7. ORR Environmental Monitoring Program

In addition to environmental monitoring conducted at the three major Oak Ridge DOE installations, reservation-wide surveillance monitoring is performed to measure radiological and nonradiological parameters directly in environmental media adjacent to the facilities. Data from the ORR surveillance programs are analyzed to assess the environmental impact of DOE operations on the entire reservation and the surrounding area. Dose assessment information based on data from ORR surveillance programs is given in Chapter 8.

7.1 Meteorological Monitoring

Nine 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, which would be used in the event of accidental releases from a facility. Data from the towers are also used to support various research and engineering projects. Meteorological data, upper air data from local vertical profiling of winds and National Weather Service forecast modeling, quality assurance notes, wind field graphics, and additional weather imagery are archived on site.

7.1.1 Description

The nine meteorological towers are depicted in Fig. 7.1:

Tower	Height (m)
Y-12 Complex	
MT5/East	100
MT6/West	60
ORNL	
MT2/C	100
MT3/B	30
MT4/C	30
ETTP	
MT1/K (1208)	60
MT7/L (1209)	30
ORNL/ETTP	
M (208A)	10
N (208B)	10

Meteorological data are collected at different altitudes (10, 30, 60, and 100 m above ground) to assess the vertical structure of the atmosphere, particularly with respect to wind shear and stability. Stable boundary layers and significant wind shear zones (related to local ridge-and-valley terrain as well as the Great Valley; see Sect. 1.3) can significantly affect the movement of a plume after a facility release (Bowen et al. 2000). All of the towers collect data at the 10-m level. Additionally, selected towers collect data at the 30-, 60-, and 100-m levels. At each measurement level, temperature, wind speed, and wind direction are measured. Data needed to determine atmospheric stability (a measure of vertical mixing properties of the atmosphere) are measured at most towers. Barometric pressure is measured at one or more of the towers at each facility (MT1, MT2, MT5, and MT7). Precipitation is measured at Towers MT5 and MT6 at the Y-12 Complex, Towers MT1 and MT7 at the ETTP, and at Tower MT2 at ORNL. Solar radiation is measured at Towers MT5 and MT6 at the Y-12 Complex, Towers MT1 and MT7 at the ETTP, and Tower MT2 at ORNL.

Data from the towers at each site are collected by a dedicated control computer (DASMET). The towers are polled, and data are archived on both hard disk and compact disk. Values collected at 1-min, 15-min, and hourly intervals are stored at two locations (Y-12 for Y-12 sites, ORNL for ORNL and ETTP sites). Long-term archives are kept of 1-min data for ORNL and ETTP and for all sites for 15-min and hourly data. The meteorological monitoring data from the ORR are summarized monthly as wind roses and daily as data tables. General quarterly calibrations of the instruments are managed by ORNL and the Y-12 Complex. (The same outside contractor conducts the instrument tests.)

Fifteen-minute and hourly data are used directly at each site for emergency-response purposes, such as for input to dispersion models.

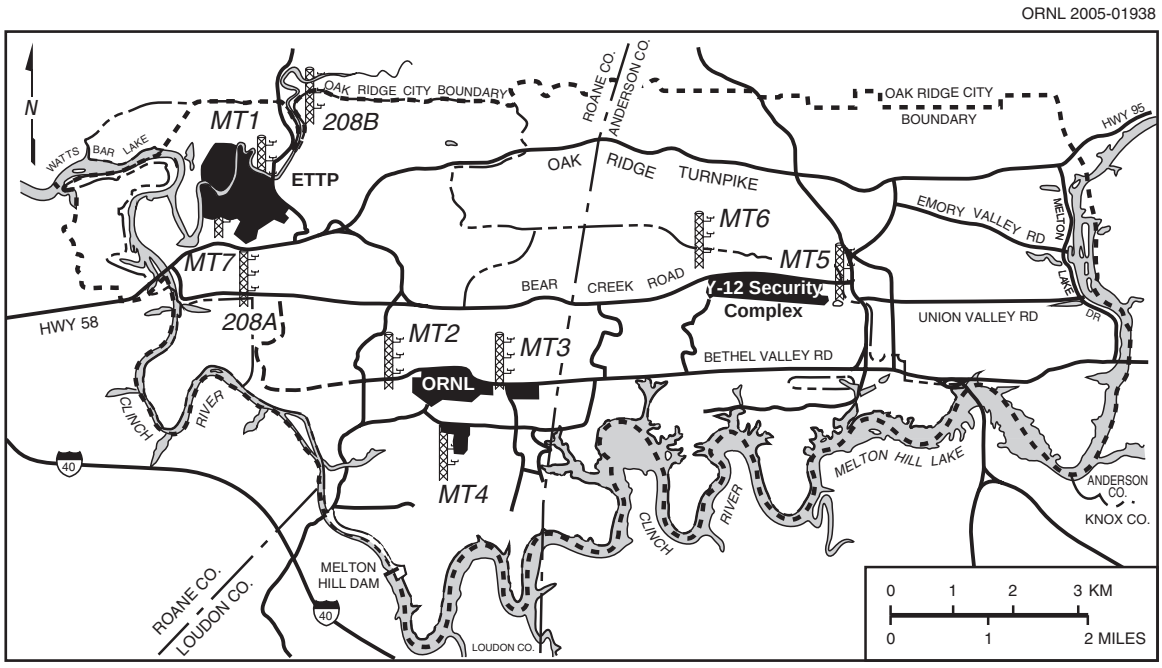

Fig. 7.1. The ORR meteorological monitoring network.

Annual dose estimates are calculated from archived data (hourly values). Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked invalid and are excluded from compliance modeling. Records of data problems and errors are routinely kept for all nine tower sites.

7.1.2 Meteorological Impacts on Modeling 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 ORR sites. Winds in the valleys tend to follow the ridge axes, with limited cross-ridge flow within local valley bottoms. These conditions are dominant over most of the reservation, with the exception of the ETTP, which is located in a relatively open valley bottom and thus has more varied flow.

On the reservation, low-speed winds dominate near the surface level. This characteristic is typical of most near-surface measurements but is amplified by the nearby ridges. Winds sometimes accelerate near ridgetop level (see Sect. 1.3).

The atmosphere over the reservation is dominated by stable conditions on most nights and during much of the morning hours. Such conditions, coupled with the low wind speeds and channeling effects of the valleys, result in poor dilution of material emitted from the facilities. However, high roughness values (caused by terrain and obstructions such as trees and buildings) may partially mitigate these factors through the increased turbulence (mixing) that results. 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/C 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 systems and the uneven, but occasionally intense, summer rainfall associated with thunderstorms. The year 2004, like 2003, was an extraordinarily wet year [69.75 in. at Tower MT2/C and 65.36 in. at Tower MT1/K(1208)].

The average data recovery rate (a measure of acceptable data) across locations used for modeling during 2004 was 98.4% for ORNL sites (Towers MT2, MT3, MT4), and 98.8% for ETTP sites (Towers MT1, MT7).

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 for establishing trends.

7.2.1 Data Collection and Analysis

External gamma measurements (exposure rates) 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 exposure.

