7. ORR ENVIRONMENTAL MONITORING PROGRAMS

Setting

Environmental monitoring is a major activity on the ORR. Environmental monitoring encompasses two activities, effluent monitoring and environmental surveillance. The first is the collection and analysis of samples or measurements of liquid and gaseous effluents at their emission point to determine and quantify contaminants released from the emission point on the ORR. Environmental surveillance consists of the collection and analysis of samples of air, water, vegetation, biota, and other media from the ORR and its surroundings. External radiation is also measured. Data from environmental monitoring activities are used to assess exposures to members of the public and to assess effects on the local population and the environment.

Update

In 1998, the mean value for external gamma radiation measurements for the ORR as measured at five ambient air monitoring stations on the ORR was 5.3 μR/h, which is not statistically different from the mean value of 5.0 μR/h observed at the reference location at Fort Loudoun Dam for the same period. The contribution to external gamma radiation from the DOE facilities, if any, is indistinguishable from background. Similarly, a comparison of sampling data from the ORR perimeter air monitoring stations with that from the reference station in 1998 shows that there are no significant differences in radionuclide concentrations measured at the ORR and at the reference station, suggesting no significant impact to air quality from radionuclides from the reservation.

Under the ORR Environmental Monitoring Plan (EMP), samples are collected and analyzed from 22 surface water locations around the ORR. Except for two locations, which were dry when sampling was attempted, radionuclides were detected at all locations in 1998. The highest levels were detected at the First Creek location and are believed to be the result of the flow of contaminated groundwater from a previously leaking underground radioactive waste storage tank. The situation is under investigation by Bechtel Jacobs Company LLC.

Analyses of locally grown hay, foodstuffs, fish, and milk provided data for assessing potential health impacts given in Chapter 8. Analytical results vary slightly from year to year, but the 1998 results are not significantly different from 1997 or 1996.

7.1 METEOROLOGICAL MONITORING

Seven meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on the ORR. Data collected at the towers are used in routine dispersion modeling to predict impacts from facility operations and as input to emergency response atmospheric models used in the event of accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

7.1.1 Description

The seven meteorological towers, depicted in Fig. 7.1, consist of one 330-ft (100-m) tower (MT5) and one 200-ft (60-m) tower (MT6) at the Y-12 Plant, one 330-ft tower (MT2) and two 100-ft towers (MT3 and MT4) at ORNL, and one 200-ft tower (MT1) and one 100-ft (30-m) tower (MT7) at the ETTP.

Data are collected at different levels to determine the vertical structure of the atmosphere and the possible effects of vertical variations on releases from facilities. At the towers, data are collected at the 32.8-ft level and at the top of the tower. At the 330-ft towers, data are collected at an intermediate 100-ft level as well. At each

ORNL-DWG 87M-7052R5

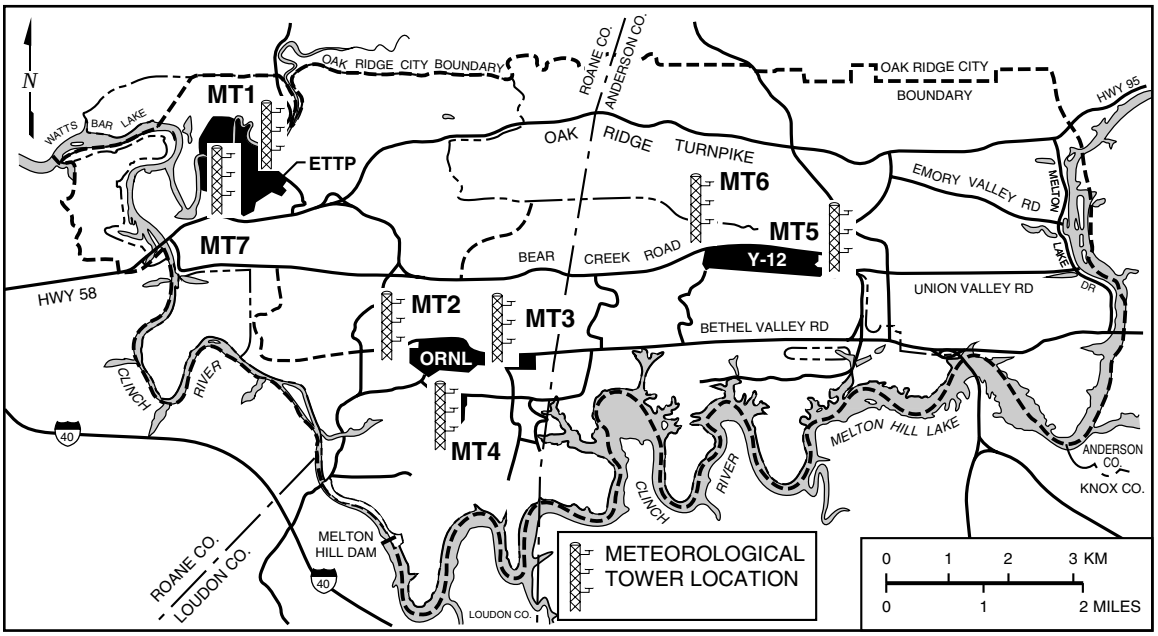

Fig. 7.1 The ORR meteorological monitoring network.

measuring level on each tower, temperature, wind speed, and wind direction are measured. Y-12 MT6 has an additional temperature measurement at 65 ft (20 m). Humidity and data needed to determine atmospheric stability (a measure of the dispersive capability of the atmosphere) are also measured at each tower. Barometric pressure is measured at one tower or more at each facility (MT1, MT2, MT5, and MT7). Precipitation is measured at MT5 and MT6 at the Y-12 Plant, at MT1 and MT7 at the ETTP, and at MT2 at ORNL; solar radiation is measured at MT2 at ORNL, MT1 and MT7 at the ETTP, and MT5 and MT6 at the Y-12 Plant.

Data from the towers at each site are collected by a dedicated control computer. The towers are polled, and the data are filed on disk. Fifteen-minute and hourly values are stored at each site for a running 24-hour period, but only hourly data are routinely stored beyond 24 hours. The meteorological monitoring data from ORNL are summarized monthly as wind roses and data tables. Quarterly calibration of the instruments is conducted for each site by an outside contractor.

Fifteen-minute and hourly data are used directly at each site computer for emergency-response purposes such as input to dispersion models. Annual dose estimates are calculated from archived data (either hourly values or summary tables of atmospheric conditions). Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked invalid and are not input to the dispersion models.

7.1.2 Results

Prevailing winds are generally up-valley from the southwest and west-southwest or down-valley from the northeast and east-northeast. This pattern is the result of the channeling effect of the ridges flanking the site. Winds in the valleys tend to follow the ridges, with limited cross-ridge flow. These conditions are dominant over the entire reservation, with the exception of the ETTP, which is located in a relatively open area that has a more varied flow. Weaker valley flows are noted in this area, particularly in locations near the Clinch River.

On the reservation, low-speed winds predominate at the surface level. This characteristic is noted at all tower locations, as is the increase in wind speed at the height at which measurements are made. This activity is typical of tower locations and is important when selecting appropriate data for input to dispersion studies.

The atmosphere over the reservation is dominated by stable conditions on most nights and in early morning hours. These conditions, coupled with the low wind speeds and channeling effects

of the valleys, result in poor dilution of material emitted from the facilities. These features are captured in the data input to the dispersion models and are reflected in the modeling studies conducted for each facility.

Precipitation data from tower MT2 are used in stream-flow modeling and in certain research efforts. The data indicate the variability of regional precipitation: the high winter rainfall amounts resulting from frontal storms and the uneven, but occasionally intense, summer rainfall associated with thunderstorms.

