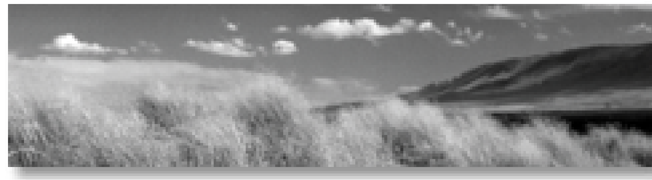

4.6 External Radiation Surveillance

E. J. Antonio

External radiation is defined as radiation originating from a source external to the body. External radiation fields consist of a natural component and a manmade component. The natural component can be divided into (1) cosmic radiation; (2) primordial radionuclides, primarily potassium-40, thorium-232, and uranium-238; and to a lesser extent (3) radiation from an airborne component, primarily radon and its progeny. The manmade component consists of radionuclides generated for or from nuclear medicine, electric power, research, waste management, and consumer products containing nuclear materials, e.g., smoke detectors. Environmental radiation fields also may be influenced by the presence of radionuclides deposited as worldwide fallout from historical atmospheric testing of nuclear weapons or those produced and released to the environment at the Hanford Site during the production of defense materials. During any year, external radiation levels can vary from 15% to 25% at any location because of changes in soil moisture and snow cover (National Council on Radiation Protection and Measurements 1975).

During 2003, environmental external radiation exposure was measured at 33 locations on the Hanford Site (Figure 4.6.1), 11 locations around the perimeter of the site, 9 locations in surrounding communities including 2 at distant locations (Figure 4.6.2), and 27 locations along the Columbia River shoreline (Figure 4.6.3) using thermoluminescent dosimeters and pressurized ionization chambers. A pressurized ionization chamber is a stainless steel spherical 8-liter (2.1-gallon) chamber, about the size of a basketball, that is filled to a pressure of 25 atmospheres with ultra-high purity argon gas. Radiation penetrating the chamber wall is captured and converted by instruments to an electric current that can be related directly to an exposure rate. The dosimeter exposure was converted to dose rates by the process described in Appendix E, then the dose rates were divided by the length of time the dosimeter was in the field. Annual results for 2003 were compared to results obtained during the previous 5 years. External radiation and surface contamination surveys at specified locations were performed with portable radiation survey instruments.

4.6.1 External Radiation Measurements

The Harshaw 8800-series environmental dosimeter consists of two TLD-700 (LiF) chips and two TLD-200 (CaF_2:Dy) chips and provides both shallow and deep dose measurement capabilities by use of filters within the dosimeter. The two TLD-700 chips were used to determine the average total environmental dose at each location. The average daily dose rate was determined by dividing the average total environmental dose by the number of days the dosimeter was exposed. Daily dose equivalent rates (millirem per day) at each location were converted to annual dose equivalent rates (millirem per year) by averaging the daily dose rates and multiplying by 365 days per year. The two TLD-200 chips were included only to determine doses in the event of a radiological emergency and were not used during 2003. Thermoluminescent dosimeters were positioned approximately 1 meter (3.3 feet) above the ground and were collected and read quarterly.

To determine the maximum dose rate for each distance classification, the annual average dose rates, calculated for each location as described above, were compared and the highest value was reported. The uncertainties associated with the maximum dose rates were calculated as two standard deviations of the quarterly dose rates then converted to annual rates.