7.2.2 Results

Table 7.1 summarizes the data collected at each station during the year. The mean observed exposure rate for the reservation network for 2004 was 5.3 μR/h, and the average at the reference location was 4.6 μR/h. Exposure rates from background sources in Tennessee range from 2.9 to 11 μR/h. The measured ORR exposure rate was within the range of normal background levels in Tennessee, indicating that activities on the ORR do not increase external gamma levels in the area above normal background levels.

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 parameters directly in the ambient air adjacent to the facilities. Ambient air monitoring also provides a means to verify that contributions of fugitive and diffuse sources are insignificant, serves as a check on dose-modeling calculations, and would allow determination of contaminant levels at monitoring locations in the event of an emergency.

The following sections discuss the ambient air monitoring networks for the ORR. Other air monitoring programs are discussed in the site-specific chapters.

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 re-

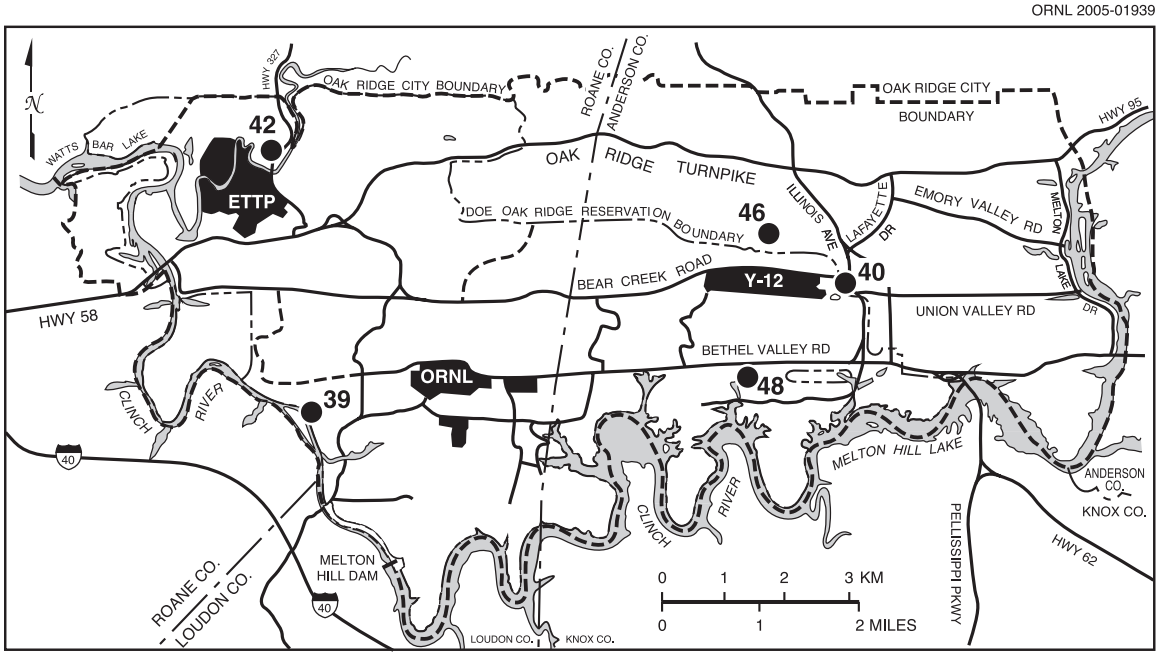

Fig. 7.2. External gamma radiation monitoring locations on the ORR.

Table 7.1. External gamma averages for the ORR, 2004

Monitoring location	Number of data values collected	Measurement (μR/h)[a]			Standard error of mean
		Min	Max	Mean	
39	52	5.2	6.3	5.6	0.00004
40	52	5.3	5.8	5.5	0.00002
42	52	4.2	5.0	4.7	0.00003
46	52	4.5	6.3	6.0	0.00004
48	52	4.2	4.8	4.5	0.00002
52	52	4.4	5.8	4.6	0.00003

[a]To convert microroentgens per hour (μR/h) to milliroentgens per year, multiply by 8.760.

mote location not affected by activities on the ORR. The ORR perimeter air monitoring network includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 7.3). Reference samples are collected from Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2004 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides and ^{3}H.

Atmospheric dispersion modeling was used to select appropriate sampler locations. The locations selected are those likely to be affected most by releases from the Oak Ridge facilities. Therefore, in the event of a release, no residence or business in the vicinity of the ORR should receive a radiation dose greater than doses calculated at the sampled locations. An additional station located at Fort Loudoun Dam, a site not affected by releases from the ORR, provides an estimate of background radionuclide concentrations.

The sampling system consists of two separate instruments. Particulates are captured on glass-fiber filters in a high-volume air sampler. The filters are collected weekly, composited quarterly, and 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 ^{3}H analysis.

The ORR ambient air network (Fig. 7.3) provides appropriate monitoring for all facilities within the reservation and thus 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 Complex operation. Station 40 monitors the east end of the Y-12 Complex, and Station 37 monitors the overlap of Y-12 Complex, ORNL, and ETTP emissions.

7.3.2 Results

Data from the ORR ambient air stations are analyzed to assess the impact to air quality of DOE operations on the entire reservation. Each measured radionuclide concentration is compared with appropriate DCGs, which serve as references for conducting environmental protection programs at DOE sites. All radionuclide concentrations measured at the ORR ambient air stations were less than 1% of applicable DCGs. Statistical significance testing is also performed to compare average radionuclide concentrations measured at ORR ambient air stations with concentrations measured at the reference location. This test reflects the mathematical probability of certain outcomes, but is not an indication of environmental significance. There were no calculated statistical differences in average concentrations of gross parameters, ^{241}Am, ^{242}Cm, ^{244}Cm, ^{210}Po, ^{90}Sr, ^{228}Th, ^{230}Th, ^{232}Th, ^{3}H, ^{7}Be, or ^{40}K. The concentrations of ^{238}Pu, ^{239}Pu, ^{234}U, ^{235}U, and ^{238}U at the ORR ambient air stations were slightly higher than those observed at the background location at the 95% confidence level. A summary of radionuclide concentrations measured at the ambient air stations is presented in Table 7.2. Table 7.3 represents the average concentration of three isotopes of uranium at each station for sampling years 2000, 2001, 2002, and 2004.