The average data recovery rate (a measure of acceptable data) across all locations and at the 16 tower levels was approximately 98.75% in 1998. That average includes the data recovery rates for ORNL MT3, which was not calibrated the last quarter of 1998. That meteorological tower is being decommissioned. The maximum data recovery was 99.5% at ORNL MT2 at 30 m (excluding a 99.9% rate at ORNL MT3). The minimum data recovery rate was 97.5% at ETTP MT7 at both 10 and 30 m.

7.2 EXTERNAL GAMMA RADIATION MONITORING

External gamma radiation monitoring is conducted to determine whether radioactive effluents from the ORR are increasing external radiation levels significantly above normal background levels. The data also provide a means for comparing results from year to year and establishing trends.

7.2.1 Data Collection and Analysis

External gamma measurements are recorded weekly at six ambient air stations from resident external gross gamma monitors (Fig. 7.2). Each consists of a dual-range, high-pressure ion chamber sensor and digital electronic count-rate meter and totalizer. Totalizing consists of multiplying the count rate by the time of exposure to obtain total dose.

7.2.2 Results

Table 7.1 summarizes the data collected at

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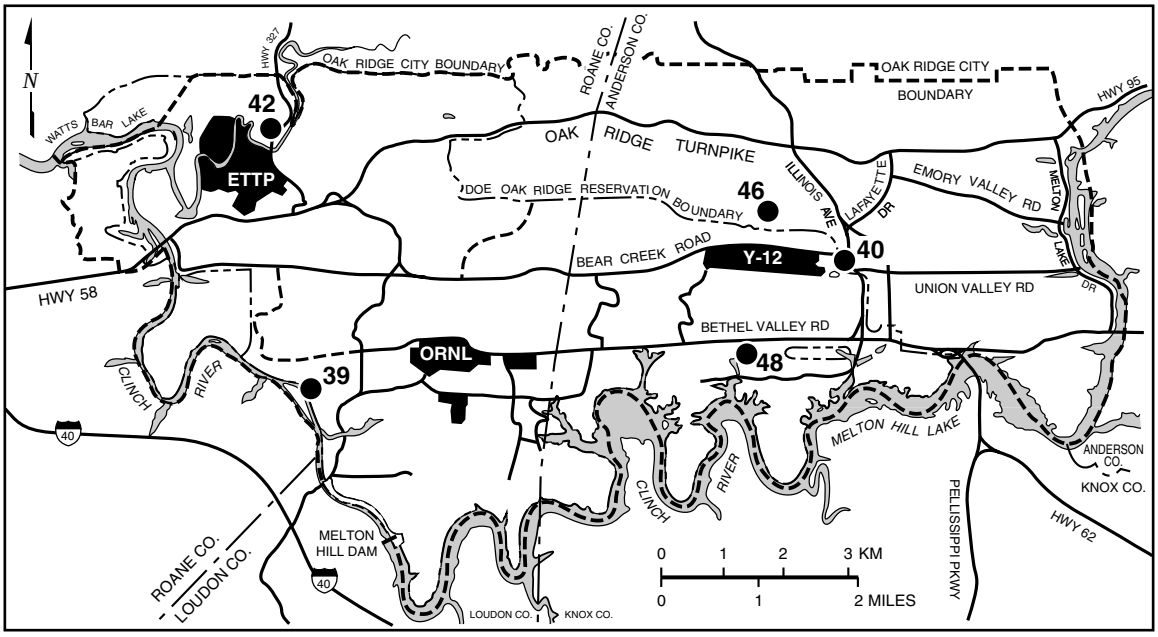

Fig. 7.2 External gamma radiation monitoring locations on the ORR. Location 52, at Fort Loudoun Dam, approximately 15 miles southwest of ORNL, is not shown on this map.

each station during the year. The maximum value of 47.5 μR/h observed at Station 42 on July 14 is an anomaly and was investigated to determine whether instrumentation malfunctions, rather than an actual increase in external gamma activity in the area, led to the extreme reading. Routine calibration procedures were being performed on the resident monitor, resulting in the complete removal and swap-out of instrumentation at the station during the sampling period, which strongly indicates that instrumentation problems led to this unusual reading. Following the observation of the anomalous reading, a portable gamma monitor was deployed to the station, and checks were made several times daily during the next week with no further indication of unusual conditions. Operating personnel at ETTP were not aware of changes in operations or projects that could have led to an increase in external gamma activity during the measurement period. External gamma readings at the other ORR stations, including Station 35, also located at the ETTP, were within normal ranges for the same time interval.

The mean value for the ORR during the year was 5.3 μR/h, which is not statistically different from the mean value of 5.0 μR/h observed at the reference location at Fort Loudoun Dam for the same period. Any contribution to the external gamma signature by the DOE facilities is not distinguishable at the ORR perimeter air monitoring (PAM) locations.

7.3 AMBIENT AIR MONITORING

In addition to exhaust stack monitoring conducted at the DOE Oak Ridge installations, ambient air monitoring is performed to measure radiological and other selected parameters directly in the ambient air adjacent to the facilities. Ambient air monitoring provides direct measurement of airborne concentrations of radionuclides in the environment surrounding the facilities, allows facility personnel to determine the relative level of contaminants at the monitoring locations during an emergency, verifies that the contributions of fugitive and diffuse sources are insignificant, and serves as a check on dose-modeling calculations.

The following sections discuss the ambient air monitoring networks for the ORR. The other monitoring programs are discussed in the site-specific chapters, Chapter 4 (ETTP), Chapter 5 (ORNL), and Chapter 6 (the Y-12 Plant).

7.3.1 ORR Ambient Air Monitoring

The objectives of the ORR ambient air monitoring program are to perform surveillance of airborne radionuclides at the reservation perimeter and to collect reference data from a remote location not affected by activities on the ORR. The ORR PAM network includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 7.3). Reference samples are collected from Station 52 (Fort Loudoun

Table 7.1. External gamma averages, 1998

Location	Number of data values collected	Measurement (μR/h)[a]			Standard error of mean
		Min	Max	Mean	
39	52	5.3	7.4	5.8	0.0004
40	52	4.4	6.4	5.0	0.0003
42	52	4.3	47.5[b]	5.5	0.0059
46	52	4.8	6.6	5.6	0.0004
48	51	3.0	5.6	4.6	0.0005
52	51	4.6	6.0	5.0	0.0003

[a]To convert microroentgens per hour (μR/h) to milliroentgens per year, multiply by 8.760.
[b]Anomalous result due to suspected instrument problems.

