4. ENVIRONMENTAL SURVEILLANCE

DOE Order 5400.5 requires that exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an EDE >100 mrem. EPA regulations establish additional public dose limits for exposures to several selected sources or exposure modes: regulations implementing the Clean Air Act (40 CFR 61) establish a dose limit of 10 mrem from airborne emissions, and regulations implementing the Safe Drinking Water Act (SDWA) (40 CFR 141) establish a dose limit of 4 mrem from beta-emitting radionuclides in drinking water.

DOE Order 5400.5 defines "public dose" as the dose received by member(s) of the public from exposure to radiation and radioactive material released by a DOE facility or operation, whether the exposure is within a DOE site boundary or off site. It does not include doses from occupational exposures, from naturally occurring "background" radiation, received by a patient from medical practices, or from consumer products. A determination of the public dose as established by EPA regulation 40 CFR 61 differs in that the 10-mrem limit applies where the members of the public reside or abide.

The *Regulatory Guide* (DOE 1991a) requires that DOE facilities perform routine environmental surveillance if an annual dose of site origin at the site boundary from all pathways exceeds a 5 mrem EDE to an individual or a 100 person-rem collective EDE within a radius of 80 km of a central point on the site. The *Regulatory Guide* further requires that DOE facilities perform periodic environmental surveillance measurements if this occurs (*Regulatory Guide*, Chap. 5, p. 5-2). An overview of routine environmental surveillance is provided in Table 4.1. The table lists for each program the number of sampling locations, sampling frequency, sample type, and laboratory analyses.

ORR contains three major operating sites: Y-12, ORNL, and ETTP. BWXT Y-12, L.L.C. assumed responsibility for managing Y-12 on November 1, 2000. UT-Battelle, LLC (UT-Battelle) was awarded the contract to manage ORNL effective April 1, 2000, and Bechtel Jacobs Company LLC (BJC) is responsible for ETTP and EMEF responsibilities at the other sites.

The EMP for ORR was written and implemented to meet requirements of DOE Orders 5400.1 and 5400.5. The surveillance program follows guidance provided in the *Regulatory Guide*. The program represents a cooperative effort in which Y-12, ORNL, and ETTP have each identified individual site surveillance requirements as well as ORR requirements.

Table 4.1. Routine environmental surveillance on the Oak Ridge Reservation[a]

Program	Number of locations	Sampling frequency	Sample type	Parameters[b]
East Tennessee Technology Park (ETTP) surface water	8	Monthly/ quarterly/ semiannually	Grab/composite	Uranium isotopes, gross alpha/beta, ^{99}Tc, gamma spectrometry, volatile organic compounds, dissolved oxygen, pH, temperature, flow, and metals
ETTP ambient air	4	Weekly	Monthly composite	Arsenic, beryllium, cadmium, chromium, lead, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{99}Tc, uranium isotopes
Y-12 National Security Complex (Y-12) perimeter groundwater	10 wells 8 streams 4 springs	Annually/ semiannually	Grab	See Table 4.5
Y-12 surface water [best management practice (BMP)]	3	Monthly/ weekly	Composite	Mercury, ammonia-N, inductively coupled plasma metals, phenols, total suspended solids
Y-12 ambient air (BMP)	2	Weekly	Composite	Mercury
Y-12 sediment	2	Annually	Grab	Polychlorinated byphenyls, mercury, uranium
Oak Ridge National Laboratory (ORNL) perimeter groundwater	10 wells 1 stream	Annually	Grab	See Table 4.4
ORNL surface water (BMP)	12	Varies monthly to semiannually	Grab/composite	See Table 4.6
ORNL sediment	3	Annually	Grab	Gamma spectrometry
ORNL ambient air (BMP)	4	Biweekly (charcoal) Weekly (silica gel) Annually (filter)	Grab (charcoal)/ Quarterly composite (silica gel)/Annual composite (filters)	Gamma spectrometry (charcoal), tritium (silica gel), gross alpha/beta/gamma and ^{234}U, ^{235}U, ^{238}U (filters)
Oak Ridge Reservation (ORR) ambient air	9	Weekly/ biweekly	Quarterly composite	Tritium (silica gel), gross alpha/beta/gamma and ^{234}U, ^{235}U, ^{238}U (filters)

Table 4.1. Routine environmental surveillance on the Oak Ridge Reservation[a] (continued)

Program	Number of locations	Sampling frequency	Sample type	Parameters[b]
ORR surface water	9	Varies, monthly to semiannually	Grab	See Table 4.6
ORR aquatic biota (fish)	3	Annually	Grab	See Table 4.8
ORR external gamma	6	Weekly reading	Continuous	Not applicable
ORR milk	3	Bimonthly	Grab	Gamma spectrometry, total radioactive strontium and tritium
ORR food crops	4	Annually	Grab	Gross alpha/beta, gamma spectrometry, ^{234}U, ^{235}U, ^{238}U.
ORR hay	7	Annually	Composite	Gross alpha/beta, gamma spectrometry
ORR wildlife	N/A	N/A	N/A	See Sect. 4.6.2

[a]This table does not include all individual site BMP surveillance activities.
[b] The specific frequencies and parameters will vary depending upon the specific monitoring location.

4.1 AMBIENT AIR

4.1.1 Introduction

Because air is a primary exposure pathway to humans from radionuclides released to the atmosphere, environmental air sampling will be conducted to evaluate potential doses to environmental populations. Additional benefits from the ambient air monitoring program include the following:

- assistance in developing an ALARA policy,
- assistance in the detection of unplanned releases, and
- promotion of public trust by providing additional radiological dose data.

The plan outlined in Sect. 4.1.2 addresses the ambient air surveillance requirements stated in DOE Orders 5400.1 and 5400.5 and the *Regulatory Guide*. This plan is designed to provide ambient air surveillance for all ORR operations. At the individual sites, ambient air surveillance is implemented not to comply with the orders but to be an additional program activity. These voluntary surveillance programs, listed in Sect. 4.1.8, need not meet the requirements of DOE 5400-series orders or the *Regulatory Guide*.

4.1.2 Rationale and Design Criteria

DOE Orders 5400.1 and 5400.5 and the *Regulatory Guide* require that an environmental surveillance program be developed and implemented. Ambient air surveillance will be one part of the overall environmental surveillance program. Radionuclides that could result in a projected annual EDE of site origin through the air pathway of >0.1 mrem/year to the maximally exposed members of the public will be monitored.

An evaluation of radionuclides is completed annually on ORR. From this evaluation, uranium-234 (^{234}U) has been identified as the only radionuclide that contributed 0.1 mrem or greater to the combined ORR dose (stack effluent). Gross alpha, gross beta, gamma spectroscopy, and tritium analyses are also performed as best management activities. An evaluation of hazardous air pollutant emissions has been conducted. At this time, no hazardous air pollutants are included in ORR ambient air monitoring program. Because Roane and Anderson counties are currently designated as attainment areas, no sampling is being conducted for the criteria pollutants.

A modified high-volume air sampler equipped with a mass-flow controller and a flow totalizer is used to collect particulate uranium. A separate sampler is used to collect tritiated water. The sampler consists of a prefilter and silica-indicating gel for capturing tritiated water. A mass-flow controller and flow totalizer are used to maintain a constant flow rate and indicate total volume of air sampled. In addition, the criteria that follow also apply.

- The air sampling flow rate should not vary more than ±20%.
- The linear flow rate across particulate filters will be kept between 20 and 50 m/min, as specified in the *Regulatory Guide.*
- The total air volume will be recorded.
- Filter media (uranium sampler only) will be selected to capture, at the operational velocity and pressure drop, at least 99% of dioctyl phthalate particles with an aerodynamic mean diameter of 0.3 μm.
- Sample intake will be 2 m above ground level.
- Air sampling devices will be designed to minimize the loss of sample during collection.

4.1.2.1 Location criteria

Atmospheric dispersion modeling was used to select appropriate sampler locations. The Industrial Source Complex (ISC) code was selected for this study. The code is employed by EPA to determine the concentrations of materials released from facilities and is sufficiently flexible to allow numerous potential sampler locations to be analyzed.

The terrain of the area is input to the ISC code. As required by the code, terrain above the point of release of materials is assumed to be at the height of release. The rectangular receptor grid option was selected, with receptors located at a 1-km spacing on a 41- by 41-point grid. An additional 23 receptors located at residences, businesses, or parks nearest to the sites were input. For each model run, concentrations at these 1704 receptors are calculated. Release and

meteorological data from each site were entered into the code, and the most affected off-site receptors were determined.

The effects of all the facility operations on the receptors were integrated by summing the impact of the unit releases from each facility on a given grid location. For example, the effects of Y-12 releases on the 1704 receptors are estimated assuming a unit (1 g/s) release from the Complex. Data from the Y-12 E Meteorological Tower 30-m level are input to the code. This model run determines the receptors most affected by Y-12 operations. The emissions from other ORR facilities might also affect receptors affected by Y-12. The effects of ETTP emissions on the receptors are estimated by inputting the ETTP source location and unit release (1 g/s) into the ISC code and using Y-12 meteorological data. ORNL effects on the receptors most affected by Y-12 operations are calculated in the same fashion. The results for each model run are then summed by cell to determine the total impact of the unit releases.

Because of the separation of primary emission points (3039 and 7911) at ORNL, primary impacts of ORNL operations on nearby receptors were calculated using two emission points. The concentrations resulting from a unit release at each modeled point source were summed at each receptor location. Receptors in the vicinity of ETTP and Y-12 have three component concentrations. Because of the two emission locations at ORNL, the receptors in the vicinity of ORNL have four component values.

The highest concentrations from ORR affecting residences, businesses, or parks were determined by evaluating the model results. Combined impacts from all sites were determined, and sites were ranked. Based on these analyses, eight receptor locations with the highest summed concentrations were identified. The locations chosen were as follows:

- the extreme east end of Y-12 (perimeter air monitor [PAM] 40),
- the ORNL 0800 area (PAM 39),
- the extreme west end of Bethel Valley Industrial Park (PAM 48),
- the Scarboro community (PAM 46),
- the west end of Y-12 (near Country Club Estates) (PAM 37),
- Blair Road (PAM 42),
- TSCA Incinerator (near Gallaher Bridge) (PAM 35), and
- the extreme west end of Oak Ridge (PAM 38).

These are the locations most likely to be affected by releases from ORR, given typical annual meteorology. Sampler sites at or near these calculated points of maximum impact are in locations under the control of ORR. No residences or businesses are predicted to be affected routinely by significant concentrations of radioactive materials released from ORR without such releases being sampled at one of the selected locations. PAM 35 was relocated in 1993 to an area closer to ETTP. This relocation was needed to separate more effectively the emissions from the TSCA incinerator and a privately owned incinerator on Bear Creek Road.

To provide an estimate of background radionuclide concentration, one additional station at Fort Loudoun Dam (Fig. 4.1) is employed. This location is the long-term background monitoring station historically used to determine regional background radionuclide concentrations. Another background location, at Norris Dam, was eliminated in FY 1997. The background station meets the *Regulatory Guide* criterion that such stations for large sites be at least 15 km from the site. To supplement the reference data obtained from the Fort Loudoun station, radiological data are available from the Environmental Radiological Monitoring Program conducted by the Tennessee Valley Authority at the Watts Bar Nuclear Plant. The Watts Bar program includes a reference station in the Dayton, Tennessee, area (southwest of the Watts Bar facility) and another in the Grandview, Tennessee, area (north-northwest of the Watts Bar facility).

4.1.2.2 Additional location criteria

In addition, all the locations also comply with the criteria that follow.

- The location is free from unusual localized effects or other conditions that could result in artificially high or low readings.
- The location is free from excessive large-particle (nonrespirable) fugitive dust that may dominate the sample.

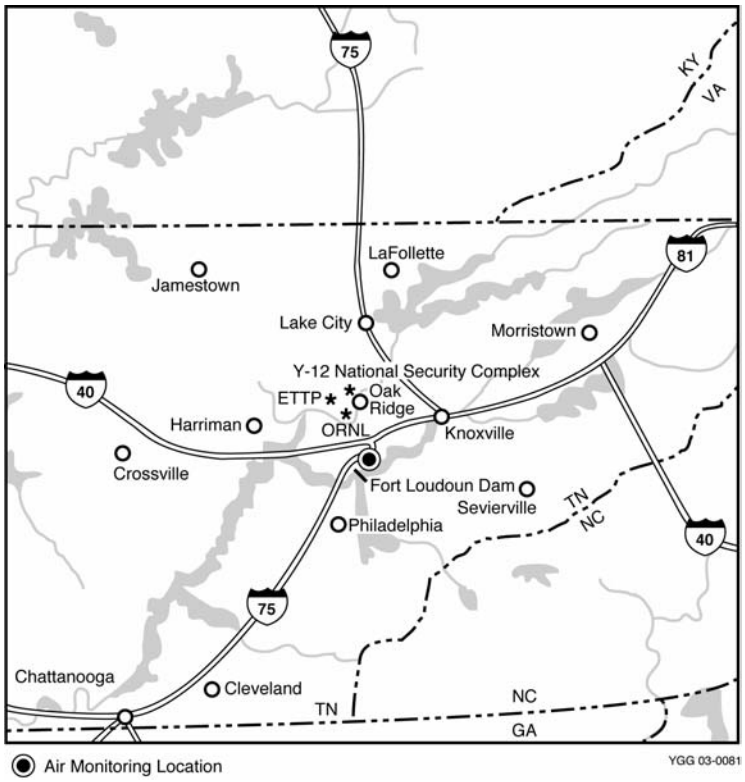

Fig. 4.1. Remote air monitoring location for the Oak Ridge Reservation.