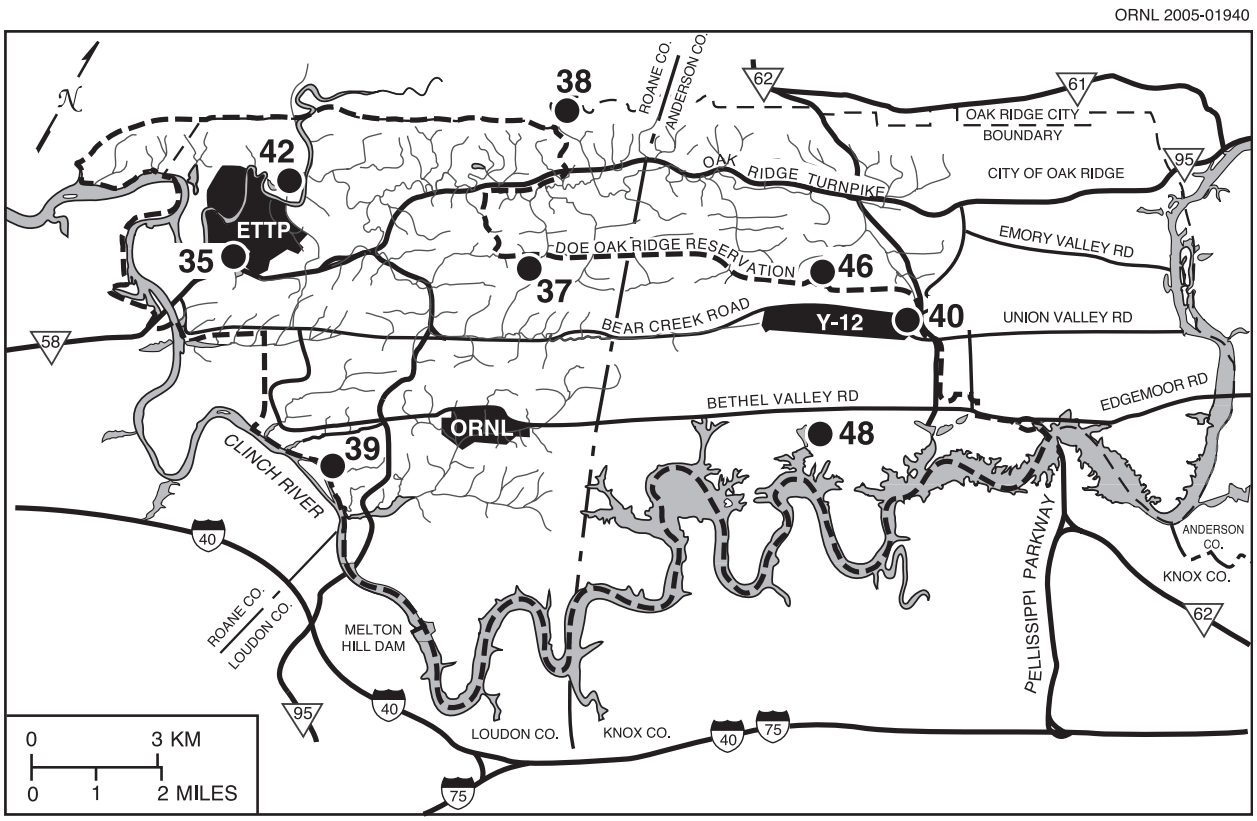

Fig. 7.3. Locations of ORR perimeter air monitoring stations.

7.4 Surface Water Monitoring

7.4.1 ORR Surface Water Monitoring

The ORR surface water monitoring program includes sample collection and analysis from three locations on the Clinch River. This program is conducted in conjunction with the ORNL surface water monitoring activities discussed in Chapter 5 to enable an assessment of the impacts of past and current DOE operations on the quality of local surface water. These programs are conducted in addition to the surface water monitoring required by NPDES permits for individual DOE ORR facilities; sampling location, frequency, and analytical parameters vary among them. Sampling locations include streams downstream of ORR waste sources, reference points on streams and reservoirs upstream of waste sources, and public water intakes (see Fig. 7.4 and Table 7.4).

Sampling frequency and parameters vary by site. Grab samples are collected and are analyzed for general water quality parameters at all locations, and all are screened for radioactivity and are analyzed for specific radionuclides when appropriate. Two of the sites are also checked for volatile organic compounds, and one is checked for PCBs. All three sites are analyzed for metals. Table 7.4 lists the specific locations and their sampling frequencies and parameters.

The sampling locations are classified by the state of Tennessee for recreation and domestic use. Tennessee water quality criteria associated with these classifications are used as references where they are applicable. The Tennessee water quality criteria do not include criteria for radionuclides.

7.4.2 Results

Comparisons of surface water sample results from locations upstream of DOE inputs with surface water results from samples obtained downstream of DOE inputs show that there were no statistically significant differences in any of the parameters of interest. None of the locations had radionuclides detected above 4% of the respective DCG. Acetone and 2-butanone, common

Table 7.2. Average radionuclide concentrations at ORR perimeter air monitoring stations, 2004 (pCi/mL)

Parameter	N detected/ N total	Avg	Min	Max	N detected/ N total	Avg	Min	Max
		Station 35				**Station 37**		
^{241}Am	1/1	5.83E–13	5.83E–13	5.83E–13	0/1	1.08E–13	1.08E–13	1.08E–13
^{7}Be	4/4	5.14E–08	3.77E–08	6.62E–08	4/4	5.21E–08	4.53E–08	5.80E–08
^{242}Cm		*a*	*a*	*a*	0/1	0	0	0
^{244}Cm	0/1	0	0	0	0/1	9.19E–14	9.19E–14	9.19E–14
^{40}K	0/4	2.14E–10	1.00E–10	3.15E–10	0/4	1.81E–10	–1.02E–10	5.58E–10
^{210}Po	1/1	6.71E–09	6.71E–09	6.71E–09	1/1	5.84E–09	5.84E–09	5.84E–09
^{238}Pu	1/1	1.92E–13	1.92E–13	1.92E–13	0/1	1.86E–13	1.86E–13	1.86E–13
^{239}Pu	1/1	5.75E–12	5.75E–12	5.75E–12	1/1	3.76E–12	3.76E–12	3.76E–12
^{90}Sr	1/1	1.22E–10	1.22E–10	1.22E–10	1/1	8.55E–11	8.55E–11	8.55E–11
^{228}Th	1/1	9.74E–12	9.74E–12	9.74E–12	1/1	7.27E–12	7.27E–12	7.27E–12
^{230}Th	1/1	4.59E–12	4.59E–12	4.59E–12	1/1	2.49E–12	2.49E–12	2.49E–12
^{232}Th	1/1	3.92E–12	3.92E–12	3.92E–12	1/1	2.55E–12	2.55E–12	2.55E–12
Tritium	1/4	3.15E–06	4.65E–07	7.41E–06	0/4	1.49E–06	–3.24E–07	2.98E–06
^{234}U	4/4	2.38E–11	1.22E–11	4.56E–11	4/4	1.24E–11	6.19E–12	2.21E–11
^{235}U	4/4	1.36E–12	6.99E–13	2.98E–12	3/4	5.40E–13	1.24E–13	9.52E–13
^{238}U	4/4	1.56E–11	1.24E–11	2.17E–11	4/4	7.90E–12	4.57E–12	1.14E–11
		Station 38				**Station 39**		
^{241}Am	0/1	1.21E–14	1.21E–14	1.21E–14	0/1	9.02E–14	9.02E–14	9.02E–14
^{7}Be	4/4	5.87E–08	4.52E–08	7.58E–08	4/4	4.72E–08	3.67E–08	5.62E–08
^{242}Cm	1/1	4.67E–13	4.67E–13	4.67E–13	0/1	2.23E–13	2.23E–13	2.23E–13
^{244}Cm	1/1	3.78E–13	3.78E–13	3.78E–13	0/1	6.37E–14	6.37E–14	6.37E–14
^{40}K	0/4	3.91E–10	–2.89E–11	7.59E–10	0/4	3.37E–10	3.92E–11	5.27E–10
^{210}Po	1/1	7.63E–09	7.63E–09	7.63E–09	1/1	5.70E–09	5.70E–09	5.70E–09
^{238}Pu	1/1	3.29E–13	3.29E–13	3.29E–13	0/1	1.65E–13	1.65E–13	1.65E–13
^{239}Pu	1/1	5.46E–12	5.46E–12	5.46E–12	1/1	7.46E–13	7.46E–13	7.46E–13
^{90}Sr	1/1	1.47E–10	1.47E–10	1.47E–10	1/1	1.22E–10	1.22E–10	1.22E–10
^{228}Th	1/1	1.15E–11	1.15E–11	1.15E–11	1/1	7.71E–12	7.71E–12	7.71E–12
^{230}Th	1/1	3.29E–12	3.29E–12	3.29E–12	1/1	1.65E–12	1.65E–12	1.65E–12
^{232}Th	1/1	3.13E–12	3.13E–12	3.13E–12	1/1	1.53E–12	1.53E–12	1.53E–12
Tritium	0/4	1.52E–06	–1.69E–06	3.57E–06	1/4	3.56E–06	1.46E–06	5.93E–06
^{234}U	4/4	9.47E–12	4.40E–12	1.21E–11	4/4	4.84E–12	4.08E–12	5.92E–12
^{235}U	4/4	6.17E–13	4.31E–13	7.07E–13	3/4	4.36E–13	2.79E–13	8.03E–13
^{238}U	4/4	8.50E–12	4.25E–12	1.44E–11	4/4	4.03E–12	2.43E–12	4.80E–12
		Station 40				**Station 42**		
^{241}Am	0/1	2.33E–13	2.33E–13	2.33E–13	1/1	2.12E–13	2.12E–13	2.12E–13
^{7}Be	4/4	5.15E–08	3.53E–08	6.21E–08	4/4	4.54E–08	3.03E–08	5.98E–08
^{242}Cm		*a*	*a*	*a*		*a*	*a*	*a*
^{244}Cm	0/1	5.28E–14	5.28E–14	5.28E–14	0/1	0	0	0
^{40}K	0/4	2.93E–10	1.43E–10	5.28E–10	1/4	4.96E–10	–1.42E–12	8.59E–10
^{210}Po	1/1	6.83E–09	6.83E–09	6.83E–09	1/1	6.25E–09	6.25E–09	6.25E–09
^{238}Pu	1/1	2.52E–13	2.52E–13	2.52E–13	1/1	3.05E–13	3.05E–13	3.05E–13
^{239}Pu	1/1	2.28E–12	2.28E–12	2.28E–12	1/1	3.87E–12	3.87E–12	3.87E–12
^{90}Sr	1/1	1.21E–10	1.21E–10	1.21E–10	1/1	1.02E–10	1.02E–10	1.02E–10