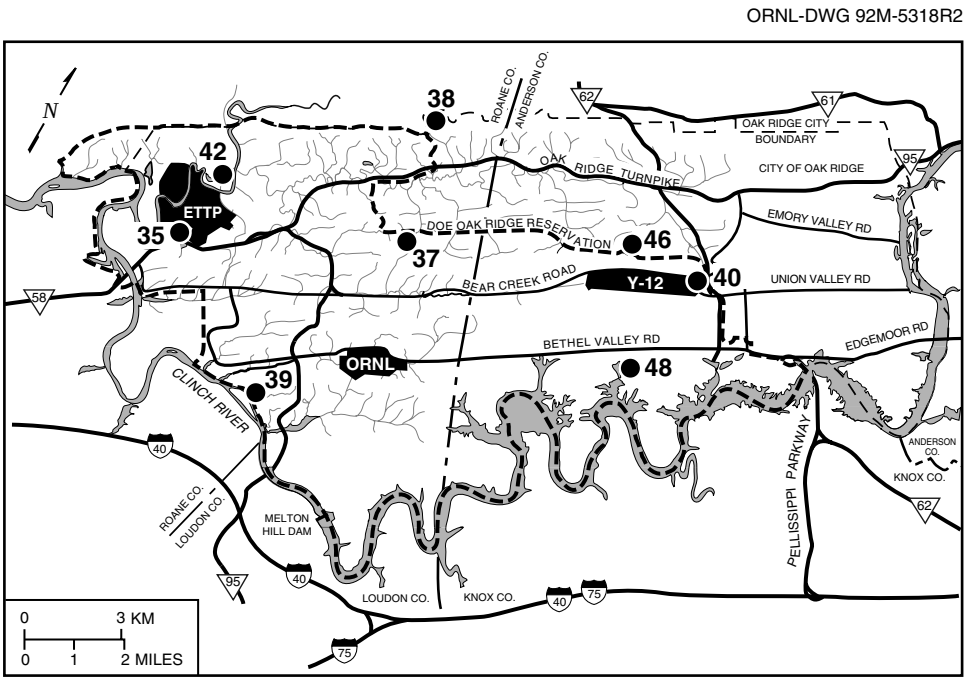

Fig. 7.3. Location of ORR perimeter air monitoring stations.

Dam). Sampling was conducted at each ORR station during 1998 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides and tritium.

Atmospheric dispersion modeling was used to select appropriate sampler locations. The locations selected are those most likely to be affected by releases from the Oak Ridge facilities. Therefore, it is predicted that no residence or business in the vicinity of the ORR would be affected by undetected releases of radioactive materials. To provide an estimate of background radionuclide concentrations, an additional station is located at Fort Loudoun Dam, a site not affected by releases from the ORR.

The sampling system consists of two separate instruments. The particulates are captured using a high-volume air sampler on glass-fiber filters. The filters are collected weekly, composited quarterly, then submitted to the laboratory for isotopic analysis. The second system is designed to collect tritiated water vapor. The sampler consists of a prefilter followed by an adsorbent trap consisting of indicating silica gel. The samples are collected weekly or biweekly, composited quarterly, then submitted to the laboratory for tritium analysis.

The ORR ambient air network (Fig. 7.3) provides appropriate monitoring for all facilities within the reservation, which eliminates the necessity for site-specific ambient air programs. As part of the ORR network, an ambient air monitoring station located in the Scarboro community of Oak Ridge (Station 46) measures offsite impacts of the Y-12 Plant operation. Station 40 of the ORR network monitors the east end of the Y-12 Plant, and Station 37 monitors the overlap of the Y-12 Plant, ORNL, and ETTP emissions.

7.3.2 Results

Data from the ORR PAM stations are analyzed to assess the impact to air quality of operations on the entire reservation. The background station provides information on reference concentrations of radionuclides and gross parameters for the region. A comparison of ORR PAM station sampling data with those from the reference station at the 95% confidence level shows that there are no significant differences in the radionuclide concentrations measured at the ORR stations and those from the reference station (Table 7.2).

Table 7.2. Radionuclide concentrations at ORR perimeter air monitoring stations, 1998[a,b]

Station	^{7}Be	^{60}Co	^{137}Cs	^{40}K	^{3}H	^{234}U	^{235}U	^{238}U	Gross alpha	Gross beta
35	1.8E–14	*c*	*c*	*c*	*c*	1.1E–17	4.5E–19	1.4E–17	2.0E–15	4.6E–15
37	1.8E–14	*c*	2.5E–17	*c*	2.6E-12	1.0E–17	5.9E–19	1.5E–17	1.5E–15	3.7E–15
38	2.2E–14	6.8E–17	*c*	*c*	6.9E-13	8.5E–18	8.5E–19	1.2E–17	*c*	4.0E–15
39	1.8E–14	*c*	*c*	*c*	*c*	5.5E–18	*c*	8.6E–18	*c*	3.7E–15
40	2.6E–14	*c*	2.3E–17	c	3.5E-12	1.8E–17	1.0E–18	1.3E–17	1.9E–15	4.7E–15
42	2.8E–14	*c*	*c*	*c*	*c*	1.0E–17	*c*	1.3E–17	3.0E–15	*c*
46	3.7E–14	*c*	*c*	*c*	*c*	1.5E–17	*c*	1.5E–17	*c*	*c*
48	2.7E–14	4.2E–17	3.9E–17	*c*	8.1E-13	7.0E–18	4.6E–19	7.1E–18	2.2E–15	6.4E–15
52[d]	3.1E–14	*c*	3.6E–17	4.7E–16	3.3E-12	5.0E–18	7.5E–19	4.6E–18	2.4E–15	*c*

[a]All values are mean concentrations.
[b]Units are μCi/mL.
[c]Not detected at 95% confidence level.
[d]Reference location.

Table 7.3 represents the average concentration of three isotopes of uranium at each station for sampling years 1995, 1996, 1997, and 1998.

There are no statistically significant differences between any of the concentrations for the three uranium isotopes when comparing the perimeter network averages with the concentrations measured at the reference station (Station 52).

7.4 SURFACE WATER MONITORING

7.4.1 ORR Surface Water Monitoring

Under the ORR Environmental Monitoring Plan (EMP) (DOE 1998d), samples are collected and analyzed from 22 locations around the ORR to assess the impact of past and current DOE operations on the quality of local surface water. Sampling locations include streams downstream of ORR waste sources, reference points on streams and reservoirs upstream of waste sources, and public water intakes (Fig. 7.4). Sampling locations include the following:

- Bear Creek downstream from Y-12 Plant inputs [Bear Creek kilometer (BCK) 0.6],
- Clinch River downstream from all DOE inputs [Clinch River kilometer (CRK) 16],
- water supply intake for the ETTP (CRK 23),
- Clinch River downstream from ORNL (CRK 32),
- water supply intake for Knox County (CRK 58),
- Melton Hill Reservoir above city of Oak Ridge water intake (CRK 66),
- Clinch River (Solway Bridge) upstream from all DOE inputs (CRK 70),
- EFPC prior to entering Poplar Creek [East Fork Poplar Creek kilometer (EFK) 0.1],
- EFPC downstream from floodplain (EFK 5.4),
- Melton Branch downstream from ORNL [Melton Branch kilometer (MEK) 0.2],
- Mitchell Branch upstream from the ETTP [Mitchell Branch kilometer (MIK) 1.4],
- WOL at WOD [White Oak Creek kilometer (WCK) 1.0],
- WOC downstream from ORNL (WCK 2.6),

