

3.2 Near-Facility Environmental Monitoring



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Near-facility environmental monitoring is conducted near facilities that have the 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 100-K Basins; inactive nuclear facilities such as N Reactor and the Plutonium-Uranium Extraction (PUREX) Plant; and active and inactive waste storage or disposal facilities such as burial grounds, cribs, ditches, ponds, underground waste storage tanks, 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 sites, and detect and monitor unusual conditions. The program implements applicable portions of DOE Orders 435.1, 450.1 (replaced DOE Order 5400.1 in January 2003), and 5400.5; DOE Manual 231.1-1A; 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. The samples and measurements taken include air, spring water, surface contamination, soil, vegetation, and external radiation fields. Samples are collected from known or expected effluent pathways, which 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 former waste disposal cribs and trenches, retention basin 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 results from monitoring during 2003 are summarized in the following sections. Strontium-90 results for this report period show overall lower values compared to historical trends. This was primarily due to changes in laboratory background correction calculations that were implemented in 2003. Both historical and current values are within accepted statistical ranges as evidenced by laboratory quality assurance and performance evaluation programs. Additional data may be found in *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2003* (PNNL-14687, APP. 2). The type and general locations of samples collected for near-facility monitoring during 2003 are summarized in Table 3.2.1.

3.2.1 Air Monitoring

During 2003, routine monitoring for radioactive materials in air near Hanford Site facilities used a network of continuously operating samplers at 82 locations (Table 3.2.2) (sampling locations illustrated in PNNL-14687, APP. 2). Air samplers were located primarily at or within approximately 500 meters (1,500 feet) of sites and/or facilities having the potential for, or history of, environmental releases and were 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 the Pacific Northwest National Laboratory.

Table 3.2.1. Hanford Site Near-Facility Routine Environmental Monitoring Samples and Locations, 2003

Sample Type	Number of Sampling Locations	Sampling Locations in Each Operational Area								
		100-B/C	100-D/DR	100-K	100-F	100-H	100-N	ERDF ^(a)	200/600	300/400
Air	82	6	3	11	6	2	5	3	41 ^(b)	5
Water	10	0	0	0	0	0	10	0	0	0
Soil	82	5	0	2	2	0	1	1	57	14
Vegetation	65	0	0	0	0	0	4	0	48	13
External radiation	134	4	0	20	5	0	14	3	67	21

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

(b) Includes 1 station at the Wye Barricade, 19 in the 200-East Area, and 21 in the 200-West Area.

Samples were collected according to a schedule established before the 2003 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 composite samples for each location.

Figure 3.2.1 shows the annual average concentrations of selected radionuclides in the 100 and 200/600 Areas compared to the DOE derived concentration guides and, when available, air concentrations measured in distant communities. The DOE derived concentration guides (DOE Order 5400.5) are dose-based 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 radionuclide concentrations than did those samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford

Site background levels, which are much less than DOE derived concentration guides but greater than those measured off the site. 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 2003. A complete listing of the 2003 near-facility ambient air monitoring results can be found in PNNL-14687, APP. 2. Results for selected Pacific Northwest National Laboratory air samples are also reported in PNNL-14687, APP. 2, as well as in Section 4.1.

At the remedial action project site in the 100-B/C Area, ambient air monitoring was conducted at five locations in 2003. The radionuclides uranium-234 and uranium-238 were consistently detected. Beginning in late February 2003 and continuing through early July 2003, one additional air sampling station was added in the 100-B/C Area during the decommissioning of the retired 118-C-4 rod cave. Isotopic analyses of the composited filter from this location detected only uranium-234 and uranium-238.

During 2003, air monitoring continued at seven locations associated with the interim safe storage of the reactor buildings in the 100-D/DR, 100-F, and 100-H Areas. Specifically, there was one sampling location at the 105-D site and two each at the 105-DR, 105-F, and 105-H sites. The quarterly analytical results from these air samples showed radionuclide concentrations and frequency of detection consistent with results observed over the past 4 years. Uranium-234 was consistently detected (in 72% of the samples) in all of the interim safe storage project's



Table 3.2.2. Hanford Site Near-Facility Air Sampling Locations and Analyses, 2003

Site	Number of Samplers	EDP Code ^(a)	Analyses	
			Biweekly	Composite ^(b)
100-B/C remedial action project	5	N464, N465, N466, N496, N497	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
118-C-4 decommissioning project	1	N536	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
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, N515	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-F remedial action project	4	N519, N520, N521, N522	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-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-KR-1 remedial action project	3	N538, N539, N540	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-NR-1 remedial action and 100-N surveillance, maintenance/transition projects	5	N102, N103, N105, N106, N526	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 and 300-FF-2 remedial action project	5	N130, N485, N486, N487, N527	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
Environmental Restoration Disposal Facility	3	N482, N517, N518	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
600 Area	1	N981	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso

(a) EDP Code = Sampler location code. See PNNL-14687, APP. 2.

(b) GEA = Gamma energy analysis; Pu-iso = isotopic plutonium-238 and plutonium-239/240; U-iso = isotopic uranium-234, uranium-235, and uranium-238.

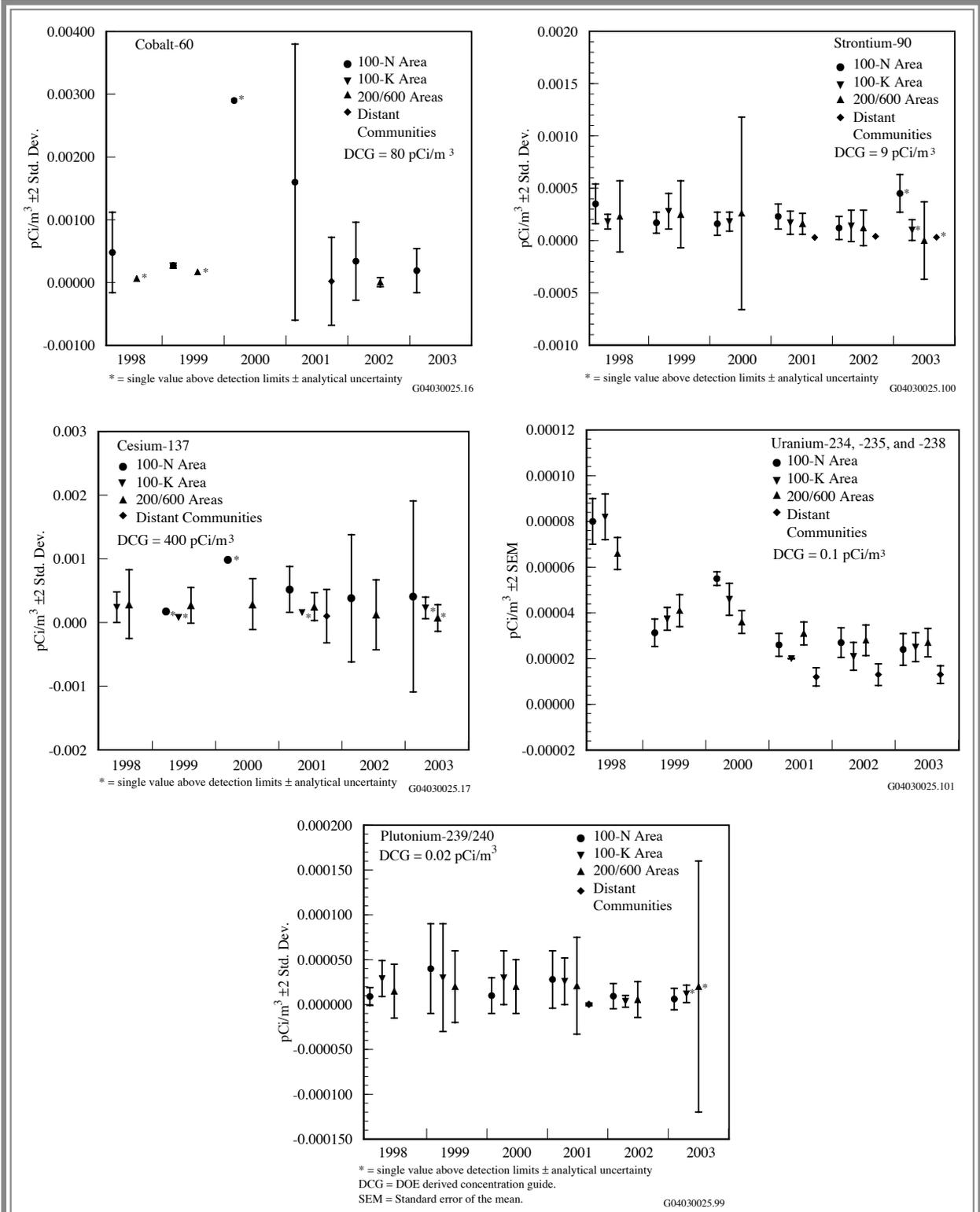


Figure 3.2.1. Average Concentrations of Selected Radionuclides in Near-Facility Air Samples Collected on the Hanford Site Compared to Those Collected in Distant Communities (PNNL-14295), 1998 through 2003. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 3.2.3. Annual Average and Maximum Concentrations (aCi/m³)^(a) of Radionuclides in Near-Facility Air Samples Collected on the Hanford Site, 2003

