

## 6. 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 Chap. 7.

### 6.1 Meteorological Monitoring

Eight 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.

#### 6.1.1 Description

The eight meteorological towers on the ORR are described in Table 6.1 and depicted in Fig. 6.1. The “MT” name format for the meteorological towers is used in this document; however, other commonly used names for the sites are provided in Table 6.1. Meteorological data are collected at different altitudes (2, 10, 15, 30, 33, 60, and 100 m above the 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 (associated with the local ridge-and-valley terrain as well as the Great Valley; see Appendix C) can significantly affect the movement of a plume after a facility release (Bowen et al. 2000). Data are

**Table 6.1. Oak Ridge Reservation meteorological towers**

Tower	Alternate tower names	Location lat., long.	Altitude (m MSL) <sup>a</sup>	Measurements heights (m)
<b>ETTP</b>				
MT1	“K,” 1208	35.93317N, 84.38833W	253	10, 60
MT7	“L,” 1209	35.92522N, 84.39414W	233	10, 30
<b>ORNL</b>				
MT2	“C,” 1057	35.92559N, 84.32379W	261	10, 30, 100
MT3	“B,” 6555	35.93273N, 84.30254W	256	10, 30
MT4	“A,” 7571	35.92185N, 84.30470W	263	10, 30
MT10	“M,” 208A	35.90947N, 84.38796W	237	10
<b>Y-12 Complex</b>				
MT6	“W,” West	35.98467N, 84.26550W	326	2, 10, 30, 60
MT9	“Y,” PSS Tower	35.98745N, 84.25363W	290	15, 33

<sup>a</sup>Mean sea level.

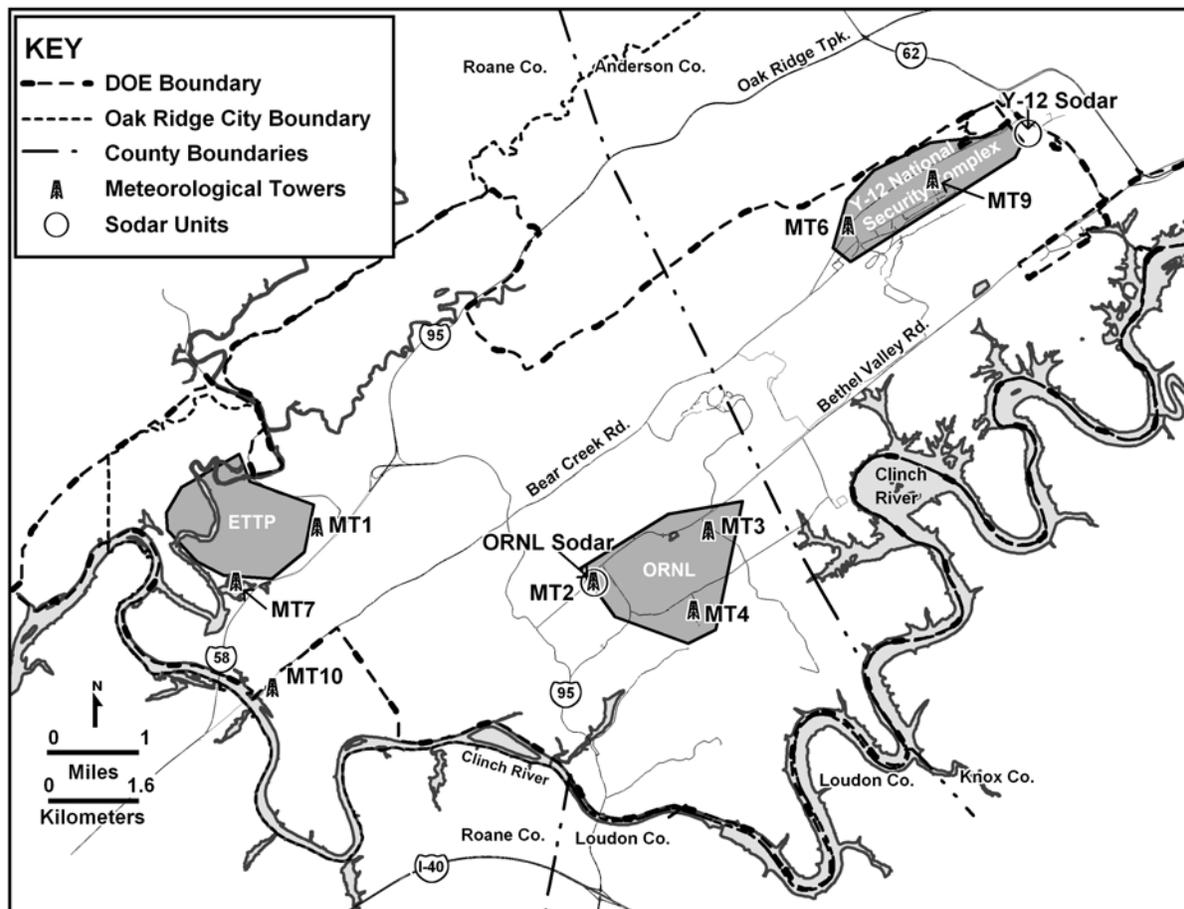


Fig. 6.1. The ORR meteorological monitoring network.

collected at the 10-m level at all towers (except Tower Y, where data are collected at 15 and 33 m). Additionally, at selected towers, data are collected 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, MT7, and MT9). Precipitation is measured at MT6 and MT9 at the Y-12 Complex, at MT1 and MT7 at the ETTP, and at MT2 at ORNL. Solar radiation is measured at MT6 and MT9 at the Y-12 Complex, at MT1 and MT7 at the ETTP, and at MT2 at ORNL. Data are collected at 1-, 15-, and 60-min intervals. General quarterly calibrations of the instruments are managed by UT-Battelle and B&W Y-12.

Data are taken directly at 15-min and hourly intervals for emergency-response purposes, such as for input to dispersion models. Data from the eight ORR meteorological towers are distributed to dispersion models at the ORNL and Y-12 Emergency Operations Centers.

Annual dose estimates are calculated using the archived hourly data. Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked invalid and are excluded from compliance modeling. Quality assurance records of data problems and errors are routinely kept for all eight tower sites.

### 6.1.2 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 ORR, with the exception of the ETP, which is located in a relatively open valley bottom (which results in slightly more varied flow).

On the ORR, low-speed winds dominate near the surface. This characteristic is typical of most near-surface measurements (as influenced by nearby ridges). Winds sometimes accelerate at ridgetop level, particularly when winds are not parallel to the ridges (see Appendix C).

The atmosphere over the ORR is dominated by stable conditions on most nights and for a few hours just after sunrise. These conditions, when 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 increased turbulence (mixing). 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 resulting from frontal systems and the uneven, but occasionally intense, summer rainfall associated with thunderstorms. The total precipitation in 2007 (911 mm) was significantly below the long-term average of 1340 mm. Precipitation wind roses for Tower MT2 during 1998 through 2007 are provided in Appendix C (Figs. C.18 thru C.21).

The average data recovery rate minimums (a measure of acceptable data) across locations used for modeling during 2007 were greater than 97.5% for ORNL sites (Towers MT2, MT3, MT4, and MT10), greater than 99.5% for ETP sites (Towers MT1 and MT7), and 96.1% for Y-12 sites (Towers MT6 and MT9). Despite a major data logger upgrade at Tower MT2, downtime was less than 3 days for all but 30-m wind speed and barometric pressure. All data recovery well exceeded the required 90% per quarter recovery rate.