Table 7.3. Uranium concentrations in ambient air on the ORR

Isotope	Concentration (10^{-15} µCi/mL)			
	1995	1996	1997	1998
Station 35				
^{234}U	1.5E–02	2.2E–02	4.0E–02	1.1E–02
^{235}U	4.4E–04	1.3E–03	2.1E–03	4.5E–04
^{238}U	1.8E–02	3.4E–02	4.6E–02	1.4E–02
Station 37				
^{234}U	1.3E–02	2.0E–02	5.4E–02	1.0E–02
^{235}U	1.4E–03	7.2E–04	4.4E–03	5.9E–04
^{238}U	1.3E–02	2.1E–02	5.3E–02	1.5E–02
Station 38				
^{234}U	1.1E–02	1.6E–02	5.3E–02	8.5E–03
^{235}U	2.7E–04	9.2E–04	1.8E–03	8.5E–04
^{238}U	1.1E–07	2.0E–02	4.4E–02	1.2E–02
Station 39				
^{234}U	1.1E–02	1.4E–02	4.6E–02	5.5E–03
^{235}U	1.1E–03	6.2E–04	1.6E–03	6.0E–04
^{238}U	9.1E–03	1.2E–02	6.1E–02	8.6E–03
Station 40				
^{234}U	5.1E–02	4.6E–02	2.2E–01	1.8E–02
^{235}U	3.4E–03	1.8E–03	5.8E–03	1.0E–03
^{238}U	1.6E–02	1.7E–02	5.9E–02	1.3E–02
Station 42				
^{234}U	1.1E–02	1.8E–02	7.2E–02	1.0E–02
^{235}U	1.3E–03	1.3E–03	6.2E–03	7.1E–04
^{238}U	1.1E–02	2.0E–02	3.9E–02	1.7E–02
Station 46				
^{234}U	2.6E–02	2.3E–02	1.0E–01	1.5E–02
^{235}U	1.7E–03	1.1E–03	3.7E–03	8.8E–04
^{238}U	1.1E–02	1.9E–02	4.7E–02	1.5E–02
Station 48				
^{234}U	1.3E–02	2.8E–02	5.3E–02	7.0E–03
^{235}U	1.0E–03	6.9E–04	4.3E–03	4.6E–04
^{238}U	9.5E–03	1.3E–02	4.8E–02	7.1E–03
Station 52				
^{234}U	1.2E–02	9.4E–03	4.1E–02	5.0E–03
^{235}U	2.2E–03	1.4E–03	3.6E–03	7.5E–04
^{238}U	8.9E–03	9.3E–03	3.7E–02	4.6E–03

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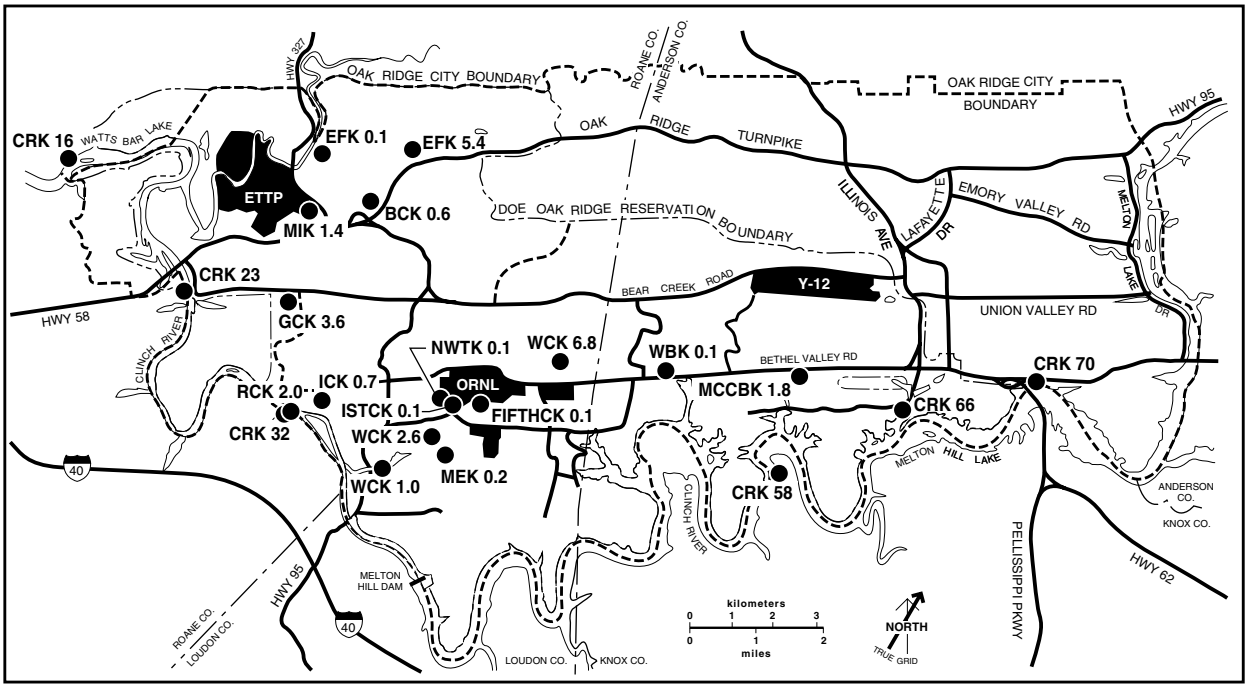

Fig. 7.4. Locations of ORR surface water surveillance sampling stations.

- WOC upstream from ORNL (WCK 6.8)
- Grassy Creek upstream of SEG and IT Corp. at CRK 23 [Grassy Creek kilometer (GCK) 3.6],
- Ish Creek prior to entering CRK 30.8 [Ish Creek kilometer (ICK) 0.7],
- Raccoon Creek sampling station prior to entering CRK 31 [Raccoon Creek kilometer (RCK) 2.0],
- Northwest Tributary prior to entering CRK 31 [Northwest Tributary kilometer (NWTK) 0.1],
- First Creek just upstream of NWT [First Creek kilometer (1STCK) 0.1], and
- Fifth Creek just upstream of White Oak Creek (ORNL) [Fifth Creek kilometer (FIFTHCK) 0.1].
- Walker Branch prior to entering CRK 53.4 [Walker Branch kilometer (WBK) 0.1].
- McCoy Branch prior to entering CRK 60.3 [McCoy Branch kilometer (MCCBK) 1.8].

Water quality measurements serve as guides to the general health of the environment. The sampling and analysis in this program are conducted in addition to requirements mandated in National Pollutant Discharge Elimination System (NPDES) permits for individual ORR DOE facilities. Although there is some overlap of sampling sites in the NPDES and environmental monitoring plan programs, frequency and analytical parameters vary between the two programs.

Sampling frequency and parameters vary by site. Grab samples are collected and analyzed for general water quality parameters at all locations, and all are screened for radioactivity and analyzed for specific radionuclides when appropriate. A few sites also are checked for volatile organic compounds (VOCs) and/or polychlorinated biphenyls (PCBs). Samples at three Clinch River sites (CRK 16, CRK 23, and CRK 70) are analyzed for metals. Table 7.4 lists the specific locations and their sampling frequencies and parameters.

Most of these sampling locations are classified by Tennessee for certain uses (e.g., domestic water supplies or recreational use). Tennessee water quality criteria for domestic water supplies, for freshwater fish and aquatic life, and for recreation (water and organisms) are used as references for locations where they are applicable. The Tennessee water quality criteria do not include criteria for radionuclides.

Table 7.4. Surface water sampling locations, frequencies, and parameters

Location (K indicates kilometer)	Frequency	Parameters
BCK 0.6; Bear Creek downstream from Y-12 Plant inputs	Semiannually (Apr, Oct)	Gross alpha, gross beta, gamma scan, field measurements[a]
CRK 16; Clinch River downstream from all DOE inputs	Monthly	Volatiles, metals, gross alpha, gross beta, gamma scan, field measurements[a]
CRK 23; water supply intake for the ETTP	Monthly	Volatiles, metals, gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[a]
CRK 32; Clinch River downstream from ORNL	Monthly	Gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, field measurements[a]
CRK 58; water supply intake for Knox County	Monthly	Gross alpha, gross beta, gamma scan, field measurements[a]
CRK 66; Melton Hill Reservoir above city of Oak Ridge	Monthly	Gross alpha, gross beta, gamma scan, field measurements[a]
CRK 70; Solway Bridge	Monthly	Volatiles, metals, gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[a]
EFK 0.1; East Fork Poplar Creek prior to entering Poplar Creek	Semiannually (Apr, Oct)	Gross alpha, gross beta, gamma scan, field measurements[a]
EFK 5.4; East Fork Poplar Creek downstream from floodplain	Semiannually (Apr, Oct)	Gross alpha, gross beta, gamma scan, field measurements[a]
MEK 0.2; Melton Branch downstream from ORNL	Bimonthly (Jan, Mar, May, Jul, Sep, Nov)	Gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, field measurements[a]
MIK 1.4; Mitchell Branch upstream from the ETTP	Quarterly (Feb, May, Aug, Nov)	Volatiles, PCBs, gross alpha, gross beta, field measurements[a]
WCK 1.0; White Oak Lake at White Oak Dam	Monthly	PCBs, gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, field measurements[a]
WCK 2.6; White Oak Creek downstream from ORNL	Bimonthly (Jan, Mar, May, Jul, Sep, Nov)	Gross alpha, gross beta, gamma scan, total radioactive strontium, tritium, field measurements[a]
WCK 6.8; White Oak Creek upstream from ORNL	Quarterly (Feb, May, Aug, Nov)	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[a]
WBK 0.1; Walker Branch prior to entering CRK 53.4	Semiannually (Apr, Oct)	Gross alpha, gross beta, gamma scan, field measurements[a]
MCCBK 1.8; McCoy Branch prior to entering CRK 60.3	Semiannually (Apr, Oct)	Gross alpha, gross beta, gamma scan, field measurements[a]

