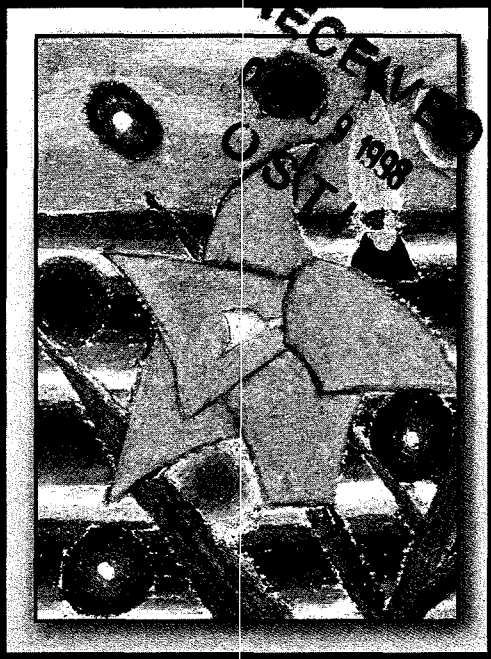
OAK RIDGE Reservation

Annual Site Environmental Report for 1997



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About the cover:
What happens tomorrow on the Oak Ridge Reservation will depend on all of us. We hope that you will help DOE and its contractors use the colors of positive to paint a bright tomorrow. Reflecting on that goal, we commend Karns High School students, John Stone and Katie Horn, who used their talents in the creation of the artwork for the cover of this 1997 ASER.

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ACRONYMS AND ABBREVIATIONS

1STCK	First Creek kilometer
ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
AM	action memorandum
AMSE	American Museum of Science and Energy
ANSI	American National Standards Institute
AOC	Area of Concern
ARAP	Aquatic Resources Alteration Permit
ARAR	applicable or relevant and appropriate requirement
ASER	Annual Site Environmental Report
ASO	Analytical Services Organization
AVLIS	Atomic Vapor Laser Isotope Separation
BCK	Bear Creek kilometer
BCV	Bear Creek Valley
BMAP	Biological Monitoring and Abatement Program
BMP	best management practice
BNFL	British Nuclear Fuels Limited
BoP	balance of plant
BOD	biological oxygen demand
CA	characterization area
CAA	Clean Air Act
CBOD	carbonaceous biochemical oxygen demand
CCS	chlorine control strategy
CDI	chronic daily intake
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CLP	Contract Laboratory Program
CMC	criterion maximum concentration
CMTS	Central Mercury Treatment System
CNF	Central Neutralization Facility
COE	(U.S. Army) Corps of Engineers
CPCF	Central Pollution Control Facility
CRADA	cooperative research and development agreement
CRK	Clinch River kilometer
CRMP	cultural resource management plan
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CWM	Center for Waste Management
CWSA	Containerized Waste Storage Area

CX	categorical exclusion
CY	calendar year
CYRTF	Coal Yard Runoff Treatment Facility
1,2 DCE	1,2 dichloroethene
DAC	derived air concentration
DCF	dose conversion factor
DCG	derived concentration guide
DEAR	Department of Energy Aquisition Regulations
D&D	decontamination and decommissioning
DEUSS	Discharge of Enriched Uranium to the Sanitary Sewer
DNAPL	dense nonaqueous phase liquid
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy Headquarters
DOE-ORO	U.S. Department of Energy Oak Ridge Operations Office
DP	(Office of) Defense Programs
dps	disintegrations per second
DWS	drinking water standard
EA	environmental assessment
EDE	effective dose equivalent
EEMTF	East End Mercury Treatment Facility
EESSMS	East End Sanitary Sewer Monitoring Station
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EIS	environmental impact statement
ELPAT	Environmental Lead Proficiency Analytical Testing Program
EM	(Office of) Environmental Restoration and Waste Management
EM	environmental management
ELPAT	Environmental Lead Proficiency Analytical Testing Program
EMEF	Environmental Management and Enrichment Facilities
EML	Environmental Measurements Laboratory
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
EPA-HQ	U.S. Environmental Protection Agency Headquarters
EPCRA	Emergency Planning and Community Right-To-Know Act
EPT	Ephemeroptera, Plecoptera, and Trichoptera (taxa)
ER	environmental restoration
ESD	Environmental Sciences Division (ORNL)
ES&H	environment, safety, and health
ETTP	East Tennessee Technology Park
EUWG	Oak Ridge End Use Working Group
FDA	U.S. Food and Drug Administration
FFA	Federal Facility Agreement
FFCA	federal facilities compliance agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act

FIFTHCK	Fifth Creek kilometer
FS	feasibility study
FONSI	finding of no significant impact
FY	fiscal year
GAAT	Gunite and Associated Tanks
GCK	Grassy Creek kilometer
GMO	General Manufacturing Organization (Y-12 Plant)
GWPP	Groundwater Protection Program
GWPS	groundwater protection standard
GWTF	groundwater treatment facility
Gy	gray
HAP	hazardous air pollutant
HC	Hinds Creek sampling station
HEPA	high-efficiency particulate air (filter)
HFIR	High Flux Isotope Reactor
HiVal	High Investment Value
HQ	hazard quotient
HS	hazardous substance
HSWA	Hazardous and Solid Waste Amendments (1984)
HV	high-volume
HVAC	heating, ventilating, and air-conditioning
I	intake
I/CDI	intake (estimated dose)/chronic daily intake
ICK	Ish Creek kilometer
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectrometry
ICRP	International Commission on Radiological Protection
ID	identification
IHgTU	Interim Mercury Treatment Unit
INEEL	Idaho National Engineering and Environmental Laboratory
IRIS	Integrated Risk Information System
ISMS	Integrated Safety Management System
IWC	instream waste concentration
IWMF	Interim Waste Management Facility
IWQP	Integrated Water Quality Program
JTU	Jackson turbidity unit
LC_{50}	effluent concentration lethal to 50% of test organisms
LDR	land disposal restriction
LEFPC	Lower East Fork Poplar Creek
LLC	limited liability company
LLLW	liquid low-level (radioactive) waste
LLW	low-level (radioactive) waste
LMER	Lockheed Martin Energy Research Corporation

LMES	Lockheed Martin Energy Systems
LRSPW	Lake Reality Spillway
LWBR	Lower Watts Bar Reservoir
MACT	maximum achievable control technology
MAP	Management Action Process
MAPEP	Mixed Analyte Performance Evaluation Program
MCCBK	McCoy Branch kilometer
MCL	maximum contaminant level
MEK	Melton Branch kilometer
Mgd	million gallons per day
M&I	management and integration
MIK	Mitchell Branch kilometer
MMES	Martin Marietta Energy Systems, Inc.
M&O	management and operating
MSDS	material safety data sheet
MSRE	Molten Salt Reactor Experiment
NEPA	National Environmental Policy Act
NERL-LV	National Exposure Research Laboratory at Las Vegas
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFCS	Nationwide Food Consumption Survey
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOD	notice of deficiency
NOEC	no-observed-effect concentration
NOEL	no-observed-effect level
NOMAD	tradename; not an acronym
NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRWTF	Nonradiological Wastewater Treatment Facility
NTU	nephelometric turbidity unit
NWTK	Northwest Tributary kilometer
OHF	Old Hydrofracture Facility
ORAU	Oak Ridge Associated Universities
ORCMT	Oak Ridge Centers for Manufacturing Technology
OREIS	Oak Ridge Environmental Information System
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORR-PCB-FFCA	Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement
OU	operable unit

PAM	perimeter air monitoring (station)
PA/SI	preliminary assessment/site investigation
PCB	polychlorinated biphenyl
PCE	perchloroethene
PCK	Poplar Creek kilometer
PIDAS	Perimeter Intrusion Detection Assessment System
PIF	Partners in Flight
PM10	particulate matter less than 10 microns in diameter
POTW	publicly owned treatment works
ppm	parts per million
PWMP	Pond Waste Management Project
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
rad	radiation absorbed dose
Rad-NESHAP	Radionuclide National Emission Standards for Hazardous Air Pollutants
RAM	remote air monitoring (station)
RCK	Raccoon Creek kilometer
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
R&D	research and development
REDC	Radionuclide Engineering Development Center
rem	roentgen equivalent man
RER	Remediation Effectiveness Report
RFA	RCRA Facility Assessment
RfD	reference dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RMP	Radiological Monitoring Plan
RMPE	Reduction of Mercury in Plant Effluent
ROD	record of decision
ROI	return on investment
RQ	reportable quantity
RTCS	Radioactive Tank Cleaning System
S&A	sampling and analysis
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SF	slope factor
SHPO	state historic preservation officer
SI	International System of units (metric system)
S&M	surveillance and maintenance
SMCL	secondary maximum contaminant level
SMO	Sample Management Office
SNS	Spallation Neutron Source
SOP	standard operating procedure

SPCC	Spill Prevention Control and Countermeasures Plan
SPMD	semipermeable membrane device
S/RIDs	Standards/Requirements Identification Documents
SSAB	Site-Specific Advisory Board
SSSR	Site-Specific Standard Request
ST	strong-tight
STP	Sewage Treatment Plant
SWDF	solid waste disposal facility
SWHISS	Surface Water Hydrological Information Support System
SWM	solid waste management
SWMU	solid waste management unit
SWPP	Storm Water Pollution Prevention
SWSA	solid waste storage area
Sv	sievert
T&E	threatened and endangered
TCE	trichloroethene
TDECD	Tennessee Department of Economic and Community Development
TCLP	toxicity characteristic leaching procedure
TCMP	Toxicity Control and Monitoring Program
TDEC	Tennessee Department of Environment and Conservation
TDECD	Tennessee Department of Economic and Community Development
TDEC/DOE-O	Tennessee Department of Environment and Conservation/DOE Oversight Division
TEMA	Tennessee Emergency Management Agency
TN	Tennessee
TN-WQC	Tennessee Water Quality Criteria
TOA	Tennessee Oversight Agreement
TOC	total organic carbon
TOX	total organic halides
TPF	Transuranic Processing Facility
TPH	total petroleum hydrocarbons
TRC	total residual chlorine
TRI	Toxic Release Inventory
TRK	Tennessee River kilometer
TRO	total residual oxidant
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSP	total suspended particulates
TSS	total suspended solids
TVA	Tennessee Valley Authority
TVS	transportable vitrification system
TWQC	Tennessee General Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency

UEFPC	Upper East Fork Poplar Creek
UE-PCB-FFCA	Uranium Enrichment Polychlorinated Biphenyl Federal Facilities Compliance Agreement
UE-TSCA-FFCA	Uranium Enrichment Toxic Substances Control Act Federal Facilities Compliance Agreement
UIC	Underground Injection Control
UST	underground storage tank
UV	ultraviolet
VDRIF	Variable Dose Rate Irradiation Facility
VEE	visible emissions evaluation
VOC	volatile organic compound
WAG	waste area grouping
WBK	Walker Branch kilometer
WCK	White Oak Creek kilometer
WETF	West End Treatment Facility
WFPC	West Fork Poplar Creek
WIPP	Waste Isolation Pilot Plant
WMP	waste management program
WMRAD	Waste Management and Remedial Action Division (ORNL)
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake
WQC	water quality criteria
WQS	water quality standard
WSS	work smart standards
Y-12 Plant	the Oak Ridge Y-12 Plant
YOY	young of the year

Acknowledgments

The authors wish to recognize those who participated in the publication of the annual site environmental report for this year. Although we cannot name everyone, we would like to mention a few names in particular.

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Charlie Valentine
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Jennifer Webb
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1. Site and Operations Overview

H. M. Braunstein, L. V. Hamilton, L. W. McMahon, and L. G. Shipe

Abstract

The U.S. Department of Energy currently oversees activities on the Oak Ridge Reservation (ORR), a government-owned, contractor-operated facility. The reservation contains three major operating sites: the Oak Ridge Y-12 Plant, Oak Ridge National Laboratory, and East Tennessee Technology Park (formerly the K-25 Site). The ORR was established in the early 1940s as part of the Manhattan Project, a secret undertaking that produced the materials for the first atomic bombs. The reservation's role has evolved over the years, and it continues to adapt to meet the changing defense, energy, and research needs of the United States. Both the work carried out for the war effort and subsequent research, development, and production activities have involved (and continue to involve) radiological and hazardous materials.

1.1 BACKGROUND

This document is prepared annually to summarize environmental activities, primarily environmental monitoring activities, on the Oak Ridge Reservation (ORR) and within the ORR surroundings. The monitoring and documentation criteria are described within the requirements of U.S. Department of Energy (DOE) Order 5400.1, "General Environmental Protection Program." The results summarized in this report are based on the data collected prior to and through 1997. The 1997 results are compiled in *Environmental Monitoring on the Oak Ridge Reservation: 1997 Results* (LMES 1998a). Reports are available on request from

Bechtel Jacobs Company LLC
EMEF Document Management Center
P.O. Box 4699, Building 1002, MS 7243
Oak Ridge, TN 37831

Environmental monitoring on the ORR consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring involves the collection and analysis of samples or measurements of liquid and gaseous effluents prior to release into the environment; these measurements allow the quantification and official reporting of contaminants, assessment of radiation and chemical exposures to the public, and demonstration of compliance with applicable standards and permit requirements. Environmental surveillance consists of the collection and analysis of environmental samples from the site and its environs; this provides direct measurement of contaminants in air, water, groundwater, soil, foods, biota, and other media subsequent to effluent release into the environment. Environmental surveillance data verify ORR's compliance status and, combined with data from effluent monitoring, allow the determination of chemical and radiation dose/exposure assessment of ORR operations and effects, if any, on the local environment.

1.2 DESCRIPTION OF SITE LOCALE

The city of Oak Ridge lies in a valley between the Cumberland and Blue Ridge mountain ranges and is bordered on two sides by the Clinch River. The Cumberland Mountains are 16 km (10 miles) to the northwest; the Blue Ridge Mountains, which include the Great Smoky Mountains National Park, are 51 km (32 miles) to the southeast (Fig. 1.1).

The ORR encompasses about 34,516 acres of the contiguous land owned by DOE in the Oak Ridge area. The majority lies within the corporate limits of the city of Oak Ridge; 608 acres, west of the East Tennessee Technology Park (ETTP), is in Roane County, outside the city limits. The residential section of Oak Ridge forms the northern boundary of the reservation. The Tennessee

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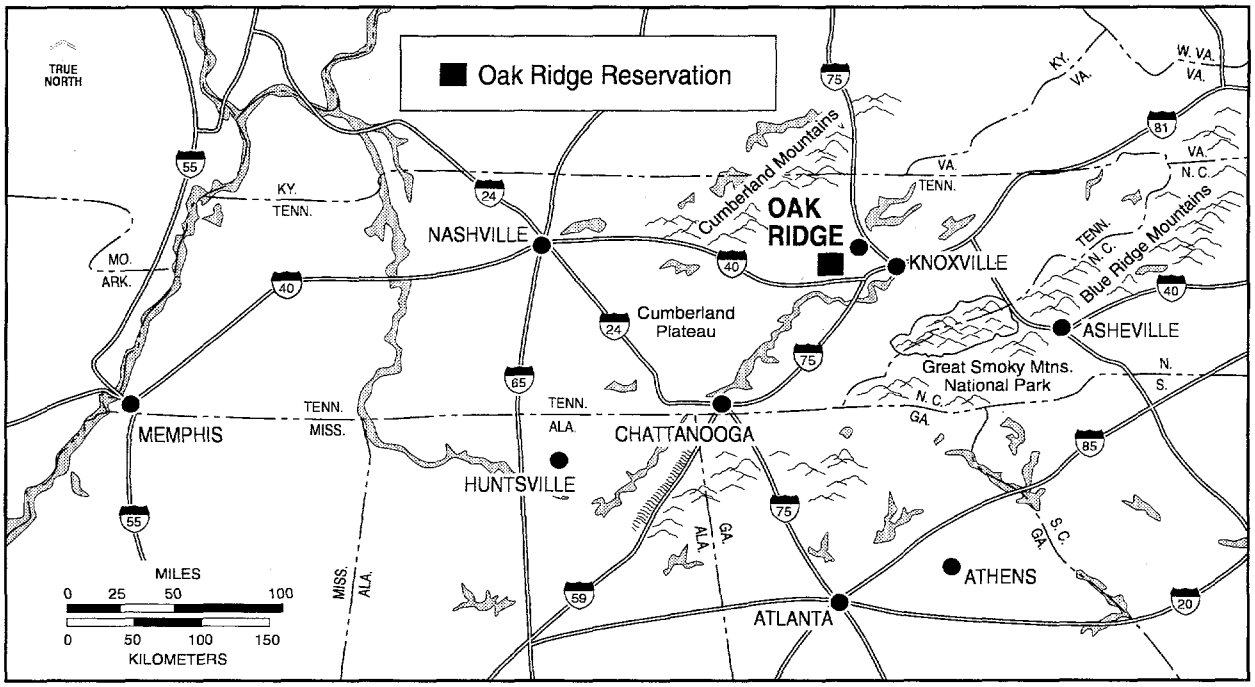

Fig. 1.1. Location of the city of Oak Ridge.

Valley Authority's (TVA's) Melton Hill and Watts Bar reservoirs on the Clinch and Tennessee rivers form the southern and western boundaries (Fig. 1.2).

The population of the ten-county region surrounding the ORR is about 798,925, with 5% of its labor force employed on the reservation (Fig. 1.3). Other towns in close proximity to the reservation include Oliver Springs, Clinton, Karns, Lenoir City, Farragut, Kingston, and Harriman (Fig. 1.4).

Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km (25 miles) to the east and has a population of about 167,535 as reported in *Population Estimates of Tennessee Cities, 1990–1996* (TDECD 1996a; http://www.state.tn.us/ecd/research/96city.htm). Except for the city of Oak Ridge, the land within 8 km (5 miles) of the ORR is predominantly rural and is used primarily for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are popular recreational activities in the area.

1.3 CLIMATE

The climate of the region may be broadly classified as humid continental. The Cumberland Mountains to the northwest help to shield the region from cold air masses that frequently penetrate far south over the plains and prairies in the central United States during the winter months.

During the summer, tropical air masses from the south provide warm and humid conditions that often produce thunderstorms; however, anticyclonic circulation around high-pressure systems centered in the western Gulf of Mexico can bring dry air from the southwestern United States into the region, leading to occasional periods of drought.

1.3.1 Temperature

The mean annual temperature for the Oak Ridge area is 14.0°C (57.2°F) (NOAA 1997). The coldest month is usually January, with temperatures averaging about 2.2°C (36°F) but once dipping as low as –31°C (–24°F). July is typically

ORNL-DWG 93M-9616R3

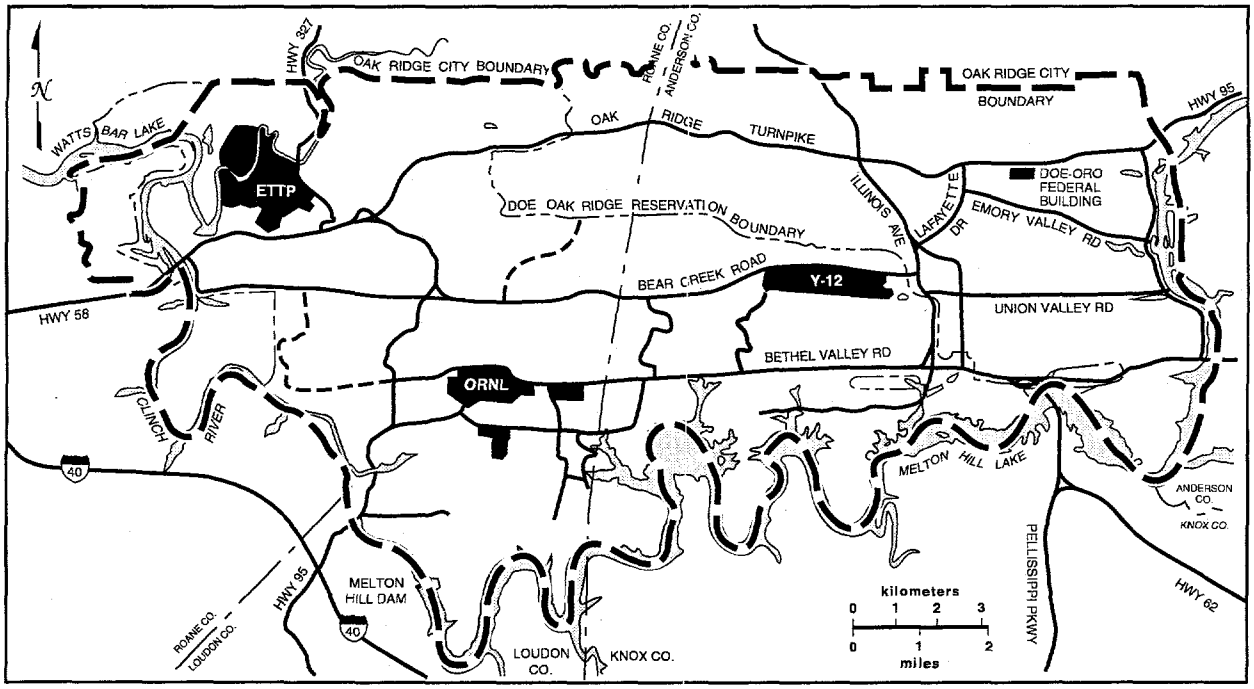

Fig. 1.2. The Oak Ridge Reservation.

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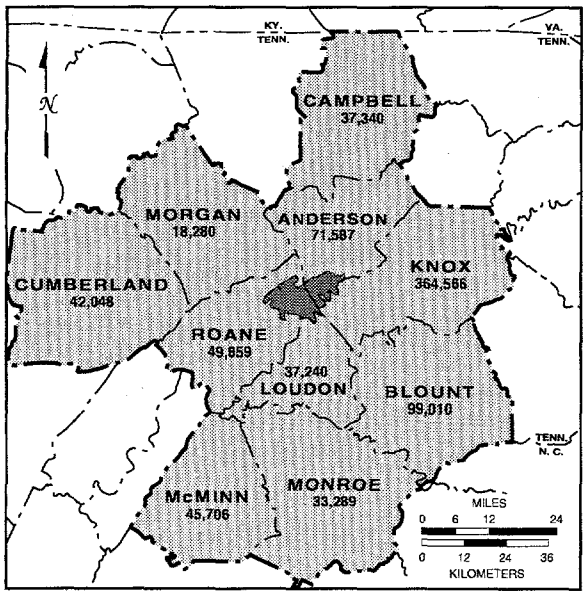

Fig. 1.3. The ten-county region surrounding the Oak Ridge Reservation. [Population figures are July 1, 1996, estimates taken from *Population Estimates for Tennessee Counties, 1990–1996* (TDECD 1996b).]

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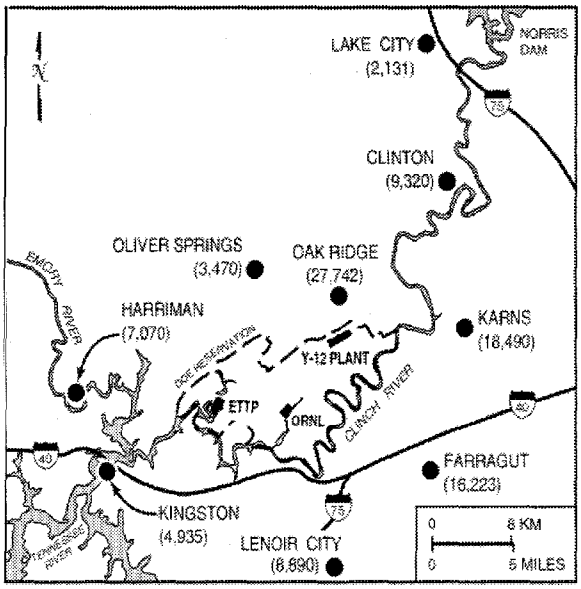

Fig. 1.4. Locations and populations of towns nearest to the Oak Ridge Reservation. [Except for the Karns community, population figures are July 1, 1996, estimates taken from *Population Estimates of Tennessee Cities, 1990–1996* (TDECD 1996a).]

the hottest month of the year, with temperatures averaging 24.9°C (76.8°F) but occasionally peaking at over 37.8°C (100°F). In the course of a year, the difference between maximum and minimum daily temperatures averages 12.5°C (22.5°F). The 1997 average temperature was 13.9°C (57.1°F).

1.3.2 Winds

Winds in the Oak Ridge area are controlled in large part by the valley-and-ridge topography. Prevailing winds are either up-valley (northeasterly) daytime winds or down-valley (southwesterly) nighttime winds. Wind speeds are less than 11.9 km/hour (7.4 mph) 75% of the time; tornadoes and winds exceeding 30 km/hour (18.5 mph) are rare. Air stagnation is relatively common in eastern Tennessee (about twice that of western Tennessee). An average of about two multiple-day air stagnation episodes occurs annually in eastern Tennessee, to cover an average of about 8 days per year. August, September, and October are the most likely months for air stagnation episodes.

1.3.3 Precipitation

The 30-year annual average precipitation is 138.5 cm (54.5 in.), including about 24 cm (9.3 in.) of snowfall (NOAA 1997). Regional precipitation in 1997 was 143.5 cm (56.5 in.), of which 22.4 cm (8.8 in) was snow and ice. Precipitation in the region is greatest in the winter months (December through February). Precipitation in the spring exceeds the summer rainfall, but the summer rainfall may be locally heavy because of thunderstorm activity. The driest periods generally occur during the fall months, when high-pressure systems are most frequent.

1.3.4 Evapotranspiration

Regionally, annual evapotranspiration has been estimated to range from 81 to 89 cm (32 to 35 in.), or 60 to 65% of rainfall (Farnsworth et al. 1982). Evapotranspiration in the Oak Ridge area is 74 to 76 cm (29 to 30 in.), or 55 to 56% of annual precipitation (TVA 1972, Moore 1988, and Hatcher et al. 1989). Evapotranspiration is greatest in association with the growing season, which in the vicinity of the ORR is 220 days, from mid-March through mid-October. During this period, evapotranspiration often exceeds the rate of precipitation, resulting in soil moisture deficits.

1.4 DESCRIPTION OF SITE, FACILITIES, AND OPERATIONS

The facilities on the ORR began operating in 1943 as part of the Manhattan Project, producing components for the first nuclear weapons. The ORR remains a government-owned facility, although the nature of the work has changed. The primary missions of the three sites have evolved during the past 50 years and continue to adapt to meet the changing defense, energy, and research needs of the United States. The reservation contains three major DOE installations: the Oak Ridge Y-12 Plant (Y-12 Plant), ORNL, and ETTP.

The DOE buildings and structures that are located on the reservation but outside the major sites consist of the Oak Ridge Institute for Science and Education (ORISE) Scarboro Operations Site, Clark Center Recreational Park, the Central Training Facility, and the Transportation Safeguards maintenance facility.

The off-reservation DOE buildings and structures consist of the Federal Office Building, the Office of Scientific and Technical Information, most of the ORISE offices and laboratories, the Atmospheric Turbulence and Diffusion Division of the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory, the American Museum of Science and Energy, the Lockheed Martin Energy Systems, Inc. (LMES, formerly Martin Marietta Energy Systems, Inc.) administrative support office buildings, and the former museum building. In addition to government-owned property, there are leased buildings housing about 4% of the government and contractor work force.

1.4.1 Lockheed Martin Energy Systems, Inc.

On March 15, 1995, Lockheed and Martin Marietta completed a merger to create the Lockheed Martin Corporation. Following the merger, Martin Marietta Energy Systems, Inc., the prime contractor for the ORR, was renamed Lockheed Martin Energy Systems, Inc. In late 1995, Lockheed Martin Corporation organized into several business sectors, each of which focused on a particular aspect of the company's business. During this reorganization, the Energy and Environment Sector was formed. All of the company's DOE business became part of the sector, including a new corporation, Lockheed Martin Energy Research Corporation (LMER), which was formed to operate ORNL. As a result, in 1997 LMES managed the Y-12 Plant, the ETTP, and programs at the Paducah facility in Kentucky and the Portsmouth plant in Piketon, Ohio. LMES carries out energy research and development (R&D), production of enriched uranium and weapons components, and other goals of national importance. For more information, visit the LMES home page on the World Wide Web (http://www. ornl.gov/mmes.html).

1.4.1.1 Oak Ridge Y-12 Plant

Until 1992, the primary mission of the Y-12 Plant (Fig. 1.5) was the production and fabrication of nuclear weapon components. Activities associated with these functions included production of lithium compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts. Fabrication operations included vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspecting, and testing.

Current assignments in the Y-12 Plant Defense Programs include dismantling nuclear weapon components returned from the national arsenal, serving as the nation's storehouse of special nuclear materials, and providing special production support to DOE programs. Another mission of long standing is the support of other federal agencies through the Work for Others Program. In addition, the technology transfer mission has as its goal applying its unique expertise, initially developed for highly specialized military purposes, to a wide range of manufacturing problems to support the capabilities of the U.S. industrial base. The all-inclusive expertise at the Y-12 Plant includes proceeding from concept, through detailed design and specification, to building prototypes and configuring integrated manufacturing processes. For more information, visit the Y-12 Plant home page on the World Wide Web (http://www.ornl.gov/Y12/).

The Oak Ridge Centers for Manufacturing Technology (ORCMT), located on the Y-12 Plant site, apply skills, capabilities, and facilities developed during the 50-year history of the Oak Ridge complex to a variety of peacetime missions. Major programs at the Y-12 Plant include metrology (measurement science), machine tool technology, technology applications, manufacturing operations, and gear and thread technology. More than 15 centers are solving manufacturing problems and deploying technology. Oak Ridge has already helped nearly 4000 companies from 49 of the 50 states solve manufacturing problems, resulting in millions of dollars of savings and growth to industry.

Manufacturers nationwide can access information and services at the Y-12 Plant through a toll-free telephone service (1-800-356-4USA) that is a direct link to scientists, engineers, and other technical experts in the full range of manufacturing technologies. For more information on ORCMT, visit the Web site at http://www.ornl.gov/orcmt/.

1.4.2 Bechtel Jacobs Company LLC

On December 19, 1997, DOE announced that it had awarded a contract to Bechtel Jacobs Company LLC for management and integration of the Environmental Management and Enrichment Facilities (EMEF) programs at the DOE sites in Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. The contract went into effect April 1, 1998. Bechtel Jacobs Company LLC is a special-purpose company created solely to support

Y-12 PHOTO 306208

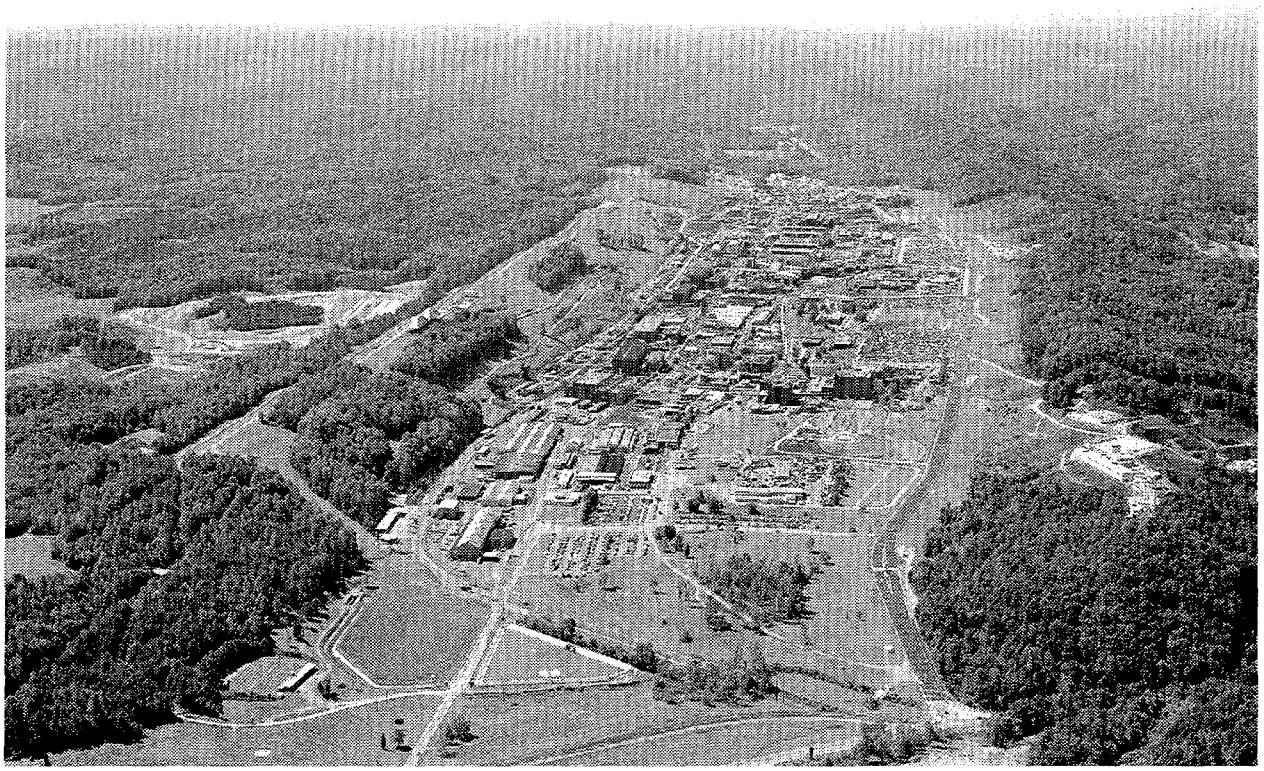

Fig. 1.5. The Oak Ridge Y-12 Plant.

EMEF. Bechtel Jacobs Company will be organized around 10 major EMEF projects: the ETTP, Upper East Fork Poplar Creek, Bethel Valley, Melton Valley, Bear Creek Valley, Legacy Waste, Waste Operations, Portsmouth, Paducah, and Enrichment Facilities. Each of these projects will be run by a project manager, who will control all work and people for that project. For more information on Bechtel Jacobs Company, visit their Web site at http://www.bechteljacobs.com/.

1.4.2.1 East Tennessee Technology Park

DOE renamed the Oak Ridge K-25 Site the East Tennessee Technology Park in an effort to further reindustrialize the former gaseous diffusion plant (Fig. 1.6).

The ETTP was built as the home of the Oak Ridge Gaseous Diffusion Plant (ORGDP). Construction of ORGDP began in the 1940s as part of the U.S. Army's Manhattan Project. The plant's mission was production of highly enriched uranium for nuclear weapons.

Enrichment was initially carried out in two process buildings, K-25 and K-27. Later, the K-29, K-31, and K-33 buildings were built to increase the production capacity of the original facilities by raising the assay of the feed material entering K-27. After military production of highly enriched uranium was concluded in 1964, the two original process buildings were shut down. For the next 20 years, the plant's primary mission was production of only slightly enriched uranium to be fabricated into fuel elements for nuclear reactors. Other missions during the latter part of this 20-year period included development and testing of the gas centrifuge method of uranium enrichment and R&D of laser isotope separation.

By 1985, demand for enriched uranium had declined, and the gaseous diffusion cascades at ORGDP were placed in standby mode. That same

DOE ORO 89-1063

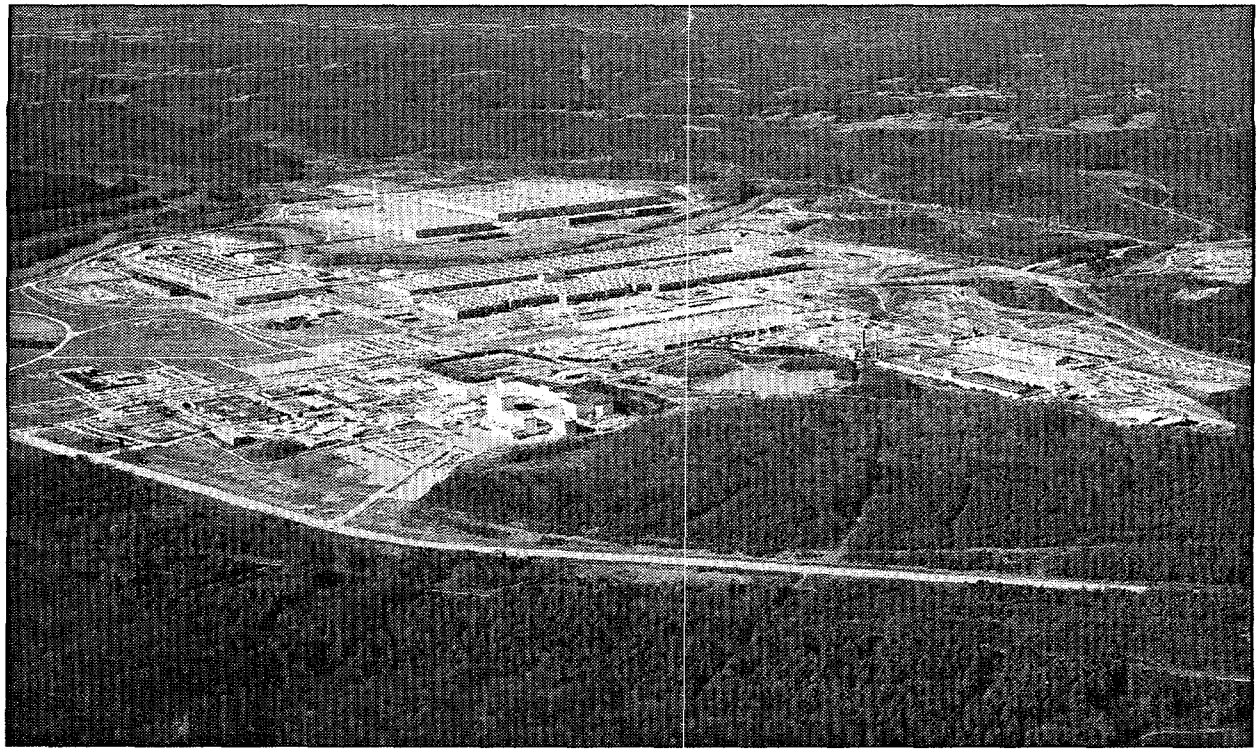

Fig. 1.6. The East Tennessee Technology Park (formerly the Oak Ridge K-25 Site).

year, the gas centrifuge program was canceled. The decision to permanently shut down the diffusion cascades was announced in late 1987, and actions necessary to implement that decision were initiated soon thereafter. Because of the termination of the original and primary missions, ORGDP was renamed the Oak Ridge K-25 Site in 1990. In 1992, the site also became known as the Center for Environmental Technology and the Center for Waste Management. The ETTP is the home of the EMEF business unit.

The current mission of the ETTP is to reindustrialize and reuse site assets through leasing of vacated facilities and incorporation of commercial industrial organizations as partners in the ongoing environmental restoration (ER), decontamination and decommissioning (D&D), waste treatment and disposal, and diffusion technology development activities.

1.4.3 Lockheed Martin Energy Research Corporation

On December 6, 1995, a contract was signed with DOE, effective January 1, 1996, that transferred the responsibility for operating ORNL from LMES to the newly formed LMER. LMER is responsible for operating ORNL and managing the Oak Ridge National Environmental Research Park, comprising 63.7% (almost 22,000 acres) of the reservation. Portions of the Park overlap areas of responsibility of the ETTP, the Y-12 Plant, ETMC [East Tennessee Mechanical Contractors (formerly Johnson Controls)] and ORISE. For more information, visit the LMER home page on the World Wide Web (http://www.ornl.gov/home.html).

DOE ORO 89-1216

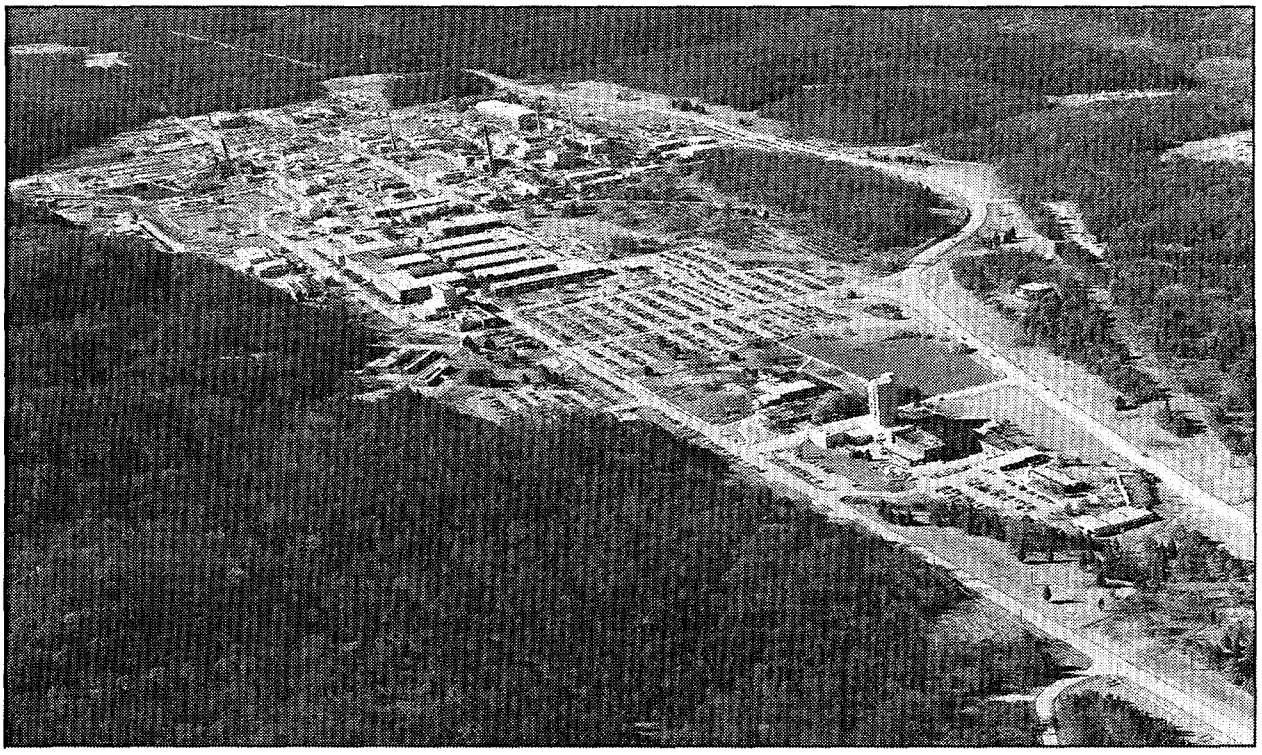

Fig. 1.7. The Oak Ridge National Laboratory.

1.4.3.1 Oak Ridge National Laboratory

ORNL was the smallest of three facilities built in 1942 and 1943 on the newly acquired 58,575-acre federal reservation (now 34,513 acres) in Oak Ridge, Tennessee. From its modest beginning as a wartime pilot plant, ORNL has grown to become one of the world's premier scientific research centers and DOE's largest and most diversified multiprogram national laboratory.

ORNL uses a total land area on the ORR approaching 26,580 acres. The primary ORNL site, known also as X-10, comprises a main laboratory building complex in Bethel Valley and outlying facilities and waste management storage areas in Melton Valley. Both areas utilize approximately 4250 acres (Fig. 1.7). Of the remaining acreage, 21,980 acres comprise mostly undisturbed natural land that has been designated as the Oak Ridge National Environmental Research Park (Fig. 1.8), and approximately 350 acres are used by ORNL in the Solway Bend area for environmental monitoring. In addition, ORNL has contractual responsibility for wildlife management on the reservation as a result of an agreement between DOE and the Tennessee Wildlife Resources Agency (TWRA), which establishes reservation land as a Tennessee Wildlife Management Area.

ORNL is currently engaged in a major reengineering effort aimed at improving its ability to support the missions of DOE. As a multiprogram national laboratory, ORNL carries out R&D in support of all four of DOE's major missions: science and technology, energy resources, environmental quality, and national security.

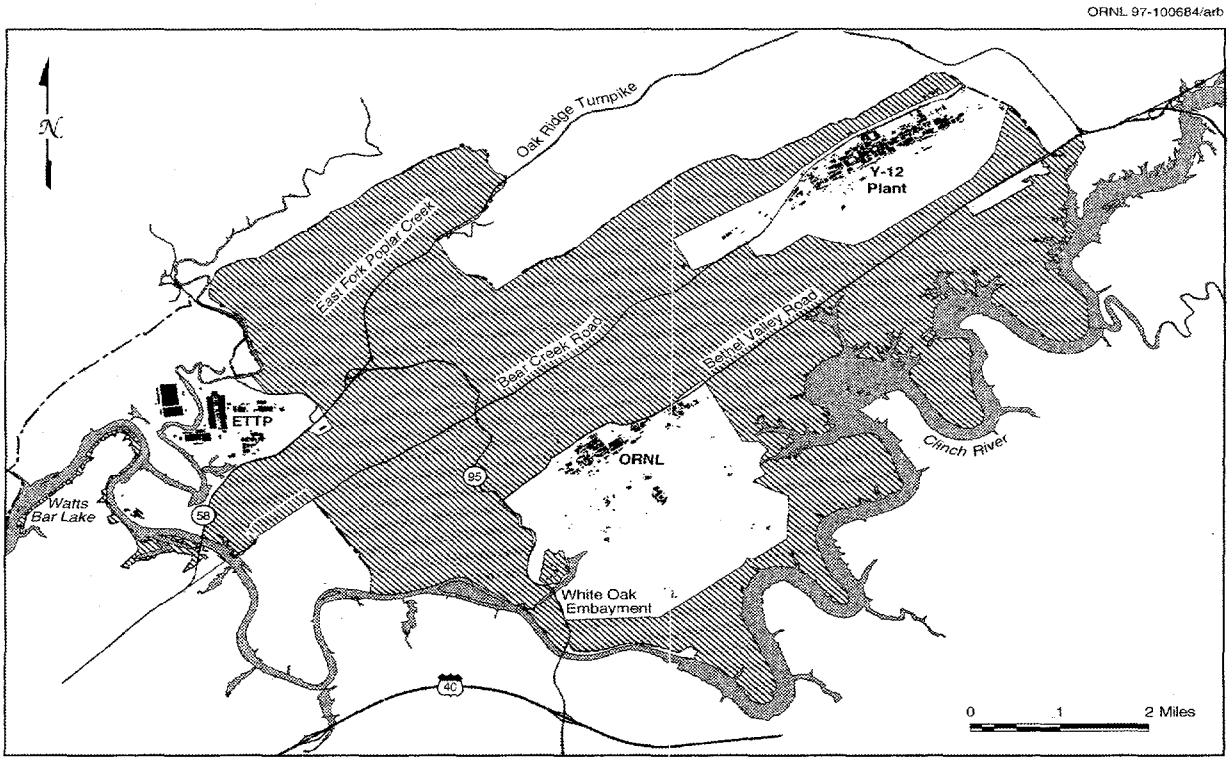

Fig. 1.8. The Oak Ridge National Environmental Research Park covers 21,980 acres on the reservation.