<u>Cobalt-60</u>				<u>Uranium-235</u>			
Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)	Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)
100-B/C RA ^(e)	21 ± 59	81 ± 78	N464	100-B/C RA ^(e)	2.6 ± 3.2	4.8 ± 78	N496
100 Area ISS ^(f)	-12 ± 580	360 ± 1,200	N523	100 Area ISS ^(f)	5.6 ± 13	22 ± 22	N523
100-F RA	-13 ± 92	7.8 ± 120	N521	100-F RA	5.8 ± 3.6	6.8 ± 6.8	N521
100-K SNF ^(g)	4.1 ± 120	81 ± 93	N403	100-K SNF ^(g)	2.4 ± 3.4	5.5 ± 4.7	N401
100-K RA	-5.7 ± 140	110 ± 84	N529	100-K RA	2.2 ± 1.8	3.3 ± 3.4	N528
100-N	190 ± 370	540 ± 230	N105	100-N	1.5 ± 4.0	5.7 ± 4.8	N526
200-East	11 ± 95	93 ± 91	N970	200-East	3.0 ± 4.8	8.4 ± 6.9	N481
200-West	1.5 ± 96	160 ± 90	N165	200-West	2.8 ± 5.1	13 ± 15	N304
300-FF-1				300-FF-1			
(300 Area)	30 ± 220	300 ± 130	N485	(300 Area)	4.0 ± 4.5	7.1 ± 6.7	N487
ERDF ^(h)	14 ± 120	88 ± 89	N963	ERDF ^(h)	3.1 ± 3.1	5.8 ± 5.2	N518
Distant community ⁽ⁱ⁾	25 ± 550	730 ± 1,000		Distant community ⁽ⁱ⁾	0.52 ± 3.7	2.7 ± 4.4	
DCG ^(j)		80,000,000		DCG ^(j)		100,000	
<u>Strontium-90</u>				<u>Uranium-238</u>			
Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)	Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)
100-B/C RA ^(e)	-39 ± 110	69 ± 78	N465	100-B/C RA ^(e)	8.2 ± 8.6	19 ± 78	N496
100 Area ISS ^(f)	-100 ± 820	670 ± 260	N524	100 Area ISS ^(f)	16 ± 27	64 ± 96	N523
100-F RA	-74 ± 210	-23 ± 140	N522	100-F RA	6.1 ± 2.2	6.1 ± 6.4	N522
100-K SNF ^(g)	-36 ± 120	100 ± 99	N403	100-K SNF ^(g)	9.8 ± 7.3	18 ± 10	N402
100-K RA	-61 ± 160	-0.36 ± 3.6	N528	100-K RA	10 ± 4.9	15 ± 8.5	N529
100-N	-36 ± 390	450 ± 180	N103	100-N	9.9 ± 8.8	16 ± 9.1	N526
200-East	62 ± 500	1,000 ± 330	N984	200-East	11 ± 13	40 ± 19	N976
200-West	-51 ± 150	140 ± 110	N441	200-West	11 ± 11	27 ± 14	N433
300-FF-1				300-FF-1			
(300 Area)	-130 ± 360	-7.0 ± 65	N130	(300 Area)	29 ± 34	58 ± 25	N527
ERDF ^(h)	-34 ± 190	100 ± 110	N482	ERDF ^(h)	14 ± 16	27 ± 14	N482
Distant community ⁽ⁱ⁾	31 ± 100	100 ± 74		Distant community ⁽ⁱ⁾	19 ± 10	28 ± 11	
DCG ^(j)		9,000,000		DCG ^(j)		100,000	
<u>Cesium-137</u>				<u>Plutonium-238</u>			
Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)	Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)
100-B/C RA ^(e)	4.6 ± 81	74 ± 78	N464	100-B/C RA ^(e)	1.7 ± 21	22 ± 78	N465
100 Area ISS ^(f)	93 ± 710	1,300 ± 1,800	N523	100 Area ISS ^(f)	-3.4 ± 110	52 ± 140	N523
100-F RA	52 ± 130	35 ± 140	N520	100-F RA	-3.6 ± 7.5	-3.4 ± 15	N521
100-K SNF ^(g)	4.0 ± 110	100 ± 92	N402	100-K SNF ^(g)	2.5 ± 22	24 ± 29	N404
100-K RA	52 ± 180	230 ± 170	N529	100-K RA	-0.54 ± 19	14 ± 15	N529
100-N	410 ± 1,600	2,500 ± 790	N526	100-N	-4.3 ± 15	7.3 ± 14	N106
200-East	55 ± 180	300 ± 150	N973	200-East	1.7 ± 18	37 ± 28	N480
200-West	79 ± 230	510 ± 210	N155	200-West	1.1 ± 15	21 ± 20	N449
300-FF-1				300-FF-1			
(300 Area)	13 ± 88	84 ± 87	N485	(300 Area)	5.8 ± 12	9.9 ± 24	N130
ERDF ^(h)	48 ± 54	84 ± 77	N482	ERDF ^(h)	-0.43 ± 13	11 ± 13	N482
Distant community ⁽ⁱ⁾	-100 ± 450	350 ± 380		Distant community ⁽ⁱ⁾	-0.83 ± 1.4	0.063 ± 1.5	
DCG ^(j)		400,000,000		DCG ^(j)		30,000	
<u>Uranium-234</u>				<u>Plutonium-239/240</u>			
Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)	Site	Average ^(b)	Maximum ^(c)	EDP Code ^(d)
100-B/C RA ^(e)	11 ± 11	20 ± 78	N465	100-B/C RA ^(e)	1.7 ± 4.5	7.0 ± 78	N496
100 Area ISS ^(f)	24 ± 26	57 ± 63	N523	100 Area ISS ^(f)	23 ± 120	300 ± 240	N523
100-F RA	13 ± 17	12 ± 14	N521	100-F RA	14 ± 54	1.8 ± 27	N521
100-K SNF ^(g)	13 ± 6.9	18 ± 9.8	N404	100-K SNF ^(g)	4.3 ± 10	12 ± 9.8	N401
100-K RA	14 ± 13	22 ± 12	N528	100-K RA	4.7 ± 6.7	9.9 ± 8.6	N529
100-N	13 ± 10	24 ± 14	N105	100-N	6.2 ± 12	20 ± 12	N526
200-East	13 ± 11	29 ± 14	N976	200-East	4.8 ± 14	26 ± 14	N967
200-West	13 ± 10	27 ± 18	N304	200-West	34 ± 180	500 ± 190	N165
300-FF-1				300-FF-1			
(300 Area)	40 ± 38	69 ± 28	N487	(300 Area)	2.9 ± 3.5	4.1 ± 8.3	N130
ERDF ^(h)	18 ± 13	27 ± 14	N518	ERDF ^(h)	12 ± 43	64 ± 28	N963
Distant community ⁽ⁱ⁾	19 ± 17	34 ± 14		Distant community ⁽ⁱ⁾	0.32 ± 1.3	1.5 ± 2.4	
DCG ^(j)		90,000		DCG ^(j)		20,000	

Table 3.2.3. (contd)

Plutonium-241				Americium-241			
Site	Average^(b)	Maximum^(c)	EDP Code^(d)	Site	Average^(b)	Maximum^(c)	EDP Code^(d)
100-K SNF ^(g)	100 ± 800	890 ± 1,100	N403	100-K SNF ^(g)	6.3 ± 13	19 ± 15	N478
200-East	-150 ± 1,000	360 ± 670	N481	200-East	3.2 ± 8.4	6.7 ± 10	N481
Distant community ⁽ⁱ⁾		Not reported		Distant community ⁽ⁱ⁾		Not reported	
DCG ^(j)		1,000,000		DCG ^(j)		20,000	

(a) To convert to international metric system units, multiply aCi/m³ by 0.000000037 to obtain Bq/m³.

(b) ±2 times the standard deviation.

(c) ± total analytical uncertainty.

(d) See PNNL-14687, APP. 2.

(e) RA = Remedial action project.

(f) ISS = Interim safe storage projects at 105-DR/F/D/H and 117-DR.

(g) SNF = Spent nuclear fuel.

(h) ERDF = Environmental Restoration Disposal Facility.

(i) See Section 4.1.

(j) DOE derived concentration guide.

air samples. Strontium-90, uranium-238, and plutonium-239/240 were detected in approximately 15%, 50%, and 25% of the quarterly samples, respectively.

In late April 2003, remedial action activities were completed and air sampling subsequently concluded at the four locations at the 100-F Area remedial action site. Uranium-234 and uranium-238 were detected consistently; strontium-90 and plutonium-239/240 were detected occasionally.

The airborne contaminant levels in the 100-K Area were similar to those measured over the previous years. Facility emissions in the 100-K Area were reduced substantially in 1996 and subsequent radionuclide concentrations in the ambient air samples have been near detection limits. Uranium-234 and uranium-238 were detected consistently in 2003. Occasionally, strontium-90, uranium-235, and plutonium-239/240 were detected also. Though routinely analyzed for, americium-241 and plutonium-241 were not detected in 2003.

Air sampling continued in 2003 at three locations at the 100-KR-1 remedial action site. Uranium-234 and uranium-238 were consistently detected.

Analytical results for ambient air samples from the 100-NR-1 remedial action site and 100-N surveillance and maintenance/transition site in 2003 were similar to those measured in previous years. Uranium-234 and uranium-238 were detected consistently. Occasionally detected were cobalt-60, cesium-137, and plutonium-239/240.

During 2003, radionuclide levels measured in the 200-East Area were generally similar to those measured over the previous years. Uranium-234 and uranium-238 were detected in more than 80% of the samples. Occasionally, strontium-90, cesium-137, uranium-235, and plutonium-239/240 were detected.

Radionuclide levels measured in the 200-West Area were similar to results for previous years. Uranium-234 and uranium-238 were detected in more than 90% of the samples, and plutonium-239/240 was detected in approximately 50% of the samples. Strontium-90, cesium-137, and uranium-235 were detected only occasionally.

The air sampling network at the Environmental Restoration Disposal Facility (200-West Area) used 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 [Section 4.1]) and three air samplers at the facility that provided downwind coverage. The 2003 analytical results were comparable to 2002 levels. Consistently detected were uranium-234 and uranium-238. Uranium-235 and plutonium-239/240 were detected occasionally.

During June 2003, remediation work at the 300-FF-1 Operable Unit (located just north of the 300 Area) was completed and air sampling was concluded. Ambient air monitoring at this site included eight samplers: one near-facility monitoring upwind sampler, located at the nearby 300 Area Treated Effluent Disposal Facility; three Pacific Northwest National Laboratory upwind samplers in the

300 Area (300 trench, 300 NE, and 300 water intake - Section 4.1); and four downwind, site-specific air samplers. Analytical results indicated that radionuclide concentrations in air samples collected at this site were much less than the DOE derived concentration guides and were slightly lower than those measured during previous remediation activities conducted at the 300-FF-1 Operable Unit during 1997 through 2000. Uranium-234 and uranium-238 were detected in 100% of the samples and uranium-235 in approximately 50% of the samples.

The remedial action, interim safe storage, and surveillance and maintenance/transition activities discussed above are described in more detail in Section 2.3.13.

3.2.2 Spring Water Monitoring

In the past, radioactive effluent streams from operations in the 100-N Area were sent to the now retired 116-N-1 (1301-N) and 116-N-3 (1325-N) liquid waste disposal facilities (i.e., engineered soil columns). After moving through the soil column to the water table, this wastewater migrated with the groundwater and entered the Columbia River via springs located along the adjacent riverbank region sometimes called N Springs. Groundwater springs and/or shoreline wells at the N Springs are sampled annually to verify that the reported radionuclide release estimates from these shoreline seeps to the Columbia River are not underreported. The amount of radionuclides entering the Columbia River at these springs is calculated based on analyses of samples collected from monitoring well 199-N-46 located near the shoreline. Analytical results and discussion of these releases may be

found in Section 3.1.3 and in HNF-EP-0527-13. A groundwater pump-and-treat system designed to reduce the discharge of strontium-90 to the Columbia River in the 100-N Area was put into operation in 1995 and continued to operate in 2003. Additional discussion about this system and its effects may be found in Section 2.3.13.1.