Table 7.4 (continued)

Location (K indicates kilometer)	Frequency	Parameters
GCK 3.6; Grassy Creek upstream of SEG and IT Corp. at CRK 23	Semiannually (Apr, Oct)	Gross alpha, gross beta, gamma scan, field measurements[a]
ICK 0.7; Ish Creek prior to entering CRK 30.8	Semiannually (Apr, Oct)	Gross alpha, gross beta, gamma scan, field measurements[a]
RCK 2.0; Raccoon Creek sampling station prior to entering CRK 31	Semiannually (Apr, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[a]
NWTK 0.1; Northwest Tributary prior to entering CRK 31 (ORNL)	Semiannually (Apr, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[a]
1STCK 0.1; First Creek just upstream of NWT (ORNL)	Semiannually (Apr, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[a]
FIFTHCK 0.1; Fifth Creek just upstream of White Oak Creek (ORNL)	Semiannually (Apr, Oct)	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[a]

[a]Field measurements consist of dissolved oxygen, pH, and temperature.

7.4.2 Results

Radionuclides were detected (statistically significant at a 95% confidence interval) at all surface water locations in 1998 except WBK 0.1 and GCK 3.6 (Table D.3 in Appendix D). Both of these locations were dry when sampling was attempted in October. High levels of gross alpha, gross beta, and total radioactive strontium continue to be detected at the First Creek (1STCK 0.1) location. The levels are seasonal: lower in the spring (wet season) because of dilution. Uranium isotopes, including ^{233}U, ^{234}U, ^{235}U, and ^{238}U, were determined to be the primary alpha emitters. These phenomena are believed to be related to the findings at Core Hole 8 and are being further investigated by Bechtel Jacobs Company LLC. In June 1991, rock core drilling at Core Hole 8 revealed radiologically contaminated groundwater, referred to as the Core Hole 8 plume, in the uppermost portion of bedrock. The source of the plume was believed to be leakage to backfill and soil from underground radioactive waste storage Tank W-1A, which is located in the North Tank Farm within the main ORNL facilities complex. Because groundwater flows toward First Creek from the tank area, it is thought that radionuclides detected in those surface waters originate in soils surrounding Tank W-1A (DOE 1998a). Work conducted in 1998 indicates that there is infiltration of storm drains that discharge into Outfall 341, which discharges into First Creek.

Considering the remaining 21 locations, the highest levels of gross beta, total radioactive strontium, and tritium continue to be at Melton Branch downstream from ORNL (MEK 0.2), WOC at WOD (WCK 1.0), and WOC downstream from ORNL (WCK 2.6) (Table D.3 in Appendix D). These data are consistent with historical data and with the processes or legacy activities nearby or upstream from these locations.

A few locations were checked for volatile organic compounds; either they were not detected or were detected in small quantity (Table D.3 in Appendix D). The common laboratory contaminants detected were either present in the associated laboratory blanks or were detected at low, estimated levels. PCBs were not detected at either of the two locations where PCBs are analyzed (MIK 1.4 and WCK 1.0). Except for zinc, detected in 3 samples out of 12 at CRK 70, above all input from the ORR, and lead in 1 sample out of 12 at CRK 70, no metals of human health concern were detected (See Table D.3 in Appendix D).

Two locations, Northwest Tributary (NWTK 0.1) and Raccoon Creek (RCK 2.0), also had

elevated levels of gross beta and total radioactive strontium. Results at both locations have a seasonal pattern. Concentrations at Northwest Tributary are higher in the spring; whereas, concentra tions at Raccoon Creek are higher in the fall. Both of these locations are impacted by contaminated groundwater from Solid Waste Storage Area (SWSA) 3.

7.5 ORR SEDIMENT

Stream and lake sediments act as a record of some aspects of water quality by concentrating and storing certain contaminants. The sediment sampling program underwent reevaluation in 1996, which resulted in significant modification to the sampling locations and parameters of interest beginning with 1997. Sampling sites are the Clinch River downstream from all DOE inputs (CRK 16), the Clinch River downstream from ORNL (CRK 32), and one background location, the Clinch River at the Solway Bridge upstream from all DOE inputs (CRK 70) (Fig. 7.5). The locations are sampled annually and, under the revised program, gamma scans were performed on the samples in 1998.

An additional sampling component was added to the program in 1997. Samples containing settleable solids are collected on a semiannual basis in conjunction with a heavy rain event to characterize sediments that exit the ORR during a storm event. The sampling locations are Melton Branch upstream from ORNL (MEK 2.1), WOL at WOD (WCK 1.0), and WOC downstream from ORNL (WCK 2.6) (Fig. 7.5). These samples are filtered, and the residue (settleable solids) is analyzed for gross alpha emitters, gross beta emitters, and gamma emitters.

7.5.1 Results

Potassium-40 was the only radionuclide detected by the gamma scan of samples from the upstream location (CRK 70). Downstream from ORNL at CRK 32, ^{137}Cs and ^{40}K were detected in the samples analyzed. At CRK 16, which is downstream from all DOE inputs, only ^{137}Cs and ^{40}K were detected by the gamma scan of the samples. Potassium-40 is a naturally occurring radio-nuclide. None of the radionuclide concentrations at any of the three locations pose a problem for humans.

The heavy rain events sampling took place in March and June 1998. Cobalt-60 and ^{137}Cs were not detected in the settleable solids of the samples from the location upstream from ORNL; however, they were detected at the other two locations. Gross alpha and gross beta were detected at all three locations, with the upstream location having the least and the downstream location having the most. The March results and associated counting statistics are higher than the June values. Sample size has a strong impact on counting statistics, and