## 6.2 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.

### 6.2.1 Data Collection and Analysis

External gamma measurements (exposure rates) are recorded weekly at six ambient air stations from resident external gross gamma monitors (Fig. 6.2). Each consists of a dual-range, high-pressure ion chamber sensor and digital electronic count-rate meter and a totalizer. Totalizing consists of multiplying the count rate by the time of exposure to obtain total exposure.

### 6.2.2 Results

Table 6.2 summarizes the data collected at each station during the year. The mean observed exposure rate for the reservation network for 2007 was 5.5  $\mu\text{R}/\text{h}$ , and the average at the reference location was 5.1  $\mu\text{R}/\text{h}$ . Exposure rates from background sources in Tennessee range from 2.9 to 11  $\mu\text{R}/\text{h}$ . The average 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.

## 6.3 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.

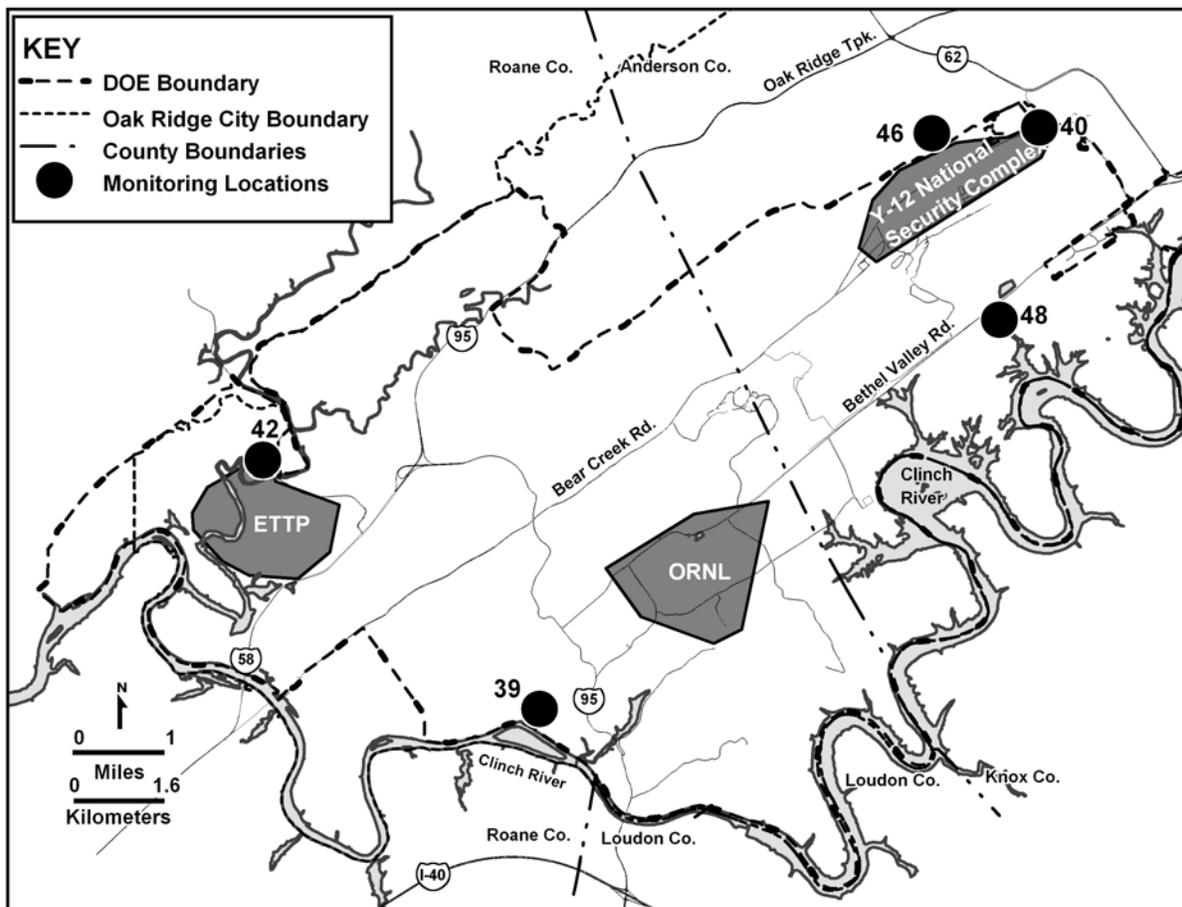


Fig. 6.2. External gamma radiation monitoring locations on the ORR.

Table 6.2. External gamma averages for the ORR, 2007

Monitoring location	Number of data values collected	Measurement ( $\mu\text{R/h}$ ) <sup>a</sup>		
		Min	Max	Mean
39	52	6.2	6.8	6.4
40	52	5.3	5.9	5.6
42	52	3.7	5.2	4.8
46	52	5.9	6.6	6.3
48	52	4.2	4.9	4.5
52	8	5.0	5.3	5.1

<sup>a</sup>To convert microrentgens per hour ( $\mu\text{R/h}$ ) to milliroentgens per year, multiply by 8,760.

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

### 6.3.1 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 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. 6.3). Reference samples are collected from Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2007 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides and  $^3\text{H}$ .

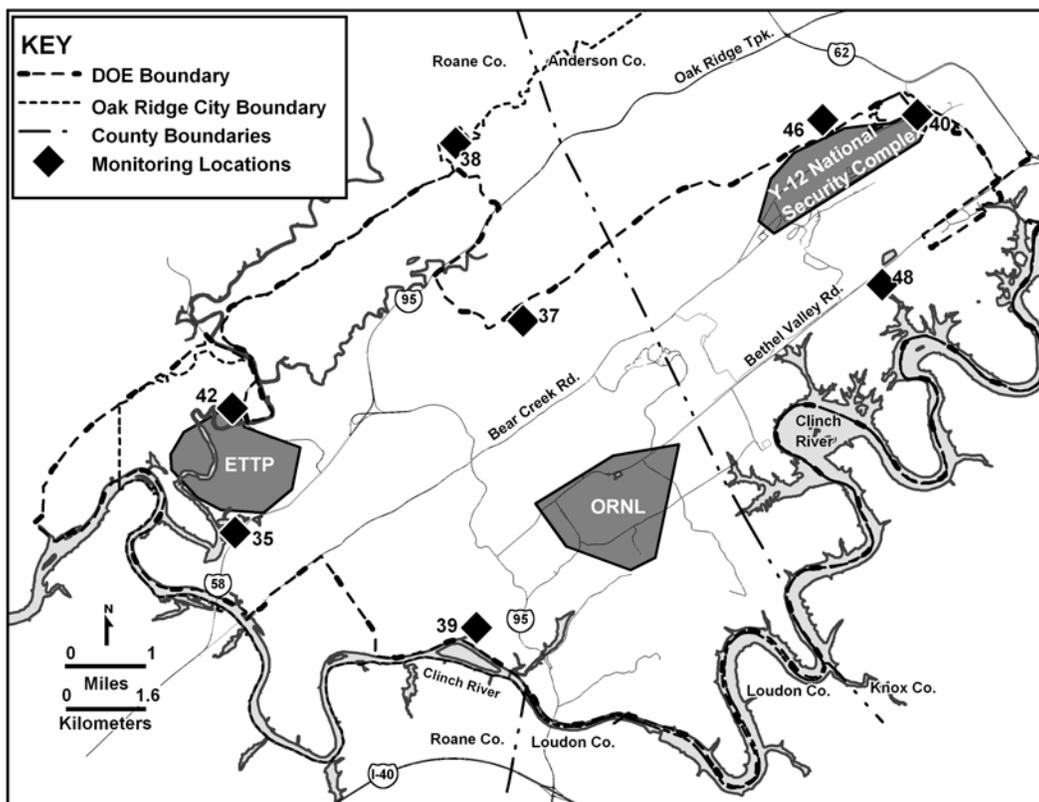


Fig. 6.3. Locations of ORR perimeter air monitoring stations.

