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ENVIRONMENTAL SURVEILLANCE DATA REPORT FOR THE FIRST QUARTER OF 1988

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EXECUTIVE SUMMARY

During the first quarter of 1988, over 1800 samples which represent more than 6,000 analyses and measurements were collected by the Environmental Monitoring and Compliance (EMC) Department. More than ten real-time monitoring stations, which telemeter 10-minute averaged readings of radiation levels, total precipitation, flows, water, and air quality parameters around ORNL also reported data. In addition, three meteorological towers sent weather data at various heights to a host computer every 15-minutes.

Real-time measurements of external gamma radiation are now being reported from several stations, including some recently activated or upgraded stations. Measurements this quarter indicate that external gamma radiation around ORNL is close to background, except at station 4, which is located between the Waste Treatment Plant and waste treatment ponds and therefore experiences higher levels of radiation.

Cobalt-60 concentrations in Melton Branch remained low, as they had been during the fourth quarter of 1987. Lack of discharge from the HFIR ponds is the apparent cause of the reduced concentrations, as these ponds appear to be the source of most of the cobalt-60 that does occur in Melton Branch.

Flow-weighted concentrations of radionuclides in surface water were found to be generally much lower than the DOE derived concentration guidelines except for tritium in Melton Branch. Tritium concentrations measured at Melton Branch Site 1 exceeded the corresponding guideline by 30% during March.

The effect of a prolonged shortage of precipitation is evident in the flow of the Clinch River. Flow for the first quarter of 1988 was less than half the corresponding value for the first quarter of 1987.

There were a total of 30 noncompliances associated with the NPDES permits during the first quarter of 1988. This was from a total of 2,292 samples, which represents a compliance ratio of greater than 98%. Three of the noncompliances involved low pH at the Acid Neutralization Facility during January and February. This situation has been addressed in an Energy Systems Quality Investigation Report. Where appropriate, corrective actions or investigations have been undertaken or are underway to address the other noncompliances. Eleven of the noncompliances involved suspended solids in Category II outfalls associated with the rain event of February 2. Because no appreciable precipitation had occurred since January 19, the samples taken on February 2 would be expected to contain the first-flush of several days accumulation of dust and other particulate matter from the areas drained by these outfalls.

INTRODUCTION

The Environmental Monitoring and Compliance (EMC) Department within the Environmental and Health Protection Division (EHP) at the Oak Ridge National Laboratory (ORNL) is responsible for environmental surveillance to: (1) assure compliance with all Federal, State, and DOE requirements for the prevention, control, and abatement of environmental pollution, (2) monitor the adequacy of containment and effluent controls, and (3) assess impacts of releases from ORNL facilities on the environment.

To meet these objectives, the EMC Department has implemented a surveillance program that consists of both monitoring and sampling of environmental constituents. Monitoring provides continuous data for rapid screening of parameters. Sampling followed by laboratory analyses is usually recommended for routine surveillance rather than continuous monitoring. In general, monitoring systems are less sensitive and as a result have much higher detection levels than laboratory analysis. Laboratory analysis provides a quantitative estimate of concentrations or activities at environmental levels.

The surveillance program for 1988 includes sampling and monitoring of air, water from surface streams and point sources, fish, milk, soil, and vegetation (grass) for radioactive and nonradioactive materials. This report includes data for air, surface water, and milk. Surveillance points are located on-site to quantify discharges from ORNL facilities, and off-site to determine public exposures and to establish background reference levels.

The purpose of this report is to provide Laboratory and Central Management personnel with the most recent information on environmental conditions. It is intended strictly as a data report. Each quarter a report that summarizes all environmental monitoring data from the various media will be prepared.

Summaries of data will be presented for each month and quarter where there are multiple observations. The summary tables give the number of samples collected at each station or location and the maximum, minimum, and average values of parameters for which analyses were done. The 95% confidence coefficients (CCs) were calculated and where possible, average values were compared with applicable guidelines, criteria, or standards as a means of evaluating the impact of effluent releases on environmental concentrations. Some averages have been rounded and reported to only two significant digits.

Results which may be negative (values less than instrument background) are reported. Using this system, apparent decreases may be attributed to the reporting of negative values and the subsequent inclusion of these data into the averaging. For radionuclides measured by gamma spectroscopy, such as ^{60}Co and ^{137}Cs, the program software is not designed for the calculation of negative values and thus "less than" values are being reported for these radionuclides. Modification of the program software to allow for the calculation of negative values for radionuclides determined by gamma spectroscopy is currently underway.

Results that are below the analytical detection limit are expressed as "less than" (<). In computing average values, less than results are assigned the detection limit. The average value is expressed as less than the computed value when at least one of the samples for the period is less than the detection limit.

AIR

Most gaseous wastes from ORNL are released to the atmosphere through stacks. Radioactivity may be present in gaseous waste streams as a solid (particulates), as an absorbable gas (iodine), or as a nonabsorbable species (noble gas). Gaseous wastes that may contain radioactivity are processed to reduce the radioactivity to acceptable levels before they are discharged. In addition to monitoring stack effluents, atmospheric concentrations of materials occurring in the general environment around ORNL, the Oak Ridge Reservation, and the vicinity are monitored continuously by an air monitoring network of 24 stations. Relative locations of these stations are shown in Figures 1 and 2. These air monitoring stations are categorized into three groups according to their geographical locations:

(1) The ORNL perimeter air monitoring network (ORNL PAMs) consists of stations 3, 7, 9, 21, and 22. These stations are located at or near the ORNL boundary (shown in Figure 1). Previously, stations 21 and 22 were used only for external gamma radiation measurements; there was no sampling equipment. However, sampling equipment was installed at station 22 and this station began operating in March 1987. Sampling equipment has now been installed at Station 21 and this station began operating in March 1988.

(2) The DOE Oak Ridge reservation network (Reservation PAMs) consists of stations 8, 23, 31, 33, 34, 36, and 40-46 (Figure 1). Stations 31 through 45 have the capability to perform both sampling and continuous monitoring. Station 46 is currently being redeveloped to collect real-time data.

(3) The remote air monitoring network (RAMs) consists of stations 51-53 and 55-57. These stations are located within a 120 km radius of ORNL outside the DOE Oak Ridge Reservation (Figure 2).

At each real-time monitoring station, there are monitors for five radiation parameters (gross alpha, gross beta, iodine, gross gamma, and noble gas), a rain gauge, and three process sensors that are used to calculate the volume of the sample collected. A central processor collects 10-minute average readings and transmits the data to a VAX computer for further analysis and reporting. The central processor checks the values against alarm limits. All alarms are reported to a printer as they occur. The primary purpose of the monitoring system is to determine if radiation levels on the Reservation are above background levels. If radiation levels appear to be higher than normal, additional sampling can be initiated to provide quantitative measures of concentrations in the atmosphere. In addition, sampling is done at each station to quantify levels of iodine, gross alpha, and gross beta. The real-time monitoring system is the only measure of noble gases in the area.

ORNL–DWG 86-17411R2

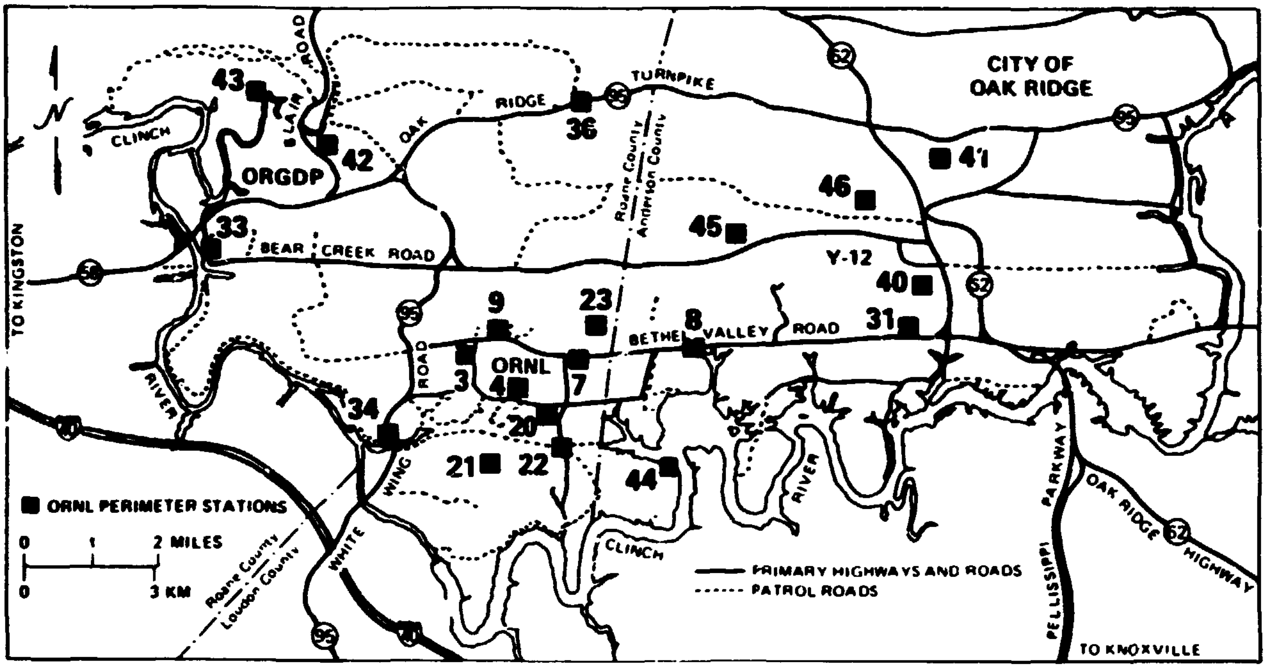

Fig. 1. Location map of the ORNL perimeter and Oak Ridge Reservation air monitoring stations.

ORNL-DWG 86-9187R6

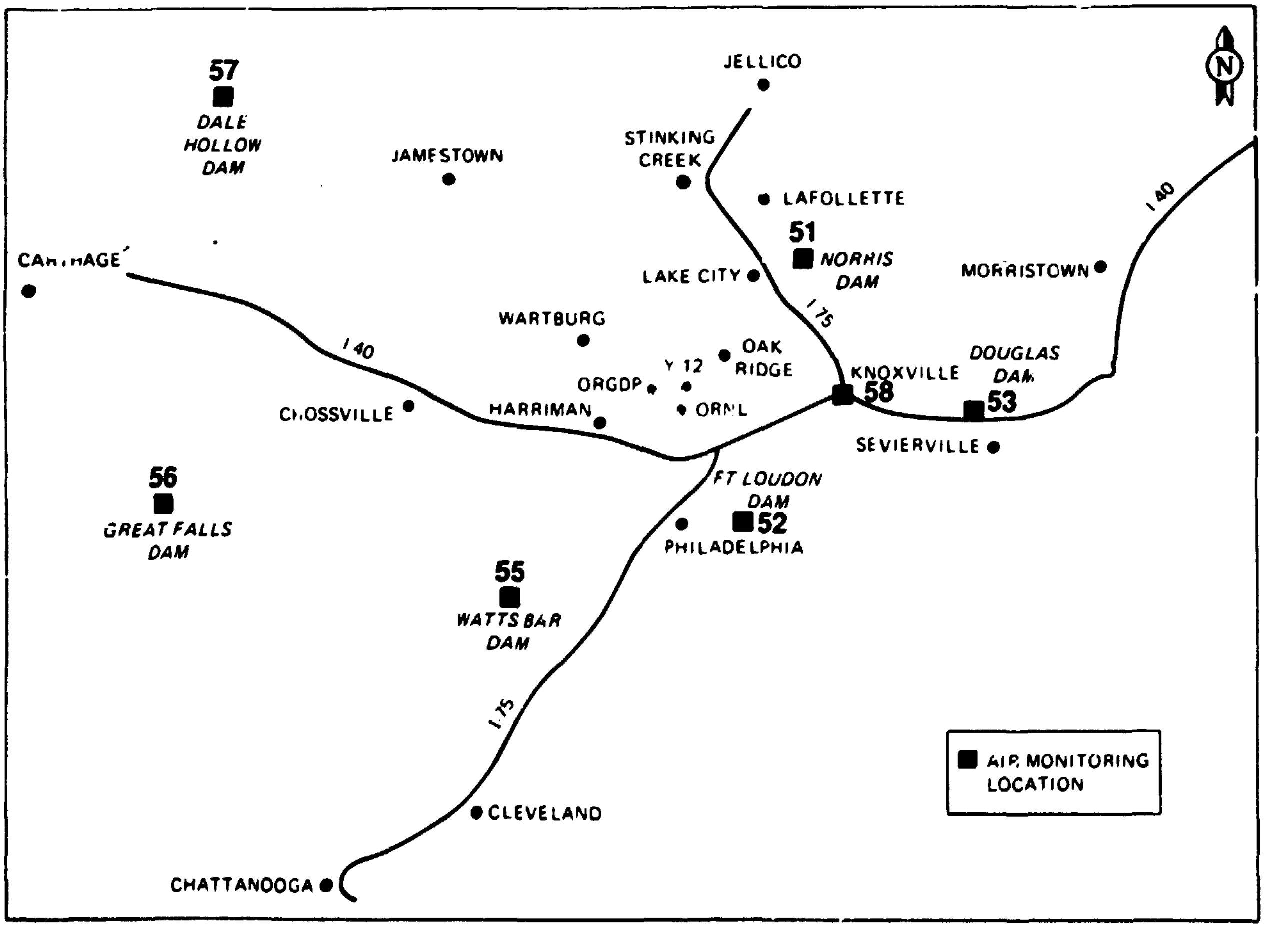

Fig. 2. Location map of the remote air monitoring stations

Airborne radioactive particulates are collected weekly by pumping a continuous flow of air through a paper filter and then through a charcoal cartridge. The filter papers are collected and analyzed weekly for gross alpha and gross beta activities. To minimize artifacts from short-lived radionuclides, the filter papers are analyzed 3-4 days after collection. The airborne ^{131}I is collected weekly using a cartridge that is packed with activated charcoal. The charcoal cartridges are analyzed within 24 hours after collection. The initial and final dates, time on and off, and flowrates are recorded when a sampler is mounted or removed. The total volume of air which flowed through the sampler at each station is calculated using this information. The flowrates at stations 3-45 are set between 1.5 and 3.0 CFM to minimize artifacts from extremely high or low flowrates. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air.

Monthly (January-March) concentrations of gross alpha, gross beta, and atmospheric ^{131}I are summarized in Tables 1-9. Instrument background concentrations of ^{131}I, gross alpha, and gross beta have been subtracted from the measured concentrations in Tables 1-9. Negative values represent concentrations below the instrument background level. Beginning with the third quarter of 1986, a new counter has been used for analyzing weekly gross alpha and gross beta activities on filter papers. This new instrument gives a higher efficiency and is more sensitive. This improvement in sensitivity has significantly lowered the maximum and minimum values for gross alpha and minimum values for gross beta (Tables 1-6).

There appears to be little or no alpha activity at any of the stations during this quarter.

The average beta activity at the RAMs was slightly higher than the average at the other two networks. All values were within the normal background range for East Tennessee.

The charcoal samples collected weekly at the air monitoring stations showed no significant differences in iodine concentrations from the fourth quarter of 1987 (Tables 7-9). There were no significant differences in iodine concentrations at either of the two monitoring networks from January to March 1988.

Monthly samples for atmospheric tritium are routinely collected from ORNL PAM stations 3, 7, and Reservation PAM station 8. Samples were not collected at ORNL PAM station 7 this period because the station is currently being upgraded and was therefore not operational during the first quarter. Atmospheric tritium in the form of water vapor is removed from the air by silica gel. The silica gel is heated in a distillation flask to remove the moisture and the distillate is counted in a liquid scintillation counter. The concentration of tritium in the air is calculated by dividing total activity accumulated per month by total volume of air sampled. A quarterly summary of the atmospheric tritium concentrations is presented in Table 10. Tritium concentrations in air showed no significant differences from the past three years' values.

Table 1. Long-lived gross alpha activity in air

January 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]
		ORNL PAM Stations[b]			
3	4	5.2	-5.2	-1.3	5.0
7	4	5.2	0	1.3	2.6
9	4	5.2	-5.2	0	4.2
22	4	4.1	-5.2	-0.26	3.8
Network summary	16	5.2	-5.2	-0.065	1.8
		Reservation PAM Stations[b]			
8	4	5.2	0	1.3	2.6
23	4	36	-5.2	7.8	19
31	4	10	0	2.6	5.2
33	4	5.2	0	1.3	2.6
34	4	5.2	-5.2	0	4.2
36	4	6.5	0	1.6	3.2
40	4	5.2	-5.8	-1.4	5.1
41	4	4.7	-5.2	-0.13	4.0
42	4	5.2	-5.2	0.52	4.4
43	4	5.2	0	1.4	2.5
44	4	5.2	-5.2	0	4.2
45	4	62	0	16	31
46	4	2.1	-5.2	-0.39	33
Network summary	52	62	-5.8	2.3	2.9
		RAM Stations[c]			
51	4	1.8	0	0.44	0.89
52	3	0	-6.0	-3.5	3.6
53	4	2.7	0	0.66	1.3
55	2	0	-6.6	-3.3	6.6

Table 1. (continued)

January 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L)			
		Max	Min	Av	95% cc[a]
56	4	0	-4.1	-1.3	1.9
57	4	1.0	-2.6	-0.39	1.5
Network summary	21	2.7	-6.6	-0.93	1.1
Overall summary	89	62	-6.6	1.1	1.8

[a]95% confidence coefficient about the average of more than two samples.
[b]See Figure 1.
[c]See Figure 2.