During October 2003, samples were collected from ten 100-N Area shoreline wells (i.e., one sample from each well). The samples were 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. Samples were analyzed for strontium-90, tritium, and gamma-emitting radionuclides.

Strontium-90 was detected in eight of the well water samples. None of the concentrations exceeded the DOE derived concentration guide value. Tritium and gamma-emitting radionuclide concentrations were below analytical detection limits. Tritium and strontium-90 data from 2003 riverbank springs samples are summarized in Table 3.2.4.

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 monitored areas are underground radioactive materials areas, contamination areas, soil contamination areas, high contamination areas, roads, and fence lines.

Underground radioactive materials areas are areas where radioactive materials occur below the soil surface. These areas are typically stabilized cribs, burial grounds, covered

Table 3.2.4. Radionuclide Concentrations (pCi/L^(a)) in Samples Collected from Wells Along the Columbia River Shoreline in the 100-N Area of the Hanford Site, 2003

Radionuclide	Shoreline Springs Monitoring Well 199-N-46		Shoreline Wells		DCG ^(d)
	Maximum ^(b)	Average ^(c)	Maximum ^(b)	Average ^(c)	
Tritium	970 ± 243	635 ± 948	Not detected		2,000,000
Strontium-90	5,100 ± 765	4,100 ± 2,828	23 ± 3.4	7.7 ± 15	1,000

(a) To convert to international metric system units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) ± total analytical uncertainty.

(c) ±2 times the standard deviation.

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

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 assess the effectiveness of the barriers.

Contamination/soil contamination areas may or may not be associated with an underground structure containing radioactive material. A breach in the surface 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 assess the current radiological status (locations of contaminated areas are illustrated in PNNL-14687, APP. 2). In addition, all paved roadways are surveyed annually and the intersections along the Environmental Restoration Disposal Facility haul route are surveyed quarterly.

No new surface or underground radioactively contaminated areas of significant size were discovered during 2003. The Hanford Site had approximately 3,651 hectares (9,022 acres) of outdoor contaminated areas (all types) and approximately 666 hectares (1,646 acres) that contained underground radioactive materials not including active facilities. It was estimated that the external dose rate at 80% of the outdoor contaminated areas was less than 1 mrem (0.01 mSv) per hour, 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 global positioning systems were again used during 2003 to accurately measure the extent of the contamination. Area measurements are entered into the Hanford Geographical Information System, a computer database maintained by Fluor Hanford, Inc.

The number and size of contaminated areas vary from year to year for several reasons. Reductions are generally attributable to the stabilization of areas of known contamination. Increases are typically due to the discovery of new areas of

Table 3.2.5. Status of Outdoor Contamination at the Hanford Site, 2003

Area	Contamination Areas, ^(a) ha (acres)		Underground Radioactive Materials Areas, ^(b) ha (acres)	
	ha	(acres)	ha	(acres)
100-B/C	10	(25)	49	(121)
100-D/DR	0	(0)	39	(96)
100-F	1	(2)	33	(82)
100-H	0	(0)	14	(35)
100-K	9	(22)	62	(153)
100-N	29	(72)	12	(30)
200-East ^(c)	72	(178)	141	(348)
200-West ^(c)	29	(72)	223	(551)
300	23	(57)	45	(111)
400	0	(0)	0	(0)
600 ^(d)	3,478	(8,594)	48	(119)
Totals	3,651	(9,022)	666	(1,646)

- (a) Includes areas with contamination/soil contamination or radiologically controlled and areas that had both underground radioactive material and contamination/soil contamination.
- (b) Includes areas with only underground contamination.
- (c) Includes tank farms.
- (d) Includes BC controlled area, Environmental Restoration Disposal Facility, and waste disposal facilities outside the 200-East and 200-West Area boundaries.

contamination that result from either contaminant migration or increased efforts to investigate existing radiologically contaminated areas. Ongoing improvements of the geographical measurements of contaminated areas using global positioning system technology to better define area boundaries can result in either a reduction or an increase in the size and number of contaminated areas and underground radioactive materials areas. Similarly, document reviews and/or administrative reclassification of contaminated areas may lead to changes. Table 3.2.6 summarizes the causes and effects of these efforts during 2003.

3.2.4 Soil and Vegetation Monitoring

Soil and vegetation samples were collected on, or adjacent to, waste disposal sites and from locations downwind and near or within the boundaries of operating facilities and remedial action sites. Samples were collected to evaluate long-term trends in environmental accumulation of radioactive material and to detect potential migration and deposition of facility emissions. Special samples also were collected where potential physical or biological pathway



Table 3.2.6. Status Change of Posted Contaminated Areas on the Hanford Site, 2003

<u>Areas</u>	<u>Changes^(a)</u>	<u>Area, ha (acres)</u>	
100	RCA to CA ^(b)	2	(5)
100	RCA to URM ^(b)	10	(25)
200-East	CA to URM ^(c)	1	(2)
200-West	CA to URM ^(c)	1	(2)
200-West	URM to CA ^(b)	2	(5)
300	RCA to URM ^(d)	4	(10)
400	None to report	0	(0)
600	URM to None ^(d)	7	(17)

- (a) RCA = Radiologically controlled area.
 CA = Contamination/soil contamination area.
 URM = Underground radioactive material area.
- (b) Changes due to contamination migration.
 (c) Changes due to stabilization activities.
 (d) Administrative correction/re-classification.

problems were identified. Contaminant movement can occur as the result of resuspension from radiologically contaminated surface areas, absorption of radionuclides by the roots of vegetation growing on or near underground and inactive surface-water disposal units, or animal intrusion at a waste site. The soil and vegetation sampling methods and locations used for near-facility monitoring are discussed in detail in DTS-OEM-001. All soil and vegetation samples were analyzed for strontium-90, uranium isotopes, plutonium isotopes, and gamma-emitting radionuclides.

The number and location of soil and vegetation samples collected during 2003 are summarized in Table 3.2.1. A comprehensive presentation of the analytical data from these samples can be found in PNNL-14687, APP. 2. Only those radionuclide concentrations reported above analytical detection limits are discussed in this section.

Each 1-kilogram (2.2-pound) soil sample represented a composite of five plugs of soil, each 2.5 centimeters (1 inch) deep and 10 centimeters (4 inches) in diameter collected from each site. Each vegetation sample (approximately 500 grams [16.1 ounces]) consisted of new-growth leaf cuttings taken from the available brushy, deep-rooted species of interest at a sample location (e.g., sagebrush and/or rabbitbrush). 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.

During the spring through early 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 occur in the areas sampled (i.e., gamma-emitting radionuclides, strontium-90, uranium isotopes, and/or plutonium isotopes). The analytical results are compared to concentrations in samples collected offsite at various sampling locations in Yakima, Benton, and Franklin Counties. Comparison of the levels was used to determine the difference between contributions from site operations and remedial action sites and contributions from natural sources 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-14687, APP. 2 for complete listing of concentrations). These radioactive concentration values were established to assure 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 assures 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.

Some degree of variability is always associated with the collection and analysis of environmental samples. Therefore, minor variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in soil and vegetation samples collected from, or adjacent to, waste disposal facilities in 2003 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 in 2003 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 200/600 Areas, and uranium in the 300/400 Areas.

3.2.4.1 Radiological Results for Soil Samples

In near-facility soil samples collected in 2003, cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were detected consistently. The concentrations of these radionuclides were elevated near and within facility boundaries when compared to historical concentrations measured off the site at distant communities. Figure 3.2.2 shows average soil values for samples collected during 2003 and the preceding 5 years. Some individual levels demonstrate a high degree of variability, though overall trends are stable.

Historical results for surface soil samples collected near the 116-N-1 liquid waste disposal facility were somewhat higher than radiological results from historical samples collected at the other soil sampling locations in the 100-N Area. During 2003, however, all but one of the routine sampling locations in the 100-N Area were not accessible or had been destroyed during decommissioning activities and comparative values were, therefore, not available.

Average radionuclide concentrations detected in the surface soil samples collected in the 100-N Area from 1998 through 2003 are presented in Table 3.2.7. The 2002 and 2003 values reported for 100-N Area surface soil represent a single routine sampling location. The 2003 result and the average for distant communities and accessible soil concentrations are compared in Table 3.2.8.

Soil samples were collected from 57 sampling locations in the 200/600 Areas during 2003. Analytical results from these soil samples demonstrated comparable average radionuclide concentration levels from 2002 compared to 2003 (Table 3.2.9). The 2003 maximums, averages, distant community averages, and accessible soil concentrations are compared in Table 3.2.10. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-14687, APP. 2.

Soil samples were collected from 14 sampling locations in the 300/400 Areas in 2003: 13 from the 300 Area and 1 from the 400 Area. Analytical results for 2003 and the preceding 5 years are summarized in Table 3.2.11. The 2003 maximums, averages, distant community average concentrations, and accessible soil concentrations are compared in Table 3.2.12. Complete listings of radionuclide

concentrations and sampling location maps are provided in PNNL-14687, APP. 2. For the samples collected during 2003, average values reported for uranium isotopes were somewhat less than the concentrations reported in 2002. Uranium concentrations were expected to be higher in the 300 Area samples than at other site locations because uranium was processed during past fuel fabrication operations in the 300 Area.

For non-routine soil sampling in support of the environmental restoration contractor projects in 2003, five soil samples were collected at the remedial action project in the 100-B/C Area, and two each at the remedial action projects in the 100-F and 100-K Areas. A single sample was collected from the Environmental Restoration Disposal Facility (200-West Area) to determine the effectiveness of contamination controls. Analytical results from each of these locations were comparable to those observed at other near-facility sampling locations at Hanford. Table 3.2.13 provides a summary of the selected analytical results for samples from these remedial action locations. All of the 2003 data are provided in PNNL-14687, APP. 2.

3.2.4.2 Radiological Results for Vegetation Samples

In 2003 near-facility vegetation samples, cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were detected consistently. Concentrations of these radionuclides in vegetation were elevated near and within facility boundaries compared to concentrations measured at distant communities. Figure 3.2.3 shows the average vegetation values for samples collected onsite during 2003 and the preceding 5 years and results through 2001 for distant communities. The results demonstrate a high degree of variability.