Atmospheric dispersion modeling was used to select appropriate sampling 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.

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 an analytical 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, and then submitted to an analytical laboratory for  $^3\text{H}$  analysis.

The ORR ambient air network (Fig. 6.3) 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 off-site impacts of the Y-12 Complex operations. Station 40 monitors the east end of the Y-12 Complex, and Station 37 monitors the overlap of the Y-12 Complex, ORNL, and ETP emissions.

### 6.3.2 Results

Data from the ORR ambient air stations are analyzed to assess the impact of DOE operations on the local air quality. Each measured radionuclide concentration is compared with appropriate derived concentration guides (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,  $^7\text{Be}$ ,  $^{238}\text{U}$ , or  $^{40}\text{K}$ . The concentrations of  $^3\text{H}$ ,  $^{234}\text{U}$ , and  $^{235}\text{U}$  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 6.3. Table 6.4 represents the average concentration of three isotopes of uranium at each station for the sampling years 2003 through 2007.

**Table 6.3. Average radionuclide concentrations at ORR perimeter air monitoring stations, 2007**

Parameter	No. detected/ No. total	Concentration (pCi/mL) <sup>a</sup>		
		Average	Minimum	Maximum
<b>Station 35</b>				
$^7\text{Be}$	4/4	5.08E-08	4.06E-08	5.99E-08
$^{40}\text{K}$	0/4	1.08E-10	-1.55E-10	5.76E-10
$^3\text{H}$	2/4	8.18E-06	1.81E-06	1.83E-05
$^{234}\text{U}$	4/4	1.28E-11	6.28E-12	2.06E-11
$^{235}\text{U}$	1/4	6.88E-13	1.92E-14	1.18E-12
$^{238}\text{U}$	4/4	1.87E-11	5.36E-12	4.12E-11
<b>Station 37</b>				
$^7\text{Be}$	4/4	4.03E-08	2.13E-08	5.44E-08
$^{40}\text{K}$	0/4	1.49E-10	-3.3E-10	7.55E-10
$^3\text{H}$	0/4	1.77E-06	7.49E-07	3.79E-06
$^{234}\text{U}$	4/4	6.02E-12	3.07E-12	9.19E-12
$^{235}\text{U}$	1/4	5.09E-13	-1.98E-13	1.3E-12
$^{238}\text{U}$	4/4	1.28E-11	2.29E-12	3.51E-11
<b>Station 38</b>				
$^7\text{Be}$	4/4	5.37E-08	2.49E-08	7.07E-08
$^{40}\text{K}$	0/4	2.26E-11	-2.84E-10	3.79E-10
$^3\text{H}$	1/4	3.39E-06	-9.88E-07	9.75E-06
$^{234}\text{U}$	4/4	6.93E-12	2.69E-12	1.27E-11
$^{235}\text{U}$	1/4	4.74E-13	3.75E-14	1.45E-12
$^{238}\text{U}$	4/4	1.41E-11	2E-12	3.98E-11
<b>Station 39</b>				
$^7\text{Be}$	4/4	4.28E-08	2.41E-08	5.37E-08
$^{40}\text{K}$	0/4	2.34E-10	-5.54E-10	7.2E-10
$^3\text{H}$	0/4	1.56E-07	-1.18E-06	8.28E-07
$^{234}\text{U}$	4/4	4.05E-12	2.33E-12	6.83E-12
$^{235}\text{U}$	1/4	3.86E-13	1.86E-13	7.13E-13
$^{238}\text{U}$	4/4	4.44E-12	1.83E-12	8.8E-12

Table 6.3 (continued)

Parameter	No. detected/ No. total	Concentration (pCi/mL) <sup>a</sup>		
		Average	Minimum	Maximum
<b>Station 40</b>				
<sup>7</sup> Be	4/4	4.95E-08	2.19E-08	6.59E-08
<sup>40</sup> K	1/4	4.39E-10	-6.17E-11	1.34E-09
<sup>3</sup> H	0/4	2.67E-06	9.50E-07	5.72E-06
<sup>234</sup> U	4/4	2.25E-11	2.07E-11	2.51E-11
<sup>235</sup> U	2/4	1.01E-12	6.95E-13	1.44E-12
<sup>238</sup> U	4/4	1.15E-11	3.67E-12	1.76E-11
<b>Station 42</b>				
<sup>7</sup> Be	4/4	4.48E-08	3.24E-08	5.64E-08
<sup>40</sup> K	0/4	1.38E-10	-2.58E-10	3.44E-10
<sup>3</sup> H	0/4	3.08E-06	7.93E-07	8.22E-06
<sup>234</sup> U	4/4	6.57E-12	3.87E-12	1.16E-11
<sup>235</sup> U	2/4	4.66E-13	2.38E-13	1.06E-12
<sup>238</sup> U	4/4	1.18E-11	3.48E-12	3.16E-11
<b>Station 46</b>				
<sup>7</sup> Be	4/4	5.54E-08	3.85E-08	6.65E-08
<sup>40</sup> K	0/4	3.9E-11	-3.54E-10	5.35E-10
<sup>3</sup> H	0/4	7.89E-07	-3.71E-07	2.48E-06
<sup>234</sup> U	4/4	1.12E-11	7.77E-12	1.53E-11
<sup>235</sup> U	3/4	7.18E-13	2.06E-13	1.73E-12
<sup>238</sup> U	4/4	1.24E-11	4.25E-12	2.67E-11
<b>Station 48</b>				
<sup>7</sup> Be	4/4	5.94E-08	4.49E-08	6.96E-08
<sup>40</sup> K	0/4	3.61E-11	-5.38E-11	2.14E-10
<sup>3</sup> H	0/4	-9.93E-08	-3.56E-06	2.17E-06
<sup>234</sup> U	4/4	7.84E-12	4.91E-12	9.52E-12
<sup>235</sup> U	1/4	5.53E-13	1.63E-13	8.97E-13
<sup>238</sup> U	4/4	9.84E-12	5.5E-12	1.49E-11
<b>Station 52</b>				
<sup>7</sup> Be	4/4	5.34E-08	4.58E-08	5.91E-08
<sup>40</sup> K	0/4	-9.42E-12	-1.83E-10	2.27E-10
<sup>3</sup> H	0/4	-8.11E-07	-1.35E-06	-3.23E-07
<sup>234</sup> U	4/4	3.74E-12	3.02E-12	4.23E-12
<sup>235</sup> U	0/4	7.2E-14	-5.87E-14	3.04E-13
<sup>238</sup> U	4/4	3.94E-12	3.13E-12	4.9E-12

<sup>a</sup>1 pCi = 3.7 × 10<sup>-2</sup> Bq.