Table 2. Long-lived gross alpha activity in air

February 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]
		ORNL PAM Stations[b]			
3	5	0	-6.0	-4.2	2.2
7	5	-1.8	-5.2	-4.2	1.2
9	5	0	-4.8	-1.1	1.9
22	5	0	-3.0	-0.99	1.1
Network summary	20	0	-6.0	-2.6	1.0
		Reservation PAM Stations[b]			
8	5	0	-5.4	-2.2	2.1
23	5	0	-5.2	-2.9	2.0
31	5	1.4	-5.2	-1.7	2.3
33	5	0.45	-6.0	-2.4	2.4
34	5	0.45	-3.6	-1.5	1.5
36	5	0	-7.6	-3.8	2.8
40	5	-1.0	-6.7	-5.1	2.2
41	5	-2.1	-5.2	-3.3	1.1
42	5	4.2	-5.2	-2.6	3.5
43	5	-1.6	-5.3	-3.3	1.6
44	5	-2.6	-6.0	-4.4	1.2
45	5	4.5	-5.2	-2.2	3.5
46	5	0	-12	-4.8	4.1
Network summary	65	4.5	-12	-3.1	0.68
		RAM Stations[c]			
51	5	11	0	3.1	5.2
52	4	-1.7	-5.5	-3.4	2.3
53	5	7.0	-0.67	1.9	3.5
55	5	0.95	-6.0	-3.2	3.1

Table 2. (continued)

February 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L)			
		Max	Min	Av	95% cc[a]
56	2	7.9	-2.8	2.6	11
57	5	6.9	-3.9	1.1	3.9
Network summary	26	11	-6.0	0.18	1.9
Overall summary	111	11	-12	-2.3	0.65

[a]95% confidence coefficient about the average of more than two samples.
[b]See Figure 1.
[c]See Figure 2.

Table 3. Long-lived gross alpha activity in air

March 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]
		ORNL PAM Stations[b]			
3	4	4.1	1.6	2.5	1.2
7	2	3.1	2.1	2.6	1.0
9	4	5.2	2.6	3.8	1.1
21	2	6.8	4.8	5.8	2.0
22	4	4.1	1.3	2.7	1.2
Network summary	16	6.8	1.3	3.3	0.76
		Reservation PAM Stations[b]			
8	4	5.2	2.1	3.6	1.3
23	4	5.2	2.1	3.8	1.3
31	4	5.7	3.1	4.4	1.2
33	4	7.8	3.1	4.7	2.1
34	4	5.6	2.9	4.5	1.2
36	4	7.2	2.7	4.8	2.0
40	4	6.8	3.1	4.1	1.8
41	4	7.0	3.4	4.9	1.6
42	4	4.6	1.6	3.2	1.4
43	4	7.6	4.2	5.6	1.5
44	4	4.1	2.1	3.4	0.90
45	4	6.3	3.1	5.1	1.4
46	4	5.1	3.3	4.2	0.72
Network summary	52	7.8	1.6	4.3	0.41
		RAM Stations[c]			
51	4	6.3	1.3	4.5	2.3
52	4	14	3.5	7.8	6.4
53	4	7.3	4.1	6.0	1.5
55	4	6.6	2.9	4.8	1.5

Table 3. (continued)

March 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]
56	4	3.6	-2.5	1.6	2.8
57	4	5.8	3.0	4.6	1.2
Network summary	23	14	-2.5	4.8	1.2
Overall summary	91	14	-2.5	4.2	0.42

[a]95% confidence coefficient about the average of more than two samples.
[b]See Figure 1.
[c]See Figure 2.

Table 4. Long-lived gross beta activity in air

January 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L)			
		Max	Min	Av	95% cc[a]
ORNL PAM Stations[b]					
3	4	100	26	56	34
7	4	78	47	65	16
9	4	130	78	100	21
22	4	120	83	100	17
Network summary	16	130	26	81	15
Reservation PAM Stations[b]					
8	4	110	52	83	31
23	4	150	41	91	46
31	4	93	57	76	15
33	4	150	73	110	31
34	4	150	78	110	34
36	4	130	69	110	29
40	4	62	46	54	6.9
41	4	110	62	87	26
42	4	120	52	100	36
43	4	120	62	95	26
44	4	120	57	87	29
45	4	250	88	150	68
46	4	110	36	71	35
Network summary	52	250	36	95	11
RAM Stations[c]					
51	4	170	100	140	31
52	3	140	96	110	26
53	4	210	120	170	42
55	2	73	72	73	1.0

Table 4. (continued)

January 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L)			
		Max	Min	Av	95% cc[a]
56	4	150	29	110	55
57	4	140	52	99	38
Network summary	21	210	29	120	20
Overall summary	89	250	26	99	8.7

[a]95% confidence coefficient about the average of more than two samples.
[b]See Figure 1.
[c]See Figure 2.

Table 5. Long-lived gross beta activity in air

February 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]
		ORNL PAM Stations[b]			
3	5	52	23	39	10
7	5	73	41	61	12
9	5	86	73	80	4.7
22	5	100	52	82	18
Network summary	20	100	23	65	9.7
		Reservation PAM Stations[b]			
8	5	67	41	53	8.8
23	5	73	31	57	14
31	5	120	81	93	13
33	5	120	73	98	16
34	5	110	78	98	13
36	5	130	78	100	18
40	5	74	45	54	10
41	5	91	57	72	12
42	5	73	62	66	5.1
43	5	120	67	88	19
44	5	73	62	67	3.3
45	5	95	52	77	15
46	5	100	52	66	17
Network summary	65	130	31	76	5.4
		RAM Stations[c]			
51	5	160	110	140	20
52	4	100	54	82	30
53	5	120	94	110	11
55	5	120	17	57	37

Table 5. (continued)

February 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]
56	2	120	95	110	21
57	5	140	94	110	17
Network summary	26	160	17	100	15
Overall summary	111	160	17	79	5.4

[a]95% confidence coefficient about the average of more than two samples.
[b]See Figure 1.
[c]See Figure 2.

Table 6. Long-lived gross beta activity in air

March 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L)			
		Max	Min	Av	95% cc[a]
		ORNL PAM Stations[b]			
3	4	78	31	48	20
7	2	52	52	52	0
9	4	78	62	69	6.5
21	2	120	96	110	20
22	4	88	57	71	13
Network summary	16	120	31	67	11
		Reservation PAM Stations[b]			
8	4	57	47	49	5.2
23	4	88	36	64	24
31	4	100	62	80	18
33	4	120	67	96	25
34	4	99	73	88	11
36	4	100	68	87	14
40	4	75	36	49	18
41	4	68	55	61	5.7
42	4	78	52	63	11
43	4	99	78	86	9.1
44	4	73	52	62	9.5
45	4	89	43	67	19
46	4	96	53	67	20
Network summary	52	120	36	71	5.6
		RAM Stations[c]			
51	4	100	47	82	25
52	3	180	89	120	61
53	4	180	68	120	49
55	4	110	68	91	16

Table 6. (continued)

March 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]
56	4	86	56	75	13
57	4	100	70	87	15
Network summary	23	180	47	96	14
Overall summary	91	180	31	76	5.6

[a]95% confidence coefficient about the average of more than two samples.
[b]See Figure 1.
[c]See Figure 2.

Table 7. ^{131}I concentrations in air

January 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]	Percent DCG[b]
		ORNL PAM Stations[c]				
3	4	2.1	-5.7	-0.39	3.7	< 0.01
7	4	6.3	-6.3	2.0	5.6	< 0.01
9	4	2.0	-2.1	-0.56	2.0	< 0.01
22	4	4.2	-4.2	0.95	3.9	< 0.01
Network summary	16	6.3	-6.3	0.50	1.9	< 0.01
		Reservation PAM Stations[c]				
8	4	4.2	0	2.1	1.7	< 0.01
23	4	7.7	2.1	5.6	2.4	< 0.01
31	4	6.4	0	2.6	3.2	< 0.01
33	4	8.3	-2.1	3.5	4.5	< 0.01
34	4	12	-6.3	4.0	8.1	< 0.01
36	4	4.2	-2.6	0.92	3.8	< 0.01
40	4	6.4	-2.1	2.6	3.6	< 0.01
41	4	6.3	-3.8	1.7	5.4	< 0.01
42	4	8.3	-4.2	2.1	5.4	< 0.01
43	4	6.3	0	3.0	2.7	< 0.01
44	4	10	-4.2	4.5	6.3	< 0.01
45	4	2.1	-4.2	-0.49	3.1	< 0.01
46	4	8.3	-6.3	-0.98	6.4	< 0.01
Network summary	52	12	-6.3	2.4	1.2	< 0.01
Overall summary	68	12	-6.3	2.0	1.1	< 0.01

[a]95% confidence coefficient about the average of more than two samples.
[b]Percent DCG = maximum value x 100/derived concentration guide (DCG). The DCG for ^{131}I is 1.5×10^{-2} Bq/L.
[c]See Figure 1.

Table 8. ^{131}I concentrations in air

February 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L) Max	Min	Av	95% cc[a]	Percent DCG[b]
		ORNL PAM Stations[c]				
3	5	5.7	0	2.0	2.1	< 0.01
7	5	6.3	-2.1	2.0	2.9	< 0.01
9	5	3.8	-2.1	0.79	2.0	< 0.01
22	5	9.5	0	3.6	3.3	< 0.01
Network summary	20	9.5	-2.1	2.1	1.3	< 0.01
		Reservation PAM Stations[c]				
8	5	11	-4.2	2.6	5.1	< 0.01
23	5	15	-1.8	5.8	5.5	< 0.01
31	5	5.7	-4.7	0.48	4.5	< 0.01
33	5	9.0	-2.0	3.3	4.2	< 0.01
34	5	4.2	-5.7	0.39	3.8	< 0.01
36	5	10	-2.6	6.0	4.7	< 0.01
40	5	16	0	6.8	5.7	< 0.01
41	5	6.3	-4.2	1.1	3.9	< 0.01
42	5	2.0	-5.5	-1.6	2.8	< 0.01
43	5	4.7	-4.2	0.73	3.3	< 0.01
44	5	10	-4.4	1.5	5.2	< 0.01
45	5	0	-6.3	-2.4	2.1	< 0.01
46	5	13	0	4.3	5.1	< 0.01
Network summary	65	16	-6.3	2.2	1.3	< 0.01
Overall summary	85	16	-6.3	2.2	1.0	< 0.01

[a]95% confidence coefficient about the average of more than two samples.
[b]Percent DCG = maximum value x 100/derived concentration guide (DCG). The DCG for ^{131}I is 1.5×10^{-2} Bq/L.
[c]See Figure 1.

Table 9. ^{131} Iodine concentrations in air

March 1988

Location	No. of Samples	Concentration (10^{-8} Bq/L)				
		Max	Min	Av	95% cc[a]	Percent DCG[b]
			ORNL PAM Stations[c]			
3	4	5.7	-5.7	-0.49	4.8	< 0.01
7	2	5.7	2.0	3.9	3.8	< 0.01
9	4	9.5	-3.8	-0.46	6.7	< 0.01
21	2	2.6	0	1.3	2.6	< 0.01
22	4	7.2	0	3.7	3.3	< 0.01
Network summary	16	9.5	-5.7	1.3	2.3	< 0.01
			Reservation PAM Stations[c]			
8	4	2.0	-2.0	0.98	2.0	< 0.01
23	4	7.7	0	3.9	3.5	< 0.01
31	4	11	-5.7	2.4	7.7	< 0.01
33	4	3.3	-3.8	-0.95	3.3	< 0.01
34	4	6.5	-3.9	1.8	4.7	< 0.01
36	4	8.0	-2.5	3.3	4.4	< 0.01
40	4	7.6	0	4.0	3.1	< 0.01
41	4	9.6	-4.1	2.0	6.5	< 0.01
42	4	2.5	-6.4	-0.49	4.1	< 0.01
43	4	5.1	-7.2	-0.52	5.1	< 0.01
44	4	5.7	-2.0	1.9	3.5	< 0.01
45	4	2.3	-2.0	0.093	1.8	< 0.01
46	4	0	-6.1	-3.1	2.6	< 0.01
Network summary	52	11	-7.2	1.2	1.2	< 0.01
Overall summary	68	11	-7.2	1.2	1.0	< 0.01

[a]95% confidence coefficient about the average of more than two samples.
[b]Percent DCG = maximum value x 100/derived concentration guide (DCG). The DCG for ^{131}I is 1.5×10^{-2} Bq/L.
[c]See Figure 1.

Table 10. Tritium activity in air

January - March 1988

Location[a]	No. of Samples	Concentration (10^{-4} Bq/L) Max	Min	Av	95% cc[b]	Percent DCG[c]
3	3	3.7	3.1	3.5	0.36	0.010
8	3	3.4	2.0	2.5	0.90	0.0091
Overall summary	6	3.7	2.0	3.0	0.63	0.010

[a]See Figure 1.
[b]95% confidence coefficient about the average of more than two samples.
[c]Percent DCG = maximum x 100/derived concentration guide (DCG). The DCG for tritium is 3.7 Bq/L. This assumes that 50% of the tritium is absorbed through the skin.

Air filters are composited quarterly from ORNL PAMs (stations 3, 7, 9, 21, and 22), Reservation PAMs (excluding stations 34, 36, 40, 41, 45, and 46), RAMs (stations 51-53 and 55-57), and from individual stations (34, 36, 40, 41, 45 and 46) and are analyzed for specific radionuclides. The results are in Tables 11 through 13. No ^{60}Co was detected on any of the quarterly air filters.

Table 11. Long-lived radioactivity in composited air filters from individual stations

January - March 1988

	Concentration (10^{-10} Bq/L)					
	Location[a]					
Analysis	Station 34	Percent DCG[b]	Station 36	Percent DCG[b]	Station 40	Percent DCG[b]
^{60}Co	< 110	< 0.01	< 130	< 0.01	< 120	< 0.01
^{137}Cs	< 55	< 0.01	< 79	< 0.01	< 61	< 0.01
^{238}Pu	0.66	< 0.01	-7.9	< 0.01	-46	< 0.01
^{239}Pu	-3.5	< 0.01	-5.5	< 0.01	-5.7	< 0.01
^{228}Th	39	0.26	45	0.30	3.6	0.024
^{230}Th	85	0.46	93	0.50	83	0.45
^{232}Th	8.4	0.23	18	0.49	19	0.51
Total Sr[c]	110	< 0.01	17	< 0.01	3.6	< 0.01
^{234}U	48	0.14	170	0.51	130	0.39
^{235}U	20	0.054	28	0.076	52	0.14
^{238}U	34	0.092	26	0.070	56	0.15

[a]See Figures 1 and 2.
[b]Percent DCG = value x 100/derived concentration guide (DCG). The DCG for ^{60}Co is 3.0×10^{-3} Bq/L; ^{137}Cs is 1.5×10^{-2} Bq/L; ^{238}Pu is 1.5×10^{-6} Bq/L; ^{239}Pu is 1.5×10^{-6} Bq/L; ^{228}Th is 1.5×10^{-6} Bq/L; ^{230}Th is 1.9×10^{-6} Bq/L; ^{232}Th is 3.7×10^{-7} Bq/L; ^{234}U is 3.3×10^{-6} Bq/L; ^{235}U is 3.7×10^{-6} Bq/L; and ^{238}U is 3.7×10^{-6} Bq/L.
[c]Total radioactive Sr = (^{89}Sr + ^{90}Sr).