Four vegetation samples were collected at locations in the 100-N Area. Average radionuclide concentrations detected in all of the near-facility vegetation samples collected in the 100-N Area from 1998 through 2003 are presented in Table 3.2.14. These concentrations were within the range of historical values. The levels of strontium-90 at the 100-N Area were higher than levels found in the 200 and 300/400 Areas. The 2003 maximum and average concentrations for vegetation samples collected at the 100-N Area are compared to historic distant community



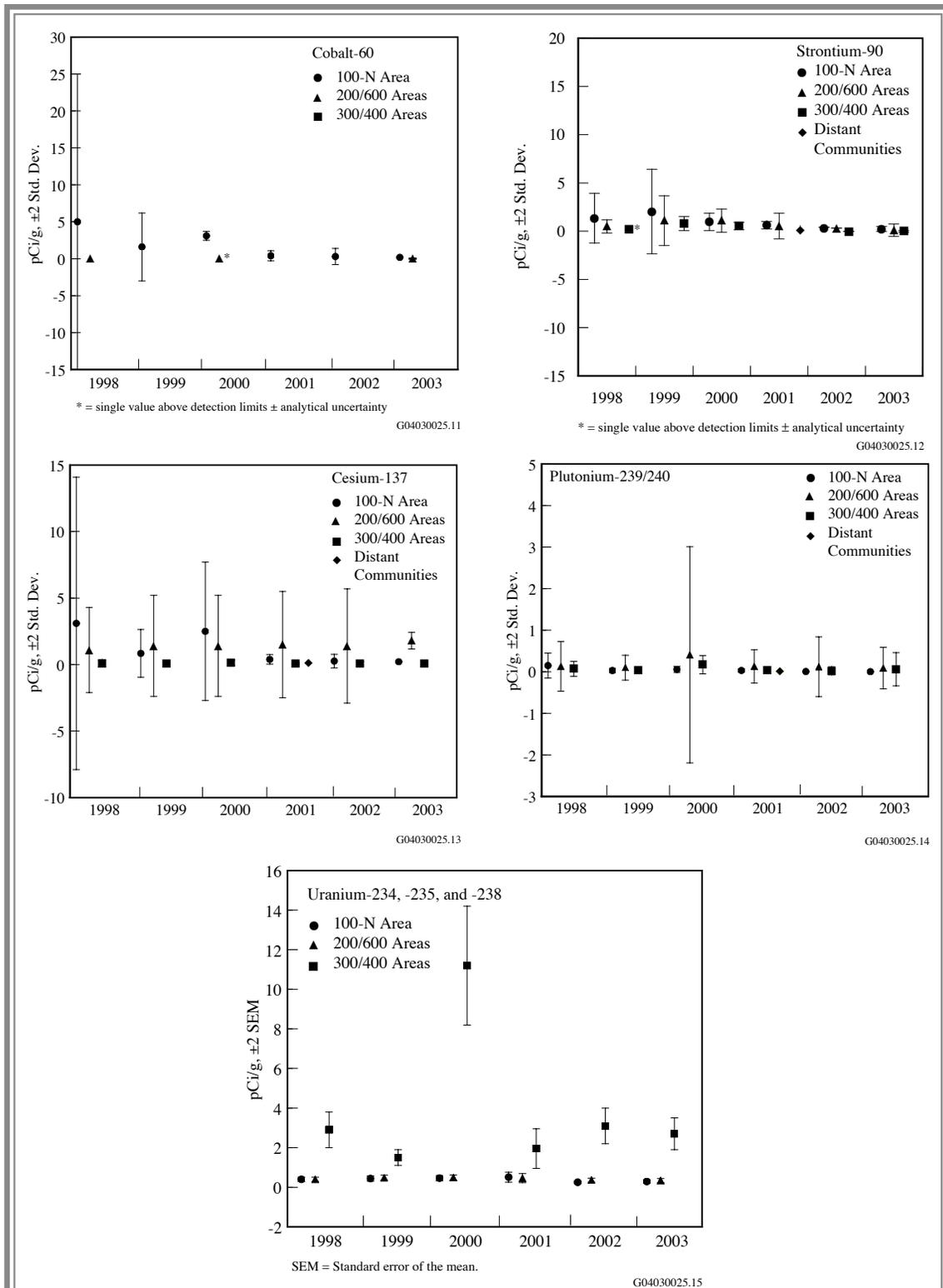


Figure 3.2.2. Average Concentrations of Selected Radionuclides in Near-Facility Soil Samples Collected on the Hanford Site Compared to Those Collected in Distant Communities (PNNL-13910), 1998 through 2003. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 3.2.7. Average Radionuclide Concentrations (pCi/g^(a) dry wt.)^(b) Detected in Surface Soil Samples Collected from the 100-N Area on the Hanford Site, 1998 through 2003

<u>Year</u>	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>²³⁴U</u>	<u>²³⁸U</u>	<u>^{239/240}Pu</u>
1998	4.9 ± 2.0	1.0 ± 2.6	3.1 ± 1.1	0.214 ± 0.063	0.166 ± 0.026	0.13 ± 0.3
1999	1.6 ± 4.6	1.9 ± 4.4	0.84 ± 1.8	0.22 ± 0.04	0.20 ± 0.03	0.026 ± 0.05
2000	3.1 ± 0.6	0.84 ± 0.9	2.1 ± 5.2	0.22 ± 0.09	0.22 ± 0.03	0.050 ± 0.074
2001	0.27 ± 0.68	0.20 ± 0.42	0.32 ± 0.44	0.24 ± 0.09	0.25 ± 0.07	0.022 ± 0.04
2002 ^(c)	0.3 ± 1.1	0.15 ± 0.47	0.26 ± 0.51	0.13 ± 0.05	0.11 ± 0.04	0.006 ± 0.006
2003 ^(c)	0.18 ± 0.02	-0.08 ± 0.24	0.21 ± 0.04	0.14 ± 0.05	0.15 ± 0.05	0.002 ± 0.006

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ±2 times the standard deviation.
 (c) Represents one sample site only; ± total analytical uncertainty.

Table 3.2.8. Concentrations of Selected Radionuclides (pCi/g^(a) dry wt.) in a Surface Soil Sample Collected from the 100-N Area on the Hanford Site, 2003

	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>²³⁴U</u>	<u>²³⁸U</u>	<u>^{239/240}Pu</u>
Result ^(b)	0.18 ± 0.02	-0.08 ± 0.24	0.21 ± 0.04	0.14 ± 0.05	0.15 ± 0.05	0.002 ± 0.006
Distant community ^(c,d)	NR ^(e)	0.052 ± 0.11	0.15 ± 0.32	NR	0.13 ± 0.11	0.0055 ± 0.012
Accessible soil concentration (WHC-SD-EN-TI-070) ^(f)	7.1	2,800	30	630	370	190

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ± total analytical uncertainty.
 (c) ±2 times the standard deviation.
 (d) PNNL-13910.
 (e) NR = Not reported.
 (f) Hanford soil that is not behind security fences.

Table 3.2.9. Average Radionuclide Concentrations (pCi/g^(a) dry wt.)^(b) Detected in Surface Soil Samples Collected from the 200/600 Areas on the Hanford Site, 1998 through 2003

<u>Year</u>	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>²³⁴U</u>	<u>²³⁸U</u>	<u>^{239/240}Pu</u>
1998	0.014 ± 0.09	0.21 ± 0.67	1.0 ± 3.1	0.19 ± 0.07	0.19 ± 0.07	0.08 ± 0.49
1999	ND ^(c)	0.51 ± 1.9	1.3 ± 3.8	0.23 ± 0.13	0.22 ± 0.13	0.08 ± 0.27
2000	0.006 ± 0.006	0.99 ± 1.3	1.4 ± 3.8	0.23 ± 0.22	0.23 ± 0.22	0.29 ± 2.3
2001	ND	0.31 ± 1.1	1.5 ± 4.0	0.22 ± 0.11	0.22 ± 0.11	0.10 ± 0.37
2002	ND	0.27 ± 0.66	1.4 ± 4.3	0.17 ± 0.10	0.17 ± 0.11	0.12 ± 0.72
2003	0.002 ± 0.013 ^(d)	0.084 ± 0.63	1.8 ± 0.63	0.16 ± 0.10	0.17 ± 0.10	0.09 ± 0.50

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ±2 times the standard deviation.
 (c) ND = Not detected.
 (d) Single value above detection limit.

Table 3.2.10. Concentrations of Selected Radionuclides (pCi/g^[a] dry wt.) in Surface Soil Samples Collected from the 200/600 Areas on the Hanford Site, 2003

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁸ U	^{239/240} Pu
Maximum ^(b)	0.002 ± 0.013 ^(c)	1.5 ± 0.30	14 ± 2.3	0.35 ± 0.10	0.41 ± 0.12	1.8 ± 0.47
Average ^(d)	0.002 ± 0.013 ^(c)	0.08 ± 0.63	1.8 ± 0.63	0.16 ± 0.10	0.17 ± 0.10	0.09 ± 0.50
Distant community ^(d,e)	NR ^(f)	0.052 ± 0.11	0.15 ± 0.32	NR	0.13 ± 0.11	0.0055 ± 0.012
Accessible soil concentration limits (WHC-SD-EN-TI-070) ^(g)	7.1	2,800	30	630	370	190

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) ± total analytical uncertainty.

(c) Single value above detection limit; ± total analytical uncertainty.

(d) ±2 times the standard deviation.

(e) PNNL-13910.

(f) NR = Not reported.

(g) Hanford soil that is not behind security fences.

Table 3.2.11. Average Radionuclide Concentrations (pCi/g^[a] dry wt.)^(b) Detected in Surface Soil Samples Collected from the 300/400 Areas on the Hanford Site, 1998 through 2003

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁸ U	^{239/240} Pu
1998	ND ^(c)	0.005 ± 0.026	0.09 ± 0.26	1.4 ± 5.3	1.4 ± 5.5	0.03 ± 0.14
1999	ND	0.85 ± 0.70	0.09 ± 0.10	0.70 ± 1.8	0.66 ± 1.8	0.03 ± 0.05
2000	ND	0.56 ± 0.40	0.09 ± 0.23	5.4 ± 24	5.4 ± 2.4	0.07 ± 0.21
2001	ND	ND	0.04 ± 0.08	0.94 ± 3.0	0.95 ± 3.1	0.03 ± 0.10
2002	ND	0.03 ± 0.03	0.07 ± 0.13	1.5 ± 6.4	1.5 ± 6.4	0.02 ± 0.10
2003	ND	0.06 ± 0.07	0.08 ± 0.14	1.3 ± 5.1	1.3 ± 5.2	0.08 ± 0.40

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) ±2 times the standard deviation.