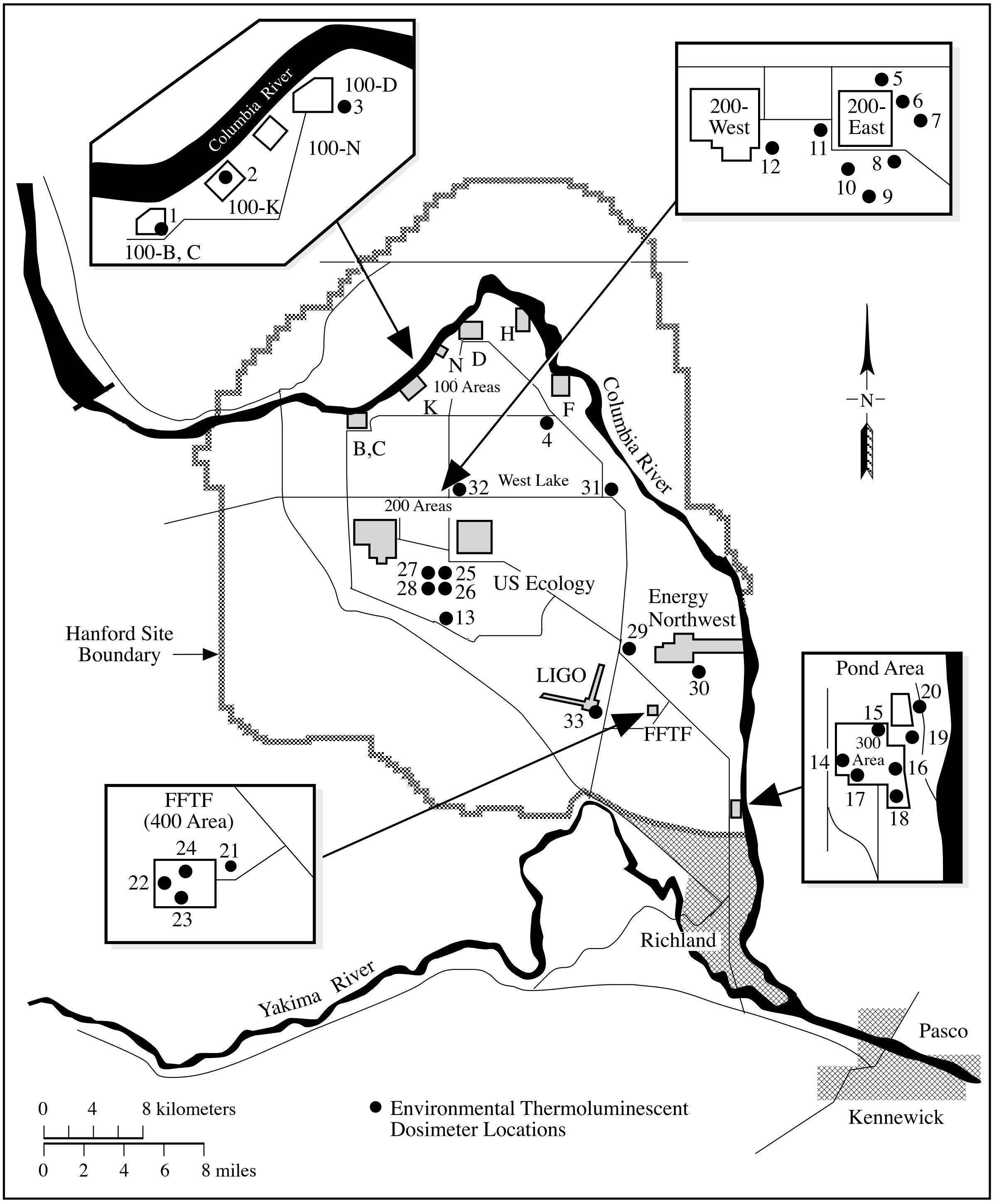

Figure 4.6.1. Surface Environmental Surveillance Project Thermoluminescent Dosimeter Locations (and Station Numbers) on the Hanford Site, 2003 (see Appendix C, Table C.10 for station names)