Table 12. Long-lived radioactivity in composited air filters from individual stations

January - March 1988

	Concentration (10^{-10} Bq/L)					
	Location[a]					
Analysis	Station 41	Percent DCG[b]	Station 45	Percent DCG[b]	Station 46	Percent DCG[b]
^{60}Co	< 110	< 0.01	< 110	< 0.01	< 130	< 0.01
^{137}Cs	< 69	< 0.01	< 56	< 0.01	< 63	< 0.01
^{238}Pu	-1.6	< 0.01	0.33	< 0.01	-0.51	< 0.01
^{239}Pu	0.46	< 0.01	-1.8	< 0.01	-0.13	< 0.01
^{228}Th	37	0.25	29	0.20	24	0.16
^{230}Th	36	0.19	33	0.18	23	0.12
^{232}Th	11	0.30	9.0	0.24	14	0.38
Total Sr[c]	-1.1	< 0.01	48	< 0.01	46	< 0.01
^{234}U	33	0.099	220	0.66	190	0.57
^{235}U	4.6	0.012	110	0.30	82	0.22
^{238}U	18	0.049	600	1.6	80	0.22

[a]See Figures 1 and 2.
[b]Percent DCG = value x 100/derived concentration guide (DCG). The DCG for ^{60}Co is 3.0×10^{-3} Bq/L; ^{137}Cs is 1.5×10^{-2} Bq/L; ^{238}Pu is 1.5×10^{-6} Bq/L; ^{239}Pu is 1.5×10^{-6} Bq/L; ^{228}Th is 1.5×10^{-6} Bq/L; ^{230}Th is 1.9×10^{-6} Bq/L; ^{232}Th is 3.7×10^{-7} Bq/L; ^{234}U is 3.3×10^{-6} Bq/L; ^{235}U is 3.7×10^{-6} Bq/L; and ^{238}U is 3.7×10^{-6} Bq/L.
[c]Total radioactive Sr = (^{89}Sr + ^{90}Sr).

Table 13. Long-lived radioactivity in composited air filters from air monitoring networks

January - March 1988

	Concentration (10^{-10} Bq/L)					
	Location[a]					
Analysis	ORNL PAMs	Percent DCG[b]	Reservation PAMs	Percent DCG[b]	RAMs	Percent DCG[b]
^{60}Co	< 26	< 0.01	< 16	< 0.01	< 19	< 0.01
^{137}Cs	< 24	< 0.01	< 14	< 0.01	25	< 0.01
^{238}Pu	0.71	< 0.01	0.45	< 0.01	0.74	< 0.01
^{239}Pu	-0.24	< 0.01	-1.1	< 0.01	-0.29	< 0.01
^{228}Th	13	0.088	10	0.068	14	0.095
^{230}Th	8.7	0.047	11	0.059	11	0.059
^{232}Th	6.6	0.18	7.3	0.20	8.8	0.24
Total Sr[c]	0	< 0.01	8.3	< 0.01	13	< 0.01
^{234}U	32	0.096	51	0.15	46	0.14
^{235}U	16	0.043	9.5	0.026	3.1	< 0.01
^{238}U	18	0.049	72	0.19	11	0.030

[a]See Figures 1 and 2.
[b]Percent DCG = value x 100/derived concentration guide (DCG). The DCG for ^{60}Co is 3.0×10^{-3} Bq/L; ^{137}Cs is 1.5×10^{-2} Bq/L; ^{238}Pu is 1.5×10^{-6} Bq/L; ^{239}Pu is 1.5×10^{-6} Bq/L; ^{228}Th is 1.5×10^{-6} Bq/L; ^{230}Th is 1.9×10^{-6} Bq/L; ^{232}Th is 3.7×10^{-7} Bq/L; ^{234}U is 3.3×10^{-6} Bq/L; ^{235}U is 3.7×10^{-6} Bq/L; and ^{238}U is 3.7×10^{-6} Bq/L.
[c]Total radioactive Sr = (^{89}Sr + ^{90}Sr).

EXTERNAL GAMMA RADIATION

External gamma radiation measurements are made to determine if routine radioactive effluents from ORNL are increasing externatl gamma radiation levels significantly above normal background.

Average gamma radiation measurements are collected at 10-minute intervals at ORNL and perimeter air monitoring stations (PAMs), except for stations 9, 21-23, and 46 (Fig. 1). From these data, hourly averages are computed. Table 14 summarizes the valid hourly measurements for the first quarter of 1988. Typical values for cities in the United States are usually between 50 and 200 nGy/h according to the recent issues of EPA Environmental Radiation Data. The most recent value for Knoxville, published in these EPA quarterly reports (EPA 1987), was 177 nGy/h for the second quarter of 1987. All of the values given in Table 14 are close to the range of background values as given above, except for LAM 4 which is located very close to the Process Waste Treatment Plant and treatment ponds. Values for station 4 are about ten times that of the typical background value, which is to be expected considering the location of that particular monitor.

Previously, external gamma radiation data was collected quarterly at the sites along the Clinch River (Fig. 3). These readings are not being published in this report due to problems in the analysis of the data.

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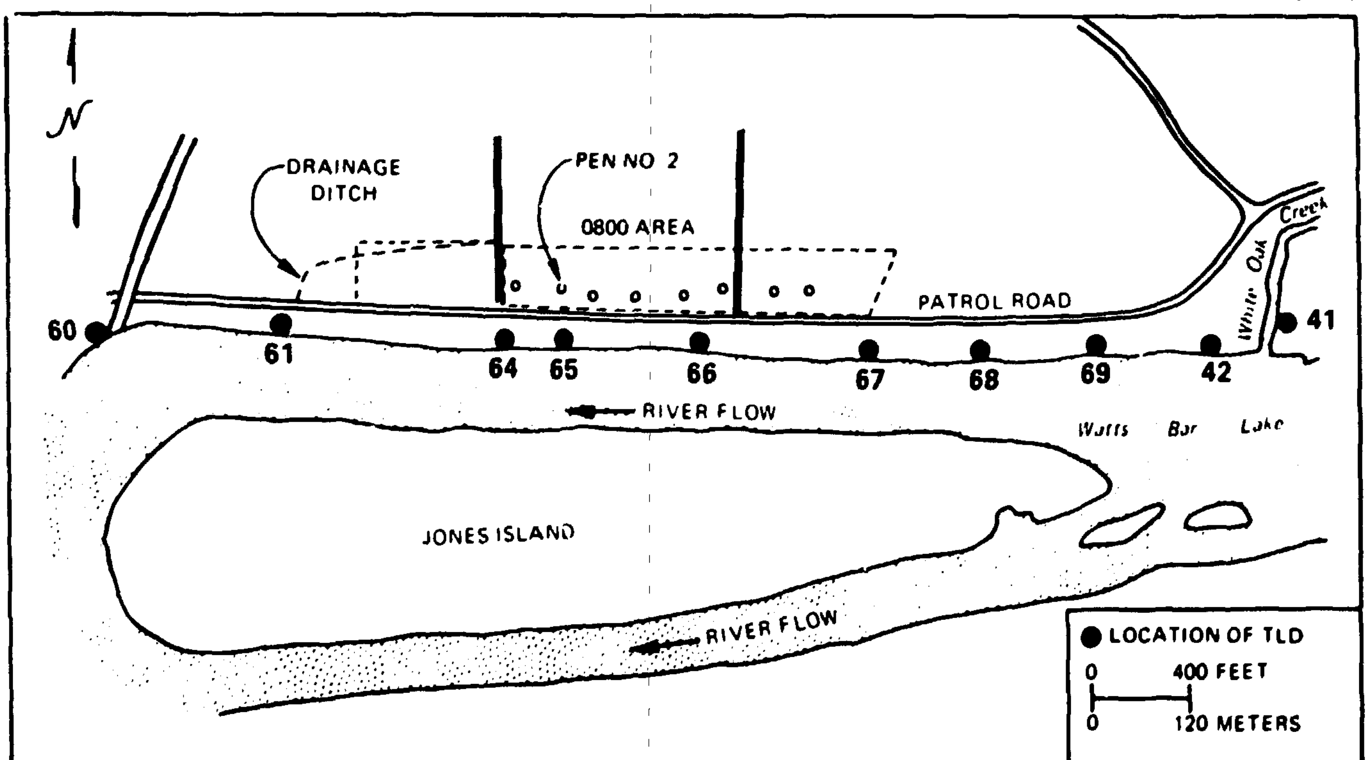

Fig. 3 Location map of TLDs along the Clinch River

Table 14. External gamma radiation measurements at ORNL and reservation perimeter air monitoring stations

January - March 1988

Location	No. of samples[a]	Concentration (nGy/h)		
		Max	Min	Av
		ORNL PAM Stations[b]		
3	1788	107	62	69
4	2020	2708	60	1713
7	2123	211	60	89
20	2151	125	78	86
Network summary	8082	2708	60	490
		Reservation PAM Stations[b]		
8	1972	115	67	72
31	2139	145	70	80
33	2145	123	76	83
34	1525	121	85	99
36	2152	102	70	75
40	1310	200	72	83
41	2154	78	61	65
42	1805	237	66	75
43	1845	107	59	68
44	2153	106	61	72
45	1434	119	66	70
Network summary	20634	237	59	76

[a]Real-time readings were collected at all stations at 10-minute intervals. The number of samples indicate the total number of valid hourly averages during the quarter.

[b]See Figure 1.

WATER

The ORNL site is drained by two main streams, White Oak Creek (WOC) and Melton Branch. With the exception of two small discharges from the 7600 area which discharge to Melton Hill Lake, all ORNL effluents discharge to these two streams or their tributaries. White Oak Creek flows through Bethel Valley where Fifth Creek, First Creek, and the Northwest Tributary enter it. White Oak Creek continues through a gap in Chestnut Ridge into Melton Valley where it is joined by Melton Branch, which drains Melton Valley. White Oak Creek empties into White Oak Lake, which is controlled by White Oak Dam (WOD), and is the last monitoring/sampling point before effluents leave the ORNL site. The majority of the drainage or liquid effluent from ORNL flows into the Clinch River by way of White Oak Creek (WOC). The Clinch River flows southwest from Virginia to its mouth near Kingston, Tennessee, where it joins with the Tennessee River. Process effluents discharged to these streams are handled in a number of ways which include: treatment (PWTP, Coal Yard Runoff), holding basins (190 ponds, HFIR/TRU ponds), and direct discharge to the stream. Sanitary effluent is discharged to White Oak Creek after treatment at the Sewage Treatment Plant. Below WOD, WOC is affected by water levels in the Clinch River which are controlled by Melton Hill Dam, shown in Figure 4.

Surveillance of the water environment consists of the collection of surface water samples and effluent samples required under the National Pollutant Discharge Elimination System (NPDES) permit. Samples are analyzed for radionuclides and nonradioactive chemicals.

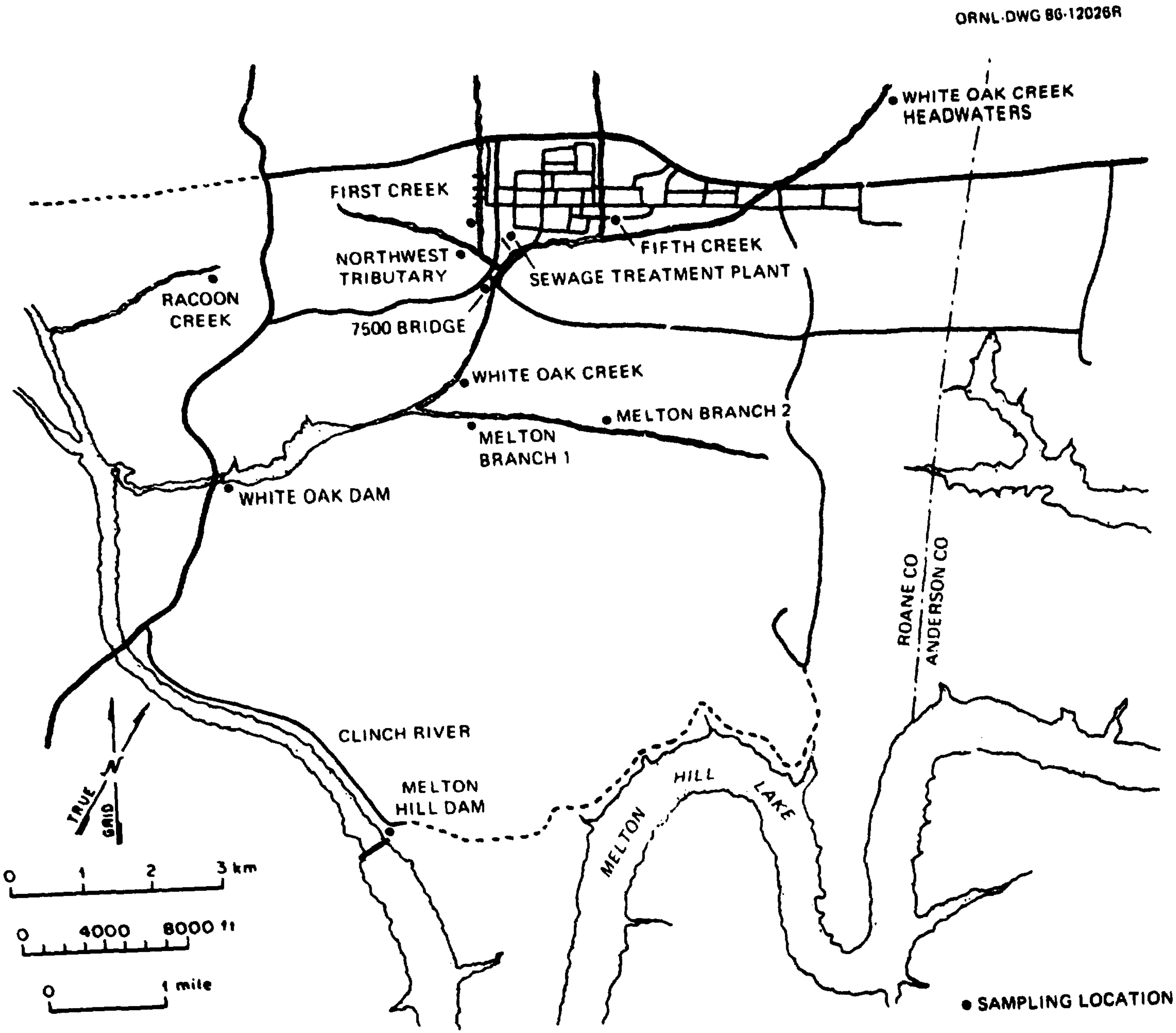

Fig. 4 Location map of ORNL streams and sampling stations

Surface Water

White Oak Creek (WOC) drains an area of 17 km^2 in Bethel and Melton Valleys and is the largest stream flowing through ORNL. Run-off from sites at ORNL reaches WOC either directly or via one of its tributaries. After entering Melton Valley, WOC is joined by its major tributary, Melton Branch (MB), at WOC kilometer 2.49. White Oak Dam (WOD), located one kilometer above the mouth of WOC, forms White Oak Lake and serves as a point for monitoring flow and discharges of contaminants from the ORNL site. Because facilities located near these creeks may discharge material to the creeks, sampling and analysis of the processes and their discharges are included in this section. ORNL's nonradiological sampling of these areas are those specified in the NPDES permit (see following section). This section is limited to a discussion of the radiological sampling that is performed by ORNL. Major discharges to WOC include: (1) treated domestic (sanitary) waste from the Sewage Treatment Plant (STP); (2) cooling tower blowdown; (3) cooling water from various sources; (4) surface drainage from the main Laboratory area, including drainage from Solid Waste Storage Areas 3, 4, and 6; (5) discharges from the process waste collection (190 ponds) and process waste treatment plant (3544); and (6) discharges from process building areas. Major discharges to MB include discharges from Solid Waste Storage Area 5, blowdown from the recirculating cooling water system at the High Flux Isotope Reactor (HFIR), and discharges from the 7900 waste pond system.

To determine discharges of radionuclides from ORNL processes, flow and concentration data from ORNL streams were recorded. Water samples were collected regularly from the following stations: 1500 area, 190 Ponds, First Creek, 2000 area, Acid Neutralization Facility (3518), Process Waste Treatment Plant (3544), Fifth Creek, 7500 Bridge, Melton Branch 1 (MB1), Melton Branch 2 (MB2), Melton Hill Dam, Northwest Tributary (NWT), High Flux Isotope Reactor (HFIR), Raccoon Creek, STP, TRU Ponds, WOC, White Oak Creek Headwaters, and WOD (Figs. 4 and 5). Real-time monitoring was performed at MB, WOC, and WOD. The parameters monitored include pH, dissolved oxygen, turbidity, conductivity, temperature, flow, beta and gamma activity (in cpm), and a gamma spectrum at WOD. The samples collected and analyzed daily at 7500 Bridge were used as an early warning of discharges of radioactivity from ORNL processes. Radiological monitoring at stations in the 1500 area, 190 Ponds, 3518, and 3544 was initiated in February 1987 to comply with the requirements of the National Pollutant Discharge Elimination System (NPDES) Radiological Monitoring Plan.

Water samples are picked up weekly at Kingston and ORGDP (Gallaher) water treatment plants and are analyzed quarterly for radionuclides (Fig. 6). For comparison, samples are collected daily from the ORNL potable water system (tap water) in Building 4500S and analyzed quarterly for radionuclides. In addition, flow proportional samples are collected weekly from Melton Hill Dam and analyzed quarterly for radionuclides (Fig. 6). This sampling location, on the Clinch River, is above ORNL's discharge point to the Clinch River and serves as a local background or reference station for ORNL.