1.4.3.2 Oak Ridge National Environmental Research Park

The Oak Ridge National Environmental Research Park is a 21,980-acre "outdoor laboratory" with relatively undisturbed ecosystems. The Research Park provides protected, biologically diverse land area for environmental research and education. It represents the eastern deciduous forest with more than 1100 species of vascular plants, some of which are state-listed rare plants, and 315 wildlife species, some of which are state-listed or federally listed rare wildlife species (see Chap. 2, Tables 2.7 and 2.8 for a listing). The park is a biosphere reserve, an ORNL user facility, a site that contains seven registered State Natural Areas, an area that plays a significant role in nesting and migration of breeding birds, and the location of two National Historic Landmarks, Freel's Cabin and the Graphite Reactor.

The biological diversity of the Oak Ridge National Environmental Research Park serves as a foundation for ecological research into how the development and use of energy as well as other issues of national importance affect the environment. More than 700 individuals have performed research in the Oak Ridge National Environmental Research Park User Facility during the last 5 years. Users include students and faculty from more than 75 colleges and universities as well as participants from ORNL and other state and federal agencies. Field research facilities occur across the reservation and include Walker Branch Watershed, the Global Change Field Research Facility, Melton Branch Watershed, and the Bear Creek Valley Hydrology Field Sites.

The National Environmental Research Park has supported research in the following areas:

- ecosystems dynamics and biodiversity—the large, unfragmented land provides a base for investigations into biogeochemical cycling, climate-change impacts, air quality, and biotechnology and offers opportunities for wildlife restoration and

- environmental characterization—as the most hydrologically and geologically complex of all DOE sites, the Oak Ridge National Environmental Research Park provides opportunities for hydrogeologic and geophysical investigations, contaminant transport and fate studies, tracers for fractured media, microbial ecology, wetland surveys, and flora/fauna species/communities characterization.

1.4.4 Oak Ridge Institute for Science and Education

ORISE is managed for DOE by Oak Ridge Associated Universities (ORAU), a nonprofit consortium of 89 colleges and universities. ORISE includes 65 ha (162 acres) on the southeastern border of the ORR that from the late 1940s to the mid-1980s was part of an agricultural experiment station owned by the federal government and, until 1981, was operated by the University of Tennessee.

The ORISE Scarboro Operations Site (formerly the South Campus) lies immediately southeast of the intersection of Bethel Valley Road and Pumphouse Road. It houses some of the offices and laboratories of one of ORISE's operating divisions, the Chemical Safety Building, and other support structures, and the site is being developed for other productive uses.

The Freels Bend tract, about 101 ha (250 acres) on the northeastern edge of Freels Bend abutting Melton Hill Lake, was transferred from ORISE to ORNL in late 1995 after removal of the six cobalt-60 sources (total of 2200 Ci) from the Variable Dose Rate Irradiation Facility (VDRIF) by a private contractor for recycling. For more information, visit the ORAU/ORISE home page on the World Wide Web (http://www.orau.gov).

2. Environmental Compliance

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Abstract

It is the policy of the U.S. Department of Energy Oak Ridge Operations Office to conduct its operations in compliance with federal, state, and local environmental protection laws, regulations, compliance agreements and decrees, settlement agreements, executive orders, DOE orders (as incorporated into the operating contracts), work smart standards, and best management practices. DOE and its contractors make every effort to conduct operations in compliance with the letter and intent of applicable environmental statutes. The protection of the public, personnel, and the environment is of paramount importance.

2.1 INTRODUCTION

DOE's operations on the reservation are required to be in conformance with environmental standards established by a number of federal and state statutes and regulations, executive orders, DOE orders, work smart standards (WSS), and compliance and settlement agreements.

Principal among the regulating agencies are the U.S. Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC). These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

During routine operations or when ongoing self-assessments of compliance status identify environmental issues, the issues are discussed with the regulatory agencies in an effort to ensure that compliance with all environmental regulations will be sustained. In the following sections, compliance status for the ORR sites with regard to major environmental statutes and DOE orders is summarized by topic.

2.2 COMPLIANCE ACTIVITIES

2.2.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) was passed in 1976 to address management of the country's huge volume of solid waste. The law requires that EPA regulate the management of hazardous waste, which includes waste solvents, batteries, and many other substances deemed potentially harmful to human health and to the environment. RCRA also regulates underground storage tanks (USTs) used for the storage of petroleum and hazardous substances; recyclable used oil; and batteries, mercury thermostats, and selected pesticides or universal wastes.

Subtitle C of RCRA controls all aspects of the management of hazardous waste, from the point of generation to treatment, storage, and disposal (TSD). Hazardous waste generators must follow specific requirements for handling these wastes.

The Y-12 Plant, ORNL, and the ETTP are large-quantity generators. Each generates both RCRA hazardous waste and RCRA hazardous waste containing or contaminated with radionuclides (mixed waste). The hazardous and/or mixed wastes are accumulated by individual generators at locations referred to as satellite accumulation areas or 90-day accumulation areas, as appropriate, where they are picked up by waste management personnel and transported to a TSD facility or shipped directly off-site for treatment, storage, or disposal. At the end of 1997, the Y-12 Plant had about 169 generator accumulation areas for hazardous or mixed waste. ORNL had about 350 generator accumulation areas, and the ETTP maintained about 89.

The Union Valley Sample Preparation Facility managed by the Analytical Services Organization is also considered a large-quantity generator. At the end of 1997, this facility had ten satellite accumulation areas and two 90-day accumulation areas.

ORISE is classified under RCRA as a conditionally exempt small-quantity generator. Its site accumulation area is located in the Chemical Safety Building on the Scarboro Operations Site.

The Central Training Facility on Bear Creek Road, the Transportation Safeguards Division Garage and ORNL's Walker Branch Watershed Laboratory are also classified as conditionally exempt small-quantity generators.

The Y-12 Plant is registered as a large-quantity generator and a TSD facility under EPA Identification (ID) Number TN3890090001. RCRA requires that owners and operators of hazardous waste management facilities have operating and/or postclosure care permits. Most of the units at the Y-12 Plant are being operated under operating permits; however, several units still operate under interim status in accordance with a Part A permit application. Amended Part A permit applications were submitted to TDEC in December 1991, August 1993, July 1994, and September 1995 but have not yet been acted on. Six RCRA Part B permit applications have been submitted for 20 active storage and treatment units listed on the Part A permit application. Four of these Part B applications have been approved and issued as RCRA operating permits (Table 2.1).

The first Y-12 Plant permit (TNHW-032) was issued by the TDEC on September 30, 1994, for tank and container storage units. Four Class 1 permit modifications were submitted to the TDEC in 1997 for Permit TNHW-032. These modifications included updating the contingency plan, updating inspection requirements for the tanks, updating security requirements, and minor modifications to the language in the permit.

Permit TNHW-083 was issued by TDEC on September 28, 1995, for container storage units. Five Class 1 permit modifications were submitted to TDEC in 1997 for Permit TNHW-083. These modifications included updating the contingency plan, updating security requirements, updating facility drawings for Buildings 9720-9 and 9811-1 (OD-8), updating inspection requirements; and minor modifications to the language in the permit.

Permit TNHW-084 was also issued by TDEC on September 28, 1995, for production-associated units. Three Class 1 and one Class 2 permit modifications were submitted to TDEC in 1997 for Permit TNHW-084. These modifications included updating the contingency plan, updating training requirements, updating Building 9212 facility drawings by adding the Organic Handling Unit, and making minor modifications to the language in the permit.

Permit TNHW-092 was issued by TDEC on September 3, 1996, for the production and storage of classified waste. Storage areas include Buildings 9720-32 and 9720-59. Three Class 1 permit modifications were submitted to the TDEC in 1997 for Permit TNHW-092. These modifications included updating the contingency plan, updating inspection requirements, and minor modifications to the language of the permit.

ORNL is registered as a large-quantity generator and a TSD facility under EPA Identification Number TN1890090003. ORNL's most recent Part A revision on August 19, 1997, included 34 units. During 1997, 27 units operated as interim-status or permitted units, another 7 units were proposed (new construction), and ORNL has been issued 4 operating permits (see Table 2.1). State action on another permit application is still pending. Although construction was essentially completed in 1996 on three new storage units (Buildings 7668, 7883, and 7572), they were not actually used for waste storage during 1997. The 1995 Part B Permit, TNHW-010A, was revised by TDEC in May 1997 to add three units (Building 7652 and two portable sampling units) in addition to the original eight units. ORNL had submitted those permit modifications in prior years. Building 7652 had operated under a separate 1986 Part B Permit [TNHW-1890090003 (or TNHW-010) and HSWA TN-001]. Tank 7830A continued to operate under a 1992 Part B Permit (TNHW-027). A Part B Permit (TNHW-097) was issued on September 30, 1997, for 15 mixed waste units. Two Class I permit modifications were submitted to the TDEC in 1997: (1) updating the Waste Analysis Plan, Contingency Plan, Training Plan, and maps, and revising security information (TNHW-027); and (2) revising security information (TNHW-010A).

Table 2.1. RCRA operating permits

Permit Number	Building/description
	Y-12 Plant
TNHW-032	Building 9811-1 Tank Storage Unit (OD-7)
	Waste Oil/Solvent Storage Unit (OD-9)
	Liquid Organic Solvent Unit (OD-10)
TNHW-083	Building 9201-4 Container Storage Unit
	Building 9720-9 Container Storage Unit
	Building 9720-25 Container Storage Unit
	Building 9720-31 Container Storage Unit
	Building 9720-58 Container Storage Unit
	Building 9811-1 Container Storage Unit
	Containerized Waste Storage Area (CWSA)
TNHW-084	Building 9206
	Building 9212
	Building 9720-12
	Cyanide Treatment and Storage Unit
	Organic Handling Unit
TNHW-092	Building 9720-32
	Building 9720-59
	ORNL
TNHW-010	HSWA Only
TNHW-010A	Building 7507 Container Storage Unit
	Building 7507W Container Storage Unit
	Building 7651 Container Storage Unit
	Building 7652 Container Storage Unit[a]
	Building 7653 Container Storage Unit
	Building 7654 Container Storage Unit
	Building 7668 Container Storage Unit
	Building 7669 Container Storage Unit
	Building 7934 Container Storage Unit
	Portable Buildings 1 & 2 Container Storage Unit
TNHW-027	Tank 7830A Storage Unit
TNHW-097	Building 7855 Container Storage Unit
	Building 7883 Container Storage Unit
	Building 7884 Container Storage Unit
	Building 7578 Container Storage Unit
	Building 7579 Container Storage Unit
	Building 7572 Container Storage Unit
	Building 7574 Container Storage Unit
	Building 7576 Container Storage Unit
	Building 7577 Container Storage Unit
	Building 7580 Container Storage Unit
	Building 7823 Container Storage Unit
	Building 7842 Container Storage Unit
	Building 7878 Container Storage Unit
	Building 7879 Container Storage Unit
	Building 7824 Container Storage Unit
	ETTP
TNHW-015	K-1435 Toxic Substances Control Act Incinerator
TNHW-015A	K-1425 and K-1435 Container and Tank Storage Units
TNHW-056	Container Storage Units and Waste Pile Units
TNHW-057	K-1202 and K-1420-A Tank Storage Units

[a]Incorporated May 1997; was originally TN1890090003 (TNHW-010) up to May 1997.

The ETTP is registered as a large-quantity generator and a TSD facility under EPA ID Number TN0890090004. The ETTP has received four RCRA permits (see Table 2.1). The K-1435 Toxic Substances Control Act (TSCA) Incinerator is a hazardous waste treatment unit operating under a RCRA permit (TNHW-015) issued by TDEC on September 28, 1987. A revised RCRA permit based on trial burn results was received in December 1995. A reapplication of this permit was submitted to TDEC in March 1997. A second permit (TNHW-015A) is for storage of waste at the incinerator. Two other permits (TNHW-056 and TNHW-057) cover container and tank storage at various locations throughout the plant.

1997 modifications to all four ETTP RCRA permits included changes in the facility name, changes in perimeter fencing, and an update of contingency plan information. Modifications to TNHW-015 and TNHW-015A allowed for the storage and treatment of F007 waste (cyanide salts present in electroplating solutions). Additional minor permit modifications provided clarification and updated information regarding the individual RCRA units.

2.2.1.1 RCRA Assessments, Closures, and Corrective Measures

The Hazardous and Solid Waste Amendments (HSWA) to RCRA, passed in 1984, require any facility seeking a RCRA permit to identify, investigate, and (if necessary) clean up all former and current solid waste management units (SWMUs). The original HSWA permit (HSWA TN-001) for the ORR was issued by the EPA as an attachment to the RCRA permit for Building 7652 at ORNL. The HSWA permit requires DOE to address past, present, and future releases of hazardous constituents to the environment. The HSWA permit requirement for corrective action has been integrated into the ORR Federal Facility Agreement (FFA) (see Sect. 2.2.2 for details). EPA issued a preliminary draft of an updated HSWA permit (HSWA TN-001) in August 1996 and DOE was asked to review and comment. During 1997, EPA responded to DOE's comments on the draft permit, and DOE has provided further information to support the permitting process.

The renewed permit will address contaminant releases from SWMUs and also from RCRA Areas of Concern (AOCs). AOCs are areas contaminated by a release of hazardous constituents that originated from something other than a SWMU. Under the existing HSWA permit, DOE must notify EPA within 30 days of identification of a new SWMU or AOC, or of planned significant changes to SWMUs that could alter further investigation or corrective action. DOE has provided to EPA a proposed Appendix A to the permit that identifies SWMUs and AOCs for action or no action (see Table 2.2). The renewed permit is expected to be issued in 1998.

At the Y-12 Plant, 26 RCRA units have been certified closed by TDEC since the mid-1980s. Closure of the Interim Reactive Waste Treatment Area at the Y-12 Plant was completed in 1997, and acceptance of the closure certification by TDEC is expected in early 1998.

Table 2.2. Summary of proposed Appendix A to HSWA permit

Appendix A section	Title	Number of sites proposed
1a	List of SWMUs and AOCs requiring further investigation under the Federal Facility Agreement	239
1b	List of SWMUs and AOCs requiring further investigation	0
2	List of SWMUs and AOCs requiring no further action/ investigation at this time.	270
3	List of SWMUs and AOCs requiring confirmatory sampling	0

ORNL's Solid Waste Storage Area (SWSA) 6 is an interim-status disposal site (landfill) that underwent partial closure that included construction of eight interim-measure caps. A revised Closure Plan for SWSA 6 (which included the eight caps, the Hillcut Test Facility, and the Former Explosives Detonation Trench) was resubmitted in July 1995 to TDEC. The revised Closure Plan defers final closure to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation process, which is expected to integrate the RCRA closure requirements. On November 26, 1996, TDEC approved one portion of the SWSA 6 Closure Plan revision: the request to discontinue the maintenance and repair of the eight interim caps. TDEC action is still pending on the balance of the Closure Plan and on the DOE submittal of the associated Environmental Monitoring Plan and Post-Closure Permit Application. The remedy selection under CERCLA is expected to be completed in 1998.

Closure of ORNL's Building 7555 was completed on December 16, 1997, and closure was approved by TDEC on December 31, 1997.

At the ETTP, closure of the K-1417-B unit is ongoing, and certification of closure must be submitted to TDEC by May 1999.

2.2.1.2 Land Disposal Restrictions

The 1984 RCRA amendments established land disposal restrictions (LDRs), which prohibit the land disposal of untreated hazardous wastes. The amendments require that all untreated wastes meet treatment standards before land disposal or that they be disposed of in a land disposal unit from which there will be no migration of hazardous constituents for as long as the waste remains hazardous. These restrictions also prohibit storage of restricted hazardous or mixed waste except as necessary to facilitate recovery, treatment, or disposal.

Currently, with the exception of a few organic mixed wastes, the same restrictions apply to mixed wastes, which are composed of a mixture of radioactive and hazardous wastes.

In September 1992 the Federal Facility Compliance Act was passed by Congress to address the extended storage of mixed waste by DOE through agreement with host states. DOE negotiated a Federal Facility Compliance Agreement with EPA in June 1992 and established the initial requirements for treating wastes stored on the reservation. This agreement was replaced in 1995 with a state commissioner's order. The Tennessee commissioner's order signed on September 26, 1995, culminated negotiations between DOE and the state and established a Site Treatment Plan to address treatment and disposal of DOE's mixed waste at Oak Ridge facilities (discussed in Sect. 2.2.4). To date, all milestones under the Site Treatment Plan have been met. The Site Treatment Plan is updated annually to reflect the most current treatment objectives (Sect. 2.2.4).

2.2.2 RCRA-CERCLA Integration

The CERCLA response action and RCRA corrective action processes are similar and include four steps with similar purposes (Table 2.3).

Table 2.3. RCRA and CERCLA corrective action processes

RCRA	CERCLA	Purpose
RCRA facility assessment	Preliminary assessment/site investigation	Identify releases needing further investigations
RCRA facility investigation	Remedial investigation	Characterize nature, extent, and rate of contaminant releases
Corrective measures study	Feasibility study	Evaluate and select remedy
Corrective measures implementation	Remedial design/remedial action	Design and implement chosen remedy

EPA, DOE, and TDEC entered into an interagency agreement known as the ORR FFA to ensure that the environmental impacts associated with past and present activities at the ORR are thoroughly investigated and that appropriate remedial actions or corrective measures are taken as necessary to protect human health and the environment. This agreement established a procedural framework and schedule for developing, implementing, and monitoring response actions on the ORR in accordance with CERCLA. The ORR FFA is also intended to integrate the corrective action processes of RCRA required under the HSWA permit with CERCLA.

As a further example, three RCRA postclosure permits, one for each of the three hydrogeologic regimes at the Y-12 Plant, have been issued and incorporate the seven major closed waste disposal areas at the Y-12 Plant. These are noted in Table 2.4. Groundwater corrective actions have been deferred to CERCLA. Reporting of groundwater-monitoring data will comply with RCRA postclosure permit conditions as well as CERCLA requirements.

Table 2.4. Postclosure permits for Y-12 Plant hydrogeologic regimes

Hydrogeologic regime	Waste area	Postclosure permit
Bear Creek Valley	1. Bear Creek Burial Grounds (including the walk-in pits) 2. Oil Landfarm 3. S-3 Pond Site (west)	TNHW-087
Chestnut Ridge	1. Chestnut Ridge Sediment Disposal Basin 2. Chestnut Ridge Security Pits 3. Kerr Hollow Quarry	TNHW-088
Upper East Fork Poplar Creek	1. New Hope Pond 2. S-3 Pond site (east)	TNHW-089

2.2.3 Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA, also known as Superfund, was passed in 1980 and was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA). Unlike the other regulatory programs summarized in this chapter, such as RCRA or the Clean Water Act (CWA), which address ongoing waste generation, storage, disposal, or discharge of waste or wastewaters, CERCLA is a process to address abandoned or uncontrolled hazardous substance sites where a release has or may have occurred. Under CERCLA, a site is investigated and remediated if it poses significant risk to health or the environment. The ORR was placed on the EPA National Priorities List (NPL) in December 1989. The NPL is a comprehensive list of sites/facilities that have been found to pose a sufficient threat to human health and/or the environment to warrant cleanup under CERCLA. An interagency agreement under Section 120(c) of CERCLA was signed in January 1991 between EPA, TDEC, and DOE known as the ORR FFA (see Sect. 2.2.2). The FFA Appendix C lists all of the inactive sites/areas that will be investigated, and possibly remediated, under CERCLA. Milestones for completion of CERCLA documents are available in Appendix E of the FFA.

It is important to note that environmental restoration activities on the ORR are in transition. DOE-ORO has incorporated aggressive management and productivity goals into its planning for the accelerated completion of the DOE Environmental Management mission as detailed in the 1997 document, *Oak Ridge Operations Office Environmental Management, Accelerating Clean-Up: Focus on 2006.* Key assumptions for the accomplishment of these goals are:

- reindustrialization will be the primary method of accomplishment for D&D of the ETTP;
- an on-site waste management facility will be operational on the ORR in fiscal year 2000 for wastes resulting from the CERCLA actions;
- the watershed approach will be implemented for assessment and cleanup of the ORR; and
- aggressive, enhanced performance (greater efficiency) will be attained by transition to a management and integration (M&I) contract with full projectization of work scope and extensive utilization of subcontractors.

2.2.4 Federal Facility Compliance Agreement

The Federal Facility Compliance Act was signed on October 6, 1992, to bring federal facilities (including those under DOE) into full compliance with RCRA. The act waives the government's sovereign immunity, allowing fines and penalties to be imposed for RCRA violations at DOE facilities. In addition, the act requires that DOE facilities provide comprehensive data to EPA and state regulatory agencies on mixed-waste inventories, treatment capacities, and treatment plans for each site. The act ensures that the public will be informed of waste treatment options and encourages active public participation in the decisions affecting federal facilities. TDEC is the authorized regulatory agency under the act for the DOE facilities in the state of Tennessee.

Site Treatment Plans are required for facilities at which DOE generates or stores mixed waste. The purpose of the Site Treatment Plan is to identify to TDEC the proposed options (treatment method, facility, and schedule) for treating mixed waste at the ORR. For some waste types, these options include continued waste characterization for use, development, and/or modification of treatment technologies.

The ORR Site Treatment Plan calls for mixed low-level (radioactive) waste (LLW) on the ORR to be treated by a combination of commercial treatment capabilities and existing and modified on-site treatment facilities. Mixed transuranic (TRU) waste streams on the ORR, composed of both contact- and remote-handled wastes, will be treated in the proposed Transuranic Processing Facility (TPF) only as necessary to meet the waste acceptance criteria for disposal at the Waste Isolation Pilot Plant (WIPP).

The Site Treatment Plan was issued to TDEC on April 4, 1995. TDEC has reviewed and modified the plan in accordance with Section 3021(b)2 of RCRA. TDEC has issued a commissioner's order (Sect. 2.2.1.2), effective October 1, 1995, that requires compliance with the approved plan.

The Site Treatment Plan provides overall schedules, milestones, and target dates for achieving compliance with LDRs; a general framework for the establishment and review of milestones; and other provisions for implementing the Site Treatment Plan that are enforceable under the commissioner's order.

Semiannual progress reports document the quantity of LDR mixed waste in storage at the end of the previous 6-month period and the estimated quantity to be placed in storage for the next five fiscal years. All milestones and commitments under the Site Treatment Plan have been met for CY 1997. The annual update of the Site Treatment Plan for CY 1997 was approved by TDEC in December 1996, and the annual update, to be in effect in FY 1998, was issued in October 1997 (*Site Treatment Plan for Mixed Wastes on the U.S. Department of Energy Oak Ridge Reservation*, October 1997).

The Site Treatment Plan will terminate when there is no longer any LDR mixed waste being stored on the ORR, regardless of when it was generated. In the absence of a compliant Site Treatment Plan, LDR mixed-waste storage would be in violation of RCRA Section 3004(j).

2.2.5 Underground Storage Tanks

USTs containing petroleum and hazardous substances (HS) are regulated under Subtitle I of RCRA, 40 CFR 280. TDEC has been granted authority by EPA to regulate USTs containing

petroleum under TDEC Rule 1200-1-15; however, HS USTs are still regulated by EPA. Table 2.5 summarizes the status of USTs on the ORR.

ORNL has responsibility for 54 USTs registered with the TDEC under Facility ID # 0-730089; all 54 USTs are in compliance with the applicable portions of 40 CFR 280 and Rule 1200-1-15. These 54 UST systems can be categorized as follows.

Three tanks remain in service and are relatively new UST systems that meet the 1998 final standards for new tank installations. One UST site is in a groundwater monitoring program, anticipated to be completed in August 1999. Twenty UST case closures are pending at TDEC. Two HS UST case closures are pending at EPA.

Table 2.5. ORR UST status, 1997

	Y-12 Plant	ORNL	ETTP
Active/in-service	4	3	2
Closed	40	51[a]	14
Hazardous substance	3[b]	0[c]	6[d]
Upgraded	0	0[e]	0
Known or suspected sites	0	0	16
Total	47	54	38

[a]The 51 "closed" USTs include deferred or excluded tanks of various categories, as detailed in the text.

[b]Two USTs are deferred because they are regulated by the Atomic Energy Act of 1954. The third is a permanently closed methanol UST.

[c]Closed tanks include two hazardous substance tanks, both of which were excavated, removed, and dismantled.

[d]Four USTs were permanently closed that were used to store natural gas odorant and are regulated under the Pipeline Safety Act. A fifth UST, designed as a spill-overflow tank, has never permanently been placed into service. A sixth UST was permanently closed that stored a methanol/gasoline mixture.

[e]In previous reports, three upgraded USTs were listed for ORNL. These are now listed above as "active/in-service" because they are in use.

Thirteen USTs are deferred or exempt from regulation under RCRA Subtitle I and can be categorized as follows: two radioactive waste oil tanks closed under RCRA Subtitle C; one radioactive waste oil tank permitted under RCRA Subtitle C; two radioactive waste tanks closed under the FFA; two exempt heating oil tanks, which were closed as a best management practice (BMP); one wastewater tank regulated under the CWA; one RCRA SWMU; and four USTs with volumes of 110 gal or less, which were closed as a BMP.

Thirteen UST case closure letters have been received from TDEC. Two tanks were closed before the effective date of 40 CFR 280 (December 22, 1988) but after the UST registration date (January 1, 1974). All USTs not meeting the 1998 standards have been closed, the last of which was closed in November 1997.

The ORNL UST Program was also given responsibility for, and completed the closure of, three additional USTs, each of which was registered to another facility. Another four USTs never required registration because they were closed prior to January 1, 1974; however, these USTs are still potentially regulated if evidence of a release is discovered.

The Y-12 Plant UST Program includes four active petroleum USTs that meet all current regulatory compliance requirements. The UST registration certificates for these tanks are current, and certificates are posted at the UST locations, enabling fuel delivery until March 31, 1999.

At four other Y-12 Plant former UST sites, alternatives to "active remediation" are being pursued. These alternatives include the Site Ranking for the 9201-1 and 9204-2 UST sites and a Site-Specific Standard Request (SSSR) for the East End Fuel Facility (9754 and 9754-2) and the Rust Garage Facility (9754-1 and 9720-15) UST sites. If the sites qualify by TDEC DUST rules for these alternatives, and with approval by TDEC, the tank owner/operator is allowed to conduct semiannual groundwater monitoring in lieu of a remediation scenario.

In 1997, TDEC granted final closure for the 9201-1 and 9204-2 UST sites following the second year of the monitoring-only program and submission of the closure reports.

TDEC did not grant approval for an SSSR for the Rust Garage Facility. However, because this site is affected by commingling plumes from adjacent former hazardous waste disposal sites, the state has approved further investigation and remediation of this site to be addressed through the CERCLA process. Additionally, TDEC did not approve the SSSR for the East End Fuel Station USTs. A petition has been submitted to the TDEC UST Board to reconsider the request. If the TDEC board denies the petition, a corrective action implementation plan will be required and a schedule for corrective action will be developed.

The ETTP UST Program includes two active petroleum USTs that meet all current regulatory compliance requirements. The UST registration certificates are updated annually and are conspicuously posted in accordance with TDEC rules. Fourteen other petroleum USTs have been removed or closed in place with TDEC regulators' recommendation of "case closed" status.

One methanol/gasoline hazardous substance UST was removed in May 1997. A "case closed" status was granted by EPA-Region IV regulators. Four methyl mercaptan hazardous substance USTs were removed in July 1996. One other hazardous substance UST designed as a spill overflow tank was never activated.

Sixteen known and/or suspected historical USTs are also included in the ETTP UST Program as a BMP. These exempted historical USTs are those UST systems that were out of service before January 1, 1974. There is a potential that historical UST sites would have to adhere to closure requirements if directed by UST regulators. Magnetic and electromagnetic geophysical techniques are being used for detection and characterization of these historical UST sites and other underground structures to provide property database information for reindustrialization of the ETTP.

A detailed description of all ORNL, Y-12 Plant, and ETTP USTs and their current status is included in Appendix E.

2.2.6 National Environmental Policy Act

The National Environmental Policy Act (NEPA) provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. The NEPA review process results in the preparation of NEPA documents in which federal, state, and local environmental regulations and DOE orders applicable to the environmental resource areas must be considered. These environmental resource areas include air, surface water, groundwater, terrestrial and aquatic ecology, threatened and/or endangered species, land use, and environmentally sensitive areas. Environmentally sensitive areas include floodplains, wetlands, prime farm land, habitats for threatened and/or endangered species, historic properties, and archaeological sites. Each ORR site NEPA program maintains compliance with NEPA through the use of its site-level procedures. These procedures assist in establishing effective and responsive communications with program managers and project engineers to establish NEPA as a key consideration in the formative stages of project planning. Table 2.6 notes the types of NEPA activities conducted at the ORR during 1997.

During 1997, ORNL operated under a procedure that provided requirements for project reviews and compliance with NEPA. It called for review of each proposed project, activity, or facility for its potential to result in significant impacts to the environment. Review and documentation included 19 cooperative research and development agreements (CRADAs) with industries and corporations and 46 other research actions, a majority of which were conducted by the Environmental Sciences Division. A CRADA is a cooperative agreement between a DOE facility and a private entity to collaborate on ideas, share costs, and pool the results of a particular R&D program. Sixteen "generic" categorical exclusions (CXs) were approved by DOE. A CX is one of a category of actions defined in 40 CFR

Table 2.6. NEPA activities during 1997

Types of NEPA documentation	Y-12 Plant	ORNL	ETTP	ORISE
Categorical exclusion (CX) recommendation	5	33	10	
Specific CX granted	5	31[a]	9	
Approved under general CX documents	63	49	40	0
Environmental assessment	0	0	1	
Special environmental analysis	0	0	0	
Programmatic environmental assessment	0	0	0	
Supplemental analysis	0	0	0	
Environmental impact statement	0	0	0	
Supplemental environmental impact statement	0	0	0	
Programmatic environmental impact statement	0	0	0	

[a]Includes 16 revised five-site generic CXs.

1508.4 that do not individually or cumulatively have a significant effect on the human environment and for which neither an environmental assessment (EA) nor an environmental impact statement (EIS) is normally required. Generic CXs expedite the NEPA process by allowing ORNL to group activities and proceed with a proposed action after completion of internal screening and documentation. NEPA compliance reviews were also completed for the transfer of El Verde Research Station Site from DOE to the Forest Service and transfer of custody of a site located at Mayaguez, Puerto Rico, from DOE to the U.S. Department of Agriculture. Reviews of NEPA values were conducted for the CERCLA actions, *Surface Impoundments Operable Unit* and *Fuel and Flush Salt Removal from the Molten Salt Reactor Experiment*. Other NEPA reviews covered routine maintenance actions, laboratory and office renovation and upgrades, reroofing of ORNL facilities, and waste minimization and reuse.

DOE has proposed development at ORNL of a high-energy linear accelerator facility, now called the Spallation Neutron Source (SNS), that would serve as a cornerstone for advanced research in neutron scattering into the next century. The proposed site for the SNS facility is on the ORR, on Chestnut Ridge approximately 2 miles northeast of ORNL. A site characterization survey, ecological resource surveys (potential habitat for federal- and state-listed animal and plant species and jurisdictional wetlands), and an archaeological survey have been completed, and findings from the these surveys have been incorporated into the draft EIS for the proposed project.

Much of the NEPA activity at the ETTP during 1997 involved review of potential leases of the land and facilities. The *Final Environmental Assessment, Lease of Land and Facilities Within the East Tennessee Technology Park, Oak Ridge, Tennessee*, was completed and approved in 1997 and was issued in December with a finding of no significant impact (FONSI). The EA was written to describe the baseline environmental conditions at the site; to analyze potential generic impacts to the baseline environment from future tenant operations based on defined bounding scenarios; and to identify and characterize cumulative impacts of future industrial uses of the site. In addition, the EA provides DOE with environmental information for developing lease restrictions. In 1997, NEPA reviews supported 13 potential lease actions and one license action at the ETTP. Reviews of NEPA values were conducted for two major D&D projects and eight CERCLA investigation or early action projects. Other NEPA reviews covered more routine maintenance actions, such as road repair, re-roofing, asbestos abatement, and equipment relocation or maintenance.

At the Y-12 Plant, job-specific CX documents were prepared and approved in 1997 for a number of projects: demolition and disposition of several unused protective services buildings and towers, improvements to treatment systems at the Central Pollution Control Facility, expansion of the Industrial Landfill spoil area, installation of a new portal security facility, and installation of a new groundwater treatment technology. Other NEPA reviews covered routine actions, such as office renovations, repairs to storm and sewer systems, security upgrades, and infrastructure improvements.

2.2.7 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires that federal agencies take into account the effects of their undertakings on properties included in or eligible for inclusion in the *National Register of Historic Places*. To comply with Section 106 of the NHPA, and its implementing regulations at 36 CFR 800, DOE-ORO was instrumental in the ratification of a programmatic agreement among DOE-ORO, the Tennessee state historic preservation officer (SHPO), and the Advisory Council on Historic Preservation concerning management of historical and cultural properties on the ORR. The programmatic agreement was ratified on May 6, 1994. It stipulates that DOE-ORO will prepare a cultural resource management plan (CRMP) for the ORR and will provide a draft of the CRMP to the Tennessee SHPO and Advisory Council on Historic Preservation within 24 months of the ratification of the agreement. The agreement also stipulates that DOE-ORO will conduct surveys to identify significant historical properties on the ORR. A draft CRMP has been completed and reviewed by the SHPO and the Advisory Council. Comments were incorporated into the CRMP in 1997 and early 1998, and the CRMP will be released for public comment in 1998.

Compliance with NHPA at ORNL, the Y-12 Plant, and the ETTP is achieved and maintained in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the programmatic agreement and, if warranted, consultation is initiated with the SHPO and the Advisory Council on Historic Preservation, and the appropriate level of documentation is prepared and submitted. ORNL submitted one historical review in 1997 for dismantlement of Building 3004. Seven reviews were prepared for submittal in 1997 from the ETTP. The submittals dealt with leasing portions of property and/or land on the ORR.

The ETTP and Y-12 Plant have been surveyed to identify sites eligible for inclusion in the *National Register*, and an archaeological survey has been completed. Final reports for both the Y-12 Plant and the ETTP are expected by the end of 1998. ORR-wide surveys to identify and evaluate pre–World War II structures and known archaeological sites for eligibility in the *National Register* were completed in 1995. Survey results were incorporated into the CRMP.

A survey of all ORISE structures was conducted to comply with the NHPA. Two properties, the Freels Cabin and the Atmospheric Turbulence Diffusion Laboratory, were identified as previously included in the *National Register*. Management responsibilities for the Freels Cabin have since been transferred to ORNL. Section 106 of the NHPA requires federal agencies to coordinate with the state and allow the SHPO to review proposed demolition projects and other activities adversely affecting existing structures. During the past 3 years, ORISE removed 40 surplus structures (some requiring decontamination) from the ORR.

2.2.8 Protection of Wetlands

Executive Order 11990 (issued in 1977) was established to mitigate adverse effects to wetlands caused by destruction or modification of wetlands and to avoid new construction in wetlands wherever possible. Avoidance of these effects is ensured through implementation of the sensitive-resource analysis conducted as part of the DOE NEPA review process. Protective buffer zones and application of BMPs are required for activities on the ORR. Coordination with TDEC, the U.S. Army Corps of Engineers (COE), and TVA is

necessary for activities involving waters of the United States, which include wetlands and floodplains. This is also true for the state and waters of the state. Generally, this coordination results in permits from the COE, TVA, and/or the state (see Sect. 2.2.13.3 for permitting details). In addition, TDEC has developed a regulatory position on impacted wetlands that includes mitigation; any affected wetlands must be replaced in area and function by newly constructed wetlands or enhancement of previously impacted areas.

The ORR implements protection of wetlands through each site NEPA program in accordance with 10 CFR 1022, "Floodplain/Wetlands Environmental Review Requirements." The Y-12 Plant, ORNL, and the ETTP practice wetlands protection by establishing buffer zones and other BMPs whenever activities are proposed that may introduce a potential environmental impact. Wetlands protection, documentation, and reporting requirements are administered through the NEPA review and documentation process. Each of the sites also has conducted surveys for the presence of wetlands, and conducts surveys on a project or program as-needed basis. Wetland surveys and delineations have been conducted on about 14,000 acres (5668 ha) of the 34,500 acres (13,968 ha) that make up the reservation. About 800 acres (324 ha) of wetlands have been identified in the areas in which surveys have been conducted. Surveys for the remaining 20,500 acres (8300 ha) will be conducted only as needed.

The Y-12 Plant has conducted two surveys of its wetlands resources. *Identification and Characterization of Wetlands in the Bear Creek Watershed* (MMES 1993) was completed in October 1993, and a wetland survey of selected areas in the Y-12 Plant area of responsibility was completed in October 1994. The first report surveys the Y-12 Plant and surrounding areas; the second report, *Wetland Survey of Selected Areas in the Oak Ridge Y-12 Plant Area of Responsibility, Oak Ridge, Tennessee*, Y/ER-279, January 1997, surveys additional areas for which ER activities are planned.

In 1995, TDEC approved a wetlands mitigation plan for First Creek at ORNL in conjunction with a sediment-removal project on Melton Branch. Implementation of the plan was completed on schedule in March 1996 with annual reports submitted to TDEC as required. The plan required that a 1000-linear-foot reach of First Creek be planted in specific trees and shrubs and that it be protected and maintained as a stream-enhancement zone. This protection and maintenance continued through 1997. A wetlands survey of ORNL areas, *Wetland Survey of the X-10 Bethel Valley and Melton Valley Groundwater Operable Units at ORNL* (Rosensteel 1996), was completed and published in 1996.

A partial wetlands survey for areas within the ETTP area of responsibility was conducted during the summer of 1994. Not all areas within the ETTP have been surveyed for wetlands, and it is likely that additional locations will be classified as wetlands. The wetlands that have been identified are protected in accordance with Executive Order 11990.

Since 1994, additional wetland surveys and wetland boundary delineations have been performed in the main ETTP area, at the K-901-A area, the Atomic Vapor Laser Isotope Separation (AVLIS) Site, and the ETTP South Site. A revised wetland assessment for site investigation activities at the ETTP was approved by DOE-ORO in December 1996.

2.2.9 Floodplains Management

Executive Order 11988 (issued in 1977) was established to require federal agencies to avoid to the extent possible adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. Agencies must determine whether a floodplain is present that may be affected by an action, assess the impacts on such, and consider alternatives to the action. The executive order requires that provisions for early public review and measures for minimizing harm be included in any plans for actions that might occur in the floodplain. Floodplain assessments and the associated notices of involvement and statement of findings are prepared in accordance with

10 CFR 1022, usually as part of the NEPA review and documentation process.

2.2.10 Endangered Species Act

Good stewardship, state laws (*The Rare Plant Protection and Conservation Act of 1985*, Tennessee Code Annotated Section 70-8-301 to 314 and *Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974*, Tennessee Code Annotated Section 70-8-101 to 110) and federal laws (*Endangered Species Act of 1973*, 16 U.S.C. 1531 et seq.) dictate that animal and plant species of concern be considered when a proposed project has the potential to alter their habitat or otherwise harm them. At the federal level, such species are classified as endangered, threatened, or species of concern; at the state level, species are considered endangered, threatened, or of special concern (plants) or in need of management (animals). All such species are termed threatened and endangered (T&E) species in this report.

2.2.10.1 Threatened and Endangered Animals

Listed animal species known to be currently present on the reservation (excluding the Clinch River bordering the reservation) are given along with their status in Table 2.7. The list illustrates the diversity of birds on the ORR, which is also habitat for many unlisted species some of which are in decline nationally or regionally. Other listed species may also be present, although they have not been observed recently. These include several species of mollusks (such as the spiny riversnail), amphibians (such as the hellbender), birds (such as Bachman's sparrow), and mammals (such as the smoky shrew). The ORR has been more thoroughly surveyed for birds than for other animal groups, except perhaps fish and aquatic invertebrates. The only federally listed animal species that have been recently observed (the gray bat, bald eagle, and peregrine falcon) are represented by one to several migratory or transient individuals rather than by permanent residents, although this situation may change as these species continue to recover. A few individual bald eagles, for example, have become winter resident rather than transient. Similarly, several state-listed bird species, such as the anhinga, olive-sided flycatcher, sandhill crane, double-crested cormorant, and little blue heron are currently uncommon migrants or visitors to the reservation; however, the double-crested cormorant and little blue heron are increasing or will probably increase in numbers. Others, such as the cerulean warbler, northern harrier, great egret, and yellow-bellied sapsucker, are common migrants or winter residents that do not nest on the reservation.

2.2.10.2 Threatened and Endangered Plants

Twenty-six plant species currently known to occur on the ORR are listed by the state of Tennessee, including the purple fringeless orchid, pink lady's slipper, and Canada lily (Table 2.8). Four species (spreading false foxglove, Appalachian bugbane, tall larkspur, and butternut) have been under review for listing at the federal level and were listed under the formerly used "C2" candidate designation.

Whorled mountain mint is found on the ORR, but its taxonomy is uncertain. A species of *Pycnathemum* is also present; it is believed to be either *Pycnathemum verticillatum* or *Pycnathemum torrei*. If the presence of either were confirmed, it would be listed by the state. Two additional species listed by the state, *Lilium michiganense* and *Carex oxylepis* (var. *pubescens*), were identified in the past on the ORR; however, they have not been found in recent years. Several state-listed plant species currently found on adjacent lands may be present on the ORR as well, although they have not been located.

2.2.11 Environmental Justice

On February 11, 1994, President Clinton promulgated Executive Order 12898, "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations." The executive order requires that federal

Table 2.7. Animal species of concern reported from the Oak Ridge Reservation[a]

Species	Common name	Legal status[b]	
		Federal	State
	Fish		
Phoxinus tennesseensis	Tennessee dace		NM
	Amphibians and reptiles		
Hemidactylium scutatum	Four-toed salamander		NM
	Birds		
Haliaeetus leucocephalus	Bald eagle	T	T
Falco peregrinus	Peregrine falcon	T	E
Dendroica cerulea	Cerulean warbler	C	
Pandion haliaetus	Osprey		T
Ammodramus savannarum	Grasshopper sparrow		NM
Accipiter striatus	Sharp-shinned hawk		NM
Accipiter cooperii	Cooper's hawk		NM
Circus cyaneus	Northern harrier		NM
Anhinga anhinga	Anhinga		NM
Casmerodius alba	Great egret		NM
Leucophoyx thula	Snowy egret		NM
Contopus borealis	Olive-sided flycatcher		NM
Grus canadensis	Sandhill crane		NM
Lanium ludovicianus	Loggerhead shrike		NM
Phalacrocorax auritus	Double-crested cormorant		NM
Sphyrapicus varius	Yellow-bellied sapsucker		NM
Egretta caerulea	Little blue heron		NM
	Mammals		
Myotis grisescens	Gray bat	E	E
Sorex longirostris	Southeastern shrew		NM

[a]Land and surface waters of the ORR exclusive of the Clinch River, which borders the ORR.

[b]E = endangered, T = threatened, C = species of concern, NM = in need of management.

Table 2.8. Protected vascular plant species found on the Oak Ridge Reservation (September 1997)

Species	Common name	Habitat on ORR	Status[a]
Aureolaria patula	Spreading false-foxglove	River bluff	(C2), T
Carex gravida	Heavy sedge	Varied	S
Carex oxylepis var. *pubescens*[b]	Hairy sharp-scaled sedge	Shaded wetlands	S
Cimicifuga rubifolia	Appalachian bugbane	River slope	(C2), T
Cypripedium acaule	Pink lady's-slipper	Dry to rich woods	E-CE
Delphinum exaltatum	Tall larkspur	Barrens and woods	(C2), E
Diervilla lonicera	Northern bush-honeysuckle	River bluff	T
Draba ramosissima	Branching whitlow-grass	Limestone cliff	S
Elodea nuttallii	Nuttall waterweed	Pond, embayment	S
Fothergilla major	Mountain witch-alder	Woods	T
Hydrastis canadensis	Golden seal	Rich woods	S-CE
Juglans cinerea	Butternut	Slope near stream	(C2), T
Juncus brachycephalus	Small-head rush	Wetland	S
Lilium canadense	Canada lily	Moist woods	T
Lilium michiganense[c]	Michigan lily	Moist woods	T
Liparis loeselii	Fen orchid	Forested wetland	E
Panax quinquifolius	Ginseng	Rich woods	S-CE
Platanthera flava var. *herbiola*	Tuberculed rein-orchid	Forested wetland	T
Platanthera peramoena	Purple fringeless orchid	Wet meadow	T
Pycnanthemum verticillatum	Whorled mountain-mint	Wetlands and barrens	E
Rhynchospora colorata	White-topped sedge	Rocky edge of pond	[S]
Ruellia purshiana	Pursh's wild-petunia	Dry, open woods	S
Saxifraga careyana	Carey saxifrage	River bluff, sinkhole	S
Scirpus fluviatilis	River bulrush	Wetland	S
Spiranthes lucida	Shining ladies'-tresses	Wetland	T
Viola tripartita var tripartita	Three-parted violet	Rocky woods	S

[a]Status codes:

(C2) Special concern, under review for federal listing; was listed under the formerly used C2 candidate designation. More information needed to determine status.

E Endangered in Tennessee.

T Threatened in Tennessee.

S Special concern in Tennessee.

-CE Status as a result of commercial exploitation.

[S] The Oak Ridge Reservation population of *Rhynchospora colorata* is the only known population of this species in the state of Tennessee. Because it is a relatively recent find, the state flora has not yet been updated to include *Rhynchospora colorata*. Tennessee Heritage Program staff have suggested that it be considered special concern pending further review (personal communication).

[b]*Carex oxylepis var. pubescens* has not been re-located during recent surveys.

[c]*Lilium michiganense* is believed to have been extirpated from the ORR by the impoundment at Melton Hill.

actions not have the effect of excluding, denying, or discriminating on the basis of race, color, national origin, or income level, and federal agencies must ensure that there are no disproportionate impacts from their actions on low-income and minority communities surrounding their facilities.

An environmental justice strategy is in place at DOE-ORO under the direction of the Diversity Programs Office. It addresses the need to effectively communicate DOE activities to minority communities. Efforts are under way to ensure that DOE activities are presented to the public in a manner that does not require stakeholders to possess a technical background in order for them to effectively participate in the decision-making process.

In addition, each DOE planned action that is addressed under NEPA must include an analysis of the health, environmental, economic, and demographic impacts of the planned action on surrounding minority and low-income communities that could be affected by the action.