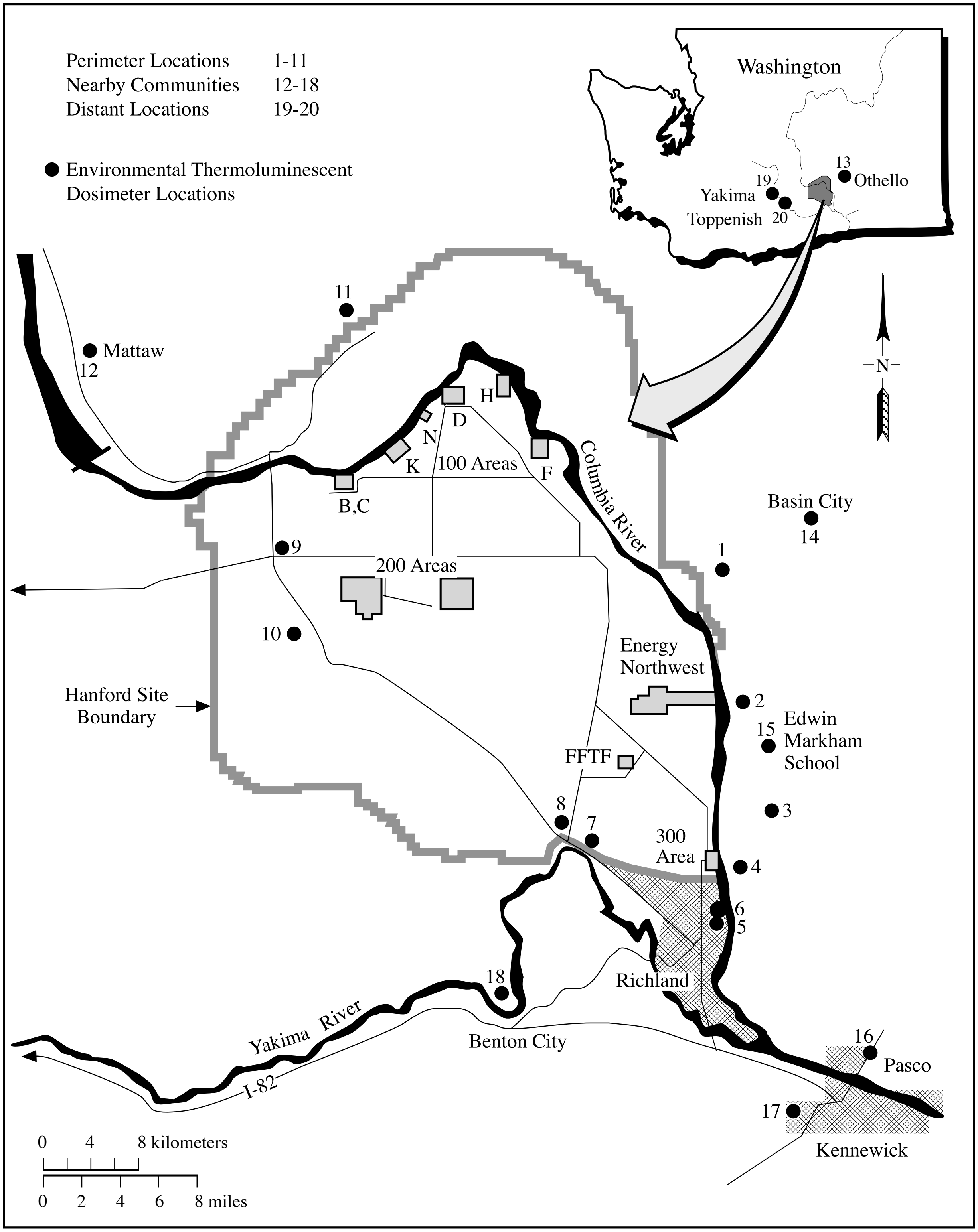

Figure 4.6.2. Community, Distant, and Perimeter Thermoluminescent Dosimeter Locations (and Station Numbers) Around the Hanford Site, 2003 (see Appendix C, Table C.10 for station names)