ORNL DWG 87-7161R

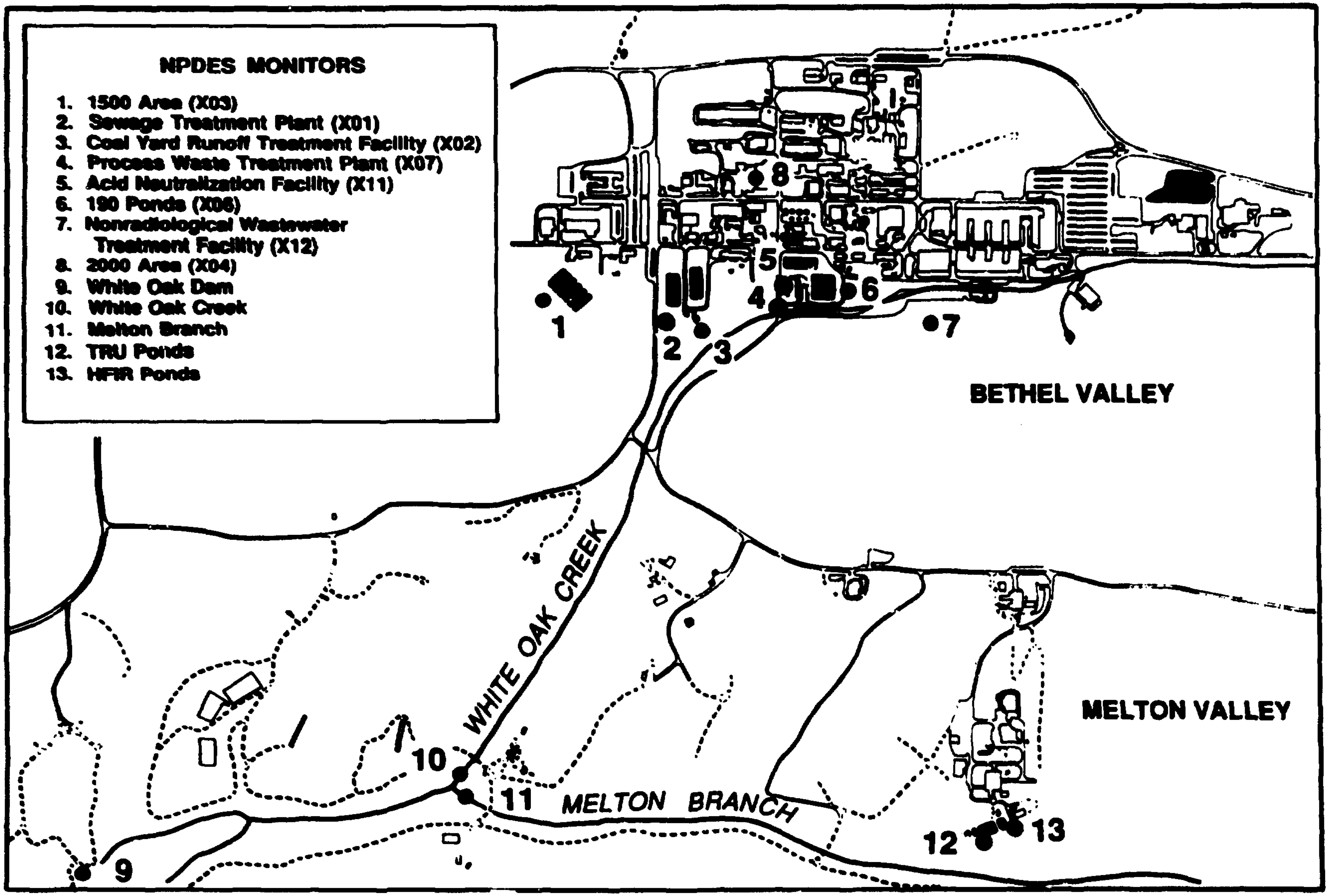

Fig 5 Location map of NPDES monitoring points

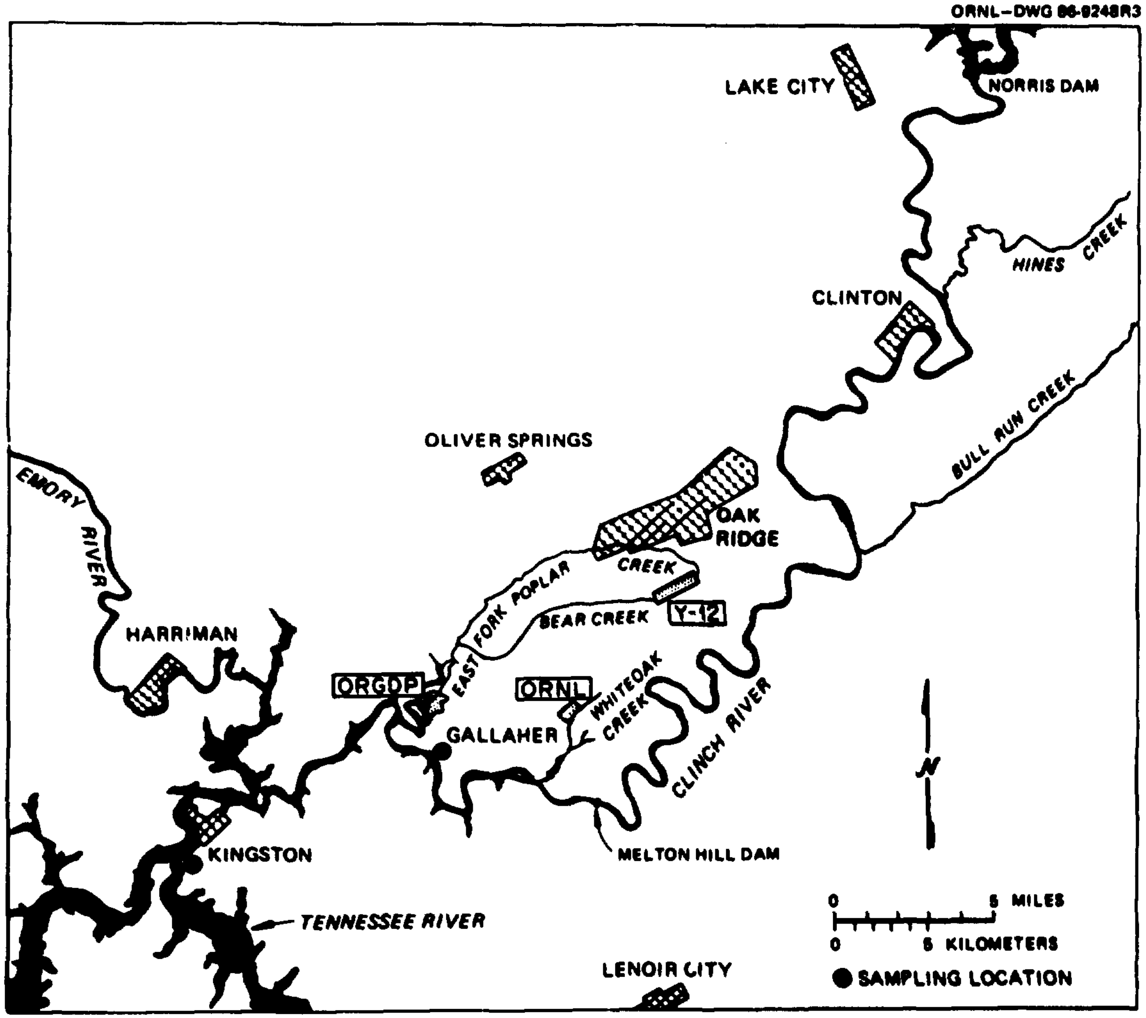

Fig. 6 Location map of Gallaher and Kingston sampling points

Table 15 summarizes the sampling and analysis frequencies, the parameters analyzed, and the type of sample collected at each of these stations. Summaries of radionuclide concentrations are presented in Tables 16-18. All determinations for "total Sr" are for total radioactive strontium which is the sum of ^{89}Sr and ^{90}Sr. The 95% confidence coefficients about the average values have not been presented for stations with less than three samples.

No ^{60}Co or ^{137}Cs were detected at any of the stations downstream from ORNL (Gallaher and Kingston) or in the ORNL tap water samples (Table 16). These were not detected in any of the quarterly samples for 1987. Concentrations of other radionuclides at the downstream locations were similar to the fourth quarter of 1987.

Cobalt-60 concentrations in Melton Branch (as measured at Melton Branch 2) were significantly lower during the last two quarters than previous quarters because there was no discharge from the HFIR ponds for several months (Table 19). These ponds appear to be the source of most of the ^{60}Co in Melton Branch.

The highest total radioactive Sr concentrations observed during this quarter were in First Creek with values ranging from 12 to 19 Bq/L (Table 17). Total radioactive Sr concentrations in Melton Branch 1 and Raccoon Creek ranged from 12 to 13 Bq/L and 1.5 to 1.6 Bq/L, respectively. At the Melton Hill Dam background station, total radioactive Sr ranged from 0.0055 to 0.11 Bq/L. Most of the total radioactive strontium appears to be coming from the main ORNL plant area (4500 complexes), the 2000 area, and a smaller portion from the 3000 area. Unlike the ^{60}Co and ^{137}Cs discharges, which are primarily process related, the total radioactive strontium releases are more diffuse and are probably the result of surface runoff rather than discharges from process facilities.

Concentrations of tritium are highest (57,000 to 94,000 Bq/L) at the Melton Branch 1 station, which is believed to be due to releases from SWSA 5. Characterization of SWSA 5, particularly the ^{3}H releases, is one of the highest priorities of the Remedial Investigation Feasibility Study (RI/FS) subcontract.

Flows in the Clinch river (as measured at Melton Dam) and in WOC (as measured at WOD) and the ratios of these flows, are presented in Table 19. The average ratios presented in the table were calculated weekly and averaged for the month. The effect of a prolonged shortage of precipitation is evident in the flow of the Clinch River. Flow values are appreciably less than for the first quarter of 1987, as are the ratios of the Clinch River flow to the White Oak Creek flow.

Table 15. Summary of collection and analysis frequencies of surface and tap water samples

Station	Parameter	Collection frequency	Type	Analysis frequency
190 Ponds	Gamma scan, gross alpha, gross beta	Weekly	Flow Proportional	Monthly
1500 Area, 3518	Gross alpha, gross beta	Weekly	Flow Proportional	Monthly
2000 Area, STP	Gamma scan, gross beta, Total Sr[a]	Weekly	Flow Proportional	Monthly
3544	Gross alpha, gross beta, gamma scan, Total Sr[a]	Weekly	Flow Proportional	Monthly
7500 Bridge	Gamma scan, Total Sr[a]	Daily	Time Proportional	Daily
7500 Bridge, MB1, WOC, MB2	Gamma scan, Total Sr[a], ^{3}H	Weekly	Flow Proportional	Monthly
First Creek, Fifth Creek, Raccoon Creek	Gamma scan, Total Sr[a]	Weekly	Grab	Monthly
Gallaher, Kingston	^{3}H, ^{60}Co, ^{137}Cs, gamma scan, gross alpha, gross beta, Pu, Total Sr[a], U	Weekly	Grab	Quarterly
HFIR Ponds	Gamma scan, gross alpha, gross beta	After Discharge	Flow Proportional	Monthly
Melton Hill Dam	^{241}Am, ^{244}Cm, ^{60}Co, ^{137}Cs, gross alpha, Pu, Th, U, Total Sr[a], ^{3}H,	Weekly	Flow Proportional	Quarterly
NWT	Gamma scan, Total Sr[a]	Weekly	Flow Proportional	Monthly
ORNL Tap	^{60}Co, ^{137}Cs, gross alpha, gross beta, Pu, Total Sr[a], U	Daily	Grab	Quarterly
ORR	^{60}Co, ^{137}Cs, gross alpha, gross beta	After Discharge	Flow Proportional	Monthly

Table 15. (continued)

Station	Parameter	Collection frequency	Type	Analysis frequency
WOC Headwaters	^{241}Am, ^{244}Cm, ^{60}Co, ^{137}Cs, gross alpha, Total Sr[a], ^{3}H, Pu, Th, U	Weekly	Grab	Monthly
WOD	^{241}Am, ^{244}Cm, ^{60}Co, ^{137}Cs, gross beta, Pu, Total Sr[a], ^{3}H	Weekly	Flow Proportional	Weekly
TRU Ponds	Gross beta	After Discharge	Flow Proportional	Monthly

[a] Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 16. Quarterly summary of radionuclide concentrations in surface streams and tap water

January - March

Radionuclide	Concentration (Bq/L)
Gallaher[a]	
^{60}Co	< 0.030
^{137}Cs	< 0.030
Gross alpha	0.034
Gross beta	0.20
Total Pu[b]	< 0.00011
Total Sr[c]	0.059
^{3}H	64
^{234}U	0.0057
^{235}U	0.00017
^{236}U	0.0000055
^{238}U	0.0036
Kingston[a]	
^{60}Co	< 0.010
^{137}Cs	< 0.010
Gross alpha	0.0030
Gross beta	0.040
Total Pu[b]	< 0.00011
Total Sr[c]	0.0070
^{3}H	6.4
^{234}U	0.0027
^{235}U	0.000083
^{236}U	0.000017
^{238}U	0.0015
Melton Hill Dam[a]	
^{60}Co	< 0.010
^{137}Cs	< 0.010
Gross alpha	0.0010
Gross beta	0.059
Total Pu[b]	< 0.00011
Total Sr[c]	0.0030
^{234}U	0.0065
^{235}U	0.00019
^{236}U	0.0000037
^{238}U	0.0038

Table 16. (continued)

January - March

Radionuclide	Concentration (Bq/L)
ORNL Tap Water	
^{60}Co	< 0.010
^{137}Cs	< 0.010
Gross alpha	0.017
Gross beta	0.090
Total Pu[b]	< 0.00011
Total Sr[c]	0.0030
^{234}U	0.0036
^{235}U	0.00010
^{236}U	< 0.0000029
^{238}U	0.0021

[a]See Figure 6.
[b]Total Pu (^{239}Pu + ^{240}Pu).
[c]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 17. Radionuclide concentrations in water around ORNL

January - March

Radionuclide	No. of Samples	Concentration (Bq/L) Max	Min	Av	95% cc[a]
		1500 Area[b]			
Gross alpha	3	0.50	0.0	0.17	0.33
Gross beta	3	1.8	0.34	1.0	0.85
		190 Ponds[b]			
^{60}Co	3	< 0.30	< 0.10	< 0.20	0.12
^{137}Cs	3	0.61	0.49	0.54	0.071
Gross alpha	3	2.2	0.030	0.83	1.4
Gross beta	3	2.8	1.8	2.3	0.58
		First Creek[c]			
^{60}Co	3	< 0.20	< 0.10	< 0.13	0.067
^{137}Cs	3	< 0.20	< 0.10	< 0.13	0.067
Total Sr[d]	3	19	12	15	4.1
		2000 Area[b]			
^{60}Co	3	< 0.20	< 0.20	< 0.20	0.0
^{137}Cs	3	< 0.20	< 0.20	< 0.20	0.0
Gross beta	3	1.9	0.0	0.66	1.2
Total Sr[d]	3	0.080	-0.010	0.043	0.055
		3518[b]			
Gross alpha	3	0.40	0.0	0.24	0.25
Gross beta	3	1.5	0.0	0.70	0.87

Table 17. (continued)

January - March

Radionuclide	No. of Samples	Concentration (Bq/L) Max	Min	Av	95% cc[a]
		3544[b]			
^{60}Co	3	4.8	3.8	4.3	0.58
^{134}Cs	2	0.79	0.48	0.64	0.31
^{137}Cs	3	150	75	110	44
^{152}Eu	1	2.1	2.1	2.1	N/A
Gross alpha	3	2.9	0.38	1.6	1.5
Gross beta	3	130	80	110	29
Total Sr[d]	3	0.16	0.020	0.087	0.081
		Fifth Creek[c]			
^{60}Co	3	< 0.30	< 0.10	< 0.17	0.13
^{137}Cs	3	< 0.20	< 0.10	< 0.13	0.067
Total Sr[d]	3	1.9	1.4	1.6	0.29
		7500 Bridge[c]			
^{60}Co	3	< 0.70	< 0.20	< 0.40	0.31
^{137}Cs	3	4.7	1.9	3.4	1.6
Total Sr[d]	3	2.9	1.7	2.5	0.80
^{3}H	3	110	67	87	25
		HFIR[b]			
^{60}Co	1	370	370	370	N/A
^{137}Cs	1	< 1.0	< 1.0	< 1.0	N/A
^{152}Eu	1	18	18	18	N/A
^{154}Eu	1	27	27	27	N/A
^{155}Eu	1	21	21	21	N/A
Gross alpha	1	1.0	1.0	1.0	N/A
Gross beta	1	490	490	490	N/A

Table 17. (continued)