Table 7.2 (continued)

Parameter	N detected/ N total	Avg	Min	Max	N detected/ N total	Avg	Min	Max
^{228}Th	1/1	1.12E–11	1.12E–11	1.12E–11	1/1	7.90E–12	7.90E–12	7.90E–12
^{230}Th	1/1	6.68E–12	6.68E–12	6.68E–12	1/1	3.08E–12	3.08E–12	3.08E–12
^{232}Th	1/1	6.34E–12	6.34E–12	6.34E–12	1/1	1.94E–12	1.94E–12	1.94E–12
Tritium	0/4	2.31E–06	1.11E–06	2.94E–06	0/4	2.73E–06	8.71E–07	5.09E–06
^{234}U	4/4	3.83E–11	1.56E–11	6.75E–11	4/4	2.00E–11	7.15E–12	3.33E–11
^{235}U	4/4	1.43E–12	7.82E–13	2.39E–12	4/4	1.06E–12	4.22E–13	1.41E–12
^{238}U	4/4	7.74E–12	6.09E–12	1.02E–11	4/4	1.31E–11	6.68E–12	1.83E–11
		Station 46				**Station 48**		
^{241}Am	0/1	2.04E–13	2.04E–13	2.04E–13	0/1	3.50E–13	3.50E–13	3.50E–13
^{7}Be	4/4	5.69E–08	4.09E–08	6.95E–08	4/4	5.71E–08	3.71E–08	7.37E–08
^{242}Cm		*a*	*a*	*a*	0/1	–2.76E–14	–2.76E–14	–2.76E–14
^{244}Cm	0/1	7.66E–14	7.66E–14	7.66E–14	0/1	7.48E–14	7.48E–14	7.48E–14
^{40}K	1/4	4.16E–10	–2.92E–10	1.07E–09	0/4	1.64E–11	–6.54E–10	5.37E–10
^{210}Po	1/1	6.52E–09	6.52E–09	6.52E–09	1/1	7.70E–09	7.70E–09	7.70E–09
^{238}Pu	0/1	1.49E–13	1.49E–13	1.49E–13	1/1	2.48E–13	2.48E–13	2.48E–13
^{239}Pu	1/1	3.62E–12	3.62E–12	3.62E–12	1/1	3.31E–12	3.31E–12	3.31E–12
^{90}Sr	1/1	1.13E–10	1.13E–10	1.13E–10	1/1	1.11E–10	1.11E–10	1.11E–10
^{228}Th	1/1	1.22E–11	1.22E–11	1.22E–11	1/1	8.94E–12	8.94E–12	8.94E–12
^{230}Th	1/1	6.80E–12	6.80E–12	6.80E–12	1/1	3.05E–12	3.05E–12	3.05E–12
^{232}Th	1/1	5.34E–12	5.34E–12	5.34E–12	1/1	3.31E–12	3.31E–12	3.31E–12
Tritium	0/4	1.46E–06	4.04E–07	2.22E–06	1/4	1.68E–06	–6.57E–07	3.84E–06
^{234}U	4/4	2.09E–11	1.61E–11	3.25E–11	4/4	7.31E–12	5.46E–12	1.02E–11
^{235}U	4/4	1.47E–12	1.03E–12	2.46E–12	4/4	6.15E–13	3.86E–13	7.87E–13
^{238}U	4/4	9.88E–12	8.88E–12	1.20E–11	4/4	5.93E–12	5.18E–12	6.61E–12
		Station 52						
^{241}Am	0/1	–2.59E–13	–2.59E–13	–2.59E–13				
^{7}Be	4/4	5.95E–08	4.19E–08	7.51E–08				
^{242}Cm		*a*	*a*	*a*				
^{244}Cm	0/1	1.99E–14	1.99E–14	1.99E–14				
^{40}K	1/4	5.91E–10	6.72E–11	9.33E–10				
^{210}Po	1/1	7.05E–09	7.05E–09	7.05E–09				
^{238}Pu	0/1	0	0	0				
^{239}Pu	1/1	1.88E–13	1.88E–13	1.88E–13				
^{90}Sr	1/1	1.37E–10	1.37E–10	1.37E–10				
^{228}Th	1/1	9.97E–12	9.97E–12	9.97E–12				
^{230}Th	1/1	4.81E–12	4.81E–12	4.81E–12				
^{232}Th	1/1	3.46E–12	3.46E–12	3.46E–12				
Tritium	0/4	2.03E–06	4.08E–07	2.75E–06				
^{234}U	4/4	5.00E–12	2.62E–12	6.33E–12				
^{235}U	2/4	3.72E–13	2.46E–13	4.74E–13				
^{238}U	4/4	4.26E–12	3.25E–12	5.97E–12				

[a]Not reported.