- Where applicable, the siting criteria in 40 CFR 58, Appendix E, will be used as guidance to place the samplers at the various locations.

4.1.3 Frequency and Parameters

The current ambient air program includes two types of samplers: one for collecting particulates and one for tritium. Each sampling site (Fig. 4.2) consists of a modified high-volume particulate sampler for uranium and a silica sorbent train for tritium.

Samples from the high-volume sampler are collected weekly. Total uranium analyses of the filters are conducted quarterly. An analysis for percent uranium-235 (^{235}U) will be performed at stations 40, 46, and 37. Tritium samples are collected at least biweekly and composited quarterly. Samples will be analyzed quarterly for tritium, gamma emitters by gamma spectrometry, gross alpha, gross beta, and any isotope that contributed 0.1 mrem or greater to the combined ORR dose (stack effluent).

In the event of unplanned releases of radionuclides that could potentially affect human health or the environment, samples may be collected from stacks and analyzed. The scenario of actions to be taken is detailed in DOE Order 232.1A. Samples could then be collected at appropriate ambient monitoring sites. Such an evaluation would take into account meterology and effluent release location.

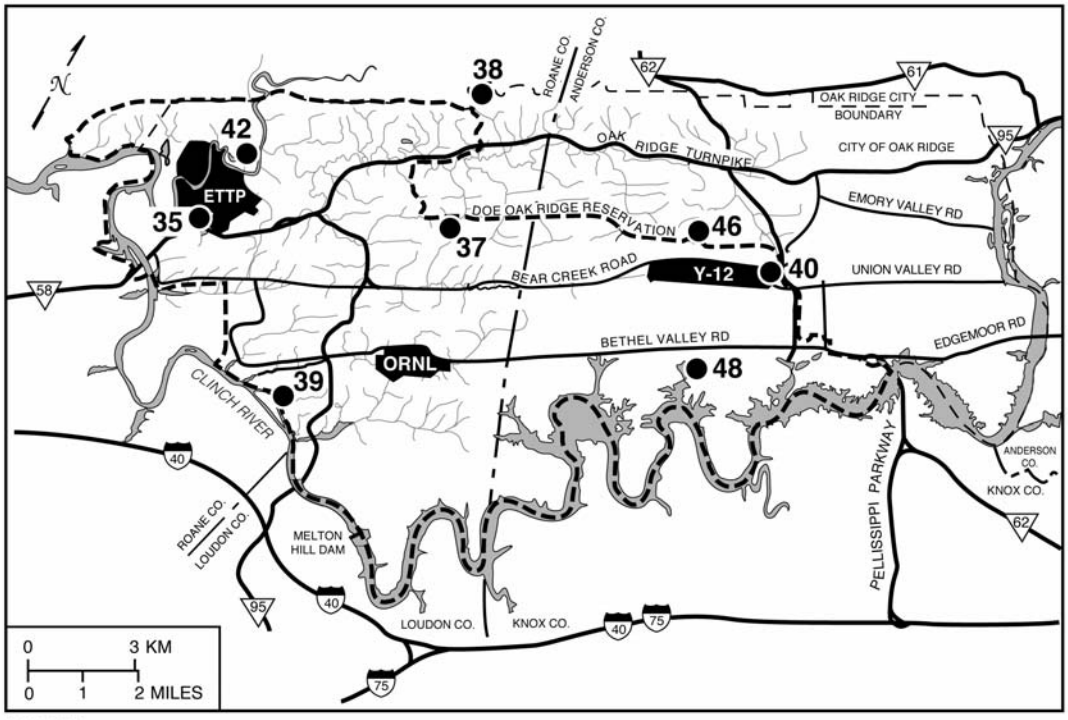

Fig. 4.2. Oak Ridge Reservation perimeter air monitor locations.

4.1.4 Procedures for Laboratory Analysis

Procedures for laboratory analysis of samples are addressed in Sect. 5 of this EMP.

4.1.5 Quality Assurance and Quality Control Requirements

QA and QC procedures are described in Sect. 9 of this EMP.

4.1.6 Data Analysis and Statistical Treatment

General data analysis and statistical treatment of ambient air data will follow guidelines stated in Sect. 7 of this EMP.

4.1.7 Reports and Records

Requirements for reports and records are addressed in Sect. 8 of this EMP.

4.1.8 Additional ORR Program Activities

The following sections document the ambient air monitoring programs at each site. The ambient monitoring data developed from these programs is site specific and managed by each site's compliance organization.

4.1.8.1 ETTP

Rationale and design criteria

The ETTP ambient air monitoring program consists of ambient air monitors located near the site boundary, which currently measure arsenic, beryllium, cadmium, lead, chromium, and total uranium (Fig. 4.3).

Two sampling stations, located north-northwest (TSCA1) and southwest (TSCA2) of the TSCA incinerator (Fig. 4.3), were designed to measure polychlorinated biphenyls (PCBs), furans, dioxins, hexachlorobenzene, and uranium at levels of concern. Location criteria were based on ambient air concentrations affecting the most exposed off-site individual (TSCA2) and the nearest off-site individual (TSCA1). The stations are remotely activated from the TSCA incinerator control room during thermal relief valve events or other process upsets that may occur. Each of the two stations is equipped with one high-volume sampler and two modified polyurethane foam filter systems.

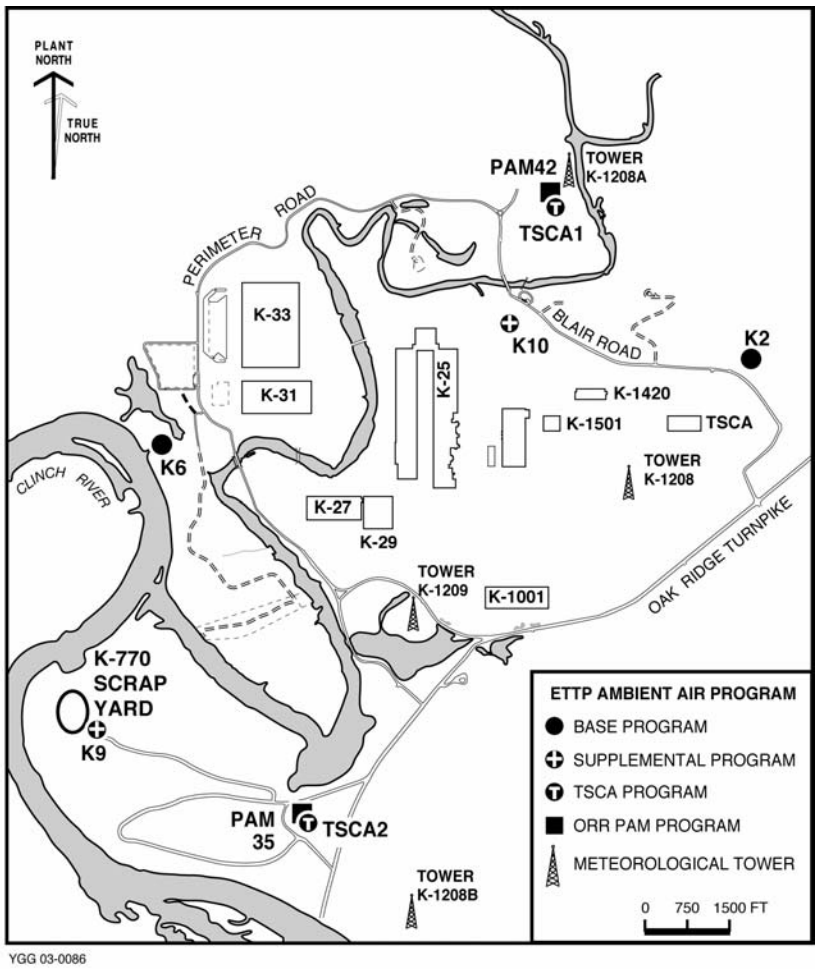

Fig. 4.3. Location of the East Tennessee Technology Park ambient air monitors.

Extent and frequency of monitoring

High-volume samplers operate continuously, with samples collected weekly. All weekly samples from each sampler are composited monthly for metals analysis, including total uranium.

The TSCA1 and TSCA2 samplers are remotely activated from the TSCA incinerator control room during a thermal relief valve event or process upset.

Procedures for laboratory analysis

The laboratory analysis of uranium and all metal samples from the high volume monitors will be performed using EPA SW846 Method 6020, "Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma Mass Spectrometry (ICP-MS)," or an equivalent approved method.

The laboratory analysis of uranium, PCBs, dioxins, furans, and hexachlorobenzene for TSCA1 and TSCA2 samples will be done as specified in the Analytical Services Organization (ASO) procedure "Ambient Air Sampling for K-1435 TSCA Incinerator," SESD-TP-8529/R3.

QA/QC procedures

QA/QC procedures for TSCA1 and TSCA2 samples are listed in EPA SW-846 reference method 8290 and in the *Quality Assurance Plan for Radionuclide Emission Measurements for Compliance with Tennessee Department of Environment and Conservation Emission Standards for Hazardous Air Contaminants at the East Tennessee Technology Park*, K/EM-504 (Energy Systems 1997a).

Data analysis and statistical treatment

Data analysis and statistical treatment of ambient sampling data are documented in the current version of the *East Tennessee Technology Park Environmental Monitoring Program Ambient Air Sampling, Analysis, and Quality Assurance Plan*, BJC/OR-760.

TSCA. Data analysis and statistical treatment of TSCA ambient monitoring data are documented in the current revision of "Ambient Air Sampling for K-1435 TSCA Incinerator Emissions," SESD-TP-8529/R3.

Reports and records

See Sect. 8 of this EMP.

4.1.8.2 ORNL

Rationale and design criteria

The ambient air monitoring program at ORNL consists of 4 PAM sites located around the site boundary (Fig. 4.4). A low-volume particulate sampler, tritium silica gel sorbent train, and charcoal filter sampler are collocated at each of the four sites. These sites were determined based on the intersection of the major wind directions at ORNL and the need to provide sampling coverage for Bethel Valley and Melton Valley.

Extent of frequency of monitoring

Charcoal cartridges are collected and analyzed biweekly. Paper filters are collected biweekly and composited and analyzed annually. Tritium is collected at least biweekly and composited and analyzed quarterly.

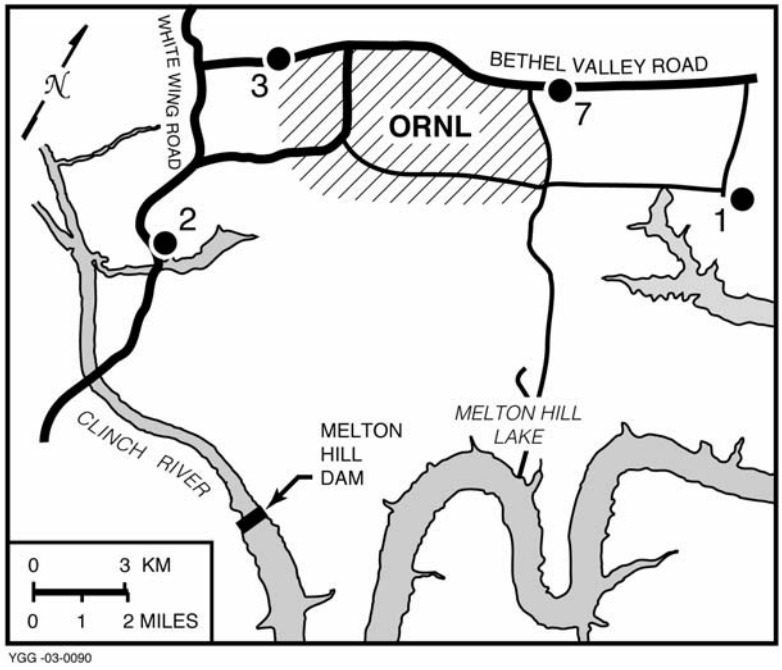

Fig. 4.4. Oak Ridge National Laboratory ambient air monitor locations.

Procedures for laboratory analysis

See Sect. 5 of this EMP.

QA/QC procedures

See Sect. 9 of this EMP.

Data analysis and statistical treatment

See Sect. 7 of this EMP.

Reports and records

See Sect. 8 of this EMP.

4.1.8.3 Y-12 National Security Complex

The ambient air network at Y-12 (Fig. 4.5) is maintained solely as a BMP and is not required to fulfill regulatory requirements or DOE orders. Continued operations are contingent on availability of funding.