January - March

Radionuclide	No. of Samples	Concentration (Bq/L) Max	Min	Av	95% cc[a]
		White Oak Creek Headwaters[c]			
^{241}Am	3	0.0010	-0.18	-0.060	0.12
^{244}Cm	3	-0.00020	-0.15	-0.050	0.10
^{60}Co	3	< 0.30	< 0.20	< 0.23	0.067
^{137}Cs	3	< 0.20	< 0.10	< 0.17	0.067
Gross alpha	3	0.51	0.0	0.21	0.31
^{238}Pu	3	0.0010	-0.00070	0.00017	0.00098
^{239}Pu	3	0.0040	-0.0013	0.00057	0.0034
Total Sr[d]	3	0.033	-0.070	-0.0090	0.062
^{3}H	3	31	-6.0	10	22
		Melton Branch 1[c]			
^{60}Co	3	0.95	< 0.20	< 0.57	0.43
^{137}Cs	3	5.2	< 0.10	< 1.8	3.4
Total Sr[d]	3	13	12	12	0.67
^{3}H	3	94000	57000	76000	21000
		Melton Branch 2[c]			
^{60}Co	3	0.83	0.41	0.58	0.25
^{137}Cs	3	< 0.20	< 0.20	< 0.20	0.0
Total Sr[d]	3	0.14	0.020	0.070	0.072
^{3}H	3	630	230	420	230
		Melton Hill Dam[c]			
^{241}Am	3	0.0020	0.0013	0.0016	0.00042
^{244}Cm	3	0.0023	0.0	0.0011	0.0013
^{60}Co	3	< 0.30	< 0.10	< 0.20	0.12
^{137}Cs	3	< 0.20	< 0.10	< 0.13	0.067

Table 17. (continued)

January - March

Radionuclide	No. of Samples	Concentration (Bq/L) Max	Min	Av	95% cc[a]
Gross alpha	3	0.080	0.0	0.027	0.053
^{238}Pu	3	0.0010	-0.00035	0.00022	0.00081
^{239}Pu	3	0.044	-0.0020	0.014	0.030
Total Sr[d]	3	0.11	0.0055	0.052	0.061
^{3}H	3	-1.0	-8.0	-4.7	4.1
		Northwest Tributary[c]			
^{60}Co	3	< 0.30	< 0.20	< 0.23	0.067
^{137}Cs	3	< 0.20	< 0.20	< 0.20	0.0
Total Sr[d]	3	2.3	1.6	1.9	0.41
		Raccoon Creek[c]			
^{60}Co	3	< 0.20	< 0.10	< 0.13	0.067
^{137}Cs	3	0.20	< 0.10	< 0.14	0.064
Total Sr[d]	3	1.6	1.5	1.6	0.067
		Sewage Treatment Plant[c]			
^{60}Co	6	< 0.20	< 0.10	< 0.17	0.042
^{137}Cs	6	0.20	< 0.10	< 0.15	0.037
Gross beta	6	9.6	7.4	8.6	0.82
Total Sr[d]	6	4.3	3.2	3.8	0.42
		TRU Ponds[b]			
Gross beta	1	3.8	3.8	3.8	N/A

Table 17. (continued)

January - March

Radionuclide	No. of Samples	Concentration (Bq/L) Max	Min	Av	95% cc[a]
		White Oak Creek[c]			
^{60}Co	3	2.5	< 0.20	< 1.0	1.5
^{137}Cs	3	3.2	0.12	2.1	2.0
Total Sr[d]	3	4.7	4.4	4.6	0.18
^{3}H	3	1600	940	1300	410
		White Oak Dam[c]			
^{241}Am	13	0.011	-0.045	0.0013	0.0080
^{244}Cm	13	0.030	-0.031	0.0065	0.0073
^{60}Co	13	0.50	< 0.20	< 0.35	0.042
^{137}Cs	13	6.3	0.63	1.8	0.87
Gross beta	13	16	10	13	1.1
^{238}Pu	13	0.20	-0.14	0.0025	0.040
^{239}Pu	13	0.015	-0.030	-0.00034	0.0060
Total Sr[d]	13	6.6	4.4	5.6	0.42
^{3}H	13	14000	3700	10000	1700

[a]95% confidence coefficient about the average of more than two samples.
[b]See Figure 5.
[c]See Figure 4.
[d]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 18. Radionuclide concentrations in water at the 7500 Bridge[a]

January - March

Radionuclide	No. of Samples	Concentration (Bq/L) Max	Min	Av	95% cc[b]
		January			
^{60}Co	20	0.91	< 0.20	< 0.46	0.088
^{137}Cs	20	36	2.0	9.4	4.0
Total Sr[c]	20	6.3	2.0	3.1	0.42
		February			
^{60}Co	20	0.60	< 0.20	< 0.33	0.046
^{137}Cs	20	13	2.1	4.7	1.1
Total Sr[c]	20	3.8	1.9	2.5	0.20
		March			
^{60}Co	23	< 0.40	< 0.10	< 0.31	0.036
^{137}Cs	23	8.4	1.5	3.6	0.67
Total Sr[c]	23	3.3	1.6	2.4	0.21

[a]See Figure 4.
[b]95% confidence coefficient about the average of more than two samples.
[c]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 19. Flow for Clinch River and White Oak Creek

January - March

	Flow (10^9 L)		
Month	Clinch River[a]	White Oak Creek[a]	Average Ratio[b]
January	270	1.00	370
February	210	0.81	290
March	100	0.98	120

[a]See Figure 4.
[b]Flow ratios for Clinch River and White Oak Creek are calculated daily and averaged for the month.

The total hourly flows at WOC, MB, and WOD were calculated by multiplying the average 10-minute flowrate (gallons per minute) transmitted via the real-time monitoring system by the number of minutes per hour. Low and high readings are recorded at WOC and MB while low, medium, and high flow readings are recorded at WOD.

Total flows per day at the STP are calculated by subtracting consecutive daily flow recorder readings and multiplying by a factor for conversion to million liters. The weekly flows are determined by averaging the total flows for the week and multiplying by the number of days in the week.

The discharges of radionuclides at WOD, MB1, and the STP are calculated by multiplying the concentration by the flow. At WOC, MB1 and the STP, a single flow proportional sample is analyzed monthly to estimate radionuclide concentrations. At WOD, weekly flow proportional samples are analyzed. At WOD, weekly radionuclide discharges are calculated by multiplying the weekly composite sample concentration by the total weekly flow. Monthly discharges of radionuclides at WOD are then calculated by averaging the weekly discharges and multiplying by the number of weeks per month (Tables 20-22). A flow weighted concentration at WOD for the month is calculated by dividing the total radionuclide discharge for the month by the total monthly flow (Tables 20-22).

Each average flow-weighted concentration is compared to a corresponding Derived Concentration Guide (DCG). A DCG, for water, is the concentration of a particular radionuclide for which a "reference man" under continuous exposure (ingestion) for one year would receive the most restrictive of (1) an effective dose equivalent of 1 mSv or (2) a dose equivalent of 50 mSv to any particular tissue (DOE draft order 5400.xx). In almost all cases the actual values are a small percentage of the corresponding DCGs. However, the percentages for strontium and tritium at Melton Branch 1 are higher. Tritium concentrations at Melton Branch 1 are typically near the corresponding DCG, and exceeded the DCG by 30% during March.

Table 20. Radionuclide concentrations and releases at ORNL

January

Radionuclide	Flow (10^6 L)	Discharge (10^4 Mega Bq)	Average Flow-Weighted Concentration (Bq/L)	Derived Concentration Guide (DCG) (Bq/L)	Percent of DCG
			Melton Branch 1[a]		
^{60}Co	420	< 0.0084	< 0.20	190	0.11
^{137}Cs	420	0.22	5.2	110	4.7
Total Sr[c]	420	0.54	13	37	35
^{3}H	420	2400	57000	74000	77
			Sewage Treatment Plant[a]		
^{60}Co	74	< 0.0015	< 0.20	190	0.11
^{137}Cs	74	0.0010	0.14	110	0.13
Gross beta	74	0.071	9.6	N/A	N/A
Total Sr[c]	74	0.030	4.0	37	11
			White Oak Creek[a]		
^{60}Co	950	0.24	2.5	190	1.4
^{137}Cs	950	0.011	0.12	110	0.11
Total Sr[c]	950	0.45	4.7	37	13
^{3}H	950	90	940	74000	1.3
			White Oak Dam[a,b]		
^{241}Am	1100	0.00098	0.0094	1.1	0.84
^{244}Cm	1100	0.0021	0.020	2.2	0.92
^{60}Co	1100	0.046	0.44	190	0.24
^{137}Cs	1100	0.45	4.3	110	3.9
Gross beta	1100	1.6	15	N/A	N/A
^{238}Pu	1100	0.012	0.11	1.5	7.5
^{239}Pu	1100	0.0011	0.010	1.1	0.92
Total Sr[c]	1100	0.66	6.3	37	17
^{3}H	1100	880	8400	74000	11

[a]See Figure 4.
[b]Concentration is a flow-weighted average of the weekly samples. Discharge is the total for the month.
[c]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 21. Radionuclide concentrations and releases at ORNL

February

Radionuclide	Flow (10^6 L)	Discharge (10^4 Mega Bq)	Average Flow-Weighted Concentration (Bq/L)	Derived Concentration Guide (DCG) (Bq/L)	Percent of DCG
			Melton Branch 1[a]		
^{60}Co	120	< 0.0051	< 0.41	190	0.22
^{137}Cs	120	< 0.029	< 2.4	110	2.1
Total Sr[c]	120	0.15	12	37	34
^{3}H	120	840	68000	74000	92
			Sewage Treatment Plant[a]		
^{60}Co	69	< 0.00081	< 0.12	190	0.063
^{137}Cs	69	< 0.00075	< 0.11	110	0.098
Gross beta	69	0.054	7.8	N/A	N/A
Total Sr[c]	69	0.023	3.3	37	9.0
			White Oak Creek[a]		
^{60}Co	670	< 0.050	< 0.75	190	0.41
^{137}Cs	670	0.16	2.4	110	2.2
Total Sr[c]	670	0.31	4.6	37	12
^{3}H	670	91	1400	74000	1.8
			White Oak Dam[a,b]		
^{241}Am	810	-0.0011	-0.014	1.1	< 0.001
^{244}Cm	810	-0.00046	-0.0056	2.2	< 0.001
^{60}Co	810	< 0.024	< 0.29	190	0.16
^{137}Cs	810	0.095	1.2	110	1.1
Gross beta	810	1.0	12	N/A	N/A
^{238}Pu	810	-0.0020	-0.024	1.5	< 0.001
^{239}Pu	810	-0.00013	-0.0016	1.1	< 0.001
Total Sr[c]	810	0.40	4.9	37	13
^{3}H	810	940	12000	74000	16

[a]See Figure 4.
[b]Concentration is a flow-weighted average of the weekly samples. Discharge is the total for the month.
[c]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 22. Radionuclide concentrations and releases at ORNL

March

Radionuclide	Flow (10^6 L)	Discharge (10^4 Mega Bq)	Average Flow-Weighted Concentration (Bq/L)	Derived Concentration Guide (DCG) (Bq/L)	Percent of DCG
			Melton Branch 1[a]		
^{60}Co	250	0.024	0.95	190	0.52
^{137}Cs	250	< 0.0025	< 0.10	110	0.090
Total Sr[c]	250	0.30	12	37	33
^{3}H	250	2300	94000	74000	130
			Sewage Treatment Plant[a]		
^{60}Co	75	< 0.0015	< 0.20	190	0.11
^{137}Cs	75	< 0.0015	< 0.20	110	0.18
Gross beta	75	0.068	8.9	N/A	N/A
Total Sr[c]	75	0.033	4.3	37	12
			White Oak Creek[a]		
^{60}Co	670	< 0.027	< 0.41	190	0.22
^{137}Cs	670	0.22	3.2	110	2.9
Total Sr[c]	670	0.30	4.5	37	12
^{3}H	670	110	1600	74000	2.2
			White Oak Dam[a,b]		
^{241}Am	960	0.00030	0.0032	1.1	0.29
^{244}Cm	960	0.00063	0.0068	2.2	0.31
^{60}Co	960	< 0.031	< 0.33	190	0.18
^{137}Cs	960	0.13	1.3	110	1.2
Gross beta	960	1.4	15	N/A	N/A
^{238}Pu	960	-0.00071	-0.0076	1.5	< 0.001
^{239}Pu	960	-0.00022	-0.0024	1.1	< 0.001
Total Sr[c]	960	0.53	5.7	37	15
^{3}H	960	840	9000	74000	12

[a]See Figure 4.
[b]Concentration is a flow-weighted average of the weekly samples. Discharge is the total for the month.
[c]Total radioactive Sr (^{89}Sr + ^{90}Sr).

National Pollutant Discharge Elimination System (NPDES) Requirements

ORNL's current NPDES permit requires that ten point source outfalls be sampled prior to their discharge into receiving waters, or before mixing with any other wastewater stream. One of these points, the Nonradiological Wastewater Treatment Plant, will not be in operation until March of 1990. In addition, there are three sampling locations that are located in the streams as reference points or for additional information and one (ORR Resin Regeneration Facility) that was taken out of operation in December 1986. These thirteen sampling locations are shown in Figure 5. There are approximately 150 additional locations that include storm drains, parking lot and roof drains, cooling tower drains, storage area drains, condensate drains, untreated process drains, and miscellaneous facilities that are sampled less frequently than the point source outfalls or surface streams.

Quarterly summary statistics for the first quarter of 1988 are given for each sampling location in Tables 23 through 39. Monitoring of the ORR Resin Regeneration Facility is no longer required because the permitted operation has been discontinued.

Data collected for the NPDES permit are also summarized monthly for reporting to DOE and the State of Tennessee. These summaries are submitted to DOE in the Monthly Discharge Monitoring Reports and are available upon request. Noncompliances are provided in Tables 40 through 42. A brief summary of the noncompliances follows.

January 1988

The pH noncompliances that were recorded at the Acid Neutralization Facility (X11) in January and February have been attributed to a combination of management and systems errors; an Energy Systems Quality Investigation Report (QIR) was filed addressing the situation. No discharge of noncompliant effluent from X11 is known to have occurred.

The chlorine noncompliance at the ORNL Sewage Treatment Plant (X01) was caused by a temporary malfunction of an automatic chlorine-control unit. The unit was promptly repaired and it functioned properly thereafter.

The Environmental Monitoring and Compliance (EMC) Department personnel were unable to determine the causes of two total suspended solids noncompliances at the Sewage Treatment Plant.

February 1988

The dissolved oxygen (DO) noncompliance at the Sewage Treatment Plant (X01) was attributed to a temporary low DO excursion in the X01 effluent.

No explanation has been determined for the low pH noncompliance that occurred at the Process Waste Treatment Plant (X07). The condition has not reoccurred at X07.

Table 23. NPDES Discharge Point X01[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Ag	3	< 0.0036	< 0.0036	< 0.0036	0
BOD[c]	39	16	< 5.0	5.3	0.56
Bromodichloromethane	3	< 0.0050	< 0.0050	< 0.0050	0
Cl	39	0.65	0.010	0.37	0.045
Cyanide	3	< 0.0020	< 0.0020	< 0.0020	0
Cu	3	0.0090	< 0.0060	0.0072	0.0019
DO[d]	62	12	4.7	8.6	0.26
Downstream pH[e]	13	7.9	7.4	NA[f]	NA[f]
Fecal coliform[g,h]	39	> 600	< 1.0	19	31
Flow[i]	62	1.6	0.33	0.64	0.035
Hg	3	< 0.00020	< 0.00020	< 0.00020	0
NH_4 (As N)	39	0.95	0.034	0.096	0.051
Oil and grease	39	19	< 2.0	2.7	0.88
pH[e]	13	8.1	6.8	NA[f]	NA[f]
Phenols	3	< 0.0020	< 0.0010	< 0.0013	0.00067
Trichloroethylene	3	< 0.0050	< 0.0050	< 0.0050	0
TSS[j]	39	58	2.0	8.0	3.8
Zn	3	0.080	0.054	0.069	0.016

[a]Sewage Treatment Plant, ORNL.
[b]95% confidence coefficient about the average.
[c]Biological oxygen demand.
[d]Dissolved oxygen.
[e]Expressed in standard units; average not applicable.
[f]NA = not applicable.
[g]Expressed in colonies per 100 mL.
[h]Geometric mean.
[i]Measured in millions of gallons per day.
[j]Total suspended solids.

Table 24. NPDES Discharge Point X02[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Ag	13	0.030	< 0.0024	0.0061	0.0041
As	13	0.078	< 0.018	0.038	0.0094
Cd	13	0.0030	< 0.0012	0.0014	0.00028
Cr	13	0.024	< 0.0036	0.0069	0.0031
Cu	13	0.012	< 0.0018	0.0061	0.0014
Downstream pH[c]	62	9.0	6.9	NA[d]	NA[d]
Fe	13	0.44	0.012	0.11	0.064
Flow[e]	62	0.0099	0	0.0020	0.00059
Mn	13	0.034	0.0032	0.019	0.0044
Ni	13	0.036	< 0.0036	0.0064	0.0049
Oil and grease	13	4.0	< 2.0	2.4	0.43
Pb	13	0.12	< 0.018	0.033	0.015
pH[c]	62	8.1	6.4	NA[d]	NA[d]
Se	13	0.12	< 0.024	0.040	0.014
SO_4	3	1300	900	1100	230
Temperature[f]	3	20	16.4	19	2.5
TSS[g]	13	9.0	< 5.0	6.0	0.75
Zn	13	0.091	< 0.0018	0.017	0.015

[a]Coal Yard Runoff Facility, ORNL.
[b]95% confidence coefficient about the average.
[c]Expressed in standard units; average not applicable.
[d]NA = not applicable.
[e]Measured in millions of gallons per day.
[f]Measured in degrees centigrade.
[g]Total suspended solids.