(c) ND = Not detected.

Table 3.2.12. Concentrations of Selected Radionuclides (pCi/g^[a] dry wt.) in Surface Soil Samples Collected from the 300/400 Areas on the Hanford Site, 2003

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁸ U	^{239/240} Pu
Maximum ^(b)	ND ^(c)	0.06 ± 0.07 ^(d)	0.21 ± 0.034	8.5 ± 1.6	8.6 ± 1.6	0.73 ± 0.15
Average ^(c)	ND	0.06 ± 0.07 ^(d)	0.08 ± 0.14	1.3 ± 5.1	1.3 ± 5.2	0.08 ± 0.40
Distant community ^(c,f)	NR ^(g)	0.052 ± 0.11	0.15 ± 0.32	NR	0.13 ± 0.11	0.0055 ± 0.012
Accessible soil concentration limits (WHC-SD-EN-TI-070) ^(h)	7.1	2,800	30	630	370	190

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) ± total analytical uncertainty.

(c) ND = Not detected.

(d) Single value above detection limit; ± total analytical uncertainty.

(e) ±2 times the standard deviation.

(f) PNNL-13910.

(g) NR = Not reported.

(h) Hanford soil that is not behind security fences.

Table 3.2.13. Radionuclide Concentrations (pCi/g^(a) dry wt.)^(b) in Soil Samples Collected for the Environmental Restoration Contractor on the Hanford Site, 2003

Site	Sample Location ^(c)	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁸ U	^{239/240} Pu
ERDF ^(d)	D146	0.011 ± 0.008	ND ^(e)	0.023 ± 0.008	0.18 ± 0.06	0.20 ± 0.064	ND
100-B/C	D150	ND	ND	0.38 ± 0.061	0.13 ± 0.047	0.16 ± 0.054	ND
100-B/C	D153	ND	ND	0.26 ± 0.044	0.16 ± 0.054	0.16 ± 0.054	0.18 ± 0.061
100-F	D154	ND	ND	0.089 ± 0.022	0.12 ± 0.038	0.11 ± 0.036	ND
100-F	D155	ND	ND	0.25 ± 0.036	0.067 ± 0.028	0.092 ± 0.031	ND
100-B/C	D160	ND	0.34 ± 0.32	0.13 ± 0.027	0.17 ± 0.056	0.16 ± 0.054	ND
100-B/C	D161	ND	ND	0.17 ± 0.032	0.15 ± 0.053	0.14 ± 0.049	ND
100-KR-1	D162	ND	0.23 ± 0.26	0.13 ± 0.028	0.13 ± 0.047	0.14 ± 0.049	ND
100-KR-1	D163	ND	ND	0.21 ± 0.030	0.21 ± 0.069	0.20 ± 0.066	ND
100-B/C	D165	ND	0.34 ± 0.27	0.18 ± 0.030	0.13 ± 0.047	0.096 ± 0.037	ND
Distant communities ^(f,g)		NR ^(h)	0.066 ± 0.059	0.0022 ± 0.034	NR	ND	0.0008 ± 0.002
Accessible soil concentration ⁽ⁱ⁾		7.1	2,800	30	630	370	190

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) ± total analytical uncertainty.

(c) Sampling location code. See PNNL-14687, APP. 2.

(d) ERDF = Environmental Restoration Disposal Facility.

(e) ND = Not detected.

(f) ±2 times the standard error of the mean.

(g) See PNNL-13910.

(h) NR = Not reported.

(i) Hanford soil that is not behind security fences.

averages in Table 3.2.15. A complete list of radionuclide concentrations and sampling location maps are provided in PNNL-14687, APP. 2. In 2003, analytical results from vegetation samples collected from the 100-N Area were comparable to those observed in 2002. The radionuclide levels measured in 100-N Area vegetation in 2003 were greater than those measured at distant communities in 2001.

Vegetation samples from 48 sampling locations were collected in the 200/600 Areas during 2003. Concentrations of selected radionuclides reported for 1998 through 2003 are summarized in Table 3.2.16. Analytical results from vegetation samples taken in 2003 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 2003 maximum and average concentrations for selected radionuclides are compared to distant communities in Table 3.2.17. A complete list of radionuclide concentrations and sampling location maps are provided in PNNL-14687, APP. 2.

Thirteen vegetation samples were collected from the 300/400 Areas in 2003. Table 3.2.18 provides a summary of the 300/400 Areas results from vegetation samples collected from 1998 through 2003. 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 higher uranium levels were expected because uranium was released to the environment during past fuel fabrication operations in the 300 Area. In the 400 Area, the concentrations recorded for most radionuclides were higher than those measured at the distant communities.

The 2003 maximum, average, and distant community average concentrations for 300/400 Areas samples are listed in Table 3.2.19. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-14687, APP. 2.

3.2.5 External Radiation

External radiation fields were monitored near facilities and waste handling, storage, and disposal sites to measure



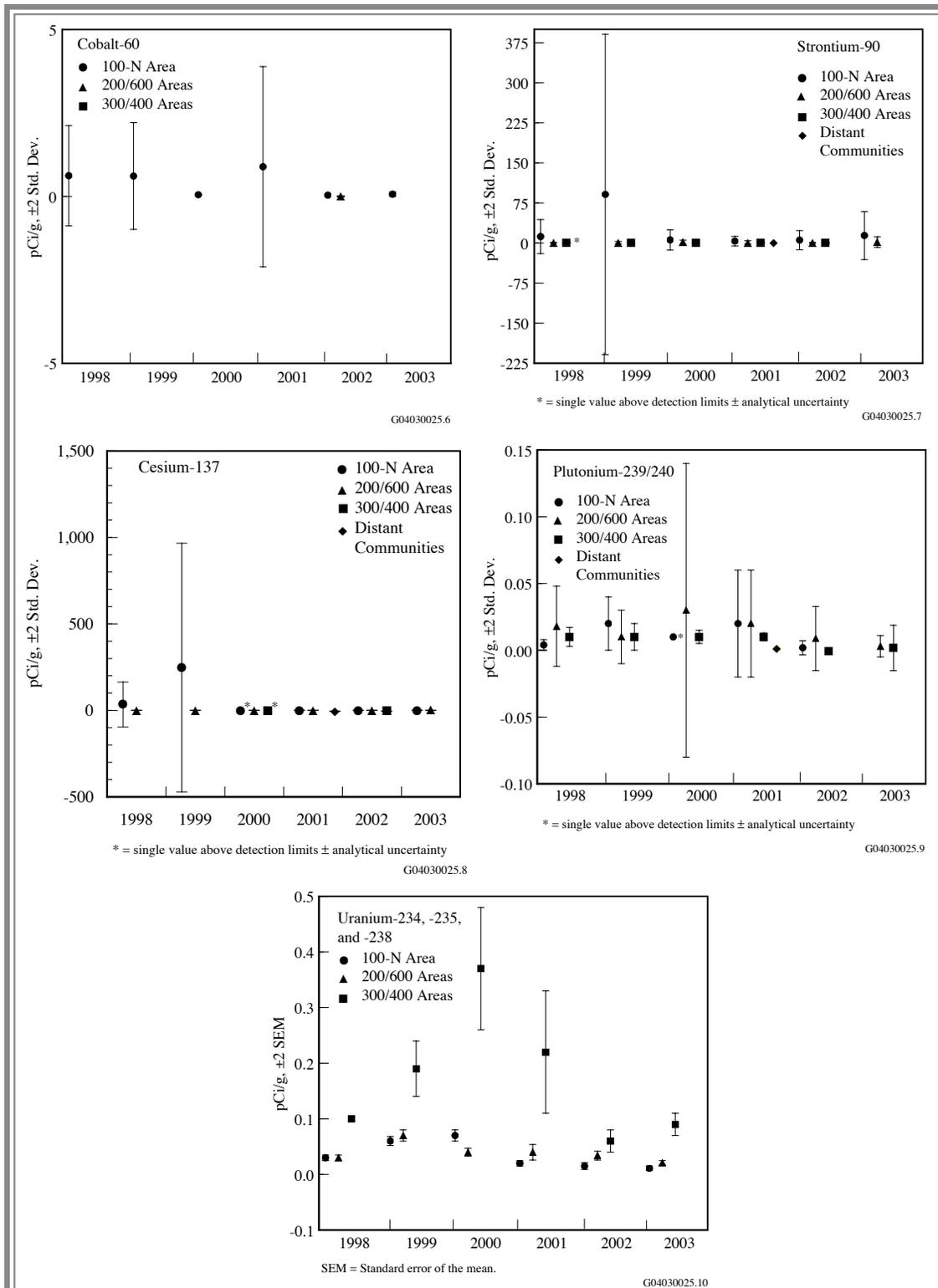


Figure 3.2.3. Average Concentrations of Selected Radionuclides in Near-Facility Vegetation Samples Collected on the Hanford Site Compared to Those Collected in Distant Communities (PNNL-13910), 1998 through 2003. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 3.2.14. Average Radionuclide Concentrations (pCi/g^(a) dry wt.)^(b) Detected in Vegetation Samples Collected from the 100-N Area on the Hanford Site, 1998 through 2003

<u>Year</u>	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>^{239/240}Pu</u>
1998	0.62 ± 1.3	12 ± 32	38 ± 94	0.002 ± 0.004
1999	0.61 ± 1.4	91 ± 300	250 ± 670	0.01 ± 0.02
2000	0.05 ± 0.09	5.7 ± 16	0.2 ^(d) ± 0.2	0.0004 ± 0.04
2001	0.89 ± 2.3	3.5 ± 8.4	0.38 ± 0.44	0.024 ± 0.03
2002	0.004 ± 0.037	5.4 ± 18.0	0.002 ± 0.008	0.002 ± 0.005
2003	0.066 ± 0.068	14 ± 45	0.15 ± 0.15	ND ^(c)

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ±2 times the standard error of the mean.
 (c) ND = Not detected.