Table 7.3. Uranium concentrations in ambient air on the ORR

Isotope	Concentration (10^{-15} µCi/mL)			
	2001	2002	2003	2004
		Station 35		
^{234}U	2.1E–02	2.0E–02	6.9E–02	2.38E–02
^{235}U	7.6E–04	1.6E–03	3.6E–03	1.36E–03
^{238}U	3.0E–02	2.1E–02	2.3E–02	1.56E–02
		Station 37		
^{234}U	1.2E–02	9.3E–03	9.1E–03	1.24E–02
^{235}U	1.0E–03	1.1E–03	4.6E–04	5.40E–04
^{238}U	1.4E–02	8.3E–03	5.6E–03	7.90E–03
		Station 38		
^{234}U	1.7E–02	1.4E–02	1.3E–02	9.47E–03
^{235}U	7.9E–04	1.8E–03	8.1E–04	6.17E–04
^{238}U	2.7E–02	1.1E–02	8.3E–03	8.50E–03
		Station 39		
^{234}U	8.1E–03	7.1E–03	5.1E–03	4.84E–03
^{235}U	1.5E–03	3.3E–04	2.8E–04	4.36E–04
^{238}U	7.7E–03	7.1E–03	3.9E–03	4.03E–03
		Station 40		
^{234}U	5.0E–02	2.6E–02	3.1E–02	3.83E–02
^{235}U	2.1E–03	1.5E–03	1.4E–03	1.43E–03
^{238}U	1.65E–02	1.30E–02	7.8E–03	7.74E–03
		Station 42		
^{234}U	2.4E–02	2.4E–02	7.0E–02	2.00E–02
^{235}U	1.1E–03	2.5E–03	3.9E–03	1.06E–03
^{238}U	3.5E–02	2.4E–02	2.8E–02	1.31E–02
		Station 46		
^{234}U	2.7E–02	2.3E–02	1.6E–02	2.09E–02
^{235}U	1.2E–03	1.2E–03	8.4E–04	1.47E–03
^{238}U	1.9E–02	1.4E–02	7.8E–03	9.88E–03
		Station 48		
^{234}U	1.1E–02	9.3E–03	8.0E–03	7.31E–03
^{235}U	5.3E–04	6.8E–04	4.9E–04	6.15E–04
^{238}U	1.1E–02	8.2E–03	5.9E–03	5.93E–03
		Station 52		
^{234}U	8.2E–03	1.2E–02	3.9E–03	5.00E–03
^{235}U	5.7E–04	9.3E–04	3.2E–04	3.72E–04
^{238}U	7.0E–03	8.2E–03	3.4E–03	4.26E–03

laboratory contaminants, were detected in a few samples in 2004. Toluene, a volatile organic compound that is not a common laboratory contaminant, was detected in the May and July samples at low, estimated levels, and in the laboratory blank, which is indicative of laboratory contamination.

7.5 Food

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

7.5.1 Hay

Hay is sampled annually from five areas on the ORR and from one area immediately adjacent to the reservation (Fig. 7.5). In previous years, hay from the six areas has been sold for silage, and each has the potential for deposition of airborne materials from ORR sources. Areas 1, 2, and 3 are within the predicted air plume for an ORNL source and could be affected by ETTP sources. Areas 4, 5, and 6 are within the predicted air plumes for ETTP, ORNL, and Y-12 sources. Individual samples are collected from all six sites; a composite sample from areas 1, 2, and 3 and a composite sample from Areas 2, 4, and 5 are submitted for laboratory analyses. In addition, a sample from area 6 is submitted separately because it best represents the combined plumes from all three sites. A reference sample is collected from a site near Norris Dam (Area 7, not shown on Fig. 7.5), which is outside the influence of ORR sources.

7.5.1.1 Results

Hay samples were collected during July 2004, and samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. None of the locations had gamma-emitting radionuclides that were detected above minimum detectable activity, with the exception of naturally occurring radionuclides ^{7}Be and ^{40}K, and ^{228}Ac (via ^{228}Ra) at the Norris reference location. Concentrations of radionuclides detected above minimum detectable activity in hay are shown in Table 7.5.

7.5.2 Vegetables

Tomatoes, lettuce, and turnips were purchased from local farmers near the ORR. The locations were chosen based on availability and

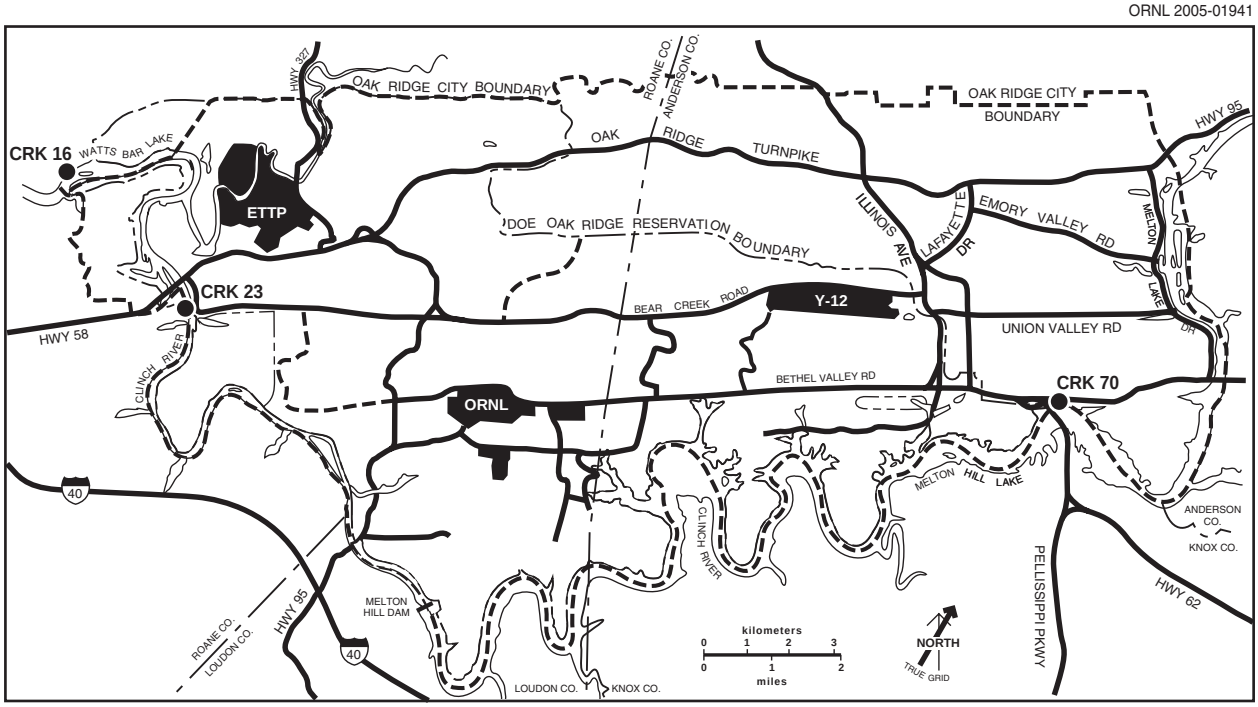

Fig. 7.4. Locations of ORR surface water surveillance sampling stations.