Table 25. NPDES Discharge Point X03[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L)			
		Max	Min	Av	95% cc[b]
As	5	0.036	< 0.018	0.027	0.0081
Cd	5	0.0020	< 0.0012	0.0014	0.00029
Cr	5	0.0097	< 0.0036	0.0050	0.0024
Cu	5	0.087	0.010	0.030	0.029
Downstream pH[c]	13	8.5	7.6	NA[d]	NA[d]
Fe	5	0.22	0.069	0.13	0.071
Flow[e]	3	0.052	0.0053	0.024	0.029
Ni	5	0.0090	< 0.0036	0.0049	0.0021
Oil and grease	5	3.0	< 2.0	2.4	0.49
P	5	1.1	0.40	0.78	0.23
Pb	5	0.030	< 0.018	0.023	0.0057
pH[c]	13	7.9	7.3	NA[d]	NA[d]
Temperature[f]	5	20.1	3.0	7.0	6.6
TOC[g]	5	11	2.6	5.1	3.0
TSS[h]	5	5.0	< 2.0	4.4	1.2
Zn	5	0.22	0.065	0.11	0.056

[a]1500 area, ORNL.
[b]95% confidence coefficient about the average.
[c]Expressed in standard units; average not applicable.
[d]NA = not applicable.
[e]Measured in millions of gallons per day.
[f]Measured in degrees centigrade.
[g]Total organic carbon.
[h]Total suspended solids.

Table 26. NPDES Discharge Point X04[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Ag	6	0.078	< 0.0036	0.021	0.024
As	6	0.060	< 0.018	0.032	0.013
Cd	6	< 0.0030	< 0.0012	< 0.0015	0.00067
Cr	6	0.024	< 0.0036	0.0089	0.0079
Cu	6	0.017	0.0069	0.011	0.0029
Downstream pH[c]	13	8.0	7.0	NA[d]	NA[d]
Flow[e]	3	0.027	0.00084	0.010	0.017
Ni	6	0.036	< 0.0036	0.0090	0.011
Oil and grease	6	3.0	< 2.0	2.2	0.33
P	6	0.50	0.20	0.30	0.10
Pb	6	0.12	< 0.018	0.040	0.032
pH[c]	13	8.1	6.9	NA[d]	NA[d]
Temperature[f]	2	20	9.8	15	10
TOC[g]	6	5.7	1.5	2.6	1.3
TSS[h]	6	< 5.0	< 5.0	< 5.0	0
Zn	6	0.12	0.067	0.091	0.014

[a]2000 area, ORNL.
[b]95% confidence coefficient about the average.
[c]Expressed in standard units; average not applicable.
[d]NA = not applicable.
[e]Measured in millions of gallons per day.
[f]Measured in degrees centigrade.
[g]Total organic carbon.
[h]Total suspended solids.

Table 27. NPDES Discharge Point X06[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
As	6	0.060	< 0.018	0.032	0.013
Cd	6	0.089	< 0.0012	0.017	0.029
Cr	6	0.024	< 0.0036	0.011	0.0061
Cu	6	0.085	0.031	0.049	0.017
Downstream pH[c]	13	8.1	6.5	NA[d]	NA[d]
Flow[e]	3	0.15	0.15	0.15	0.0033
Ni	6	0.036	< 0.0036	< 0.010	0.010
Oil and grease	6	4.0	< 2.0	2.7	0.84
Pb	6	0.12	< 0.018	0.043	0.031
pH[c]	13	8.0	6.5	NA[d]	NA[d]
Se	6	< 0.12	< 0.024	< 0.046	0.030
SO_4	6	29	25	27	1.0
Temperature[f]	2	20	4.8	13	15
TOC[g]	6	18	2.6	5.9	4.9
TSS[h]	6	6.0	< 5.0	5.2	0.33
Zn	6	0.098	0.063	0.081	0.011

[a]3539/40 ponds, ORNL.
[b]95% confidence coefficient about the average.
[c]Expressed in standard units; average not applicable.
[d]NA = not applicable.
[e]Measured in millions of gallons per day.
[f]Measured in degrees centigrade.
[g]Total organic carbon.
[h]Total suspended solids.

Table 28. NPDES Discharge Point X07[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L)			
		Max	Min	Av	95% cc[b]
Ag	6	0.030	< 0.0036	0.0084	0.0087
As	6	0.060	< 0.018	0.031	0.014
Cd	6	0.0030	< 0.0012	0.0016	0.00057
Cr	6	0.024	< 0.0036	0.0079	0.0066
Cu	6	0.012	< 0.0060	0.0078	0.0018
Downstream pH[c]	13	8.2	6.2	NA[d]	NA[d]
Flow[e]	62	0.19	0.00020	0.031	0.010
Ni	6	0.036	< 0.0036	0.0094	0.011
NO_3	6	5.0	< 5.0	5.0	0
Oil and grease	6	4.0	< 2.0	2.5	0.68
Pb	6	< 0.12	< 0.018	< 0.039	0.033
pH[c]	13	8.4	3.5	NA[d]	NA[d]
SO_4	6	200	140	170	20
Temperature[f]	2	20	7.4	14	13
TOC[g]	6	3.7	1.7	2.5	0.57
TSS[h]	6	< 5.0	< 2.0	< 4.5	1.0
TTO[i]	6	0.16	0	0.042	0.057
Zn	6	0.012	< 0.0018	0.0050	0.0041

[a]Process Waste Treatment Plant (3544), ORNL.
[b]95% confidence coefficient about the average.
[c]Expressed in standard units; average not applicable.
[d]NA = not applicable.
[e]Measured in millions of gallons per day.
[f]Measured in degrees centigrade.
[g]Total organic carbon.
[h]Total suspended solids.
[i]Total toxic organics.

Table 29. NPDES Discharge Point X08[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av
As	1	< 0.036	< 0.036	< 0.036
Cd	1	< 0.0012	< 0.0012	< 0.0012
Cr	1	< 0.0036	< 0.0036	< 0.0036
Cu	1	0.014	0.014	0.014
Downstream pH[b]	1	7.5	7.5	NA[c]
Flow[d]	1	0.0010	0.0010	0.0010
Ni	1	< 0.0036	< 0.0036	< 0.0036
NO_3	1	< 5.0	< 5.0	< 5.0
Oil and grease	1	4.0	4.0	4.0
Pb	1	< 0.030	< 0.030	< 0.030
pH[c]	1	7.2	7.2	NA[c]
SO_4	1	26	26	26
Temperature[e,f]	0			
TOC[g]	1	2.8	2.8	2.8
TSS[h]	1	< 5.0	< 5.0	< 5.0
Zn	1	0.12	0.12	0.12

[a]TRU waste basins, ORNL.
[b]Expressed in standard units; average not applicable.
[c]NA = not applicable.
[d]Measured in millions of gallons per day.
[e]Measured in degrees centigrade.
[f]Not taken.
[g]Total organic carbon.
[h]Total suspended solids.

Table 30. NPDES Discharge Point X09[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av
As	1	< 0.018	< 0.018	< 0.018
Cd	1	0.0021	0.0021	0.0021
Cr	1	0.0066	0.0066	0.0066
Cu	1	0.043	0.043	0.043
Downstream pH[b]	1	7.5	7.5	NA[c]
Flow[d]	1	0.0042	0.0042	0.0042
Ni	1	< 0.0036	< 0.0036	< 0.0036
NO_3	1	< 5.0	< 5.0	< 5.0
Oil and grease	1	3.0	3.0	3.0
Pb	1	< 0.018	< 0.018	< 0.018
pH[c]	1	7.9	7.9	NA[c]
SO_4	1	34	34	34
Temperature[e]	1	20	20	20
TOC[f]	1	6.3	6.3	6.3
TSS[g]	1	5.0	5.0	5.0
Zn	1	0.056	0.056	0.056

[a]HFIR waste basins, ORNL.
[b]Expressed in standard units; average not applicable.
[c]NA = not applicable.
[d]Measured in millions of gallons per day.
[e]Measured in degrees centigrade.
[f]Total organic carbon.
[g]Total suspended solids.

Table 31. NPDES Discharge Point X11[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
As	6	0.060	0.026	0.043	0.011
Cd	6	0.0030	< 0.0012	0.0017	0.00061
Cr	6	0.024	0.0041	0.0099	0.0063
Cu	6	0.085	0.0082	0.027	0.024
Downstream pH[c]	13	8.6	6.2	NA[d]	NA[d]
Flow[e]	3	0.038	0.026	0.031	0.0076
Ni	6	0.036	0.0051	0.013	0.0099
NO_3	13	9.4	< 5.0	5.3	0.68
Oil and grease	6	7.0	< 2.0	3.2	1.7
P	6	4.2	1.3	3.4	0.91
Pb	6	0.12	< 0.018	< 0.039	0.033
pH[c]	13	8.1	1.6	NA[d]	NA[d]
SO_4	13	3400	39	1600	470
Temperature[f]	6	20	0	16	7.8
TOC[g]	13	8.7	3.5	5.9	0.92
TSS[h]	6	42	10	23	9.5
Zn	6	0.84	0.25	0.63	0.17

[a]3518 Acid Neutralization Facility, ORNL.
[b]95% confidence coefficient about the average.
[c]Expressed in standard units; average not applicable.
[d]NA = not applicable.
[e]Measured in millions of gallons per day.
[f]Measured in degrees centigrade.
[g]Total organic carbon.
[h]Total suspended solids.

Table 32. NPDES Discharge Point X13[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Ag	3	< 0.0050	< 0.0050	< 0.0050	0
Al	3	0.25	0.15	0.21	0.061
As	3	< 0.036	< 0.018	< 0.024	0.012
BOD[c]	3	< 5.0	< 5.0	< 5.0	0
Cd	3	< 0.0020	< 0.0020	< 0.0020	0
Chloroform	3	< 0.0050	< 0.0050	< 0.0050	0
Cl	13	0.010	< 0.010	0.010	0
Conductivity[d]	3	340	300	310	27
Cr	3	< 0.0036	< 0.0036	< 0.0036	0
Cu	3	< 0.0060	< 0.0060	< 0.0060	0
DO[e]	13	11	8.0	9.7	0.60
F	3	< 1.0	< 1.0	< 1.0	0
Fe	3	0.20	0.17	0.18	0.018
Flow[f]	62	41	0.36	1.7	1.3
Hg	3	< 0.00005	< 0.00005	< 0.00005	0
Mn	3	0.11	0.068	0.086	0.025
NH_4 (as N)	3	7.2	0.060	2.7	4.5
Ni	3	< 0.0036	< 0.0036	< 0.0036	0
NO_3	3	< 5.0	< 5.0	< 5.0	0
Oil and grease	13	3.0	< 2.0	2.2	0.21
P	3	0.70	< 0.10	0.33	0.37
Pb	3	< 0.0040	< 0.0040	< 0.0040	0
PCB	3	< 0.00050	< 0.00050	< 0.00050	0
pH[g]	3	8.0	8.0	NA[h]	NA[h]
Phenols	3	< 0.0020	< 0.0010	< 0.0013	0.00067
SO_4	3	32	27	30	3.1
TDS[i]	3	240	180	200	37
Temperature[j]	3	8.9	1.6	5.0	4.3
TOC[k]	3	1.9	1.9	1.9	0
Trichloroethylene	3	< 0.0050	< 0.0050	< 0.0050	0
TSS[l]	3	12	< 5.0	7.3	4.7
Turbidity[m]	3	30	5.0	13	17

Table 32. (continued)

January - March 1988

Parameter	No. of Samples	Concentration (mg/L)			
		Max	Min	Av	95% cc[b]
Zn	3	0.0065	< 0.0018	0.0049	0.0031

[a]Melton Branch, ORNL.
[b]95% confidence coefficient about the average.
[c]Biological oxygen demand.
[d]Expressed in μmhos/cm.
[e]Dissolved oxygen.
[f]Measured in millions of gallons per day.
[g]Expressed in standard units; average not applicable.
[h]NA = not applicable.
[i]Total dissolved solids.
[j]Measured in degrees centigrade.
[k]Total organic carbon.
[l]Total suspended solids.
[m]Measured in Jackson turbidity units.

Table 33. NPDES Discharge Point X14[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Ag	3	0.0050	0.0050	0.0050	0
Al	3	1.3	0.28	0.77	0.59
As	3	< 0.036	< 0.018	< 0.024	0.012
BOD[c]	3	< 5.0	< 5.0	< 5.0	0
Cd	3	< 0.0020	< 0.0020	< 0.0020	0
Chloroform	3	0.0080	0.0050	0.0063	0.0018
Cl	13	0.12	< 0.010	0.018	0.017
Conductivity[d]	3	390	300	350	52
Cr	3	0.0047	< 0.0036	0.0040	0.00073
Cu	3	0.015	< 0.0060	0.011	0.0053
DO[e]	13	11	8.8	9.7	0.40
F	3	1.2	1.0	1.1	0.13
Fe	3	1.3	0.23	0.76	0.62
Flow[f]	62	43	3.1	6.7	1.8
Hg	3	0.00010	< 0.00005	0.000083	0.000033
Mn	3	0.10	0.028	0.066	0.042
NH_4 (as N)	3	0.17	0.070	0.11	0.061
Ni	3	< 0.0036	< 0.0036	< 0.0036	0
NO_3	3	< 5.0	< 5.0	< 5.0	0
Oil and grease	13	3.0	< 2.0	2.1	0.15
P	3	0.40	0.30	0.33	0.067
Pb	3	< 0.0040	< 0.0040	< 0.0040	0
PCB	3	< 0.00050	< 0.00050	< 0.00050	0
pH[g]	3	8.1	8.0	NA[h]	NA[h]
Phenols	3	< 0.0020	< 0.0010	< 0.0013	0.00067
SO_4	3	55	44	49	6.4
TDS[i]	3	240	230	240	3.5
Temperature[j]	3	13	8.3	11	2.9
TOC[k]	3	2.3	2.0	2.2	0.18
Trichloroethylene	3	< 0.0050	< 0.0050	< 0.0050	0
TSS[l]	3	15	< 5.0	9.3	5.9
Turbidity[m]	3	20	15	18	3.1

Table 33. (continued)

January - March 1988

Parameter	No. of Samples	Concentration (mg/L)			
		Max	Min	Av	95% cc[b]
Zn	3	0.076	0.037	0.062	0.025

[a]White Oak Creek, ORNL.
[b]95% confidence coefficient about the average.
[c]Biological oxygen demand.
[d]Expressed in μmhos/cm.
[e]Dissolved oxygen.
[f]Measured in millions of gallons per day.
[g]Expressed in standard units; average not applicable.
[h]NA = not applicable.
[i]Total dissolved solids.
[j]Measured in degrees centigrade.
[k]Total organic carbon.
[l]Total suspended solids.
[m]Measured in Jackson turbidity units.

Table 34. NPDES Discharge Point X15[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Ag	3	< 0.0050	< 0.0050	< 0.0050	0
Al	3	1.1	0.39	0.73	0.41
As	3	< 0.036	< 0.018	< 0.024	0.012
BOD[c]	3	< 5.0	< 5.0	< 5.0	0
Cd	3	< 0.0020	< 0.0020	< 0.0020	0
Chloroform	3	< 0.0050	< 0.0050	< 0.0050	0
Cl	13	0.10	< 0.010	0.017	0.014
Conductivity[d]	3	400	350	380	31
Cr	3	0.016	< 0.0036	0.011	0.0075
Cu	3	0.0069	< 0.0060	0.0066	0.00060
DO[e]	13	12	7.1	9.8	0.69
F	3	1.0	1.0	1.0	0
Fe	3	0.94	0.36	0.68	0.34
Flow[f]	62	84	3.6	9.4	3.1
Hg	3	0.00010	< 0.00005	0.000067	0.000033
Mn	3	0.073	0.038	0.056	0.020
NH_4 (as N)	3	0.096	0.070	0.082	0.015
Ni	3	< 0.0036	< 0.0036	< 0.0036	0
NO_3	3	< 5.0	< 5.0	< 5.0	0
Oil and grease	13	4.0	< 2.0	2.5	0.43
P	3	0.20	0.20	0.20	0
Pb	3	< 0.0040	< 0.0040	< 0.0040	0
PCB	3	< 0.00050	< 0.00050	< 0.00050	0
pH[g]	3	8.4	8.1	NA[h]	NA[h]
SO_4	3	49	46	47	1.8
TDS[i]	3	250	210	230	24
Temperature[j]	3	8.3	1.6	4.8	3.9
TOC[k]	3	2.3	2.2	2.2	0.067
Trichloroethylene	3	< 0.0050	< 0.0050	< 0.0050	0
TSS[l]	3	13	< 5.0	8.0	5.0
Turbidity[m]	3	30	8.0	23	15

Table 34. (continued)

January - March 1987

Parameter	No. of Samples	Concentration (mg/L)			
		Max	Min	Av	95% cc[b]
Zn	3	0.024	0.012	0.019	0.0074

[a]White Oak Dam, ORNL.
[b]95% confidence coefficient about the average.
[c]Biological oxygen demand.
[d]Expressed in µmhos/cm.
[e]Dissolved oxygen.
[f]Measured in millions of gallons per day.
[g]Expressed in standard units; average not applicable.
[h]NA = not applicable.
[i]Total dissolved solids.
[j]Measured in degrees centigrade.
[k]Total organic carbon.
[l]Total suspended solids.
[m]Measured in Jackson turbidity units.

