average dose rate measured in the 400 Area in 2000 was 80 mrem/yr, which is a 6% decrease compared to the average dose of 85 mrem/yr measured in 1999. The annual average thermoluminescent dosimeter results for the 300 and 400 Areas from 1991 through 2000 are presented in Figure 3.2.7.

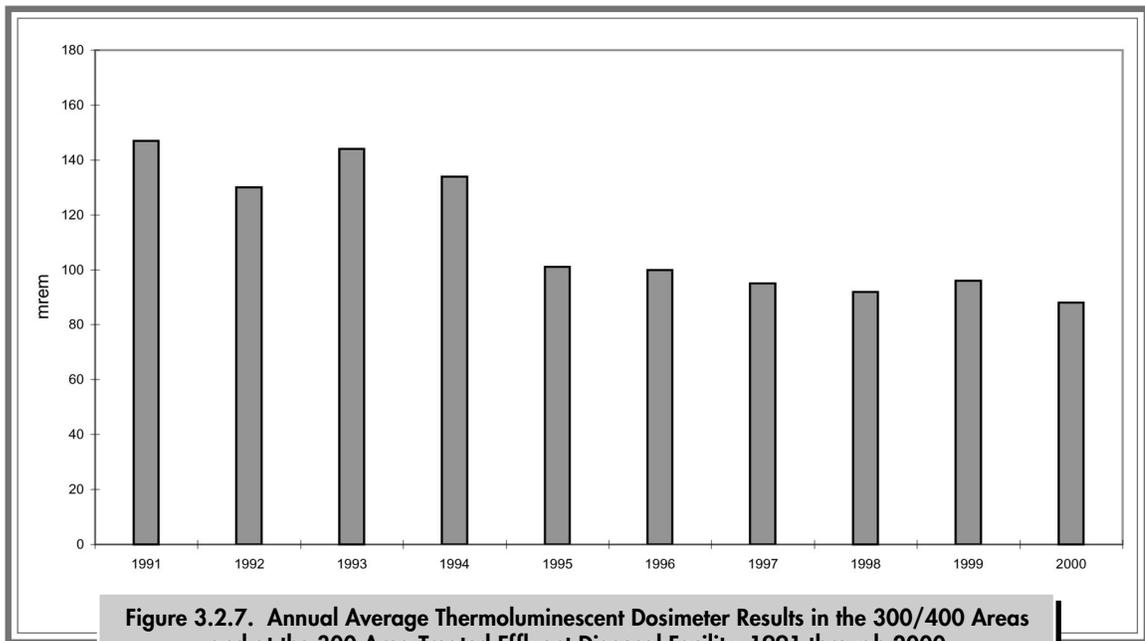
One new thermoluminescent dosimeter monitoring site was established in the 200 North Area, at the (contaminated) 212-R Railroad Car Disposition Area in 1999 to monitor expected high radiation levels in the immediate vicinity. The annual average dose rate at 212-R in 2000 was 2,005 mrem/yr. This value exceeds the DOE annual external dose (greater than 100 mrem/yr) limit to the members of the public. However, no member of the public, or Hanford worker, would conceivably spend an entire year at this location.

3.2.6 Investigative Sampling

Investigative sampling was conducted in the operations areas to monitor the presence or movement of radioactive and/or hazardous materials around areas of known or suspected contamination or to verify radiological conditions at specific project sites. Investigative sampling took place near

facilities such as storage and disposal sites for at least one of the following reasons:

- to follow up radiological surface surveys that had indicated radioactive contamination was present



- to conduct preoperational surveys to characterize the radiological/chemical conditions at a site before facility construction, operation, or ultimate remediation
- to determine if biotic intrusion (e.g., animal burrows or deep-rooted vegetation) had created a potential for contaminants to spread
- to determine the integrity of waste containment systems.

Generally, the predominant radionuclides discovered during these efforts were cesium-137, strontium-89/90, and plutonium-239/240 in the 100 and 200 Areas and uranium-234, -235, and -238 in the 300 Area. Hazardous chemicals generally have not been identified above background levels in preoperational environmental monitoring samples.

Investigative samples collected in 2000 included mammals (mice, bats, rabbit), feces (mouse, coyote, bird), and tumbleweed fragments. Methods for collecting investigative samples are described in WMTS-OEM-001. Field monitoring was conducted to detect radioactivity in samples before they were submitted for analysis. Field monitoring results are expressed as disintegrations per minute when a Geiger-Müller detector was used, or as millirad per hour when an ion chamber was used. To obtain the field instrument readings, measured background radioactivity was subtracted from the Geiger-Müller readings (in counts per minute) and the results were converted to disintegrations per minute per 100 cm². Laboratory sample analysis results are expressed in picocuries per gram, except for extremely small samples. Small samples are expressed in picocuries per sample. Maximum concentrations, rather than averages, are presented in this section.

In 2000, nine investigative samples were analyzed for radionuclides at the 222-S Laboratory in the 200-West Area. Of the samples analyzed, all showed measurable levels of activity. Analytical results are provided in PNNL-13487, APP. 2. Another 102 contaminated investigative

environmental samples were reported and disposed of without isotopic analyses (though field instrument survey readings were recorded) during cleanup operations. These results are also provided in PNNL-13487, APP. 2. Only radionuclide concentrations above analytical detection limits are provided in this section.