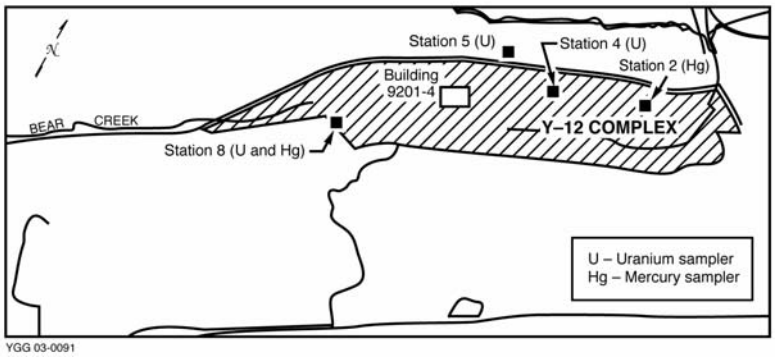

Fig. 4.5. Ambient air monitoring network at the Y-12 National Security Complex.

Until 1995, the ambient network consisted of 12 low-volume, particulate monitoring stations, 11 fluoride monitoring stations, 2 collocated total suspended particulate and respirable particulate (PM-10) monitoring stations, and 4 ambient mercury monitoring stations. Since January 1995, three low-volume stations have remained for collection of uranium particulates. The rationale for this change has been documented in *Evaluation of the Ambient Air Monitoring Program at the Oak Ridge Y-12 Plant*, Y/TS-1157/R1 (Energy Systems 1994b), and through discussions with TDEC DOE Oversight Division (DOE-O) personnel. Effective April 1999, TDEC personnel took responsibility for sampling and analysis of the three remaining uranium samplers.

Additionally, Y-12 has monitored ambient concentrations of mercury since July 1986. The goals of the program were to establish an historical database of mercury concentration in ambient air at Y-12, identify spatial and temporal trends in mercury vapor concentrations at Y-12, and demonstrate protection of the environment and human health from releases of mercury from Y-12 to the atmosphere.

Two outdoor ambient mercury monitoring stations (stations on the east and west ends of the Complex) are currently monitored. These stations have been monitored since 1986. In December 1999, DOE submitted to TDEC a letter providing justification for reducing the number of on-site mercury monitoring stations from four to two. Effective January 1, 2000, operation of the two monitors located in the interior of the Complex (near Buildings 9805-1 and 9422-13) was discontinued. The two boundary mercury monitoring stations (stations 2 and 8) remain in operation. The locations of these monitoring stations are shown in Fig 4.5.

Because no established or EPA-approved methods for measuring mercury vapor in ambient air existed when the program was initiated, staff of the ORNL Environmental Sciences Division developed a method to meet the needs of the monitoring program for Y-12. Details of this method are in *Mercury in Ambient Air at the Oak Ridge Y-12 Plant, July 1986 through December 1990*, Y/TS-574 (Energy Systems 1991d). At each of the monitoring sites, airborne mercury vapor is adsorbed onto iodated charcoal by pulling air through a Teflon™ filter, a flow-limiting orifice, and a glass sampling tube packed with the iodated charcoal. The charcoal sampling tubes are changed every 7 days.

Extent and frequency of monitoring

Iodated charcoal tubes used to collect mercury are changed every 7 days.

Procedures for laboratory analysis

The charcoal tubes are submitted quarterly for analysis by an off-site laboratory.

QA/QC procedures

QA/QC procedures used in sampling and retrieval of ambient air monitoring data are documented in the EC organization's Y-50- and Y-71-series technical and administrative procedures.

Reports and records

The data derived from Y-12 ambient air samplers are used exclusively for BMP surveillance and for historical reference. Reports of these data are not mandated by regulations, but the data are presented in ASER.

4.2 EXTERNAL GAMMA RADIATION

4.2.1 Introduction

This section describes the objectives and general methods for the external gamma radiation monitoring program. At several locations on ORR and off-site, external gamma radiation exceeds background levels. The on-site areas are accessible to members of the public on a restricted basis (drive-through traffic or visiting the facilities), while those off-site are unrestricted. Although estimated doses are below the 100-mrem DOE standard, these areas, under the direction of DOE, will be monitored periodically to ensure that the public and the environment are protected.

The objectives of this program are to assess the actual or potential radiation dose to persons (1) living near ORR, (2) visiting facilities on ORR or passing through ORR, and (3) fishing or boating in creeks or rivers near ORR. This program does not address personnel monitoring, which is covered by the radiation control organization at each of the facilities.

4.2.2 Rationale and Design Criteria

Members of the public could hypothetically be exposed directly to gamma radiation from radionuclides released into the environment; previously released radionuclides deposited on soil and vegetation or in sediments; radiation-generating facilities, especially high-energy accelerators; and the storage of radioactive materials.

Aerial radiological (gamma) surveys of ORR have been conducted. The survey sites included ORNL, ETTP, Y-12, the Freels Bend area, the Oak Ridge Institute for Science and Education, East Fork Poplar Creek (100-year floodplain extending from ETTP to Y-12), Elza Gate (former uranium ore storage site located in the city of Oak Ridge), Parcel A, the Clinch River (river banks extending from Melton Hill Dam to the city of Kingston), and the CSX Railroad tracks (extending from Y-12 to the city of Oak Ridge). The radionuclides, cesium-137 (^{137}Cs) and cobalt-60 (^{60}Co), ^{235}U, and uranium-238 (^{238}U), were detected at several sites on ORR.

Besides these areas identified during the aerial surveys, the public may be exposed to external radiation levels above background while visiting the facilities or driving by on the public highways. However, theoretical calculations indicate that the doses received from this limited exposure are negligible.

Because the sources of public exposure to external radiation are different (airborne emissions, soil and sediments, cylinder storage), the design criteria are also different. The primary factor in selecting the monitoring locations for airborne radionuclides was the potential for public exposure. Continuous gamma monitoring will continue at selected ambient air stations (39, 40, 42, 46, and 48) described in Sect. 4.1 of this EMP. Locations were selected based on models using the average meteorological conditions and existing population distributions. In addition, an external gamma monitor is installed at Fort Loudoun Dam (Station 52) to measure background exposure levels.

4.2.3 Sample Frequency and Parameters

External gamma radiation levels will be monitored continuously at six ambient air stations, including the Fort Loudoun reference station, using a pressurized ionization chamber gross gamma monitor. It measures dose rate levels from 1 μR/h to 100 mR/h. External gamma readings will be taken and recorded on a weekly basis.

4.2.4 Procedure for Laboratory Analysis

N/A.

4.2.5 QA/QC Requirements

The external gross gamma monitors and exposure-rate instruments will be calibrated periodically in accordance with written procedures and sources or standards traceable to National Institute of Standards and Technology (NIST) standards. The data from the gross gamma monitors will be analyzed routinely, and the instruments will be on a schedule of regular documented inspection and maintenance.

4.2.6 Data Analysis and Statistical Treatment

Results from the external gamma monitoring program will be converted to potential dose rates. To calculate the dose, an assumption of continuous exposure (24 hours a day, 365 days a year) will be used for all locations unless a specific rationale for an alternate exposure time is developed and documented.

4.2.7 Reports and Records

All records will be maintained by EP&WS personnel at ORNL.

All external gamma radiation measurements for the previous calendar year and those made periodically (every 3 and 5 years) will be listed and summarized in ASER. In addition to presenting results, this report will document the exposure assumptions used in the dose assessments.

4.2.8 Direct Radiation Program at ETTP

The uranium hexaflouride (UF_6) cylinder storage areas at ETTP along Poplar Creek are the primary identified source of potential exposure to the public from gamma radiation emanating from a source at ETTP. These sections of Poplar Creek are sometimes used by anglers. Theoretical doses, using measured exposure rates, are calculated to hypothetical, maximally exposed individuals. Calculated doses will be modified to reflect any changes in the measured dose rates. If other sources of direct radiation are identified, appropriate exposure scenarios will be devised and doses estimated.

Gamma dose rates from the cylinder yards at ETTP are measured either directly with a tissue-equivalent dose response meter or with environmental dosimeters placed in locations accessible to the public in the vicinity of the cylinder yards. The calculated EDEs are based on the measured dose rates and are adjusted for gamma background readings established at the ambient air monitor stations surrounding ETTP. Neutron measurements are also obtained in the vicinity of the cylinder yards, but to date the readings have been negligible. Results of the direct radiation monitoring program at ETTP are included each year in ASER. The results are also incorporated in the dose assessment evaluation section of ASER.

4.3 GROUNDWATER

Perimeter surveillance monitoring is intended to monitor the exit pathways that contaminated groundwater would likely travel from each facility to the environment. It is designed to monitor any effects the facility has on local groundwater and/or surface water quality, consistent with the objectives stated in DOE Order 5400.1. Perimeter sampling locations, parameters, and frequencies are determined through evaluating the best technical information available on the hydrogeologic setting of the facilities (Forstrom et al. 1993).

The IWQP was established in 1996 to develop a consistent approach to long-term watershed-based monitoring across ORR. The IWQP plan (ES/ER/TM-205, Lockheed 1996a), describes the overall approach for a comprehensive surface water, groundwater, and biological monitoring program to support watershed management decisions. See ES/ER/TM-205 for specific details associated with IWQP. The current groundwater sampling program is described in the WRRP sampling and analysis plan (BJC 2002), which is the programmatic successor to IWQP.

4.3.1 Rationale and Design Criteria

Groundwater investigations on ORR have indicated groundwater flow above the water table in the storm flow zone; below the water table in the unconsolidated zone; and in the bedrock, which is largely influenced by topography. That is, groundwater moves from recharge areas under ridges or local topographic highs to discharge areas in valleys or local topographic lows (Moore 1988, 1989; Geraghty and Miller 1989b). This topographic influence can be significantly modified by structural features (e.g., bedding planes, joints, fractures) such that the "downhill" movement of groundwater is typically skewed along strike (parallel to valley axes and ridge crests). Because most ORR facilities are located within valleys, the combination of topographic and structural influences indicates that groundwater surveillance should be conducted at exit pathways generally found within the valleys downgradient of and/or along strike from the facilities. See the IWQP plan, ES/ER/TM-205, for specific details of the groundwater monitoring program at ETTP.

One exit pathway has been identified for monitoring at ORNL (Fig. 4.6). Other potential exit pathways are monitored under WRRP. Perimeter surveillance of groundwater in both the unconsolidated zone and the bedrock will be supported by surface water surveillance to detect any off-site migration of contaminated groundwater through the exit pathways.

Y-12 has been subdivided into three distinct hydrogeologic regimes based on topography, surface water drainage, and groundwater flow patterns (Geraghty and Miller 1990a). These three distinct hydrogeologic regimes are the Bear Creek, Upper East Fork Poplar Creek, and Chestnut Ridge hydrogeologic regimes. The exit pathways for each of these hydrogeologic regimes are monitored at the perimeter of Y-12 (Fig. 4.7). All monitoring is described in annual sampling and analysis plans.

In the Bear Creek hydrogeologic regime, perimeter surveillance of groundwater in four wells [GW-712 through GW-715 (Fig. 4.7 and Table 4.2)] in the unconsolidated and bedrock zones is currently conducted semiannually to detect any migration of contaminated groundwater through the exit pathways. These wells monitor the Maynardville Limestone, which is the primary geologic unit of concern for contaminant transport. These wells also comprise the corrective action plume delineation monitoring transect required by the current Bear Creek hydrogeologic regime RCRA postclosure permit.

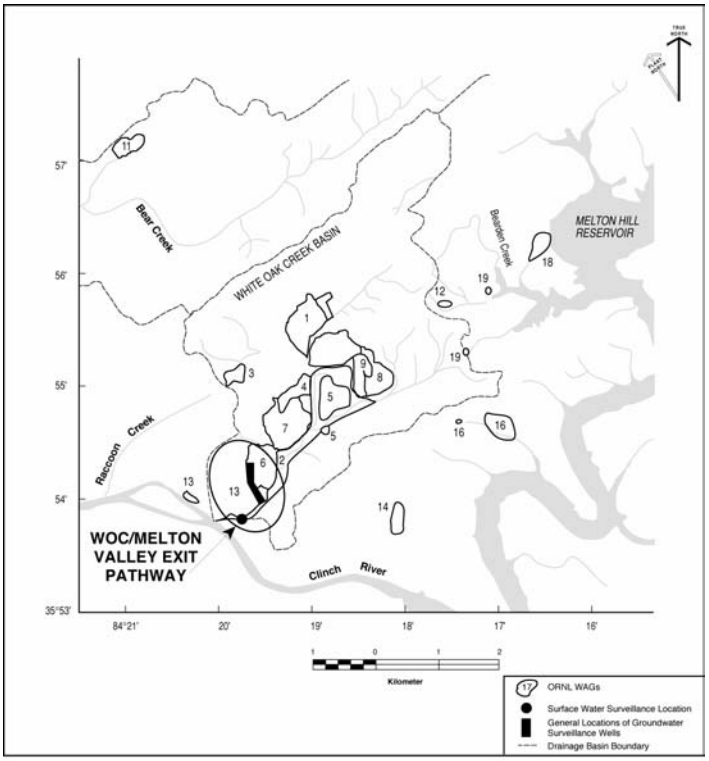

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Fig. 4.6. Exit pathways, plant perimeter groundwater surveillance wells, and surface water surveillance locations for the Oak Ridge National Laboratory.