2.2.12 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) of 1974 is an environmental statute for the protection of drinking-water sources. The act requires EPA to establish primary drinking-water regulations for contaminants that may cause adverse public health effects. Although many of the requirements of the SDWA apply to public water supply systems, Section 1447 states that each federal agency having jurisdiction over a federally owned or maintained public water system must comply with all federal, state, and local requirements regarding the provision of safe drinking water. Because the systems that supply drinking water to the ORR are DOE-owned, the requirements of Section 1447 apply. The Underground Injection Control (UIC) program, adopted pursuant to the SDWA, regulates the emplacement of fluids into the subsurface by means of injection wells.

Potable water for the city of Oak Ridge, the Y-12 Plant, and ORNL is received from a DOE-owned water-treatment facility located northeast of the Y-12 Plant and currently managed by East Tennessee Mechanical Contractors in partnership with Johnson Controls World Services, Inc. Both ORNL and the Y-12 Plant are designated as nontransient, noncommunity water-distribution systems by the TDEC Division of Water Supply and are subject to the Tennessee Regulations for Public Water Systems and Drinking Water Quality, Chapter 1200-5-1. Under the TDEC regulations, distribution systems that do not perform water treatment can use the records sent to the state by the water treatment facility from which water is received to meet applicable compliance requirements. In 1997, the DOE water treatment plant met all of the Tennessee radiological and nonradiological standards and scored 100 on the annual TDEC review.

ORNL's water distribution system has qualified for triennial lead and copper sampling. In 1997, the system was sampled; none of the samples exceeded the Tennessee lead or copper action levels.

In June 1997, ORNL received two Class V Underground Injection Control Permits from TDEC for Environmental Sciences Division experiments in ORNL Waste Area Grouping (WAG) 5. The experiments involve the use of underground tracers (i.e., isotopes of cobalt, cadmium, and chromium; an isomer of fluorobenzoic acid; and a bromide salt) to improve the predictive capability of the fate and transport of subsurface plumes. One of these permits was renewed by TDEC in December 1997. The other permit does not have an expiration date and therefore does not require renewal.

The K-1515 Sanitary Water Plant provides drinking water for the ETTP and for an industrial park located on Bear Creek Road south of the site. The DOE-owned facility is classified as a nontransient, noncommunity water-supply system by TDEC and is subject to state regulations. The plant is in compliance with the drinking-water quality standards; monthly and quarterly testing for required constituents is carried out and reported to TDEC. Requirements of the lead and copper rule have been met, and the plant has been granted approval to reduce monitoring for these constituents to once per year. In 1997, the DOE

water treatment plant met Tennessee radiological and nonradiological standards.

A cross-contamination control program implemented at the Y-12 Plant, ORNL, and the ETTP prevents and eliminates cross-connects of sanitary water with process water and uses backflow-prevention devices and an engineering review and permitting process. As part of the program, an inventory of installed backflow-prevention devices is maintained, and inspection and maintenance of the devices are conducted in accordance with regulatory requirements.

2.2.13 Clean Water Act

The CWA was originally enacted as the Water Pollution Control Act in 1948, then later established as the Federal Water Pollution Control Act in 1972. Since that time, the CWA received two major amendments. The objective of the CWA is to restore, maintain, and protect the chemical, physical, and biological integrity of the nation's waters. With continued amendments, the CWA has established a comprehensive federal and state program to protect the nation's waters from pollutants. Congress continues to work on amendments to and reauthorization of the CWA.

2.2.13.1 National Pollutant Discharge Elimination System

One of the strategies developed to achieve the goals of the CWA was the establishment by the EPA of limits on specific pollutants that are allowed to be discharged to waters of the United States by municipal sewage treatment plants and industrial facilities. In 1972, the EPA established the National Pollutant Discharge Elimination System (NPDES) permitting program to regulate compliance with these pollutant limitations. The program was designed to protect surface waters by limiting effluent discharges into streams, reservoirs, wetlands, and other surface waters.

The Y-12 Plant NPDES permit (TN0002968) became effective on July 1, 1995, and encompasses approximately 100 active point-source discharges or storm water monitoring locations requiring compliance monitoring. The monitoring resulted in approximately 9800 laboratory analyses in 1997, in addition to numerous field observations. Monitoring of discharges demonstrates that the Y-12 Plant has achieved an NPDES permit compliance rate of 99.7%; biological monitoring programs conducted on nearby surface streams provide evidence of the continued ecological recovery of the streams. At the Y-12 Plant, there were seven NPDES noncompliances in 1997, compared with ten in 1996 (Fig. 2.1).

In May 1995, the Y-12 Plant appealed two provisions of the permit: the biomonitoring limitations placed on East Fork Poplar Creek (EFPC) Outfall Point 201 and the mercury limitations at Monitoring Station 17. These limits are stayed while resolution of both issues is being sought by personnel from the Y-12 Plant and TDEC. The current permit requires storm water characterizations at selected monitoring locations in accordance with the Y-12 Plant Storm Water Pollution Prevention Plan. Other documents submitted to TDEC in accordance with the NPDES permit include the revised Radiological Monitoring Plan

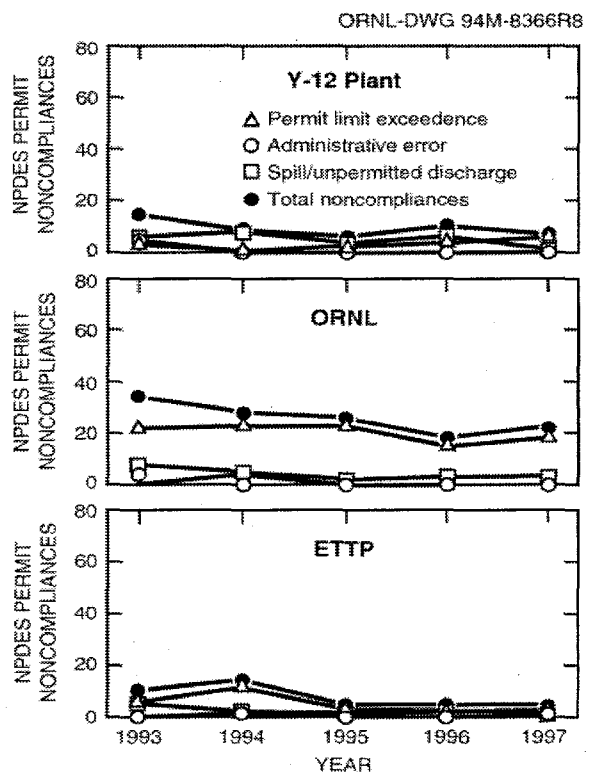

Fig. 2.1. Five-year summary of NPDES noncompliances.

and the Biological Monitoring and Abatement Program (BMAP) Plan. A report on the analysis of fecal coliform bacteria levels at selected storm water monitoring points has been previously submitted.

ORNL is currently operating under NPDES Permit 0002941, which was renewed by TDEC on December 6, 1996, and went into effect February 3, 1997. The ORNL NPDES permit lists 164 point-source discharges that require compliance monitoring. Approximately 100 of these are storm drains, roof drains, and parking lot drains. Compliance was determined by approximately 18,000 laboratory analyses and measurements in 1997, in addition to numerous field observations by ORNL field technicians. The NPDES permit limit compliance rate for all discharge points for 1997 was greater than 99% (Fig. 2.1).

Compared with the previous permit, the new ORNL permit includes more stringent limits, based on compliance with water quality criteria, at a number of outfalls. The new permit also requires ORNL to conduct detailed characterization of numerous storm water outfalls, conduct an assessment and evaluation to modify the Radiological Monitoring Plan, develop and implement a Storm Water Pollution Prevention Plan, implement a revised BMAP plan, and develop and implement a Chlorine Control Strategy. DOE appealed certain contested limits and conditions of the renewed permit, including numeric limits on effluent mercury, arsenic, and selenium.

The ETTP NPDES permit includes 3 major outfalls, 2 minor outfalls, and 136 storm drain outfalls. From about 35,000 NPDES laboratory and field measurements completed in 1997, only 4 noncompliances occurred, indicating a compliance rate of more than 99% (Fig. 2.1). Only one of the noncompliances occurring during 1997 was the result of an exceedence of the wastewater discharge limits.

The ETTP is operating under NPDES Permit TN0002950, issued with an effective date of October 1, 1992. A major permit modification became effective June 1, 1995, and the permit expired on September 29, 1997. To facilitate the transfer of ownership/operation of ETTP facilities to other parties, it was determined that separate NPDES permits would be required for each of the ETTP treatment facilities. In addition, it was determined that a separate NPDES for the storm water drainage system would be necessary. The EPA forms that must be completed as part of the application for the ETTP NPDES permit for the storm drainage system required a large quantity of analytical data that had not been collected during previous storm drain sampling efforts. Therefore, Phase I of the 1996–1997 Storm Water Pollution Prevention (SWPP) sampling effort was conducted to collect analytical data that would allow for completion of the NPDES permit renewal application for the ETTP storm water drainage system. Phase I sampling included collection of samples from specific storm water outfalls during wet weather conditions and collection of samples from storm water outfalls that flow on a continuous basis during dry weather conditions.

Phase II sampling was conducted to further define the presence of contaminants in the the storm drain system that have been detected during SWPP sampling efforts conducted in previous years. Analytical results from these past sampling efforts were compared to screening criteria developed from several sources. Parameters for which the analytical results exceeded these screening criteria were monitored as part of the 1996–1997 SWPP sampling effort to determine if any change in the levels of these contaminants had occurred over time.

2.2.13.2 Sanitary Wastewater

The CWA includes pretreatment regulations for publicly owned treatment works (POTW). Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW under an industrial and commercial wastewater discharge permit. City personnel performed semiannual inspections on February 5 and August 26, 1997. No deficiencies of the Y-12 Plant Sanitary Sewer Compliance Program were noted during the inspections.

Lockheed Martin Energy Systems received a pump-and-haul permit, State Permit No. 97-010, for operation of a pump-and-haul system for disposal of sanitary wastewater to an off-site

municipal sewage facility on September 30, 1997. The permit became effective on October 1, 1997, and will expire September 30, 2002. The permit was issued for removal of sanitary waste from a temporary office trailer that is being used during a 3-year sludge disposal project associated with the Y-12 Plant West End Treatment Facility.

A revised discharge permit (Permit Number 1-91) was issued August 25, 1997, by the city of Oak Ridge. A number of allowable discharge concentrations were modified in the new permit. The permit sets a discharge limit for radionuclides, and this limitation has been appealed by DOE. The city of Oak Ridge has noted that the appeal must be resolved before the city will approve a request from the Y-12 Plant to discharge any new nondomestic wastewaters.

Sanitary sewer radiological sample results at the Y-12 Plant are routinely reviewed to determine compliance with DOE Order 5400.5, "Radiation Protection of the Public and Environment." Sample results are compared to the derived concentration guides (DCGs) listed in the order. No radiological parameter that is monitored (including uranium) has exceeded a DCG. Typically, sample results indicate that the Y-12 Plant radiological discharges are three orders of magnitude below their respective DCG.

During 1997, the Y-12 Plant experienced three exceedences of the Industrial User discharge permit issued by the city of Oak Ridge. The exceedences were for iron, copper, and cyanide. The limit for iron was 0.15 mg/L, and the discharge concentration on January 16 was 1.91 mg/L (the new discharge limit for iron is 15.0 mg/L). The limit for copper was 0.04 mg/L, and the discharge concentration on February 11 was 0.217 mg/L (the new discharge limit for copper is 0.092 mg/L). The limit for cyanide was 0.014 mg/L, and the discharge concentration on June 24 was 0.015 mg/L (the new discharge limit for cyanide is 0.062 mg/L). Although no specific cause could be determined, there are a number of construction activities involving the sanitary sewer that may have contributed to these exceedences. The construction activities are part of an ongoing multimillion dollar sanitary sewer upgrade project that is expected to continue through FY 1999.

At ORNL, sanitary wastewater is collected, treated, and discharged separately from other liquid wastewater streams through an on-site sewage treatment plant. Wastewater discharged into this system is regulated by means of internally administered waste acceptance criteria based on the plant's NPDES operating permit parameters. Wastewater streams currently processed through the plant include sanitary sewage from facilities in Bethel and Melton valleys, area runoff of rainwater that infiltrates the system, and specifically approved small volumes of nonhazardous biodegradable wastes such as scintillation fluids. The effluent stream from the sewage treatment plant is ultimately discharged into White Oak Creek (WOC) through an NPDES-permitted outfall (X-01). Infiltration into the system and the discharge from the on-site laundry have, at times, caused the sludge generated during the treatment process to become slightly radioactive. As a result, the sludge is treated as solid LLW and is stored in an ORNL SWSA. ORNL has completed a line-item project for comprehensive upgrades of its sanitary sewage system. Upgrades include sealing the collection system to reduce infiltration of contaminated groundwater and surface water and redirecting discharges from the laundry to appropriate alternative treatment facilities. The activity level of ORNL Sewage Treatment Plant sludge continues to decline.

ETTP domestic wastewater is treated at the on-site K-1203 Sewage Treatment Plant and discharged pursuant to the NPDES permit. A sewer use ordinance and a wastewater control and surveillance program are in effect to ensure adequate treatment of wastewater at the K-1203 Sewage Treatment Plant and also to ensure that effluent from the facility continues to meet all NPDES permit limits. During calendar year 1995, numerous NPDES noncompliances were experienced at the K-1203 Sewage Treatment Plant as a result of upset conditions resulting from inflow and infiltration into the sewage collection system during periods of heavy rainfall. A sewer rehabilitation project to reline and refurbish the sewage collection system to reduce inflow and infiltration

was completed in July 1997. Since completion of the project, inflow and infiltration have been significantly reduced and no upset conditions resulting in NPDES noncompliances have occurred at the facility. Past operations at the site have resulted in the sludge generated at the K-1203 Sewage Treatment Plant being slightly radioactive. As a result, the sludge is treated as LLW and stored on site upon removal from the drying beds.

2.2.13.3 Aquatic Resources Protection

The COE, TVA, and TDEC conduct permitting programs for projects and activities with the potential to affect aquatic resources, including navigable waters, surface waters (including tributaries), and wetlands. These are the COE Section 404 dredge-and-fill permits, TDEC Aquatic Resources Alteration Permits (ARAPs), and TVA 26A approvals. (See Sect. 2.5, Environmental Permits, for ARAP permits.)

An ARAP was issued to the Y-12 Plant in 1997 for removal of debris in EFPC.

On August 22, 1997, a COE permit was issued to the ETTP for the K-1250-4 Bridge Replacement Project.

In 1997 ORNL received ARAP, COE, and TVA permits for a variety of projects including culvert and roadbed upgrades on Jones Island Road and debris removal from weirs on White Oak Creek and Northwest Tributary.

2.2.13.4 Oil Pollution Prevention

Section 311 of the CWA regulates the discharges of oils or petroleum products to waters of the United States and requires the development and implementation of a Spill Prevention Control and Countermeasures (SPCC) Plan to minimize the potential for oil discharges. Currently, each facility implements a site-specific SPCC plan. This section of the CWA was significantly amended by the Oil Pollution Act of 1990, which has as its primary objective the improvement of responses to oil spills.

The Oil Pollution Act requires certain facilities to prepare and implement a facility response plan for responding to a worst-case discharge of oil. The ETTP is subject to the requirements for preparing such a plan because of its oil storage capacity and location. An updated plan was issued in February 1997. The plan includes designation of response personnel, description of response equipment, identification of the worst-case discharge scenario and associated response actions, personnel training requirements, testing and inspection requirements, and other oil spill-prevention and response measures. No facility response plan was required for the Y-12 Plant or ORNL beyond those outlined in the site SPCC.

2.2.14 Clean Air Act

Authority for enforcement of the Clean Air Act (CAA) is shared between TDEC for nonradioactive emission sources and EPA for radioactive emission sources. EPA also enforces rules issued pursuant to the 1990 CAA Amendment, Title VI—Stratospheric Ozone Protection.

2.2.14.1 General CAA Compliance

The TDEC Air Permit Program ensures compliance with the federal CAA and TDEC rules for air emission sources. All three ORR facilities are subject to TDEC air permitting program rules. Each site is in compliance with all federal air regulations and TDEC air-permit conditions.

CAA compliance program staff participate in regulatory inspections and internal compliance assessment audits to improve compliance with applicable regulations or permit conditions. All sources of air emissions are permitted, and documentation of compliance is maintained at each site. A number of sources that are exempt from permitting requirements under state of Tennessee rules are identified for internal purposes as well. All emission sources permitted by TDEC are operating in compliance with their respective permits. Programs for permitting, compliance inspection, and documentation of compliance are in place and have been effective and ensure that all ORR operations remain in compliance with all federal and state air pollution control regulations.

2.2.14.2 Compliance with 1990 CAA Amendments

To comply with Title III, Hazardous Air Pollutants (HAPs), the major emphasis at the three sites has been on continued applicability determinations of final rules promulgated by EPA during 1997.

With respect to Title V, New Operating Permit Program, TDEC continues to administer the Title V Major Source Operating Permit Program based on EPA's 1996 interim final approval. In 1997, Title V operating permit applications were submitted for ORNL and Y-12 Plant facilities. The ETTP submitted a Title V application in 1996 as part of Tennessee's early Title V submittal program. All three applications have been declared complete by TDEC. A comprehensive Title V permit, or combination of permits, for each ORR facility will replace the individual source permits that are currently active at each facility. During 1997, the three ORR facilities began preparations for expected state program changes. Several changes will be required prior to the state receiving EPA final approval. The most notable changes will be in regulations addressing insignificant (exempt) activities. As a result of changes in the 40 CFR 70 regulations, EPA has extended the date for final approval for state Title V programs. TDEC is expected to get full approval for Title V in 2000.

The Title VI, Stratospheric Ozone Protection Activities, regulations include maintenance of established programs for stratospheric ozone protection. These programs have been implemented for motor vehicle air-conditioner and other refrigeration equipment and include elements for demonstrating compliance with equipment leak repair, container labeling, regulated substances purchasing, and technician and equipment certifications.

2.2.14.3 National Emission Standards for Hazardous Air Pollutants for Radionuclides

The ORR facilities were in compliance with the Radionuclide National Emission Standards for Hazardous Air Pollutants (Rad-NESHAP) dose limit of 10 mrem/year to the maximum exposed individual of the public during 1997. Based on modeling of emissions from major and minor point sources, the off-site effective dose equivalent (EDE) was 0.41 mrem/year in 1997.

Continuous emissions monitoring is conducted at the ETTP TSCA Incinerator, seven stacks at ORNL, and exhaust stacks serving uranium-processing areas at the Y-12 Plant. Grab samples and other EPA-approved estimation techniques are used on remaining minor emission points, grouped area sources, and fugitive emissions. All three ORR facilities met the emission and test procedures of 40 CFR 61, Subpart H in 1997.

2.2.14.4 NESHAP for Asbestos

The ORR facilities have numerous buildings and equipment that contain asbestos materials. The compliance program for asbestos management includes demolition and renovation notifications, inspections, monitoring, abatement, and disposal of asbestos materials. One asbestos release of reportable quantities (RQs) under CERCLA was identified at the ETTP in 1997. Release quantities were small with no observable off-site migration. No releases of RQs were reported at the Y-12 Plant or ORNL.

2.2.14.5 State-Issued Air Permits

The Y-12 Plant has 40 active air permits covering 162 air emission points. There are 169 documented exempt minor sources and 395 exempt minor emission points. During 1997, Y-12 Plant personnel requested cancellation of 18 permits for air sources no longer in service or exempt under Tennessee Air Pollution Rule 1200-3-9.

At the end of CY 1997, ORNL had 21 active operating permits covering 250 sources. During 1997, the state rescinded four of ORNL's operating permits as insignificant emissions units and one new operating permit was issued consolidating three permitted sources.

There were 253 active air emission sources at the ETTP at the end of 1997. The total includes 45 sources covered by 12 TDEC air operating permits. All remaining active air emission sources are exempt from permitting requirements, except one source that initiated operations under a permit to construct.

2.2.15 Toxic Substances Control Act

TSCA was passed in 1976 to address the manufacture, processing, distribution in commerce, use, and disposal of chemical substances and mixtures that present an unreasonable risk of injury to human health or the environment. TSCA mandated that EPA identify and control chemical substances manufactured, processed, distributed in commerce, and used within the United States. The EPA imposes strict information-gathering requirements on both new and existing chemical substances, including polychlorinated biphenyls (PCBs).

2.2.15.1 Polychlorinated Biphenyls

TSCA specifically bans the manufacture, processing, and distribution in commerce of PCBs but authorizes the continued use of some existing PCBs and PCB equipment. TSCA also imposes marking, storage, and disposal requirements for PCBs. The codified regulation governing PCBs mandated by TSCA is found at 40 CFR 761 and is administered by EPA. Most of the requirements of 40 CFR 761 are matrix and concentration dependent. For example, the ban on manufacturing, processing, use, and distribution in commerce applies to PCBs at any concentration. Storage and disposal requirements generally apply to PCBs at 50 parts per million (ppm) or greater; however, these requirements may apply at lower concentrations in some instances. TDEC restricts PCBs from disposal in landfills and classifies PCBs as special wastes under Tennessee solid waste regulations. A special waste exemption is required from the state of Tennessee to dispose of PCBs at concentrations of 2 ppm up to 49 ppm in landfills. Additionally, PCB discharges into waterways are restricted by the state-regulated CWA and NPDES programs.

2.2.15.2 Authorized and Unauthorized Uses of PCBs

EPA promulgated regulations in 1979 implementing the TSCA ban on the manufacture, use, processing, and distribution in commerce of PCBs; however, specific applications of PCBs were authorized for continued use under restricted conditions. A variety of PCB systems and equipment have been in service at the ORR during its 50-year history. Many of these systems and equipment were used in accordance with industry standards at the time, and their continued use was authorized under the 1979 PCB regulations. Systems that were authorized included transformers, capacitors, and other electrical distribution equipment; heat-transfer systems; and hydraulic systems. The vast majority of these PCB uses have been phased out at the ORR. Small amounts of PCBs remain in service in PCB light ballasts; however, ballasts containing PCBs are being replaced by non-PCB ballasts during normal maintenance. Most transformers that contained PCBs either have been retrofilled (replacement of PCB fluid with non-PCB dielectric fluid) to reduce the PCB concentration to below regulated limits or have been removed from service altogether. Some small pole-mounted transformers remaining in service at the ETTP and Y-12 Plant electrical systems are scheduled to be tested for PCBs during normal maintenance. It is unlikely that any of these small transformers contain PCBs at concentrations regulated for disposal; however, they are assumed to contain PCBs until verified otherwise. In 1997, thirty-five pole mounted transformers were removed from the Y-12 Plant PCB Annual Inventory after analytical verification.

The 1979 regulations did not anticipate the use of PCBs in many applications for which they were used. As a result, those past uses not specifically authorized present compliance issues under TSCA. At the ORR, unauthorized uses of PCBs have been found in building materials, lubricants, and nonelectrical systems. More such unautho-

rized uses are likely to be found during the course of D&D activities. The most widespread of these unauthorized uses of PCBs are PCB-impregnated gaskets in the gaseous diffusion process motor ventilation systems at the ETTP. A discovery occurred in 1997 at the Y-12 Plant when expansion joint material containing regulated PCB levels was discovered in the basement of a building on the Y-12 Plant site. EPA was notified of this discovery and the intent to leave the material in place for the duration of its useful life.

2.2.15.3 PCB Compliance Agreements

The Oak Ridge Reservation PCB Federal Facilities Compliance Agreement (ORR-PCB-FFCA) between EPA Region 4 and DOE became effective on December 16, 1996. The agreement addresses PCB compliance issues at the ETTP, ORNL, the Y-12 Plant, and ORISE. For the ETTP, the agreement supersedes a previous agreement known as the Uranium Enrichment Toxic Substances Control Act Federal Facilities Compliance Agreement (UE-TSCA-FFCA). The UE-TSCA-FFCA continues in force for the Portsmouth and Paducah gaseous diffusion plants. Additionally, the ORR-PCB-FFCA supersedes the National PCB FFCA of August 8, 1996, between DOE-HQ and EPA-HQ for ORNL, the Y-12 Plant, and those wastes at the ETTP that were not covered under the UE-TSCA-FFCA.

The agreement specifically addresses the unauthorized use of PCBs, storage and disposal of PCB wastes, spill cleanup and/or decontamination, PCBs mixed with radioactive materials, PCB R&D, and records and reporting requirements for the ORR. During 1997, two variances were granted by the EPA: one to allow an alternate inspection method for remote-handled and Class III/ IV radioactive PCB waste, dated August 19, 1997, and one concerning "legacy" laboratory waste, dated August 14, 1997.

2.2.15.4 ETTP TSCA Incinerator PCB Disposal Approval

The ETTP TSCA Incinerator is currently operating under an extension of EPA Region 4 approval granted on March 20, 1989. This extension is based on submittal of a reapplication for PCB disposal approval filed with EPA Region 4 on December 20, 1991, which was within the time frame allowed for reapplication. Minor amendments, updates, and corrections to this reapplication identified by DOE have been made in the interim and have been submitted to EPA. Since the submittal of the December 20, 1991, reapplication, a joint RCRA/PCB permit reapplication has been under development. This joint reapplication was submitted in March 1997 to TDEC under RCRA for treatment of hazardous wastes and to EPA Region 4 for disposal of PCB wastes. The new reapplication will replace the December 20, 1991, PCB disposal reapplication. In anticipation of this joint application, EPA Region 4 has delayed action on renewal of the PCB incineration approval.

2.2.15.5 PCB Research and Development Approvals

EPA Region 4 had previously granted ORNL authorization to conduct R&D for development of alternative disposal techniques for PCBs. The approvals authorized PCB R&D using stabilization/solidification techniques, base-catalyzed destruction processes, a chemically enhanced oxidation/reduction process, and a microbial degradation procedure. During 1997, ORNL researchers continued investigations of alternative disposal methods for PCBs under the approval of EPA Region 4.

2.2.16 Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) governs the sale and use of pesticides and requires that all pesticide products be registered by EPA before they may be sold. The regulations for the application, storage, and disposal of pesticides are presented in 40 CFR 150–189.

The Y-12 Plant, the ETTP, and ORNL maintain procedures for the storage, application, and disposition of pesticides. Individuals responsible for application of FIFRA materials are certified by the Tennessee Department of Agriculture. If a pesticide can be used according to directions without unreasonable adverse effects on the environment or applicator (i.e., if no special training is required), it is classified for general use. A pesticide that can harm the environment or injure the applicator even when being used according to directions is classified for restricted use.

No restricted-use pesticide products are used at the Y-12 Plant, the ETTP, or ORNL. Safrotin®, used for control of cockroaches, is the only restricted-use pesticide stored at the Y-12 Plant. No purchases of this restricted-use material have been made since August 1993, and it was last used in 1995. Ficam-W, a general-use pesticide, has been substituted for Safrotin, and efforts for proper disposal of the remaining Safrotin are under way. An inventory of pesticide products is maintained for use at each facility. It is site policy to store, apply, and dispose of these products in a manner that ensures full compliance with FIFRA requirements.

2.2.17 Emergency Planning and Community Right-To-Know Act

The Emergency Planning and Community Right-To-Know Act (EPCRA), also referred to as Superfund Amendments and Reauthorization Act (SARA) Title III, requires reporting of emergency planning information, hazardous chemical inventories, and environmental releases to federal, state, and local authorities. The ongoing requirements of EPCRA are contained in Sections 302, 303, 304, 311, 312, and 313 of SARA Title III and are given in the notes to Table 2.9.

The ORR had no releases subject to Section 304 notification requirements during 1997. The Section 311 lists are updated frequently and are provided to the appropriate officials. The Section 312 inventories for 1997 identified hazardous chemicals, documented their locations, and summarized the hazards associated with them. Of these Section 312 chemicals, 55 were located at the Y-12 Plant, 26 at ORNL, and 19 at the ETTP.

The annual Toxic Release Inventory (TRI) report is a requirement of Section 313. The report is due to the EPA and TDEC by July 1 of each year for the previous calendar year and addresses releases of toxic chemicals into the environment, waste management activities, and pollution prevention activities associated with those chemicals. Chemicals that exceed the reporting threshold, based on quantities used, processed, or manufactured, are identified and included in the report. The TRI report covering CY 1997 has been submitted for the ORR and reports eight of the

Table 2.9. EPCRA (SARA Title III) compliance information for the ORR

Y-12 Plant	ORNL	ETTP
302–303, Planning notification[a]		
In compliance	In compliance	In compliance
304, Extremely hazardous substance release notification[b]		
In compliance	In compliance	In compliance
311–312, Material safety data sheet/ chemical inventory[c]		
In compliance	In compliance	In compliance
313, Toxic chemical release reporting[d]		
In compliance	In compliance	In compliance

[a]Requires that Local Emergency Planning Committee and State Emergency Response Commission be notified of EPCRA-related planning.

[b]Addresses reporting to state and local authorities of off-site releases.

[c]Requires that either material safety data sheets (MSDSs) or lists of hazardous chemicals for which MSDSs are required be provided to state and local authorities for emergency planning.

[d]Requires that releases of toxic chemicals be reported annually to EPA and the state.

nine toxic chemicals given in Table 2.10. Only those chemicals that exceed the reporting threshold must be reported, and tetrachloroethene, which had been reported in previous reports, had fallen below the reporting threshold for the current report. This material had been used in CY 1996 for the TSCA Incinerator trial burns but was not used in CY 1997.

Because of new EPA guidance regarding Section 313 reporting, two new toxic chemicals (copper compounds and manganese compounds) were added to the CY 1997 report, and the quantities of other chemicals reported increased substantially as a result of the new bases for reporting. The report for 1997 included higher quantities for chemicals, such as aerosol forms of HCl, which were manufactured incidentally as by-products of coal combustion in the steam plants, as well as lead, which was transferred off-site for treatment or disposal.

The Y-12 Plant triggered the reporting threshold for ozone as a result of its manufacture as a by-product of microbial control at cooling towers. The ETTP also created ozone as a by-product in the ultraviolet system at the Sewage Treatment Plant. In both cases, the ozone by-product is immediately dissolved in water and results in a release measuring zero.

Table 2.10. EPCRA Section 313 toxic chemical release and off-site transfer summary for the ORR

Chemical	Year	Quantity (lb)			
		Y-12 Plant[a]	ORNL	ETTP	Total
Methanol	1996	27,630	107	0	27,737
	1997	32,405	436	0	32,841
Hydrochloric acid	1996	870[b]	0	160	1,030
	1997	98,100	46,508	37	144,645
Lead	1996	9	3,355	69	3,433
	1997	1,392	6,598	15,554	23,544
Nitric acid	1996	161	1	0	162
	1997	545	129	0	674
Tetrachloroethene	1996	1	32	1	34
	1997	*c*	*c*	*c*	*c*
Ozone	1996	*d*	*d*	*d*	*d*
	1997	0	0	0	0
Copper compounds	1996	*d*	*d*	*d*	*d*
	1997	34,040	297	949	35,286
Manganese compounds	1996	*d*	*d*	*d*	*d*
	1997	40,190	1,080	3,372	44,642
Chlorine	1996	0	0	0	0
	1997	0	0	0	0
Total	1996	28,671	3,495	230	32,396
	1997	206,672	55,048	19,912	281,632

[a]Represents total releases to air, land, and water, and includes off-site transfer.

[b]On July 25, 1996, EPA changed the EPCRA 313 implementing regulations to require reporting only for aerosol forms of hydrochloric acid.

[c]Tetrachloroethene fell below reporting threshold for the CY 1997 EPCRA report.

[d]Not reported.

The reporting of copper compounds and manganese compounds was triggered by the Y-12 Plant and ORNL coal-burning steam plants. The ETTP report includes copper compounds and manganese compounds in wastes treated at the Central Neutralization Facility (CNF), the TSCA Incinerator, and transportable vitrification system (TVS) and waste shipments to Envirocare.

The large increase in lead reporting was in part a result of activities at the ORNL lead shop, where 23,600 pounds of lead was melted and poured to form bricks and other shapes during 1997. Also, the ETTP report reflects 15,250 pounds of lead shipped off-site to Envirocare for treatment and disposal. This lead came from Puerto Rico and had been stored on-site since the late 1980s.

2.2.18 Environmental Occurrences

CERCLA requires that the National Response Center be notified if a nonpermitted release of an RQ or more of a hazardous substance (including radionuclides) is released to the environment within a 24-hour period. The CWA requires that the National Response Center be notified if an oil spill causes a sheen on navigable waters, such as rivers, lakes, or streams. When notified, the National Response Center alerts federal, state, and local regulatory emergency organizations so they can determine whether government response is appropriate.

During 1997, Y-12 Plant staff reported no CERCLA RQ releases to federal and state agencies.

The National Response Center and Tennessee Emergency Management Agency (TEMA) were notified of four incidents that involved oil sheens observed on EFPC, and TEMA was notified of a fish kill that affected approximately 24,000 fish (detailed in Sect. 2.6).

During 1997, ORNL reported no CERCLA RQ releases to federal and state agencies.

In 1997, one release occurred at the ETTP that required notification of the National Response Center or TEMA. This involved the discovery of asbestos-containing material from plant steam lines on the ground.

2.3 DOE ORDERS AND STANDARDS DEVELOPMENT

Until recently, DOE directed the environmental, safety, and health (ES&H) aspects of all work through rules and directives such as orders, notices, and manuals. However, this approach suffers from several disadvantages. Most notably, it has been difficult to develop orders that recognize and deal with the wide diversity of the work. This can lead to inappropriate application of high-hazard requirements to low-hazard activities. Also, because the order-based approach does not easily incorporate the benefits of experience, safety practices can rapidly become obsolete or ineffective. In many cases, order requirements duplicate what is already required by law or regulation. In the past, DOE orders were not always clear about DOE's expectations for contractors. To compensate for this uncertainty, contractors took conservative steps to ensure that their operations would meet DOE orders.

Recognizing the disadvantages of that approach, DOE has developed and implemented a policy for an integrated standards program. This policy addresses evolving obligations with regard to federal, state, and local laws and regulations; use of technical standards; and development of new standards for programs, processes, and products unique to the department's operations, consistent with statutes and procedures for involvement of the public and other stakeholders. The current process has evolved over the past few years.

2.3.1 Standards/Requirements Identification Documents

In 1995, DOE implemented the Standards/Requirements Identification Documents (S/RIDs) concept in response to a recommendation from the Defense Nuclear Facilities Safety Board (DNFSB). The recommendation was that DOE

should develop mechanisms for identifying which standards are applicable to the specific work being performed, determining whether those standards are fully implemented, and determining whether the standards are appropriate and adequate to ensure protection to workers, the public, and the environment. The S/RIDs covering all environment-, safety-, and health-related activities were included in the DOE contracts for LMES and LMER in October 1995 and January 1996, respectively. This change established the S/RIDs as the contractual set of ES&H requirements rather than DOE orders at that time.

2.3.2 Work Smart Standards

In 1996, LMER and LMES implemented the "Necessary and Sufficient" process to identify standards for ES&H activities as part of a pilot project sanctioned by the DOE Department Standards Committee. This process was subsequently renamed by DOE as "work smart standards." WSS are sets of environment, safety, and health laws, regulations, and other standards that have been chosen for applicability and appropriateness for a particular scope of work. Although S/RIDs are generally limited to activities conducted under the offices of Defense Programs (DP) and Environmental Restoration and Waste Management (EM), WSS are intended to apply to all departmental activities. The WSS process allows adoption of consensus standards, developed and used by others in industry, and all applicable requirements from laws and regulations are automatically included. The WSS sets of standards are designed to provide adequate protection (when properly implemented) against the hazards associated with a particular scope of work.

2.3.2.1 Status of WSS Development and Implementation

For the ORR EMEF activities, headquartered at the ETTP site, WSS have been established and are the contractual set of ES&H requirements (with the exception of Occurrence Reporting and Emergency Management S/RIDs, which are still applicable to EMEF) rather than DOE orders.

Implementation of WSSs for Defense and Manufacturing Programs (Y-12 Plant) has been completed for the Y-12 General Manufacturing Organization (GMO), which provides manufacturing and support services to the Y-12 Plant and its customers, including the Y-12 nuclear facilities and the U.S. Navy, in the areas of machining, forming, rolling, heat treating, welding, and laser cutting on a wide variety of metals and nonmetals. These operations are equivalent to those found in private industry general machine shops. The expansion of this WSS set, to encompass the remaining Y-12 site activities having standard industrial hazards and activities with radiological and nuclear hazards, is progressing.

At LMER, WSSs have been approved for all R&D activities and on a facility-specific basis for the Radiochemical Research Facilities, the five Accelerator Facilities, the Radiochemical Technology Facilities, the Radiochemical Engineering Development Center, the Radiochemical Development Facility, the Irradiated Materials Examination and Testing Facility, the Irradiated Fuels Examination Laboratory, the Hazardous Waste Operations Facilities, the Waste Management and Remedial Action Division (WMRAD) Radiological and Industrial Facilities, and the WMRAD Nuclear Category 2 and 3 facilities. Exceptions to the WSSs include the emergency management requirements and occurrence reporting requirements

A stand-alone set of WSS for construction and construction-like activities on the ORR have also been approved.

2.3.3 Department of Energy Acquisition Regulations

On June 27, 1997, DOE published a final rule (62 FR 34842 - 34872) amending the Department of Energy Acquisition Regulations (DEAR) to require each DOE contract to contain a requirement for the contractor to develop, document, and implement an Integrated Safety Management System (ISMS). An ISMS integrates environment, safety, and health into work planning and execution and includes pollution prevention and waste minimization. The regulation provides detailed

guiding principles for contractors and any of their subcontractors to follow in the performance of work (DEAR clause 970.5204-2).

In June 1997, in response to DEAR clause 970.5204-2, the Y-12 Plant implemented a sitewide ISMS through upgrades and improved integration of existing health, safety, and environmental programs and resources. A guidance document was issued (*Y-12 Integrated Safety Management System*, Y/AD-635, May 30, 1997) that describes implementation in the Y-12 Plant's highest-risk facilities and a tailored approach in the balance-of-plant (BoP) facilities based on the hazards and risks associated with work in those facilities.

In October 1997, in a rapidly changing ETTP administrative environment resulting from the transition from a management and operating (M&O) to an M&I contractor, an ISMS program description was issued (*Description of the Integrated Safety Management System for Environmental Management and Enrichment Facilities*, October 1997). The EMEF ISMS, which was designed to serve business unit elements operating in either the M&O or M&I mode, is based on the seven guiding principles and five safety management functions contained in DOE policy DOE P 450.4, Safety Management System Policy.

Late in 1997, ORNL drafted a program description for implementing an ISMS at the Laboratory. Prior to preparation of the draft, however, benchmarking was conducted to observe ISMS programs at other DOE sites, including Fermi National Accelerator Laboratory, Argonne National Laboratory, and the Lawrence Berkeley National Laboratory. In addition, an ORNL ISMS steering committee was established and an ORNL-level policy statement (*Integrated Safety Management Policy Statement*, Effective Date January 1, 1998), which was endorsed by all upper-level managers at the Laboratory, was issued.

2.3.4 DOE Order 5400.1, General Environmental Protection Program, and DOE Order 231.1, Environment, Safety and Health Reporting

Through DOE's Accelerated Orders Reduction effort, certain requirements in DOE Order 5400.1, General Environmental Protection Program, have been modified. Some have been transferred to DOE Order 231.1, Environment, Safety and Health Reporting, and others have been canceled. For example, the requirement to produce the Annual Site Environmental Report documenting the site's environmental management performance has been transferred to DOE Order 231.1. However, canceled orders or paragraphs of orders incorporated by reference into a contract shall remain in effect until the contract is modified. DOE Order 5400.1 remains the contractual requirement for LMES; thus, this Annual Site Environmental Report is prepared as a requirement of DOE Order 5400.1.

DOE Order 5400.1 establishes environmental protection program requirements, authorities, and responsibilities for DOE operations to ensure compliance with applicable federal, state, and local environmental protection laws and regulations, executive orders, and internal DOE policies. The order specifically defines the mandatory environmental protection standards (including those imposed by federal and state statutes), establishes reporting of environmental occurrences and periodic routine significant environmental protection information, and provides requirements and guidance for environmental monitoring programs. Implementation of the order is provided by specific program plans, as detailed in Chapter III of the order. The internal environmental protection programs mandate the creation of several environmental reports.

An environmental monitoring plan (EMP) is to be prepared, reviewed annually, and updated every 3 years or as needed. Revision 2 of *The Environmental Monitoring Plan for the ORR* (DOE 1997a) was reissued by DOE in December 1997. The EMP provides a single point of reference for the effluent monitoring and environmental surveillance programs of the Y-12 Plant, ORNL, the ETTP, and ORR areas outside specific facility boundaries.

2.3.5 DOE Order 5400.5, Radiation Protection of the Public and the Environment

DOE Order 5400.5 provides guidance and establishes radiation protection standards and central practices designed to protect the public and the environment against undue risk from DOE operations. This order requires that no member of the public receive an EDE in a year greater than 100 mrem via all pathways and that no member of the public receive a radiation dose equivalent greater than 10 mrem in a year from airborne emissions. In addition, dose limits imposed by other federal regulations (40 CFR Parts 61, 191, and 192 and 10 CFR Parts 60 and 72) must be met. The primary dose limit is expressed as an EDE, which requires the weighted summation of doses to specified organs of the body. Monitoring effluents released to the environment is required to ensure that radiation doses to the public are as low as reasonably achievable (ALARA) and are consistent with prescribed dose standards.

2.4 APPRAISALS AND SURVEILLANCES OF ENVIRONMENTAL PROGRAMS

Numerous appraisals, surveillances, and audits of the ORR environmental activities occurred during 1997 (see Tables 2.11, 2.12, and 2.13). These tables do not include internal LMER, LMES, or Lockheed Martin corporate assessments for 1998.

2.4.1 Defense Nuclear Facilities Safety Board

Under its enabling statute (Public Law 100-456), the board is responsible for independent, external oversight of all activities in DOE's nuclear weapons complex affecting nuclear health and safety. The board reviews operations, practices, and occurrences at DOE's defense nuclear facilities and makes recommendations to the secretary of Energy to protect public health and safety.

In September 1994, during a DNFSB tour of a storage building in 9204-2E, a discrepancy with specific stipulations of the criticality safety approval for storage of fissile material in that area was identified. As a result, a number of operations at the Y-12 Plant were curtailed. However, environmental operations (compliance monitoring, reporting, and oversight) have continued uninterrupted, and there have been no environmental impacts as a result of the stand-down. Operations in Y-12 facilities have been resumed in phases, and restart of the Enriched Uranium Operations is planned for 1998.

2.5 ENVIRONMENTAL PERMITS

Table 2.14 contains a summary of environmental permits for the three ORR sites. Continuing permits, required at each of the ORR facilities, are RCRA operating permits, NPDES permits, and operating air permits.

2.6 NOTICES OF VIOLATIONS AND PENALTIES

Tennessee State Landfill Permit IDL-01-103-0083 prohibits disposal of radioactive waste in the Industrial Landfill V at the Y-12 Plant. Thirty-five pCi/g of uranium has been established by TDEC and DOE as the threshold

Table 2.11. Summary of environmental audits and assessments conducted at the Y-12 Plant, 1997

Date	Reviewer	Subject	Issues
2/5/97	City of Oak Ridge	Sanitary Sewer	0
2/5/97	TDEC	Landfills IV, V, VI, and VII	0
3/29/96–5/21/97	TDEC/DOE-O[a]	Facility Survey of Building 9720-48	0
4/22/96–5/21/97	TDEC/DOE-O	Facility Survey of Building 9722-3	2
5/6/97	TDEC	Landfills IV, V, and VI	0
5/12–13/97	TDEC	RCRA	0
5/20–21/97	TDEC	NPDES CEI	0
7/16–25/97	TDEC	Annual Air Permit Inspection	0
6/24/97	TDEC	Y-12 Centralized Landfill II Post Closure Inspection	0
8/26/97	City of Oak Ridge	Sanitary Sewer	0
7/15/97	TDEC	Drinking Water Survey	2
9/9/97	TDEC	RCRA Groundwater CEI	0
9/15/97	TDEC	Landfills IV, V, VI, and VII	0
9/16/97	FERC	Dam and Water Impoundments Inspection	0
12/11/97	TDEC	Landfills IV, V, and VI	0

[a]Tennessee Department of Environment and Conservation/DOE Oversight Division.

Table 2.12. Summary of environmental audits and assessments conducted at ORNL, 1997

Date	Reviewer	Subject	Issues
4/23–24	TDEC	Inspection of RCRA generator areas and treatment, storage, and disposal operations	0
5/27	TDEC/DOE-O[a]	Permitted air emission sources	0
5/28	TCEC/DOE-O	Permitted air emission sources	0
6/02	TDEC/DOE-O	Opacity evaluation Paint Shop	0
6/11–12	TDEC/DOE-O	NPDES Compliance Evaluation Inspection	0
6/18	TDEC/DOE-O	Opacity evaluation Steam Plant	0
6/24	TDEC/DOE-O	Opacity evaluation Coal Pile	0
7/16	TDEC/DOE-O	Inspection of Process Waste Treatment Plant Upgrades	0
9/8	TDEC	Inspection of RCRA groundwater wells and operations	0
9/15	TDEC/DOE-O	CYRTF Upgrades final inspection	0
12/3	TDEC/DOE-O	Solid Waste Storage Area 6	0
12/9	TDEC/DOE-O	CWA inspection	1
12/18	TDEC/DOE-O	Waste Area Grouping 5	0
12/29	TDEC/DOE-O	CWA inspection	1

[a]Tennessee Department of Environment and Conservation/DOE Oversight Division.

Table 2.13. Summary of environmental audits and assessments conducted at the ETTP, 1997

Date	Reviewer	Subject	Issues
2/25	TDEC, TDEC/DOE-O[a]	Solid waste inspection	0
3/4	EPA, TDEC, TDEC/DOE-O	Multi-inspection	0
4/23	TDEC	RCRA inspection	0
5/5	TDEC	SDWA inspection	0
5/14	COE, TVA	CWA inspection	0
6/20	TDEC	RCRA inspection	0
9/15	TDEC	RCRA inspection	0
9/17	Federal Energy Regulatory Commission, TDEC/DOE-O	CWA inspection	0
10/14	TDEC	CAA	0
10/16	TDEC	RCRA inspection	0
10/30	EPA	RCRA inspection	0

[a]Tennessee Department of Environment and Conservation/DOE Oversight Division.

above which waste will be considered to be radioactively contaminated. During review of waste characterization data from an ongoing disposal activity, it was discovered that 167 B-25 boxes containing waste exceeded that limit. The average uranium activity per gram for waste in the boxes was 256 pCi/g with a maximum of 850 pCi/g of uranium activity. These boxes were disposed of in Industrial Landfill V between April 1996 and discovery of the noncompliance in December 1996.