Table 3.2.15. Concentrations of Selected Radionuclides (pCi/g^(a) dry wt.) in Vegetation Samples Collected from the 100-N Area on the Hanford Site, 2003

	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>²³⁴U</u>	<u>²³⁸U</u>	<u>^{239/240}Pu</u>
Maximum ^(b)	0.066 ± 0.068	53 ± 7.9	0.15 ± 0.15	0.0083 ± 0.0056	0.0059 ± 0.0047	ND ^(c)
Average ^(d)	0.066 ± 0.068 ^(b,e)	14 ± 45	0.15 ± 0.15	0.0068 ± 0.0021	0.0046 ± 0.029	ND
Distant communities ^(d,f)	NR ^(g)	0.066 ± 0.059	0.0022 ± 0.034	NR	ND	0.00078 ± 0.0016

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ± total analytical uncertainty.
 (c) ND = Not detected.
 (d) ±2 times the standard deviation.
 (e) Single value above detection limit.
 (f) PNNL-13910.
 (g) NR = Not reported.

Table 3.2.16. Average Radionuclide Concentrations (pCi/g^(a) dry wt.)^(b) Detected in Vegetation Samples Collected from the 200/600 Areas on the Hanford Site, 1998 through 2003

<u>Year</u>	<u>⁶⁰Co</u>	<u>⁹⁰Sr</u>	<u>¹³⁷Cs</u>	<u>²³⁴U</u>	<u>²³⁸U</u>	<u>^{239/240}Pu</u>
1998	ND ^(c)	0.14 ± 0.50	0.051 ± 0.18	0.016 ± 0.002	0.010 ± 0.009	0.007 ± 0.024
1999	ND	0.79 ± 2.3	0.13 ± 0.18	0.033 ± 0.004	0.023 ± 0.003	0.009 ± 0.017
2000	ND	1.30 ± 3.3	0.16 ± 0.21	0.020 ± 0.02	0.014 ± 0.002	0.033 ± 0.06
2001	ND	1.00 ± 2.3	0.17 ± 0.24	0.019 ± 0.002	0.018 ± 0.018	0.021 ± 0.03
2002	0.0003 ± 0.0018	0.32 ± 1.10	0.089 ± 0.42	0.016 ± 0.016	0.014 ± 0.015	0.009 ± 0.024
2003	ND	1.5 ± 10	0.27 ± 2.0	0.01 ± 0.01	0.008 ± 0.009	0.003 ± 0.008

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ±2 times the standard deviation.
 (c) ND = Not detected.

Table 3.2.17. Concentrations of Selected Radionuclides (pCi/g^(a) dry wt.) in Vegetation Samples Collected from the 200/600 Areas on the Hanford Site, 2003

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁸ U	^{239/240} Pu
Maximum ^(b)	ND ^(c)	25 ± 3.8	6.0 ± 4.3	0.022 ± 0.010	0.022 ± 0.010	0.023 ± 0.011
Average ^(d)	ND	1.5 ± 10	0.27 ± 2.0	0.01 ± 0.01	0.008 ± 0.009	0.003 ± 0.008
Distant communities ^(d,e)	NR ^(f)	0.066 ± 0.059	0.0022 ± 0.034	NR	ND	0.00078 ± 0.0016

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ± total analytical uncertainty.
 (c) ND = Not detected.
 (d) ±2 times the standard deviation.
 (e) PNNL-13910.
 (f) NR = Not reported.

Table 3.2.18. Average Radionuclide Concentrations (pCi/g^(a) dry wt.)^(b) Detected in Vegetation Samples Collected from the 300/400 Areas on the Hanford Site, 1998 through 2003

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁸ U	^{239/240} Pu
1998	ND ^(c)	0.17 ± 0.09	ND	0.046 ± 0.12	0.044 ± 0.12	0.003 ± 0.011
1999	ND	0.45 ± 0.25	ND	0.094 ± 0.20	0.890 ± 0.19	0.005 ± 0.008
2000	ND	0.21 ± 0.15	ND	0.018 ± 0.72	0.017 ± 0.73	0.004 ± 0.008
2001	ND	0.26 ± 0.39	ND	0.098 ± 0.33	0.110 ± 0.33	0.003 ± 0.004
2002	ND	0.21 ± 0.47	0.011 ± 0.079	0.032 ± 0.055	0.029 ± 0.33	-0.0004 ± 0.0007 ^(d)
2003	ND	ND	ND	0.043 ± 0.11	0.036 ± 0.19	0.0017 ± 0.017 ^(e)

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ±2 times the standard deviation.
 (c) ND = Not detected.
 (d) Negative value indicates a result at or below background levels of radioactivity.
 (e) Single value above detection limit; ± total analytical uncertainty.

Table 3.2.19. Concentrations of Selected Radionuclides (pCi/g^(a) dry wt.) in Vegetation Samples Collected from the 300/400 Areas on the Hanford Site, 2003

	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁴ U	²³⁸ U	^{239/240} Pu
Maximum ^(b)	ND ^(c)	ND	ND	0.22 ± 0.05	0.19 ± 0.04	0.0017 ± 0.017 ^(d)
Average ^(e)	ND	ND	ND	0.043 ± 0.011	0.036 ± 0.19	0.0017 ± 0.017 ^(d)
Distant communities ^(e,f)	NR ^(g)	0.066 ± 0.059	0.0022 ± 0.034	NR	ND	0.00078 ± 0.0016

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
 (b) ± total analytical uncertainty.
 (c) ND = Not detected.
 (d) Single value above detection limit; ± total analytical uncertainty.
 (e) ±2 times the standard deviation.
 (f) PNNL-13910.
 (g) NR = Not reported.

and assess the impact of operations. Thermoluminescent dosimeters were used at numerous fixed locations to gather dose rate information over long periods of time. Thermoluminescent dosimeter results were used individually or averaged to determine dose rates in a given area for a particular sampling period. A summary of the 2002 and 2003 thermoluminescent dosimeter results for waste handling facilities on the Hanford Site, as well as historical comparative results from offsite locations can be found in Table 3.2.20. Individual thermoluminescent dosimeter results and locations are provided in PNNL-14687, APP. 2. Specific information regarding external radiation sampling methods and locations can be found in DTS-OEM-001. Additional dose rate information for Hanford Site 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 past nuclear

weapons testing, as well as any contribution from Hanford Site activities. These outside radiation sources are not constant and may cause an estimated 20% deviation in thermoluminescent dosimeter results.

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 waste disposal sites, and remedial action projects. The dosimeters were exchanged and analyzed each calendar quarter. The Radiological Calibration Facility in the 318 Building (300 Area) calibrated the response of the dosimeters; results were reported in terms of external dose.

During 2003, there were 134 near-facility thermoluminescent dosimeter locations collecting external radiation

Table 3.2.20. Near-Facility Thermoluminescent Dosimeter Results (mrem/yr)^(a) at the Hanford Site for 2002 and 2003 and Comparative Offsite Location Results for 1998 through 2003

Hanford Site Locations	No. of Locations, 2003	2002		2003		% Change ^(c)
		Maximum ^(b)	Mean ^(b)	Maximum ^(b)	Mean ^(b)	
100-B/C	4	93 ± 10	87 ± 9	88 ± 6	85 ± 5	-2
100-F	5	93 ± 7	86 ± 9	80 ± 22	76 ± 4	-12
100-K	11	439 ± 120	129 ± 210	523 ± 1,060	162 ± 304	26
100-KR-1	5	106 ± 2	96 ± 20	103 ± 11	95 ± 15	-1
100-N	14	1,042 ± 178	274 ± 543	993 ± 71	261 ± 485	-5
200-East	42	289 ± 82	113 ± 97	482 ± 225	118 ± 138	4
200-West	24	215 ± 36	108 ± 64	189 ± 21	106 ± 52	-2
200-North	1	3,400 ± 89	3,200 ± 400	3,400 ± 131	3,000 ± 570	-6
300	8	129 ± 49	99 ± 39	112 ± 2	92 ± 24	-7
300 TEDF ^(d)	6	88 ± 3	85 ± 4	90 ± 12	85 ± 5	0
400	7	86 ± 3	82 ± 5	85 ± 7	81 ± 5	-1
CVDF ^(e)	4	83 ± 7	79 ± 5	82 ± 4	80 ± 6	1
ERDF ^(f)	3	95 ± 5	90 ± 10	99 ± 11	94 ± 11	4
Offsite Locations ^(g)	No. of Locations, 2003	2003		1998-2002		
		Maximum ^(b)	Mean ^(h)	Maximum ^(b)	Mean ^(h)	
Perimeter	11	96 ± 3	90 ± 3	106 ± 8	90 ± 2	
Community	7	88 ± 5	79 ± 3	90 ± 9	79 ± 2	
Distant	2	72 ± 6	72 ± 1	75 ± 8	71 ± 1	

(a) To convert to international metric system units, multiply mrem/yr by 0.01 to obtain mSv/yr.

(b) ±2 times the standard deviation.

(c) Numbers indicate a decrease (-) or increase from the 2002 mean.

(d) TEDF = 300 Area Treated Effluent Disposal Facility.

(e) CVDF = Cold Vacuum Drying Facility.

(f) ERDF = Environmental Restoration Disposal Facility.

(g) Section 4.6.

(h) ±2 times the standard error of the mean.

information. At three of the operational areas, the dosimeter results showed a decrease of 6% or more in external radiation from 2002 levels. In the 100-K Area, there was a 26% increase in the annual average dose rate in 2003, which was attributable to the transfer and storage of radioactive materials associated with cleanup activities in the K Basins. At the remaining operational areas, changes in the external radiation levels from 2002 to 2003 were 5% or less.

At the former 116-B-11 and 116-C-1 liquid waste disposal facilities (located in the 100-B/C Area), four thermoluminescent dosimeter sites monitored dose rates in 2003. Dose rates measured at these locations were comparable to those measured in 2002.

In the 100-F Area, five thermoluminescent dosimeter monitoring sites were used from January through April 2003, coinciding with the conclusion of remedial action activities in that area. Dose rates measured during the 4-month period were approximately 4% lower than 2002 levels.

Cleanup activities at the 100-K Area Basins and adjacent retired reactor buildings continued in 2003 and dose rates were monitored at 11 locations. Overall average dose rates measured in 2003 increased by approximately 26% relative to 2002 values. This increase was primarily due to temporary, elevated dose rates at two monitoring locations situated near radioactive materials transfer and storage areas; one location was near the 105-K East load-out station and the other was near the 105-K West basin. Dose rates at both locations decreased by year's end to typical site background levels.

Four thermoluminescent dosimeter monitoring sites around the 100-K Area's Cold Vacuum Drying Facility also showed a slight annual dose rate increase of 1% in 2003.

Five thermoluminescent dosimeters, installed during the fourth quarter of 2002 to monitor activities at the 100-KR-1 (100-K Area) remedial action site, showed dose rate levels in 2003 to be at typical site background levels.