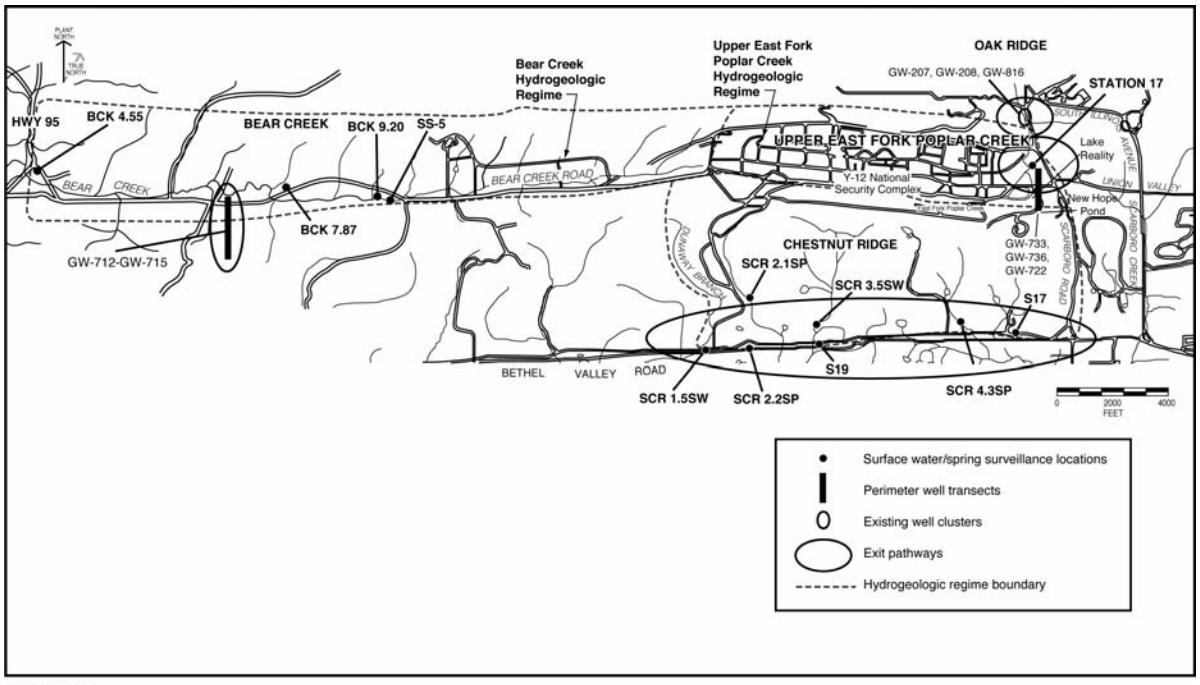

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Fig. 4.7. Hydrogeologic regimes and exit pathway perimeter surveillance locations for surface water and groundwater monitoring at the Y-12 National Security Complex.

Table 4.2. Summary of formal perimeter groundwater and surface water surveillance locations at the Y-12 Nuclear Security Complex

Exit pathway	Perimeter surveillance wells	Surface water surveillance locations
Bear Creek regime	GW-712, GW-713, GW-714, GW-715	BCK 4.55[b], BCK 9.20, BCK 7.87, SS-5 (spring station)
UEFPC[a] regime		Station 17[b] (UEFPC km 23.4)
Pine Ridge Gap	GW-207, GW-208, GW-816	
Scarboro Road	GW-733, GW-735, Westbay system GW-722	
Chestnut Ridge regime	Not applicable	South Chestnut Ridge 4.3 spring (SCR 4.3SP), SCR2.1SP, SCR2.2SP, SCR1.5SW, SCR3.5SW, S-17, S-19[b]

[a]UEFPC = Upper East Fork Poplar Creek.

[b]See Sect. 4.4.3.4 for additional information.

Because of extensive karst features within the shallow and intermediate groundwater zones and the known connection of surface water and groundwater in the regime, the wells do not provide complete coverage for perimeter surveillance monitoring in this part of the hydrogeologic system. Thus, a spring station (SS-5) and three surface water stations (BCK 4.55, BCK 7.87, and BCK 9.20) will be monitored semiannually as formal perimeter locations to augment the well transect. Additional exit pathway surveillance locations, depending on programmatic resources and drivers, will be monitored within the Maynardville Limestone and along geologic strike of major WM units to meet regulatory compliance requirements, provide trend data, and monitor the edges of contaminant plumes. These locations will be specifically identified in the annual sampling and analysis plan (BWXT 2002d; BJC 2002) as surveillance monitoring locations and will remain relatively constant over time.

In the Upper East Fork Poplar Creek hydrogeologic regime, three monitoring wells [GW-816, GW-207, and GW-208 (Table 4.2)] located northeast of Y-12 will be monitored. Surface water surveillance of Upper East Fork Poplar Creek below Lake Reality (Station 17) is discussed in Sect. 4.4.3.4. These locations monitor the exit pathway for surface water and shallow groundwater through a water gap in Pine Ridge. Within the Maynardville Limestone in the Upper East Fork Poplar Creek hydrogeologic regime, contaminants are known to have migrated off site into Union Valley to the east of Y-12. Thus, perimeter surveillance monitoring serves only to monitor trends in contaminant levels in the exit pathway at the ORR boundary. Three wells (GW-733, GW-735, and GW-722) are monitored along Scarboro Road as formal perimeter surveillance locations. Well GW-722 is a multilevel Westbay well having several sampling ports at various depths to 700 ft below ground surface. These formal perimeter surveillance monitoring locations are augmented by long-term monitoring of the known extent of the off-site

contaminant plume in Union Valley using wells and a number of surface water and spring locations under requirements of a CERCLA interim action. These locations are a component of WRRP, and monitoring is expected to remain relatively constant pending issuance of a final CERCLA ROD for all of the Upper East Fork Poplar Creek hydrogeologic characterization area.

In the Chestnut Ridge hydrogeologic regime, perimeter surveillance monitoring using monitoring wells has limited utility due to extensive karst development beneath the ridge. Two dye-trace studies were conducted on Chestnut Ridge, but the results were of limited value in identifying discharge points (Goldstrand and Haas 1994). Three springs (SCR2.1SP, SCR2.2SP, and SCR4.3SP) and three surface water locations are monitored as a formal perimeter surveillance monitoring location. Additional springs and spring-fed streams that flow from the ridge may be sampled as surveillance sites to provide additional data; these locations will be identified in the Y-12 annual sampling and analysis plans. This surveillance monitoring is augmented by corrective action monitoring of exit pathways under the RCRA postclosure permit for the Chestnut Ridge hydrogeologic regime and the extent of the known groundwater contaminant plume emanating from the Chestnut Ridge Security Pits. In addition, detection monitoring dictated by operating permits for SWMUs provides additional data. These monitoring activities are also detailed in Y-12 annual sampling and analysis plans. Monitoring of potential transport of contaminants off ORR along geologic strike beneath Chestnut Ridge is also addressed as part of the Union Valley interim actions discussed above.

Background wells are not included in the Complex's perimeter surveillance program because groundwater effluent monitoring programs are expected to provide sufficient data to allow determinations of background water quality for surveillance purposes.

The principal contaminants identified at Y-12 are volatile organic compounds (VOCs), nitrate, PCBs, and certain radionuclides (DOE 1997, 1998, BWXT 2002d). Groundwater investigations have determined that VOCs and certain radionuclides are also the principal contaminants at ETTP and ORNL [Forstrom 1990b; *Groundwater Quality Assessment Report for the Solid Waste Storage Area 6 at the Oak Ridge National Laboratory, 1996* (Lockheed Martin 1997a); *Groundwater Remedial Site Evaluation Report for the Oak Ridge K-25 Site, Oak Ridge, Tennessee* (DOE/OR/01-1468V1&D1, SAIC 1996)]. Based on this information and on consideration of facility history and contaminant mobility, VOCs, uranium, fluoride, and technetium-99 (^{99}Tc) were determined to be key indicator contaminants for perimeter monitoring at exit pathways from ETTP; tritium, strontium-90 (^{90}Sr), VOCs, ^{60}Co, and ^{137}Cs were identified as key indicators for monitoring at the ORNL site; and VOCs, mercury, nitrate, uranium, and ^{99}Tc were identified as key indicators for the Y-12 perimeter.

The appropriate frequency for perimeter surveillance monitoring is based on estimated contaminant travel time to off-site groundwater users (Forstrom 1990a). This approach is intended to ensure that any contamination migrating off site is detected in time to institute control measures before it reaches an off-site user. See the IWQP plan, ES/ER/TM-205.

4.3.2 Sampling Frequency and Parameters

A combination of wells, several springs and spring-fed streams, and surface water monitoring stations associated with certain exit pathways comprise the ORR perimeter groundwater surveillance network.

Ten wells completed at various depths and one surface water monitoring station will comprise the ORNL perimeter groundwater surveillance network (Table 4.3). The general locations of the wells are depicted in Fig. 4.6. The perimeter surveillance network for Y-12 will include nine conventional wells completed at various depths, one multilevel (Westbay) sampling system, eight surface water monitoring stations and four natural springs (Table 4.2). The general locations of all of these monitoring locations are depicted in Fig. 4.7. Other locations sampled to meet surveillance monitoring requirements are identified in annual Y-12 sampling and analysis plans.

Monitoring parameters for facility perimeter surveillance will be the key indicator contaminants for the individual facilities identified in Sect. 4.3.1 plus gross alpha and gross beta radioactivity, which are included as trend indicators. Parameters for the individual facilities are listed in Tables 4.4 and 4.5.

Table 4.3. Summary of perimeter groundwater and surface water surveillance locations at the Oak Ridge National Laboratory

Exit pathway	Surveillance wells	Surface water surveillance locations
White Oak Creek/ Melton Valley	0859 0860 1236 0857 0858 1239 1189 1190 1191 1192	White Oak Creek at White Oak Dam

Table 4.4. Parameters for perimeter groundwater surveillance at the Oak Ridge National Laboratory

Parameter
Volatile organic compounds
Tritium
Total radioactive ^{90}Sr
Gross alpha
Gross beta
Gamma emitters by gamma spectrometry
Inductively coupled plasma metals

Table 4.5. Parameters for perimeter groundwater surveillance at the Y-12 National Security Complex

Parameter
^{99}Tc (selected locations only)
Volatile organic compounds (target list)
Gross alpha
Gross beta
Total uranium
Nitrate
Mercury

Perimeter surveillance sampling at all ORR perimeter wells will be conducted at least annually by each site program. The nearest groundwater users to ETTP and ORNL are separated from the facilities by the Clinch River and Black Oak Ridge, which form distinct hydrogeologic boundaries based on existing geologic and hydrologic data. For Y-12, perimeter monitoring supplements an extensive effluent monitoring program. Results from effluent monitoring suggest that observed contaminant plumes in the Complex area migrate many times more slowly than is implied by the calculated groundwater velocities. The best indicator of the rate of contaminant migration is the present configuration of contaminant plumes at Y-12, as detailed in the annual Y-12 groundwater data evaluation report (BWXT 2002d). Thus, minimum annual sampling should provide sufficient warning of off-site contaminant migration to institute control measures to protect off-site users. Many of the perimeter surveillance locations are monitored at a greater frequency dictated by other drivers (i.e., CERCLA or RCRA).

Sample collection shall be performed using site-specific procedures that follow general industry and EPA guidelines and procedures.

4.3.3 Procedures for Laboratory Analysis

Guidelines for laboratory analysis and procedures are addressed in Sect. 5 of this EMP.

QA requirements are addressed in Sect. 9 of this EMP. The Y-12 groundwater protection program management plan (BWXT 2001) provides details and references to the program implementing procedures at Y-12.

4.4 ORR SURFACE WATER, SEDIMENT, AND AQUATIC BIOTA

4.4.1 Introduction

Surface water

Measurement of water quality parameters in surface water samples provides a general guide to the environmental health of the system. Certain contaminants that are not particularly concentrated in other media (e.g., VOCs) are more efficiently analyzed in water samples.

Sediments

Sediments collect, concentrate, and store specific kinds of contaminants at specific locations. Concentrations of contaminants in sediments thus are integrated measures of aqueous contaminant concentrations over some preceding period of time. A single sediment sample can represent information that would require a large number of water samples, spaced over a period of time, to reconstruct.

Aquatic biota

Aquatic foods, including fish, may be eaten in relatively large quantities by residents of the area.