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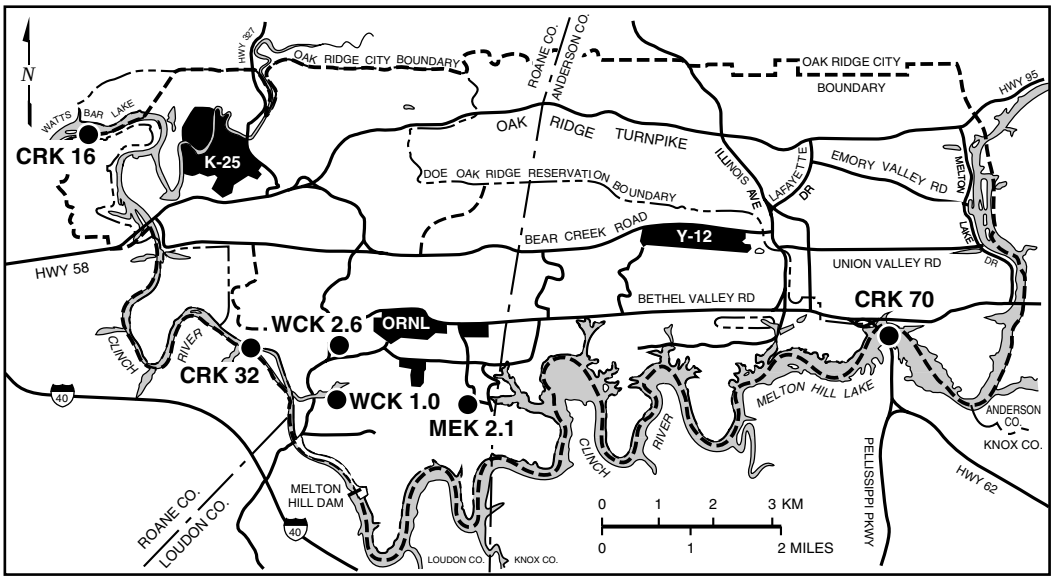

Fig. 7.5. ORR environmental monitoring plan sediment sampling locations.

the March settleable solid sample size was less than that filtered in June.

7.6 FOOD

Collection and analysis of vegetation samples serves three purposes: to evaluate potential radiation doses received by people consuming food crops; to predict possible concentrations in meat, eggs, and milk from animals consuming grains; and to monitor trends in environmental contamination and possible long-term accumulation of radionuclides.

7.6.1 Hay

Hay is cut on the ORR and sold to area farmers for fodder. Six areas from which hay is cut have been identified as potential depositional areas for airborne materials from ORR sources (Fig. 7.6). Areas 1, 2, and 3 are within the predicted air plume for an ORNL source and could also be affected by the ETTP. Area 8 is near Fort Loudoun Dam outside the influence of the ORR. Baled hay was collected from sites 1, 2, and 3 and composited for analysis. Areas 2, 4, 5, and 6 are within the predicted air plume for an ETTP, an ORNL, and a Y-12 Plant source. Baled hay was collected from each of these sites and composited for laboratory analysis. Area 6 best represents the combined plumes from all three sites; baled hay was collected from this site. Area 8, not shown on Fig. 7.6, represents a reference site near the Fort Loudoun ambient air monitoring station (Station 52). Hay was collected and analyzed from this site, too.

7.6.2 Results

Hay samples were collected during September 1998, and samples were analyzed for gross alpha and beta, and gamma emitters. Table 7.5 summarizes the results of the sampling effort. Composite samples from all areas and Area 8 had measurable and similar concentrations of ^{137}Cs, indicating no appreciable difference between the radionuclide content of hay from the ORR-influenced sites and the off-site reference site. Beryllium-7 is a naturally occurring isotope. There were no other significant radiological results in the 1998 hay samples.

7.7 VEGETABLES

Tomatoes and lettuce were purchased from local farmers near the ORR. The locations were chosen based on availability and the likelihood of being affected by routine releases from the Oak Ridge facilities. Lettuce and turnip greens were also purchased from an additional Scarboro location in support of another monitoring activity.

7.7.1 Results

Samples were analyzed for gross alpha, gross beta, and gamma emitters. Table 7.6 summarizes the results of the sampling effort. Gross alpha was detected in one of the lettuce samples, and gross beta was detected in all of the samples. Cesium-137, ^{60}Co, ^{7}Be, and ^{40}K are detected by the gamma scan. Beryllium-7 and ^{40}K are naturally occurring radionuclides. Information regarding potential health impacts associated with chemical and radiological constituents detected in the lettuce and tomatoes is discussed in Chap. 8. A person receiving the maximum potential dose from both types of produce (excluding ^{7}Be and ^{40}K) could have received 0.069 mrem from the radionuclides that could have been released from the ORR (see Chap. 8 for details).

7.8 MILK

Ingestion is one of the pathways of exposure to radioactivity for humans. Radionuclides can be transferred from the environment to people via food chains such as the grass-cow-milk pathway. Milk is a potentially significant source to humans of some radionuclides deposited from airborne emissions because of the relatively large surface area that a cow can graze daily, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

The 1998 milk sampling program consisted of grab samples collected every other month from three locations in the vicinity of the ORR (Fig. 7.7) Milk samples are analyzed at ORNL for

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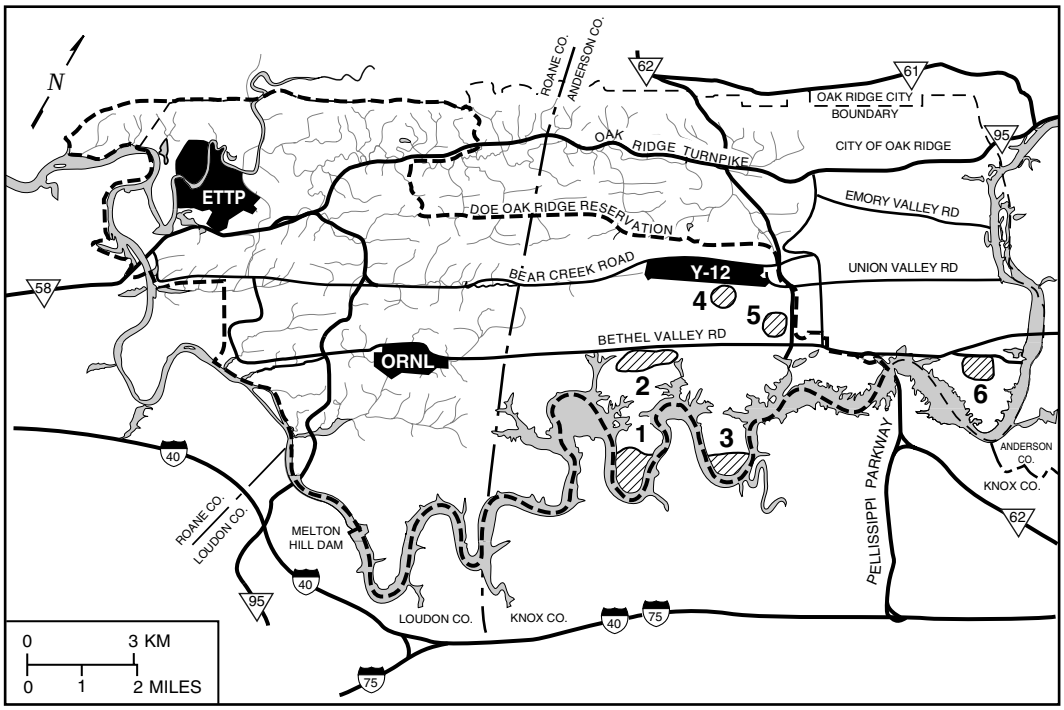

Fig. 7.6. Hay sampling locations on the ORR, indicated by numbered areas. Area 8 is a reference location at Fort Loudoun Dam and is not shown on this map.

Table 7.5 Significant concentrations of radionuclides in hay from the ORR, 1998[a]

Analyte	Area			
	1,2,3	2,4,5	6	8[c]
Gross beta	9300	4300	6200	8000
^{7}Be	2100	3900	3200	2200
^{137}Cs	*b*	15	*b*	16

[a]All radionuclide data are given in picocuries per kilogram (1 pCi = 3.7E–02 Bq).
[b]Not significant.
[c]Reference site.

radioactive iodine (^{131}I) by gamma spectrometry and for total radioactive strontium (^{89}Sr + ^{90}Sr) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for tritium (^{3}H).