Table 7.4. ORR surface water sampling locations, frequencies, and parameters, 2004

Location[a]	Description	Frequency	Parameters
CRK 16	Clinch River downstream from all DOE ORR inputs	Monthly	Volatiles, metals, gross alpha, gross beta, gamma scan, field measurements[b]
CRK 23	Water supply intake for the ETTP	Monthly	Gross alpha, gross beta, total radioactive strontium, gamma scan, ^{3}H, field measurements[b]
CRK 70	Solway Bridge	Monthly	Volatiles, metals, gross alpha, gross beta, total radioactive strontium, gamma scan, ^{3}H, field measurements[b]

[a]Locations identify bodies of water and locations on them (e.g., CRK 16 = 16 km upstream from the confluence of the Clinch and the Tennessee rivers).

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

on their likelihood of being affected by routine releases from the Oak Ridge facilities.

7.5.2.1 Results

Samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. None of the vegetables had gamma-emitting radionuclides that were detected above minimum detectable activity, with the exception of the naturally occurring radionuclide ^{40}K. Concentrations of radionuclides detected above minimum detectable activity are shown in Table 7.6.

7.5.3 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

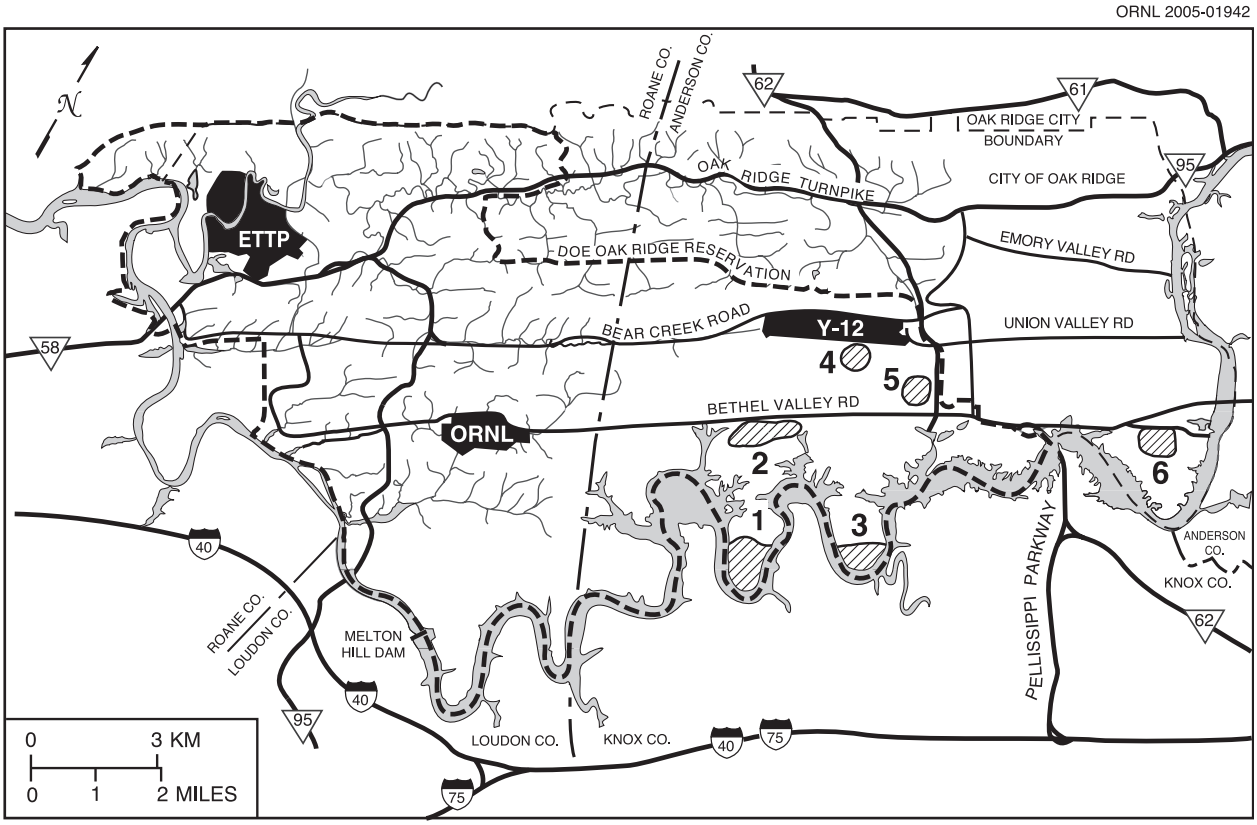

Fig. 7.5. Hay sampling locations on the ORR, indicated by numbered areas.

Table 7.5. Concentrations of radionuclides detected in hay, 2004 (pCi/kg)[a]

Gross alpha	Gross beta	^{7}Be	^{40}K	^{228}Ac	^{234}U	^{235}U	^{238}U
Area 1-2-3 composite							
b	0.010	0.010	*b*	*b*	0.000010	*b*	*b*
Area 2-4-5 composite							
0.000060	0.0030	0.017	*b*	*b*	0.0000061	*b*	*b*
Area 6							
0.00043	0.0032	0.012	*b*	*b*	0.000052	0.0000062	0.000053
Area 7–Norris reference location							
0.000091	0.0041	0.011	*b*	0.0016	0.0000072	*b*	*b*

[a]Detected radionuclides are detected above the minimum detectable activity.
[b]Value was not detected above the minimum detectable activity.

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 2004 milk-sampling program consisted of grab samples collected every other month from three locations (Fig. 7.6). One is a commercial dairy in Powell that processes milk from various locations in east Tennessee; the second dairy is in Claxton, and the third is in Maryville (a reference location). Milk samples are analyzed for gamma emitters and for total radioactive strontium (^{89}Sr + ^{90}Sr) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for ^{3}H.

7.5.3.1 Results

Concentrations of radionuclides detected above minimum detectable activity in milk are presented in Table 7.7. Total radioactive strontium (^{89}Sr + ^{90}Sr) was detected twice at the Powell location.