**Table 6.4. Uranium concentrations in ambient air on the ORR**

Isotope	Concentration (pCi/mL) <sup>a</sup>				
	2003	2004	2005	2006	2007
<b>Station 35</b>					
<sup>234</sup> U	6.90E-11	2.38E-11	1.24E-11	1.43E-11	1.28E-11
<sup>235</sup> U	3.60E-12	1.36E-12	1.10E-12	1.09E-12	6.88E-13
<sup>238</sup> U	2.30E-11	1.56E-11	2.16E-11	1.94E-11	1.87E-11
<b>Station 37</b>					
<sup>234</sup> U	9.10E-12	1.24E-11	8.01E-12	4.52E-12	6.02E-12
<sup>235</sup> U	4.60E-13	5.40E-13	9.22E-13	5.83E-13	5.09E-13
<sup>238</sup> U	5.60E-12	7.90E-12	1.01E-11	6.84E-12	1.28E-11
<b>Station 38</b>					
<sup>234</sup> U	1.30E-11	9.47E-12	6.21E-12	5.69E-12	6.93E-12
<sup>235</sup> U	8.10E-13	6.17E-13	5.72E-13	4.72E-13	4.74E-13
<sup>238</sup> U	8.30E-12	8.50E-12	7.50E-12	8.28E-12	1.41E-11
<b>Station 39</b>					
<sup>234</sup> U	5.10E-12	4.84E-12	4.58E-12	4.46E-12	4.05E-12
<sup>235</sup> U	2.80E-13	4.36E-13	5.74E-13	4.08E-13	3.86E-13
<sup>238</sup> U	3.90E-12	4.03E-12	4.40E-12	4.51E-12	4.44E-12
<b>Station 40</b>					
<sup>234</sup> U	3.10E-11	3.83E-11	2.85E-11	2.07E-11	2.25E-11
<sup>235</sup> U	1.40E-12	1.43E-12	1.43E-12	1.22E-12	1.01E-12
<sup>238</sup> U	7.80E-12	7.74E-12	8.73E-12	6.65E-12	1.15E-11
<b>Station 42</b>					
<sup>234</sup> U	7.00E-11	2.00E-11	7.51E-12	1.01E-11	6.57E-12
<sup>235</sup> U	3.90E-12	1.06E-12	4.58E-13	3.55E-13	4.66E-13
<sup>238</sup> U	2.80E-11	1.31E-11	1.03E-11	9.68E-12	1.18E-11
<b>Station 46</b>					
<sup>234</sup> U	1.60E-11	2.09E-11	1.82E-11	1.07E-11	1.12E-11
<sup>235</sup> U	8.40E-13	1.47E-12	1.10E-12	4.14E-13	7.18E-13
<sup>238</sup> U	7.80E-12	9.88E-12	1.04E-11	7.01E-12	1.24E-11
<b>Station 48</b>					
<sup>234</sup> U	8.00E-12	7.31E-12	7.63E-12	5.50E-12	7.84E-12
<sup>235</sup> U	4.90E-13	6.15E-13	5.01E-13	2.49E-13	5.53E-13
<sup>238</sup> U	5.90E-12	5.93E-12	6.60E-12	4.15E-12	9.84E-12
<b>Station 52</b>					
<sup>234</sup> U	3.90E-12	5.00E-12	5.03E-12	3.52E-12	3.74E-12
<sup>235</sup> U	3.20E-13	3.72E-13	5.31E-12	-6.54E-14	7.20E-14
<sup>238</sup> U	3.40E-12	4.26E-12	3.95E-12	3.69E-12	3.94E-12

<sup>a</sup>1 pCi = 3.7 × 10<sup>-2</sup> Bq.

## 6.4 Surface Water Monitoring

### 6.4.1 ORR Surface Water Monitoring

The ORR surface water monitoring program was modified in October 2007 per the revised *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE 2007c). The current program consists of sample collection and analysis from six locations on the Clinch River (see Fig. 6.4 and Table 6.5). This program is conducted in conjunction with site-specific surface water monitoring activities to enable an assessment of the impacts of past and current DOE operations on the quality of local surface water.

Sampling frequency and parameters vary by site. Grab samples are collected at all locations and are analyzed for general water quality parameters, screened for radioactivity, and analyzed for mercury and specific radionuclides when appropriate. Samples from two sites were also checked for volatile organic compounds under the previous program (i.e., through September 2007). Table 6.5 lists the specific locations and associated 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 (TDEC 2004). The Tennessee water quality criteria do not include criteria for radionuclides. Four percent of the DOE DCG is used for radionuclide comparison because this value is roughly equivalent to the 4 mrem dose limit from ingestion of drinking water on which the EPA radionuclide drinking water standards are based.

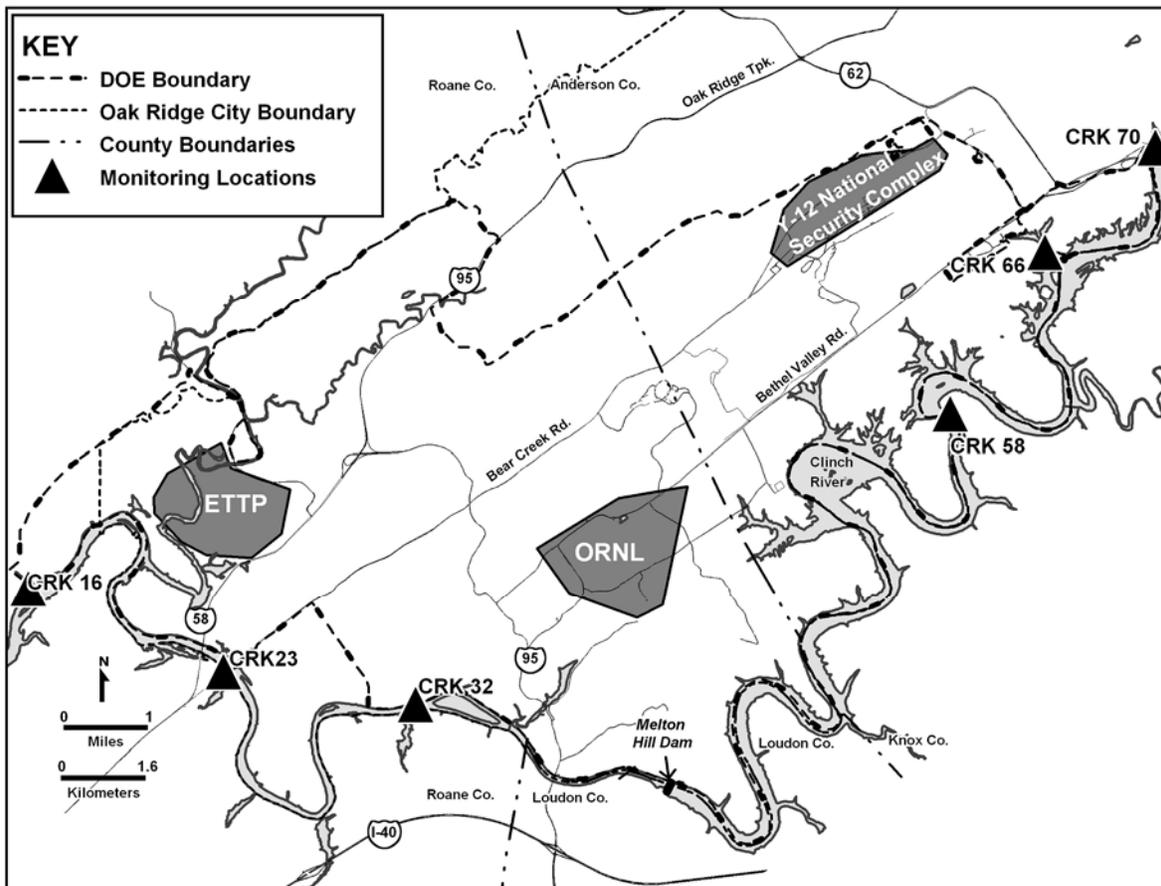


Fig. 6.4. ORR surface water surveillance sampling locations.