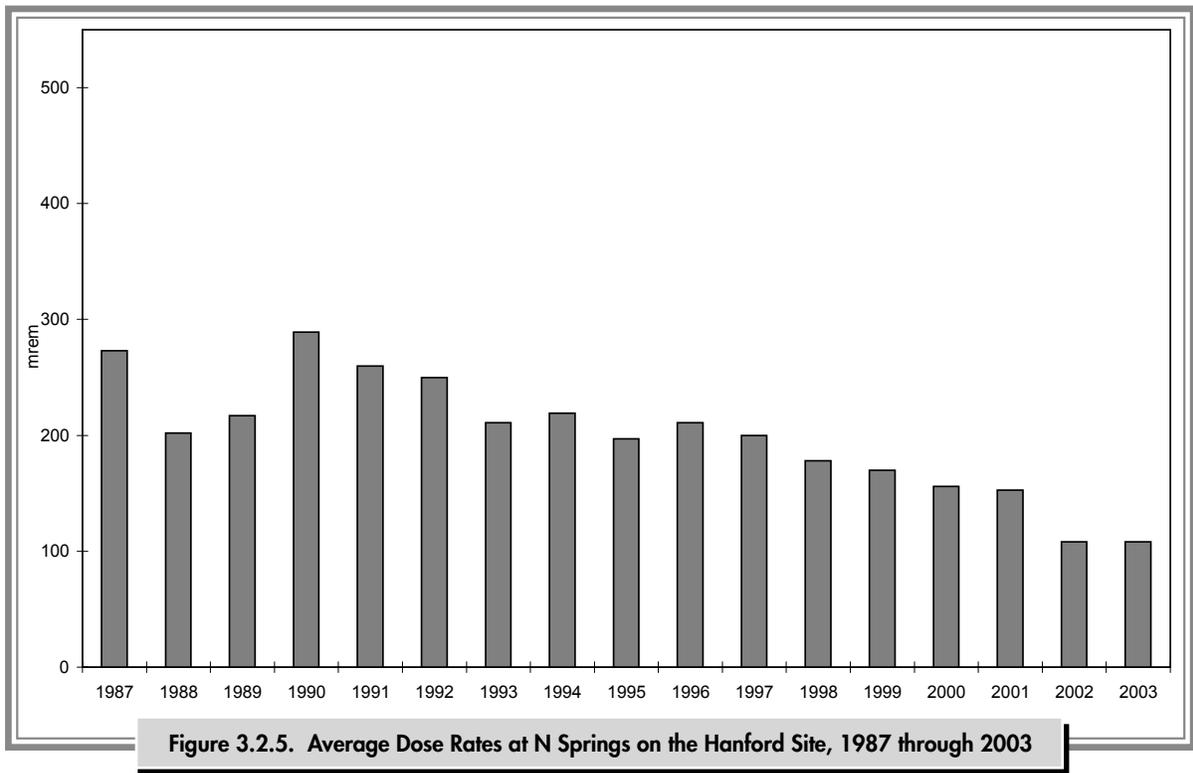
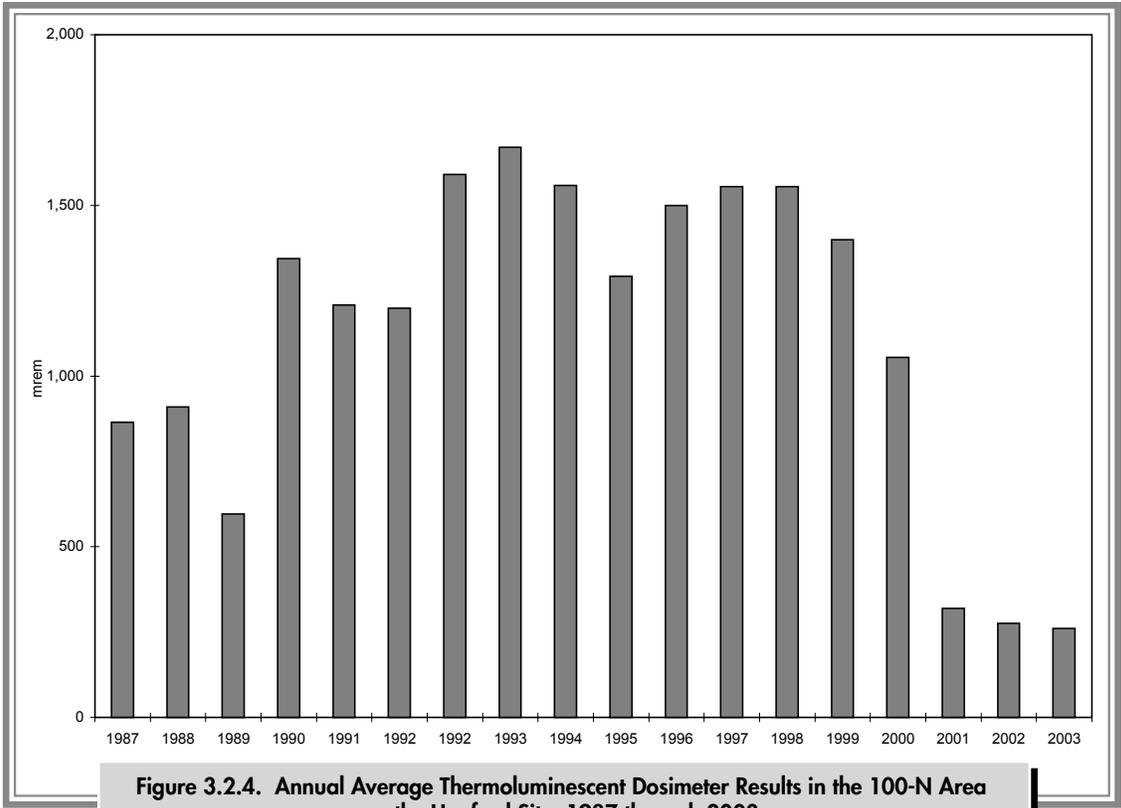
The 2003 results for the 100-N Area again indicated direct radiation levels to be highest near facilities that contained or received liquid effluent from N Reactor. These facilities primarily included the retired 116-N-1 (1301-N) and 116-N-3 (1325-N) liquid waste disposal facilities. The

levels at these two facilities were noticeably higher than those for other 100-N Area thermoluminescent dosimeter locations. Three of the five monitoring locations near the 116-N-1 trench showed an increase of approximately 17% in annual average dose rate levels compared to those measured at the same locations in 2002. This increase may be ascribed to the removal of low-level, radioactively contaminated material from selected portions of the 116-N-1 trench soil column. Removal of this layer of natural shielding from atop the residual, slightly higher level radioactively contaminated subsurface materials may have led to the moderate increases observed in dose rates in the immediate vicinity of the excavation work. Remedial action activities will resume in mid-2004 to remove additional contamination with a scheduled completion date of fiscal year 2005. The 2003 annual average dose rate levels at the three monitoring locations at the 116-N-3 facility showed a decrease of approximately 12% from 2002 levels. This reduction in dose rates was directly attributable to the removal of source material from the facilities by the environmental restoration contractor. Overall, the average dose rate measured in the 100-N Area in 2003 was approximately 5% lower than that measured in 2002. Annual average thermoluminescent dosimeter results for the entire 100-N Area from 1987 through 2003 are presented in Figure 3.2.4.

Dose rates were measured at the 100-N Area shoreline springs to determine potential external radiation doses to the public as well as to onsite workers. Cleanup activities at these former liquid waste disposal facilities located near the Columbia River have reduced the "skyshine" effect (i.e., radiation reflected by the atmosphere back to the earth's surface) at the springs and the dose rates there have decreased notably over the past few years. The 2003 levels were unchanged from the 2002 levels (see Figure 3.2.5 for annual averages since 1987).

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 in 2003 was in the 200-East Area at the A Tank Farm. The average annual dose rate measured in 2003 in the 200 Areas was slightly higher than the 2002 average level. The annual average thermoluminescent dosimeter results in the 200 Areas from 1987 through 2003 are presented in Figure 3.2.6.





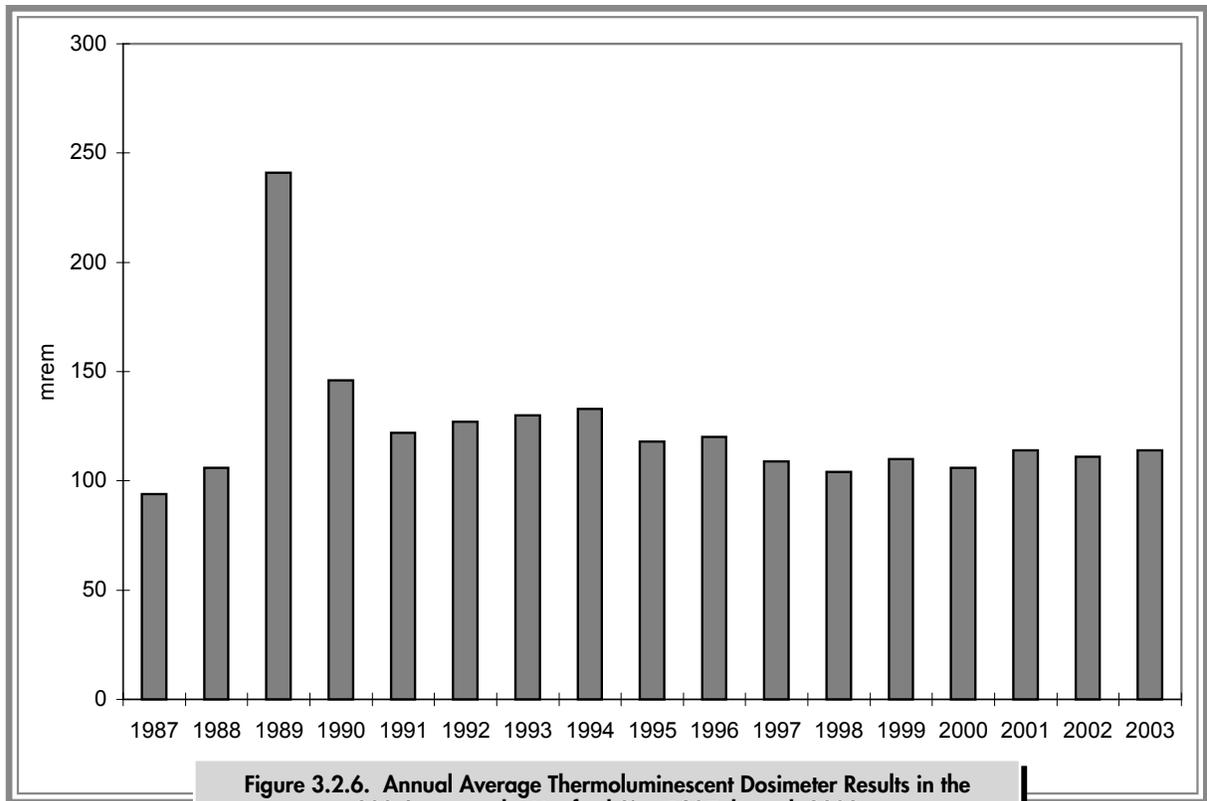


Figure 3.2.6. Annual Average Thermoluminescent Dosimeter Results in the 200 Areas on the Hanford Site, 1987 through 2003

Average dose rates measured in 2003 at the Environmental Restoration Disposal Facility were similar to 2002 levels, with only a slight increase of approximately 4%.