Table 7.6. Concentrations of radionuclides detected in vegetables, 2004 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{40}K	^{234}U	^{235}U	^{238}U
Lettuce						
East of Y-12, #1	0.000023	0.0022	0.0025	*b*	*b*	0.0000039
East of Y-12, Claxton	*b*	0.0034	0.004	0.0000069	*b*	0.0000037
Northeast of Y-12, Scarboro #1	0.000053	0.0027	0.0036	0.0000098	0.0000028	0.0000063
Northeast of Y-12, Scarboro #2	*b*	0.0025	0.0028	0.0000081	*b*	0.0000054
Southeast of ORNL	0.000029	0.0021	0.0031	0.0000088	0.0000027	*b*
West of ETTP	*b*	0.0026	0.0035	0.000009	0.0000021	*b*
Tomato						
East of Y-12, #1	*b*	0.0017	0.0019	*b*	*b*	*b*
East of Y-12, Claxton	0.000025	0.0015	*b*	*b*	*b*	*b*
Northeast of Y-12, Scarboro #1	0.00022	0.0026	0.0027	0.000017	*b*	0.00001
Northeast of Y-12, Scarboro #2	0.000035	0.0014	*b*	0.0000071	*b*	*b*
Southeast of ORNL	0.000044	0.0017	0.0029	0.000023	*b*	*b*
West of ETTP	*b*	0.0015	0.0025	0.0000096	*b*	*b*
Turnip						
East of Y-12, #1	0.000033	0.0025	*b*	*b*	*b*	0.0000065
East of Y-12, Claxton	*b*	0.0022	0.0022	*b*	*b*	*b*
Northeast of Y-12, Scarboro #1	0.000034	0.0025	0.002	*b*	*b*	*b*
Northeast of Y-12, Scarboro #2	0.00015	0.0029	0.0032	0.000028	*b*	0.000019
Southeast of ORNL	0.000062	0.0028	0.0032	*b*	*b*	*b*
West of ETTP	*b*	0.003	0.0045	*b*	*b*	*b*

[a]Detected radionuclides are detected above the minimum detectable activity.
[b]Value was not detected above the minimum detectable activity.

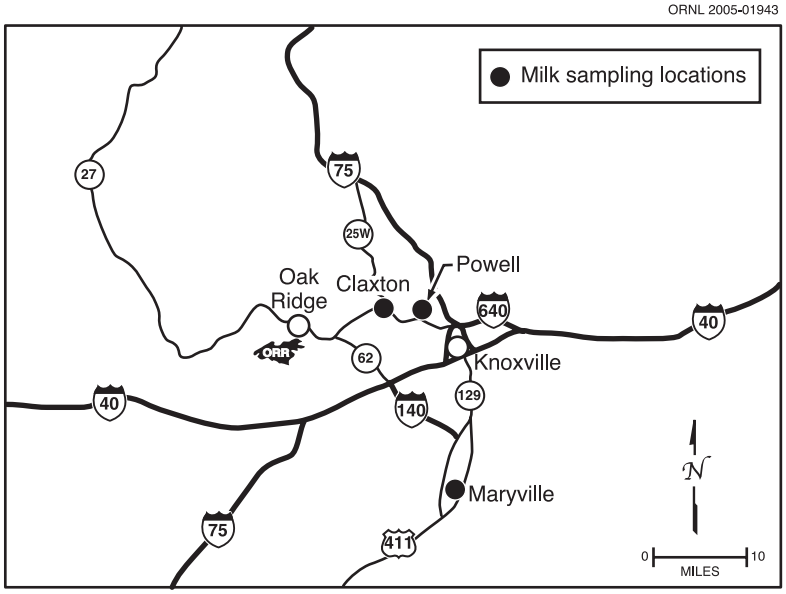

Fig. 7.6. Milk sampling locations in the vicinity of the ORR.

Table 7.7. Concentration of radionuclides detected in raw milk, 2004

Analysis	No. detected/ no. total	Detected concentration (pCi/L)[a,b]			Standard error of mean
		Max	Min	Avg	
Claxton					
Potassium-40	6/6	1400*	1100*	1300*	41
Tritium	1/6	860*	72	560*	140
Maryville					
Potassium-40	6/6	1500*	1200*	1300*	37
Tritium	2/6	1200*	100	650*	160
Powell					
Potassium-40	6/6	1300*	1100*	1200*	22
Total rad Sr	2/6	1.8*	–0.6	1.1*	0.37
Tritium	2/6	1100*	270*	600*	130

[a]Detected radionuclides are those detected above minimum detectable activity.
[b]Individual and average concentrations significantly greater than zero at the 95% confidence level are identified by an asterisk (*).

7.6 Fish

Members of the public could be exposed to contaminants originating from DOE-ORO activities through consumption of fish caught in area waters. This exposure pathway is monitored by collecting fish from three locations on the Clinch River annually and analyzing edible fish flesh. The locations are as follows (see Fig. 7.7):

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

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) and catfish (*Ictalurus punctatus*) are collected from each of the three locations, filleted, and frozen. In 2004, two composite samples of each species at each location were analyzed for selected metals, pesticides, PCBs, and ^{3}H, and two samples of each species at each location were analyzed for gross alpha, gross beta, and gamma-emitting radionuclides and for total radioactive strontium.

7.6.1 Results

TDEC has 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 for catfish in the Clinch River arm of Watts Bar Reservoir because of PCB contamination (TDEC 2002). This advisory is 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.

In 2004, mercury and radionuclides were detected in both species of fish at all locations at levels that indicate an unlikely potential for adverse health effects. The 2004 results also show pesticides and PCBs detected in both species of fish at all locations. Endrin, a pesticide, was detected in the sunfish composite samples at all three locations; PCB-1260 was also detected in the sunfish composite samples at all three locations; and PCB-1016 was detected in the sunfish composite samples at CRK 32. PCB-1260 was detected in the catfish composite samples at all three locations; 4,4-DDE, alpha-chlordane, and gamma chlordane, all pesticides, were detected in the catfish composite samples at all three locations. TDEC has issued a fish advisory for the Melton Hill Reservoir in its entirety due to PCB contamination and the 2004 ORR fish data at upstream and downstream locations are consistent with the advisory.