4.4.2 Rationale and Design Criteria

The surface water, sediment, and biological sampling sites included in this environmental surveillance program are located on (1) selected receiving streams immediately downstream from possible contaminant sources; (2) public drinking water supply intakes; and (3) reference locations, either off site or upstream of DOE facilities. Water samples will be monitored at public drinking water supply intakes to ensure the quality of these sources. The locations of the water supply intakes are not necessarily appropriate for achieving the objectives of sediment and biota monitoring. Biological monitoring is also conducted as part of the NPDES compliance programs and therefore is discussed under liquid effluent monitoring.

Several basic assumptions are inherent in the sampling design. The first major assumption is that the level of knowledge of the surface water hydrology is sufficient to define suitable stream reaches for water sediment and fish sampling. Proposed sampling stations are based on a body of

information that is being supplemented by other ongoing projects, such as delineation of contaminated groundwater plumes.

4.4.3 Sampling Frequency and Parameters

4.4.3.1 Surface water

Surface water will be sampled at locations downstream from Oak Ridge facilities and multiple reference sites (Fig. 4.8). The sampling sites, which are listed below, are designated by the distance (in kilometers) upstream from the mouth (e.g., CRK = Clinch River Kilometer; WCK = White Oak Creek Kilometer, etc.).

- Melton Hill Reservoir above all DOE inputs (CRK 70), Solway Bridge
- Clinch River downstream of DOE inputs (CRK 16)
- Bear Creek downstream from all DOE inputs (BCK 0.6)—UT-Battelle Management Area
- East Fork Poplar Creek downstream from floodplain (EFK 5.4)
- East Fork Poplar Creek 0.1 (EFK 0.1)—UT-Battelle Management Area
- Clinch River downstream from ORNL (CRK 32)
- Water supply intake for city of Oak Ridge (CRK 66)
- Water supply intake for Knox County (CRK 58)
- Water supply intake for ETTP (CRK 23)

Grab samples will be collected at frequencies ranging from 2 to 12 times annually in such a way as to be representative of the bulk water flowing past the sampling site.

Tables 4.6 and 4.7 identify constituents that may be analyzed, depending on location.

4.4.3.2 Surface water sampling at ORNL

Environmental surveillance at surface water locations on creeks and streams at ORNL is conducted to assess the impacts, if any, of current operations at ORNL on the public and environment. The sampling sites, which are listed below, are designated by the distance (in kilometers) upstream from the mouth.

- White Oak Creek upstream from ORNL (WCK 6.8)—reference for ORNL
- White Oak Creek downstream from ORNL (WCK 2.6)—ORNL discharges from Bethel Valley
- Melton Branch downstream from ORNL (MEK 0.2)—ORNL discharges from Melton Valley
- White Oak Lake at White Oak Dam (WCK 1.0)—ORNL discharges from Bethel Valley and Melton Valley
- Northwest Tributary 0.1 (NWTK 0.1)—ORNL discharges from Solid Waste Storage Area (SWSA) 3

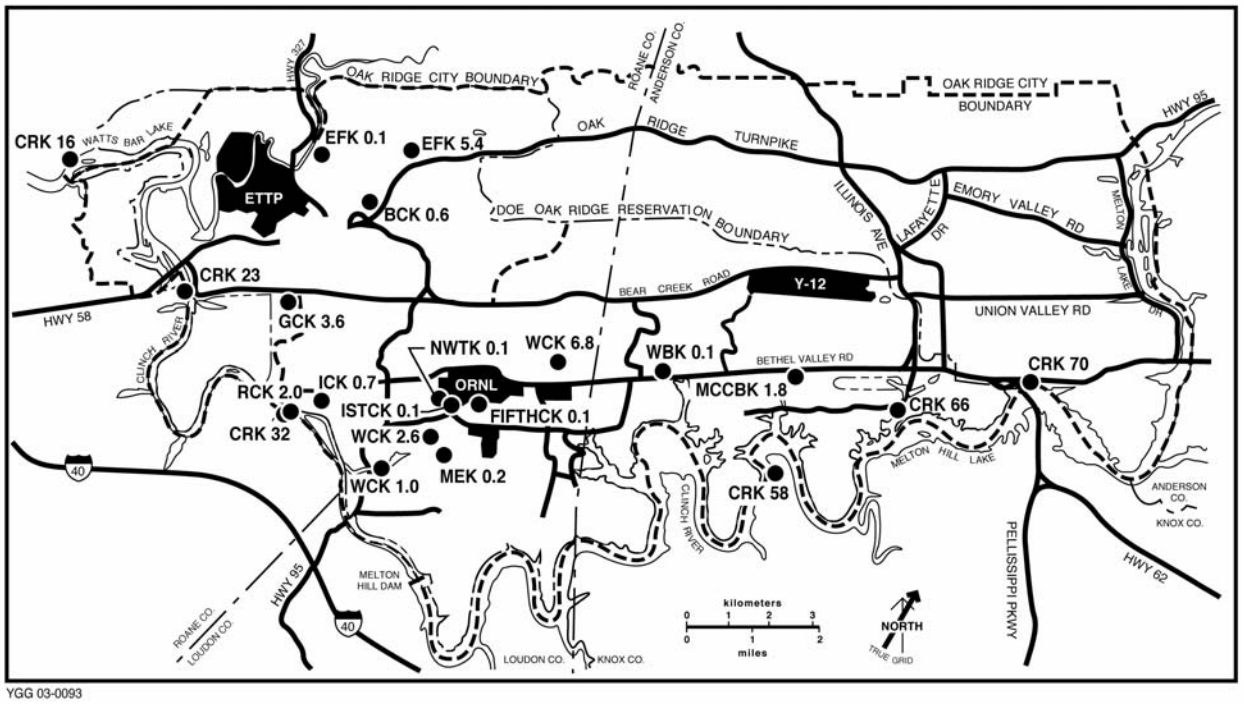

Fig. 4.8. Sampling sites for surface water in the Oak Ridge Reservation and Oak Ridge National Laboratory environmental surveillance program.

- First Creek 0.1 (1STCK 0.1—ORNL discharges from portion of Bethel Valley
- Fifth Creek 0.1 (FIFTHCK 0.1) —ORNL discharges from portion of Bethel Valley
- Walker Branch 0.1 (WBK 0.1) —UT-Battelle Management Area
- McCoy Branch 1.8 (MCCBK 1.8) — UT-Battelle Management Area
- Grassy Creek 3.6 (GCK 3.6) — UT-Battelle Management Area
- Ish Creek 0.7 (ICK 0.7) — UT-Battelle Management Area
- Raccoon Creek 2.0 (RCK 2.0) — UT-Battelle Management Area

Grab samples will be collected at frequencies ranging from 2 to 12 times annually. Tables 4.6 and 4.7 identify constituents that may be analyzed, depending on location.

4.4.3.3 Surface water at ETTP

Environmental surveillance is conducted at ETTP to assess the impacts, if any, of ETTP operations on the public and environment and to assess the efficacy of remedial actions. Results obtained from the K-1710 and Mitchell Branch Kilometer 1.4 (MIK 1.4) monitoring locations provide information representative of surface water conditions at points upstream from most ETTP activities. Monitoring at three other locations (K-901-A, K-1007-B, and K-1700) provides data on stream conditions at the exit points for the three major ETTP watersheds (Fig. 4.9). K-716 and Clinch River Kilometer 16 (CRK 16) provide data on stream conditions downstream of ETTP. Monitoring at the spring east of the railroad embankment at MIK 0.4 provides data on a potential source of contaminated surface water entering Mitchell Branch.

Table 4.6. Oak Ridge Reservation/Oak Ridge National Laboratory surface water parameters and sampling frequencies

Parameters

General water quality/nutrients	Metals/inorganics		Volatile organic compounds	Radionuclides
	Aluminum	Lead	Target compound list[a]	Gross alpha[b]
	Antimony	Magnesium		^{90}Sr
	Arsenic	Manganese		^{3}H
	Barium	Mercury		^{99}Tc
	Beryllium	Nickel		
	Cadmium	Potassium		Gamma emitters by gamma spectrometry
	Calcium	Selenium		Gross beta
Dissolved oxygen	Chloride	Silver		
	Chromium	Sodium		
	Cobalt	Thallium		
pH	Copper	Uranium		
	Cyanide	Vanadium		
	Fluoride	Zinc		
	Iron			
Temperature				

Water sampling frequencies

Sampling frequency per year	Sampling sites[c]
2	EFK 5.4, EFK 0.1, BCK 0.6, WBK 0.1, MCCBK 1.8, GCK 3.6, ICK 0.7, RCK 2.0, NWTK 0.1, 1STCK 0.1, FIFTHCK 0.1
4	WCK 6.8
6	WCK 2.6, MEK 0.2
12	CRK 70, CRK 66, CRK 58, CRK 32, CRK 23, WCK 1.0

[a] A detailed listing of chemicals is provided in Table 4.7.

[b] If > 3pCi/L (20% of EPA drinking water limit), do isotope-specific analysis for ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, ^{237}Np, ^{228}Th, ^{230}Th, ^{232}Th, ^{241}Am, and ^{244}Cm as needed to identify cause.

[c] See Sect. 4.4.3.1 and Fig. 4.8.

Table 4.7. Target compound list—volatile organic compounds (VOCs), pesticides, polychlorinated byphenyls (PCBs), and herbicides

VOCs	Pesticides/PCBs/herbicides
Chloromethane	Aldrin
Bromomethane	α-BHC
Vinyl chloride	β-BHC
Chloroethane	δ-BHC
Methylene chloride	γ-BHC (Lindane)
Acetone	Chlordane (technical)
Carbon disulfide	4,4'-DDD
1,1-Dichloroethene	4,4'-DDE
1,1-Dichloroethane	4,4'-DDT
1,2-Dichloroethene (total)	Dieldrin
Chloroform	Endosulfan I
1,2-Dichloroethane	Endosulfan II
2-Butanone (MEK)	Endosulfan sulfate
1,1,1-Trichloroethane	Endrin
Carbon tetrachloride	Endrin aldehyde
Bromodichloroemethane	Heptachlor
1,1,2,2-Tetrachloroethane	Heptachlor epoxide
1,2-Dichloropropane	Methoxydhlor
cis-1,3-Dichloropropene	Toxaphene
Trichloroethene	PCB-1016
1,1,2-Trichloroethane	PCB-1221
Dibromochloromethane	PCB-1232
Benzene	PCB-1242
trans-1,3-Dichloropropene	PCB-1248
Bromoform	PCB-1254
2-Hexanone	PCB-1260
4-Methyl-2-pentanone (MIBK)	2,4-D
Tetrachloroethene	2,4,5-TP (Silvex)
Toluene	
Chlorobenzene	
Ethylbenzene	
Styrene	
Xylenes, total	

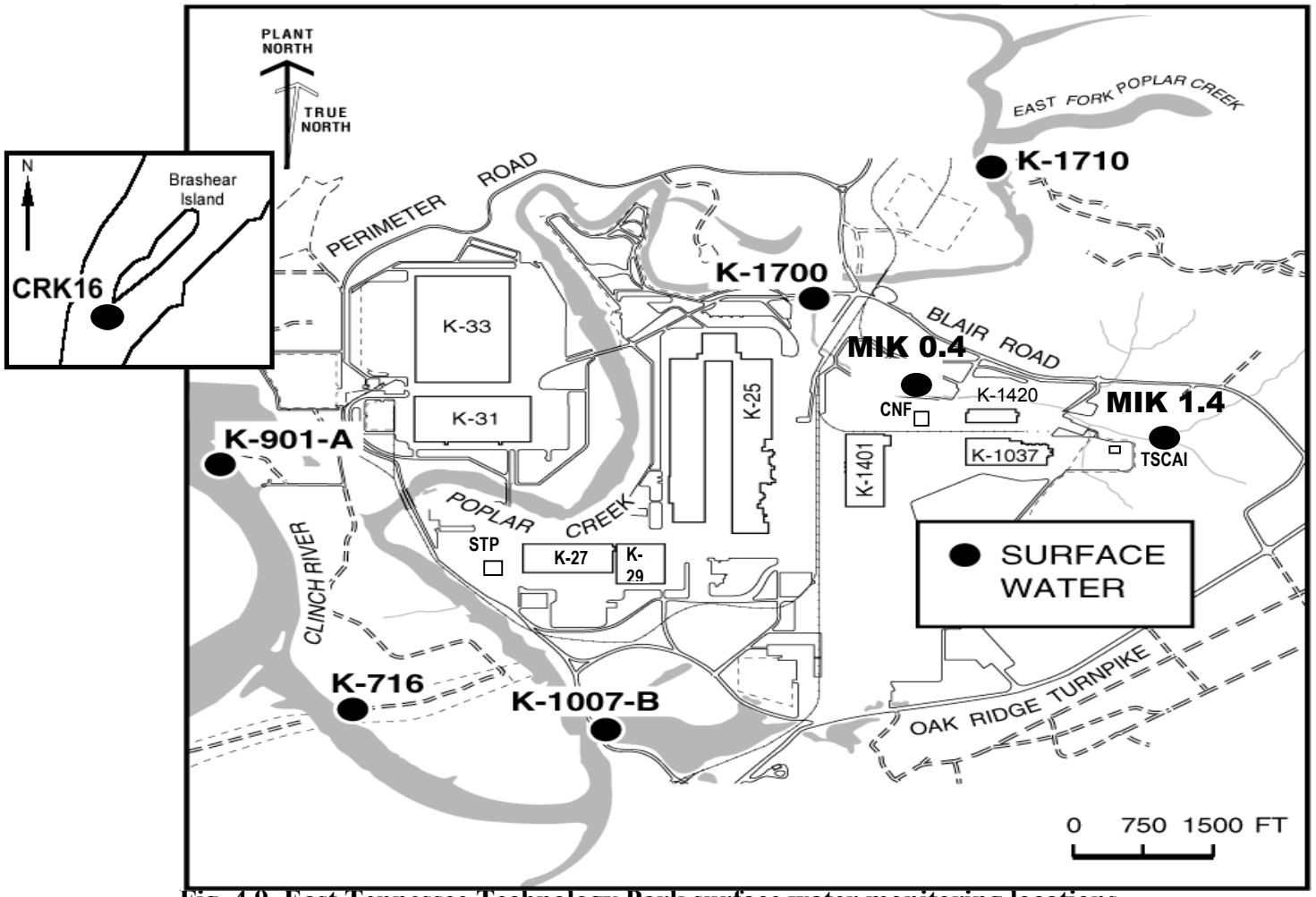

Fig. 4.9. East Tennessee Technology Park surface water monitoring locations.