In 2000, there were 25 instances of radiological contamination in investigative soil samples. Of the 25, 16 were identified as speck or soil speck contamination. None of the investigative soil samples were submitted for radioisotopic analysis. Twenty-four of the 25 areas of soil contamination were cleaned up and the contaminated soil was disposed of in low-level burial grounds without analysis. At the remaining site, the contamination levels did not exceed limitations of the posting and was left in place. For all samples, external radioactivity levels ranged from 6,000 dpm/100 cm² to more than 1 million dpm/100 cm².

The number of investigative soil contamination incidents, range of radiation dose levels, and radionuclide concentrations in 2000 were generally within historical values (WHC-MR-0418). Areas of special soil sampling that were found outside radiological control areas and that had dose levels greater than radiological control limits were cleaned up or posted as surface contamination areas.

In 2000, there were 66 instances of radiological contamination in investigative vegetation samples. Of the 66, 65 were identified as tumbleweed or tumbleweed fragments and one as rabbitbrush. One tumbleweed sample was analyzed for radionuclide activities. There were six tumbleweed samples with field readings of 1 million dpm/100 cm² or higher. Of these, three were suspected to have originated from the 218-E-12B burial ground in the 200-East Area, two were found on the 218-A-30 crib also in the 200-East Area, and one was suspected to have originated from an inactive transfer line in the 200-West Area. Investigative vegetation samples not sent to the laboratory for analysis were disposed of in low-level burial grounds.





The number of incidents of contaminated vegetation in 1999 (84) was the highest number of annual incidents since 1994 when data collections began. These high numbers can be attributed largely to situations in which herbicide applications were not made at optimum times, and in some cases, not made at all. Tumbleweed and rabbitbrush are deep-rooted species and become radiologically contaminated by the uptake of below ground contaminants through their root systems. Herbicide application is intended to halt vegetation growth before this uptake occurs. During 2000, application techniques were improved, and administrative procedures were implemented to improve vegetation management. The somewhat reduced number of incidents in 2000 (66) appears to reflect these improvements. Nevertheless, contaminated vegetation continued to be identified by radiological surveys. However, as “old” contaminated vegetation from past years is identified and cleaned up, subsequent years will show the results of program improvements.

Investigative wildlife samples were collected directly from or near facilities to monitor and track the effectiveness of measures designed to deter animal intrusion. Samples were collected either as part of an integrated pest management program designed to limit the exposure of animals to radioactive materials, or as a result of finding radiologically contaminated wildlife-related material (e.g., feces, nests) during radiation surveys.

Radiological surveys were performed after the collection of wildlife to determine whether an animal was radioactively contaminated. If a live animal was found to be free of contamination, it was taken to an area of suitable habitat, still in a controlled area, and released. If an animal was contaminated, a decision was made based on the level of contamination, location, and frequency of occurrence either to collect the animal as a sample or to dispose of the animal in a low-level burial ground.

In 2000, 12 wildlife and wildlife-related samples were collected, 8 of which were submitted for laboratory analysis. The number of samples submitted for analysis depended on opportunity (i.e., resulting from the pest control activities) and analytical budget, rather than prescheduled sampling at established sampling points.

The maximum radionuclide concentrations in investigative wildlife samples in 2000 were in mouse feces collected near the 241-TX-155 Diversion Box in the 200-West Area. Field readings showed 300,000 dpm/100 cm² beta/gamma and 2,800 dpm/100 cm² alpha. Contaminants included cobalt-60 (93 pCi/g), strontium-89/90 (116,000 pCi/g), cesium-137 (42,900 pCi/g), europium-154 (627 pCi/g), europium-155 (417 pCi/g), plutonium-238 (39,100 pCi/g), and plutonium-239/240 (384,000 pCi/g). The numbers of animals found to be contaminated with radioactivity, their radioactivity levels, and the range of radionuclide activities were within historical levels (WHC-MR-0418).

There were four cases of contaminated wildlife or related samples found during cleanup operations that were not submitted to a laboratory for analysis. These samples included ant mounds and mouse feces. The field instrument readings for these samples ranged from 12,000 to 129,000 dpm/100 cm².

Special characterization projects conducted or completed in 2000 to ascertain the radiological, and in some cases, potential hazardous chemical status of site-specific operations included the projects listed below.

- A preoperational environmental survey was completed in support of the Spent Nuclear Fuels Project Facilities. Environmental samples were collected in the proximity of the Canister Storage Building and the Interim Storage Area in the 200-East Area and near the Cold Vacuum Drying Facility in the 100-K Area. A final report (HNF-6150) was prepared and issued.

- A preoperational monitoring plan (RPP-6877) was developed to support the Waste Vitrification initiative. As a part of this plan, a survey will be conducted on the proposed location for the Remote-Handled Immobilized Low-Activity Waste Disposal Facility to be located

in the 200-East Area. Efforts will include radiological and ground penetrating radar surveys, surface and subsurface soil sampling, vegetation sampling, and air and thermoluminescent dosimeter monitoring.