Table 35. NPDES miscellaneous source VC7002[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
BOD[c]	3	< 5.0	< 5.0	< 5.0	0
Downstream pH[d]	3	7.8	7.7	NA[e]	NA[e]
Fecal coliform[f]	3	1.0	< 1.0	1.0	0
Oil and grease	3	< 2.0	2.0	< 2.0	0
pH[d]	3	7.7	7.5	NA[e]	NA[e]
Phenols	3	0.0060	0.0010	0.0030	0.0031
TSS[g]	3	19	< 5.0	13	8.3

[a]Vehicle and Equipment Cleaning Facility, Building 7002.
[b]95% confidence coefficient about the average.
[c]Biological oxygen demand.
[d]Expressed in standard units; average not applicable.
[e]NA = not applicable.
[f]Expressed in colonies per 100 mL.
[g]Total suspended solids.

Table 36. NPDES cooling towers[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Cl[c]	0				
Cr	6	0.021	0.0036	0.011	0.0056
Cu	6	0.35	0.0060	0.14	0.11
Flow[d]	6	0.13	0.0011	0.026	0.041
Temperature[e]	6	27	10	18	5.1
Zn	6	0.79	0.081	0.45	0.21

[a]Cooling towers 1505, 2539, 3026, 3517, 4509, and 6000.
[b]95% confidence coefficient about the average.
[c]Not taken.
[d]Measured in millions of gallons per day.
[e]Measured in degrees centigrade.

Table 37. NPDES miscellaneous outfalls

January - March 1988

	Concentration (mg/L)
	Location
Parameter	EF7002[a]
Downstream pH[c]	7.7
Oil and grease	< 2.0
pH[c]	7.5

[a]Vehicle and Equipment Maintenance Facility, Building 7002.
[b]Central Steam Plant, Building 2519.
[c]Expressed in standard units.

Table 38. NPDES discharge point: category II outfalls[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L)			
		Max	Min	Av	95% cc[b]
Flow[c]	44	0.17	0.00013	0.036	0.016
Oil and grease	44	11	2.0	3.0	0.58
pH[d]	44	8.2	5.3	NA[e]	NA[e]
Temperature[f]	44	60	9.7	17	2.7
TSS	44	770	5.0	70	46

[a]ORNL.
[b]95% confidence coefficient about the average.
[c]Measured in millions of gallons per day.
[d]Expressed in standard units; average not applicable.
[e]NA = not applicable.
[f]Measured in degrees centigrade.

Table 39. NPDES discharge point: category III outfalls[a]

January - March 1988

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
Flow[c]	23	0.22	0.00072	0.034	0.023
pH[d]	23	8.7	7.4	NA[e]	NA[e]

[a]ORNL.
[b]95% confidence coefficient about the average.
[c]Measured in millions of gallons per day.
[d]Standard units; average not applicable.
[e]NA = not applicable.

Table 40. NPDES noncompliances

January 1988

Station	Parameter	Concentration (mg/L) Daily Maximum	Permit Limit (mg/L)
Sewage Treatment Plant (X01)	Biological oxygen demand	38.3[a]	26.2[a]
Sewage Treatment Plant (X01)	Total suspended solids	58	45
Sewage Treatment Plant (X01)	Total suspended solids	138.8[a]	39.2[a]
Sewage Treatment Plant (X01)	Total suspended solids	57	45
Sewage Treatment Plant (X01)	Total suspended solids	139.7[a]	39.2[a]
Sewage Treatment Plant (X01)	Total suspended solids	33.5[a,b]	26.2[a,b]
Sewage Treatment Plant (X01)	Residual chlorine	0.65	0.5
3518 Acid Neutralization Facility (X11)	pH	1.6[c,d]	6.0[c,d]

[a]Loading (Kg/d)
[b]Monthly average.
[c]Standard units.
[d]Minimum.
[e]Daily minimum.
[f]Colonies per 100 mL.
[g]Maximum.
[h]Degrees centigrade.

Table 41. NPDES noncompliances

February 1988

Station	Parameter	Concentration (mg/L) Daily Maximum	Permit Limit (mg/L)
Sewage Treatment Plant (X01)	Dissolved oxygen	5.5[e]	6.0[e]
Process Waste Treatment Plant (X07)	pH	3.5[c,d]	6.0[c,d]
3518 Acid Neutralization Facility (X11)	pH	4.6[c,d]	6.0[c,d]
3518 Acid Neutralization Facility (X11)	pH	2.3[c,d]	6.0[c,d]
Category II Outfall 202	Total suspended solids	184	50
Category II Outfall 204	Total suspended solids	109	50
Category II Outfall 206	Total suspended solids	141	50
Category II Outfall 209	Total suspended solids	88	50
Category II Outfall 213	Total suspended solids	542	50
Category II Outfall 216	Total suspended solids	766	50
Category II Outfall 224	Total suspended solids	127	50
Category II Outfall 225	Total suspended solids	454	50

Table 41. (continued)

February 1988

Station	Parameter	Concentration (mg/L) Daily Maximum	Permit Limit (mg/L)
Category II Outfall 243	Total suspended solids	124	50
Category II Outfall 224	Total suspended solids	66	50
Category II Outfall 283	Total suspended solids	90	50

[a]Loading (Kg/d).
[b]Monthly average.
[c]Standard units.
[d]Minimum.
[e]Daily minimum.
[f]Colonies per 100 mL.
[g]Maximum.
[h]Degrees centigrade.

Table 42. NPDES noncompliances

March 1988

Station	Parameter	Concentration (mg/L) Daily Maximum	Permit Limit (mg/L)
Sewage Treatment Plant (X01)	Residual chlorine	0.6	0.5
Sewage Treatment Plant (X01)	Dissolved oxygen	4.7[e]	6.0[e]
Sewage Treatment Plant (X01)	Fecal coliform	> 600[f]	400[f]
Sewage Treatment Plant (X01)	Oil and grease	19	15
Sewage Treatment Plant (X01)	Oil and grease	48.9[a]	13.1[a]
Steam Plant (SP2519)	pH	9.8[c,g]	9.0[g]
Steam Plant (SP2519)	Temperature	41.1[h]	38[h]

[a]*Loading (Kg/d).*
[b]Monthly average.
[c]Standard units.
[d]Minimum.
[e]Daily minimum.
[f]Colonies per 100 mL.
[g]Maximum.
[h]Degrees centigrade.

The total suspended solids noncompliances that were recorded at several Category II outfalls (storage area and parking lot drains) during rainfall were attributed to the fact that many Category II outfalls only flow during rain events; therefore, the resulting effluent often contained the first-flush of accumulated dust and other particulate matter from the area drained by the outfalls.

March 1988

The dissolved oxygen and fecal coliform bacteria noncompliances that were detected at X01 were attributed to the high rainfall event (two inches) that resulted in a temporary excess inflow to X01. The two violations were attributed to the incomplete treatment that the wastewater received during the high inflow condition. Corrective measures have been implemented, including adjustment of the level of X01 effluent aeration may have.

The chlorine level noncompliance that occurred at X01 has been attributed to the possible occurrence of a temporary, high chlorine excursion at the time EMC personnel were measuring effluent chlorine at X01. No operational or equipment problems occurred at X01 at the time.

The pH and temperature exceedances recorded at the ORNL steam plant are currently unavoidable, due to the routing of a portion of the existing wastewater piping at that facility. An investigation is in progress, exploring possible piping and/or treatment alternatives to correct the situation.

The oil and grease violation that occurred at the Sewage Treatment Plant was investigated; however, no clear reason for the incident was determined.

METEOROLOGICAL PROCESSES

The ORNL meteorological system consists of three towers (A, B, and C) with sensors mounted at two levels (10 and 30 meters) for Towers A and B, and three levels (10, 30, and 100 meters) for Tower C. Locations of meteorological towers at ORNL are shown in Figure 7. Data from the sensors are acquired, stored, edited, and formatted by a data collection system consisting of a central processor and remote data logger. One-minute vector averages of wind velocity are calculated in the conventional way and retained for twenty-four hours. These velocities are processed into fifteen-minute averages using a procedure that avoids the unrealistically low windspeed values obtained when appreciable winds of nearly opposite direction are vector averaged in the conventional way. This alternative averaging procedure involves calculating a unit vector to represent the direction of each one-minute wind velocity, finding the vector average of those unit vectors, scaling that average to a unit vector, and multiplying the result by the mean (scalar) windspeed. A similar calculation is used to convert the fifteen-minute averages into hourly averages. The fifteen-minute averages are retained for one day and the hourly averages, from which the wind roses in Figure 8-14 are obtained, are stored for at least one year and eventually archived.

Examination of quarterly wind roses reveal that the prevailing winds are split into two directions that are 180° apart: one prevailing direction is from the SW to WSW sector and the other prevailing direction is from the NE to ENE sector. The winds are strongly aligned along these directions because of the channeling effect induced by the ridge and valley structure of the area. Another feature observed from the wind roses is that the wind speeds increase with height (tower level) at each of the towers. On the average, the wind speeds can be expected to increase steadily from ground level to 100 meters.