In a separate but related incident, a waste shipment from the ETTP to the Y-12 Plant's Landfill V between December 20, 1996, and January 27, 1997, was discovered to have been shipped in error. The waste was in fact mixed RCRA waste (incinerator ash from a test burn at the ETTP TSCA incinerator) and not nonhazardous/nonradioactive solid waste as was expected. The documentation and shipping papers for two waste streams had been switched in error. Two notices of violation (NOVs) were received from TDEC related to these incidents. One was received from the Division of Solid Waste in February 1997 and the other from the Division of Hazardous Waste in March 1997. On April 30, 1997, a show-cause hearing was held to discuss the violations. A draft commissioner's order was subsequently received in November 1997 with a proposed fine. Resolution of these NOVs is expected to continue into 1998.

In addition, a Commissioner's Order and Assessment of Civil Penalty was received from the TDEC on November 14, 1997, for failure to meet Tennessee State Water Quality Criteria, resulting in a significant fish kill (~24,000) that occurred at the Y-12 Plant on July 24, 1997. Raw water discharge to UEFPC had been stopped after a major flooding event (>100-year flood) that occurred on July 22, 1997. A slug of sodium bisulfite, a chemical used to reduce levels of in-stream residual chlorine, had accumulated in the raw water weir basin and was released when the raw water discharge was returned to UEFPC. The sodium bisulfite caused the dissolved oxygen concentrations in UEFPC to drop (<5 ppm), resulting in a fish kill. There is a $7,005 fine associated with this order; however, the order is under appeal.

ORNL received three TDEC NOVs in 1997 for NPDES permit limit excursions; NOVs were received in January, June, and September 1997. ORNL provided responses to TDEC as to corrective actions for excursions cited in the NOVs. No fines or penalties were assessed by TDEC in connection with the ORNL NOVs.

Table 2.14. Summary of permits as of December 1997

	Y-12 Plant	ORNL	ETTP
Resource Conservation and Recovery Act			
RCRA operating (Part A and Part B)	4[a]	4[b]	4
Part B applications in process	1[c]	1	0
Postclosure	3[d]	0	0
Permit-by-rule units	13[e]	170[f]	9[e]
Solid waste landfills	6[g]	0	0
Annual petroleum UST facility certificate	2	1	1
Transporter permit	1	2[h]	1
Clean Water Act			
NPDES	1[i]	1	1
Storm water	1[j]	1[j]	1[j]
Aquatic resource alteration/U.S. Army	3[k]	6	0
Corps of Engineers 404 permits	0	1	1
General storm water construction	2[l]	0	0
Clean Air Act			
Operating air	40	21	12
Construction	0	0	2
Prevention of significant deterioration	0	0	0
Sanitary Sewer			
Sanitary sewer	1	0	0
Pump-and-haul permit	1	0	0
Toxic Substances Control Act			
TSCA Incinerator	0	0	1
R&D for alternative disposal methods	0	4	0
Safe Drinking Water Act			
Water Treatment Plant and distribution	2	1	1
Class V underground injection control permits	0	2	0

[a]Four permits have been issued, representing 17 active units.

[b]Four permits have been issued, representing 20 active units and 7 proposed units. One permit covers corrective action (HSWA) only.

[c]One application is under review by TDEC, representing three active units.

[d]Three permits have been issued, representing units closed under RCRA in Bear Creek Hydrogeologic Regime, Chestnut Ridge Hydrogeologic Regime, and UEFPC Regime.

[e]Number of units reported in 3016 Report/Inventory of Federal Hazardous Waste Activities. This report/inventory includes each tank unit (i.e., facility) and does not count individual tanks as a separate unit.

[f]Three tanks have been grouted in place since the last reporting cycle.

[g]Four landfills are operational: one (Spoil Area 1) is inactive and has an ROD under CERCLA, and one (Landfill II) is in postclosure care and maintenance.

[h]One permit for solid waste and one for hazardous waste.

[i]Issued 4/28/95 and effective 7/1/95. TDEC has incorporated requirements for storm water into individual NPDES permits.

[j]TDEC has incorporated into individual NPDES permits.

[k]One aquatic resource alteration permit is issued in the name of East Tennessee Mechanical.

[l]Notice of intent that accesses a general NPDES permit. Two notices of intent remain on file for construction at Landfill V, VII, and for tree maintenance on tributary 7 at the Walk-in Pits closure.

2.7 CURRENT ISSUES

2.7.1 Actions Filed by Friends of the Earth, Inc.

On January 17, 1992, Friends of the Earth, Inc., a nonprofit corporation, filed a lawsuit against Admiral James D. Watkins (then Secretary of Energy) and DOE in the U.S. District Court for the Eastern District of Tennessee, Northern Division. The suit alleges that DOE is violating the terms and conditions of its NPDES permits for the Y-12 Plant, ORNL, and the ETTP. Specifically, the complaint alleges that discharges of certain quantities of various pollutants into tributaries of the Clinch River that have their sources at the Y-12 Plant, ORNL, and the ETTP have exceeded (and are exceeding) the allowable discharge limits established by the NPDES permits. The suit seeks to force DOE to comply in all respects with its NPDES permits, declaratory judgments, and the award of various other costs.

On September 26, 1996, U.S. District Judge Leon Jordan issued an order requiring DOE to install tablet dechlorinator units at the Y-12 Plant at sources of chlorinated water to ensure compliance with the requirements of the facility's NPDES permit and to eliminate all unpermitted outfalls at the Y-12 Plant. The order also required DOE to conduct a comprehensive survey of all pipes, sinks, and other connections to the storm drain systems at the Y-12 Plant, ORNL, and the ETTP by September 26, 1997. A copy of the report summarizing the survey was provided to Friends of the Earth by October 25, 1997, in accordance with the order.

Friends of the Earth asked the court to reconsider the order. The court declined this request, and at the time of this writing, Friends of the Earth and DOE are in settlement negotiations.

2.7.2 Hazardous/Toxic Waste Off-Site Shipment Moratorium

In May 1991, a moratorium on the off-site shipment (to non-DOE sites) of PCB and RCRA hazardous waste was implemented throughout the DOE complex, including the DOE sites located on the ORR. The purpose of the moratorium was twofold: (1) to ensure that hazardous/toxic wastes shipped from DOE facilities to commercial TSD facilities do not have bulk (volume) radioactive contamination as a result of DOE operations and (2) to ensure that the wastes do not have surface contamination exceeding DOE Order 5400.5 criteria unless the receiving facility is specifically licensed to manage radioactive waste.

In October 1993, the ETTP received a partial lifting of the moratorium for wastes composed of solid materials that do not have the potential for bulk contamination. The ETTP moratorium continues to remain in effect for hazardous/toxic wastes that are not solid materials (because of the potential for bulk contamination) until such time as DOE develops generic criteria for bulk contamination release. Off-site shipments of solid, hazardous/toxic wastes resumed at the ETTP following DOE's issuance of the partial lifting.

The moratorium at the Y-12 Plant was fully lifted by DOE in January 1994. The Y-12 Plant resumed off-site shipment activities for hazardous/toxic wastes following the lifting of the site moratorium.

In November 1994, ORNL received a partial lifting of the moratorium for wastes composed of solid materials that do not have the potential for bulk contamination. The ORNL moratorium continues to remain in effect for hazardous/toxic wastes that are not solid materials (because of the potential for bulk contamination) until such time

as ORNL develops criteria for evaluating bulk contamination and obtains DOE approval of the criteria. The ban on shipping wastes to off-site commercial facilities was partially lifted in 1996 following DOE approval of ORNL's program to make "no-rad added" determinations. During 1997, wastes with suitable generator process knowledge for no-rad added were shipped to commercial vendors, while mixed wastes were shipped to the ETTP. Wastes requiring sampling and analysis for no-rad added determinations are still banned for shipment to off-site commercial facilities.

2.7.3 Tennessee Oversight Agreement

On May 13, 1991, the state of Tennessee and DOE entered into a 5-year monitoring and oversight agreement in which DOE agreed to provide the state with financial and technical support for "independent monitoring and oversight" of DOE activities on the ORR. In June 1996, the state and DOE signed a 5-year extension of the agreement that will expire in June 2001. The agreement provides the state of Tennessee $26.15 million over the 5-year period. Activities that are conducted under the agreement include oversight of DOE's environmental monitoring, waste management, ER, and emergency management programs. The agreement is intended to assure Tennessee citizens that their health, safety, and environment are being protected by DOE through existing programs and substantial new commitments.

TDEC is the lead Tennessee state agency for implementation of the agreement. TDEC has established the Tennessee Department of Environment and Conservation/DOE Oversight Division (TDEC/DOE-O), located in the city of Oak Ridge. TDEC has entered into contracts with various state and local agencies to support oversight activities. Contracts have been signed with TWRA for fish and wildlife monitoring activities, TEMA for emergency management support, and the ORR Local Oversight Committee for assistance in achieving a better public understanding of the issues and activities on the ORR.

A DOE-Tennessee Oversight Agreement (TOA) steering committee composed of site and major program representatives has been established to coordinate implementation of the TOA and to promote consistency in its implementation across the ORR. LMES, LMER, and other selected DOE prime contractors have established internal organizations, including the designation of TOA coordinators, to facilitate implementation of the agreement.

To date, a variety of activities have been conducted under the agreement. DOE has provided security clearances and training necessary for state employees to gain access to the sites. Environmental data and documents pertaining to the environmental management, ER, and emergency management programs are provided or made available to the state for its review. TDEC/DOE-O routinely visits the three DOE sites to attend formal meetings and briefings, conduct walk-throughs of buildings and grounds, and conduct observations of site operations to assess compliance with environmental regulations.

In October 1997, TDEC/DOE-O published a "Status Report to the Public" (DOE 1997b), which presents TDEC/DOE-O's activities for the year and explains the complex issues surrounding DOE's storage, treatment, and disposal of mixed and radioactive waste and its handling of contaminated sites and buildings.

3. Environmental Management and Reservation Activities

H. M. Braunstein

Abstract

The law requires federal agencies and private-sector companies to investigate and remedy abandoned or uncontrolled hazardous waste sites where a release has occurred or may occur. A number of monitoring and cleanup activities are conducted on the ORR under the Environmental Management Program to meet the legal requirements. Additional activities, such as wildlife management and activities that encourage public involvement, are also conducted.

3.1 INTRODUCTION

For nearly half a century, one of the primary missions of DOE and its predecessor agencies was the production of nuclear weapons for the nation's defense. Production of materials for nuclear weapons, which began on the ORR in 1943 as part of the Manhattan Project, also produced radioactive and hazardous wastes. In 1989, EPA placed the reservation on the NPL, which names waste sites across the country most in need of cleanup.

Once the reservation was added to the NPL, cleanup became subject to the process specified in CERCLA, more commonly known as Superfund. This law requires federal agencies and private-sector companies to investigate and remedy abandoned or uncontrolled hazardous waste sites where a release has occurred or may occur. It also requires public involvement to ensure that citizens are informed of and are involved in making cleanup decisions.

In 1990, DOE-HQ established the Office of Environmental Management, making DOE-ORO responsible for cleanup of the reservation; Lockheed Martin Energy Systems, Inc., served as its managing and operating contractor until the end of 1997, when responsibility was transitioned to Bechtel Jacobs Company LLC (see Sects. 1.4.2 and 1.4.3). The following sections highlight some of the environmental management activities for 1997 and some related activities carried out to ensure good stewardship of the reservation.

3.2 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

CERCLA activities continued throughout 1997 on the ORR under implementation of the ORR FFA (see Sects. 2.2.2 and 2.2.3). These activities take place at a CERCLA area, which is any inactive unit or area at which a release or threatened release of hazardous substances, pollutants, or contaminants exists. These sites are listed in Appendix C of the FFA under various names according to their remediation status. When remediation decisions for an area have been approved, the area becomes an operable unit (OU) in Appendix C of the FFA.

3.2.1 Oak Ridge Y-12 Plant

The remedial action strategy at the Y-12 Plant integrates the numerous applicable federal and state regulations for efficient compliance on a watershed basis. CERCLA remedial actions at two watersheds or hydrogeologic regimes have been initiated at the facility: Bear Creek Valley and UEFPC.

The following CERCLA accomplishments were reported for 1997 [DOE/OR/01-1565/V1, V2, V3 and DOE/OR/01-1696/V1]: the record of decision (ROD) for the Bear Creek OU (spoil

area 1 and SY-200) was approved, the action memorandum (AM) for the Y-12 decommissioning surveillance and maintenance (S&M) for Alpha 4 outside piping was approved, the Filled Coal Ash Pond Remedial Action was completed, and plans were made to hold the fourth in a series of workshops on the ORR watersheds in February 1998 to focus on the UEFPC watershed.

3.2.2 East Tennessee Technology Park

The remedial action strategy taken by DOE involves a watershed approach in the planning and implementation of the ETTP Sitewide ROD. The watershed approach will assist DOE in selecting consistent cleanup alternatives that optimally balance cost effectiveness and risk reduction by considering all contamination, including sources, groundwater, surface water, etc., within ETTP boundaries rather than focusing on one site or one pathway at a time.

Remedial action accomplishments for 1997 include removing RCRA hazardous waste from two release sites and submitting closure documentation for the K-1417/1419 RCRA closures. The decision documentation for the K-1070-C/D G-pit and concrete pad was revised and submitted to the regulatory agencies. A public meeting was held to discuss the ETTP K-1007 and K-901-A Ponds project decision documents. K-1070-C/D and Mitchell Branch Plumes Project accomplishments include data collection and evaluation, submission and approval of the Engineering Evaluation/Cost Analysis, Action Memorandum and Removal Action Work Plan, Design and Construction field mobilization and site preparation. K-1401 & K-1420 Sumps project activities include modifications to discharge from sumps in the basement of the two buildings at the ETTP to stop the collection of contaminated groundwater in basement sumps from discharging to storm drains. The new conveyance system will pipe the contaminated groundwater to the ETTP CNF. Major accomplishments for the K-25Auxiliary Facilities Demolition Group I Buildings Project since the project was reauthorized on July 30, 1997, include issuing the Removal Action Work Plan to regulators, preparing performance specification, and mobilizing a subcontractor to demolish K-724/K-725; preparing performance specification to D&D K-1131/K-1410/K-1031 and start site preparation for D&D of K-1131/K-1410/K-1031. Deposit Removal project personnel placed four deposits in the K-25 Building and one deposit in the K-29 Building into safe configuration.

3.2.2.1 ETTP Record of Decision

The ETTP Sitewide ROD project is currently addressing facilities, buildings, and contaminated sites with either a remediation project or a determination that no action is required. More than 100 individual units at the ETTP have been identified as known or suspected sources of environmental contamination to the soil, groundwater, and surface water. A remedial investigation had been initiated during CY 1997 to characterize the nature and extent of contamination by using the document *Groundwater Remedial Site Evaluation for the Oak Ridge K-25 Site* (SAIC 1996) as the starting point for these activities. Methods for remediating contaminated areas that pose an ecological or human health risk are being evaluated in a feasibility study and proposed plan, due to be completed in 1999. Remediation strategies will be agreed upon in a ROD between the stakeholders, DOE, EPA, and TDEC. The CERCLA remedial actions listed in Sect. 3.2.2 are scheduled to be completed and reevaluated as part of the ETTP Sitewide ROD.

3.2.3 Oak Ridge National Laboratory

The cleanup strategy for ORNL involves two watersheds, or hydrogeologic regimes, WOC/Bethel Valley and WOC/Melton Valley.

The following CERCLA accomplishments were reported for 1997 [DOE/OR/01-1565/V1,V2,V3 and DOE/OR/01-1696/V1]: Approval was received from TDEC and EPA on the proposed plan for remediation of the surface impoundments, which consist of basins 3513, 3524, and 3539 and 3540, the ROD submitted for the action was signature approved, and these areas

were added to the OU category of Appendix C of the FFA; the approved AM for the ORNL Main Plant Inactive Tanks [liquid low-level waste (LLLW) tank W-14] was issued, and this area was added to the OU category of Appendix C of the FFA; the Gunite and Associated Tanks (GAAT) project continued completing treatability studies to determine the most effective way to remediate sludges remaining in the tanks and initiated waste removal actions on tank W-4; and removal actions continued at the Molten Salt Reactor Experiment (MSRE) by trapping the reactive gases and chemical treatment of the blockages in the off-gas system.

3.2.4 ORR Boundary Areas

These areas are on the border of the ORR and help define the boundary of the ORR NPL area. They consist of the ORAU South Campus Area, the ClinchRiver/Poplar Creek Area, Lower Watts Bar Reservoir (LWBR), and Lower East Fork Poplar Creek (LEFPC).

The following CERCLA accomplishments were reported for 1997 [DOE/OR/01-1565/V1, V2, V3 and DOE/OR/01-1696/V1] in these areas: the signed ROD for the Clinch River/Poplar Creek and Union Valley areas was received, and they were added to the OU category of Appendix C of the FFA, and excavation of mercury-contaminated soil and restoration activities at the LEFPC Bruner and NOAA sites were completed.

3.3 ORR INTEGRATED WATER QUALITY MONITORING PROGRAM

The EM program established the Integrated Water Quality Program (IWQP) as a comprehensive approach to addressing the requirements for groundwater, surface water, and biological monitoring programs on the ORR. The purpose of the IWQP is to develop a consistent and watershed-based approach that will support watershed management decisions. The IWQP produces two annual reports: the IWQP Annual Monitoring Report and the Remediation Effectiveness Report (RER). The RER (DOE/OR/01-1548&D2) was submitted on July 17, 1997, and approved by EPA and TDEC on August 15 and 17, 1997, respectively. Off-site residential drinking water quality is reported under this program.

3.4 THE DOE-ORO ENVIRONMENTAL MANAGEMENT RADIOLOGICAL SCRAP METAL PROGRAM

During CY 1997, the principal scrap metal recycle activities involved the definition and establishment of a national recycle program for metals and the development and award of fixed-price contracts for recovery and recycle of structural and miscellaneous metal from the demolition of facilities at the ETTP and the Y-12 Plant. The benefit arising from these activities will be a significant demonstration of methods and costs for the recycle of both contaminated and clean scrap metal. These methods can be used at other sites in future years as environmental cleanup continues. One recycle contract has been awarded by DOE, and two recycle subcontracts are anticipated to be awarded by Bechtel Jacobs Company. The first, a performance-based fixed-price contract, has been awarded to British Nuclear Fuels Limited (BNFL) for the removal of approximately 126,000 tons of uranium-contaminated process equipment from three large uranium enrichment process facilities. Two similar subcontracts are in the planning phase that include a combined total of 52,000 tons of uranium contaminated ferrous scrap metal from the Y-12 and ETTP sites.

The Oak Ridge National Scrap Metal Reuse/Recycle Program will also develop DOE policy for release of contaminated scrap metal and establish national procurements to maximize recycle of scrap metal and avoid burial when shown to be economically feasible. The Oak Ridge program has the lead for coordination with state and local regulators concerning any established polices and release criteria.

The Oak Ridge National Scrap Metal Reuse/Recycle Program is currently using the ORR as an incubator for the national program. The program is developing a business plan to identify opportunities and commitments at other sites. The program will move to establish commitments during the second half of FY 1998 and FY 1999.

3.5 REMEDIATION UNDER WAY FOR THE MOLTEN SALT REACTOR EXPERIMENT FACILITY

Remediation of the MSRE facility continued during 1997. The facility operated from 1965 to 1969. The reactor was fueled by molten uranium tetrafluoride salt and was cooled by molten salts of lithium and beryllium. After being shut down, the reactor was mothballed. The fuel was solidified in tanks for long-term storage, and surveillance and maintenance programs were initiated.

In subsequent years, a number of potential problems were found in the facility. Samples of off-gas revealed that fluorine and uranium hexafluoride gas were being emitted, leading to the discovery of a 7-lb deposit of uranium in a charcoal-bed off-gas filter. Because the charcoal bed was within a water-filled chamber, it raised a concern that a nuclear criticality was possible. In addition, the fluorine had reacted with the charcoal to form chemically unstable compounds. These discoveries led to the initiation of remedial actions, which began in 1994 and are currently ongoing.

The MSRE remediation project was initiated to reduce and eliminate three potential risks: a nuclear criticality accident, an explosive release of radioactive material, and a release of reactive and/or radioactive gases. Since 1994, the water was drained from around the charcoal bed, and the atmosphere was replaced with an inert gas (CO_2); the charcoal bed was isolated from the off-gas system to prevent further migration of uranium and fluorine; and a hold-down ring was installed to contain the radioactive and reactive gas if the events posed in a "worst-case scenario" were to occur.

A system to remove uranium hexafluoride was designed, fabricated, and installed during 1995 and 1996. The system, which began operation on November 21, 1996, contains chemical traps that adsorb gases emitted by the MSRE. The traps are being stored until equipment can be fabricated to process and package the material for long-term storage.

On June 28, 1996, DOE issued an action memorandum for a removal action for the uranium in the charcoal bed. Once the gases are eliminated from the MSRE, the solid uranium deposits will be removed. A mockup of the charcoal bed has been built, and prototype robotic tools are being fabricated.

During 1997, the removal action report, *Removal Action Report on the Molten Salt Reactor Experiment Time-Critical Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1623&D1) (DOE 1997c), was submitted to and approved by the regulators. Also, chemical treatment of the blockages was initiated and the reactive gas removal system was operated 62 times with the removal of a total of 6 kg of uranium (84% ^{233}U).

The final phase of the MSRE remediation project will involve removing the fuel and flushing salts from their storage tanks.

3.6 GUNITE AND ASSOCIATED TANKS REMEDIATION

The GAAT are large underground storage tanks with a total capacity of approximately 1 million gallons that were constructed in the early 1940s to collect, neutralize, store, and transfer liquid radioactive and/or hazardous waste. They are located in the main facilities complex of ORNL in Bethel Valley and have been identified as a high priority for cleanup because of their radionuclide content and the age of the tanks. The GAAT comprise 16 tanks, 12 of which were constructed of gunite (gunite is a mixture of

cement, sand, and water sprayed through a nozzle over a steel reinforcing framework), and the remaining 4 are stainless steel. The tanks vary in capacity from 1500 to 170,000 gal each. With the exception of two tanks, they are located in the North and South Tank Farm sites in the center of ORNL on the north and south sides of Central Avenue, the main pedestrian and vehicular thoroughfare through the Laboratory, with research facilities, office buildings, and the cafeteria nearby.

The tanks have been divided into three groupings for the purpose of remediation: group 1 tanks, which contain no sludge and very little radioactivity; group 2 tanks (W-3, W-4, and TH-4), which have sludges with low radioactivity; and group 3 tanks (W-5 through W-10), which contain sludges with high radioactivity. At the start of the remediation, these tanks contained mixed transuranic waste with 68,000 Ci of radioactivity in 253,000 gal of liquid and 81,000 gal of sludge.

It was recognized early that remediation of the tanks by removal of the contents would be complicated by the high concentration of radionuclides in the sludge, the location of the tanks underground, and the fact that they are located in the middle of the ORNL complex. Therefore, it was determined that remotely operated systems would be required to handle some of the sludges to ensure worker safety.

The Radioactive Tank Cleaning System (RTCS), which is the first full-scale, remotely operated system to clean radioactive liquid, sludge, and other debris from large underground storage tanks, was developed as part of a CERCLA treatability study, which was designed specifically to support remediation of the GAAT. The treatability study involved a partnership between DOE, EPA Region 4, TDEC, local government, and stakeholders. In addition to a control system, the RTCS comprises a waste dislodging and conveyance system and confined sluicing to dislodge waste and clean the tank floors and walls; a modified light-duty utility arm to perform automated operations inside the tank; a plow blade to move sludge and other tools to pick up debris; a camera system to allow the operators to view the waste removal operations; and a decontamination system to remove the majority of contamination from the equipment before it is brought to the surface.

In CY 1997, the first two of eight gunite tanks that contain approximately 40% of ORNL's transuranic sludge were successfully cleaned. The completion of waste removal operations in tanks W-3 and W-4 prove the RTCS is capable of removing thick, deep sludge. Approximately 96% of the contaminants contained in the tanks was removed by a combination of sludge mining and wall scarification. The amount of residual waste in each tank is estimated to be 100 gallons, which is 0.25% of the the total tank volume.

The experience gained during this remediation project and the proven operation of the RTCS have the potential to save hundreds of millions of dollars on the cleanup of similar tanks at DOE sites around the country. The goal of the remediation project is to remove the waste and stabilize the tanks to protect workers, the public, and the environment.

3.7 LAND APPLICATION OF SEWAGE SLUDGE

The city of Oak Ridge owns and operates a POTW that receives wastewater from a variety of industrial, commercial, and residential generators in Anderson and Roane counties. One of the chief contributors, with approximately 20% of the POTW's total influent, is the Oak Ridge Y-12 Plant. The POTW uses a standard activated-sludge process, in which biosolids from both primary and secondary sedimentation are fed into four anaerobic digesters. Under an agreement with DOE and the state of Tennessee, the city transports digested municipal sewage to approved sites on the ORR and applies the biosolids as a soil conditioner and fertilizer. The city of Oak Ridge has been applying biosolids at selected, state-approved sites on the ORR since 1983 (Fig. 3.1). The current biosolids land-application program uses six sites totaling approximately 190 acres on which about 432 tons (dry weight) of sewage sludge was applied in 1997. The sludge contains

ORNL-DWG 95M-7718

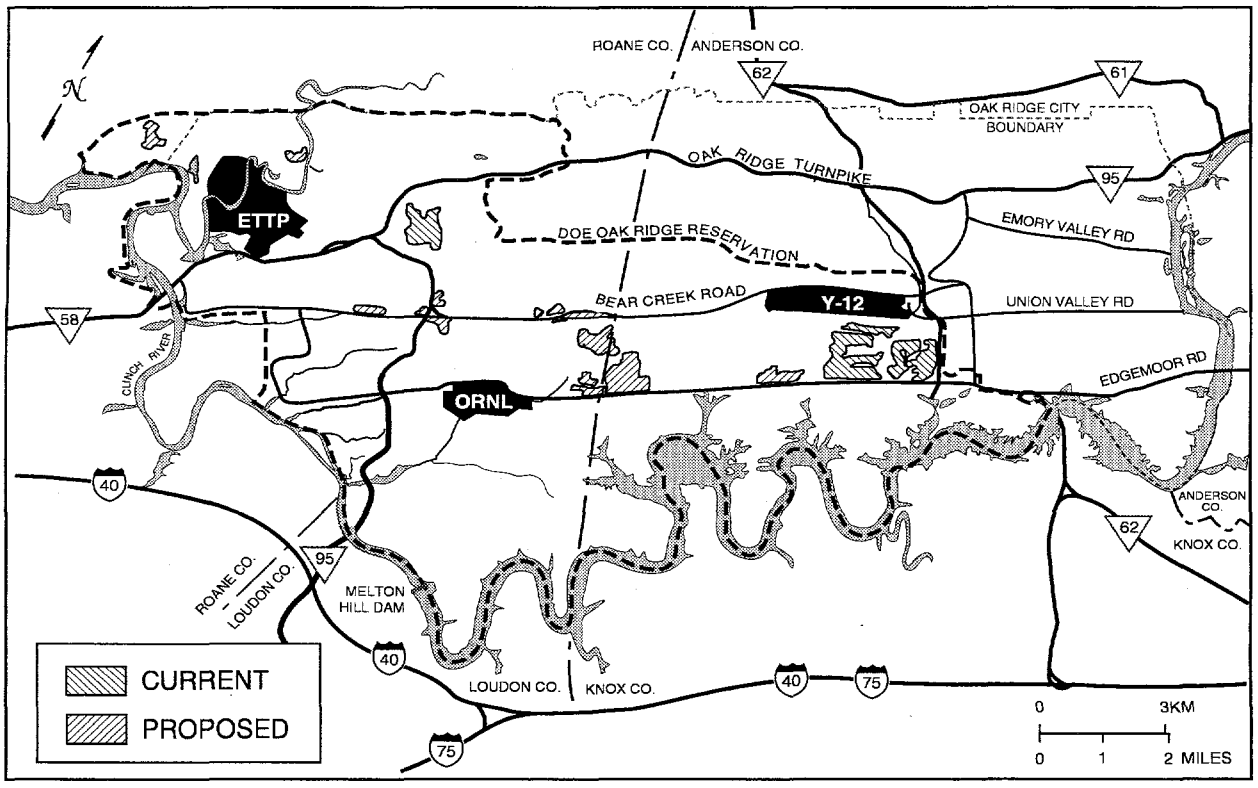

Fig. 3.1. Current and proposed sites for the land application of sewage sludge on the ORR.

trace quantities of heavy metals and radionuclides; however, it is not considered to be RCRA or radioactive waste and is regulated under the provisions of 40 CFR 503 of the CWA.

In 1997, the joint City of Oak Ridge/DOE-ORO Biosolids Land Application Program received one of only two Biosolids Management *Excellence Awards* from the Tennessee/Kentucky Water Environment Association, which is an organization comprising municipal and state government representatives from these respective states.

The highest detected levels of heavy metals detected in 1997 are compared with established limits in Table 3.1.

3.8 PARTNERS IN FLIGHT SURVEY

Partners in Flight (PIF) is an international program with partners from various governments, agencies, nongovernment groups, and volunteers collaborating in bird conservation and monitoring. ORNL is cooperating with TWRA in its monitoring program of breeding birds in Tennessee. Permanent plots on the ORR have been monitored by TWRA, ORNL staff, and volunteers from the Tennessee Ornithological Society for four years as part of the Tennessee PIF program. The Tennessee Conservation League is coordinating data compilation for TWRA. A manuscript about the

Table 3.1. Highest levels of heavy metals detected in 1997 at the city of Oak Ridge POTW compared with limits established in 40 CFR 503.13 and 40 CFR 503.23

Heavy metal	Highest level detected in sludge (mg/kg)[a]	Limits (mg/kg)[a]	
		40 CFR 503.13, Table 1	40 CFR 503.23, Table 1
Arsenic	7.5	75	73
Cadmium	5.2	85	—
Chromium	92.5	*b*	600
Copper	570.0	4300	—
Lead	74.6	840	—
Mercury	20.0	57	—
Molybdenum	13.0	*b*	—
Nickel	42.0	420	420
Selenium	3.1	100	—
Zinc	1910.0	7500	—

[a]Dry weight basis.
[b]This limit has been excised by EPA.

PIF program is currently in press for 1998 publication in the journal *The Migrant*. This report contains historical records for occurrences of species of conservation concern from surveys conducted on the ORR since the early 1950s.

3.9 COMMUNITY HIKES ON THE OAK RIDGE NATIONAL ENVIRONMENTAL RESEARCH PARK

In May 1996, ORNL began sponsoring community hikes on the Oak Ridge National Environmental Research Park. The hikes allowed participants from the local community to explore areas of the reservation usually closed to the public. The purpose of the hikes was to strengthen the local community's sense of pride in the ORR and to help them recognize its regional value.

Building on the successful pilot community hikes in 1996, ORNL with the American Museum of Science and Energy (AMSE) sponsored seven public wildflower and two public bird walks between April 26 and May 18, 1997. The walks were led by volunteers from ORNL, JACOR Environmental, and TWRA so that no cost accrued to participants, ORNL, or AMSE. A total of 70 persons participated; 49 people went on the six wildflower walks (one was rained out), and 21 people took the bird walks.

3.10 PUBLIC INVOLVEMENT ACTIVITIES

As part of its public involvement program, the DOE-ORO EM Public Involvement Plan for the ORR (DOE/OR/01-1552&D1) was submitted on January 14, 1997. In addition, DOE continued to hold regular stakeholder meetings in 1997 to solicit input and disseminate information on environmental management work on the reservation. DOE also hosted other workshops and public meetings.

Some of the public involvement activities included the following:

- a public workshop to gather input on the Ten-Year Plan was held on January 9, 1997, and weekly work sessions with regulators and stakeholders to draft the plan were held from January 13, 1997, until it was successfully concluded on February 18, 1997;
- a public meeting was conducted on June 2, 1997, to receive comments on the Feasibility Study (FS)/Proposed Plan for remediating the GAAT at ORNL;
- a public workshop was held June 25, 1997, to discuss the draft report *Accelerating Cleanup: Focus on 2006, Discussion Draft*. This was the first of four follow-on workshops, which were held July 14, July 22, August 14, and August 25, 1997;
- a public meeting on the proposed plan for remediation of the ORNL main plant surface impoundments was held July 15, 1997;
- the second in a series of workshops on the ORR watersheds was held July 21, 1997, to discuss the Bear Creek Valley Watershed and waste disposal options, and a third workshop was held November 4, 1997, to discuss the Bethel Valley Watershed; and
- a public workshop was held December 15, 1997, to discuss EM prioritization and respond to a concern that not all DOE sites apply the same criteria to prioritization, resulting in more funding for some sites.

Meetings were also held on a variety of other topics.

3.10.1 EnvironMENTAL Fair

The sixth annual EnvironMENTAL Fair was held October 8–9, 1997, on the grounds of the AMSE in Oak Ridge. More than 300 DOE and contractor volunteers welcomed more than 3500 sixth-grade students each day for this 2-day fair. Sixth-graders from 19 counties in East Tennessee and from the Cherokee Reservation participated. This was the first 2-day fair, which enabled all of the targeted students to attend the same year. More than 50 hands-on activities encouraged the students' interest in environment, science, and technology.

3.10.2 Site-Specific Advisory Board

The Oak Ridge Environmental Management Site-Specific Advisory Board (SSAB), formed in 1995, continued to advise DOE on environmental management issues such as recommendations for cleanup levels, technology development, and long-term waste management issues. Throughout 1997, the SSAB held regular board meetings as well as topic-specific meetings, and all meetings were open to the public. SSAB information, including meeting schedules, meeting minutes, membership, and recommendations to DOE, are available on the Web at http://www.ornl.gov/doe_oro/em/ssab/hpage.htm.

3.10.2.1 End Use Working Group

In response to the state of Tennessee's recommendation that broad public involvement should be part of final remediation decisions on the ORR, DOE asked the SSAB to develop a process for deciding remediation levels for contaminated areas. In January 1997, the SSAB sponsored a public meeting to form the Oak Ridge End Use Working Group (EUWG). The EUWG, which is a special project team of the SSAB, held its first official meeting February 20, 1997, and met 22 additional times in1997. The EUWG, a citizens' group, is made up entirely of community volunteers operating under an open meeting process in which any member of the public is encouraged to join, participate, and contribute a viewpoint. The original goal of the EUWG, to provide informed stakeholder input to DOE on the future use of contaminated areas on the ORR, has expanded to include providing recommendations to DOE, which, at its discretion, may be adopted by the SSAB and submitted formally. In addition to recommendations, the EUWG continues to work on other issues of stakeholder concern, including development of a stewardship plan for the ORR,

which is expected to be completed in the summer of 1998.

3.10.3 Use and Reuse of Contaminated Land

To provide a consistent land-use approach that would involve stakeholders in remediation and reutilization of contaminated land on the ORR, a reservation-wide strategy had been developed under the EM program in 1994 and 1995. The Common Ground process was a stakeholder-driven process to determine preferred land-use options for the ORR so that cleanup operations would be based on the most likely and acceptable land uses (*Common Ground—Future Land Use Process for the Oak Ridge Reservation*, December 1995). Subsequent to the Common Ground process, and in response to requirements in DOE O 430.1, *Life Cycle Assets Management*, DOE-ORO established an integrated land- and facility-use process for land-use decision-making for proposed changes in land use outside the immediate plant boundaries. DOE O 430.1 requires DOE to involve stakeholders in land-use planning. Under the Integrated Plan, each site identifies and plans land- and facility-use changes based on programmatic need. The individual sites also ensure project review for various compliance issues. Any changes in land or facility uses in areas outside the sites must be approved by the process described in the Integrated Plan (see Sect. 3.11 for the Web address for the Integrated Plan). The review process includes the application of the following land-use priorities, which summarize stakeholder input from Common Ground and other citizen/stakeholder processes since 1994, including the EUWG of the ORREMSSAB (see Sect. 3.10.2.1):

- Priority 1—Preserve and protect land for meeting the requirements of existing and future DOE mission-related facilities and programs;
- Priority 2—Maintain land and facilities to promote sustainable economic development; and
- Priority 3—Protect the environment, meet the requirements of scientific and technical education, and support educational research opportunities on the ORR.

3.11 SOME WEB SITES AND A NEW TOLL-FREE NUMBER

Information on environmental cleanup and waste management in Oak Ridge, including the Public Involvement Calendar, is available at the following Web addresses:

- http//www.doe.gov reaches the national DOE Web site;
- http//www.em.doe.gov takes you to the national DOE environmental management Web site;
- http//www.ornl.gov/emef/facts/public.htm provides public involvement information for the environmental management program in Oak Ridge;
- http//www-internal.ornl.gov/~dmsi/cip/cip.htm gives you the Comprehensive Integrated Plan for the ORR;
- http//www.ornl.gov/emef/facsheet.htm gives you a list of fact sheets on each of the Oak Ridge environmental management projects;
- http//www.ornl.gov provides access to all ORNL home pages, plus home pages for the Y-12 Plant, the ETTP, ORAU, Energy Systems, and other sites of local interest; and
- http//www.ornl.gov/doe_oro/ reaches the DOE Oak Ridge Operations Web site.

Stakeholders outside the local calling area may reach the Environmental Management Community Relations Office by calling toll-free 1-800-382-6938.

4. Effluent Monitoring

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Abstract

Effluent monitoring is a major activity on the ORR. Effluent monitoring is the collection and analysis of samples or measurements of liquid and gaseous effluents to determine and quantify contaminants and process-stream characteristics, assess any chemical or radiological exposures to members of the public, and demonstrate compliance with applicable standards.

4.1 AIRBORNE DISCHARGES

Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA, the TDEC Division of Air Pollution Control, and DOE orders. Radioactive emissions are regulated by EPA under NESHAP regulations in 40 CFR 61, Subpart H. (See Appendix A for a list of radionuclides and their radioactive half-lives.) Nonradioactive emissions are regulated under the rules of the TDEC Division of Air Pollution Control.

Radionuclide NESHAP regulations limit the annual radioactive dose from air emissions to the most exposed member of the public. In December 1989, radionuclide NESHAP regulations were reissued. Negotiations between EPA and DOE were initiated to bring the ORR into full compliance with the new regulations. As a result of those negotiations, an FFCA was signed in May 1992 by the DOE-ORO manager and was implemented at the ORR facilities. The ORR fulfilled all of its FFCA commitments and came into compliance with the regulations by December 1992. On March 26, 1993, EPA Region 4 certified that DOE-ORO had completed all actions required by the FFCA and was considered to be in full compliance with radionuclide NESHAP regulations. An updated Radionuclide NESHAP Compliance Plan was sent to EPA Region 4 in May 1994.

In addition to federal regulations, DOE requirements for airborne emissions are established in DOE Order 5400.1, DOE Order 5400.5, and the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991). The criteria in NESHAP regulations and DOE orders define major radionuclide effluent sources as emission points that have the potential to discharge radionuclides in quantities that could cause an EDE of 0.1 mrem/year or greater to the nearest member of the public. Calculations of potential emissions from a source do not take into account efficiencies of pollution control equipment where the source is otherwise operating normally.

Each ORR facility has a comprehensive air regulation compliance assurance and monitoring program to ensure that airborne discharges meet all regulatory requirements and therefore do not adversely affect ambient air quality. Common air pollution control devices employed at the three Oak Ridge facilities include exhaust gas scrubbers, baghouses, and other exhaust filtration systems designed to remove contaminants from exhaust gases before their release to the atmosphere. Process modifications and material substitutions are also made to minimize air emissions. In addition, administrative control plays a role in regulating emissions.

4.1.1 Y-12 Plant Radiological Airborne Effluent Monitoring

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 Plant occurs almost exclusively as a result of plant production, maintenance, and waste management activities. NESHAP regulations for radionuclides require continuous emission sampling of major sources (a "major source" is considered to be any emission point that potentially can contribute >0.1 mrem/year EDE to an off-site individual). During 1997, 46 of the Y-12 Plant's 58 stacks were judged to be major sources. Seven of these sources were not operational in 1997 because of work in progress on process or stack modifications. Twenty of the stacks having the greatest potential to emit significant amounts of uranium are equipped with alarmed breakthrough detectors, which alert operations personnel to process-upset conditions or to a decline in filtration-system efficiencies, allowing them to investigate and correct the problem before a significant release occurs.

As of January 1, 1997, the Y-12 Plant had a total of 58 stacks, 51 active and 7 temporarily shut down. During 1997, one stack was permanently shut down. Thus, 50 active stacks were being monitored at the end of 1997.

Uranium and other radionuclides are handled in millicurie quantities at facilities within the boundary of the Y-12 Plant as part of ORNL and Y-12 Plant laboratory activities. In addition, in 1996 an Analytical Services Organization (ASO) laboratory was relocated from the DOE Y-12 Plant to a location approximately 1/3 mile east of the Y-12 Plant on Union Valley Road. The laboratory is operated in a leased facility that is not within the ORR boundary. The emissions from the ASO Union Valley laboratory are included in the Y-12 Plant source term. The releases from these laboratories are minimal, however, and have negligible impact on the total Y-12 Plant dose.

Emissions from Y-12 Plant room ventilation systems are estimated from radiation control data collected on airborne radioactivity concentrations in the work areas. Areas where the monthly average concentration exceeded 10% of the DOE derived air concentration (DAC) worker protection guidelines are included in the annual emission estimate.

Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to EPA-approved calculation methods. In 1997, 54 minor emission points were identified from unmonitored radiological processes and laboratories. Twenty-eight minor emission points were identified from ORNL laboratory activities at facilities within the boundary of the Y-12 Plant. Three minor emission points were identified at the ASO Union Valley laboratory. No areas were identified in 1997 where room ventilation emissions exceeded 10% of the DAC worker protection guidelines

4.1.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on 58 process exhaust stacks in 1997. Particulate matter (including uranium) was filtered from the stack sample; filters at each location were changed routinely, from one to three times per week, and analyzed for total uranium. In addition, the sampling probes and tubing were removed quarterly and washed with nitric acid; the washing was analyzed for total uranium. At the end of the year, the probe-wash data were included in the final calculations in determining total emissions from each stack.

4.1.1.2 Results

An estimated 0.013 Ci (6.0 kg) of uranium was released into the atmosphere in 1997 as a result of Y-12 Plant activities (Table 4.1). The specific activity of enriched uranium is much greater than that of depleted uranium, and about 78% of the curie release was composed of emissions of enriched uranium particulate, even though less than 3% of the total mass of uranium released was enriched material (Figs. 4.1 and 4.2).

Table 4.1. Y-12 Plant airborne uranium emission estimates, 1997

Source of emissions	Quantity emitted	
	Ci[a]	kg
Enriched uranium		
Process exhaust (monitored)	0.01	0.153
Process and laboratory exhaust (unmonitored)	0.00015	0.002
Room exhaust (from health physics data)	0.00	0.00
Depleted uranium		
Process exhaust (monitored)	0.0026	4.8
Process and laboratory exhaust (unmonitored)	0.0005	1.0
Room exhaust (from health physics data)	0.00	0.0
Total	0.013	6.0

[a]1 Ci = 3.7E+10 Bq.

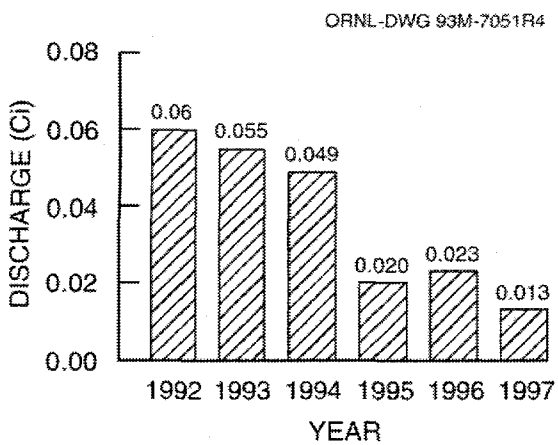

Fig. 4.1. Total curies of uranium discharged from the Y-12 Plant to the atmosphere, 1992–97.

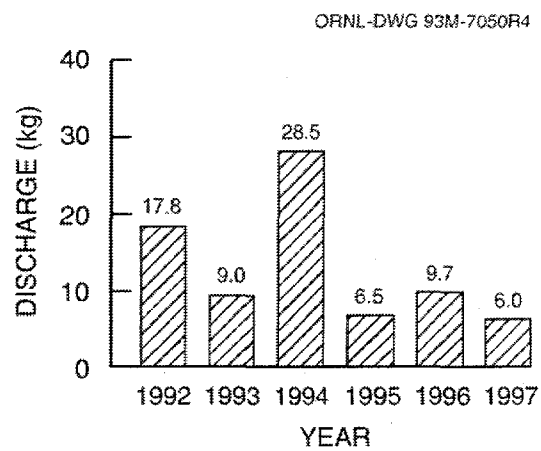

Fig. 4.2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1992–97.

4.1.2 ORNL Radiological Airborne Effluent Monitoring

Airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. These airborne emissions are treated, then filtered with high-efficiency particulate air (HEPA) and/or charcoal filters before discharge to ensure that any radioactivity released is as low as possible. Radiological gaseous emissions from ORNL consist of solid particulates, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases. The major radiological emission point sources for ORNL consist of the following four stacks located in Bethel and Melton valleys (Fig. 4.3):

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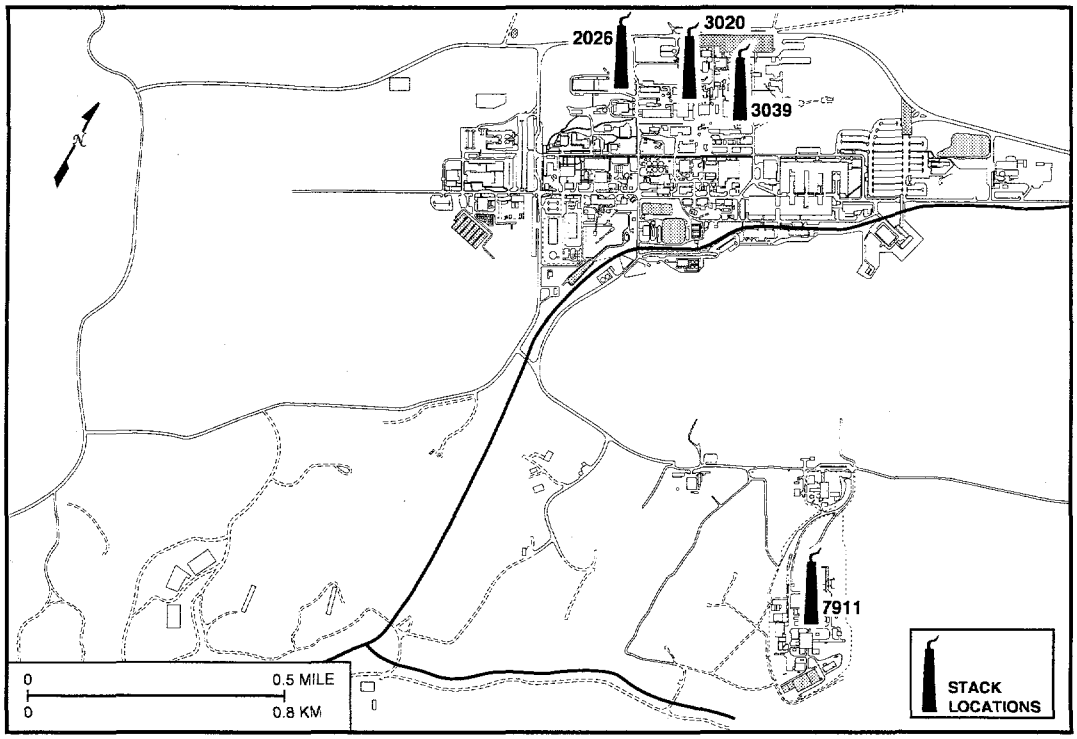

Fig. 4.3. Locations of major stacks (rad emission points) at ORNL.