**Table 6.5. ORR surface water sampling locations, frequencies, and parameters, 2007<sup>a</sup>**

Location <sup>b</sup>	Description	Frequency	Parameters
CRK 16	Clinch River downstream from all DOE ORR inputs	Monthly (Jan.–Sept.)	Volatiles, metals, gross alpha, gross beta, gamma scan, field measurements <sup>c</sup>
		Quarterly (Oct.–Dec.)	Mercury, gross alpha, gross beta, gamma scan, <sup>3</sup> H, field measurements <sup>c</sup>
CRK 23	Water supply intake for the ETPP	Monthly (Jan.–Sept.)	Gross alpha, gross beta, total radioactive strontium, gamma scan, <sup>3</sup> H, field measurements <sup>c</sup>
		Quarterly (Oct.–Dec.)	Mercury, gross alpha, gross beta, gamma scan, <sup>3</sup> H, field measurements <sup>c</sup>
CRK 32 <sup>d</sup>	Clinch River downstream from ORNL	Monthly (Jan.–Sept.)	Gross alpha, gross beta, gamma scan, total radioactive strontium, <sup>3</sup> H, field measurements <sup>c</sup>
		Quarterly (Oct.–Dec.)	Gross alpha, gross beta, gamma scan, total radioactive strontium, <sup>3</sup> H, field measurements <sup>c</sup>
CRK 58 <sup>d</sup>	Water supply intake for Knox County	Monthly (Jan.–Sept.)	Gross alpha, gross beta, gamma scan, field measurements <sup>c</sup>
		Quarterly (Oct.–Dec.)	Gross alpha, gross beta, gamma scan, field measurements <sup>c</sup>
CRK 66 <sup>d</sup>	Melton Hill Reservoir above city of Oak Ridge water intake	Monthly (Jan.–Sept.)	Gross alpha, gross beta, gamma scan, field measurements <sup>c</sup>
		Quarterly (Oct.–Dec.)	Mercury, gross alpha, gross beta, gamma scan, total radioactive strontium, <sup>3</sup> H, field measurements <sup>c</sup>
CRK 70 <sup>e</sup>	Solway Bridge	Monthly (Jan.–Sept.)	Volatiles, metals, gross alpha, gross beta, total radioactive strontium, gamma scan, <sup>3</sup> H, field measurements <sup>c</sup>

<sup>a</sup>Sampling plans (i.e., locations, frequencies, and parameters) changed October 1, 2007 according to the revised *Environmental Monitoring Plan for the Oak Ridge Reservation*.

<sup>b</sup>Locations indicate bodies of water and distances (e.g., CRK 16 = 16 km upstream from the confluence of White Oak Creek and the Clinch river).

<sup>c</sup>Field measurements consist of dissolved oxygen, pH, and temperature.

<sup>d</sup>In previous years these locations were reported in the ORNL Surface Water Surveillance Monitoring section of the *Annual Site Environmental Report*.

<sup>e</sup>Location dropped from sampling plan effective October 1, 2007.

## 6.4.2 Results

Comparison of 2007 surface water sample results from locations upstream of DOE inputs with results from surface water samples obtained downstream of DOE inputs shows that there were no statistically significant differences in any of the parameters of interest. Radionuclides were not detected above 4% of the respective DCG at any location. Acetone and methylene chloride, both common laboratory contaminants, were detected in a few samples from Clinch River Kilometer (CRK) 16 and CRK 70 at estimated levels in 2007.

## 6.5 Food

Vegetation samples are collected from areas that could be affected by activities on the reservation. Analysis of the samples enables (1) the evaluation of potential radiation doses received by people who consume local food crops and (2) the prediction of possible radionuclide concentrations in meat and milk

from animals that consume hay in the potential impact areas. Food crop monitoring data are also used to monitor trends in environmental contamination and possible long-term accumulation of radionuclides.

### 6.5.1 Hay

Hay is sampled annually from five areas on the ORR and from one area immediately adjacent to the reservation (Fig. 6.5) that have 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 ETPP sources. Areas 4, 5, and 6 are within the predicted air plumes for ETPP, 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 Fort Loudoun Dam (Area 8, not shown on Fig. 6.5), which is outside the influence of ORR sources.