7.8.1 Results

Radioactivity measurements are reported as the net activity (the difference between the gross activity and instrument background). A 95% confidence level is used to determine statistical significance. Concentrations of radionuclides detected in milk are presented in Table 7.7. Tritium was detected in only one sample out of six at the Powell location and not at all at the other two locations (see Table 7.7). Average values for detected radionuclides were converted to doses and are presented in Chap. 8 of this report.

7.9 FISH

Members of the public potentially could be exposed to contaminants originating from DOE-ORO activities through consumption of fish caught in area waters. This exposure pathway is monitored under the Environmental Monitoring Plan (EMP) (DOE 1998d) by collecting fish from three river locations annually and analyzing edible fish flesh. Because of the limited number and size of fish available for sampling on creek locations, different fish-processing and analytical procedures are used.

The program was revised, which resulted in fewer sampling locations beginning in 1997. The river locations are on the Clinch River (see Fig. 7.8):

Table 7.6. Radiological constituents in lettuce, tomatoes, and turnip greens at sites near the ORR, 1998[a]

Location	^{7}Be	^{60}Co	^{137}Cs	^{40}K	Gross alpha	Gross beta
			Lettuce			
East of the Y-12 Plant	730	*b*	*b*	7100	*b*	3300
Northeast of the Y-12 Plant, Scarboro #1	960	*b*	*12*	9700	190	3400
South of ORNL	690	11	8.7	6000	*b*	2700
West of the ETTP	380	*b*	*b*	5200	*b*	3000
			Tomatoes			
East of the Y-12 Plant	*b*	*b*	*b*	2200	*b*	2100
Northeast of the Y-12 Plant, Scarboro #1	*b*	*b*	*b*	2100	*b*	1600
South of ORNL	*b*	*b*	*b*	1900	*b*	1300
Northeast of the Y-12 Plant, Scarboro #2	*b*	*b*	*b*	2300	*b*	1800
West of the ETTP	*b*	*b*	*b*	2000	*b*	1400
			Turnip greens			
Northeast of the Y-12 Plant, Scarboro #2	33	*b*	*b*	4700	*b*	3300

[a]All data are given in picocuries per kilogram (1 pCi = 3.7E–2 Bq).
[b]No significant result.

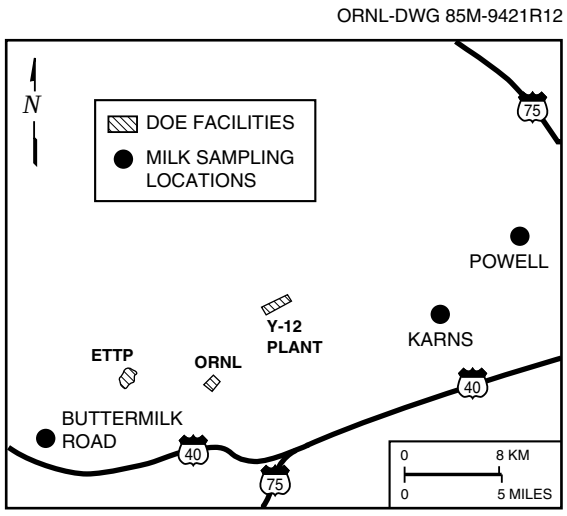

Fig. 7.7 Milk sampling locations in the vicinity of the ORR

- Clinch River upstream from all ORR inputs (CRK 70),
- Clinch River downstream from ORNL (CRK 32), and
- Clinch River downstream from all DOE inputs (CRK 16).

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) are collected from each of the three river locations, filleted, and frozen. When enough fish have been collected (typically 150 to 200 per location), the samples are thawed and fillets from six of the largest are analyzed for selected metals, pesticides, and PCBs. The rest (separated into three composite samples) are ashed and analyzed for ^{60}Co, ^{137}Cs, and total radioactive strontium. To provide data from a second species, annual catfish sampling was initiated in 1993. Six to ten catfish are collected, and a composite sample is analyzed for selected metals, pesticides, and PCBs. A composite sample is also ashed and analyzed for ^{60}Co, ^{137}Cs, and total radioactive strontium.

7.9.1 Results

In 1998, most nonradiological parameters analyzed in sunfish and catfish were undetected or detected in a few samples. For PCBs, reported values for sunfish and catfish were below the U.S. Food and Drug Administration (FDA) tolerance of 2 ppm (FDA 1984a); for mercury, all reported

Table 7.7. Concentrations of radionuclides detected in raw milk, 1998 (pCi/L)[a]

Analysis	No. detected/ No. total	Detected concentration			Standard error of mean
		Max[b]	Min[b]	Av[b]	
Buttermilk Road					
^{131}I	1/5	2.4	–0.25	1.3*	0.43
^{40}K	5/5	1,900*	1,100*	1,300*	150
Total radioactive Sr	4/5	2.7*	0.61	1.6*	0.33
Karns					
^{7}Be	1/5	15*	–7.0	0	3.9
^{40}K	5/5	1,300*	1,100*	1,200*	40
Total radioactive Sr	3/5	1.8*	0.56	1.1*	0.24
Powell					
^{3}H	1/6	520*	–460	6.7	140
^{40}K	6/6	1,400*	1,300*	1,400*	21
Total radioactive Sr	4/6	2.9*	–0.93	1.1	0.60
Network summary					
^{7}Be	1/16	15	–7.0	0.89	1.7
^{3}H	1/16	520	–890	–95	90
^{131}I	1/16	2.4	–2.5	0.45	0.29
^{40}K	16/16	1,900	1,100	1,300*	48
Total radioactive Sr	11/16	2.9	–0.93	1.3*	0.25

[a]1 pCi = 3.7E-02 Bq.

[b]Individual and average concentrations significantly greater than zero at the 95% confidence level are identified by an asterisk (*).

values were below the FDA action level of 1 ppm (FDA 1984b). These limits apply only to fish sold commercially and consumed at rates applicable to the ordinary consumer. For the purposes of this report, much lower tolerance levels are used as proposed by EPA (EPA 1991) for individuals consuming fish caught in local rivers and streams and consumed at higher levels. Fishermen are reported to consume 3 to 4 times as much fish as the ordinary consumer. The Tennessee Department of Environment and Conservation (TDEC) adopted the EPA method for establishing fish consumption advisories for carcinogenic contaminants found in fish collected in waters designated for recreation and domestic water supply. There is a "do not consume" fish advisory (applicable to typical fishermen consumers) for catfish in Melton Hill Reservoir (in its entirety) because of PCB contamination and a precautionary fish advisory (applicable to atypical consumers, those persons who, because of physiological factors or previous exposures, are more sensitive to specific pollutants; this may include pregnant or nursing women, children, and subsistence fishermen) for catfish in the Clinch River arm of Watts Bar Reservoir because of PCB contamination (TDEC 1993). The PCB concentration in catfish tissue that corresponds to the precautionary advisory is estimated to be about 0.06 mg/kg, using the methodology cited in TDEC 1200-4-3-.03 (j).