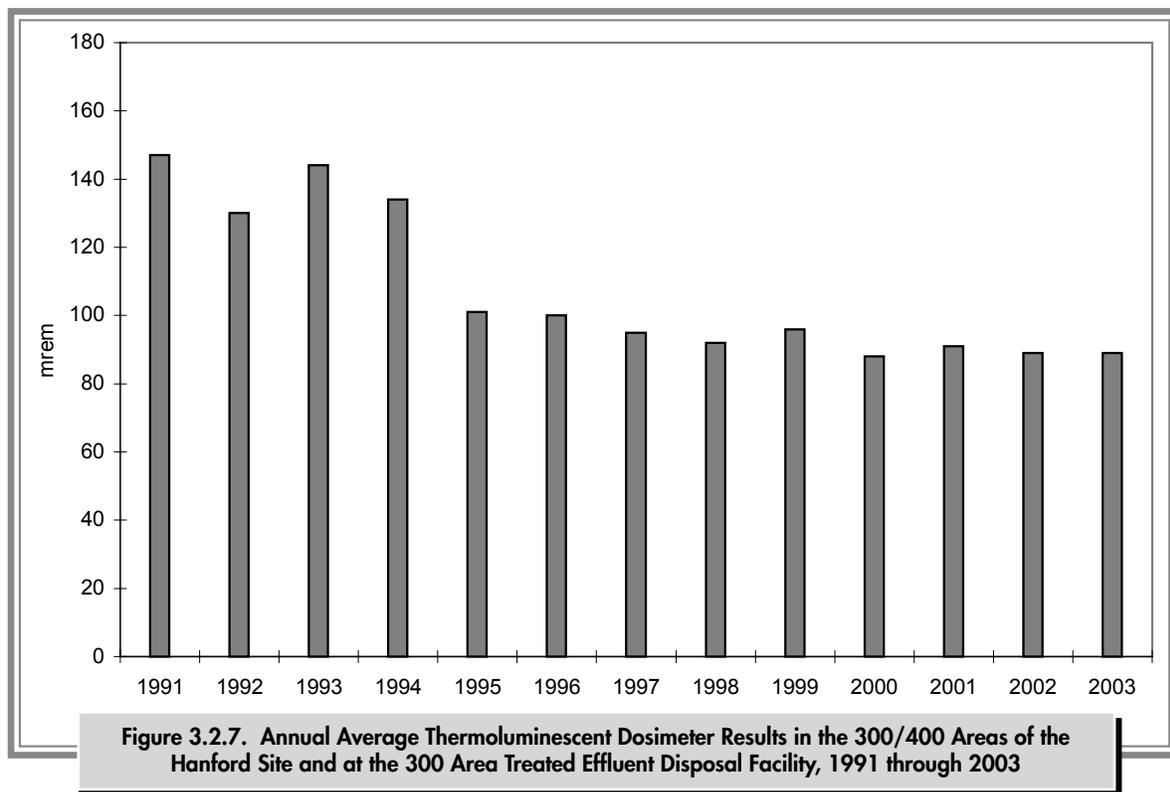
The average dose rates in the 300 Area in 2003 were approximately 7% lower than the 2002 levels, while those observed at the 300 Area Treated Effluent Disposal Facility and in the 400 Area were virtually unchanged from the dose rates measured in 2002. The annual average thermoluminescent dosimeter results for the 300 and 400 Areas from 1991 through 2003 are presented in Figure 3.2.7.

One thermoluminescent dosimeter monitoring site is located in the unoccupied 200-North Area at the (contaminated) 212-R Railroad Car Disposition Area. This thermoluminescent dosimeter location was established in 2000 to monitor expected high radiation levels emitted from contaminated railroad cars staged in the immediate vicinity. The annual average dose rate at the 212-R Railroad Car Disposition Area in 2003 (approximately 3,000 mrem/yr) showed a decrease of 6% compared to 2002.

3.2.6 Investigative Sampling

Investigative sampling was conducted in the operational 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 pre-operational 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 detected during these efforts were strontium-90, cesium-137, and plutonium-239/240 in the 100 and 200 Areas and uranium-234, uranium-235, and uranium-238 in the 300 Area.

Investigative samples collected in 2003 included soil, vegetation, and animals. Methods for collecting investigative samples are described in DTS-OEM-001. Field monitoring was conducted to detect beta/gamma and alpha radiation from samples before they were submitted for analysis. Field monitoring results are expressed as disintegrations per minute per 100 square centimeters. Beta/gamma radiation field surveys were conducted with a Geiger-Mueller detector, while alpha radiation field surveys were performed with a portable alpha meter.

In 2003, investigative samples were analyzed for radionuclides at the 222-S laboratory in the 200-West Area. Refer to Table 3.2.21 for a summary of historical investigative sample collections. Typically, there are numerous contaminated investigative environmental samples that are field screened and disposed of without isotopic analyses each year. In 2003, there were 89 of these. Laboratory analyses results and field readings are provided in PNNL-14687, APP. 2, Chapter 7.

Table 3.2.21. Investigative Samples Collected on the Hanford Site, 1994 through 2003^(a)

Year	Sample Type		
	Soil	Vegetation	Wildlife ^(b)
1994	94	39	27
1995	73	39	25
1996	37	21	41
1997	51	46	30
1998	41	51	55
1999	42	85	16
2000	25	66	12
2001	20	31	10
2002	22	16	10
2003	30	32	26

(a) Annual number of samples collected.

(b) May include wildlife-related materials (e.g., feces, nests)

During 2003, there were 30 instances of radiological contamination in investigative soil samples. Of the 30, 19 were identified as speck or soil speck contamination. One of the investigative soil samples was submitted for radioisotopic analysis. Twenty-two of the 30 locations were cleaned up, and the contaminated soil was disposed of

in low-level burial grounds. At the remaining sites, the contamination levels did not exceed limitations of the posting and the soil was left in place.

The number of investigative soil contamination incidents, range of radiation dose levels, and radionuclide concentrations in 2003 were generally within historical values (WHC-MR-0418). Areas of special soil sampling that were found outside radiological control areas and that had dose rate levels greater than radiological control limits were cleaned up or posted as surface contamination areas.

In February 2003, contaminated soil was found to the west of the TX-TY Tank Farm (200-West Area) in an old construction debris site. Contaminants included strontium-89/90 and cesium-137.

During 2003, there were 32 instances of radiological contamination in investigative vegetation samples. Identified were tumbleweeds (Russian thistle [*Salsola kali* var. *tenuifolia*]), tumbleweed fragments, and gray rabbitbrush (*Chrysothamnus nauseosus*). None were analyzed for radionuclide activity. One sample, collected outside the BX-BY Tank Farm in the 200-East Area, exhibited elevated field readings. Investigative vegetation samples not sent to the laboratory for analysis were disposed of in low-level burial grounds.

Tumbleweed and gray rabbitbrush are deep-rooted species and become radiologically contaminated by the uptake of belowground contaminants through their root systems. Herbicide application is intended to halt vegetation growth before this uptake occurs. In 2003, application techniques were enhanced, and administrative procedures were implemented to improve vegetation management. The overall reduction in the number of contamination incidents since 1999 reflects these improvements. Nevertheless, contaminated vegetation continued to be identified by radiological surveys.

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 access 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. The number of contaminated animals discovered during 2003, and their levels and ranges of radioactivity were within historical levels (WHC-MR-0418).

In 2003, 26 contaminated wildlife and wildlife-related incidents were investigated and from these, 6 wildlife specimens were surgically transitioned into 9 samples that were submitted for laboratory analysis. The analytical results and field readings obtained from each sample can be found in PNNL-14687, APP. 2, Tables 7-1 and 7-2, respectively. The number of samples submitted for analysis depended on opportunity (i.e., resulting from the pest control activities), the technical merits of having isotopic analyses result locations, and the costs involved, rather than prescheduled sampling at established sampling points.

In November 2002, two contaminated mice were found along the perimeter of the BX-BY Tank Farm in the 200-East Area. Contaminants included strontium-89/90 and cesium-137. The results are being reported in 2003 because analyses were not completed in time to be included in the 2002 report.

In June 2003, a contaminated mouse was found in the 105-KE radiological monitoring office in the 100-KE Area. Contaminants included strontium-89/90 and cesium-137.

In June 2003, a contaminated starling carcass was found in the 317 Building stairwell. Contaminants included cobalt-60, strontium-89/90, and cesium-134/137.

In August 2003, a contaminated house mouse was found at the 105-KE reactor building. Contaminants included strontium-89/90 and cesium-137.

In August 2003, a contaminated cottontail rabbit was found outside the 272-S paint shop (200-West Area) east of the S-SX-SY Tank Farm complex. Samples of skin, bone, gastrointestinal tract, and muscle were analyzed.



Contaminants included strontium-89/90 and cesium-137 with the highest result of cesium-137 found in the muscle tissue.

Listed below are special characterization projects conducted or completed during 2003 to ascertain the radiological status, and in some cases, physical condition of specific sites or operations:

- A preoperational monitoring plan (RPP-6877) was developed in support of the Waste Vitrification initiative. As part of this plan, an ongoing environmental survey is being conducted on the proposed location for the Integrated Disposal Facility, formerly the

Immobilized Low-Activity Waste Disposal Facility, in the 200-East Area. Tasks completed in 2003 included bulk soil sampling for geophysical properties. Following the completion of all the tasks outlined in the monitoring plan, the data collected will be published in a final report. The report is currently scheduled for publication in 2005.

- Soil, vegetation, and ground-dwelling invertebrate samples were collected at the location of the former Gable Mountain Pond and B Pond in October 2003 to identify potential exposure pathways to biota and to support remedial action decisions (Lane et al. 2003).