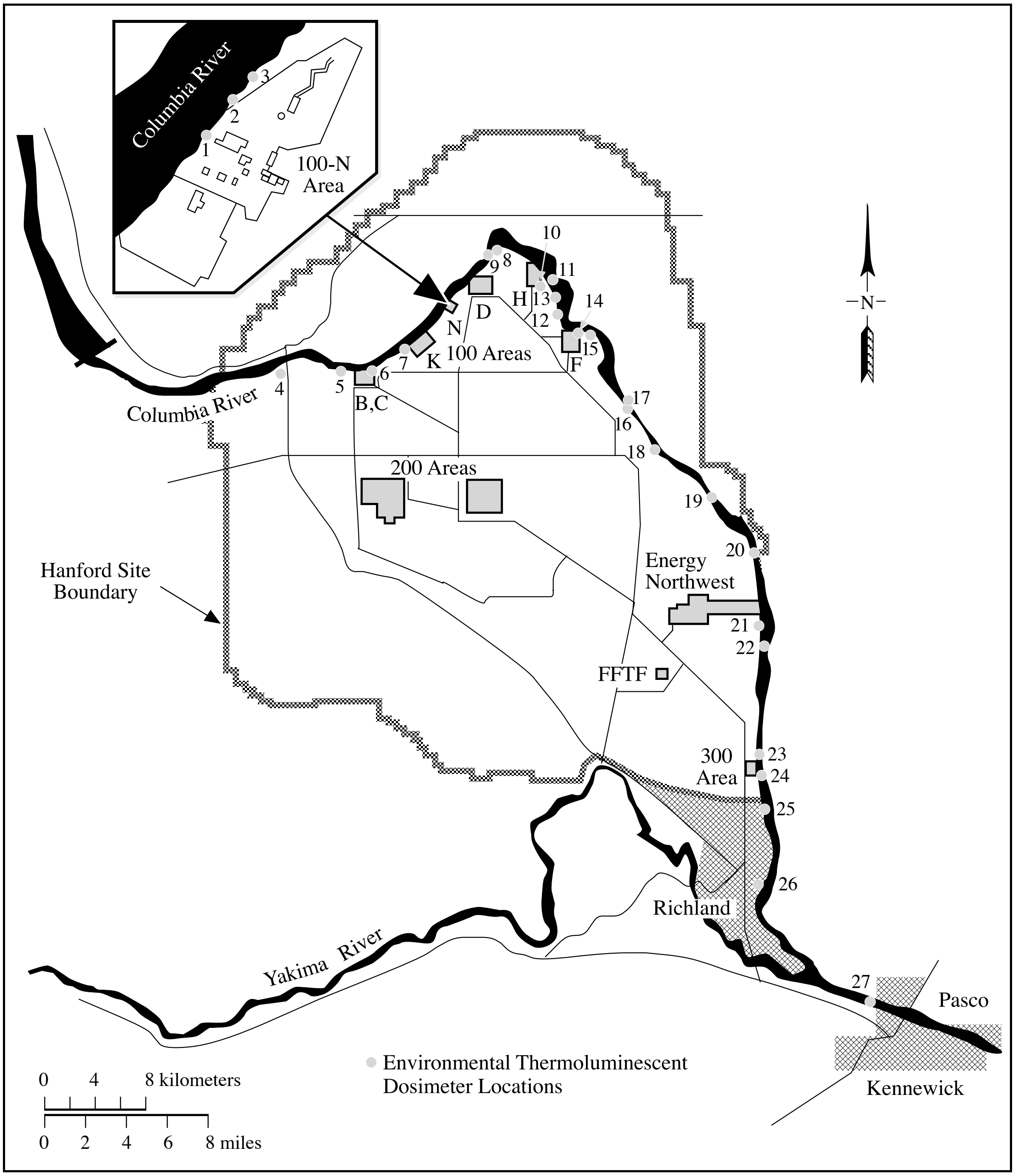

Figure 4.6.3. Hanford Site Surface Environmental Surveillance Project Thermoluminescent Dosimeter Locations (and Station Numbers) Along the Columbia River, 2003 (see Appendix C, Table C.10 for station names)

All community and most of the onsite and perimeter thermoluminescent dosimeter locations were collocated with air-monitoring stations. The onsite and perimeter locations were selected based on determinations of the high potential for public exposure (i.e., access areas, downwind population centers) from past and current Hanford Site operations. The two background stations in Yakima and Toppenish were chosen because they are generally upwind and distant from the site.

The shoreline of the Columbia River in the Hanford Reach was monitored by a series of 27 thermoluminescent dosimeters located along the Columbia River from the Vernita Bridge to downstream of Bateman Island at the mouth of the Yakima River. Ground contamination surveys also were conducted quarterly at 13 shoreline locations. These measurements were made to estimate radiation exposure levels attributed to sources on the Hanford Site, to estimate background levels along the shoreline, and to help assess exposures to onsite personnel and offsite populations. Ground contamination surveys were conducted using Geiger-Mueller meters (Geiger, or GM counters) and Bicron® Microrem meters. Readings were in counts per minute and microrem per hour, respectively. Geiger counter measurements were made within 2.54 centimeters (1 inch) of the ground and covered a 1-square-meter (10-square-foot) area. The Bicron® measurements were taken 1 meter (3.3 feet) above the ground surface and at least 10 meters (33 feet) away from devices or structures which may have contributed to the ambient radiation levels.

Pressurized ionization chambers were situated at four community-operated monitoring stations (Section 4.6.3). These instruments provided a way to measure ambient exposure rates near and downwind of the site and at locations distant and upwind of the site. Continuous exposure-rate data are displayed at each station to provide information to the public and to serve as an educational tool for the teachers who manage the stations.

External Radiation Results

Thermoluminescent dosimeter readings were converted to annual dose equivalent rates by the process described previously. External dose rates reported in Tables 4.6.1 through 4.6.3 include the maximum annual dose rate (±2 standard deviations) and the average dose rate (±2 standard error of the mean) for all locations within a surveillance zone. Locations were classified (or grouped) based on their location on or their proximity to the Hanford Site.