When PCBs have been detected, it has been primarily Aroclor-1260, mostly at estimated low

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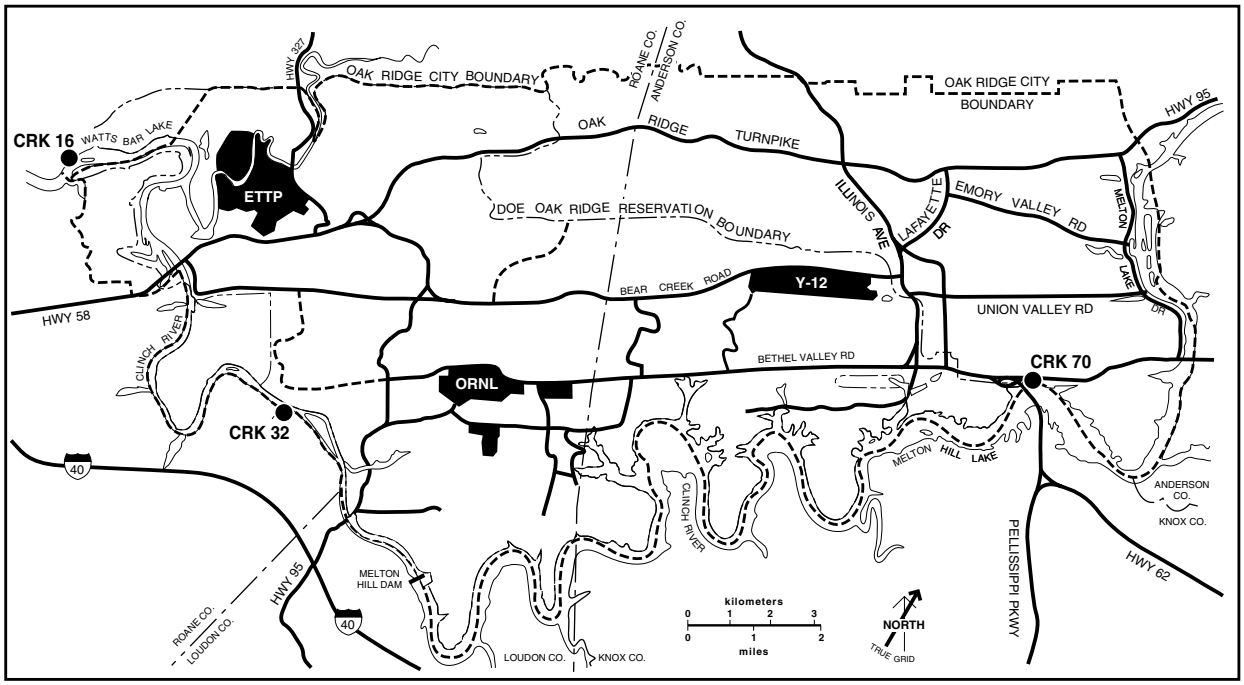

Fig. 7.8. Fish sampling locations for ORR environmental monitoring plan.

levels. Information regarding potential health impacts associated with chemical and radiological constituents detected in the sunfish and catfish is discussed in Chap. 8, Sect. 8.2.2.2.

7.10 WHITE-TAILED DEER

The 14th annual deer hunts managed by DOE and the Tennessee Wildlife Resources Agency (TWRA) were held on the ORR during the final quarter of 1998. ORNL staff, TWRA, and student members of the Wildlife and Fishery Society (University of Tennessee Chapter) performed most of the necessary operations at the checking station.

The 1998 hunts were held on three weekends. Shotgun/muzzle loader hunts were held October 17–18 , November 14–15, and December 12–13 with 800 permitted hunters for each hunt. During the November 14–15 hunt, the Tower Shielding/Park City Road area was opened for an archery-only hunt with 350 permitted hunters. A few areas are also designated as archery only during the gun hunts and do not require special permitting. A two-deer limit (no more than one antlered) was established for the December 12–13 shotgun/muzzle loader hunt as well as for the archery-only hunt at the Tower Shielding/Park City Road area.

The year's total harvest was 336 deer, which is the lowest harvest since deer hunts were initiated on the ORR in 1985. The weather was a major factor in the low harvest, as well as a lower number of permitted hunters and lower acreage available for hunting. From the total harvest of 336 animals, 187 (55.6%) were bucks and 149 (44.4%) were does. The heaviest buck had ten antler points and weighed 218 lb. The greatest number of antler points (16) was found on a buck weighing 152 lb. The heaviest doe weighed 118 lb.

7.10.1 Results

Of the 336 deer harvested, 3 were confiscated because they exceeded established release limits (5 pCi/g for ^{137}Cs and/or 20 pCi/g for ^{90}Sr). The average concentration of ^{137}Cs (based on field measurements) in the deer released to the public was 0.2 pCi/g (0.007 Bq/g). The deer confiscated during the 1998 hunt represent 0.9% of the total deer harvested on the ORR. Since the hunts began in 1985, 7123 deer have been harvested; a total of

161 (2.3%) were retained because of radiological contamination.

7.11 FOWL

7.11.1 Waterfowl Surveys—Canada Geese

Two primary objectives of the ORR waterfowl program are to monitor the number and distribution of waterfowl on the ORR and to determine concentrations of gamma-emitting radionuclides accumulated by waterfowl that feed and live on the ORR. Canada geese are rounded up each summer and subjected to noninvasive, gross radiological surveys. The 1998 roundup was conducted on the ORR June 24, 25, and 30. A total of 182 geese was captured on or near the ORR: ETTP (69), Y-12 (4), ORNL (58), Melton Hill Dam (30), and Oak Ridge Marina (21).

Of the 182 geese captured, 112 geese were subjected to live whole-body gamma scans. These geese were collected from ETTP (25), Y-12 (4), ORNL (58), Melton Hill Dam(4), and Oak Ridge Marina (21). Of the 112 geese scanned, 38 geese (including one roadkill) were retained from the west end of ORNL because the ^{137}Cs concentrations exceeded the 5 pCi/g release limit. The retained geese had ^{137}Cs levels ranging from 10 to 120 pCi/g and were sacrificed to ensure that they would not be a vector for the spread of contaminants. The 25 geese analyzed from the ETTP had ^{137}Cs levels at or below 0.10 pCi/g, as did the 4 geese captured at the Y-12 Plant. The highest level of ^{137}Cs recorded from 4 of 30 geese captured from below Melton Hill Dam was 1.0 pCi/g.

Because of the unusually high number of geese that were retained near ORNL, an environmental sampling plan was developed to identify potential contaminant source locations. Based on the results of this environmental sampling, administrative controls are to be established to limit waterfowl access to these suspected areas of contamination. In addition, efforts to identify and track flocks feeding and nesting on the west end of ORNL will be increased.

The number of waterfowl observations (n=7373) and the number of species observed (n=33) on the ORR in 1998 was relatively low when compared with results from the three prior years. During the period 1995–97, the mean number of observations (n=8963) and the mean number of species observed (n=37) were both notably higher than in 1998. Even though these surveys underestimate both numbers and diversity of waterfowl present, they are likely to be fairly reliable indicators of local waterfowl trends.

7.11.1.1 Results

The average ^{137}Cs concentration in the released geese was 0.18 pCi/g (0.007 Bq/g). The maximum ^{137}Cs concentration in the released geese was 3.6 pCi/g (0.13 Bq/g). The average weight of the Canada geese screened during the roundup was about 4 kg (8.9 lb). The maximum goose weight was about 5.3 kg (11.7 lb).

7.11.2 Turkey Monitoring

Two wild turkey hunts managed by DOE and TWRA were held on the reservation April 11–12, 1998, and April 18–19, 1998. Hunting was open for both shotguns and archery. A total of 48 birds was harvested, and none exceeded the administrative release limits established for specified contaminants. Of the birds harvested, 5 were juveniles and 43 were adults. The average turkey weight was 8.5 kg (19 lb). The largest tom weighed 23.5 lb, had 1.3-in. spurs, and had a 10-in. beard. Two toms had 1.5-in. spurs and weighed 21.5 and 21.8 lb, respectively. The longest beard (12 in.) was measured on a tom weighing 21.4 lb. The average ^{137}Cs concentration in the released turkeys was 0.2 pCi/g (0.007 Bq/g), and the maximum ^{137}Cs concentration was 1.6 pCi/g (0.06 Bq/g).