ORNL-DWG 86-9142R4

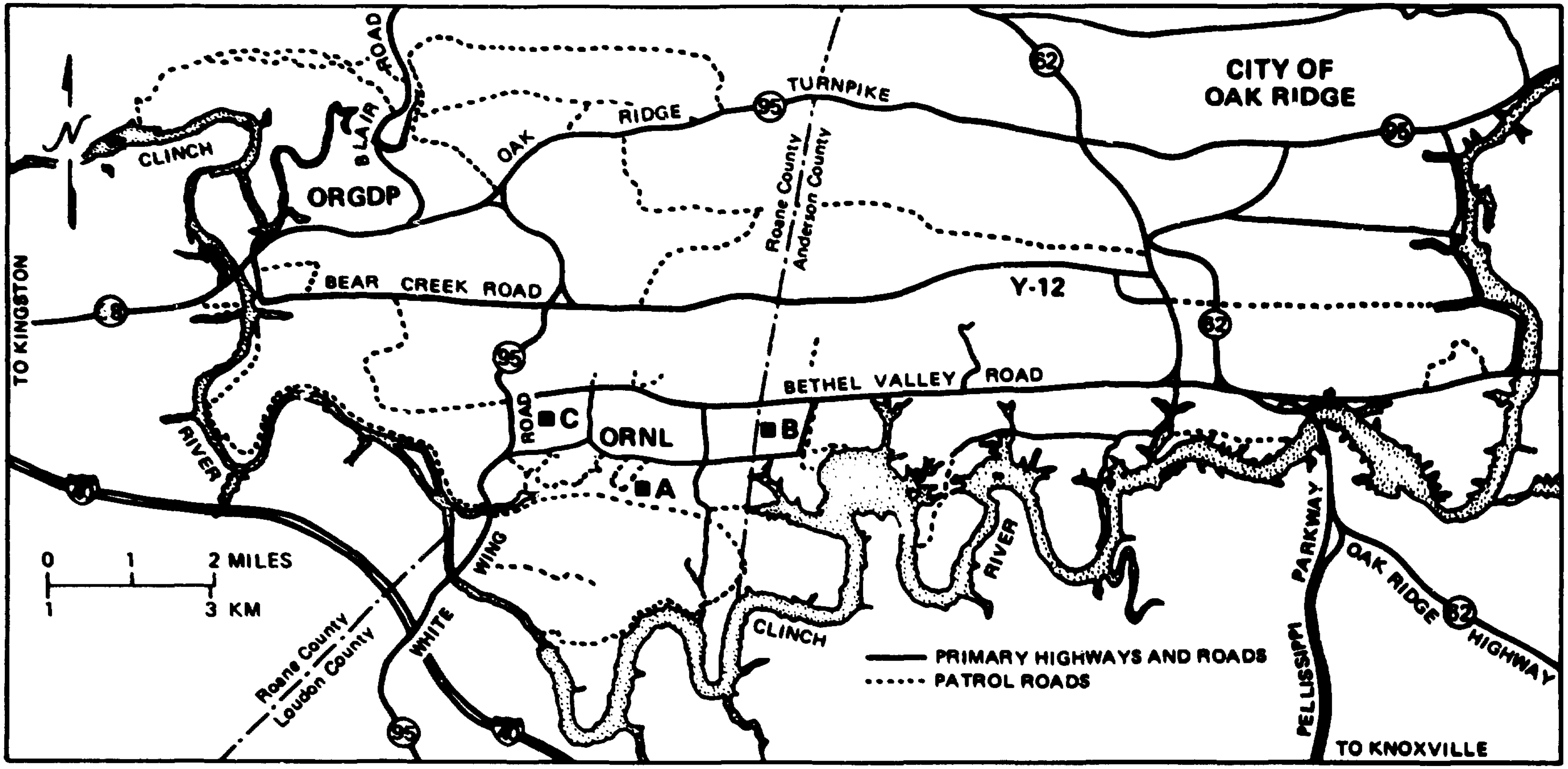

Fig. 7. Locations of meteorological towers at ORNL

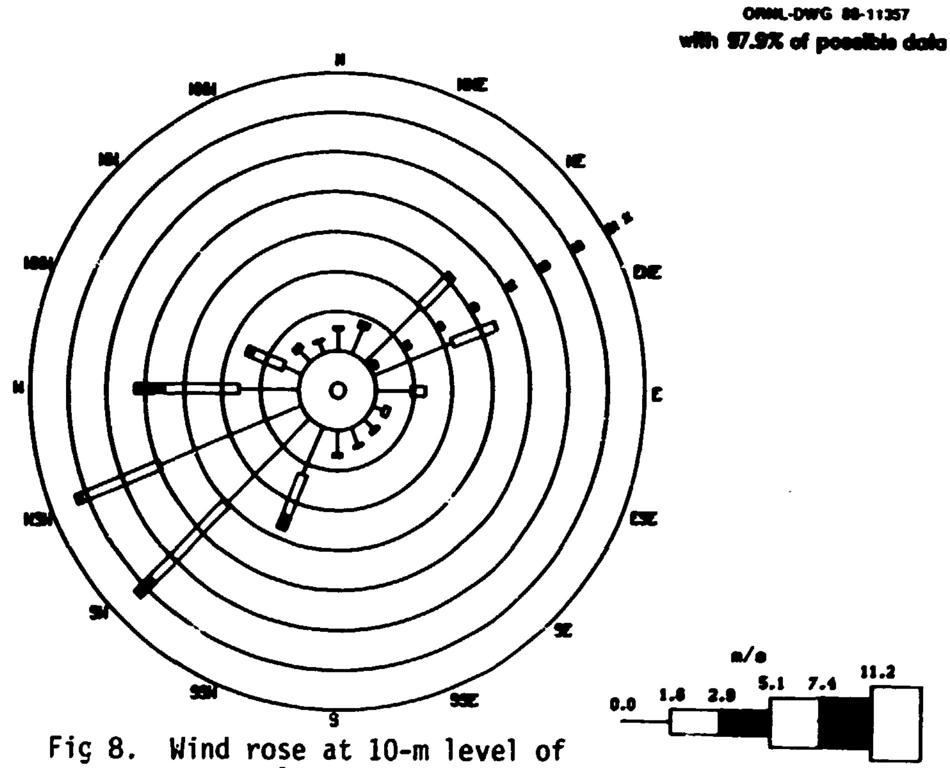

Fig 8. Wind rose at 10-m level of meteorological tower A, January-March 1988

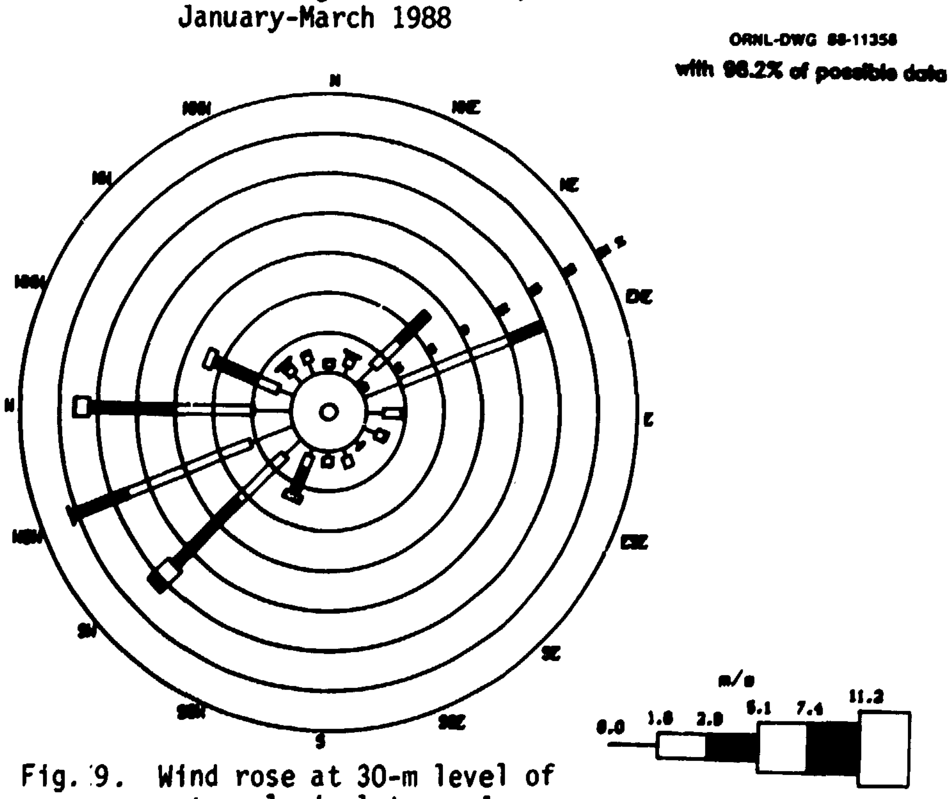

Fig. 9. Wind rose at 30-m level of meteorological tower A, January-March 1988

ORNL-DWG 88-11359
with 84.3% of possible data

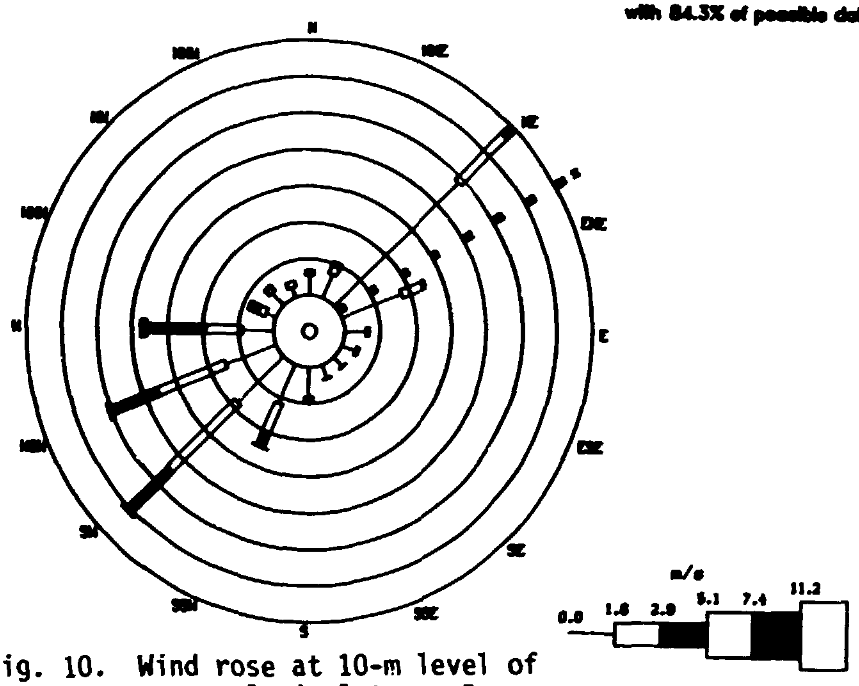

Fig. 10. Wind rose at 10-m level of meteorological tower B, January-March 1988

ORNL-DWG 88-11360
with 97.9% of possible data

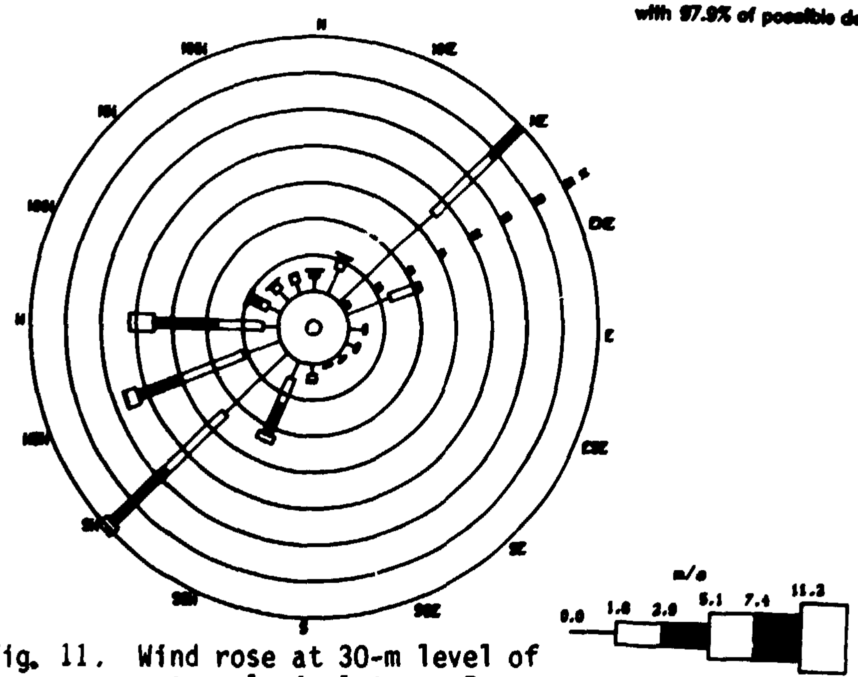

Fig. 11. Wind rose at 30-m level of meteorological tower B, January-March 1988

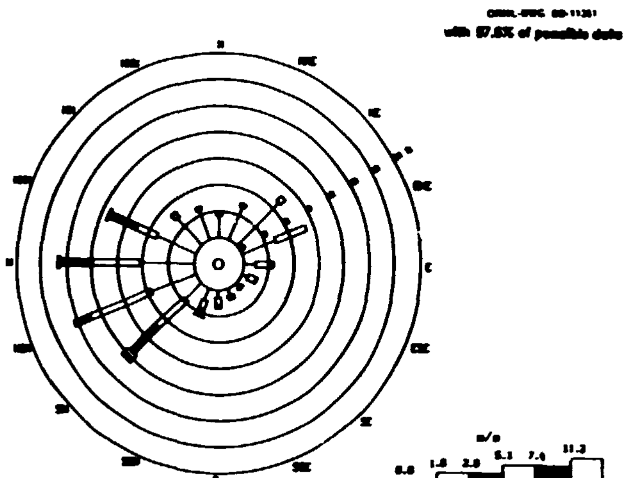

Fig. 12. Wind rose at 10-m level of meteorological tower C, January-March 1988

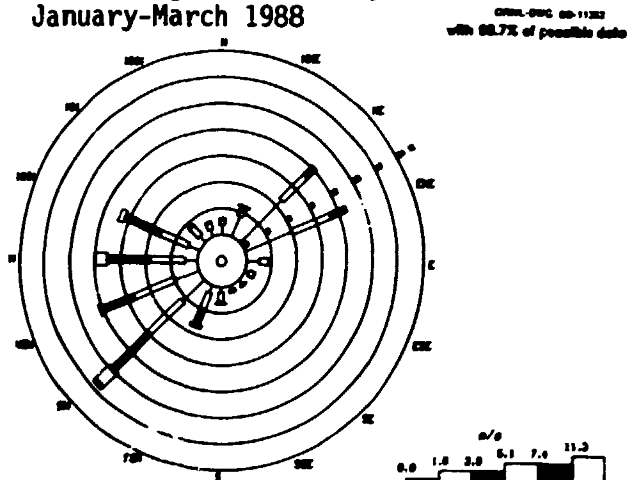

Fig. 13. Wind rose at 30-m level of meteorological tower C, January-March 1988

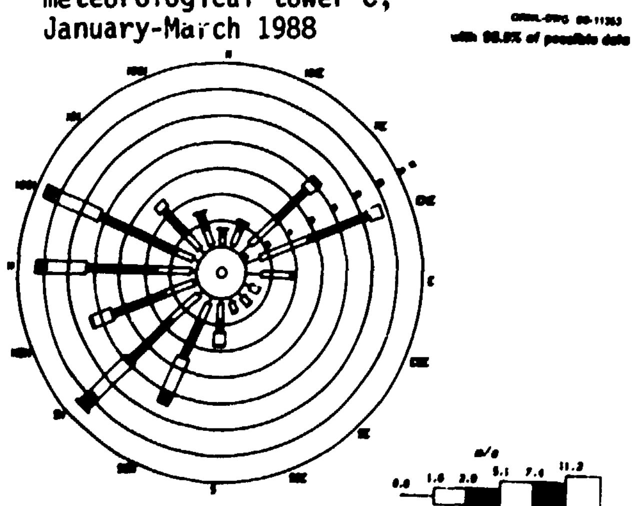

Fig. 14. Wind rose at 100-m level of meteorological tower C, January-March 1988

BIOLOGICAL MONITORING

Milk

Raw milk from five locations and one dairy within a radius of 80 km of Oak Ridge is monitored for ^{131}I and total radioactive Sr. Samples are collected every two weeks from the stations located near the Oak Ridge area (Fig. 15). Three other stations are more remote with respect to the Oak Ridge facilities and are usually sampled semiannually (Fig. 16). None of the remote stations were sampled during this period. At station 7, the cow had a calf, so no milk samples were collected. Samples were analyzed for ^{131}I by gamma spectroscopy and for total radioactive Sr by chemical separation and low-level beta counting. The results (Table 43 and 44) are compared with intake guidelines specified by the Federal Radiation Council.

During the last quarter of 1987, the software program on the Nuclear Data Analyzer for computing the lower limits of detection for the analysis of ^{131}I in milk was updated. The old system used a value of < .08 Bq/L for the detection limit while the new one uses < 0.1 Bq/L. This assumes that the milk samples are brought into the laboratory in the afternoon and are counted the same night. Because ^{131}I has such a short half-life (8.04 d), it quickly decays and the precision of the result decreases. Therefore, detection limits of 0.2 or greater may be observed in the data for this quarter.

Concentrations of total radioactive Sr are shown in Table 44. The average concentration of total radioactive Sr at all stations in the immediate Oak Ridge area was 0.12 Bq/L. This concentration is not significantly different than the average for the fourth quarter of 1987 (0.25 Bq/L). All total radioactive Sr results are within Range I of the FRC guidelines.

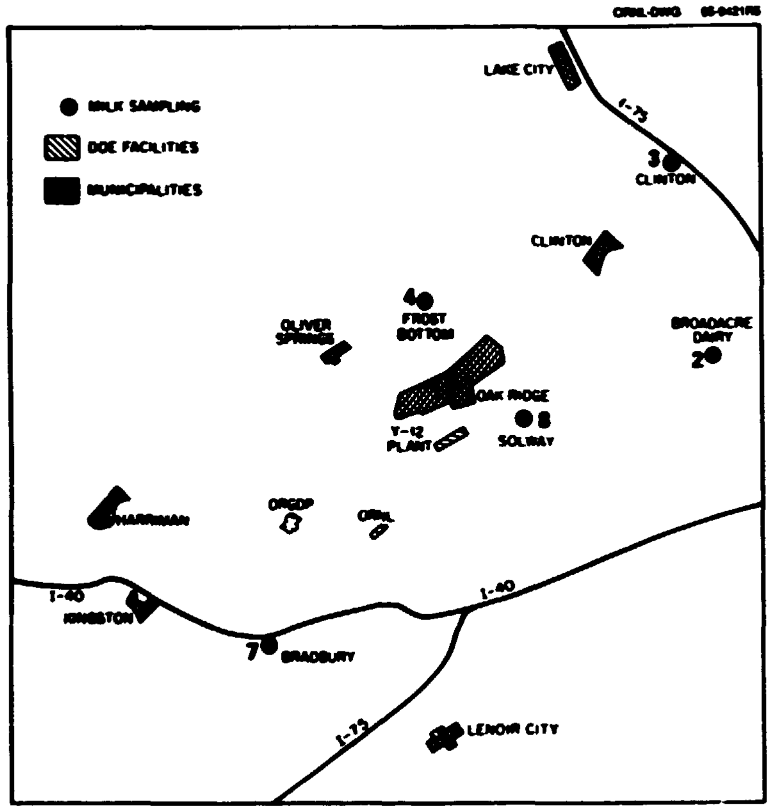

Fig. 15. Locations of milk sampling stations near the Oak Ridge facilities

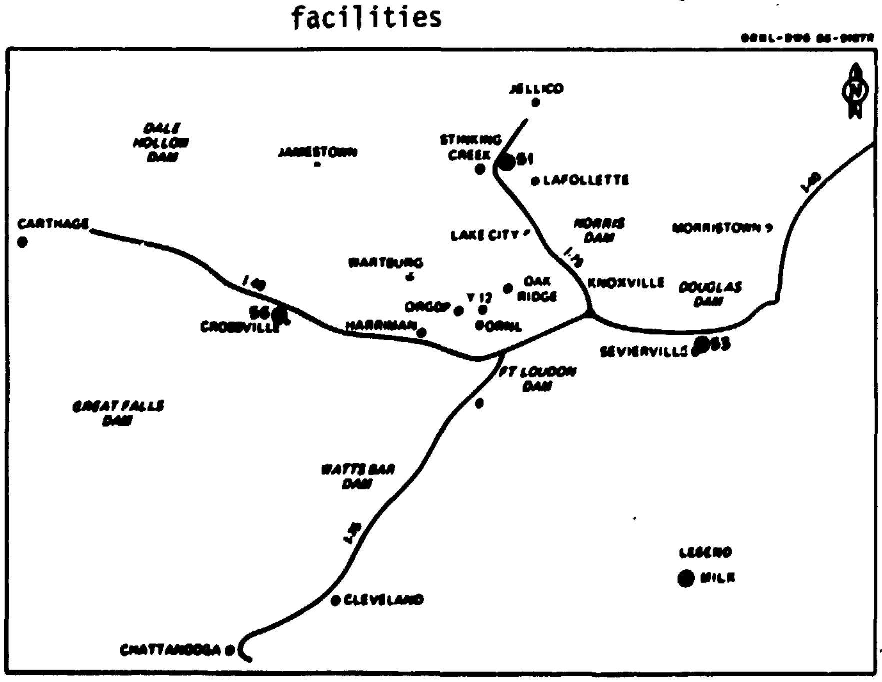

Fig. 16. Locations of milk sampling stations remote from the Oak Ridge facilities

Table 43. Concentrations of ^{131}I in milk[a]

January - March 1988

Station	No. of Samples	Concentration (Bq/L) Max	Min	Av	95%cc[b]	Percent of guideline[c]
			Immediate Environs[d]			
2	7	< 0.20	< 0.10	< 0.13	0.029	34
3	6	< 0.20	< 0.10	< 0.13	0.032	34
4	7	< 0.20	< 0.10	< 0.12	0.028	32
8	7	< 0.20	< 0.10	< 0.13	0.031	36
Network summary	27	< 0.20	< 0.10	< 0.12	0.014	34

[a]Raw milk samples; Station 2 is a dairy.
[b]95% confidence coefficient about the average.
[c]Percent of applicable FRC standard assuming 1 L/d intake:
Range I, 0 - 0.37 Bq/L, adequate surveillance required to confirm calculated intakes.
[d]See Figure 15.

Table 44. Concentrations of total radioactive Sr in milk[a]

January - March 1988

Station	No. of Samples	Concentration (Bq/L) Max	Min	Av	95%cc[b]	Percent of guideline[c]
		Immediate Environs[d]				
2	7	0.25	0.010	0.092	0.066	12
3	6	0.15	0.041	0.094	0.039	13
4	7	0.44	-0.022	0.17	0.12	24
8	7	0.35	-0.030	0.13	0.094	18
Network summary	27	0.44	-0.030	0.12	0.043	17

[a]Raw milk samples; Station 2 is a dairy.
[b]95% confidence coefficient about the average.
[c] Percent of applicable FRC standard assuming 1 L/d intake: Range I, 0 - 0.74 Bq/L, adequate surveillance required to confirm calculated intakes.
[d]See Figure 15.

REFERENCES

Environmental Protection Agency (EPA), 1987. Environmental Radiation Data, Report 50. (April 1987 - June 1987). Eastern Environmental Radiation Facility, Montgomery, Alabama, pp 33.

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