Onsite External Radiation Results. The average dose rates in all operational areas (Table 4.6.1) were higher than average dose rates measured at distant locations (Table 4.6.2). The highest annual average dose rate measured by Pacific Northwest National Laboratory dosimeters

Table 4.6.1. Dose Rates (mrem/yr[a]) Measured by Thermoluminescent Dosimeters on the Hanford Site, 2003 Compared to Previous 5 Years

		2003		1998-2002		
Location	Map Location[b]	Maximum[c]	Mean[d]	No. of Samples	Maximum[c]	Mean[d]
100 Areas	1 - 4	87 ± 7	81 ± 6	15	88 ± 8	82 ± 3
200 Areas	5 - 13	95 ± 4	87 ± 3	43	98 ± 6	88 ± 1
300 Area	14 - 20	96 ± 8	85 ± 4	31	107 ± 6	84 ± 2
400 Area	21 - 24	86 ± 6	83 ± 2	20	89 ± 7	83 ± 1
600 Area	25 - 33	96 ± 5	86 ± 3	37	128 ± 19	89 ± 3
Combined onsite	1 - 33	96 ± 8	87 ± 3	146	128 ± 19	86 ± 1

(a) Multiply by 10 to convert to µSv/yr.
(b) All station locations are shown on Figure 4.6.2 and are described in Appendix C, Table C.10.
(c) Maximum annual average dose rate for all locations within a given distance classification (±2 standard deviations).
(d) Means computed by averaging annual means for each location within a given distance classification (±2 standard error of the mean).

Table 4.6.2. Dose Rates (mrem/yr[a]) Measured by Thermoluminescent Dosimeters at Perimeter and Offsite Locations Around the Hanford Site, 2003 Compared to Previous 5 Years

		2003		1998-2002		
Location	Map Location[b]	Maximum[c]	Mean[d]	No. of Samples	Maximum[c]	Mean[d]
Perimeter	1 - 11	96 ± 3	90 ± 3	55	106 ± 8	90 ± 2
Community	12 - 18	88 ± 5	79 ± 3	39	90 ± 9	79 ± 2
Distant	19 - 20	72 ± 6	72 ± 1	10	75 ± 8	71 ± 1

(a) Multiply by 10 to convert to µSv/yr.
(b) All station locations are shown on Figure 4.6.2 and are described in Appendix C, Table C.10.
(c) Maximum annual average dose rate for all locations within a given distance classification (±2 standard deviations).
(d) Means computed by averaging annual means for each location within a given distance classification (±2 standard error of the mean).

Table 4.6.3. Dose Rates (mrem/yr[a]) Measured by Thermoluminescent Dosimeters Along the Shoreline of the Hanford Reach of the Columbia River, 2003 Compared to Previous 5 Years

		2003		1998-2002		
Location	Map Location[b]	Maximum[c]	Mean[d]	No. of Samples	Maximum[c]	Mean[d]
100-N Area shoreline	1 - 3	99 ± 7	94 ± 8	15	152 ± 5	112 ± 10
Typical shoreline	4 - 27	98 ± 5	86 ± 3	109	102 ± 13	87 ± 1
All shoreline	1 - 27	99 ± 7	87 ± 3	124	152 ± 5	90 ± 2

(a) Multiply by 10 to convert to µSv/yr.
(b) All station locations are shown on Figure 4.6.2 and are described in Appendix C, Table C.10.
(c) Maximum annual average dose rate for all locations within a given distance classification (±2 standard deviations).
(d) Means computed by averaging annual means for each location within a given distance classification (±2 standard error of the mean).

on the Hanford Site during 2003 (96 ± 8 mrem [0.96 ± 0.08 mSv] was detected at the location on the north side of the 300 Area (location 17 in Figure 4.6.1). The 5-year maximum onsite dose rate (128 ± 19 mrem [1.28 ± 0.19 mSv] per year) was measured during 1999 near the US Ecology low-level waste disposal facility located in the 600 Area, south of the 200 Areas on the Central Plateau.