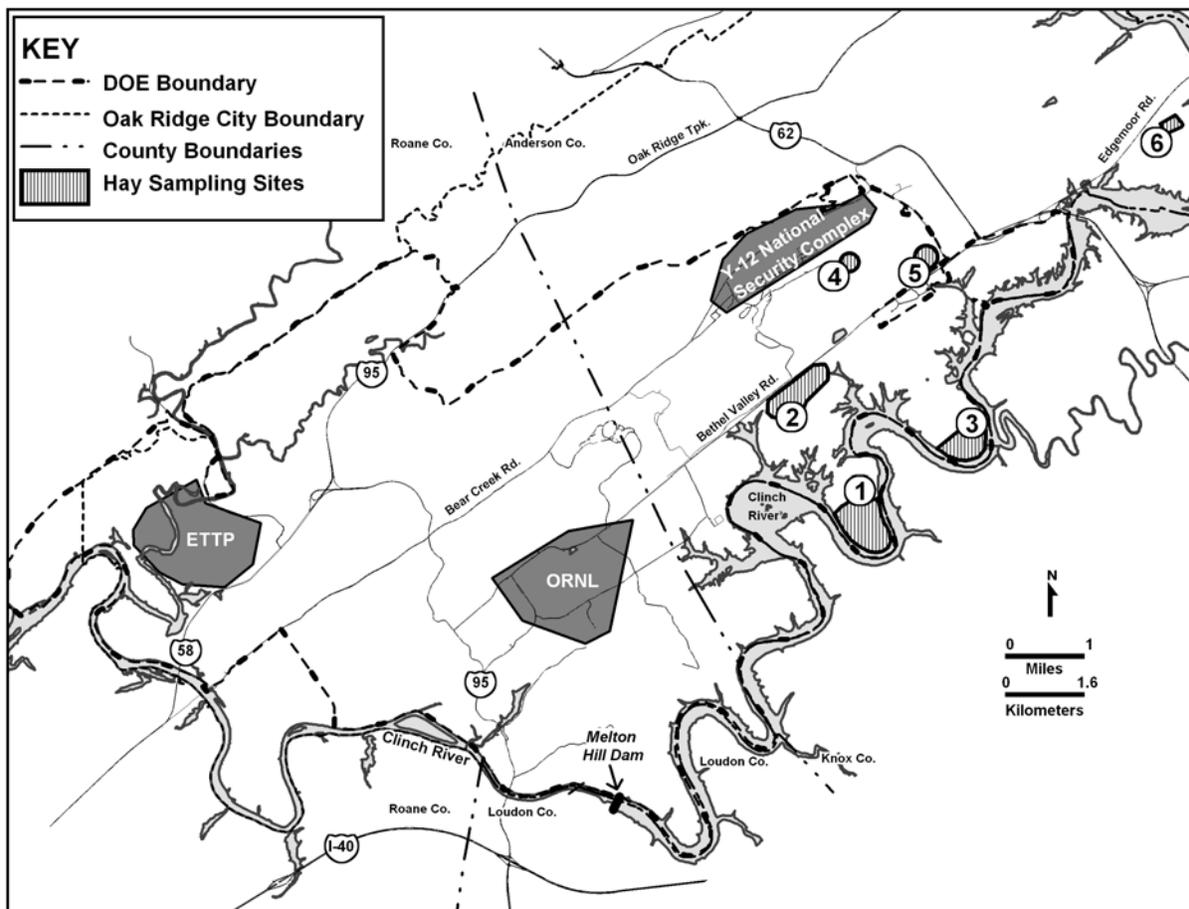


Fig. 6.5. Hay sampling locations on the ORR, indicated by numbered areas.

#### 6.5.1.1 Results

Hay samples collected during June 2007 were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. No gamma-emitting radionuclides were detected above minimum detectable activity (MDA), with the exception of the naturally occurring radionuclides  $^7\text{Be}$  and  $^{40}\text{K}$ . Information on detected radionuclides in hay is shown in Table 6.6.

**Table 6.6. Concentrations of radionuclides detected in hay, 2007 (pCi/kg)<sup>a</sup>**

Gross alpha	Gross beta	<sup>7</sup> Be	<sup>40</sup> K	<sup>234</sup> U	<sup>235</sup> U	<sup>238</sup> U
<b>Area 1-2-3 composite</b>						
<i>b</i>	0.014	<i>b</i>	0.022	<i>b</i>	<i>b</i>	0.0000051
<b>Area 2-4-5 composite</b>						
0.00019	0.010	<i>b</i>	0.020	0.0000046	<i>b</i>	0.0000087
<b>Area 6</b>						
<i>b</i>	0.011	<i>b</i>	0.017	<i>b</i>	<i>b</i>	<i>b</i>
<b>Area 8—Fort Loudoun Dam reference location</b>						
0.00013	0.011	<i>b</i>	0.011	0.0000034	<i>b</i>	0.0000042

<sup>a</sup>Detected radionuclides are detected above the minimum detectable activity.  
1 pCi =  $3.7 \times 10^{-2}$  Bq.

<sup>b</sup>Value was not detected above the minimum detectable activity.

## 6.5.2 Vegetables

Tomatoes, lettuce, and turnips were purchased from farmers near the ORR. The locations were chosen based on availability and on the likelihood of being affected by routine releases from the Oak Ridge facilities.

### 6.5.2.1 Results

Samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. No gamma-emitting radionuclides were detected above MDA, with the exception of the naturally occurring radionuclide <sup>40</sup>K. Concentrations of radionuclides detected above MDA are shown in Table 6.7.

**Table 6.7. Concentrations of radionuclides detected in vegetables, 2007 (pCi/kg)<sup>a</sup>**

Location	Gross alpha	Gross beta	<sup>7</sup> Be	<sup>40</sup> K	<sup>234</sup> U	<sup>235</sup> U	<sup>238</sup> U
<b>Lettuce</b>							
East of ORR (Claxton vicinity)	0.000091	0.0025	<i>b</i>	0.0048	<i>b</i>	<i>b</i>	<i>b</i>
North of ETPP	0.000061	0.0024	<i>b</i>	0.0067	0.0000092	0.0000036	0.00001
Northeast of Y-12, Scarboro #1	<i>b</i>	0.0028	<i>b</i>	0.0042	0.0000091	0.0000022	0.0000091
Northeast of Y-12, Scarboro #2	<i>b</i>	0.0018	<i>b</i>	0.0046	0.000006	<i>b</i>	<i>b</i>
Southeast of ORNL	0.000091	0.003	<i>b</i>	0.005	<i>b</i>	<i>b</i>	<i>b</i>
Southwest of ORNL	<i>b</i>	0.0025	<i>b</i>	0.0068	<i>b</i>	<i>b</i>	<i>b</i>
<b>Tomato</b>							
East of ORR (Claxton vicinity)	<i>b</i>	0.0015	<i>b</i>	0.0020	<i>b</i>	<i>b</i>	<i>b</i>
North of ETPP	<i>b</i>	0.0012	<i>b</i>	0.0031	0.0000053	<i>b</i>	0.0000039
Northeast of Y-12, Scarboro #1	<i>b</i>	0.0017	<i>b</i>	0.0018	<i>b</i>	0.0000025	<i>b</i>
Northeast of Y-12, Scarboro #2	<i>b</i>	0.0015	<i>b</i>	0.0016	<i>b</i>	<i>b</i>	<i>b</i>
Southeast of ORNL	<i>b</i>	0.00054	<i>b</i>	0.0018	<i>b</i>	<i>b</i>	<i>b</i>
Southwest of ORNL	<i>b</i>	0.0008	<i>b</i>	0.0018	<i>b</i>	<i>b</i>	<i>b</i>

Table 6.7 (continued)

Location	Gross alpha	Gross beta	<sup>7</sup> Be	<sup>40</sup> K	<sup>234</sup> U	<sup>235</sup> U	<sup>238</sup> U
<b>Turnips</b>							
East of ORR (Claxton vicinity)	<i>b</i>	0.0018	<i>b</i>	0.0019	<i>b</i>	<i>b</i>	<i>b</i>
North of ETPP	0.000056	0.002	<i>b</i>	0.0026	0.000006	0.0000027	<i>b</i>
Northeast of Y-12, Scarboro #1	<i>b</i>	0.0015	<i>b</i>	0.0018	<i>b</i>	<i>b</i>	<i>b</i>
Northeast of Y-12, Scarboro #2	0.00005	0.0025	<i>b</i>	0.0021	<i>b</i>	<i>b</i>	<i>b</i>
Southeast of ORNL	<i>b</i>	0.0022	<i>b</i>	0.0032	<i>b</i>	<i>b</i>	<i>b</i>
Southwest of ORNL	<i>b</i>	0.0018	<i>b</i>	0.0024	<i>b</i>	<i>b</i>	<i>b</i>

<sup>a</sup>Detected radionuclides are those detected at or above minimum detectable activity. 1 pCi =  $3.7 \times 10^{-2}$  Bq.

<sup>b</sup>Value was not detected above minimum detectable activity.

### 6.5.3 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 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 milk-sampling program was discontinued in the fall of 2007 per the *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE 2007c) due to the inability to locate any dairy operations in potential impact areas; consequently, grab samples were collected in February, April, June, and August 2007 from three locations (Fig. 6.6). 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 were analyzed for gamma emitters and for total radioactive strontium (<sup>89</sup>Sr + <sup>90</sup>Sr) by chemical separation and low-background beta counting. Liquid scintillation was used to analyze for <sup>3</sup>H.