- 2026 High Radiation Level Analytical Laboratory;
- 3020 Radiochemical Processing Plant;
- 3039 central offgas and scrubber system, which includes 3500 and 4500 areas cell ventilation system, isotope solid state ventilation system, and 3025 and 3026 areas cell ventilation system; and
- 7911 Melton Valley complex, which includes the High Flux Isotope Reactor (HFIR) and the Radiochemical Engineering Development Center (REDC).

In 1997, there were 21 minor point/group sources, and emission calculations/estimates were made for each of these sources. Three of these sources are continuously sampled.

4.1.2.1 Sample Collection and Analytical Procedure

Each of the four major point sources is equipped with a variety of surveillance instrumentation, including radiation alarms, near real-time monitors, and continuous sample collectors. Only data resulting from analysis of the continuous samples are used in this report because the other equipment does not provide data of sufficient accuracy and precision to support the quantitation of emission source terms. All ORNL in-stack source sampling systems comply with American National Standards Institute N 13.1 (ANSI 1969) criteria. The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges, a silica gel cartridge (if required), flow measurement and totalizing instruments, a sampling pump, and a return line to the stack. In addition to that instrumentation, the system at Stack 7911 includes a high-purity germanium detector with a NOMAD analyzer, which allows continuous isotopic identification and quantification of radioactive noble gases (i.e., ^{41}Ar) present in the effluent stream. To ensure that all radioactive particulates are accounted for, end-of-the-year samples are collected and analyzed by cleaning

the in-stack sampling probes. This program requires annual removal, inspection, and cleaning of sample probes.

Velocity profiles are performed quarterly following the criteria in EPA Method 2 at all major and at some minor sources. The profiles provide accurate stack flow data for subsequent emission rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. Minor sources are composed of any ventilation systems or components such as vents, laboratory hoods, room exhausts, and stacks that do not meet the criteria for a major source but are located in or vent from a radiological control area. A variety of methods are used to determine the emissions from the various minor sources. All methods used for minor source emission calculations comply with criteria agreed upon by EPA and/or are included in the NESHAP Compliance Plan for the ORR. These minor sources are evaluated on a 1- to 3-year basis, depending on the source type. All emissions, both major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

The charcoal cartridges, particulate filters, and silica gel traps are collected weekly. The use of charcoal cartridges is a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantified the adsorbable gases. Analysis is performed weekly. Particulate filters are held for 8 days prior to a weekly gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as ^{220}Rn and its daughter products. At Stack 7911, a weekly gamma scan is conducted to better detect short-lived gamma isotopes. The weekly filters are then composited quarterly and analyzed for alpha-, beta-, and gamma-emitting isotopes. Compositing provides a better opportunity for quantification of these low-concentration isotopes. At the end of the year, each sample probe is rinsed, and the rinsate is collected and submitted to the laboratory for isotopic analysis identical to that of the particulate filter. The data from the charcoal cartridges, silica gel, probe wash, and the quarterly filter composites are compiled to give the annual emissions for each major source and some minor sources.

4.1.2.2 Results

Annual radioactive airborne emissions for ORNL major sources in 1997 are presented in Table 4.2. All data presented were determined to be significantly different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emission calculation. Historical trends for ^{3}H and ^{131}I are presented in Figs. 4.4 and 4.5, respectively.

The tritium emissions for 1997 totaled approximately 148 Ci (Fig. 4.4), which is down significantly from previous years. The ^{131}I emission for 1997 is 0.055Ci, which is lower than that of the past years (Fig. 4.5). Emissions from the HFIR have increased in 1997. The major contributor to off-site dose is ^{41}Ar, which totaled 10,000 Ci in 1997 (Fig. 4.6).

4.1.3 ETTP Radiological Airborne Effluent Monitoring

Locations of airborne radionuclide point sources at the ETTP are shown in Fig. 4.7. These locations include both individual point sources and grouped point sources, such as laboratory hoods. Radioactive emissions data were determined from either EPA-approved sampling results or EPA-approved calculation methods.

4.1.3.1 Sample Collection and Analytical Procedure

Radionuclide emission measurements from the TSCA Incinerator were determined using a continuous stack sampling system. Radionuclide emission measurements were also determined from the K-1775 TVS, a new source, using a continuous stack sampling system. Measurements of TSCA Incinerator emissions were based on

Table 4.2. Major sources of radiological airborne emissions at ORNL, 1997 (in curies)[a]

Isotope	Stack			
	2026	3020	3039	7911
^{3}H			2.3E+001	6.9E+001
^{7}Be	5.9E-007	2.2E-007	2.6E-005	3.8E-007
^{41}Ar				1.0E+004
^{141}Ce				1.3E-006
^{144}Ce				3.2E-007
^{60}Co			1.8E-005	
^{203}Hg			5.3E-004	
^{85}Kr				1.1E+002
^{85m}Kr				1.5E+000
^{87}Kr				5.6E+001
^{88}Kr				5.9E+001
^{89}Kr				6.0E+000
Total Sr	1.0E-006	1.9E-006	1.4E-005	1.2E-005
^{129}I				2.3E-005
^{130}I				1.8E-006
^{131}I			1.6E-004	5.5E-002
^{132}I				1.4E-001
^{132m}I				5.1E-001
^{133}I	3.2E-007		2.2E-003	2.3E-001
^{134}I				4.0E-002
^{135}I			8.7E-003	9.4E-001
^{192}Ir			6.4E-004	
^{105}Ru				5.0E-002
^{133}Xe			3.5E-006	6.8E-003
^{135}Xe		4.7E-007	3.1E-004	1.0E+002
^{135m}Xe				6.1E+001
^{137}Xe				1.2E+002
^{138}Xe				3.4E+002
^{137}Cs	5.7E-006	2.8E-006	1.2E-004	2.9E-006
^{138}Cs				1.7E+003
^{139}Ba				6.7E-003
^{140}Ba				5.6E-005
^{191}Os			2.2E-001	3.2E-006
^{212}Pb	1.5E-001	4.9E-001	9.0E-001	2.6E-001
^{228}Th	1.8E-007	1.3E-007	1.2E-009	6.4E-009
^{230}Th		1.2E-009		2.7E-009
^{232}Th	1.0E-009			8.8E-010
^{234}U	3.6E-007	2.4E-007	2.2E-007	5.6E-008
^{235}U	2.6E-008	3.2E-008	8.3E-008	1.7E-008
^{238}U	1.9E-008	3.8E-008	7.6E-008	1.9E-008
^{238}Pu	8.6E-008	2.0E-008	3.1E-009	
^{239}Pu	2.9E-007	3.2E-007	2.3E-007	1.7E-009
^{241}Am	3.2E-008	6.3E-008	7.4E-008	1.4E-005
^{244}Cm	2.9E-007		8.6E-008	1.6E-008
^{152}Eu			1.2E-006	
^{154}Eu			5.8E-007	
^{140}La				1.6E-004

[a]1 Ci = 3.7E+10 Bq.

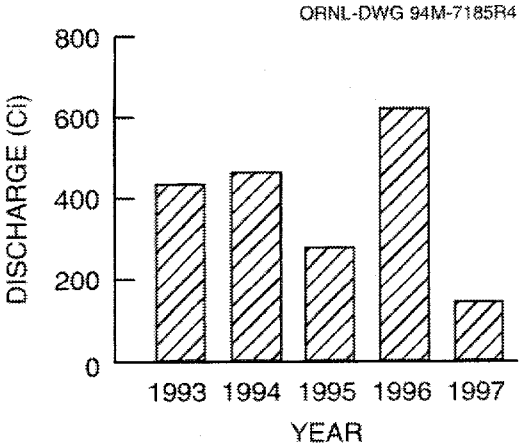

Fig. 4.4. Total discharges of ^{3}H from ORNL to the atmosphere, 1993–97.

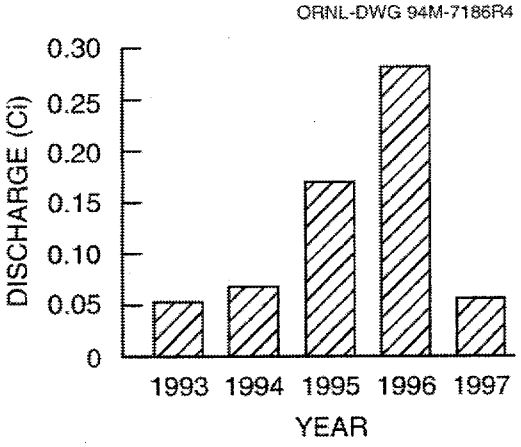

Fig. 4.5. Total discharges of ^{131}I from ORNL to the atmosphere, 1993–97.

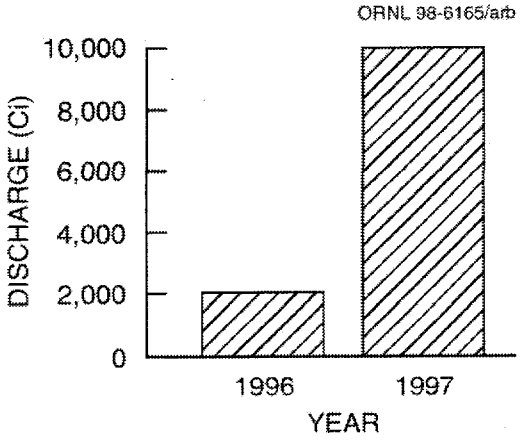

Fig. 4.6. Total discharges of ^{41}Ar from ORNL to the atmosphere, 1996–97.

monthly composites of weekly stack samples. Measurements of TVS emissions were not based on composite samples.

Other techniques were used to determine all other radiological point source emissions. Material balance calculations were used to generate emission estimates for the UF_6 Cylinder Program, Deposit Removal Project, and K-1004-A through D laboratories. The remaining active sources were calculated using surrogate sample techniques as described in the EPA-approved NESHAP compliance plan or from emission factors specified in 40 CFR 61, Appendix D. Both techniques are conservative methods of estimating emissions based on the physical form of the radionuclides and the maximum operating temperature of the process.

The K-1775 TVS began operation on low-level mixed waste in 1997. One new minor point source was approved for operation in 1997. A project for the UF_6 Cylinder Refurbishment Program was evaluated and approved for operation. The project includes controlled venting of cylinders containing depleted uranium hexafluoride. The controlled venting is performed to minimize the potential of uncontrolled releases caused by overpressurization of breached cylinders during repairs.

The following minor sources were reactivated during 1997: the K-304-5 Deposit Removal Project activities to mechanically remove solidified deposits of radiological material from the interior of cascade components; K-1423 drum crushing of radiologically contaminated empty drums; and a HEPA vacuum cleaning facility located in K-1310-DC for servicing vacuum cleaners containing potentially contaminated debris.

4.1.3.2 Results

The ETTP 1997 radionuclide emissions from the TSCA Incinerator, the TVS, and minor emission sources are shown in Table 4.3. Additionally, Figs. 4.8 and 4.9 show a comparison of the total 1997 discharges of uranium with those of previous years. The total curies and mass of uranium discharged have decreased from previous years.

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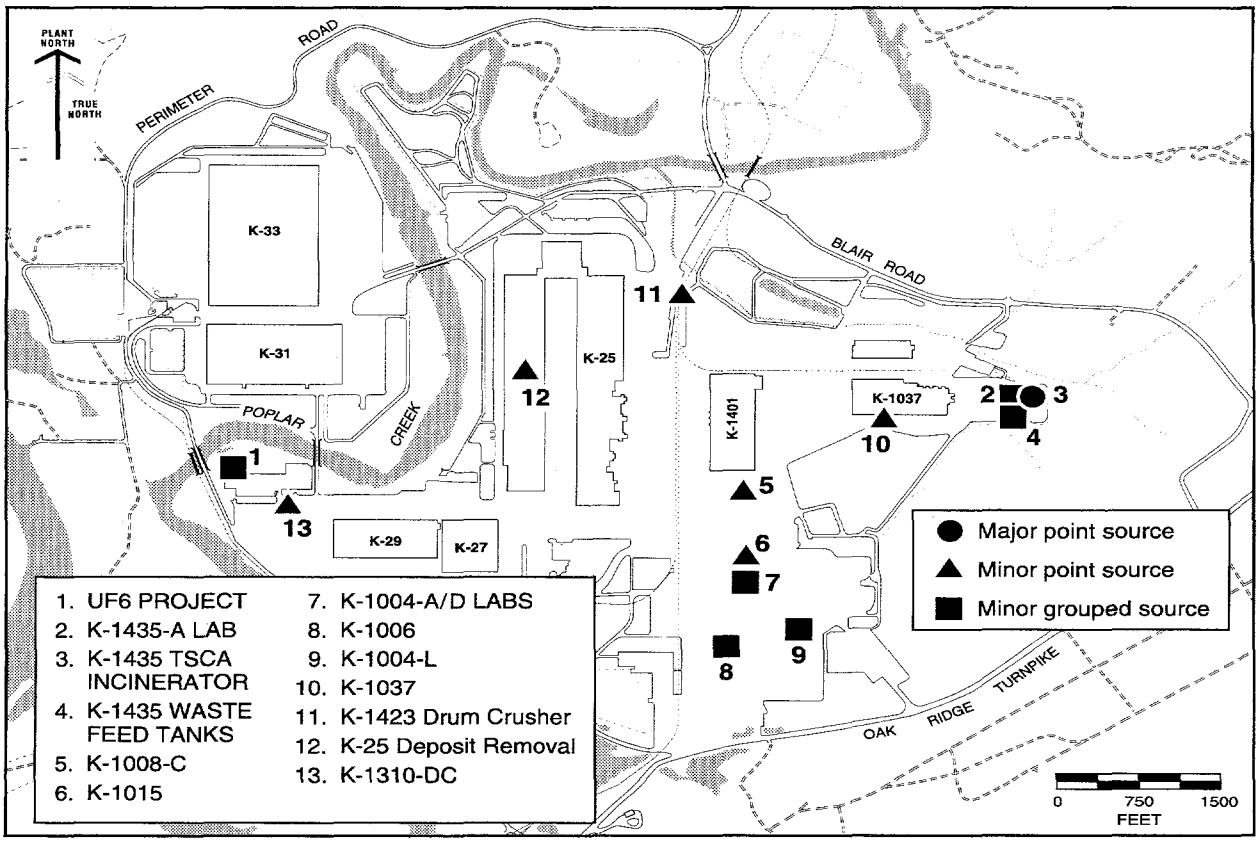

Fig. 4.7. ETTP active point sources of airborne radioactivity.

Variations are typically caused by changing levels of activities, waste burning, and uranium assay from year to year.

4.1.4 Y-12 Plant Nonradiological Airborne Emissions Monitoring

The release of nonradiological contaminants into the atmosphere at the Y-12 Plant occurs as a result of plant production, maintenance, and waste management operations and steam generation. Most process operations are served by ventilation systems that remove air contaminants from the workplace. In 1997, a major effort was expended preparing the Y-12 Plant's first-ever major source (Title V) operating permit application for these sources. This application implements the significant changes resulting from the 1990 Clean Air Act Amendments (Sect. 2.2.14.2) and replaces more than 50 individual emission source permit applications prepared in the early and mid-1990s. The nearly 1000-page application was submitted to TDEC in July 1997. The timely submission of the application allows the Y-12 Plant to continue to operate air emission sources under existing permits until a new permit is issued.

The 1997 Y-12 Plant annual emission fee was calculated based on 10,033 tons per year of allowable emission of regulated pollutants, with an annual emission fee of $158,521.40, as defined in TDEC regulations, Chapter 1200-3-26-.02(9)(i). In calculating the annual emission fee, Schedule III of Chapter 26 was used, in which the adjusted emissions equal the total emissions minus carbon monoxide and exempt emissions and a 4000-ton cap is imposed for SO_2 and NO_x. The emission fee rate was based on $15.80 per ton of regulated pollutant allowable emissions. The actual emis-

Table 4.3. ETTP radionuclide air emission totals, 1997 (in curies)[a]

Radionuclide	TSCA incinerator	TVS	Minor
^{3}H	3.85E–01	–	2.01E–04
^{14}C	–	–	1.19E–04
^{40}K	5.52E–05	1.20E–07	1.67E–05
^{51}Cr	–	–	–
^{57}Co	–	–	8.33E–07
^{60}Co	–	1.96E–07	2.15E–06
^{85}Kr	–	–	2.18E–03
^{90}Sc	–	–	1.12E–06
^{99}Tc	3.98E–03	4.64E–06	1.43E–03
^{106}Ru	–	–	1.01E–07
^{109}Cd	–	–	7.52E–06
^{131}I	–	–	2.05E–05
^{137}Cs	5.40E–04	–	4.22E–06
^{143}Ce	–	–	4.06E–06
^{210}Pb	–	–	7.95E–06
^{203}Hg	–	–	9.00E–09
^{237}Np	3.60E–07	7.47E–10	5.48E–06
^{238}Pu	8.83E–07	–	8.59E–06
^{239}Pu	9.45E–08	–	2.10E–06
^{228}Th	1.27E–07	5.22E–09	5.75E–06
^{230}Th	5.28E–07	–	8.08E–05
^{232}Th	1.11E–07	4.71E–10	5.70E–06
^{234}Th	1.01E–02	–	2.05E–03
^{234m}Pa	1.62E–02	–	4.67E–03
^{233}U	–	–	9.48E–07
^{234}U	1.36E–04	4.33E–09	6.18E–04
^{235}U	2.14E–07	–	6.42E–05
^{236}U	–	–	8.07E–06
^{238}U	7.70E–04	–	1.09E–03
^{242}Am	–	–	2.53E–07
Totals	4.17E–01	4.97E–06	1.26E–02

[a]1 Ci = 3.7E+10 Bq.

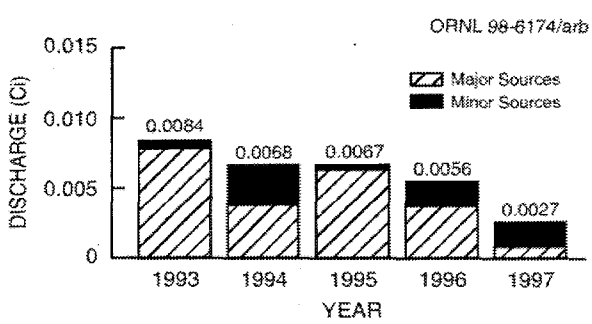

Fig. 4.8. Total curies of uranium discharged from the ETTP to the atmosphere, 1993–97.

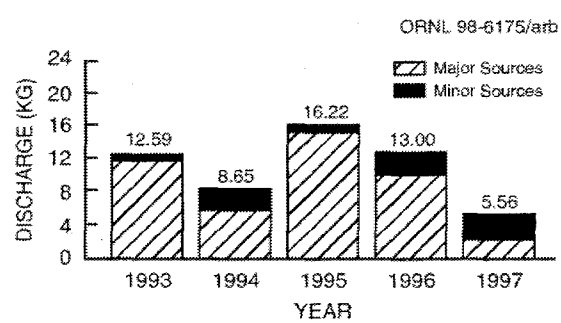

Fig. 4.9. Total kilograms of uranium discharged from the ETTP to the atmosphere, 1993–97.

sions are much lower than the allowable amount; however, major sources are required to pay their annual emission fee based on allowable emissions until the issuance of the major source operating permit.

The level of pollutant emissions is expected to decline in the future because of the changing mission of the Y-12 Plant and downsizing of production areas. More than 90% of the pollutants are attributed to the operation of the Y-12 Steam Plant. Nonradiological airborne emissions of materials have been estimated and are provided in Table 4.4.

Planning for continued compliance with anticipated and newly issued requirements under Title VI of the CAA amendments is a major effort. In accordance with the Y-12 Plant CAA implementation plan, a stratospheric ozone protection plan has been issued outlining current and historical actions necessary to comply with the new limitations on the release of ozone-depleting chemicals and with the 1995 production ban on these chemicals. An annual status report is prepared regarding these activities (*Y-12 Plant Stratospheric Ozone Protection Plan*, Y/TS-1179/R1).

The Y-12 Plant Environmental Compliance Organization personnel and refrigeration maintenance personnel successfully implemented work practices required to minimize releases of ozone-

Table 4.4. Y-12 Plant nonradiological airborne emissions, 1997

Chemical	Quantity released		Major release source	Basis of estimate
	lb	kg		
		SARA 313 chemicals[a]		
Hydrochloric acid	98,100	44,591	Chemical processing aid	Engineering calculation
Lead	1,392	633	Ancillary	Engineering calculations
Methanol	32,405	14,730	Cleaning/cooling	Engineering calculation
Nitric acid	545	246	Chemical processing aid	Engineering calculation
Tetrachloroethene	0	0	Storage	Engineering calculation
		Other large-inventory chemicals[b]		
Freon 11	890	405	Refrigerant	Quarterly report
Freon 12	248	113	Refrigerant	Quarterly report
Freon 22	3,358	1,526	Refrigerant	Quarterly report
Freon 13	1	0.5	Refrigerant	Quarterly report
Freon 502	3	1	Refrigerant	Quarterly report
		Steam plant emissions (all calculated emissions)[c]		
Particulates	74,000	33,636	Stack emission	Engineering calculations based on emission facts
SO_x	5,714,000	2,597,273	Stack emission	Engineering calculations based on emission facts
Carbon monoxide	44,000	20,000	Stack emission	Engineering calculations based on emission facts
Volatile organic compounds	4,000	1,818	Stack emission	Engineering calculations based on emission facts
NO_x	2,816,000	1,280,000	Stack emission	Engineering calculations based on emission facts

[a]Superfund Amendments and Reauthorization Act, Title III, Section 313.
[b]Fugitive emissions.
[c]Point-source emissions.

depleting refrigerants to the atmosphere. Requirements for refrigeration-system and motor-vehicle air-conditioner maintenance compliance are being met. To accommodate the production ban on ozone-depleting chemicals, studies are proceeding to find suitable replacements, and plant refrigeration equipment is being modified as needed. Funding was received and design work implemented on a line-item project, Retrofit Heating, Ventilating, and Air-Conditioning (HVAC) Systems and Chillers for Ozone Protection. This project will eliminate the use of chlorofluorocarbon (CFC) refrigerants in chillers, direct expansion air conditioners, and process coolers, either by direct replacement with new equipment that operates with "ozone-friendly" refrigerants or by retrofit of existing equipment with new components to operate on "ozone-friendly" refrigerants. In addition, two general plant projects were completed to retrofit low-pressure chillers with high-efficiency purge units and pressurization/leak-detection units to reduce CFC emissions to the atmosphere. Figure 4.10 illustrates the five-year trend of fugitive CFC emissions as reported by the Y-12 Plant. Table 4.4 includes the 1997 estimated emissions of these ozone-depleting substances as a result of Y-12 Plant activities.

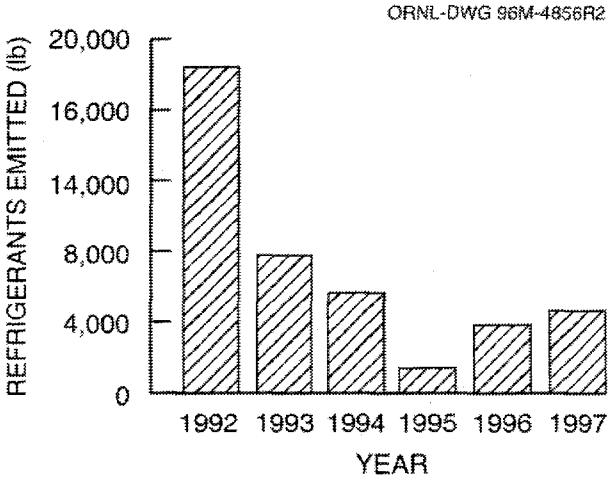

Fig. 4.10. Y-12 Plant CFC emissions, 1992–1997.

4.1.4.1 Sample Collection and Analytical Procedure

The two Y-12 Steam Plant exhaust stacks are each equipped with Lear Siegler RM41 opacity-monitoring systems. Under the current operating permit, the opacity-monitoring systems are required to be fully operational for at least 95% of the operational time of the monitored units during each month of a calendar quarter.

4.1.4.2 Results

The east and west Y-12 Steam Plant stack opacity monitors were each operational more than 99% of the time in 1997. Both systems were taken out of service for annual calibration/recertification by Spectrum Systems Engineering, Inc., on April 22 and 23, 1997. The annual opacity calibration error test reports were submitted to TDEC in July 1997.

During 1997, there were a total of 14 six-minute periods of excess emissions and 7 occasions where the monitors were out of service. Quarterly opacity reports of the operational status of the Y-12 Steam Plant are submitted to personnel at TDEC within 30 days after the end of each calendar quarter to comply with the current air permit.

Table C.4 in Appendix C is a record of excess emissions and out-of-service conditions for the east and west stack opacity monitors for 1997.

4.1.5 ORNL Nonradiological Airborne Emissions Monitoring

ORNL operates 21 permitted air emission sources. Most of these sources are small-scale activities and result in very low emission rates. TDEC air permits for ORNL sources do not require stack sampling or monitoring; however, an opacity monitor is used at the steam plant to ensure compliance with visible emissions. The steam plant and two small oil-fired boilers are the largest emission sources at ORNL and account for 98% of all allowable emissions.

For the period from July 1, 1996, through June 30, 1997, ORNL paid $82,333 in annual emission fees to TDEC. These fees are based on allowable emissions (actual emissions are lower than allowable emissions). During 1997, TDEC inspected all permitted emission sources. They were all found to be in compliance.

The ORNL Title V permit application was submitted to TDEC on May 5, 1997. In a letter dated June 5, 1997, TDEC indicated that the application was complete and that ORNL met the requirement to submit an application. TDEC anticipates that the ORNL Title V permit will be issued in 1999.

Actions have been implemented to comply with the prohibition against releasing ozone-depleting substances under Title VI. Also, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements have been implemented. ORNL has taken actions to phase out the use of Class I ozone-depleting substances. The most significant challenge, the replacement or retrofit of large chiller systems that require Class I refrigerants, is progressing on schedule.

4.1.5.1 Results

The primary sources of nonradioactive emissions at ORNL include the steam plant, on the main ORNL site, and two small boilers located in the 7600-area complex. These units use fossil fuels, and therefore criteria pollutants are emitted. A listing of actual vs allowable emissions from these sources is included in Table 4.5. Actual emissions were calculated from fuel usage and EPA emission factors. The steam plant and the 7600-area boilers operated in compliance with visible emission standards during 1997.

4.1.6 ETTP Nonradiological Airborne Emissions Monitoring

Under an application shield granted by the TDEC Division of Air Pollution Control, the ETTP operates 12 major air emissions sources which are subject to Tennessee Title V Major Source Operating Permit Program Rules. No direct monitoring of airborne emissions is required for nonradionuclide emissions from permitted sources. Instead, monitoring of key process parameters is done to ensure compliance with all permitted emission limits.

The ETTP is required to pay annual major source emission fees. To verify the annual air emission fee assessment, based on the ETTP's allowable limits for air pollutants, an inventory of allowable emissions from the permitted sources at the ETTP is updated annually. Table 4.6 shows the allowable emissions of criteria pollutants from ETTP operations for the past 5 years. The ETTP paid annual emission fees based on allowable emissions in 1997 amounting to $14,630. An inventory of actual emissions from all permitted sources in operation at the ETTP was also completed for 1997. Table 4.7 shows actual 1997 emissions from the ETTP.

Title VI of the CAA amendments addresses stratospheric ozone protection. EPA has promulgated a number of regulations to phase out the production and to eliminate the intentional release of regulated ozone-depleting substances to the atmosphere. Ozone-depleting substances are used at the ETTP primarily for office comfort cooling. All Class I CFC-11 comfort cooling units at the site were replaced in 1996 with Class II HCFC-22 units. Recovered CFC-11 from the replaced units (~1600 lb) plus a large inventory of new CFC-11 (~14,000 lb) was sent to Portsmouth and Paducah Gaseous Diffusion Plants for use at those facilities.

4.1.6.1 Results

The major sources of criteria air pollutants at the ETTP are the three remaining steam-generating units in operation at the K-1501 Steam Plant. These remaining units use natural gas as their primary fuel source, with No. 2 fuel oil used as backup during curtailment of natural gas supplies. Table 4.8 presents the actual and allowable emissions from the steam plant for 1997.

Table 4.5. Actual vs allowable air emissions from ORNL steam production, 1997

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate	2	441	0.5
Sulfur dioxide	1072	9062	11.8
Nitrogen oxides	103	531	19.4
Volatile organic compounds	1	3	33.3
Carbon monoxide	82	336	24.4

Table 4.6. Allowable emissions of criteria pollutants from the ETTP, 1993–97

Pollutant	Allowable emissions (tons/year)				
	1993	1994	1995	1996	1997
Particulate matter	180	141	296	247	194
Volatile organic compounds	166	153	167	150	120
Sulfur dioxide	429	429	428	428	428
Nitrogen oxides	226	226	224	224	224
Carbon monoxide	157	157	157	157	157
Miscellaneous	291	145	149	0	0
Total	1449	1251	1421	1206	1122

Table 4.7. Actual emissions of criteria pollutants from the ETTP, 1997

Pollutant	Actual emissions (tons/year)
Particulate matter	6.16
Volatile organic compounds	3.70
Sulfur dioxide	5.53
Nitrogen oxides	23.14
Carbon monoxide	26.48

The TSCA Incinerator is permitted as a major source of air emissions from the ETTP. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Thus, actual emissions from the incinerator are significantly less than the permitted allowable emissions (Table 4.9).

4.2 LIQUID DISCHARGES

4.2.1 Radiological Liquid Discharges

DOE Order 5400.5 sets annual dose standards to members of the public, as a consequence of routine DOE operations, of 100 mrem through all exposure pathways and 4 mrem from the drinking water pathway. Effluent monitoring results are a major component in the determination of compliance with these dose standards.

DOE Order 5400.5 also established DCGs for radionuclides in water. (See Appendix A for a list of radionuclides and their half-lives.) The DCG is the concentration of a given radionuclide for one exposure pathway (e.g., drinking water) that would result in an EDE of 100 mrem (1 mSv) per year to reference man, as defined by the Interna-

Table 4.8. Actual vs allowable air emissions from the K-1501 Steam Plant at the ETTP, 1997

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate matter	1.74	143	1.2
Sulfur dioxide	1.53	389	0.4
Nitrogen oxides	16.06	191	8.4
Volatile organic compounds	1.07	9	11.9
Carbon monoxide	24.71	135	18.3

Table 4.9. Actual vs allowable air emissions from the TSCA Incinerator at the ETTP, 1997

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Lead	0.0012	0.575	0.2
Beryllium	0.000004	0.00037	1.1
Mercury	0.0024	0.088	2.7
Fluorine	0.0009	2.82	0.03
Chlorine	0.019	15.68	0.1
Sulfur dioxide	0.036	38.54	0.09
Particulate	0.006	13.14	0.05

tional Commission on Radiological Protection (ICRP) publication 23 (ICRP 1975). The consumption of water is assumed to be 730 L/year at the DCG level. DCGs were calculated using methodologies consistent with recommendations found in ICRP publications 26 (ICRP 1977) and 30 (ICRP 1978). DCGs are used as reference concentrations for conducting environmental protection programs at DOE sites, as screening values for considering best available technology for treatment of liquid effluents, and for making dose comparisons. Using radiological data, percentages of the DCG for a given isotope are calculated. In the event that a sum of the percentages of the DCGs for each location ever exceeds 100%, an analysis of the best available technology to reduce the sum of the percentages of the DCGs to less than 100% would be required as specified in DOE Order 5400.5.

4.2.1.1 Y-12 Plant Radiological Monitoring Summary

At the Y-12 Plant, a Radiological Monitoring Plan is in place to address compliance with DOE orders and the NPDES permit (TN002968). The permit, issued in 1995, required that the Y-12 Plant reevaluate its RMP and submit results from the monitoring program quarterly, as an addendum to the NPDES Discharge Monitoring Report. There were no discharge limits set by the NPDES permit for radionuclides; the requirement is only to monitor and report. A revised plan (*Radiological Monitoring Plan for the Y-12 Plant: Surface Water*, LMES 1995a) was fully implemented in 1995. The RMP was expanded at that time to allow sufficient collection of data such that an assessment of alpha, beta, and gamma emitters could be made. The intent was to more appropriately identify parameters to be monitored and establish analytical detection limits necessary for dose evaluations.

Based on an analysis of operational history, expected chemical and physical relationships, and historical monitoring results, the plan was updated again in October 1997 (*Radiological Monitoring Plan for the Oak Ridge Y-12 Plant: Surface Water*, Y/TS-1704). Under the monitoring program, effluent monitoring is continued at three types of locations: (1) treatment facilities, (2) other point and area source discharges, and (3) instream locations. One new outfall will be added to the monitoring progam in 1998 (outfall 551, the Central Mercury Treatment Facility), and two outfalls were discontinued during 1997.

Monitoring at Outfall 142 was discontinued for lack of flow, and Station 8, because of its close proximity to Outfall 200, was deemed to be unnecessary. Routine gamma spectometry was discontinued in 1997 because sufficient gamma information has been collected and reported to TDEC as required by the 1995 plan.

Operational history and past monitoring results have provided a basis for monitoring parameters routinely under the plan (Table 4.10).

The RMP also addresses monitoring of the sanitary sewer. The Y-12 Plant is permitted to discharge domestic wastewater to the city of Oak Ridge POTW under Industrial and Commercial User Wastewater Discharge Permit No. 1-91. Radiological monitoring of this discharge is also conducted and is reported to the city of Oak Ridge. Potential sources of radionuclides discharging to the sanitary sewer have been identified in previous studies at the Y-12 Plant as part of an initiative to meet the ALARA goals of the Y-12 Plant. These data show that levels of radioactivity are orders of magnitude below levels established in DOE orders and are not thought to pose a safety or health risk. The radiological monitoring needs for the sanitary sewer were reviewed and summarized in the 1997 update to the RMP (Y/TS-1704).

The following parameters are monitored routinely:

alpha, beta, and gamma activity;
plutonium (^{238}Pu and $^{239/240}$Pu); and
uranium (^{234}U, ^{235}U, ^{236}U, ^{238}U, total uranium, and percentage of ^{235}U).

Furthermore, radiological monitoring of storm water is required by the NPDES permit, and a comprehensive monitoring plan has been designed to fully charactize pollutants in storm-water runoff. The most recent revision of this plan was issued in May 1997, *Storm Water Pollution Prevention Plan for the Oak Ridge Y-12 Plant* (Y/TS-1180/R2), and this plan incorporates the

Table 4.10. Radiological parameters monitored at the Y-12 Plant in 1997

Parameters	Specific isotopes	Rationale for monitoring
Uranium isotopes	^{238}U, ^{235}U, ^{234}U, total U, weight % ^{235}U	These parameters reflect the major activity, uranium processing, throughout the history of the Y-12 Plant and are the dominant detectable radiological parameter in surface water.
Fission and activation products	^{90}Sr, ^{3}H, ^{99}Tc, ^{137}Cs	These parameters reflect a minor activity at Y-12, processing recycled uranium from reactor fuel elements, from the early 60s to the late 80s and will continue to be monitored as tracers for beta and gamma radionuclides although their concentrations in surface water are low.
Transuranium isotopes	^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	These parameters are related to recycle uranium processing. Monitoring continued because of their half-lives and presence in groundwater.
Other isotopes of interest	^{232}Th, ^{230}Th, ^{228}Th, ^{226}Ra, ^{228}Ra	These parameters reflect historical thorium processing and natural radionuclides necessary to characterize background radioisotopes.

radiological monitoring requirements. The NPDES permit requires characterization of a minimum of 25 storm-water outfalls per year, including both grab and composite sampling.

Results

RMP locations sampled in 1997 are noted in Fig. 4.11 (Outfall 142 and Station 8 monitoring was discontinued in 1997). Table 4.11 identifies the monitored locations, the frequency of monitoring, and the sum of DCG percentages for radionuclides measured in 1997. Radiological data for all locations were well below the allowable DCGs. The highest summed percentage of DCGs was from the in-stream location at Station 8. Radium (^{228}Ra) and Uranium (^{238}U) were the major contributors of radioactivity there, contributing 6.2, and 1.1%, respectively, to the total 8.3% of the sum of the percentages of the DCGs.

The Central Pollution Control Facility (Outfall 501) is the only treatment facility that has exceeded maximum allowable DCGs in the past; however, improvements in the treatment process since 1989 have resulted in effluent data consistently well below DCGs. This improvement can be seen in Fig. 4.12, which shows ^{238}U concentrations since 1989.

In 1997, the total mass of uranium and associated curies released from the Y-12 Plant at the easternmost monitoring station, Station 17 on UEFPC, and the westernmost monitoring station, at BCK 4.55 (former NPDES Outfall 304), was 383 kg, or 0.214 Ci (Table 4.12). Figure 4.13 illustrates an 8-year trend of these releases. The total release is calculated by multiplying the average concentration (grams/liter) by the average flow (million gallons/day). Converting units and multiplying by 365 days/year yields the calculated discharge.

The City of Oak Ridge Industrial and Commercial User Wastewater Discharge Permit allows the Y-12 Plant to discharge wastewater to be treated at the Oak Ridge POTW through the East End Sanitary Sewer Monitoring Station (EESSMS), also identified as SS-6 (Fig. 4.11). Compliance samples are collected at this location.

No single radionuclide in the Y-12 Plant contribution to the sanitary sewer exceeded 1% of the DCG listed in DOE Order 5400.5. Summed percentages of DCGs calculated from the Y-12 Plant contribution to the sewer are essentially

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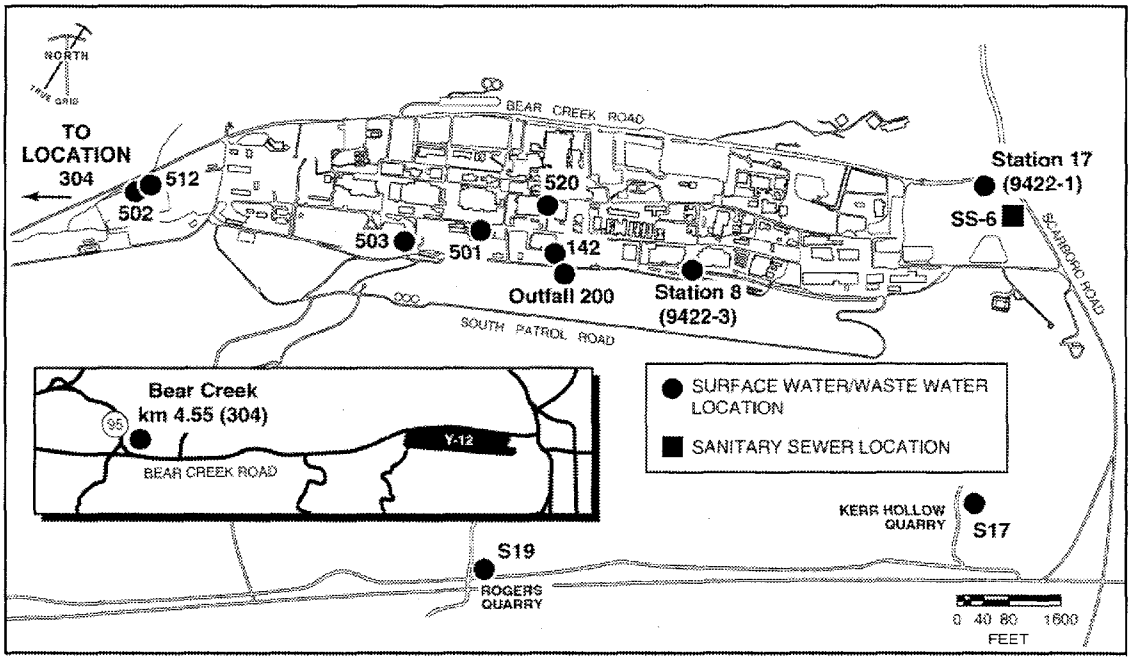

Fig. 4.11. Surface water and sanitary sewer radiological sampling locations at the Y-12 Plant.

Table 4.11. Summary of Y-12 Plant radiological monitoring plan sample requirements

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG percentage
	Y-12 Plant wastewater treatment facilities			
501	Central Pollution Control Facility	1/week	Composite during batch operation	3.4
502	West End Treatment Facility	1/week	24-hour composite	2.4
503	Steam Plant Wastewater Treatment Facility	1/week	24-hour composite	No flow
512	Groundwater Treatment Facility	1/week	24-hour composite	4.2
520 (402)[a]	Steam condensate	1/week	Grab	No flow
	Other Y-12 Plant point and area source discharges			
142[b]	Isotope separation process	1/month	24-hour composite	No flow
S17 (301)[a]	Kerr Hollow Quarry	1/month	24-hour composite	1.1
S19 (302)[a]	Rogers Quarry	1/month	24-hour composite	1.6
	Y-12 Plant instream locations			
BCK 4.55 (304)[a]	Bear Creek, plant exit (west)	1/week	7-day composite	6.7
Station 17	East Fork Poplar Creek, plant exit (east)	1/week	7-day composite	2.9
Station 8[b]	East Fork Poplar Creek, plant site	1/week	7-day composite	8.3
200	North/south pipes	1/week	24-hour composite	6.5

[a]Outfall identifications were changed by the NPDES permit effective July 1, 1995. Former outfall identifications are shown here in parentheses.

[b]Monitoring at this location discontinued in 1997.

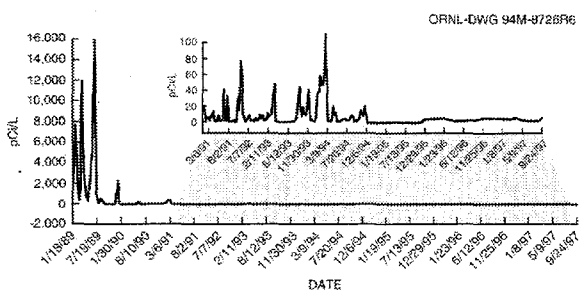

Fig. 4.12. Concentrations of ^{238}U at the Y-12 Plant Outfall 501, January 1989 through December 1997. The allowable DCG for ^{238}U is 600 pCi/L.

zero. Results of radiological monitoring were reported to the city of Oak Ridge with the quarterly monitoring report and are summarized for 1997 in Table 4.13. Figure 4.14 illustrates the 5-year trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

Radiological monitoring of storm water is consistent with past years results. Uranium is the dominant constituent and increases during storm flow, likely because of surface sources as well as from increased groundwater flow. Some parameters are not present at specific outfalls, and grab samples have not provided useful data. Composite samples generally exhibit higher (i.e., detectable) results. Thus a request to discontinue grab sampling of storm-water runoff for radiological analyses was made to TDEC in late 1997. With TDEC approval, the next revision to the Storm Water Monitoring Plan will reflect this change.

4.2.1.2 ORNL Radiological Monitoring Summary

To meet a permit requirement of the new NPDES permit, ORNL submitted to TDEC a revised RMP; approval of the RMP was received from TDEC on July 1, 1997. Under the revised

Table 4.12. Release of uranium from the Y-12 Plant to the off-site environment as a liquid effluent, 1991–97

Year	Quantity released	
	Ci[a]	kg
	Station 17	
1991	0.162	235
1992	0.087	130
1993	0.081	134
1994	0.11	185
1995	0.069	143
1996	0.135	215
1997	0.098	184
	Outfall 304	
1991	0.082	159
1992	0.060	110
1993	0.094	167
1994	0.13	236
1995	0.066	105
1996	0.149	259
1997	0.116	199

[a]1 Ci = 3.7E+10 Bq.

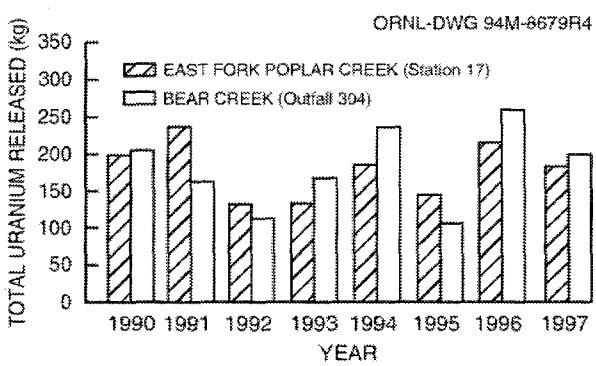

Fig. 4.13. Eight-year trend of Y-12 Plant release of uranium to surface water.

RMP, monitoring of radioactivity is required at three treatment facilities: the Sewage Treatment Plant (STP), the Coal Yard Runoff Treatment Facility (CYRTF), and the Nonradiological Wastewater Treatment Facility (NRWTF), as well as at three instream locations: X13 on Melton Branch, X14 on White Oak Creek, and X15 at White Oak Dam. Additional sites that were monitored under the previous RMP, namely, First Creek, Fifth Creek, Northwest Tributary, 7500 Road Bridge, Raccoon Creek, White Oak Creek Headwaters, and Melton Hill Dam (Fig. 4.15), continued to be monitored by the NPDES program through the remainder of 1997 to ensure continuity of data during transition to another monitoring program. Data for those sites are included with all the other ORNL radiological monitoring results. An assessment of radiological liquid effluents, including numerous category outfalls, was conducted in the summer of 1997. Data gathered during the assessment will be used to complete another revision of the RMP in 1998.

DOE DCGs are used as a means of standardized comparison for effluent points with different isotope signatures. The average concentration is expressed as a percentage of the DCG when a DCG exists and when the average concentration is significantly greater than zero. The calculation of percentage of the DCG for ingestion of water does not imply that effluent points or ambient water sampling stations at ORNL are sources of drinking water.