Offsite and Perimeter External Radiation Results. The average perimeter dose rate was 90 ± 3 mrem (0.90 ± 0.03 mSv) per year in 2003; the maximum was 96 ± 3 mrem (0.964 ± 0.03 mSv) per year. The 5-year perimeter average dose rate was 90 ± 2 mrem (0.90 ± 0.02 mSv) per year and the 5-year maximum was 106 ± 8 mrem (1.06 ± 0.08 mSv) per year. The location of the 2003 maximum perimeter dose was Rattlesnake Springs (location number 10 on Figure 4.6.2). The variation in dose rates may be partially attributed to changes in natural background radiation that can occur as a result of changes in annual cosmic radiation (up to 10%) and terrestrial radiation (15% to 25%) (National Council on Radiation Protection and Measurements 1987). Other factors possibly affecting the annual dose rates reported here have been described in PNL-7124.

The average background dose rate (measured in distant communities) in 2003 was 72 ± 1 mrem (0.72 ± 0.01 mSv) per year, which was the same as the average for 2002 (PNNL-14295) and the 5-year average of 71 ± 1 mrem (0.71 ± 0.01 mSv) per year. Onsite and perimeter average dose rates were 15 mrem (0.15 mSv) and 18 mrem (0.18 mSv) per year higher (respectively) than average dose rates measured at distant locations (Figure 4.6.4).

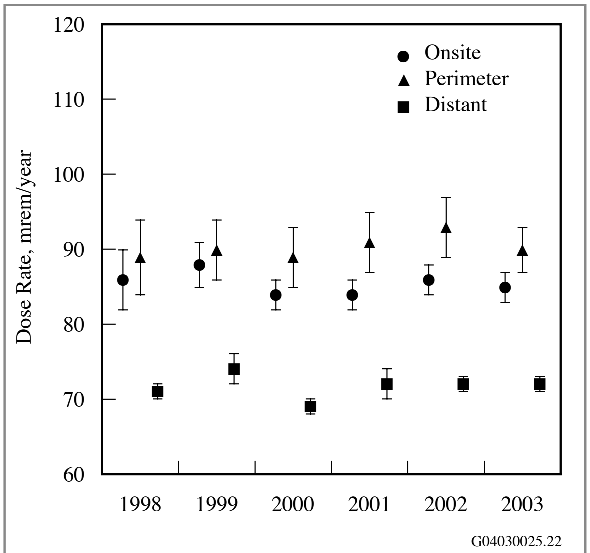

Figure 4.6.4. Annual Average Dose Rates (±2 standard error of the mean) at Onsite, Perimeter, and Distant Locations of the Hanford Site, 1998 through 2003

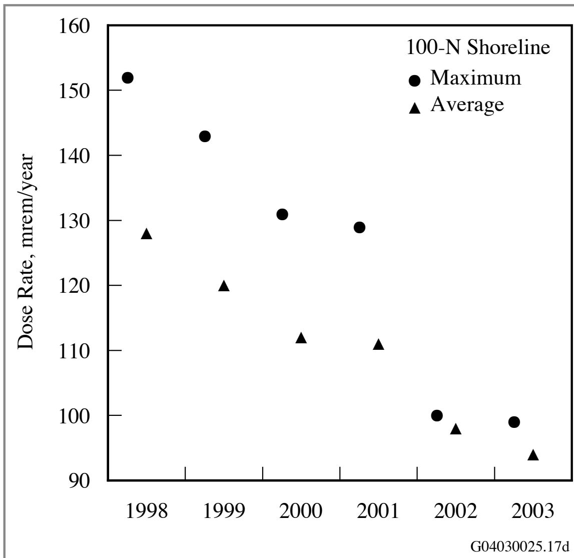

Figure 4.6.5. Maximum and Average External Dose Rates Measured Along the Columbia River at 100-N Area Shoreline Locations on the Hanford Site, 1998 through 2003

Columbia River Shoreline External Radiation Results. During 2003, average dose rates along the Columbia River shoreline near the 100-N Area were approximately 6 mrem (0.06 mSv) per year higher than the average of all other shoreline dose rates (Table 4.6.3). Higher dose rates historically measured along the 100-N Area shoreline were attributed to waste management practices in that area (PNL-3127). The shoreline location of the highest average thermoluminescent dosimeter reading was along the 100-N Area shoreline. The 2003 maximum annual 100-N Area shoreline dose rate of 99 ± 7 mrem (0.99 ± 0.07 mSv) is about the same as the maximum of 100 ± 7 mrem (1.00 ± 0.07 mSv) measured in 2002 (PNNL-14295), but is significantly different (i.e., the 95% confidence intervals associated with the two measurements do not overlap) than the 5-year maximum of 152 ± 5 mrem (1.52 ± 0.5 mSv) per year measured during 1998. Over the past 5 years, the maximum dose rates along the 100-N Area shoreline have decreased as a result of cleanup efforts in the 100-N Area (Figure 4.6.5). The general public does not have legal access to the 100-N Area shore above the high water line but does have boat access to the Columbia River. The dose implications associated with using the Columbia River near the 100-N Area are discussed in Chapter 5.