Sampling consists of monthly monitoring for radionuclides, water quality parameters, metals, and VOCs at CRK 16; quarterly monitoring for radionuclides, water quality parameters, and VOCs at MIK 1.4; quarterly monitoring for radionuclides, water quality parameters, metals, VOCs, and continuous flow at K-1700; semiannual monitoring for radionuclides, water quality parameters, metals, and continuous flow at K-901-A and K-1007-B; semiannual monitoring for radionuclides and water quality parameters at K-716 and K-1710; and semiannual monitoring for radionuclides, water quality parameters, metals, and VOCs at MIK 0.4. Radiological results are compared with the DCGs published in DOE Order 5400.5. Details on the parameters are documented in the program-specific sampling and analysis plan, which is updated and issued annually.

4.4.3.4 Surface water BMPs at the Y-12 National Security Complex

Y-12 EC organization staff monitor the surface water as it exits from each of the three hydrogeologic regimes that serve as an exit pathway for surface water (Fig. 4.10). Radiological monitoring of these exit pathways is a component of the RMP required by NPDES (see Chap. 2, "Effluent Monitoring"). Continuation of BMP monitoring is contingent on the availability of funding. Monitoring is conducted in East Fork Poplar Creek (EFK 23.4) at Station 17 (9422-1), near the junction of Scarboro and Bear Creek roads. The present sampling program consists of two 48-h composites plus a 3-day weekend composite. These samples are analyzed for mercury, ammonia-N, metals by inductively coupled plasma (ICP), and total suspended solids. Monitoring is conducted in Bear Creek at BCK 4.55 (formerly NPDES station 304), which is at the western boundary of the Y-12 area of responsibility. A surveillance sample (a 7-day composite sample) is collected monthly for mercury, anions (sulfate, chloride, orthophosphate, nitrate, nitrite), ICP metals, total phenols, and total suspended solids.

The exit pathway from the Chestnut Ridge regime is monitored by NPDES location S19 (formerly NPDES station 302) at Rogers Quarry. S19 is an in-stream location of McCoy Branch and is sampled monthly for ICP metals. The NPDES requirement for this location is to monitor and report only. As part of the surface water BMP surveillance activity, surface water data from this location, as well as from Station 17 and BCK 4.55, are compared with state water quality criteria and with DOE order requirements. Data collected for nonradiological parameters are compared with Tennessee water quality criteria if a criterion exists for a given parameter. The most restrictive of either the fresh water fish and aquatic life criterion maximum concentration or the "recreation concentration for organisms only" standard (10^{-5} risk factor for carcinogens) is used.

Within the boundary of Y-12 a network of real-time monitors is located at in-stream locations along Upper East Fork Poplar Creek and at key points on the storm drain system that flows to the creek. The stations are available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 4.11. Not all stations are operated on a routine basis, but all are available as necessary and as available funding allows.

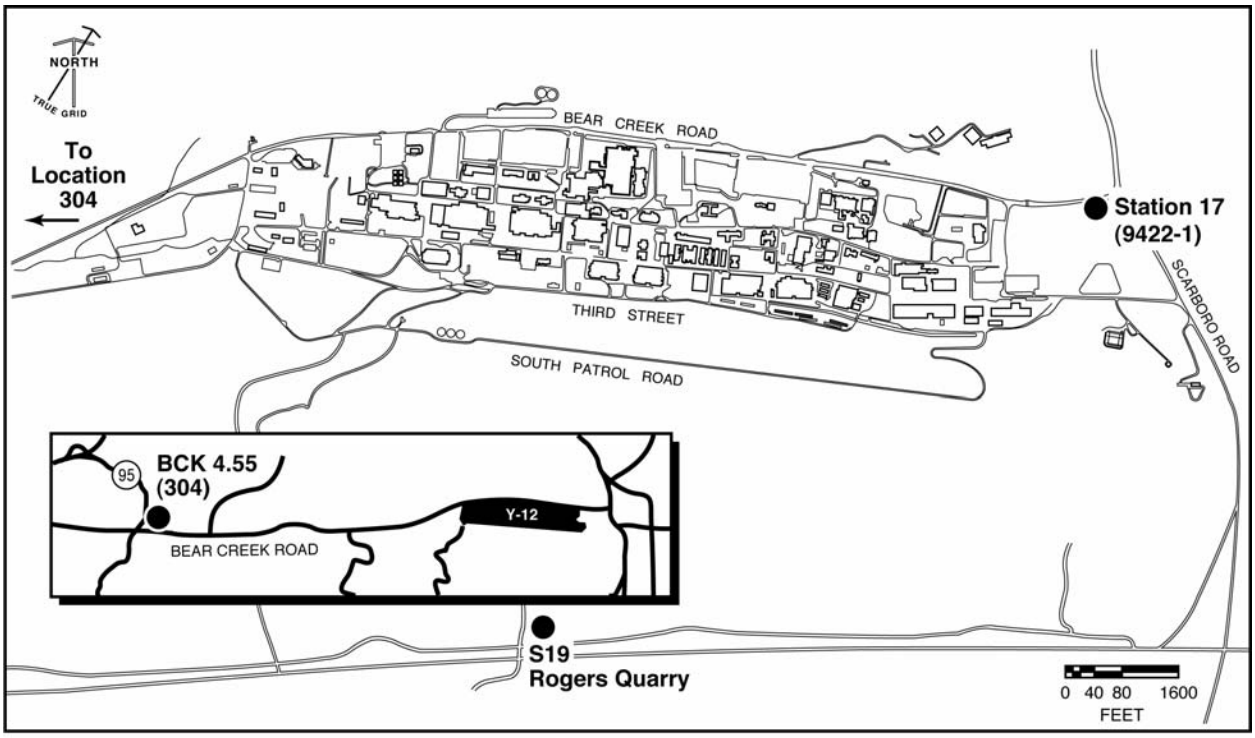

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Fig. 4.10. Surface water best management practice locations at the Y-12 National Security Complex.

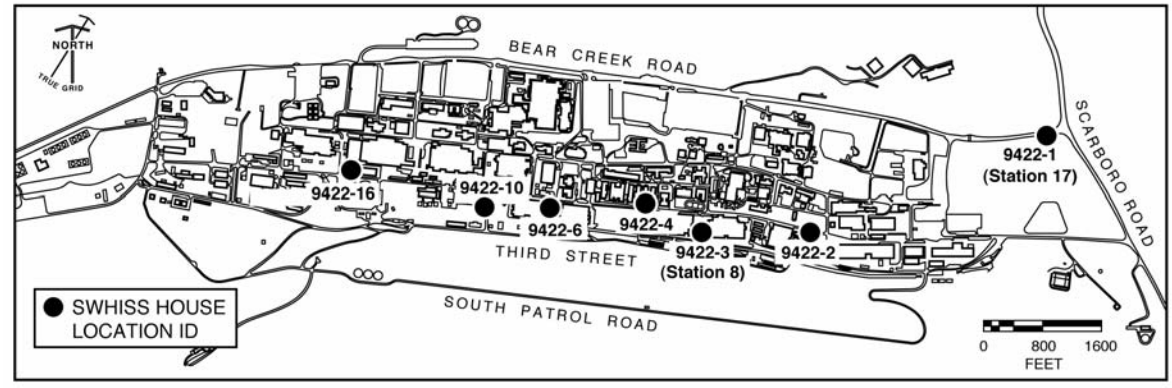

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Fig. 4.11. Surface water hydrological information support system monitoring locations at the Y-12 National Security Complex.

4.4.3.5 Sediment

Sediments can collect and store contaminants and therefore are integrators of contaminant concentrations over a period of time. Numerous sediment studies of ORR streams and the Clinch River have been conducted. Based on the results of these studies and the results of the ORR surveillance sediment program, the sediment program will be significantly reduced. The rationale for this decision follows.

- Any sampling of sediment would be a study of the dynamics of sediment movement, and not sediment accumulation, because (1) the quality of water discharged from the ORR facilities has improved, based on NPDES results, which in turn reduces the opportunity for sediment loading; (2) ^{137}Cs is the most serious radiological contaminant in sediments of the Clinch River, and data in the Clinch River study indicated that 97% of the ^{137}Cs (689 Ci) was released between 1949 and 1969, 3% (20 Ci) was released between 1970 and 1991, and <1% (1.6 Ci) was released between 1992 and 1994; and (3) peak releases of mercury, which is the most serious nonradiological contaminant in sediments, occurred in 1957–1958.
- Except for a few cases, sediment data did not exceed EPA sediment quality guidelines (EPA 1996) for metals and PCBs. The exceedences included mercury in East Fork Poplar Creek, Mitchell Branch, and Poplar Creek; nickel in Mitchell Branch; and PCBs in East Fork Poplar Creek.
- The Clinch River study conducted tests to evaluate the toxicity of whole sediment, sediment elutriate, and sediment pore water. The results indicated that toxicity was low in all tests and across all sites. Few tests indicated statistically significant toxic effects in comparison with the appropriate reference tests, and no meaningful pattern of toxicity could be identified. This test, when compared to the potential hazard identified in the fish program, is an indication that fish are a better measure of contaminant accumulation than sediment.
- The sediment data from the ORR program, 1993–1996, have been evaluated with no apparent evidence of increased contaminant accumulation in area sediment.
- Sediment is an indirect pathway, whereas fish are a direct pathway.

Based on the above, ^{137}Cs is the parameter of interest for the revised program. Grab samples will be collected and analyzed annually at selected surface water locations, shown in Fig. 4.12. Settleable solids will be sampled semiannually during storm events and analyzed annually by gamma spectroscopy.

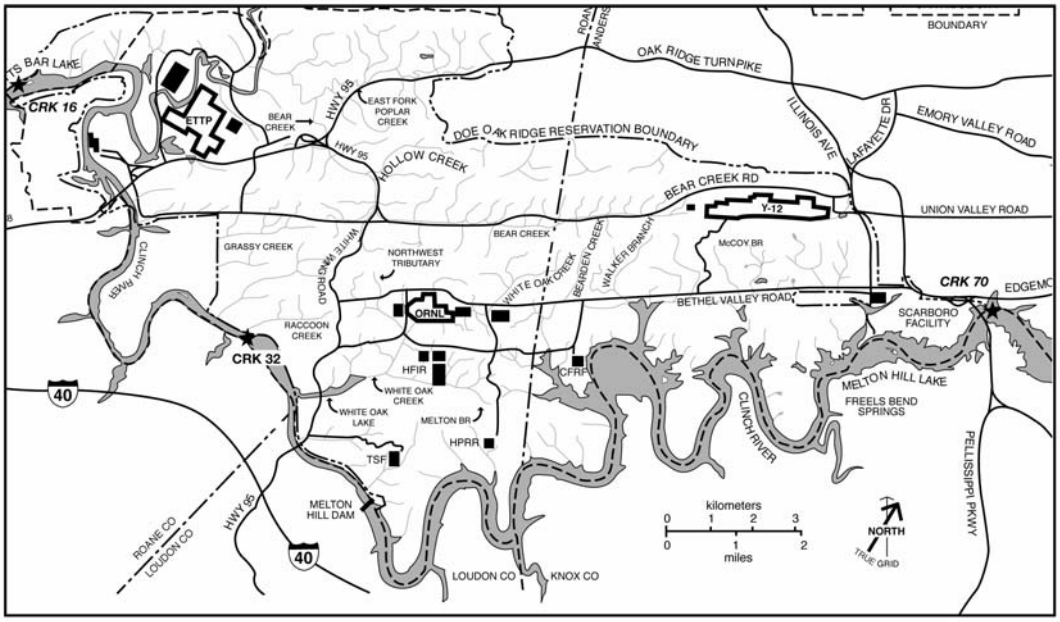

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Fig. 4.12. Sediment and aquatic biota sampling locations for the Oak Ridge Reservation environmental surveillance program.