Results

For 1997, only three radionuclides had an average concentration greater than 4% of the relevant DCG; they were total radioactive strontium (^{89}Sr + ^{90}Sr) with the highest value at NRWTF (24% of the DCG, down from 43% in 1996); ^{3}H with the highest value at monitoring station MB1 (23% of the DCG, down from 34% in 1996), and ^{137}Cs at NRWTF (13% of the DCG, up from 12% in 1996) (Fig. 4.16). Following guidelines given in DOE Order 5400.5, fractional DCG values for the radionuclides detected at each monitoring point are summed to determine whether radioactivity is within acceptable levels. In 1997, the sum of DCG percentages at each effluent point and ambient water station was less than 100% and therefore within acceptable levels. The largest sum of DCG percentages was 42.9%

Table 4.13. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6 (1/1/97–12/31/97)

Parameter	Number of samples	Concentration pCi/L						Standard error	Percentage of DCG	Total curies
		Max	+/–	Min	+/–	Median	+/–			
Alpha activity	56	44.0[a]	56	–1.1[a]	3.2	3.9	*b*	0.96	*b*	5.43E–03
Beta activity	56	290.0[a]	100	0.57[a]	3.6	7.5	*b*	6.2	*b*	2.05E–02
Gamma activity	56	300.0	45	–8.0[a]	30	17.0	*b*	6.5	*b*	3.52E–02
^{238}Pu	1	–0.066[a]	0.076	–0.066[a]	0.076	–0.066[a]	0.076	*b*	–0.16	–6.88E–05
$^{239/240}$Pu	1	–0.087[a]	0.088	–0.087[a]	0.088	–0.087[a]	0.088	*b*	–0.29	–9.07E–05
^{234}U	56	8.3	1.4	1.2	0.58	3.2	*b*	0.18	0.64	3.62E–03
^{235}U	57	6.4[a]	15	–0.73[a]	0.15	0.11[a]	0.16	0.11	0.018	2.23E–04
^{236}U	19	0.17[a]	0.24	–0.016[a]	0.031	0.054[a]	0.11	0.012	0.011	5.93E–05
^{238}U	56	5.1	1.0	1.2	0.42	1.85	*b*	0.14	0.31	2.33E–03

[a]Result was below the minimum detectable activity.
[b]Not applicable.

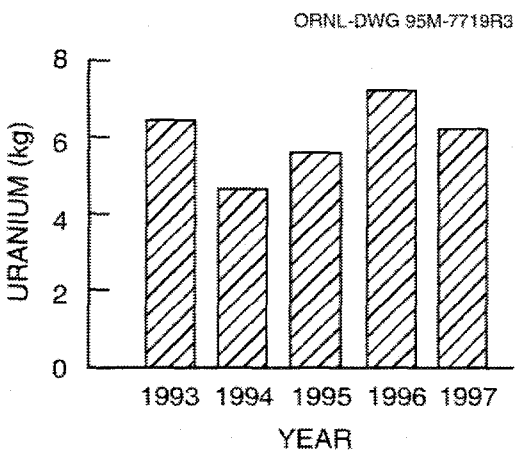

Fig. 4.14. Five-year trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

at NRWTF (down from 59.9% at NRWTF in 1996).

Amounts of radioactivity released at WOD are calculated from concentration and flow. As shown in Figs. 4.17, 4.18, 4.19, 4.20, 4.21, and 4.22, the total discharges (or amounts) of radioactivity released at WOD during the past 5 years have remained in the same range of values.

4.2.1.3 ETTP Radiological Monitoring Summary

The ETTP conducts radiological monitoring of liquid effluent to determine compliance with applicable dose standards. It also applies the ALARA process to maintain potential exposures to members of the public as low as is reasonably achievable.

Sample Collection and Analytical Procedure

The ETTP monitored two major effluent discharge points for radiological parameters: the K-1203 STP discharge (Outfall 005) and the treated effluent from the K-1407-J Central Neutralization Facility (CNF) (Outfall 014) (Fig. 4.23). Weekly samples were collected from the CNF. The weekly samples were composited into monthly samples. A single monthly 24-h composite sample is collected at K-1203. These samples are then analyzed for radionuclides. Results of these sampling efforts were compared with the DCGs.

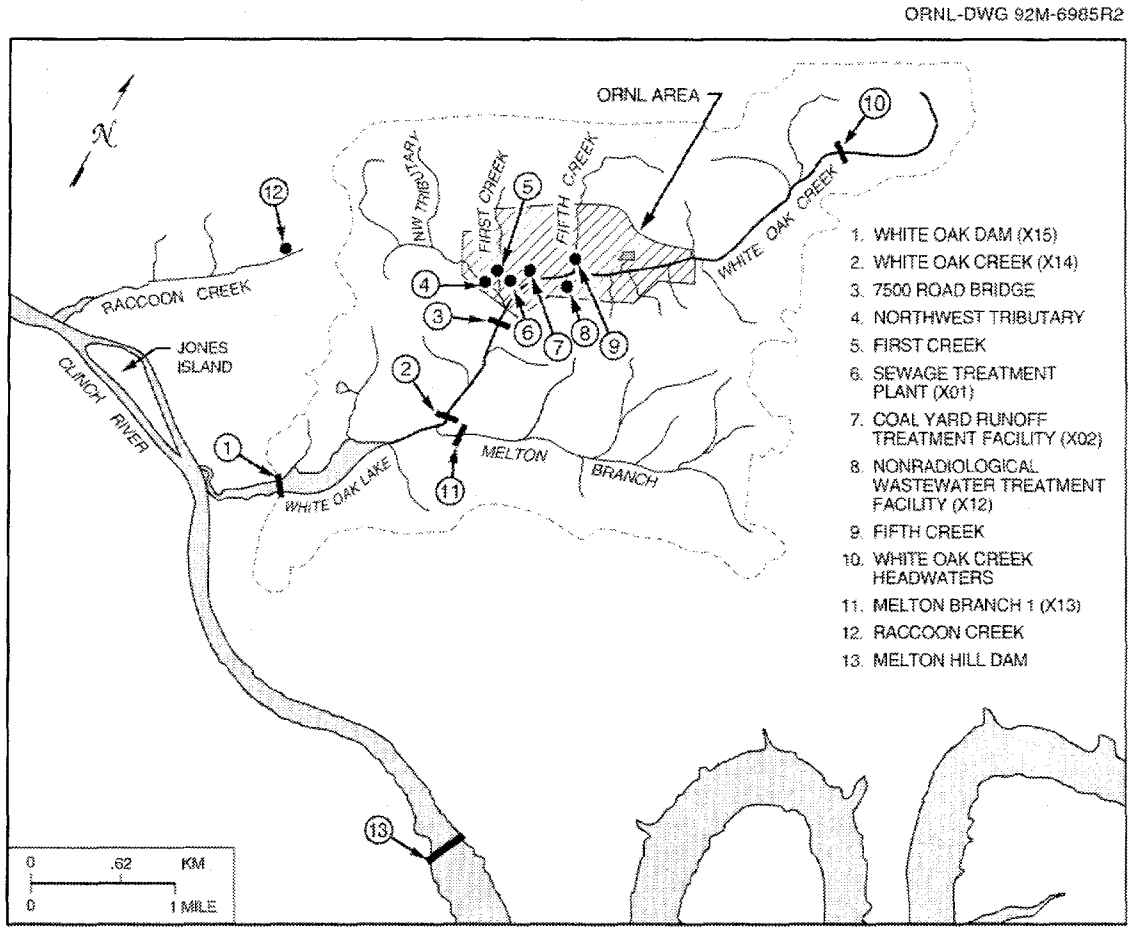

Fig. 4.15. ORNL surface water, NPDES, and reference sampling locations. Bars (I) indicate sampling locations that have weirs.

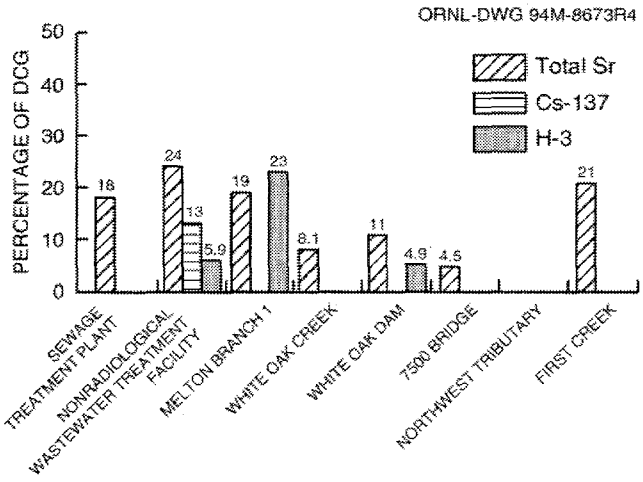

Fig. 4.16. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 1997.

Results

The sum of the fractions of the DCGs at K-1407-J was calculated at 31.4% for CY 1997, up from 18% for CY 1996. The increase was determined to be caused by changes in TSCA Incinerator feed material. The sum of the fractions of the DCGs for effluent location K-1203 was less than 1%. Table 4.14 lists radionuclides discharged from the ETTP to off-site surface waters in 1997.

Uranium discharges to surface waters during a 5-year period were investigated to observe their trend (Fig. 4.24). The effluent point having the greatest DCG percentage was the K-1407-J outfall. Uranium isotopes were the major contri-

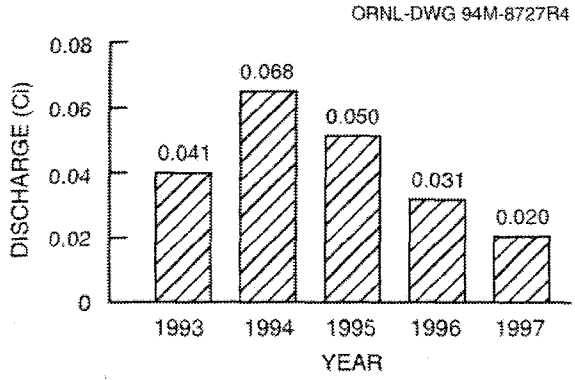

Fig. 4.17. Cobalt-60 discharges at White Oak Dam, 1993–97.

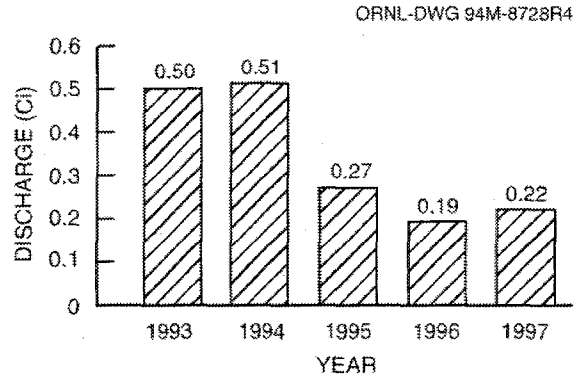

Fig. 4.18. Cesium-137 discharges at White Oak Dam, 1993–97.

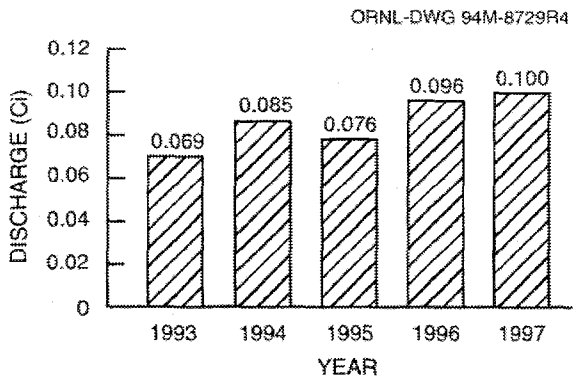

Fig. 4.19. Gross alpha discharges at White Oak Dam, 1993–97.

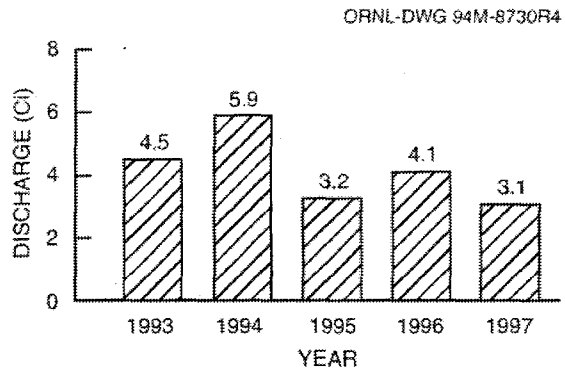

Fig. 4.20. Gross beta discharges at White Oak Dam, 1993–97.

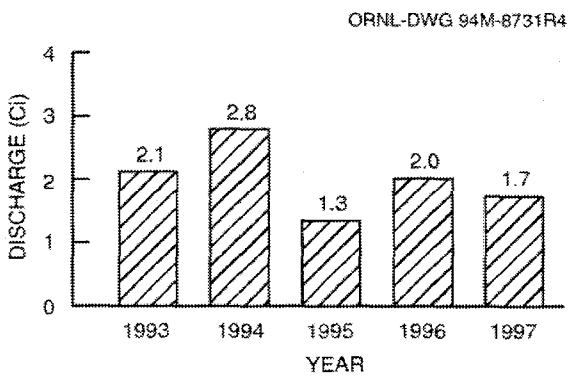

Fig. 4.21. Total radioactive strontium discharges at White Oak Dam, 1993–97.

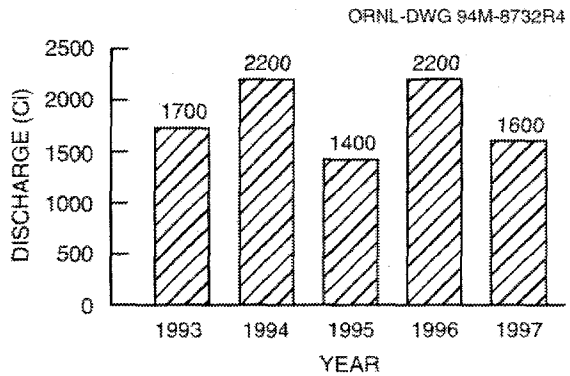

Fig. 4.22. Tritium discharges at White Oak Dam, 1993–97.

ORNL-DWG 94M-7183R3

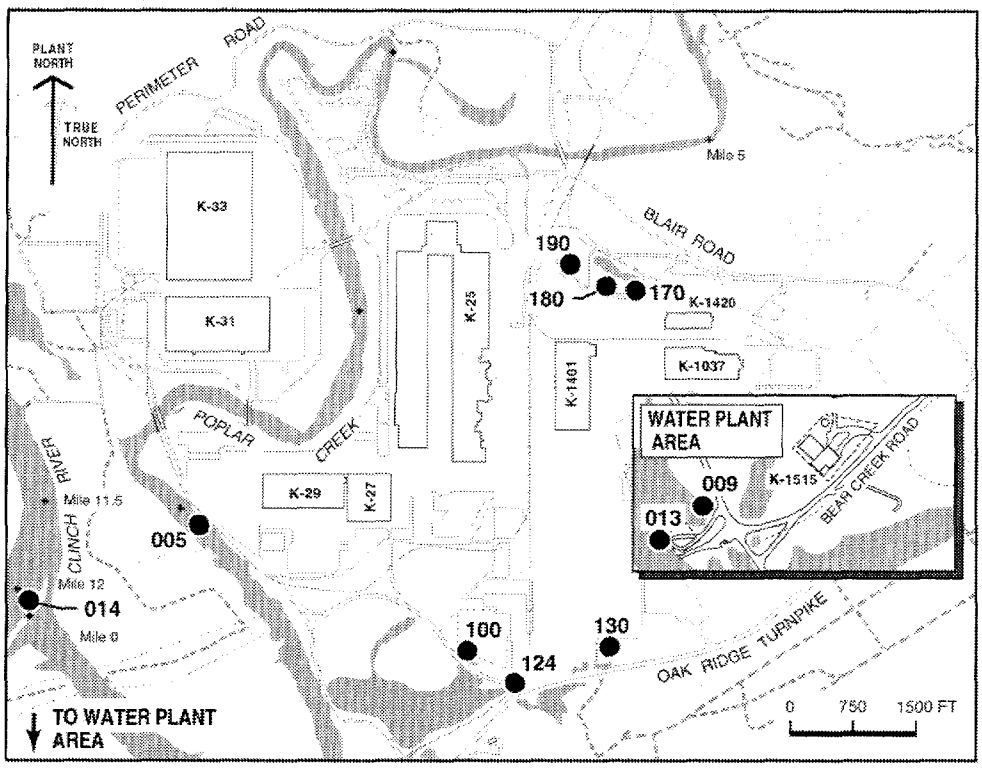

Fig. 4.23. ETTP NPDES major outfalls and Category I storm drain outfalls.

Table 4.14. Radionuclides released to off-site surface waters from the ETTP, 1997
Effluent discharge locations K-1203 and K-1407-J

Isotope	Amount (Ci)[a]	Isotope	Amount (Ci)[a]
^{137}Cs	9.5E–4	^{234}Th	2.1E–3
^{237}Np	2.3E–5	^{234}U	6.4E–3
^{238}Pu	6.7E–4	^{235}U	4.8E–4
^{239}Pu	1.2E–5	^{236}U	8.4E–4
^{99}Tc	6.0E–2	^{238}U	1.1E–2

[a]1 Ci = 3.7E+10 Bq.

butors (Fig. 4.25). The fluctuation in uranium discharges is attributed to TSCA Incinerator wastewater, which is sent to the CNF for treatment before discharging at K-1407-J (Outfall 014).

4.2.2 Nonradiological Liquid Discharges

The Federal Water Pollution Control Act and its amendments, more commonly known as the CWA, were the culmination of almost a century of litigation and political debates about water pollution. The two main goals of the CWA are (1) to attain a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water and (2) to eliminate the discharge of pollutants into waters of the United States.

The CWA requires that EPA establish limits on the amounts of specific pollutants that may be discharged to surface waters. The standards,

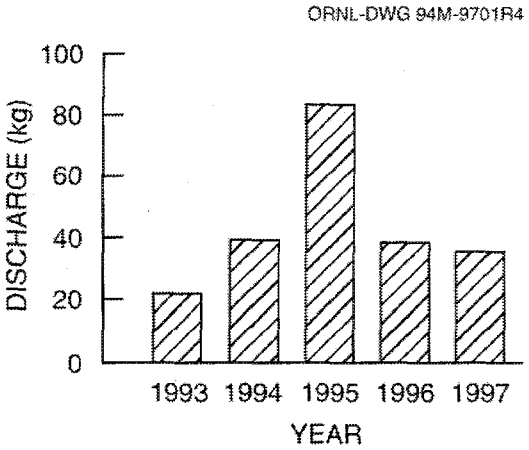

Fig. 4.24. Five-year trend of uranium releases to surface waters from the ETTP. Analysis includes discharge locations K-1203 and K-1407-J.

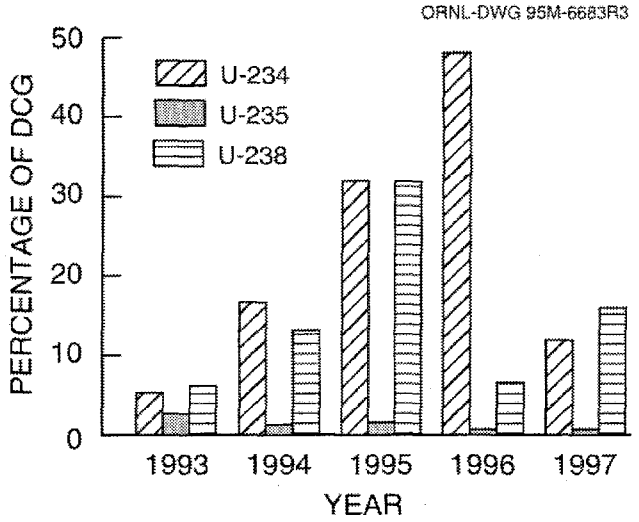

Fig. 4.25. Percentage of DCG for uranium isotopes from K-1407-J.

called effluent limitations, are written into NPDES permits issued to all municipal and industrial dischargers. The Y-12 Plant, ORNL, and the ETTP are each required to monitor discharges at frequencies specified in their permits to ensure compliance with the NPDES effluent limitations. The TDEC Division of Water Pollution Control has the authority to issue NPDES permits and to monitor compliance with the permits in the state of Tennessee under the Tennessee Water Quality Control Act and according to the rules and regulations of the Tennessee Water Quality Control Board. DOE wastewater treatment facilities have formal wastewater acceptability control and surveillance programs that ensure the protection of the facilities and the proper treatment of wastes. Among other things, these programs define pretreatment requirements and waste acceptance criteria. Discharges are regulated under NPDES permits.

The CWA also created the Federal Pretreatment Program to regulate industrial discharges to sanitary sewer systems, which are also referred to as POTWs. Under the Federal Pretreatment Program, industries are required to monitor and regulate their discharges to a POTW. The state of Tennessee has created the Tennessee Pretreatment Program, which requires municipalities to develop their own municipal POTWs for their local industries. Municipal POTWs issue permits to industries, spelling out the responsibilities of the industries for pretreatment and compliance with the sewer-use ordinance. These responsibilities include monitoring their waste streams to determine pollutant concentration limits.

Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW. Both ORNL and the ETTP have on-site sewage treatment plants.

4.2.2.1 Y-12 Plant Surface Water and Liquid Effluents

The current Y-12 Plant NPDES permit, issued on April 28, 1995, and effective on July 1, 1995, requires sampling, analysis, and reporting at approximately 100 outfalls. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. In 1997, one outfall (Outfall 066) was physically eliminated. During the previous several years, approximately 100 outfalls were eliminated as part of a program to remove or consolidate outfall pipes on EFPC. Currently, the Y-12 Plant has outfalls and monitoring points in the following water drainage areas: EFPC, Bear Creek, and several unnamed tributaries on the south side of Chestnut Ridge. These creeks and tributaries eventually drain to the Clinch River.

At the end of 1997, there were 60 outfalls discharging various types of wastewater (condensate, cooling water, groundwater, water from building sumps, treated process wastewaters, and other wastewaters) to EFPC. Of the 60 outfalls, 9 discharge storm water only, 3 discharge steam condensate only, 2 discharge groundwater only, and 2 are potable water blowdowns. Twenty-seven other storm water outfalls are actually instream monitoring locations throughout the Y-12 Plant area. Seven internal monitoring points are used to monitor the effluent from wastewater treatment facilities.

Discharges to surface water allowed under the permit include storm drainage, cooling water, cooling tower blowdown, and treated process wastewaters, including effluents from wastewater treatment facilities. Sumps that collect groundwater inflow in building basements are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permittted discharges are compared to NPDES limits where a limit exists for each parameter. Some parameters are "monitor only," with no limits specified.

The water quality of surface streams in the vicinity of the Y-12 Plant is affected by current and past operations. Discharges from Y-12 Plant processes affect water quality and flow in EFPC before the water enters Lake Reality at the eastern end of the Y-12 Plant and eventually flow through the city of Oak Ridge to Poplar Creek and into the Clinch River. In past years, discharge of coal bottom ash slurry to the McCoy Branch from the Y-12 Steam Plant occurred. This practice has been stopped, and coal ash is currently collected dry and is being used for recycle or for filler to support landfill operations. Bear Creek water quality is affected by area source runoff and groundwater discharges, and only storm water runoff is monitored under the NPDES permit (see Chap. 7 for details on groundwater).

Nineteen ninety-seven was the second full calendar year the Y-12 Plant operated under the permit that had been issued in 1995. The effluent limitations contained in the permit are based on the protection of water quality in the receiving streams. The permit places emphasis on storm water runoff and biological, toxicological, and radiological monitoring. Some of the more significant requirements in the permit and the status of compliance are as follows:

- toxicity limitation for the headwaters of EFPC (see Sect. 4.3.1)
- quarterly toxicity testing at the wastewater treatment facilities (see Sect. 4.3.1)
- a compliance schedule to reduce mercury in EFPC (see Reduction of Mercury in Plant Effluent in Sect. 4.2.2.2)
- a compliance schedule for chlorine limitations at outfalls containing cooling water (complete)
- chlorine limitations based on water quality criteria at the headwaters of EFPC (monitoring ongoing, chlorine limits are being met)
- a compliance schedule for correction of elevated ammonia concentrations discharged to EFPC from a groundwater spring (complete)
- a requirement to manage the flow of EFPC such that a minimum flow of 7 million gal/day is guaranteed by adding raw water from the Clinch River to the headwaters of EFPC (complete)
- sampling of storm water at a minimum of 25 locations per year (in second year of monitoring)
- a storm water pollution plan (plan updated in 1997), and
- instream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge (monitoring ongoing)

Sanitary Wastewater

Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW under Industrial and Commercial Users Wastewater Permit Number 1-91. A revision to the permit was issued August 25, 1997, by the city of Oak Ridge. A number of allowable discharge concentrations were modified in the new permit. Monitoring is conducted under the terms of the permit for a variety of organic and inorganic pollutants. During 1997, the wastewater flow in this

system averaged about 754,000 gal/day (2,850,000 L/day).

Compliance sampling is conducted at the EESSMS (SS-6, Fig. 4.11) on a weekly basis. In addition, throughout 1997 mercury composite samples were obtained daily, Monday through Thursday, and a 3-day composite was obtained for the weekend (Friday through Sunday). This monitoring station is also used for 24-hour flow monitoring. As part of the city of Oak Ridge pretreatment program, city personnel also use this monitoring station to perform compliance monitoring as required by pretreatment regulations.

Storm Water

The development and implementation of a Storm Water Pollution Prevention Plan for the Y-12 Plant is required by Part IV of the NPDES permit. The objective of the plan is to minimize the discharge of pollutants in storm water runoff at the Y-12 Plant by assessing the quality of storm water discharges from the site, determining potential sources of pollutants affecting storm water, and providing effective controls to reduce or eliminate these pollutant sources. The plan is reviewed at least annually and updated, as necessary, to reflect changes in plant operations and incorporate revised monitoring strategies based on data from past years. The most recent revision of this plan was issued in May 1997, *Storm Water Pollution Prevention Plan for the Oak Ridge Y-12 Plant,* (Y/TS-1180/R2). The NPDES permit requires sampling of a minimum of 25 storm water outfalls per year, including both grab and composite sampling. Each year approximately 1500 chemical analyses are conducted on storm water samples at the Y-12 Plant.

4.2.2.2 Results and Progress in Implementing Corrective Actions

In 1997, the Y-12 Plant reduced NPDES excursions from ten in 1996 to seven in 1997. The seven excursions were attributed to following: an oil sheen on EFPC from a diesel fuel spill during filling of an underground tank, a high pH reading from a discharge from the Central Pollution Control Facility (CPCF), two exceedences of the permit limit for mercury from bypass of the East End Mercury Treatment Facility during a hundred-year flood event, two exceedences of the permit limit for nitrates from the discharge of the CPCF, and one excursion for low flow (monthly average) at Station 17. Additional detail on all Y-12 Plant NPDES permit excursions recorded in 1997 and the associated corrective action are summarized in Appendix F, Table F.1. As in the past year, none of the Y-12 Plant NPDES excursions were attributable to administrative errors such as missing analytical sample holding times, loss of a sample, or improper sample preservation. Table 4.15 lists the NPDES compliance monitoring requirements and the 1997 compliance record.

During 1997, the Y-12 Plant experienced three exceedences of the Industrial and Commercial Users Wastewater Permit for discharge of sanitary wastewater to the city of Oak Ridge POTW. The exceedences were for iron, copper, and cyanide. Although no specific cause could be determined, there are a number of construction activities involving the sanitary sewer that may have contributed to these exceedences. The construction activities are part of an ongoing multimillion-dollar sanitary sewer upgrade project that is expected to continue through FY 1999. Table 4.16 summarizes Y-12 Plant monitoring of the discharge to the sanitary sewer during 1997.

Review of storm water data from past years has established that some pollutants are not present at specific outfalls. It also has been established that for some parameters, grab and composite sample results are very similar. For these reasons, and with TDEC approval, the Storm Water Monitoring Plan will be revised to reflect reduced storm water monitoring in 1998.

East Fork Poplar Creek Dechlorination and Fish Kill Summary

During 1997, as in the past 4 years, instream levels of total residual chlorine were about 0.01 mg/L (outfall discharge levels prior to 1993 were about 0.3 to 1.0 mg/L). This reduction is a result of two dechlorination systems and 42 tablet

Table 4.15. NPDES compliance monitoring requirements and record for the Y-12 Plant, January through December 1997

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 066	pH, standard units			*a*	9.0	100	3
Outfall 068	pH, standard units			*a*	9.0	100	12
Outfall 117	pH, standard units			*a*	9.0	100	12
Outfall 073	pH, standard units			*a*	9.0	100	11
	Total residual chlorine				0.5	100	12
Outfall 077	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	13
Outfall 122	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	0
Outfall 133	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	0
Outfall 125	pH, standard units			*a*	9.0	100	14
	Total residual chlorine				0.5	100	12
Category I outfalls (Storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			*a*	9.0	100	60
Category I outfalls (Outfalls S15 and S16)	pH, standard units			*a*	10.0	100	5
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			*a*	9.0	100	108
	Total residual chlorine				0.5	100	68
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			*a*	10.0	100	26
Outfall S19 (Rogers Quarry)	pH, standard units			*a*	9.0	100	14

Table 4.15 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Category III outfalls (storm water, cooling water, cooling tower blowdown, steam condensate, and groundwater)	pH, standard units			*a*	9.0	100	157
	Total residual chlorine				0.5	100	130
Outfall 201 (below the North/South pipes)	Total residual chlorine			0.011	0.019	100	157
	Temperature, °C			*a*	30.5	100	157
	pH, standard units		8.5	*a*		100	157
Outfall 200 (North/South pipes)	Oil and grease			10	15	100	159
Outfall 021	Total residual chlorine			0.080	0.188	100	157
	Temperature, °C			*a*	30.5	100	158
	pH, standard units				9.0	100	159
Outfall 017	pH, standard units			*a*	9.0	100	54
	Ammonia as N			32.4	64.8	100	54
Outfall 055	pH, standard units			*a*	9.0	100	103
	Mercury				0.004	98	108
	Total residual chlorine				0.5	100	103
Outfall 55A	pH, standard units			*a*	9.0	b	0
	Mercury				0.004	b	0
Outfall 550	pH, standard units			*a*	9.0	100	52
	Mercury			0.002	0.004	100	52
Outfall 551	pH, standard units				9.0	100	52
	Mercury				0.004	100	52
Outfall 051	pH, standard units			*a*	9.0	100	103
Outfall 501 (Central Pollution Control Facility)	pH, standard units			*a*	9.0	94	18
	Total suspended solids			31.0	40.0	100	16
	Total toxic organics				2.13	100	1
	Oil and grease			10	15	100	16
	Cadmium	0.16	0.4	0.075	0.15	100	16
	Chromium	1.0	1.7	0.5	1.0	100	16
	Copper	1.2	2.0	0.5	1.0	100	16
	Lead	0.20	0.4	0.1	0.2	100	16
	Nickel	1.4	2.4	2.38	3.98	100	16
	Nitrate/Nitrite				100	88	16
	Silver	0.14	0.26	0.05	0.05	100	16
	Zinc	0.9	1.6	1.48	2.0	100	16
	Cyanide	0.4	0.72	0.65	1.20	100	16
	PCB				0.001	100	1

Table 4.15 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 502 (West End Treatment Facility)	pH, standard units			*a*	9.0	100	35
	Total suspended solids	18.6	36.0	31.0	40.0	100	35
	Total toxic organics				2.13	100	5
	Nitrate/nitrite			100	150	100	35
	Oil and grease		10		15	100	35
	Cadmium	0.16	0.4	0.075	0.15	100	35
	Chromium	1.0	1.7	0.5	1.0	100	35
	Copper	1.2	2.0	0.5	1.0	100	35
	Lead	0.26	0.4	0.10	0.20	100	35
	Nickel	1.4	2.4	2.38	3.98	100	35
	Silver	0.14	0.26	0.05	0.05	100	35
	Zinc	0.9	1.6	1.48	2.0	100	35
	Cyanide	0.4	0.72	0.65	1.2	100	35
	PCB				0.001	100	5
Outfall 503 (Steam Plant Wastewater Treatment Facility)	pH, standard units			*a*	9.0	*b*	0
	Total suspended solids	125	417	30.0	40.0	*b*	0
	Oil and grease	62.6	83.4	10	15	*b*	0
	Iron	4.17	4.17	1.0	1.0	*b*	0
	Cadmium			0.075	0.15	*b*	0
	Chromium	0.83	0.83	0.20	0.20	*b*	0
	Copper	4.17	4.17	0.20	0.40	*b*	0
	Lead			0.10	0.20	*b*	0
	Zinc	4.17	4.17	1.0	1.0	*b*	0
Outfall 512 (Groundwater Treatment Facility)	pH			*a*	9.0	100	147
	Iron				1.0	100	147
	PCB				0.001	100	12
Outfall 520	pH, standard units				9.0	*b*	0
Outfall 05A	pH				9.0	100	4

[a]Not applicable.
[b]No discharge.

dechlorinators that were brought on line from 1992 through 1995. While reduced chlorine levels have contributed to ecological recovery of EFPC, a large, accidental release of a dechorination chemical on July 24, 1997, killed approximately 24,000 fish in UEFPC.

Most of these fish were central stonerollers (*Campostoma anomalum*) and blacknose dace (*Rhinichthys atratulus*). Other species killed included striped shiners (*Luxilus chrysocephalus*) and redbreast sunfish (*Lepomis auritus*). The fish kill was caused by an excess amount of dechlorinating chemical—sodium bisulfite—that was added to the creek, reacted with the water, reduced oxygen levels, and killed the fish. The problem followed heavy flooding during the night of July 22. A storm cell associated with Hurricane Danny released approximately 6 in. of rain on the Y-12 Plant in approximately 1½ hours. The dechlorinating system, and the raw water line

Table 4.16. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6, nonradiological summary (1/1/97–12/31/97)

Parameter	Number of samples	Concentration[a]			Reference value[b]	Number of values exceeding reference
		Max	Min	Avg		
Flow, gpd[c]	365	1814831.0	456418.0	754190.7	*d*/1.4	*d*
pH, std unit	54	7.9	7.0	*d*	9/6(*e*)	0
Silver	53	0.011	0.0014	<0.0066	0.1/0.1	0
Arsenic	53	<0.042	<0.003	<0.03	0.1/0.0045	0
Boron	53	0.47	<0.02	<0.04	*d*/*d*	*d*
Benzene	13	0.01	0.005	0.008	0.87/0.015	0
Biochemical oxygen demand	53	90.0	11.0	39.2	300/300	0
Cadmium	53	<0.004	<0.0015	<0.003	0.004/0.004 5	0
Chemical oxygen demand	8	103.0	41.0	71.4	*d*/*d*	*d*
Chromium	53	<0.006	0.0013	<0.005	0.44/0.075	0
Chromium, hexavalent	8	<0.01	<0.01	<0.01	0.01/*d*	0
Copper	53	0.217	0.007	0.03	0.04/0.092	1
Cyanide	13	0.015	<0.01	<0.01	0.01/0.062	1
Iron	53	1.91	0.34	0.61	1.5/15	1
Mercury	248	0.013	0.0003	0.002	0.035/0.035	0
Kjeldahl nitrogen	53	20.0	0.34	9.6	90/90	0
Methylene chloride	13	0.01	0.005	0.008	0.22/0.041	0
Manganese	53	0.085	0.031	0.056	1/*d*	0
Nickel	53	<0.008	<0.003	<0.008	0.1/0.032	0
Oil and grease	53	20.1	2.2	<6.2	50/50	0
Lead	53	<0.02	<0.003	<0.02	0.02/0.074	0
Phenols—total recoverable	22	0.032	<0.005	<0.02	5/0.5	0
Selenium	53	<0.1	<0.003	<0.1	*d*/*d*	*d*
Suspended solids	58	85.5	<5.0	<55	300/300	0
Toluene	13	0.01	0.005	0.008	5.35/0.02	0
Trichloroethene	13	0.002	0.001	0.002	0.045/0.027	0
Zinc	53	0.37	0.07	0.1	2/0.75	0
Uranium	56	0.014	0.0026	0.006	*d*/*d*	*d*
^{235}U, weight %	56	2.2	0.38	0.80	*d*/*d*	*d*

[a]Units in mg/L unless otherwise indicated.
[b]Sanitary sewer permit limits prior to August 25/ limits effective August 25 or after.
[c]Flow during operations and/or discharging.
[d]Not applicable.
[e]Maximum value/minimum value.

from the Clinch River that supplements the flow in EFPC, were shut off after the rainfall. Even though the dechlorinating system was shut off, an elevated tank allowed some of the chemical to bleed through a pump line into a mixing box. When the system was restarted on July 24, the excess chemical in the box was released to the creek. The malfunctioning feed system has been modified to prevent similar incidents.

Flow Management (or Raw Water) Project

Because of concern about maintaining water quality and stable flow in the upper reaches of EFPC, the NPDES permit requires addition of Clinch River water to the headwaters of EFPC (North/South Pipe-Outfall 200 area) so that a minimum flow of 7 million gal/day (26.5 million L/day) is maintained at the point where EFPC leaves the reservation (Station 17). The permit required that this project be implemented by March 1997, but the work was completed ahead of schedule (August 1996). With the completion of this project, instream water temperatures decreased approximately 5°C (from approximately 26°C at the headwaters). During September 1997, the monthly average daily flow at Station 17 was 6.9 million gallons per day. This was a result of a drier (less rainfall) than normal month and the unavailability of one of two raw water feed lines because of needed repair. A funding request has been made for repair to the second raw water line.

Drain Modifications and Reroutes

Extensive drain surveys conducted prior to 1993 identified building drains that were incorrectly connected to either the sanitary or storm sewers. Most of these drains were administratively closed at that time. Permanent and physical changes to provide correct drain routings have been completed for 29 buildings. In addition, a project to survey all the remaining and previously unsurveyed building drains at the Y-12 Plant was completed in early 1995. Incorrectly routed drains were identified for closure or correction, and many drains were corrected or eliminated. A validation project was initiated in 1996 to confirm the status of building floor drains. Any drains found to be open are required to be plugged or "permitted" open by an internal process. New building drain maps and drain status records are being generated. This work is planned for completion in 1998.

Reduction of Mercury in Plant Effluent: Phase II

The legacy of contamination resulting from use and storage of mercury at the Y-12 Plant has prompted a series of remedial measures. These efforts are directed toward meeting the NPDES permit requirements of 5 g/day from the Y-12 Plant by December 31, 1998. To date, six projects (four building source elimination efforts and two treatment units) have been completed under the Reduction of Mercury in Plant Effluent (RMPE) II program to reduce mercury contamination to UEFPC.

Additional work continued in 1997, which included development of a treatment approach for Outfall 51 (a mercury-contaminated spring), evaluation of stannous chloride additive to enhance air stripping of mercury, evaluation of several potential mercury-removing media in small-scale column tests, and a temporary, dry-weather bypass test of Lake Reality.

Although Lake Reality tends to trap sediment during storm events, it appears to have been a source of contaminants during dry weather, and anaerobic conditions in the lake generate methyl mercury. During dry weather there was a mercury increase across the lake (inlet to outlet) of approximately 5 grams per day. During the bypass test, mercury levels, as measured at Station 17, were approximately the same as at the lake inlet, thus reflecting an approximate 5-gram reduction as a result of the bypass. Because of these positive results achieved with a temporary bypass, a permanent bypass configuration is planned for 1998 where all flow, except for the most significant storm flows, will bypass the lake. However, the configuration will maintain the capability to divert flow to Lake Reality to capture a spill from within the plant if necessary.

Additional work in 1998 will consider treatment of Outfall 51 and redirection of some small volume of mercury-contaminated drainage to treatment. Future long-range mercury remediation for EFPC will be driven by the CERCLA process and the record of decision (ROD) for UEFPC Characterization area.

4.2.2.3 ORNL NPDES Summary

NPDES Permit Monitoring

ORNL NPDES Permit TN0002941 was renewed on December 6, 1996, and became effective on February 3, 1997. Data collected for the NPDES permit are submitted to the state of Tennessee in the monthly *Discharge Monitoring Report*. The renewed permit includes 164 separate outfalls and monitoring points.

ORNL's NPDES permit requires that point-source outfalls be sampled before they are discharged into receiving waters or before they mix with any other wastewater stream (see Fig. 4.15). Under the renewed permit, numeric and aesthetic effluent limits have been placed on the following locations:

- X01- Sewage Treatment Plant;
- X02-Coal Yard Runoff Treatment Facility;
- X12-Nonradiological Wastewater Treatment Facility;
- X13-Melton Branch (MB1);
- X14-White Oak Creek;
- X15-White Oak Dam;
- Instream chlorine monitoring points (X16-X26);
- Steam condensate outfalls;
- Groundwater from building foundation drains;
- Category I outfalls (storm drains, water discharged under best management practices, groundwater, steam and water condensate);
- Category II outfalls (storm drains, water discharged under best management practices, groundwater, steam and water condensate);
- Category III outfalls (storm drains, water discharged under best management practices, groundwater, steam and water condensate, cooling water, and cooling tower blowdown);
- Category IV outfalls (storm drains, water discharged under best management practices, groundwater, steam and water condensate, cooling water, and cooling tower blowdown); and
- Cooling systems (cooling water, cooling tower blowdown).

Permit limits and compliance statistics are shown in Table 4.17. Permit limit exceedences in 1997 are shown in Fig. 4.26. Most permit limit excursions in 1997 involved exceedence of chlorine limits at cooling water and cooling tower blowdown outfalls. Dechlorination systems have been upgraded to guard against recurrence.

ORNL Outfall X01, the STP, experienced a daily maximum concentration and a daily maximum loading exceedence of the carbonaceous biochemical oxygen demand (CBOD) limit on October 9, 1997. As a corrective measure, the dechlorination system feed was modified at the STP. There were no additional instances of nonconformance after the one on October 9, 1997.

One Category IV outfall, 302, experienced one pH limit exceedence (pH of 9.1 measured on November 17, 1997). Corrective actions to mitigate the exceedence included identifying and repairing an underground leak in a waste treatment system component.

Under the renewed NPDES permit, ORNL has initiated several new monitoring plans and programs. These include the RMP, the Chlorine Control Strategy (CCS), and the Storm Water Pollution Prevention (SWPP) Plan. Each of these is discussed in the following sections.

Radiological Monitoring Plan

To meet a permit requirement of the new NPDES permit, ORNL submitted to TDEC a revised RMP. Approval of the RMP was received from TDEC July 1, 1997. Under the revised RMP, monitoring of radioactivity is required at three treatment facilities, STP, CYRTF, and NRWTF, and at three instream locations, X13 on Melton

Table 4.17. 1997 NPDES compliance at ORNL (NPDES permit effective Feb. 3, 1997)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)	96-hour LC_{50} for *Ceriodaphnia* (%)					41.1	0	3	100
	96-hour LC_{50} for fathead minnows (%)					41.1	0	3	100
	Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	79	100
	Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	64	100
	Carbonaceous biochemical oxygen demand	8.7	13.1	10	15		2	143	99
	Dissolved oxygen					6	0	144	100
	Fecal coliform (col/100 mL)			1000	5000		0	144	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					12.3	0	3	100
	No-observed-effect conc. for fathead minnows (%)					12.3	0	3	100
	Oil and grease	8.7	13.1	10	15		0	144	100
	pH (std. units)				9	6	0	144	100
	Total residual chlorine			0.038	0.066		2	147	99
	Total suspended solids	26.2	39.2	30	45		0	143	100
X02 (Coal Yard Runoff Treatment Facility)	96-hour LC_{50} for *Ceriodaphnia* (%)					4.2	0	4	100
	96-hour LC_{50} for fathead minnows (%)					4.2	0	4	100
	Copper, total			0.07	0.11		0	22	100
	Iron, total			1.0	1.0		0	22	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					1.3	0	2	100
	No-observed-effect conc. for fathead minnows (%)					1.3	0	2	100
	Oil and grease			10	15		0	48	100
	pH (std. units)				9.0	6.0	0	48	100
	Selenium, total			0.22	0.95		0	22	100
	Silver, total				0.008		0	22	100
	Total suspended solids				50		0	48	100
	Zinc, total			0.87	0.95		0	22	100

Table 4.17 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X12 (Nonradiological Wastewater Treatment Facility)	96-hour LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
	96-hour LC_{50} for fathead minnows (%)					100	0	4	100
	Cadmium, total	0.79	2.09	0.008	0.034		0	48	100
	Chromium, total	5.18	8.39	0.22	0.44		0	48	100
	Copper, total	6.27	10.24	0.07	0.11		0	48	100
	Cyanide, total	1.97	3.64	0.008	0.046		0	4	100
	Lead, total	1.3	2.09	0.028	0.69		0	48	100
	Nickel, total	7.21	12.06	0.87	3.98		0	48	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					30.9	0	4	100
	No-observed-effect conc. for fathead minnows (%)					30.9	0	4	100
	Oil and grease	30.3	45.4	10	15		0	48	100
	pH (std. units)				9.0	6.0	0	144	100
	Silver, total	0.73	1.3		0.008		0	48	100
	Temperature (°C)				30.5		0	144	100
	Total toxic organics		6.45		2.13		0	11	100
	Zinc, total	4.48	7.91	0.87	0.95		0	48	100
Instream chlorine monitoring points	Total residual oxidant			0.011	0.019		2	242	99
Steam condensate outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	17	100
Groundwater/ pumpwater outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	8	100

Table 4.17 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
Cooling tower blowdown outfalls	pH (std. units)				9.0	6.0	0	2	100
Category I outfalls	pH (std. units)				9.0	6.0	0	13	100
Category II outfalls	pH (std. units)				9.0	6.0	0	15	100
Category III outfalls	pH (std. units)				9.0	6.0	0	63	100
Category IV outfalls	pH (std. units)				9.0	6.0	1	296	100
Cooling tower blowdown/ cooling water outfalls	pH (std. units)				9.0	6.0	0	44	100
	Total residual oxidant			0.011	0.019		12	53	77

[a]Percent compliance = 100 – [(number of noncompliances/number of samples) * 100].

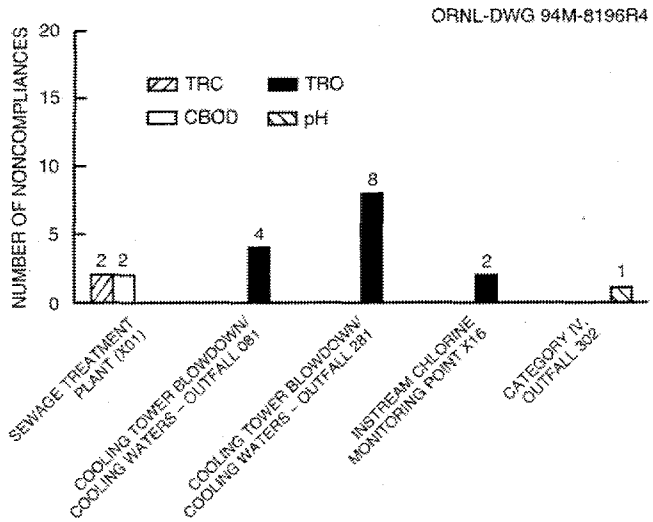

Fig. 4.26. ORNL NPDES permit limit exceedences in 1997 (total = 19).