#### 6.5.3.1 Results

Concentrations of radionuclides detected above MDA in milk are presented in Table 6.8. Total radioactive strontium (<sup>89</sup>Sr + <sup>90</sup>Sr) was detected once at the Powell and Claxton locations.

### 6.6 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. 6.7):

- 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 2007, two composite samples of flesh from each species at each location were analyzed for selected metals, pesticides, PCBs, <sup>3</sup>H, gross alpha, gross beta, gamma-emitting radionuclides, and total radioactive strontium.

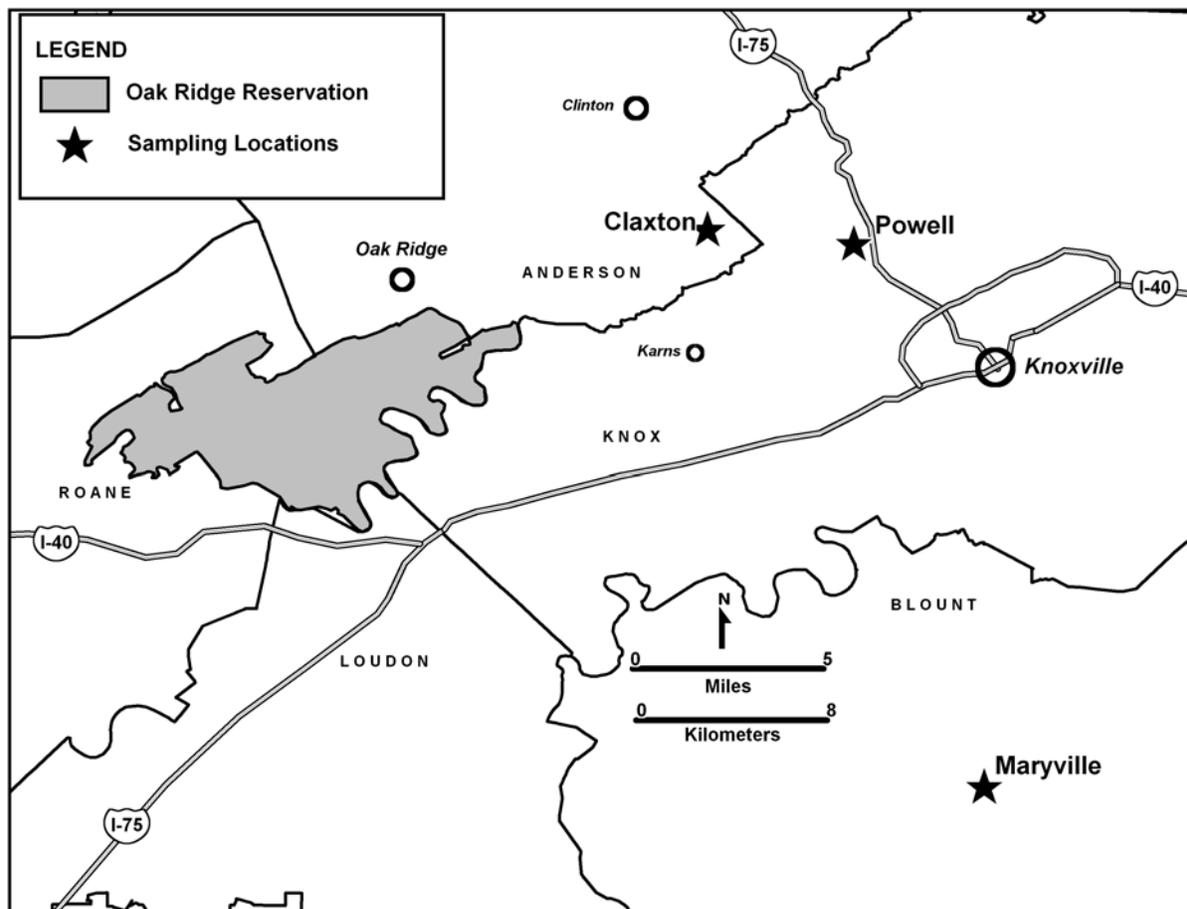


Fig. 6.6. Milk sampling locations in the vicinity of the ORR.

Table 6.8. Concentration of radionuclides detected in raw milk, 2007

Analysis	No. detected/ No. total	Detected concentration (pCi/L) <sup>a,b</sup>			Standard error of mean
		Max	Min	Avg	
<b>Claxton</b>					
Potassium-40	4/4	1300*	1200*	1300*	12
Total rad strontium	1/4	2.3*	1.6*	1.9*	0.15
<b>Maryville</b>					
Potassium-40	4/4	1400*	950*	1200*	94
<b>Powell</b>					
Potassium-40	4/4	1300*	1200*	1300*	15
Total rad strontium	1/4	2.3*	0.9*	1.8*	0.33

<sup>a</sup>Detected radionuclides are those detected above minimum detectable activity.  
1 pCi =  $3.7 \times 10^{-2}$  Bq.

<sup>b</sup>Individual and average concentrations significantly greater than zero at the 95% confidence level are identified by an asterisk (\*).