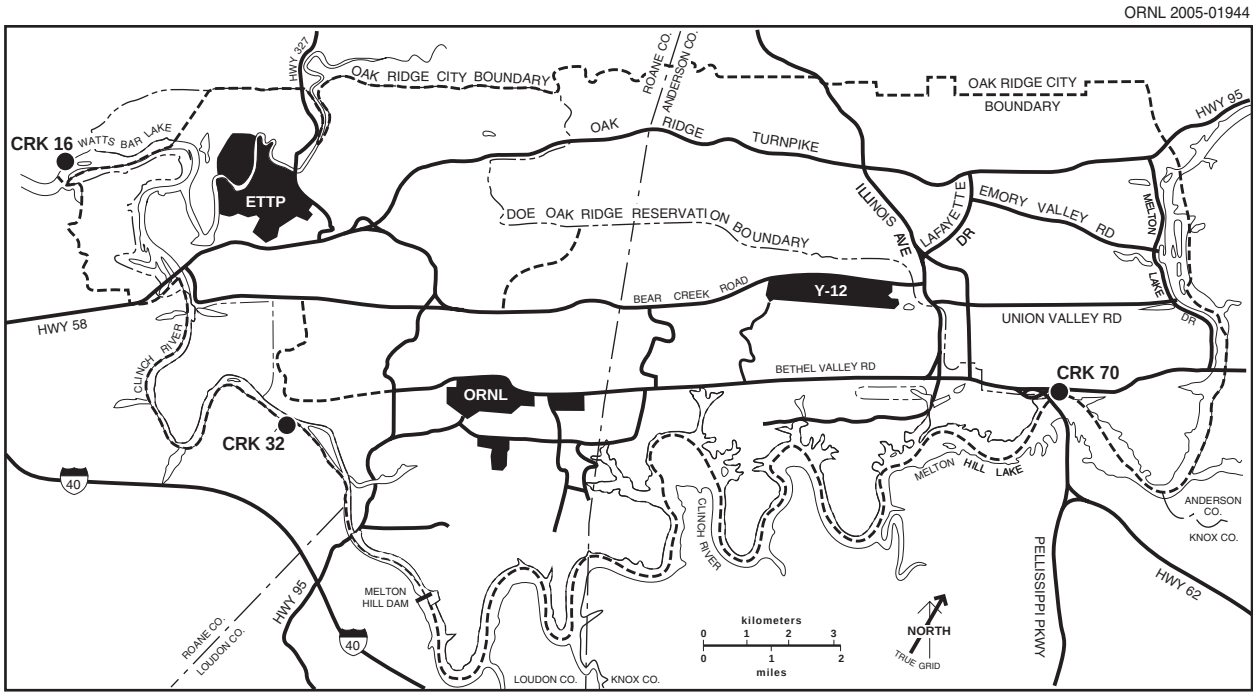

Fig. 7.7. Fish sampling locations for the ORR.

7.7 White-Tailed Deer

The nineteenth annual deer hunts managed by DOE and TWRA were held on the ORR during the final quarter of 2004. ORNL staff, TWRA personnel, and student members of the Wildlife Society (University of Tennessee Chapter) performed most of the necessary operations at the checking station.

The 2004 hunts were held on three weekends. Shotgun/muzzleloader and archery hunts were held November 13–14, December 4–5, and December 18–19. In 2004, there were about 500 shotgun/muzzleloader-permitted hunters and 525 archery-permitted hunters. The Tower Shielding area, Park City Road area, Chestnut Ridge area, and Poplar Creek Road area were opened for an archery-only hunt on all three weekends. There was a one-deer limit for the October hunt and a two-deer limit for the November and December hunts. In addition, only one antlered buck could be harvested. It had to have four or more one-inch antler points on one side of the rack or an outside antler spread of 15 inches or larger.

The year's total harvest was 342 deer. From the total harvest of 342 animals, 145 (42.4%) were bucks and 197 (57.6%) were does. The heaviest buck had eleven antler points and weighed 170 lb. The greatest number of antler points (12) was found on one buck. The heaviest doe weighed 114 lb).

Since 1985, 8865 deer have been harvested. Of these only 180 (2.0%) have been retained due to potential radiological contamination. The heaviest buck was 218 lb (harvested in 1998), and the average weight is 85.6 lb. The eldest deer harvested was 12 years old; the average age is 1.9 years. For more information, see the ORNL wildlife webpage: http://www.ornl.gov/sci/rmal/huntinfo.htm.

7.7.1 Results

In the 2004 hunts, 342 deer were harvested. Of the deer harvested, ten (2.9%) were retained for exceeding the administrative release limits (1.5 times the background for beta activity in bone (~20 pCi/g) or 5 pCi/g of ^{137}Cs in edible tissue). The ten retained deer exceeded the limit for beta-particle activity in bone. The average weight was 86.96 lb, and the maximum weight of the released deer was 170 lb. The average ^{137}Cs concentration in the released deer was 0.66 pCi/g, and the maximum ^{137}Cs concentration in the released deer was 0.96 pCi/g.

It is assumed that 55% of the field weight is edible meat; therefore, the average deer would yield 47.8 lb of meat. Based on the average

weight, the total harvest of edible meat (332 released deer) is estimated to be 15,879 lb. The estimated dose to an individual consuming a deer harvested from the ORR during 2004 was calculated to be in the range of 0.5 to 1.7 mrem.

7.8 Fowl

No new species were observed on the ORR in 2004, and the 27 species that were observed represent the fewest recorded in the last ten years. Species of interest observed on the ORR in 2004 include snow goose (*Chen caerulescens*), greater yellowlegs (*Tringa melanoleuca*), lesser yellowlegs (*Tringa flavipes*), and bald eagle (*Haliaeetus leucocephalus*). Two hundred ninety-seven Canada geese (*Anser canadensis*) were rounded up on the ORR in 2004, of which 168 received legbands and 99 were fitted with neck collars. Six Canada geese from the 13+ year age class were observed on the ORR in 2004, including one female known to be at least 16 years old. The four mute swans (*Cygnus olor*) at the ORNL Swan Pond were captured in October and were moved to private farm ponds in Scott County. Supplemental feeding of ducks, geese, and swans was terminated at the pond following removal of the swans.

7.8.1 Waterfowl Surveys—Canada Geese

The consumption of Canada geese is a potential pathway for exposure of members of the public to radionuclides released from Oak Ridge operations because open hunts for Canada geese are held in counties adjacent to the ORR each year. 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 are subjected to noninvasive gross radiological surveys. At a minimum, three geese, selected from the different roundup locations, are sacrificed to conduct further radiological analysis. The 2004 ORR roundup was conducted on June 24 and 25.

From the roundup, 70 geese were subjected to live whole-body gamma scans. The geese were collected from ETTP (28), ORNL (21), and Clark Center Park (21). None exceeded the administrative release limits.

7.8.1.1 Results

The average ^{137}Cs concentration in the released geese was 0.15 pCi/g. The maximum ^{137}Cs concentration in the released geese was 0.27 pCi/g. The average weight of the geese screened during the roundup was 8.6 lb. The maximum goose weight was 11.7 lb. Three adult geese were sacrificed for radiological analyses. Laboratory analyses on the sacrificed geese is used to verify that the field screening approach is an appropriate method for quantifying radionuclide concentrations.

7.8.2 Turkey Monitoring

Two wild turkey hunts managed by DOE and the Tennessee Wildlife Resources Agency were held on the reservation April 3–4, 2004, and April 17–18, 2004. Hunting was open for both shotguns and archery. Thirty-seven turkeys were harvested, 2 (5.4%) were juveniles and 35 (94.6%) were adults. The average turkey weight was about 19.1 lb. The largest tom weighed 24.3 lb, and had 0.8-in. spurs and a 10.5-in. beard. The longest beard (10.5 in.) was measured on seven toms ranging weight from 19.5 to 24.3 lb.

Since 1997, 414 turkeys have been harvested. Of these, only 2 (0.48%) have been retained due to potential radiological contamination. The heaviest turkey was 24.6 lbs; the average weight is 18.6 lb. The longest spur on turkey harvested on the ORR was 1.5 in. (average 0.8 in.) and the longest beard was 13.5 in. (average 9.2 in.). See the ORNL wildlife webpage (http://www.ornl.gov/rmal/huntinfo.htm) for additional information.

7.8.2.1 Results

In 2004, 37 birds were harvested, and none exceeded the administrative release limits established for radiological contamination. The average ^{137}Cs concentration in the released turkeys was 0.1 pCi/g, and the maximum ^{137}Cs concentration in the released birds was 0.2 pCi/g. It is assumed that about 50% of the field weight is edible meat; therefore, the average turkey would yield about 9.6 lb of meat. Based on the average weight, the total harvest of edible meat (37 released birds) is estimated to be about 353.4 lb.