Branch, X14 on White Oak Creek, and X15 at White Oak Dam (see Fig. 4.15). Additional sites that were monitored under the previous RMP, namely, First Creek, Fifth Creek, Northwest Tributary, 7500 Road Bridge, Raccoon Creek, White Oak Creek Headwaters, and Melton Hill Dam (Fig. 4.15), continued to be monitored under the NPDES program through the remainder of 1997 to ensure continuity of data while those sites were transitioned to another monitoring program. An assessment of radiological liquid effluents, including numerous category outfalls, was conducted in the summer of 1997. Data gathered during the assessment will be used to complete another revision of the RMP in 1998. Results for the 1997 monitoring are presented in the ORNL Radiological Monitoring Summary section, Sect. 4.2.1.2.

Chlorine Control Strategy

The NPDES permit regulates the discharge of chlorinated water at ORNL by setting either total residual chlorine concentration limits or total residual oxidant (TRO) mass-loading action levels on outfalls, depending on the outfall's location and volume of its discharge. At ORNL, TRO measurements may include both chlorine and bromine residuals. Most outfalls with TRO mass-loading action levels are monitored quarterly under the Chlorine Control Strategy in dry-weather conditions; five outfalls are monitored weekly in dry-weather conditions. These outfalls have a mass-loading action level for TRO that requires ORNL to reduce or eliminate TRO in the discharge if it exceeds the action level. The action level is 1.2 grams per day (g/d) and is calculated by multiplying the instantaneous measured concentration by the instantaneous flow rate of the outfall. During 1997, 74 outfalls had one or more measurable dry-weather flows and 20 outfalls exceeded the TRO action level one or more times. Corrective actions have been fully implemented at 11 outfalls by either rerouting or eliminating the chlorinated discharge or by installing dechlorination systems. Sources or corrective actions for the remaining outfalls are under investigation.

Storm Water Pollution Prevention Plan

The SWPP requires (1) assessment of storm water quality at ORNL, (2) characterization of storm water by monitoring, (3) training of employees, and (4) implementation of measures to minimize storm water pollution in areas of ORNL that may be affected. These four components of the plan were initiated in 1997 at ORNL. Monitoring for this program will begin in 1998.

Mercury and PCBs in the Aquatic Environment

The mercury and PCB monitoring programs at ORNL were conducted to comply with the ORNL NPDES permit issued in 1986. The new permit requires neither mercury nor PCB monitoring programs; monitoring of mercury and PCBs is continued as a requirement of the ORNL BMAP. Mercury found at the ORNL site was a result of spills that occurred from 1954 through 1963. Because processes using mercury are no longer in operation and analytical results of aquatic samples have consistently indicated concentrations well below the reference value established by the Tennessee Water Quality Criteria for the protec-

tion of fish and aquatic life, monitoring for mercury in the aquatic environment at ORNL was terminated in 1997. Monitoring for PCBs in water samples was terminated in 1992 because analytical values were consistently below analytical detection limits. Monitoring for PCBs in sediment was continued through 1996 and then terminated. Results for most samples in 1996 were below analytical detection limits or were estimated by the laboratory as at or below the detection level.

4.2.2.4 ETTP Surface Water Effluents

The current ETTP NPDES permit went into effect on October 1, 1992, and a major modification was issued effective June 1, 1995. The modification included removal of inactive outfalls, addition of effluent limits for new treatment technologies at the CNF, addition of new storm drains, and clarification of various requirements. In accordance with the NPDES permit, the ETTP is authorized to discharge process wastewater, cooling water, storm water, steam condensate, and groundwater to the Clinch River, Poplar Creek, and Mitchell Branch. The permit currently includes 4 facility outfalls and 136 storm water outfalls. Compliance with the permit for the last 5 years is summarized by the major effluent locations in Fig. 4.27. Table 4.18 details the permit requirements and compliance records for all of the outfalls that discharged during 1997. The table provides a list of the discharge points, effluent analytes, permit limits, number of noncompliances, and the percentage of compliance for 1997. Samples from these outfalls are collected and analyzed as specified in the NPDES permit.

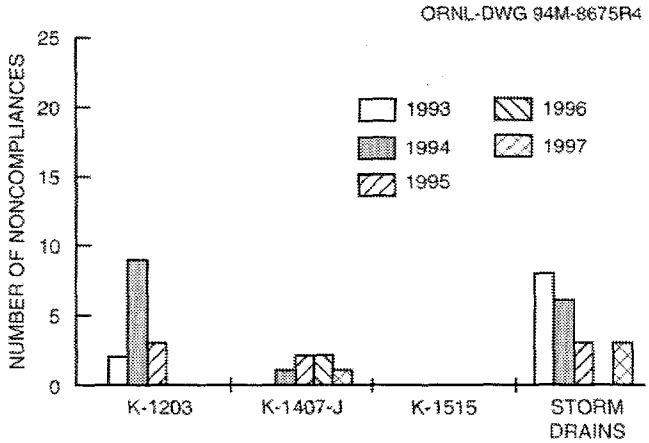

Fig. 4.27. ETTP NPDES compliance history by source of noncompliance.

The following are the four permitted major outfalls at the ETTP (Fig. 4.23):

- 005 (K-1203 Sewage Treatment Plant),
- 009 (K-1515 Sanitary Water Treatment Facility),
- 013 (K-1513 Sanitary Water Intake Backwash Filter), and
- 014 (K-1407-J CNF discharge to the Clinch River).

Although no monitoring is required at Outfall 013, routine inspections are conducted to ensure that no unsightly debris or scum is discharged through this point as the result of backwash operations at the K-1513 sanitary intake filter. Outfall 014 is a permitted outfall for the discharge of effluent from the CNF to the Clinch River.

Results

Outfall 005 is the discharge point for the ETTP STP, which is an extended aeration treatment plant having a rated capacity of 2.3 million L/d [0.6 million gallons per day (Mgd)] and a current use of about 1.4 million L/d (0.36 Mgd). Treated effluent from the main plant is discharged into Poplar Creek through this outfall. This facility had no NPDES permit noncompliances during 1997.

Outfall 009 is the discharge point for the K-1515 sanitary water plant, which provides sanitary water to the ETTP to be used for drinking, fire protection, and other purposes. It also provides water to two industries in the Bear Creek Road Industrial Park through an arrangement with the city of Oak Ridge. Raw water is taken from the Clinch River and treated at K-1515. The K-1515 sanitary water plant exhibited 100% compliance with the ETTP NPDES permit during 1997.

Table 4.18. NPDES compliance at the ETTP, 1997

Discharge point	Effluent parameter	Effluent limits				No. of noncompliances	Percentage of compliance
		Monthly av[a]	Daily max[a]	Monthly av (lb/day)	Daily max (lb/day)		
005 (K-1203 Sewage Treatment Facility)	Ammonia nitrogen	5	7	12	17		100
	Biochemical oxygen demand	15	20	37	49		100
	Chlorine, total residual	0.14	0.24				100
	Dissolved oxygen		5[b]				100
	Fecal coliform, col/100 mL	200[c]	1,000				100
	Flow, Mgd	*d*	*d*				100
	LC_{50}, *Ceriodaphnia*, %		14.6[b]				100
	LC_{50}, *Pimephales*, %		14.6[b]				100
	NOEL,[e] *Ceriodaphnia*, %		4.2[b]				100
	NOEL,[e] *Pimephales*, %		4.2[b]				100
	pH, standard units		6.0–9.0				100
	Settleable solids, mL/L		0.5				100
	Suspended solids	30	45	74	111		100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
009 (K-1515-C Sanitary Water Plant)	Aluminum	1.0	2.0				100
	Chlorine, total residual		1.0				100
	Flow, Mgd	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Settleable solids, mL/L		0.5				100
	Suspended solids	30	40				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
013 (K-1513 Sanitary water intake and backwash filter	Visual inspection of receiving stream						
014 (K-1407-J Central Neutralization Facility to Clinch River)	1,1,1-Trichloroethane	*d*	*d*				100
	Acetone	*d*	*d*				100
	Acetonitrile	*d*	*d*				100
	Benzene	*d*	0.005				100
	Bromoform	*d*	*d*				100
	Cadmium	0.18	0.69				100
	Carbon tetrachloride	0.5	0.5				100
	Chemical oxygen demand	*d*	*d*				100
	Chloride, total	35,000	70,0000				100
	Chlorine, total residual		1.0				100
	Chlorodibromomethane	*d*	*d*				100
	Chloroform	0.5	0.5				100
	Chromium	1.71	2.77				100
	Copper	1.34	2.15				100
	Dichlorobromemethane	*d*	*d*				100
	Flow, Mgd	*d*	*d*				100
	Ethylbenzene	*d*	0.01				100
	Gross alpha, pCi/L	*d*	*d*				100
	Gross beta, Pci/L	*d*	*d*				100
	Lead	0.38	0.69				100
	Methyl ethyl ketone	*d*	*d*				100
	Methylene chloride	*d*	*d*				100
	Naphthalene	*d*	*d*				100
	Nickel	2.38	3.98				100
	Oil and grease		30				100
	PCB	0.00022	0.00045				100
	Petroleum hydrocarbons	*d*	0.1			1	91.7
	pH, standard units		6.0–9.0				100

Table 4.18 (continued)

Discharge point	Effluent parameter	Effluent limits				No. of noncompliances	Percentage of compliance
		Monthly av[a]	Daily max[a]	Monthly av (lb/day)	Daily max (lb/day)		
014 (continued)	Silver	0.24	0.43				100
	Suspended solids		40				100
	Tetrachloroethylene		0.7				100
	Toluene	*d*	0.01				100
	Total toxic organics		2.13				100
	Trichloroethylene	0.5	0.5				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*100*
	Uranium, total	*d*	*d*				100
	Vinyl chloride	0.2	0.2				100
	Zinc	1.48	2.61				100
Category I storm drains	Flow, Mgd	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Missed sample	*f*	*f*	*f*	*f*	1	50
Category II storm drains	Flow, Mgd	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
Category III storm drains	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
Category IV storm drains (to Poplar Creek)	Chlorine, total residual		0.14			1	98
	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*		1	*f*
Category IV storm drains (to Mitchell Branch)	Chlorine, total residual		0.019				100
	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*

[a]Units are mg/L unless otherwise stated.
[b]Daily minimum.
[c]Geometric mean.
[d]Nonlimited parameter.
[e]No-observed-effect limit.
[f]Not applicable.

The ETTP CNF, Outfall 014, has provisions for treatment of nonhazardous and hazardous wastes. Nonhazardous flow entering the CNF consists of steam plant effluents and various small-quantity or infrequent streams from waste disposal requests. Hazardous streams include effluents from the TSCA Incinerator, the steam plant hydrogen softener waste stream, and various small-quantity or infrequent streams from waste disposal requests.

To begin treatment of waste streams contaminated with various organics, the CNF was upgraded in 1996 to include pressure filters, carbon adsorption, and air stripping. These upgrades were approved by TDEC, and construction was completed in April 1996. Operational testing was completed in June 1996, and the new organics

treatment system went on line in July 1996. The CNF had one NPDES noncompliance in 1997.

The CNF experienced an exceedence of the NPDES permit limit for total petroleum hydrocarbons (TPH) in March 1997. The Outfall 014 permit limit of 0.1 mg/L for TPH was established as a technology-based limit contingent upon the upgrade of the CNF to include organics waste treatment capabilities. On March 17, 1997, the TPH concentration in a routine sample collected on effluent from Outfall 014 at the CNF was measured at 1.64 mg/L. This concentration exceeded the maximum permitted level of 0.1 mg/L for TPH at this outfall. Previous samples collected at the CNF after installation of the organic treatment unit in 1995 had shown no detectable levels of TPH. In addition, TPH concentrations in all influent streams to CNF were within the waste acceptance criteria guidelines for the CNF. Although an extensive investigation, which included close scrutiny of operating records and analytical procedures, was conducted, no definitive source of the elevated TPH concentration was identified.

The ETTP NPDES permit includes 136 storm water outfalls that are grouped into four categories based on their potential for pollutants to be present in their discharge. Category I storm water outfalls have intermittent flow and drain storm water runoff from areas remotely associated with plant activities and subsurface runoff; Category II storm water outfalls have intermittent flow and drain storm water runoff from building roof drains and paved areas associated with plant activities; Category III storm water outfalls have intermittent flow and drain storm water runoff from areas associated with concentrated storage areas, roof drains, coolant systems, and parking lots; and Category IV storm water outfalls have continuous flow and drain cooling water discharges and runoff from industrial areas. Monitoring at storm water outfalls is conducted semiannually, quarterly, monthly, or weekly for Categories I through IV, respectively, with those outfalls that have the highest potential for pollution being sampled most frequently.

The remaining three ETTP NPDES noncompliances for 1997 occurred at storm water outfalls. These noncompliances occurred at Outfall 100, Outfall 124, and Outfall 500.

On September 24, 1997, a routine weekly sample collected at storm water outfall SD-124 resulted in a total residual chlorine (TRC) measurement of 0.18 mg/L. This measurement exceeded the maximum permitted level of 0.14 mg/L for TRC at this outfall. A thorough investigation was conducted to determine the source of the elevated TRC. Buildings, paved areas and grassy areas that drain to SD-124 were walked down to identify potential TRC sources. Smoke testing was conducted at catch basins above SD-124 and maps and video tapes resulting from a storm drain video survey conducted in 1995 were reviewed. No TRC sources were identified. Dechlorination tablets were placed in a catch basin upstream of SD-124 as a precautionary measure, and daily surveillance of SD-124 was conducted to identify flow patterns. Sampling conducted at SD-124 since the September 24, 1997 incident have identified no presence of TRC.

On October 1, 1997, a liquid solution of an absorbent material was discovered entering the storm drain system via a catch basin outside a building being used by a private industrial firm. The catch basin is part of the storm drain network that discharges through storm drain outfall SD-100. The quantity of material that entered the storm drain system is unknown. The absorbent material is produced by the firm leasing the building, and although its exact formulation is proprietary, it is primarily composed of portland cement, attapulgite clay, and quartz. Best management practices to eliminate migration of the material into the storm drain system were recommended to the private industrial firm. No adverse environmental impacts were observed as a result of the incident.

During an October 2, 1997, administrative review of sampling records, it was discovered that NPDES Category I storm water outfall SD-500 had not been sampled during the semiannual reporting period of April 1, 1997, through September 30, 1997. An investigation was conducted to determine why SD-500 was not sampled and to identify corrective actions to prevent recurrence. Several contributing factors were identified,

including physical relocation of sampling personnel, reductions in personnel in the sampling and program management departments, and access problems at SD-500 because of ongoing construction activities. The existing administrative systems for tracking outfall sampling progress were found to be satisfactory, and discussions emphasizing attention to detail were conducted with all staff involved in collecting samples.

The SWPP Program is another requirement of the NPDES permit. The purpose of the ETTP SWPP Program is to assess the quality of storm water discharges from the ETTP, determine potential sources of pollutants affecting storm water, and provide effective controls to reduce or eliminate these pollutant sources. The SWPP program provides a means whereby sources of pollutants that are likely to affect the quality of storm water discharges are identified, BMPs that can be used to control the entry of pollutants into storm water discharges are developed, and methods for implementing pollution prevention practices are devised.

As part of the 1996–97 SWPP sampling effort, storm water outfalls at the ETTP were grouped (as permitted under Part IV.C.4 of the ETTP NPDES permit), and storm water samples were collected from a representative outfall from each group. Storm water outfalls were placed in a group based on several criteria: (1) knowledge of drainage areas obtained from block plans and maps of the ETTP, (2) knowledge of various processes and functions conducted at the ETTP, and (3) information in the ETTP NPDES permit application. The individual outfall chosen to represent the group was selected based on the location of the outfall's storm drain network in relation to the other storm drain networks in the group, the representativeness of previously collected analytical data in relation to other outfalls in the group, the likelihood of the outfall having sufficient flow for sample collection to take place during a storm event, ease of access to the outfall during storm events, and categorization of the outfall in the ETTP NPDES permit.

Several of the storm water outfalls did not fit into groups and were therefore sampled individually. Screening criteria used to determine the outfalls that should be sampled individually were developed from the TDEC general water quality criteria for various uses, Part III.A.a. (Toxic Pollutants) criteria of the ETTP NPDES permit, discussions in NPDES permit rationale and addendums, and SDWA maximum contaminant levels. These criteria were applied to data collected under previous SWPP monitoring efforts. In general, the most stringent criterion was selected to be included in the overall screening criteria.

Analytical parameters that were monitored under this sampling and analysis (S&A) plan were selected based on the review of previous SWPP analytical data, historical knowledge of the ETTP, information obtained from the sitewide storm drain camera survey, data from sump discharge sampling efforts, and groundwater data from plant areas near drains where significant groundwater and surface water interactions are suspected. The previously mentioned screening levels were used to indicate the outfalls that may discharge pollutants at potentially significant levels.

The objectives of the 1996–97 SWPP sampling program were twofold: (1) to provide analytical data necessary for the ETTP NPDES permit renewal process and (2) to evaluate and characterize storm water runoff from the ETTP.

To facilitate the transfer of ownership/operation of ETTP facilities to other parties, it was determined that separate NPDES permits would be required for each of the ETTP treatment facilities. In addition, it was determined that a separate NPDES permit for the storm water drainage system would be necessary. The EPA 2F forms that must be completed as part of the application for the ETTP NPDES permit for the storm drainage system required a large quantity of analytical data that had not been collected during any previous storm drain sampling effort. Therefore, Phase I of the 1996–97 SWPP sampling effort was conducted to collect analytical data that would allow for completion of the NPDES permit application for the ETTP storm drainage system. Phase I sampling included collection of samples from specific storm drains during wet weather conditions and collection of samples from storm drains that flow on a continuous basis during dry

weather conditions. Analytical data from both wet and dry weather conditions were required for completion of the 2F forms.

Because Phase I of the 1996–97 SWPP sampling effort was performed in an effort to obtain analytical data required by TDEC for completion of the ETTP NPDES permit renewal application, Phase I analytical data were not compared to the screening criteria.

Phase II sampling was conducted to further define the presence of contaminants in the storm drain system that have been detected during SWPP efforts conducted in 1993–94, 1994–95, and 1995–96. Analytical results from these past sampling efforts were compared to screening criteria that were developed from several sources. Parameters for which the analytical results exceeded these screening criteria were monitored as part of the 1996–97 SWPP sampling effort to determine the change in the levels of these contaminants over time, if any.

PCBs (Aroclor-1254) were detected at storm water Outfall 280 at a concentration of 0.88 µg/L. This storm water outfall is located at the north end of the K-1064 peninsula and drains a grassy and graveled area. Storm water Outfall 280 drains areas that are within the K-1064 Operable Unit. A remedial investigation of this unit will be conducted as part of the Environmental Restoration program.

Alpha activity was detected at levels of 58.6 pCi/L, 93.7 pCi/L, and 25.7 pCi/L at storm water outfalls 150, 158, and 382, respectively. All of these alpha activity levels were above the screening criteria level of 15 pCi/L, which is the maximum contaminant level (MCL) established for alpha activity in SWDA.

Trichloroethene was detected in concentrations above the applicable screening level at storm water outfalls 170 and 180. The screening level for trichloroethene is 5 µg/L, which is the limit for this compound found in the Tennessee Water Quality Criteria for domestic water supplies. Tricholorethene was detected at 16 µg/L and 130 µg/L at outfalls 170 and 180, respectively. In addition, vinyl chloride was detected in concentrations above the applicable screening level at storm water Outfall 190. The screening level for vinyl chloride is 2 µg/L, which is the limit for this compound found in the Tennessee Water Quality Criteria for domestic water supplies. Vinyl chloride was detected at Outfall 190 at 20 µg/L.

The presence of volatile organic compounds in these storm water outfalls is likely a result of the discharge of contaminated groundwater. The presence of a contaminated groundwater plume that discharges to Mitchell Branch via these outfalls is well documented. Currently, CERCLA remedial actions are being evaluated to construct trenches and extraction wells to intercept the plume. The contaminated groundwater would be collected and pumped to the K-1407 CNF, where it would be treated and discharged to the Clinch River via an NPDES-permitted outfall.

Metals concentrations above applicable screening levels were detected at several locations throughout the ETTP as part of the 1996–97 SWPP sampling effort. Metals commonly detected in storm water runoff included iron, magnesium, aluminum, copper, and zinc. However, the presence of these particular metals in storm water runoff in concentrations above screening levels is not believed to be problematic. All of these metals are commonly found in soils and sediments within this geographic region. Also, many of the elevated metals levels were associated with elevated levels of total suspended solids, which suggests that the source of the metals is more closely related to the amount of sediment being transported by the storm water runoff and not the storm water itself.

4.3 TOXICITY CONTROL AND MONITORING PROGRAM

4.3.1 Y-12 Plant Biomonitoring Program

In accordance with the 1995 NPDES permit (Part III-C, p. 39), a Biomonitoring Program that evaluates an EFPC instream monitoring location (Outfall 201), wastewater treatment system discharges, and locations in the storm sewer system is required. Table 4.19 is a summary of the results of biomonitoring tests conducted on effluent

Table 4.19. Y-12 Plant Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 1997[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Central Pollution Control Facility (Outfall 501)	1/8	*Ceriodaphnia*	>100	0.09
Groundwater Treatment Facility (Outfall 512)	1/8	*Ceriodaphnia*	43.0	0.23
9422-17 Storm Sewer	1/8	*Ceriodaphnia*	>100	*d*
Central Mercury Treatment System (Outfall 551)	1/15	*Ceriodaphnia*	>100	8.32
Storm Sewer Drain D2426	1/15	*Ceriodaphnia*	>100	*d*
Storm Sewer Drain D2426 (dechlorinated)	1/15	*Ceriodaphnia*	>100	*d*
Storm Sewer Drain D3321	1/15	*Ceriodaphnia*	70.7	*d*
Storm Sewer Drain E3305	1/15	*Ceriodaphnia*	>100	*d*
West End Treatment Facility (Outfall 502)	3/7	*Ceriodaphnia*	91.1	0.07
Central Pollution Control Facility (Outfall 501)	4/3	*Ceriodaphnia*	>100	0.10
Groundwater Treatment Facility (Outfall 512)	4/10	*Ceriodaphnia*	30.5	0.15
Central Mercury Treatment System (Outfall 551)	4/10	*Ceriodaphnia*	>100	23.73
Storm Sewer Drain D2426	4/10	*Ceriodaphnia*	56.0	*d*
Storm Sewer Drain D2426 (dechlorinated)	4/10	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (Outfall 501)	4/11	*Ceriodaphnia*	>100	0.06
9422-17 Storm Sewer	4/15	*Ceriodaphnia*	Invalid[e]	Invalid[e]
Storm Sewer Drain D3321	4/15	*Ceriodaphnia*	17.1	*d*
Storm Sewer Drain E3306	4/15	*Ceriodaphnia*	>100	*d*
9422-17 Storm Sewer	5/1	*Ceriodaphnia*	>100	*d*
Storm Sewer Drain E3306	7/9	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (Outfall 512)	7/10	*Ceriodaphnia*	40.9	0.25
Central Mercury Treatment System (Outfall 551)	7/10	*Ceriodaphnia*	>100	0.15
Storm Sewer Drain D2426	7/10	*Ceriodaphnia*	70.7	*d*
Storm Sewer Drain D2426 (dechlorinated)	7/10	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (Outfall 501)	7/12	*Ceriodaphnia*	73.8	0.11
9422-17 Storm Sewer	7/15	*Ceriodaphnia*	>100	*d*
Storm Sewer Drain D3321	7/15	*Ceriodaphnia*	>100	*d*
West End Treatment Facility (Outfall 502)	8/15	*Ceriodaphnia*	>100	0.11
Groundwater Treatment Facility (Outfall 512)	10/2	*Ceriodaphnia*	77.5	0.14
9422-17 Storm Sewer	10/2	*Ceriodaphnia*	>100	*d*
9422-10 Storm Sewer	10/3	*Ceriodaphnia*	14.7	*d*
9422-10 Storm Sewer (dechlorinated)	10/3	*Ceriodaphnia*	75.8	*d*
Storm Sewer Drain D3121	10/3	*Ceriodaphnia*	12.9	*d*
Storm Sewer Drain D3121 (dechlorinated)	10/3	*Ceriodaphnia*	81.6	*d*
Central Mercury Treatment System (Outfall 551)	10/7	*Ceriodaphnia*	>100	0.04
Outfall 135 Storm Sewer	10/7	*Ceriodaphnia*	>100	*d*
West End Treatment Facility (Outfall 502)	10/17	*Ceriodaphnia*	43.5	0.18

[a]Summarized are the effluents and their corresponding 48-h LC_{50}s and instream waste concentrations (IWCs). NOTE: Discharges from treatment facilities are intermittent because of batch operations.

[b]The concentration of effluent (as a percentage of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 48 h.

[c]IWC = instream waste concentration. The IWC is based on actual flows at East Fork Poplar Creek kilometer 24.6 (Station 8).

[d]This point is in the storm sewer system; therefore, an IWC is not applicable.

[e]This test was invalid because of unacceptable survival of control organisms. This location was retested on May 1, 1997.

samples from wastewater treatment systems and storm sewer effluents. The results of the biomonitoring tests are expressed as the concentration of effluent that is lethal to 50% of the test organisms (LC_{50}) during a 48-hour period. Thus, the lower the value, the more toxic an effluent. The LC_{50} is compared to the effluent's calculated instream waste concentration (IWC) to determine the likelihood that the discharged effluent would be harmful to aquatic biota in the receiving stream. If the LC_{50} is much greater than the IWC, it is less likely that there is an instream impact. Table 4.20 is a summary of the no-observed-effect concentrations (NOECs) and 96-hour LC_{50}s for the instream monitoring location, Outfall 201. The NOEC is the concentration of effluent that does not reduce survival, growth, or reproduction of the biomonitoring test organisms. Thus, like the LC_{50}, the higher the value the less toxic an effluent.

Effluent from the CPCF was tested in January, twice in April, and in July using *Ceriodaphnia dubia*. In January and April, treated effluent from the CPCF had 48-hour LC_{50}s of >100%. In July, the effluent had a 48-hour LC_{50} of 73.8%. The calculated IWCs of the CPCF effluent were 0.09% in January, 0.10% and 0.06% in April, and 0.11% in July. Because the IWCs were less than the LC_{50}s, it is unlikely that treated effluent from that facility adversely affected the aquatic biota in EFPC.

Effluent from the Groundwater Treatment Facility (GWTF) was tested in January, April, July, and October using *Ceriodaphnia*. The effluent's 48-hour LC_{50}s were 43.0%, 30.5%, 40.9%, and 77.5%, respectively. The calculated IWCs (0.23%, 0.15%, 0.25%, and 0.14%, respectively) were below the LC_{50}s; therefore, it is unlikely that treated effluent from the GWTF adversely affected the aquatic biota in EFPC.

Effluent from the Central Mercury Treatment System (CMTS) was tested in January, April, July, and October using *Ceriodaphnia*. The 48-hour LC_{50}s were all >100%. The calculated IWCs were 8.32%, 23.73%, 0.15%, and 0.04%, respectively. Because the IWCs were less than the LC_{50}s, it is unlikely that treated effluent from the CMTS adversely affected aquatic biota in EFPC.

Table 4.20. Y-12 Plant Biomonitoring Program summary information for Outfall 201 for 1997[a]

Site	Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
Outfall 201	1/8	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	4/9	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	7/9	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	10/1	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100

[a]Summarized are the no-observed effect concentrations and the 96-h LC_{50}s for the instream monitoring location, Outfall 201.

[b]No-observed-effect concentration (NOEC) as a percent of full-strength effluent from Outfall 201 diluted with laboratory control water. The NOEC must equal one of the test concentrations and is the concentration that does not reduce *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

[c]The concentration of effluent (as a percent of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 96 h.

West End Treatment Facility (WETF) effluent was tested in March, August, and October using *Ceriodaphnia*. The effluent's 48-hour LC_{50}s were 91.1%, >100%, and 43.5%, respectively. The calculated IWCs (0.07%, 0.11%, and 0.18%, respectively) were below the LC_{50}s; therefore, it is unlikely that treated effluent from theWETF adversely affected aquatic biota in EFPC.

Toxicity testing of storm sewers was conducted at Drains D2426, D3121, D3321, E3305, and E3306 and at Outfall 135. Buildings 9422-10 and 9422-17, which are monitoring locations in the storm system as part of the SWHISS, were also tested. Water from Storm Sewer Drain D2426 was tested in January, April, and July using *Ceriodaphnia*. In January, water from Drain D2426 had a 48-hour LC_{50} of >100%. A portion of this water was treated by dechlorination before testing. The 48-hour LC_{50} of the dechlorinated water was >100%. In April, the 48-hour LC_{50} was 56.0%, and the 48-hour LC_{50} of dechlorinated water was >100%. In July, the 48-hour LC_{50} was 70.7%, and the 48-hour LC_{50} of dechlorinated water was >100%.

Water from Storm Sewer Drain D3121 was tested in October using *Ceriodaphnia*. The 48-hour LC_{50} was 12.9%, and the 48-hour LC_{50} of dechlorinated water was 81.6%. Water from Storm Sewer Drain D3321 was tested in January, April, and July using *Ceriodaphnia*. The 48-hour LC_{50}s were 70.7%, 17.1%, and >100%, respectively.

The storm sewer at Drain E3305 was tested in January using *Ceriodaphnia*. The 48-hour LC_{50} was >100%. The storm sewer at Drain E3306 was tested in April and July. The 48-hour LC_{50}s were both >100% for *Ceriodaphnia*.

The storm sewer at Outfall 135 was tested in October using *Ceriodaphnia*. The 48-hour LC_{50} was >100%. The storm sewer at Building 9422-10 was tested in October using *Ceriodaphnia*. The 48-hour LC_{50} was 14.7%, and the 48-hour LC_{50} for dechlorinated water was 75.8%.

The storm sewer at Building 9422-17 was tested in January, April, May, July, and October using *Ceriodaphnia*. In January the 48-hour LC_{50} was >100%. In April, the test was determined to be invalid because of unacceptable survival of control organisms. This location was retested in May, and the 48-hour LC_{50} was >100%. In July and October, the 48-hour LC_{50}s were >100%.

Water from the instream monitoring point, Outfall 201, was tested four times in 1997 using fathead minnow larvae and *Ceriodaphnia dubia*. For tests in January, April, July, and October, the NOECs were all 100% for both *Ceriodaphnia* and fathead minnows; the 96-hour LC_{50}s were all >100% for both *Ceriodaphnia* and fathead minnows.

4.3.2 ORNL Wastewater Biomonitoring

Under the ORNL NPDES permit, wastewaters from the STP, the CYRTF, and the NRWTF were evaluated for toxicity. The results of the toxicity tests of wastewaters from the three treatment facilities are given in Table 4.21. This table provides the NOEC and LC_{50} for fathead minnows and *Ceriodaphnia* for each wastewater stream and the month it was tested. The NOEC is the concentration that did not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. The LC_{50} is the concentration of wastewater that kills 50% of the test organisms in 96 hours. Average water quality measurements obtained during each toxicity test are shown in Table 4.22. The NPDES permit effective February 3, 1997, defines the limits for the biomonitoring tests. For the X01 (STP) discharge, toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 hours in 41.1% effluent (LC_{50}) or the NOEC is <12.3%. For the X02 discharge (CYRTF), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 hours in 4.2% effluent or the NOEC is <1.3%. Because of the batch mode of discharge at CYRTF, the limit for the NOEC only applies if the facility discharges for a sufficient length of time. For the X12 discharge (NRWTF), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 hours in 100% effluent (LC_{50}) or the NOEC is <30.9%. Prior to issuance of the renewed permit in 1997, there were no numeric limits for the biomonitoring tests.

Table 4.21. 1997 toxicity test results of ORNL wastewaters

Outfall	Test date	Test species	NOEC[a]	LC_{50}[b]
Sewage Treatment Plant (X01)	January	*Ceriodaphnia*	<6	70.7
	February[c]	*Ceriodaphnia*	50	>100
	April	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	September	*Ceriodaphnia*	32.9	>100
		Fathead minnow	100	>100
	November	*Ceriodaphnia*	41.1	>100
		Fathead minnow	100	>100
Coal Yard Runoff Treatment Facility (X02)	March	Fathead minnow	100	>100
		Ceriodaphnia	4.2	>100
	June	Fathead minnow	100	>100
		Ceriodaphnia	3.36	>100
	September	Fathead minnow	*d*	>100
		Ceriodaphnia	*d*	>100
	November	Fathead minnow	*d*	>100
		Ceriodaphnia	*d*	>100
Nonradiological Wastewater Treatment Facility (X12)	March	Fathead minnow	100	>100
		Ceriodaphnia	80	>100
	May	Fathead minnow	100	>100
		Ceriodaphnia	80	>100
	August	Fathead minnow	100	>100
		Ceriodaphnia	100	>100
	November	Fathead minnow	100	>100
		Ceriodaphnia	80	>100

[a]NOEC = No-observed-effect concentration [the concentration (as percent of full-strength wastewater) that caused no reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth].

[b]LC_{50} = the concentration (as percent of full-strength wastewater) that kills 50% of the test species in 96 h.

[c]Confirmatory test.

[d]Insufficient discharge for chronic test and determination of NOEC.

Table 4.22. 1997 average water quality measured during toxicity tests of ORNL wastewaters
Values are for full-strength wastewater for each test (n = 2 or 7)

Outfall	Test date	pH[a]	Conductivity[b]	Alkalinity[c]	Hardness[c]
Sewage Treatment Plant (X01)	January	7.71	476	93	167
	April	7.86	409	98	158
	September	7.92	425	89	154
	November	7.82	440	91	157
Coal Yard Runoff Treatment Facility (X02)	March	8.02	3980	31	2113
	June	7.53	3316	23	2029
	September	7.82	3350	25	840
	November	7.47	5110	26	700
Nonradiological Wastewater Treatment Facility (X12)	March	7.86	654	78	64
	May	8.08	549	79	83
	August	7.90	541	94	87
	November	7.92	502	88	79

[a]Standard units.
[b]µS/cm; corrected to 25°C.
[c]mg/L as $CaCO_3$.

During 1997, the STP, CYRTF, and NRWTF were tested four times each. The STP wastewater's NOECs ranged from <6 to 100%, and the LC_{50}s from 70.7 to >100%. A confirmatory test conducted following the low NOEC for *Ceriodaphnia* in January showed that the toxicity of the effluent was transient. The biomonitoring limits for STP in the renewed permit were not exceeded during the March–November biomonitoring tests. The CYRTF wastewater's NOECs ranged from 3.36 to 100%, and the LC_{50}s were always greater than 100%. The biomonitoring limits for the CYRTF in the renewed permit were not exceeded during the March–November biomonitoring tests. The NRWTF wastewater's NOECs ranged from 80 to 100%, and the LC_{50}s were always greater than 100%. The biomonitoring limits for NRWTF in the renewed permit were not exceeded during the March–November biomonitoring tests.

4.3.3 ETTP Toxicity Control and Monitoring Program

The ETTP NPDES permit requires that biannual toxicity testing be performed at Outfall 005 (K-1203, the Sewage Treatment Plant).The results of the toxicity tests of wastewaters conducted during 1997 are given in Table 4.23. This table provides the wastewater's NOEC and 96-hour LC_{50} for fathead minnows and *Ceriodaphnia* for each test. Average water quality measures obtained during each toxicity test are shown in Table 4.24.

Effluent from K-1203 was tested twice with fathead minnows and *Ceriodaphnia*. In both tests, full-strength samples did not reduce survival, growth, or reproduction. Thus the NOECs were 100% and the LC_{50}s were >100%.

Table 4.23. 1997 ETTP NPDES Permit Number TN 0002950 toxicity tests results

ETTP Outfall	Test date	Species	NOEC[a] (%)	LC_{50}[b] (%)	IWC[c] (%)
K-1203 (Outfall 005)	January	Fathead minnow	100	>100	2.45
		Ceriodaphnia	100	>100	2.45
	July	Fathead minnow	100	>100	2.5
		Ceriodaphnia	100	>100	2.5

[a]No-observable-effect concentration.
[b]96-hour lethal concentration for 50% of the test organisms.
[c]Instream waste concentration (based on critical low flow of Poplar Creek).

Table 4.24. 1997 ETTP average water quality parameters measured during toxicity tests of ETTP wastewaters
Values are averages of full-strength wastewater for each test (N = 6 or 7)

ETTP Outfall	Test date	pH (standard units)	Conductivity (µS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1203 (005)	January	8.12	365	107	158
	July	8.1	337	82	133

4.4 BIOLOGICAL MONITORING AND ABATEMENT PROGRAMS

The NPDES permits issued to the Y-12 Plant in 1995, the ETTP in 1992, and ORNL in 1996 mandate BMAPs with the objective of demonstrating that the effluent limitations established for each facility protect the classified uses of the receiving streams. The Y-12 Plant effluents discharge to EFPC; ETTP effluents discharge to Mitchell Branch, Poplar Creek, and the Clinch River; and ORNL effluents discharge to WOC and its tributaries. Each of the BMAPs is unique and consists of three or four major tasks that reflect different but complementary approaches to evaluating the effects of the effluent discharges on the aquatic integrity of the receiving streams. Tasks present in one or more of the BMAPs include (1) toxicity monitoring; (2) bioaccumulation studies; (3) biological indicator studies; (4) waterfowl surveys; and (5) ecological surveys of the periphyton, benthic macroinvertebrate, and fish communities.

4.4.1 Y-12 Plant BMAP

Two major changes initiated in the UEFPC watershed during 1996, flow management and a bypass of Lake Reality, continued to influence water quality and the biota of EFPC during 1997. Flow management, which was first fully implemented in the fall of 1996, operated except for short down-periods throughout 1997. The bypass of Lake Reality, testing for which did not begin until mid-December 1996, also continued throughout 1997.

The levels of exposure of EFPC biota to contaminants continued to decrease during 1997, at least partly as a result of these two management actions (flow management and the Lake Reality bypass). Y-12 Plant activities continued to have some adverse effects on the biota of EFPC, as

evidenced by a major fish kill in UEFPC (see Sects. 4.2.2.2 and 4.4.1.4) as well as by the improving but still relatively poor state of fish and invertebrate communities in UEFPC in terms of species diversity. However, distinct increases in species richness and diversity at upstream locations, along with improving trends in a number of other BMAP indicators, suggests that the overall ecological health of EFPC continues to improve.

4.4.1.1 Toxicity monitoring

Toxicity monitoring uses EPA-approved methods with *Ceriodaphnia dubia* (an invertebrate "water flea") to assess the toxicity of stream water to aquatic life. Toxicity monitoring in the first quarter of 1997 was conducted monthly at several sites upstream of Bear Creek Road, including Lake Reality outlet or LR-o (EFK 23.8), LR inlet or LR-i (EFK 24.1), and Area Source Study Site 8 or AS-8 (EFK 24.6). Water samples from sites downstream of Bear Creek Road (EFKs 22.8, 21.9, 20.5, 18.2, 13.8, and 10.9) were tested once during the quarter. No evidence for toxicity was found during the first-quarter *Ceriodaphnia* tests.

As a result of the continuing absence of toxicity to *Ceriodaphnia* in ambient water samples from EFPC, the scope of the toxicity monitoring program was reduced beginning in the second quarter of 1997 under the revised BMAP sampling plan (YTS-1613). Testing of ambient sites downstream of Bear Creek Road were discontinued, and testing of sites upstream of Bear Creek Road were reduced to a quarterly frequency at two sites (EFK 23.8 and EFK 24.1). No evidence for toxicity was found during *Ceriodaphnia* tests conducted during the remainder of 1997.

4.4.1.2 Bioaccumulation studies

Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are associated with proximity to the Y-12 Plant. Redbreast sunfish (*Lepomis auritus*) were collected twice during 1997 from six sites along the length of EFPC to evaluate spatial and temporal trends in mercury and PCB contamination. Largemouth bass (*Micropterus salmoides*) were collected once from two sites in EFPC (Lake Reality and EFK 23.4) and analyzed for mercury and PCBs to provide an estimate of bioaccumulation in larger piscivorous fish. A forage fish species (the stoneroller, *Campostoma anomalum*) was also collected once in 1997 from one site in UEFPC (EFK 24.8) to evaluate metal contamination in the food of fish-eating wildlife. These collections reflected the deletion of one previously sampled site (EFK 2.2) from the redbreast sunfish monitoring program and two previously sampled sites (EFK 23.4 and EFK 18.2) from the forage fish monitoring program in 1997 under the revised Y-12 BMAP sampling plan.

In spring 1997, the mean mercury concentrations in sunfish sampled from EFPC ranged from 5 to 13 times higher than the average concentration in fish from the reference stream. Highest levels of contamination continued to occur upstream of Lake Reality, suggesting that Y-12 Plant discharges remain an important source of mercury in fish in the upper reaches of EFPC. However, mercury concentrations in fish have decreased in UEFPC over the last few years in parallel with decreases in water concentrations of mercury (Fig. 4.28).

PCB concentrations in sunfish sampled from EFPC during 1997 fell within ranges typical of past monitoring efforts at these sites. Mean PCB concentrations remain highest in Lake Reality and the reaches of EFPC above Lake Reality, indicating a source or sources within the Y-12 Plant (Fig. 4.29).

In an effort to identify the primary sources of PCBs to EFPC, semipermeable membrane devices (SPMDs) were deployed in UEFPC and in drains and outfalls discharging to UEFPC. SPMDs are passive sampling devices that provide a time-integrated measurement of dissolved (bioavail able) PCB concentrations. The use of these devices during 1997 led to the identification of several sources of PCBs entering UEFPC from outfalls and to the discovery that the majority of PCBs in UEFPC do not actually originate from such outfalls but instead come from unknown sources along two reaches of the stream (N/S Pipe to 109 Bridge and Station 8 Bridge to East Patrol

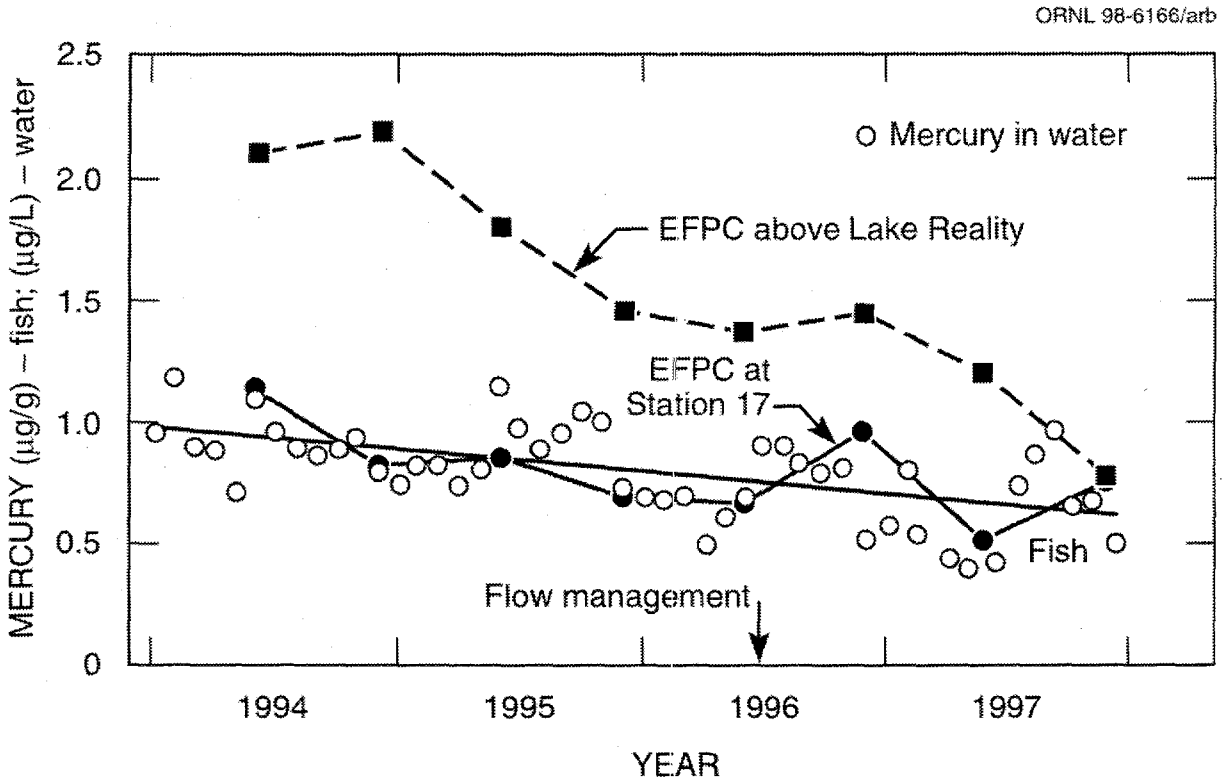

Fig. 4.28. Average mercury concentrations in fish and water above and below Lake Reality, 1994–97.

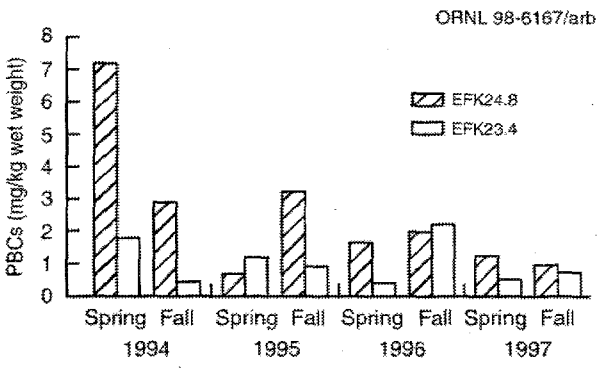

Fig. 4.29. PCB concentrations in fish above and below Lake Reality, 1994–97.

Road Bridge). This latter finding suggests that most of the PCBs exiting the Y-12 Plant originate from historical contamination in the vicinity of the stream bed and enter EFPC through shallow groundwater flow.

Kingfishers are highly piscivorus birds that consume up to half their body weight each day in fish or crayfish. For two years, the ORR ecological risk assessment (Sample et al. 1995, 1996) identified kingfishers as being highly at risk on all ORR streams. In 1996, BMAP researchers began to study kingfishers in the EFPC floodplain. Three birds (two females and one male) were regularly observed at Lake Reality and along EFPC upstream of Lake Reality, and a presumably mated pair were observed along LEFPC in the vicinity of EFK 13. However, only one nest site, in the Scarboro Bend area of Melton Hill Lake, was confirmed in 1997, and this belonged to the male using Lake Reality and UEFPC. No kingfisher burrows were found along EFPC after extensive searching, and little suitable habitat was identified for such burrows. Thus, despite the calculated risk to kingfishers from ORR contamination, further kingfisher monitoring along EFPC was considered unlikely to yield practical results, and the task was therefore deleted from the Y-12 BMAP during 1997.