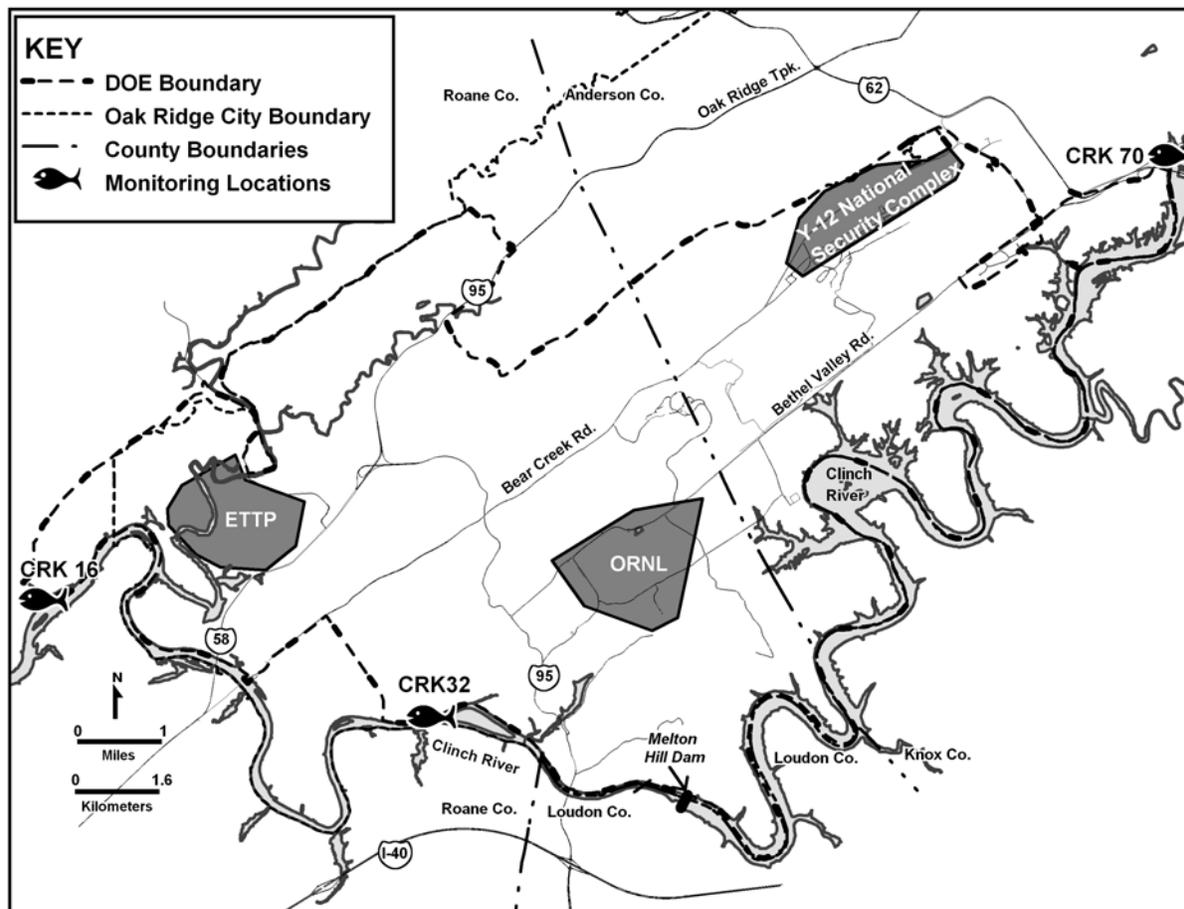


Fig. 6.7. Fish sampling locations for the ORR.

### 6.6.1 Results

The Tennessee Department of Environment and Conservation (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 2007, mercury and radionuclides were detected in both sunfish and catfish at all locations. The 2007 results also show pesticides and PCBs detected in both species of fish at all locations. PCB-1260 was found in all of the sunfish and catfish composite samples from all of the locations; PCB-1254 was found in all of the catfish composite samples from all of the locations. Downstream from all DOE ORR inputs, at CRK 16, pesticides 4,4'-DDE and alpha-Chlordane were found in both species; 4,4'-DDT and alpha-BHC were also found in the sunfish composites. Similarly, at CRK 32, 4,4'-DDE and alpha-Chlordane were present in the both species; alpha-BHC was also present in the sunfish samples at CRK 32. Upstream from all DOE ORR inputs, at CRK 70, alpha-Chlordane was present in both species of fish; 4,4'-DDE and gamma-Chlordane were also measured in the catfish samples. TDEC has issued a fish advisory for the Melton Hill Reservoir in its entirety because of PCB contamination, and the 2007 ORR fish data at upstream and downstream locations are consistent with the advisory.

## 6.7 White-Tailed Deer

The twenty-second annual deer hunts managed by DOE and the Tennessee Wildlife Resources Agency (TWRA) were held on the ORR during the final quarter of 2007. 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 2007 hunts were held on three weekends. Shotgun/muzzleloader and archery hunts were held November 10–11, December 1–2, and December 15–16. In 2007, there were about 500 shotgun/muzzleloader-permitted hunters and 600 archery-permitted hunters. The Tower Shielding area, Park City Road/Chestnut Ridge area, and Poplar Creek Road area were opened for an archery-only hunt on all three weekends. There was a two-deer limit for the November and December hunts; one could be an antlered buck.

The year's total harvest was 361 deer. From the total harvest of 361 animals, 221 (61.2%) were bucks and 140 (38.8%) were does. The heaviest buck had fourteen antler points and weighed 179 lb. The greatest number of antler points found on one buck was 14. The heaviest doe weighed 108 lb.

Since 1985, 9,862 deer have been harvested. Of these only 188 (1.91%) have been retained as a result of potential radiological contamination. The heaviest buck was 218 lb (harvested in 1998); the average weight is 85.8 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>.

### 6.7.1 Results

In the 2007 hunts, 361 deer were harvested on the ORR and 3 (0.8%) were retained for exceeding the administrative release limits (1.5 times the background for beta activity in bone [ $\sim 20$  pCi/g] or 5 pCi/g of  $^{137}\text{Cs}$  in edible tissue). The three retained deer exceeded the limit for beta-particle activity in bone. The average weight of the released deer was 86.2 lb; the maximum weight was 179 lb. The average  $^{137}\text{Cs}$  concentration in the released deer was 0.65 pCi/g, and the maximum  $^{137}\text{Cs}$  concentration in the released deer was 1 pCi/g.

It is assumed that 55% of the field weight is edible meat; therefore, the average deer would yield 47.4 lb of meat. Based on the average weight, the total harvest of edible meat (358 released deer) is estimated to be 16,975 lb.

## 6.8 Fowl

### 6.8.1 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 on the ORR and in counties adjacent to the reservation 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.

From the roundup, 202 geese were subjected to live whole-body gamma scans. The geese were collected from ETPP (143), ORNL (26), Y-12 (14), and Clark Center Park (19). None exceeded the administrative release limits.

#### 6.8.1.1 Results

The average  $^{137}\text{Cs}$  concentration in the released geese was 0.19 pCi/g. The maximum  $^{137}\text{Cs}$  concentration in the released geese was 0.4 pCi/g. The average weight of the geese screened during the roundup was 8.2 lb, and the maximum goose weight was 11 lb. One adult goose was sacrificed for radiological analyses. Laboratory analyses of the sacrificed geese are used to verify that the field screening approach is an appropriate method for quantifying radionuclide concentrations.

## 6.8.2 Turkey Monitoring

Two wild turkey hunts managed by DOE and TWRA were held on the reservation (March 31 and April 1, and April 14 and 15, 2007). Hunting was open for both shotguns and archery. Thirty-one turkeys were harvested, of which 5 (16.1%) were juveniles and 26 (83.93%) were adults. The average turkey weight was about 18.9 lb. The largest tom weighed 23.2 lb. The longest beard was 11.7 inches and the average was 8.7 inches. The longest spur was 1.4 inches and the average was 0.8 inches.

Since 1997, 489 turkeys have been harvested. Of these, only three (0.66%) have been retained because of potential radiological contamination. The heaviest turkey was 24.6 lb; 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 9.1 in.). For additional information, see the ORNL wildlife webpage: <http://www.ornl.gov/rmal/huntinfo.htm>.

### 6.8.2.1 Results

In 2007, none of the 31 birds harvested exceeded the administrative release limits established for radiological contamination. The average  $^{137}\text{Cs}$  concentration in the released turkeys was 0.1 pCi/g, and the maximum  $^{137}\text{Cs}$  concentration in the released birds was 0.21 pCi/g. It is assumed that about 50% of the field weight is edible meat; therefore, the average turkey would yield about 9.3 lb of meat. Based on the average weight, the total harvest of edible meat (31 released birds) is estimated to be about 288 lb.

## 6.9 Quality Assurance

The activities associated with administration, sampling, data management, and reporting for the ORR environmental surveillance programs are performed by the UT-Battelle Environmental Protection and Waste Services Division (EP&WSD). Project scope is established by a task team composed of members representing DOE and each of the three major ORR facilities. UT-Battelle integrates quality assurance, environmental, and safety considerations into every aspect of ORR environmental monitoring. See Sect. 5.11 for a discussion of UT-Battelle quality assurance program elements for environmental monitoring and surveillance activities.