4.6.2 Radiological Survey Results

During 2003, Bicron® Microrem meters and Geiger counters were used to perform radiological surveys at selected Columbia River shoreline locations. These surveys provided a coarse screening for external radiation fields. The highest dose rate measured with the Bicron® Microrem meter (70 µrem [0.7 µSv] per hour) (approximately 600 mrem per year) was measured in September along the 100-N Area shoreline; the lowest dose rate measured with the Bicron® Microrem meter was 0.4 µrem (0.004 µSv) per hour and was recorded at the south end of the Vernita Bridge (location 4 on Figure 4.6.3) in June. The 70 µrem (0.7 µSv) per hour dose rate is abnormally high, approximately 350% higher than the maximum shoreline survey result reported last year and 700% higher than any other shoreline Bicron® Microrem meter measurement made during 2003. The thermoluminescent dosimeter result for the September quarter at the 100-N Area shoreline did not corroborate the high Bicron® Microrem meter reading. Likewise, the lowest Bicron® Microrem meter reading, 0.4 µrem (0.004 µSv) per hour, did not agree with the thermoluminescent dosimeter reading obtained at the Vernita Bridge location. The highest reported count rate measured with the Geiger counter in ground level surveys (100 counts per minute) was measured at various locations and in multiple yearly quarters. The lowest ground level count rate (50 counts per minute) was recorded at several locations throughout the year.

4.6.3 Pressurized Ionization Chamber Results

Gamma radiation levels were monitored with pressurized ionization chambers at four community-operated air-monitoring stations during 2003 (Section 7.4). These stations were located in Leslie Groves Park in Richland, at Edwin Markham Elementary School in north Franklin County, at Basin City Elementary School in Basin City, and at Heritage College near Toppenish (locations 36, 40, 35, and 44, respectively on Figure 4.1.1). Measurements were collected to determine ambient gamma radiation levels near and downwind of the site and upwind and distant from the site, to display near-continuous exposure rate information to the public living near the station, and for educational information for the teachers who manage the stations.

Data collection systems consisted of computers, data loggers, and modems or radiotelemetry instruments. The computers at Leslie Groves Park and Heritage College were accessed using telephone modems and data were obtained directly from the station. The computers at Edwin Markham Elementary School and Basin City Elementary School were connected by radiotelemetry to a computer at the Hanford Meteorology Station (near the 200-West Area). These data were summarized and posted on the Internet <http://terrassa.pnl.gov:2080/HMS/stamap.htm> (Section 7.4).

Readings at the Leslie Groves Park and Heritage College stations were collected every 5 seconds with a Reuter-Stokes Model RSS-121 pressurized ionization chamber and an average reading was recorded every hour. Data at Basin City and Edwin Markham School were collected every second with a Reuter-Stokes Model RSS-131 pressurized ionization chamber and averaged every 15 minutes. The 15-minute averages were then used to generate a 60-minute average (Table 4.6.4).

Average hourly exposure rates ranged from a maximum of 12.4 μR per hour (26.1 pW/kg per second) at Edwin Markham School during October to a minimum of 2.1 μR per hour (4.4 pW/kg per second) in Leslie Groves Park in November (Table 4.6.4). Monthly mean readings were consistently between 7.6 and 8.8 μR per hour (16.0 and 18.6 pW/kg per second) at the stations near Hanford, and ranged between 7.9 and 8.6 μR per hour (16.7 and 18.1 pW/kg per second) at the distant station (Heritage College). These average exposure rates were similar to exposure rates measured at these locations in past years and by thermoluminescent dosimeters located at or near these locations in 2003 (Table 4.6.5). One μR per hour is approximately equal to 1 microrem per hour.