4.4.3.6 Sediment Sampling at ETTP

Annual sediment sampling at ETTP is conducted through the ETTP water quality project. Sampling locations include the K-901 Pond, K-1007-P1 Pond, Mitchell Branch, Poplar Creek, and the Clinch River. Contaminants of concern are established based on CERCLA decision documents as well as DOE Order requirements. The reports on the sampling programs are documented in the annual remedial effectiveness report in the same manner as the ETTP groundwater sampling program.

4.4.3.7 Sediment BMPs at the Y-12 National Security Complex

Historical data have shown that mercury, PCBs, and isotopes of uranium are present at detectable levels in sediment. Therefore, as a BMP, Y-12 maintains an annual sampling program to determine whether these constituents are accumulating in the sediments of East Fork Poplar Creek and Bear Creek as a result of Y-12 discharges. Results of the monitoring activity are reported annually in ASER.

This monitoring is also used to address DOE Order 5400.5, which states in Chapter II.3.a.2 that measures be taken to prevent the buildup of radionuclides in sediments caused by releases of waste streams to natural waterways. The Order limits the amount of activity that may be present in released settleable solids. Because waste streams from Y-12 have very low settleable-solid contents (below the detection limit), this sampling program provides long-term trend data of East Fork Poplar Creek and Bear Creek sediment to determine whether a buildup of radionuclides is occurring.

4.4.3.8 Aquatic biota

Fish will be sampled at locations downstream from Oak Ridge facilities and at one minimally impacted reference site. The sampling sites, shown in Fig. 4.12, are as follows:

- Melton Hill Reservoir above all DOE inputs (CRK 70),
- Solway Bridge; Clinch River downstream from ORNL (CRK 32); and
- Clinch River downstream from all DOE inputs (CRK 16).

CRK 70 will serve as the reference site for these screening analyses. Criteria for selecting appropriate species to monitor include the following:

- limited range ,
- year-round abundance at the sampling site,
- ability to accumulate contaminants to a maximum extent in comparison to other species, and
- likelihood of ingestion by humans (i.e., food or game species).

Samples will be collected annually at each of the three sites.

Fish samples will be ashed in preparation for radiological analysis. Only edible portions of the fish will be included in the ashing process. Previous experience indicates that 200–250 sunfish will be required to prepare two 10- to 15-g ashed samples. Two composite samples of sunfish or bluegill from each river site will be prepared and submitted for analysis for the radiological parameters listed in Table 4.8. In addition, two large, individual sunfish will be collected and submitted for analysis for metals and PCBs/pesticides. To provide data from a second species, catfish samples from each location will be collected. Two composite samples will be analyzed for radiological parameters, and two individual catfish will be analyzed for metals and PCBs/pesticides.

4.4.4 Procedures for Laboratory Analysis

The approved procedures of the responsible organizations will be used. These procedures are referenced through the QA flowdown in Sect. 9. Laboratory analysis is addressed in Sect. 5 of this EMP.

4.4.5 QA/QC Requirements

QA/QC procedures are described in Sect. 9 of this EMP.

General data analysis and statistical treatment of data will follow guidelines stated in Sect. 7 of this EMP.

Table 4.8. Fish parameters

Metals/ inorganics	Pesticides	PCBs	Radionuclides
Antimony	4,4'-DDD	Aroclor-1016	^{60}Co
Arsenic	4,4'-DDE	Aroclor-1221	^{137}Cs
Beryllium	4,4'-DDT	Aroclor-1232	Total radioactive ^{90}Sr
Cadmium	Aldrin	Aroclor-1242	Gross α, β
Chromium	Alpha-BHC	Aroclor-1248	
Copper	Alpha-Chlordane	Aroclor-1254	
Lead	Beta-BHC	Aroclor-1260	
Mercury	Delta-BHC		
Nickel	Dieldrin		
Selenium	Endosulfan I		
Silver	Endosulfan II		
Thallium	Endosulfan sulfate		
Uranium	Endrin		
Zinc	Endrin ketone		
	Gamma-BHC (Lindane)		
	Gamma-Chlordane		
	Heptachlor		
	Heptachlor epoxide		
	Methoxychlor		
	Toxaphene		

4.4.6 Data Analysis and Statistical Treatment

Although metals other than mercury are unlikely to accumulate to excessive levels in fish muscle, selected metals will be monitored using inexpensive procedures (e.g., ICP or ICP-mass spectrometry) that provide data suitable for determining that concentrations are below levels of concern.

4.4.7 Reports and Records

Requirements for reports and records are addressed in Sect. 8 of this EMP.

4.5 ORR—SOIL

Soil plots were erected at nine of the ambient air stations in 1992 in conjunction with the food crop program discussed in Sect. 4.6. After 4 years of analyses, no evidence exists of increased radionuclide levels that can be attributed to deposition from the atmosphere. A calculation of total resuspension at each site shows that maximum EDEs range from 0 to 0.2 mrem. The maximum EDE for the background station was 0.1 mrem. Based on this information and the 0.5 mrem EDE for the maximally exposed individual from gaseous effluents from the ORR, soil sampling from the controlled plots has been discontinued.

4.5.1 Soil Sampling at ETTP

Annual soil sampling at ETTP is conducted to assess impacts and trends associated with continued long-term radionuclide buildup. As a complement to ambient air monitoring, the soil sampling locations are adjacent to the ETTP ambient air monitoring stations and the two ORR PAM stations located at ETTP. Soil samples are analyzed for radionuclides and selected metals; the specific analytes are chosen based upon the ambient air monitoring results at these locations.

4.6 ORR—FOOD CROPS/TERRESTRIAL ENVIRONMENT

4.6.1 Introduction

Contaminants released from facilities on ORR may accumulate in food crops and in terrestrial animals. The primary exposure pathway for humans is the ingestion of crops, meat (i.e., deer, geese, and turkey), and milk.

4.6.2 Rationale and Design Criteria

Milk—Radionuclides can be transferred from the environment to humans through food chains such as the grass⇒cow⇒milk⇒human pathway. Milk is a potentially significant source to humans of radionuclides deposited from airborne emissions because of the relatively large surface area that can be grazed daily by the cow, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

Although historical measurements of radionuclides in milk indicate that the maximum individual EDE is extremely low (≤0.1 mrem), the ORR surveillance program will continue to collect and analyze milk to confirm that doses are low and that no harm comes to the public from ingestion of milk. Milk will be collected bimonthly at three locations from local residents as available. Samples will be analyzed for radioiodines, total radioactive strontium, and tritium.

Food crops—Depending on availability, food crops are purchased from growers in the following vicinities:

- Claxton community, Anderson County
- Woodland/Scarboro area, City of Oak Ridge

- Across the Clinch River (east of Jones Island)
- Across the Clinch River (west of ETTP)

Tomatoes and lettuce are purchased and analyzed to assist in selection and verification of dose models. Tomatoes represent a root-plant-vegetable system, and lettuce represents a broad-leaf system that receives both direct deposition from air and root system uptake.

Food crops are analyzed for gross alpha, gross beta, gamma spectroscopy, and radionuclides that contribute ≥0.1 mrem to the ORR EDE. This information is attained through the ORR NESHAP program and is updated annually.

Hay—Hay from the ORR has been sold to individuals for silage. Five of the areas harvested on the ORR and one area immediately adjacent to the ORR that have the greatest potential for deposition have been selected for sampling (Fig. 4.13). Areas 1, 2, and 3 are within the predicted air plume for an ORNL source and could be affected by ETTP. Hay will be collected from each of the three sites and composited into two samples. Areas 2, 4, 5, and 6 are within the predicted air plume for an ETTP, ORNL, and Y-12 source. Hay will be collected from areas 2, 4, and 5 and composited into two samples.

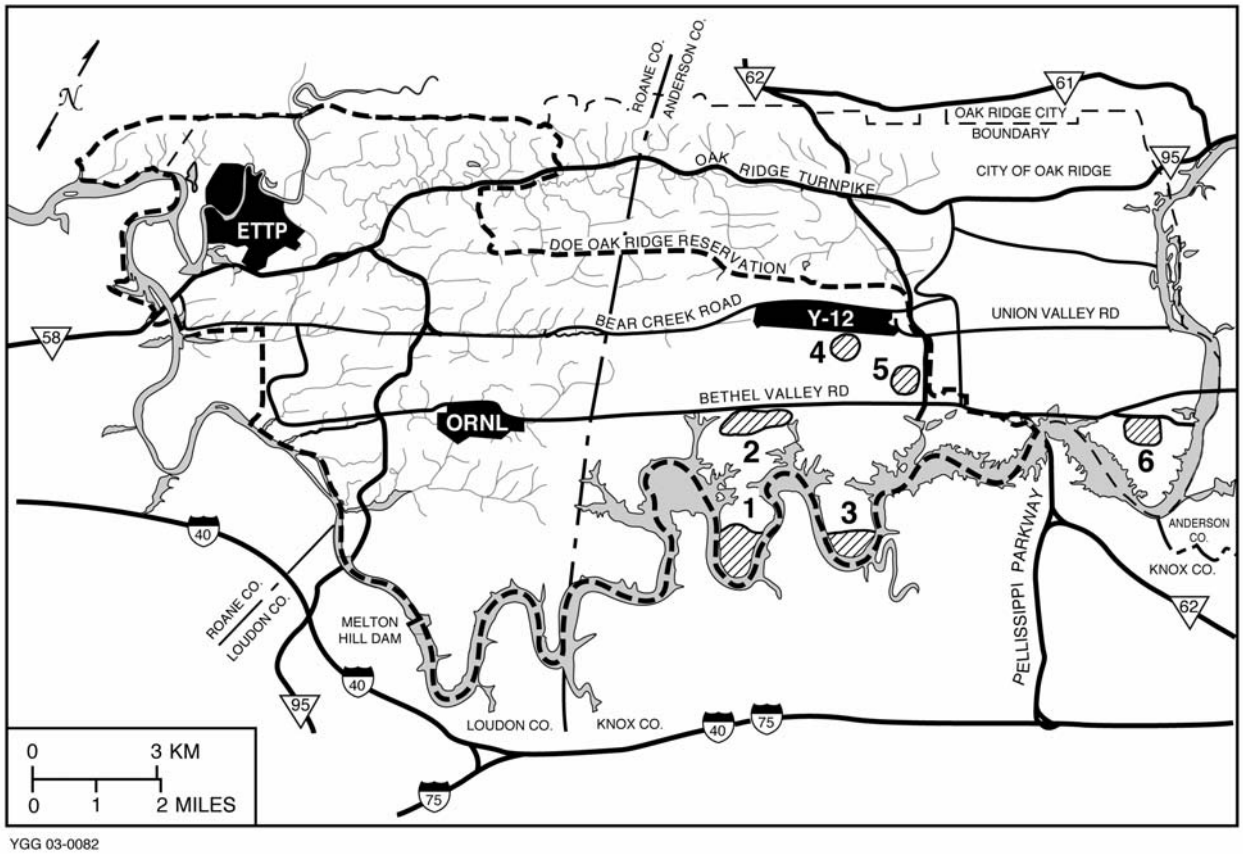

Fig. 4.13. Areas where hay is harvested for the Oak Ridge Reservation environmental surveillance program.

For comparison, hay will also be collected from a location near the Fort Loudoun Dam ambient air reference site.

Area 6 best represents the combined plumes from all three sites. Baled hay from area 6 will be collected and submitted for analysis.

Hay is analyzed for gross alpha, gross beta, and gamma emitters (particularly ^{129}I) by gamma spectroscopy.

Wildlife—The objectives of the wildlife program are to:

- evaluate the radionuclides in wildlife (or wildlife products) to determine their potential influence in dose to human consumers, and
- evaluate radionuclides in wildlife as an indication of biointrusion.

The wildlife surveillance program provides data on radionuclide concentrations in various resident species such as deer, geese, and turkey.

Deer hunts on the ORR—Three deer hunts are held annually on ORR. In cooperation with the Tennessee Wildlife Resource Agency (TWRA), the livers and, in some cases, muscle samples from deer harvested during the hunts are analyzed for gamma-emitting radionuclides by gamma spectrometry. Additionally, bone samples are analyzed for beta emitters.

Goose roundup—An annual goose roundup has been performed in cooperation with TWRA each year since 1988. Geese are rounded up during late June or early July (when the birds are molting) and taken to the checking station for analysis by gamma spectrometry. Although they may vary, round-up locations are on or near ORR. These locations are considered sites where the geese may frequent areas of contamination on ORR.

Honey—Beehives were monitored on ORR from 1978 through 1984 to assess the significance of the honey pathway as a means of radiation exposure reaching the public. Because of the existence of private hives on ORR, hives were again established in 1995 to better assess the honey pathway. In 1995 and 1996, all private hives were removed from the reservation. Dose assessments from the honey analyses show that honey is not a significant pathway. Assuming that an adult consumed 1 kg (2.2 lb) of the sampled honey during the year, the resulting EDE could be no higher than 0.09 mrem. Therefore, the annual honey-monitoring program has been discontinued.

Turkey—In 1995 TWRA approved turkey hunting in the counties that make up and border ORR, and managed turkey hunts on ORR were initiated in the spring of 1997. Mandatory checking for gamma- and beta-emitting radionuclides will be performed for all birds harvested during the reservation hunts. Additionally, if TWRA traps turkeys for relocation, checking by gamma spectroscopy will be performed.

4.6.3 Sampling Frequency and Parameters

Milk—Milk will be collected bimonthly as available. Parameters are gamma spectrometry, tritium, and total radioactive strontium.

Food crops—Food crops will be collected annually during the growing season. Parameters are gross alpha and beta, gamma emitters (by gamma spectroscopy), and any radionuclide contributing 0.1 mrem or more to the ORR EDE.

Hay—Hay will be collected annually. Parameters are gross alpha, gross beta, and gamma emitters.

Deer—Deer will be collected during the three annual deer hunts in October, November, and December. Hunters are required to bring each deer harvested to the checking station. Parameters are gross beta and gamma emitters. If gamma or beta radiation is detected above established limits, additional laboratory analysis will be performed to identify and quantify key radionuclides of interest (i.e., ^{90}Sr, ^{137}Cs).

Geese—The goose roundup will be held each year in the June–July time frame to coincide with the molting season. The goose hunts near the reservation are held in the September–November time frame. Parameters are gamma-emitting radionuclides.

Turkey—Parameters are gamma-emitting radionuclides. Turkeys will also be collected during the annual managed ORR hunt in the spring of each year. Parameters include gross beta and gamma emitters.

4.6.4 Procedures for Laboratory Analyses

Milk, food crops, hay, and animal tissues will be analyzed for parameters of concern using ASO procedures.

4.6.5 QA/QC Requirements

QA requirements are identified in Sect. 9 of this EMP.

4.6.6 Data Analysis and Statistical Treatment

Sample results will be reported to the environmental monitoring programs. Results will include the sampling location, date, type of sample, analysis, results, units, uncertainty (for radionuclides), wet weight, and dry weight. Data will be converted to wet weight if they are used to calculate doses through the food chain. Data from ORR will be compared to background locations, if available.

4.6.7 Reports and Records

Summary statistics for each sampling location for the previous calendar year will be presented in ASER. Comparisons to background locations will also be presented.

4.7 *REGULATORY GUIDE* PERFORMANCE CRITERIA

4.7.1 General Criteria

a. An evaluation *should be conducted and used as the basis for establishing an environmental surveillance program for all DOE-controlled sites. The purpose of the surveillance program is to characterize the radiological conditions of the off-site environs and, if appropriate, estimate public doses related to these conditions, confirm predictions of public doses based on effluent monitoring data, and, where appropriate, to provide compliance data for all applicable regulations. The results of this evaluation *should** be documented in the site EMP.**

Off-site dose is routinely estimated for several pathways and documented in ASER. The estimated maximum individual off-site EDE due to airborne emissions from ORR as a whole ranged from 0.4 to 2.0 mrem for the last 5 years. Other pathways that have yielded estimable doses are consumption of fish at CRK 32 (0.2 to 0.4 mrem), drinking milk from dairies in the vicinity of ORR (0.1 mrem to 0.3 mrem), and drinking water from the Kingston Water Plant (0.04 to 0.3 mrem). These estimates are based on fish, milk, and water sample collection and resultant data.

b. The environmental surveillance program for DOE-controlled sites *should be conducted in accordance with the requirements of DOE 5400.1 and DOE 5400.5.**

This section of the EMP is designed to address the requirements of DOE Orders 5400.1 and 5400.5, as well as the *Regulatory Guide* and other regulatory criteria.

c. The criteria for environmental surveillance programs listed in Chap. 5 *should be used for establishing the environmental surveillance program for DOE-controlled sites. Additional site-specific criteria *should** be documented in the site EMP.**

The Chap. 5 criteria are the basis for the radioactivity environmental surveillance program of this EMP. An evaluation of the need for an ambient air sampling program for nonradiological contaminants was conducted at ORNL in accordance with DOE Order 5400.1 and EPA regulations. Environmental surveillance for nonradiological pollutants for ORNL is not required. Ambient air monitoring at Y-12 is not required but is conducted as BMP.

d. The need for environmental sampling and analysis *should be evaluated, by exposure pathway analysis, for each site radionuclide effluent or emission (liquid or airborne). This analysis with appropriate data, references, and site-specific assumptions, along with site-specific criteria for selection of samples, measurements, instrumentation, equipment, and sampling or measurement locations *should** be documented in the site EMP.**

The estimated maximum individual off-site dose and population dose have consistently been below the 5 mrem EDE and 100 person-rem criteria for routine surveillance of all pathways.

Pathway estimates are documented in the response to criterion "a." The conceptual design of the environmental surveillance program is founded upon the requirements of the *Regulatory Guide* and is intended to address the following objectives:

- confirmation of estimated off-site radionuclide concentrations by computing these concentrations at surveillance points using effluent data and models and then comparing the model results to empirical data collected at the point,
- quantification of the impacts of diffuse source terms on the radionuclide signatures off site, and
- empirical demonstrations of modeled pathways and confirmation of model estimates.

Specific information regarding the selection of sample types, instruments, equipment, and locations is provided in Sect. 4 or by reference. Site specific assumptions regarding pathways are documented in ASER.

e. A critical pathway analysis (radionuclide/media) *should be performed, documented, and referenced in the ASER.**

Pathways analyses are performed and documented in ASER. The results, as published, form the basis for determining critical pathways and the environmental surveillance program design. Many of the pathway estimates have been based on air and water effluent source terms and the assumptions built into the dose assessment models. Certain elements of the proposed program will generate empirical data for evaluating the dose model estimates. These results and a comparison to the model results will be published in ASER.

f. If the projected dose equivalent from inhalation of particulates exceeds the criteria of Chap. 5, particle-size analysis of the emission *should be conducted at least annually.**

The total estimated EDE to the maximally exposed individual does not exceed the criteria in the *Regulatory Guide*, Chap. 5. Consequently, particle-size analysis of particulate emissions is not required.

g. Further provisions *should be made, as appropriate, for the detection and quantification of unplanned releases to the environment of radioactive materials, including radionuclides that may be transported by stormwater runoff, flooding, or resuspension of ground-deposited material.**

The sampling programs for ambient air and surface water use continuous sampling and flow-proportional sampling, respectively. The locations of the air sampling stations were selected to intercept the major wind directions and the directions to potential maximally exposed individuals. The water sampling stations are located to assess the total impact of the facilities, including point-source outfalls and diffuse sources from historical activities. These design elements accommodate the detection of unplanned releases and resuspension of deposited material.

h. For all new or modified facilities coming online, a preoperational assessment *should be made and documented in the site EMP to determine the types and quantities of effluents to be expected from the facility and to establish the associated surveillance program.**

All DOE prime contractors have an organization responsible for ensuring that all environmental documentation requirements for projects are met. The basis for this organization is the institutionalization of NEPA determinations of environmental impact.

j. Gross radioactivity analyses *should be used only as trend indicators, unless documented supporting analyses provide a reliable relationship to specific radionuclide concentrations or doses.**

The surveillance program discussed in Sect. 4 of this EMP takes into account the types and quantities of effluents from facilities. Gross radioactivity analyses are used with worst radionuclide assumptions to demonstrate that potential doses are acceptable. If unacceptable doses are calculated, the program specifies a protocol for specific isotopic analyses. For ETTP surface water and storm water data, the gross radioactivity analyses are only used as trend indicators and screening tools. If a gross alpha result exceeds 15 pCi/L or a gross beta result exceeds 50 pCi/L, then specific isotopic analyses are performed at the same location.

k. The overall accuracy (±% accuracy) *should be estimated, and the approximate Environmental Detection Limit at a specified % confidence level for environmental measurements of beta-gammas, alphas, and neutrons, as appropriate, *should** be determined and documented.**

This requirement is addressed in Sect. 7, "Data Analysis and Statistical Treatment," under the response to criterion "a."

l. Sample preservation methods *should be consistent with the analytical procedures used.**

Samples are preserved in accordance with either guidance from EPA or the method.

m. All environmental surveillance techniques *should be designed to take a representative sample or measurement of the important radiation exposure pathway media.**

All compliance monitoring is conducted in accordance with guidance and specific requirements of the applicable regulations. The environmental surveillance programs are specifically designed to take representative samples or measurements from the transport media that are directly affected by radionuclide releases. These requirements are addressed in the SOPs for the environmental surveillance section. The place of this section within the overall organization is identified in Sect. 9, "Quality Assurance Program."

n. Sampling or measurement frequencies for each significant radionuclide or environmental medium combination (e.g., those contributing 10% or more to off-site

dose greater than 0.1 mrem EDE from emissions in a year) *should take into account the half-life of the radionuclides to be measured and *should** be documented in the site EMP.**

Pathways that contribute to the estimated maximum individual EDE are reviewed and reported annually in both the annual NESHAP compliance report and ASER. Generally, the pathways that contribute to the estimated maximum individual EDE are associated with airborne emissions, drinking water, eating fish, and direct radiation. Half-lives are considered for air sampling at ORNL. It should be pointed out that uranium is the only element contributing more than 10% to the off-site dose and the half-life is very long.

o. "Background" or "control" location measurements *should be made for every significant radionuclide and pathway combination (e.g., those contributing 10% or more to off-site dose greater than 0.1 mrem EDE from emissions in a year) for which environmental measurements are used in the dose calculations.**

All environmental surveillance programs that support dose assessment through environmental measurements include background or "reference" sampling locations for the purpose of determining the net impact to the public of operations on ORR. Specifics regarding the reference sampling locations are contained in the program descriptions in this EMP.

p. An annual review of the radionuclide composition of effluents or emissions *should be made and compared with those used to establish the site EMP. Any deviations from routine environmental surveillance requirements, including sampling or measurement station placement, *should** be documented in an approved revised site EMP.**

The effluent and emissions data relative to the program specifications in the EMP will be reviewed in parallel with the preparation of ASER.

t. Any changes in the site-specific or generic factors *should be noted in the EMP and the retired or replaced values preserved for historical purposes.**

Change control and preservation of retired information is addressed in Sect. 9. Additionally, the environmental surveillance program and any changes are described each year in ASER.

x. As they apply to environmental surveillance activities, the general QA program provisions of Chap. 10 of this guide *should be followed.**

The activities discussed in this section are conducted by organizations that have QA plans that are consistent with the requirements of DOE Order 414.1A and ASME standard NQA-1. Additional information is provided in Sect. 9 of this EMP.

4.7.2 Air Criteria

q. The air sampling rate *should not vary by more than ±20%, and total air flow or total running time *should** be indicated; air sampling systems *should** be leak-tested, flow calibrated, tested, and inspected on a routine basis at a minimum, using the calibration frequency recommendations of the equipment manufacturers.**

The performance goals and maintenance, testing, and calibration requirements are specified and documented in the SOPs of the environmental monitoring programs. All of the specifications meet, or are more restrictive than, the *Regulatory Guide* requirements.

u. When neutron monitoring is required, the method of measurement *should be based on the anticipated flux and energy spectrum.**

ORR does not now operate any neutron-monitoring equipment, but if neutron monitoring is required in the future, measurements will be based on the anticipated flux and energy spectrum.

v. The sample exchange frequency for non-particulate sampling *should be determined on a site-specific basis and *should** be documented in the environmental surveillance files.**

Sections 2.3 and 4.1 of this EMP address the sample exchange frequency for nonparticulate sampling, which is based on the half-lives of the isotopes and the required detection limits.

4.7.3 Gamma Radiation Criteria

i. Calibration of dosimeters and exposure-rate instruments *should be based on traceability to NIST standards.**

All instruments and dosimeters used to measure external gamma radiation will be calibrated periodically in accordance with written procedures and sources or standards traceable to NIST.

4.7.4 Groundwater Criteria

s. DOE Operations Office and contractor staff *should ensure that groundwater monitoring plans are consistent with state and regional EPA groundwater monitoring requirements under RCRA and CERCLA to avoid unnecessary duplication. DOE Operations Office and contractor staff *should** consult with state and regional EPA offices, as needed, to ensure that the requirements are incorporated into the Radiological Monitoring Plan.**

Each Oak Ridge DOE site has a groundwater program coordinator who is tasked with the responsibility of keeping the groundwater protection program management plan current and

ensuring the interaction among all the entities that are investigating or are impacting groundwater.

4.7.5 Terrestrial Environment Criteria

r. State and local game officials *should be consulted when selecting appropriate protected species to sample.**

Collection of game species for environmental surveillance is controlled by TWRA. Permits for this purpose are obtained annually and kept on file by ORNL Environmental Protection.

w. The analytical procedure to be used *should be considered when choosing a method for preserving milk samples.**

Milk samples are preserved by keeping them in coolers with ice. This method of preservation is acceptable to the analytical laboratory.