Table 4.6.4. Exposure Rates[a] Measured by Pressurized Ionization Chambers at Four Locations Around the Hanford Site,[b] 2003

Month		Exposure Rate, μR/h[c] (number of hourly averages)							
		Leslie Groves Park[d]		Basin City[e]		Edwin Markham[e]		Toppenish[d]	
January	Mean	8.76	(744)	7.7	(715)	7.76	(717)	ND[f]	
	Maximum	10.15		9.9		9.7		ND	
	Minimum	8.33		7.3		7.3		ND	
February	Mean	8.75	(672)	7.7	(616)	7.8	(616)	8.29	(544)
	Maximum	10.70		9.6		10.4		9.34	
	Minimum	8.31		7.4		7.4		7.66	
March	Mean	8.63	(744)	7.8	(615)	7.83	(597)	8.20	(742)
	Maximum	9.28		8.5		8.6		9.38	
	Minimum	6.98		7.5		7.5		7.64	
April	Mean	8.63	(720)	7.82	(730)	7.74	(720)	8.36	(721)
	Maximum	9.95		9.7		9.2		9.41	
	Minimum	7.28		7.5		7.4		7.62	
May	Mean	8.49	(744)	7.7	(738)	7.68	(737)	8.13	(708)
	Maximum	10.04		10.0		10.9		9.61	
	Minimum	8.14		7.4		7.4		7.54	
June	Mean	ND		7.73	(680)	7.65	(699)	8.02	(361)
	Maximum	ND		8.7		8.7		9.9	
	Minimum	ND		7.3		7.4		7.5	
July	Mean	ND		7.75	(719)	7.63	(733)	7.86	(714)
	Maximum	ND		8.6		7.9		9.86	
	Minimum	ND		7.5		7.4		7.50	
August	Mean	ND		7.78	(738)	7.71	(742)	7.91	(744)
	Maximum	ND		8.5		8.6		9.6	
	Minimum	ND		7.4		7.3		7.5	
September	Mean	ND		7.73	(653)	7.82	(656)	8.22	(691)
	Maximum	ND		8.2		8.8		10.00	
	Minimum	ND		7.4		7.5		7.48	
October	Mean	8.59	(177)	7.77	(613)	7.88	(636)	8.60	(744)
	Maximum	9.13		8.5		12.4		10.40	
	Minimum	8.21		7.3		7.3		7.50	
November	Mean	8.80	(672)	7.93	(683)	7.87	(58)	8.51	(722)
	Maximum	9.77		8.5		8.0		9.71	
	Minimum	2.08		7.6		7.7		7.89	
December	Mean	8.67	(741)	7.86	(712)	7.61	(316)	8.30	(745)
	Maximum	9.94		9.2		8.7		10.20	
	Minimum	5.11		7.3		7.2		7.64	

(a) Maximum and minimum values are hourly averages. Means are monthly means.
(b) Measurement locations are illustrated in Figure 4.1.1.
(c) To convert to international metric system units (picowatts per kilogram), multiply exposure rates by 2.109.
(d) Readings are stored every 60 minutes. Each 60-minute reading is an average of measurements collected at 5-second intervals.
(e) Readings were collected every second and averaged every 15 minutes. Fifteen-minute averages were used to compute 60-minute averages (as many as 3,600 individual measurements per hour).
(f) ND = No data collected; instrument problems at Toppenish. Detector removed for re-calibration at Leslie Groves Park.

Table 4.6.5. Quarterly Average Exposure Rates (μR/h[a,b]) Measured by Thermoluminescent Dosimeters at Four Locations Around the Hanford Site,[c] 2003

Quarter Ending	Leslie Groves Park[d]	Basin City	Edwin Markham	Toppenish
March	8.50 ± 0.13	8.75 ± 0.21	8.67 ± 0.00	7.79 ± 0.17
June	8.58 ± 0.42	8.83 ± 0.33	8.96 ± 0.29	8.21 ± 0.21
September	8.75 ± 0.17	[e]	8.67 ± 0.25	8.38 ± 0.08
December	8.58 ± 0.17	[e]	9.04 ± 0.75	8.63 ± 0.17

(a) ± counting error.
(b) To convert to international metric system units (picowatts per kilogram), multiply exposure rates by 2.109.
(c) Sampling locations shown on Figure 4.1.1.
(d) Thermoluminescent dosimeter located ~1 kilometer (0.6 mile) north of Leslie Groves Park at map location 26, Figure 4.6.3.
(e) Dosimeter missing.