4.4.1.3 Biological indicator studies

The biological indicator task is designed to evaluate the effects of water quality and other environmental variables on the health and reproductive condition of individual fish and fish populations in EFPC. Redbreast sunfish were sampled from four sites in EFPC (upstream of Lake Reality, EFK 23, EFK 19, and EFK 14) and from two reference streams (Brushy Fork and Hinds Creek) in the spring of 1997 prior to the onset of the breeding season. A formerly sampled site at EFK 6.3 was deleted from the bioindicator task because of improvements in the ecological condition of LEFPC. Physiological and biochemical indicators measured in these fish indicated that the health of individual sunfish in EFPC upstream of Bear Creek Road continues to differ significantly from fish at reference sites. However, temporal trends in several bioindicators indicate distinct improvement in overall fish health in UEFPC over the course of the last few years.

Fish reproductive health continued to be adversely impacted in UEFPC during 1997. Following a consistent trend established over the last decade, female sunfish had characteristically high incidences of oocyte atresia (death of immature eggs) at sites upstream of Bear Creek Road. However, atresia was much higher than expected at all sites sampled during 1997, including the reference sites, apparently because of a delayed spawn throughout the region because of an abnormally cool spring. This spawning delay was accentuated in EFPC by the extra chilling effect from the addition of cool Melton Hill water during flow management. The long-term effects of the shift toward cooler water temperatures in UEFPC are expected to be beneficial to the majority of fish species typically found in similar types of streams in the East Tennessee region but may have negative impacts on some of the current fish populations in EFPC in the short term.

Water sampled throughout the length of EFPC during 1997 remained toxic to developing fish embryos in the medaka test. The specific cause(s) for this toxicity have not yet been identified, but medaka embryos, like the embryos of many other species of fish, are quite sensitive to many chemical constituents originating within the Y-12 Plant, including various metals (particularly mercury), ammonia and other nitrogenous wastes, and apparently even the chemicals involved in, or the by-products of, chlorination/dechlorination water treatment procedures.

4.4.1.4 Ecological surveys and fish kill results

Periphyton monitoring in EFPC occurs four times a year. Algal biomass and photosynthetic rates measured during 1997 were generally within the range of measurements made over the past several years, remaining elevated in EFPC in comparison with reference streams (such as Brushy Fork). Concentrations of nutrients, including nitrate, ammonia, and phosphate, also continued to be much higher in EFPC than in reference streams, although levels decreased significantly at upstream sites (EFK 24.4 and EFK 23.4) from 1996 to 1997 in conjunction with the implementation of flow management. Flow management may also have been responsible for significant decreases from 1996 to 1997 at several EFPC sites in the periphyton concentrations of five metals (mercury, cadmium, chromium, copper, and zinc). However, metal concentrations continued to be relatively high during 1997 in EFPC periphyton, with a trend toward decreasing concentrations at downstream sites, supporting the existence of a source or sources of these metals at the Y-12 Plant. And remarkable similarities in the mercury concentrations of periphyton collected in September 1993 and April 1997 from three sites in EFPC (EFKs 24.4, 23.4, and 18.4) suggest that short-term changes in periphyton metal concentrations and similar ecological measurements need to be cautiously interpreted in light of possible overriding long-term trends and natural cyclicity.

The fish community task is responsible for conducting biannual estimates of the fish community at six EFPC sites and two reference stream sites and for investigating fish kills near the Y-12 Plant. Improvements in the fish communities of EFPC continued during 1997, although species richness and diversity in upstream locations remain much lower than in comparable reference

streams (Fig. 4.30). Two sensitive species, the northern hog sucker and the snubnose darter, which were first observed at EFK 23.4 in 1996, were again found at this site in 1997. They were joined by another sensitive species, the greenside darter. Other sensitive species, including rock bass, redline darter, and spotted sucker, were collected at intermediate sites such as EFK 18.7 and EFK 13.8 where they had never previously occurred or been only rarely encountered. The new temperature regime in UEFPC now approximates that of other area streams and is no longer elevated to potentially stressful levels for sensitive fish species. However, whether many additional species will ever occur upstream of Lake Reality is questionable because of the difficulty of fish migration through the bypass arrangement used to shunt water around the lake.

Fish kill investigations are conducted in response to chemical spills and unplanned water releases or when dead fish are observed in EFPC. The basic procedure for fish kill investigations is a survey of UEFPC (above Bear Creek Road to the north-south pipes), during which numbers and locations of dead, dying, and stressed fish are recorded. In previous years, fish kills were often associated with the spawning period of stonerollers in EFPC. A total of 100 dead fish, including 91 central stonerollers, were found in daily surveys during April 7–14. Thereafter, the average dead per survey decreased to less than one fish, a value similar to background mortality levels.

In late July 1997, two events occurred in EFPC that had tremendous impacts on the fish communities in the vicinity of the Y-12 Plant and further downstream. In late July, a record rainfall occurred in a few hours and resulted in a pulsed flow that blasted through the EFPC watershed. In UEFPC, particularly inside the plant, fish were displaced, stranded, and killed by this pulse. Usually in July most of the fish have spawned and small young of the year (YOY) individuals are widespread in the shallow and backwater areas of the system. Because this pulse of water was so large, many of these YOY fishes may have been

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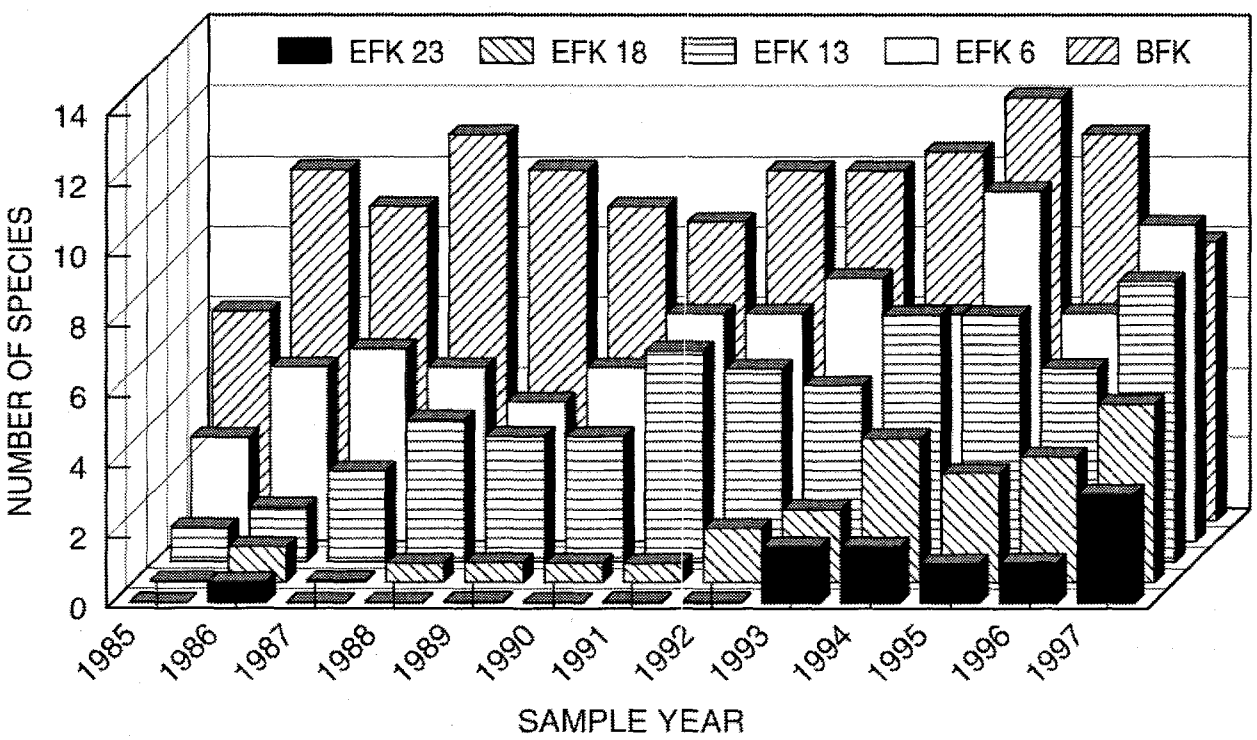

Fig. 4.30. Colonization of EFPC by sensitive fish species.

killed or displaced out of EFPC, even as far down as EFK 6.3. In addition to the record rainfall and partly as a result of the alterations to the flow management operations that were necessitated by the rain, an extremely large fish kill occurred in UEFPC on July 24, 1997. The kill was acute, based on zero or low dissolved oxygen conditions augmented by sodium bisulfide toxicity that affected the stream from just below the north-south pipes down to Lake Reality. The result was a fish kill with an estimated total of approximately 24,000 fish (see also Sect. 4.2.2.2). This was almost 5 times larger than any previous kill in UEFPC. The kill included all species and all size classes within that section of stream. Unlike most previous fish kills in this stream section, all of the mortality occurred within a few hours if not minutes on July 24. Conditions within the stream returned to normal and acceptable shortly after full flow was restored to the stream. Effects on future community assessments may be evident from these impacts, including lower species richness, density, and biomass during the next few sampling seasons.

Benthic macroinvertebrate communities are sampled from four sites in EFPC and from two reference streams in the fall and spring of each year. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded through 1997 (Figs. 4.31 and 4.32). However, subtle but persistent increases in total richness and the richness of pollution-tolerant taxa at these sites indicate continuing improvement in water quality. The benthic macroinvertebrate communities at sites farther downstream (i.e., EFK 13.8) appear only minimally impacted relative to reference conditions.

4.4.2 ORNL BMAP

4.4.2.1 Toxicity Monitoring

Instream toxicity monitoring was terminated in 1997 because instream toxicity has not been detected for the past several years. However, wastewater is actively monitored for toxicity (Sect. 4.3.2).

4.4.2.2 Bioaccumulation studies

Monitoring of mercury contamination in sunfish and largemouth bass continued in 1997. Redbreast sunfish were collected in the spring (January through March) of 1997 from WOC (WCK 2.9), and bluegill sunfish (*Lepomis macrochirus*) and largemouth bass *(Micropterus salmoides)* were collected from White Oak Lake (WOL). Mercury concentrations (relative to local reference sites) in sunfish were highest in WOC proper; mercury concentrations in bluegill collected approximately 1.4 km downstream inWOL were not much different from reference stream values. The present level of mercury contamination in WOC sunfish is approximately 5 times higher than concentrations observed in fish from the reference stream. As expected, mercury concentrations in largemouth bass were higher than in sunfish collected at the same site because of their position in the food chain. Unlike past years, no fish in the WOC watershed in 1997 contained mercury concentrations in excess of 0.50 μg/g.

In 1997, monitoring of PCB contamination in sunfish was conducted at two WOC sites: WCK 2.9 and WOL. Monitoring of PCB contamination in largemouth bass was conducted at WOL. The mean PCB concentrations in sunfish from WCK 2.9 and WOL were 0.39 ± 0.10 and 0.69 ± 0.06 μg/g, respectively. These PCB levels are high for relatively short-lived, lipid-poor fish such as sunfish. Reference site sunfish analyzed at the same time averaged <0.02 μg/g PCBs. Largemouth bass, a species that achieves a large size, is at the top of the food chain, and contains relatively high levels of intramuscular lipids, were sampled in WOL to evaluate the maximum PCB concentrations likely in the WOC system. The mean PCB concentration in WCK 1.5 bass exceeded the Food and Drug Administration threshold limit of 2 μg/g. A high degree of variation was evident in the collection; the range of values was 0.43 to 3.80 μg/g. Five of eight bass exceeded the 2 μg/g FDA threshold limit. Since 1994, PCB concentrations in WOC sunfish and largemouth bass have remained approximately 2 to 3 times higher than concentrations reported in the early 1990s.

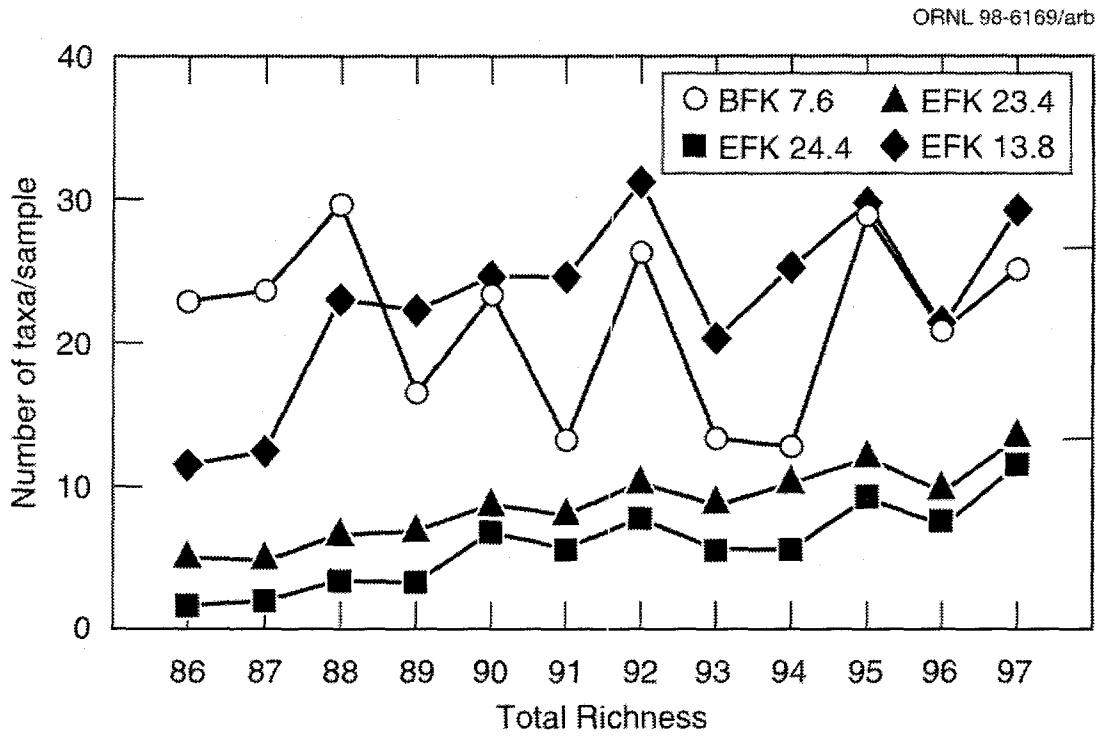

Fig. 4.31. Comparison of number of species in EFPC and Brushy Creek.

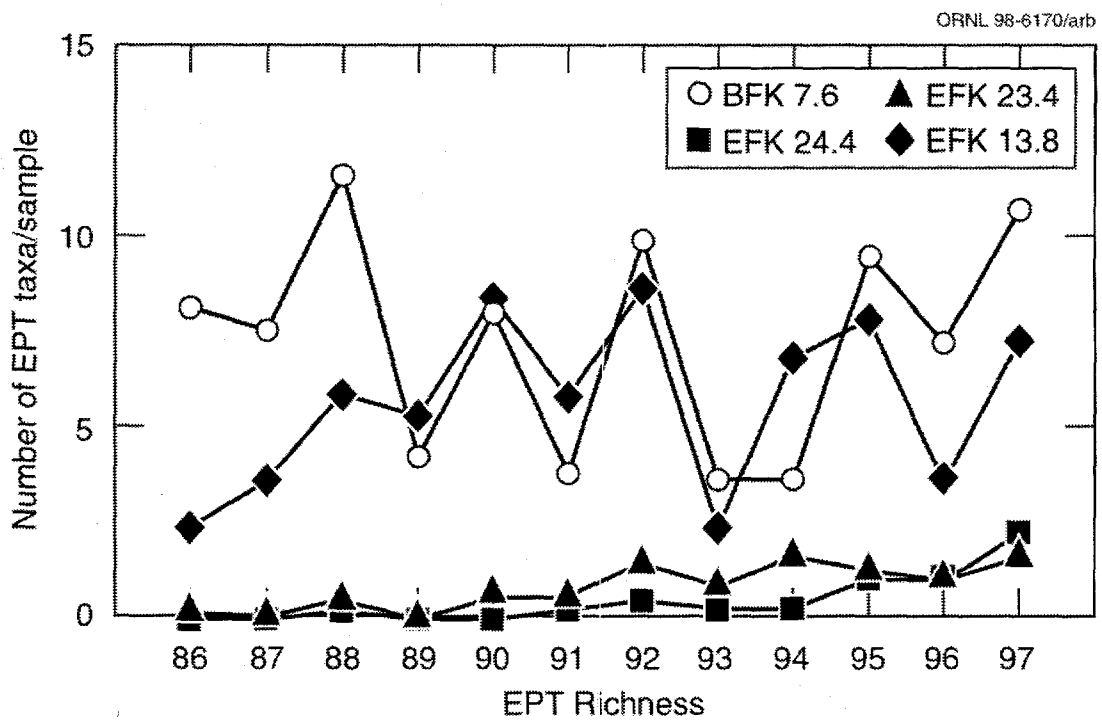

Fig. 4.32. Number of sensitive species in EFPC and Brush Creek.

Water samples were collected from White Oak Creek at four sites on November 25, 1997, and analyzed for total mercury by Lockheed Martin Energy Systems Analytical Services Organization using EPA Method 245.1 (low-level notification/reporting limit). Stream conditions were representative of base-flow (dry weather) conditions at the time of sampling. The mercury concentration in White Oak Creek at the weir upstream from ORNL (WCK 6.8) was 11 ng/L, typical of background or reference streams in East Tennessee. At WCK 3.5 (the flume upstream from the NRWTF (MS 3619), mercury concentrations were 520 and 540 ng/L in duplicate samples. The mercury concentration was 160 ng/L at WCK 2.9 (Melton Valley Road bridge) and 63 ng/L at the discharge of White Oak Dam.

4.4.2.3 Ecological surveys

Quantitative samples at established biomonitoring sites in the WOC watershed in the spring and fall of 1997 were collected under the fish community task. For spring 1997, total fish density at the downstream site on First Creek remained depressed from fall 1996. Estimated total density values at this site have generally been low since fall 1992. The majority of the decline in estimated total fish density is from the decline in blacknose dace (*Rhinichthys atratulus*) and western mosquitofish (*Gambusia affinis*) numbers. The sampling site downstream on Fifth Creek contains a stable population of central stoneroller (*Campostoma anomalum*), blacknose dace, and banded sculpin (*Cottus carolinae*). A single creek chub (*Semotilus atromaculatus*) was found at this site in fall 1997. Estimated total fish density at the lower site on Fifth Creek declined in 1995 and 1996 from a previous high in fall 1994. This decline was followed by a slight increase in spring 1997.

The fish community at two sites in the mid-reach of WOC (WCK 3.4 and WCK 3.9) have exhibited overall declines in estimated total fish density over the past 5 years. Estimated total fish density at WCK 3.4 increased overall from fall 1991 through spring 1995, from which time density has declined, with a slight increase in spring 1997. WCK 3.9 exhibited a similar pattern of an overall decline in estimated total fish density from peak values in fall 1992 through fall 1996, with a slight increase in density in spring 1997. Bluegill sunfish (*Lepomis macrochirus*) were absent at WCK 3.4 in the spring and the fall 1997 after being collected during every sampling period since August 1985.

The benthic macroinvertebrate communities were sampled at nine sites in the WOC watershed during the spring and fall of 1997. Results of the April sampling periods through 1996 continued to show that ORNL operations are impacting streams on the ORNL site. The average number of taxa and number of pollution sensitive taxa (i.e., Ephemeroptera, Plecoptera, and Trichoptera, or EPT) remain markedly lower downstream of ORNL effluent discharges in First Creek, Fifth Creek, and WOC. However, after two consecutive years of declines in the number of sensitive taxa (EPT taxa/sample) in First Creek at FFK 0.2 (i.e., 1994 and 1995), the number increased in 1996. This either demonstrates improvement after two consecutive years of declining conditions, may simply be a change associated with natural annual variation, or may be the slow result of a major dechlorination of ORNL outfalls in 1995–96. In Melton Branch, the total number of taxa/sample and the number of sensitive taxa/sample continue to be slightly lower downstream of the High Flux Isotope Reactor discharge tributary than at the reference site. This difference has persisted since 1992.

4.4.3 ETTP BMAP

4.4.3.1 Toxicity monitoring

The toxicity monitoring task for the ETTP BMAP includes tests of effluent from treatment facilities (see ETTP Toxicity Control and Monitoring Program, Sect. 4.3.3); effluent from storm drains SD170, SD180, and SD190; and surface water from six sites within Mitchell Branch. Effluent from SD170 and SD190 was evaluated for toxicity six times using *Ceriodaphnia dubia*. Full-strength effluent from SD170 reduced *Ceriodaphnia* survival or reproduction in four of

six tests. Full-strength effluent from SD190 reduced *Ceriodaphnia* survival or reproduction in four of six tests. Effluent from SD180 was evaluated for toxicity two times in 1997; the effluent did not reduce *Ceriodaphnia* survival or reproduction in any test. Toxicity tests were conducted using ambient water from Mitchell Branch downstream of each storm drain. For each test period, the toxicity of the storm drain effluents was not reflected in reduced survival or reproduction of *Ceriodaphnia* in the corresponding Mitchell Branch samples.

4.4.3.2 Bioaccumulation studies

In July and August 1997, caged clams were used to evaluate potential PCB sources to ETTP waters. In Mitchell Branch, caged clam studies showed that SD190 and a site near the Mitchell Branch weir provide the highest influx of PCBs to downstream waters and that at the K-1007-P1 pond the highest PCB concentration was at the SD100 outfall (15.46 μg/g). The average PCB concentration in clams placed for four weeks at the K901-A outlet (0.20 μg/g) was approximately 20 times higher than reference clams but was relatively low compared with that at lower Mitchell Branch and the K-1007-P1 pond outlets to Poplar Creek (4.31 and 1.14 μg/g, respectively). The clam studies in 1997 indicate that Mitchell Branch and the K-1007-P1 pond are the major ETTP sources of PCBs to downstream waters.

4.4.4 Waterfowl Surveys

In conjunction with TWRA personnel, ORR personnel monitor waterfowl populations on the ORR, and geese are measured occasionally for gross radiological activity. A roundup of Canada geese was performed on June 24 and 25, 1997. Roundup participants included employees and students from Oak Ridge National Laboratory, the ETTP, Department of Energy, Tennessee Wildlife Resources Agency, Animal Damage Control (ADC, a division of the U.S. Department of Agriculture), Tennessee Department of Environment and Conservation, and Shaw University in North Carolina. A total of 140 geese were captured during the roundup, including 88 adults and 52 goslings. Twenty-two of the 88 adults were recaptures (previously leg-banded and/or neck-collared). Eighty-two of the 88 adult geese captured were subjected to live whole-body gamma scans.

Of the 83 geese analyzed, all but 2 had activity levels below 0.2 pCi/g of ^{137}Cs. The other two, both captured at the ORNL Swan Pond, had levels of 0.69 ± 0.09 pCi/g and 15 ± 1 pCi/g of ^{137}Cs. This latter goose was sacrificed because of the relatively high presence of ^{137}Cs.

The overall number and diversity of waterfowl observed on the ORR have increased in recent years, a pattern consistent with national trends.

4.4.5 Ecological Surveys

The benthic macroinvertebrate communities downstream of the main storm drains in Mitchell Branch continue to show impacts compared with the upstream reference site. The most affected site is MIK 0.45 (downstream of SD 190), where very few pollution-intolerant EPT (i.e., mayflies, stoneflies, and caddisflies) taxa exist, and the least affected site is MIK 0.78 (immediately upstream of SD 170). Since showing some recovery at MIK 0.45 and MIK 0.71 after the 1989 or 1990 sampling periods, "steady state" conditions appear to have been reached. Some slight increases in the EPT taxa at MIK 0.45 were found, indicating that slight improvements in conditions may be occurring at that location.

In April 1996, the fish communities were quantitatively sampled at sites MIK 0.71, MIK 0.45, and the reference site, Scarboro Creek. In general, fish community studies have shown that stream conditions have improved since the early 1990s, when fish populations first became established in Mitchell Branch. The estimated fish density decreased slightly from 1996 at MIK 0.71. Total estimated fish density also has shown an overall decline at MIK 0.45 from 1996. In comparison to the reference stream, Mitchell Branch is lacking stable populations of several fish species. Although some improvements have been

observed in comparison to 1990 data, Mitchell Branch still exhibits signs of adverse impact.

4.4.6 BMAP Trends on the ORR

Several tasks were common to each of the three ORR BMAPs during 1997, and these provide some basis for examining trends in environmental quality for the ORR. Toxicity was consistently not demonstrated in standardized fish- and invertebrate-based tests of ambient water samples collected from the Y-12 Plant and the ETTP during 1997 (ambient samples were not collected near ORNL). However, water from EFPC (the only receiving stream tested by this procedure) continued to be toxic to fish embryos in themedaka embryo test. Mercury and PCB accumulation in fish continued to be a concern in 1997 at numerous ORR sites. Trends over time *include* decreased mercury concentrations in fish near the Y-12 Plant and increased PCBs in biota at some sites near the ETTP. Canada geese, which cross facility boundaries, averaged levels of gamma radiation comparable with those of geese collected at other sites in the area, although a few geese—all at ORNL—continued to show individual levels of elevated gamma radiation. Fish communities continued to improve to varying degrees during 1997 in streams draining all three facilities, although the fish communities remained largely degraded relative to reference streams. Invertebrate communities showed similar trends. Improvements were observed at some sites on the reservation; continuing significant degradation was observed elsewhere relative to reference sites.

5. Environmental Surveillance

M. A. Bogle, M. L. Coffey, L. L. Cunningham, K. G. Hanzelka, J. F. Hughes, and H. B. McElhoe

Abstract

Annual environmental surveillance is a major activity on the ORR. Environmental surveillance consists of the collection and analysis of samples of air, water, vegetation, biota, and other media from the reservation and its surroundings. External radiation is also measured. Samples are analyzed for the presence of radioisotopes and for chemical content. Data collected from environmental surveillance activities are used to demonstrate compliance with applicable standards, to assess exposures to members of the public, and to assess effects on the local population and the environment.

5.1 ENVIRONMENTAL SURVEILLANCE PROGRAM CHANGES

In 1997, major revisions to the environmental surveillance program were implemented. These revisions were the result of an extensive review of each program component, conducted primarily because management authority for the ORR was divided between LMES and LMER. The modified surveillance program was developed in a cooperative effort between LMER and LMES in which both entities identified those monitoring activities necessary to meet all applicable requirements for the individual sites, as well as those applicable to the ORR. Consequently, many of the activities described in the following sections have changed significantly in terms of locations, parameters, and sampling frequencies from the environmental surveillance activities reported in the *Oak Ridge Reservation Annual Site Environmental Report for 1996.*

5.2 METEOROLOGICAL MONITORING

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

5.2.1 Description

The seven meteorological towers, depicted in Fig. 5.1, consist of one 330-ft (100-m) tower (MT5) and one 200-ft (60-m) tower (MT6) at the Y-12 Plant, one 330-ft tower (MT2) and two 100-ft towers (MT3 and MT4) at ORNL, and one 200-ft tower (MT1) and one 100-ft (MT7) tower at the ETTP.

Data are collected at different levels to determine the vertical structure of the atmosphere and the possible effects of vertical variations on releases from facilities. At all towers, data are collected at the 32.8-ft level and at the top of the tower. At the 330-ft towers, data are collected at an intermediate 100-ft level as well. At each measuring level on each tower, temperature, wind speed, and wind direction are measured. Humidity and data needed to determine atmospheric stability (a measure of the dispersive capability of the atmosphere) are also measured at each tower. Barometric pressure is measured at one tower at each facility. Precipitation is measured at MT1 and MT7 at the ETTP and at MT2 at ORNL; solar radiation is measured at MT2.

Data from the towers at each site are collected by a dedicated control computer. The towers are polled, and the data are filed on disk. Fifteen-minute and hourly values are stored at each site

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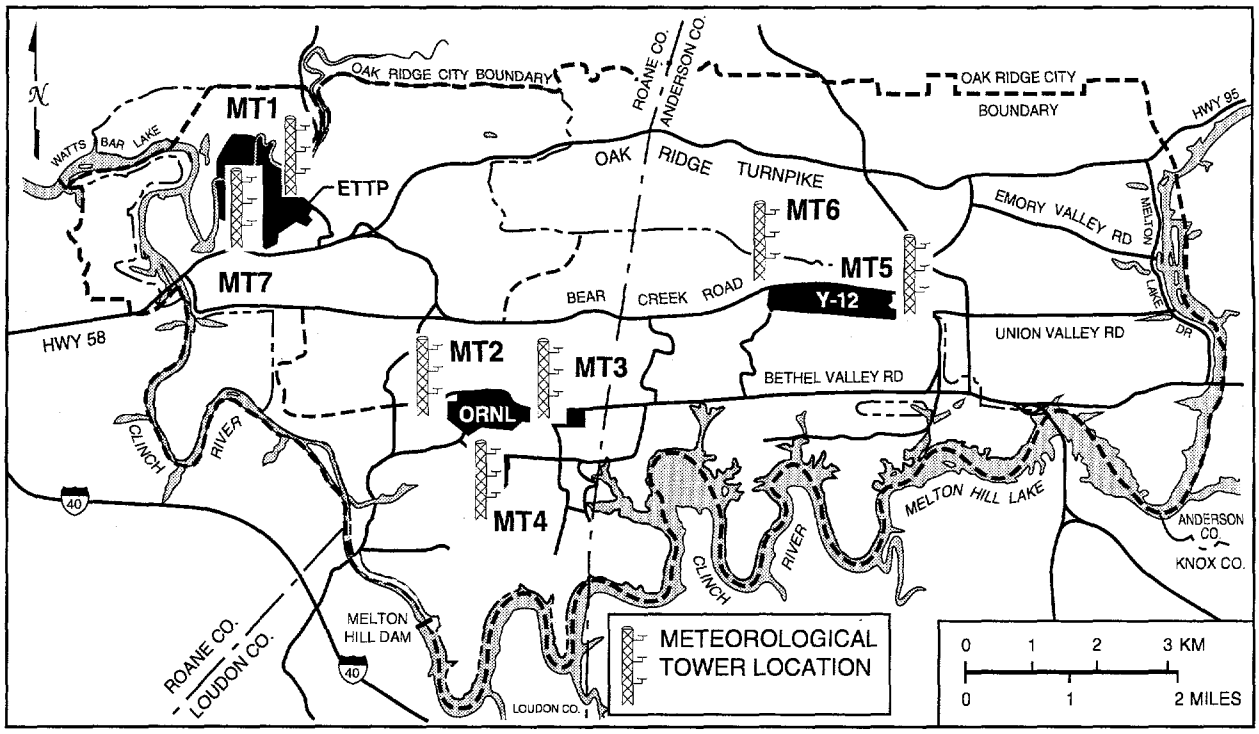

Fig. 5.1. The ORR meteorological monitoring network.

for a running 24-hour period, but only hourly data are routinely stored beyond 24 hours. The meteorological monitoring data from all towers are summarized quarterly at the Y-12 Plant and monthly at ORNL and the ETTP. Quarterly calibration of the instruments is conducted for each site by an outside contractor.

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

5.2.2 Results

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

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

The atmosphere over the reservation is dominated by stable conditions on most nights and in early morning hours. These conditions, coupled with the low wind speeds and channeling effects of the valleys, result in poor dilution of material emitted from the facilities. These features are captured in the data input to the dispersion models

and are reflected in the modeling studies conducted for each facility.

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

The average data recovery rate (a measure of acceptable data) across all locations and at the 16 tower levels was 96.3% in 1997. The maximum data recovery was 99.6% at ETTP MT1 at 60 m and at ORNL MT2 at both 10 and 30 m. The minimum data recovery rate was 74.5% at ETTP MT7 at 30 m.

5.3 EXTERNAL GAMMA RADIATION MONITORING

External gamma radiation measurements are made to determine whether routine radioactive effluents from the ORR are increasing external radiation levels significantly above normal background levels.

5.3.1 Data Collection and Analysis

External gamma measurements are recorded weekly at six ambient air stations from resident external gross gamma monitors (Fig. 5.2). Each consists of a dual-range, high-pressure ion chamber sensor and digital electronic count-rate meter and totalizer. Totalizing consists of multiplying the count rate by the time of exposure to obtain total dose. The doses are analyzed for average and median values, which are compared with national median values.

5.3.2 Results

Table 5.1 summarizes the data collected at each station during the year. The minimum, maximum, and average values reported in 1997 appear to differ significantly from the corresponding values in the 1996 ASER. These differences are actually the result of changes in the way the data are reported. The summary data for 1997 are based on average exposure rates for each measurement period, whereas the values summarized for 1996 were actual rates observed at the time of data collection. Averaging the total exposure over each measurement cycle provides more information about the entire period of interest and is more comparable to national median values used as reference information.

5.4 AMBIENT AIR MONITORING

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

The following sections discuss the ambient air monitoring networks for the ORR, the Y-12 Plant, ORNL, and the ETTP.

5.4.1 ORR Ambient Air Monitoring

The objectives of the ORR ambient air monitoring program are to perform surveillance of airborne radionuclides at the reservation perimeter and to collect reference data from a remote location not affected by activities on the ORR. The ORR perimeter air monitoring (PAM) network includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 5.3). Reference samples are collected from station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 1997 to

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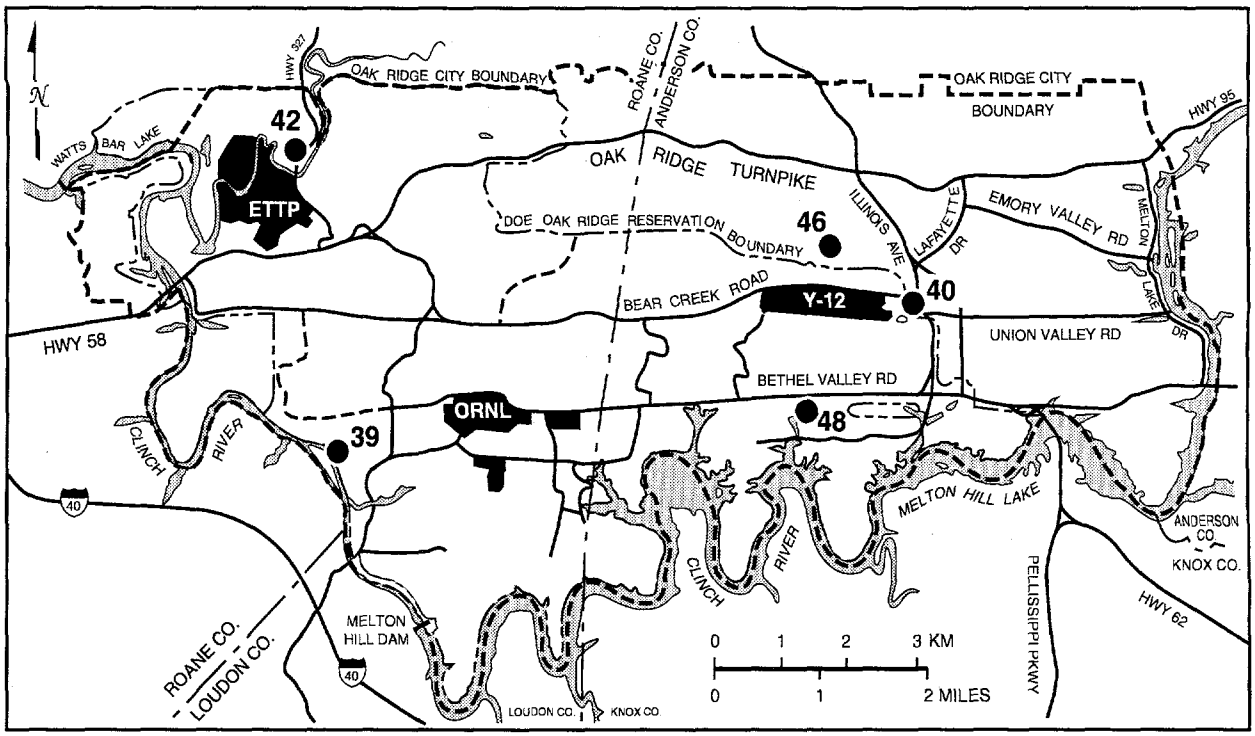

Fig. 5.2. External gamma radiation monitoring locations on the ORR. Location 52, at Fort Loudoun Dam, approximately 15 miles southwest of ORNL, is not shown on this map.

Table 5.1. External gamma averages, 1997

Location	Number of data values collected	Measurement (μR/h)[a]			Standard error of mean
		Min	Max	Mean	
39	51	0.02	6.8	5.8	0.0002
40	51	4.9	10.9	5.7	0.0002
42	52	4.6	14.7	5.2	0.0002
46	49	5.4	6.5	5.8	0.00003
48	49	1.2	6.5	4.9	0.0002
52	50	4.5	5.5	5.1	0.00004

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

quantify levels of alpha-, beta-, and gamma-emitting radionuclides and tritium.

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

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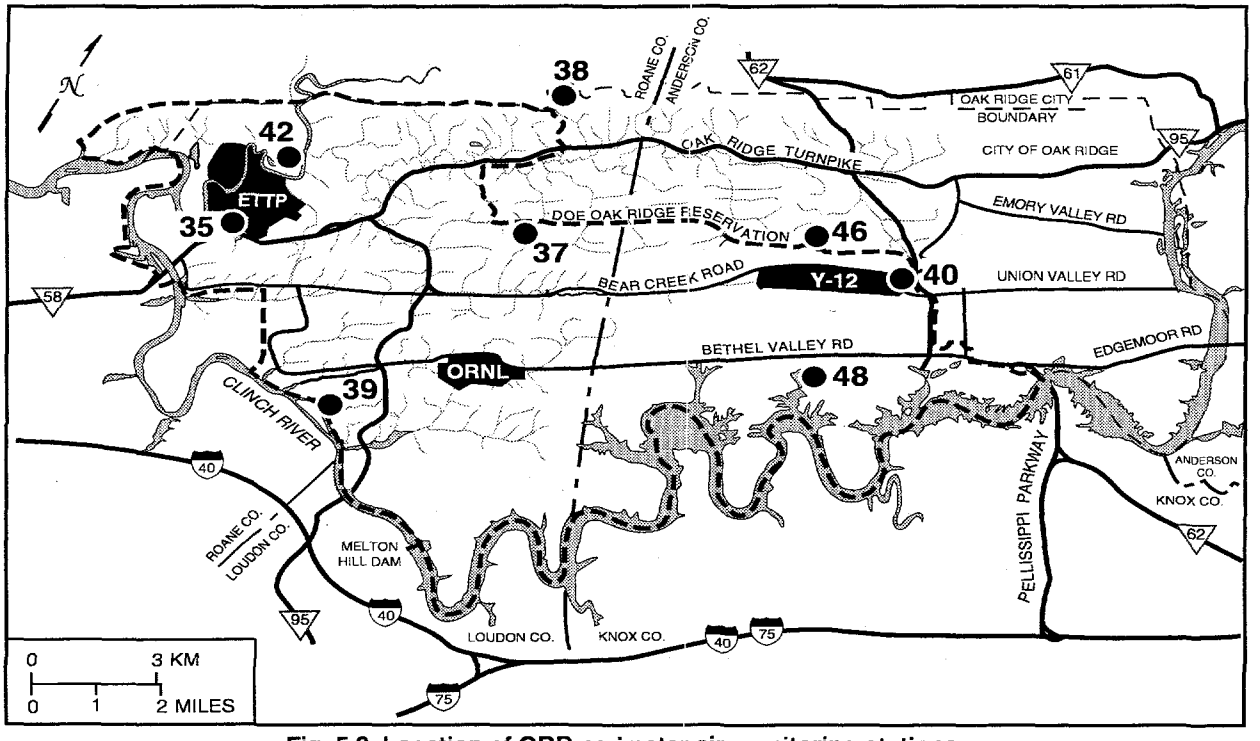

Fig. 5.3. Location of ORR perimeter air monitoring stations.

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

The ORR PAM or ambient air network (Fig. 5.3) provides appropriate monitoring for all facilities within the reservation, which eliminates the necessity for site-specific ambient air programs. As part of the ORR network, an ambient air monitoring station located in the Scarboro Community of Oak Ridge (Station 46) measures off-site impacts of the Y-12 Plant operation and is located near the theoretical area of maximum public pollutant concentrations as calculated by air-quality modeling. Station 40 of the ORR network monitors the east end of the Y-12 Plant, and Station 37 monitors the overlap of the Y-12 Plant, ORNL, and ETTP emissions.

5.4.1.1 Results

Data from the ORR PAM stations are analyzed to assess the impact to air quality of operations on the entire reservation. The background station provides information on reference concentrations of radionuclides and gross parameters for the region. A comparison of ORR PAM station sampling data with those from the reference station at the 95% confidence level shows that there are no significant differences in the radionuclide concentrations from the ORR stations and the reference station (Table 5.2).

Table 5.3 represents the average concentration of three isotopes of uranium at each station for sampling years 1994, 1995, 1996, and 1997.

Table 5.2. Radionuclide concentrations at ORR perimeter air monitoring stations, 1997[a,b]

Station	^{7}Be	^{60}Co	^{137}Cs	^{40}K	^{3}H	^{234}U	^{235}U	^{238}U	Gross alpha	Gross beta
35	*c*	3.6E–17	1.0E–16	1.9E–15	*c*	4.0E–17	2.1E–18	4.6E–17	1.2E–15	2.7E–15
37	*c*	3.2E–17	3.4E–17	1.6E–15	*c*	5.3E–17	4.4E–18	5.4E–17	1.5E–15	2.6E–15
38	*c*	3.0E–17	1.2E–17	1.8E–15	*c*	5.3E–17	1.8E–18	4.4E–17	1.4E–15	2.7E–15
39	4.2E–14	1.7E–17	4.8E–18	1.6E–15	5.5E–11	4.6E–17	1.6E–18	6.1E–17	2.1E–15	3.3E–15
40	5.5E–14	8.4E–18	4.1E–18	1.7E–15	*c*	2.2E–16	5.8E–18	5.9E–17	1.5E–15	3.0E–15
42	*c*	5.2E–17	3.0E–17	2.2E–15	*c*	7.2E–17	6.2E–18	3.9E–17	2.0E–15	2.9E–15
46	6.3E–14	2.0E–17	2.0E–17	2.5E–15	*c*	1.0E–16	3.7E–18	4.7E–17	1.6E–15	3.8E–15
48	4.6E–14	2.3E–17	5.7E–18	1.8E–15	*c*	5.3E–17	4.3E–18	4.8E–17	1.6E–15	2.8E–15
52[d]	*c*	1.1E–17	2.3E–17	2.3E–15	*c*	4.1E–17	3.6E–18	3.7E–17	2.1E–15	4.0E–15

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

5.4.2 Y-12 Plant Ambient Air Monitoring

In 1994, Y-12 Plant personnel issued *Evaluation of the Ambient Air Monitoring Program at the Oak Ridge Y-12 Plant* (MMES 1994) and worked with DOE and TDEC in reviewing the ambient air program for applicability and usefulness of the data. There are no federal regulations, state regulations, or DOE orders that require this monitoring. All ambient air monitoring systems at the Y-12 Plant are operated as a BMP. With the reduction of plant operations and improved emission and administrative controls, levels of measured pollutants have decreased significantly during the past several years. In addition, processes that result in emission of enriched and depleted uranium are equipped with stack samplers that have been reviewed and approved by EPA to meet requirements of the NESHAP regulations. ORR air sampling stations, operated by ORNL in accordance with DOE orders, are located around the reservation. Their locations ensure that areas of potentially high exposure to the public are monitored continuously for parameters of concern.

With agreement from TDEC personnel, the ambient air sampling program at the Y-12 Plant was significantly reduced, effective at the end of 1994. All fluoride, total suspended particulates (TSPs), and particulate matter less than 10 microns in diameter (PM10) sampling was discontinued, and all but 3 of the 12 uranium samplers were shut down. The mercury sampling program was continued to monitor ambient air level concentrations through 1997 but may be curtailed in the near future because of decreasing monitoring budgets.

In 1997, three low-volume uranium particulate monitoring stations and four mercury monitoring stations were operated by the Y-12 Plant. The locations of these monitoring stations are shown in Fig. 5.4.

Table 5.3. Uranium concentrations in ambient air on the ORR

Isotope	Concentration (10^{-15} µCi/mL)			
	1994	1995	1996	1997
		Station 35		
^{234}U	3.5E–02	1.5E–02	2.2E–02	4.0E–02
^{235}U	3.0E–03	4.4E–04	1.3E–03	2.1E–03
^{238}U	2.4E–02	1.8E–02	3.4E–02	4.6E–02
		Station 37		
^{234}U	3.5E–02	1.3E–02	2.0E–02	5.4E–02
^{235}U	3.0E–03	1.4E–03	7.2E–04	4.4E–03
^{238}U	1.9E–02	1.3E–02	2.1E–02	5.3E–02
		Station 38		
^{234}U	2.9E–02	1.1E–02	1.6E–02	5.3E–02
^{235}U	4.0E–03	2.7E–04	9.2E–04	1.8E–03
^{238}U	1.6E–02	1.1E–07	2.0E–02	4.4E–02
		Station 39		
^{234}U	2.7E–02	1.1E–02	1.4E–02	4.6E–02
^{235}U	5.0E–03	1.1E–03	6.2E–04	1.6E–03
^{238}U	9.0E–03	9.1E–03	1.2E–02	6.1E–02
		Station 40		
^{234}U	8.9E–02	5.1E–02	4.6E–02	2.2E–01
^{235}U	9.0E–03	3.4E–03	1.8E–03	5.8E–03
^{238}U	1.6E–02	1.6E–02	1.7E–02	5.9E–02
		Station 42		
^{234}U	1.9E–02	1.1E–02	1.8E–02	7.2E–02
^{235}U	2.0E–03	1.3E–03	1.3E–03	6.2E–03
^{238}U	1.5E–02	1.1E–02	2.0E–02	3.9E–02
		Station 46		
^{234}U	4.4E–02	2.6E–02	2.3E–02	1.0E–01
^{235}U	6.0E–03	1.7E–03	1.1E–03	3.7E–03
^{238}U	1.5E–02	1.1E–02	1.9E–02	4.7E–02
		Station 48		
^{234}U	2.3E–02	1.3E–02	2.8E–02	5.3E–02
^{235}U	1.0E–03	1.0E–03	6.9E–04	4.3E–03
^{238}U	1.1E–02	9.5E–03	1.3E–02	4.8E–02
		Station 52		
^{234}U	1.6E–02	1.2E–02	9.4E–03	4.1E–02
^{235}U	2.0E–02	2.2E–03	1.4E–03	3.6E–03
^{238}U	6.0E–03	8.9E–03	9.3E–03	3.7E–02

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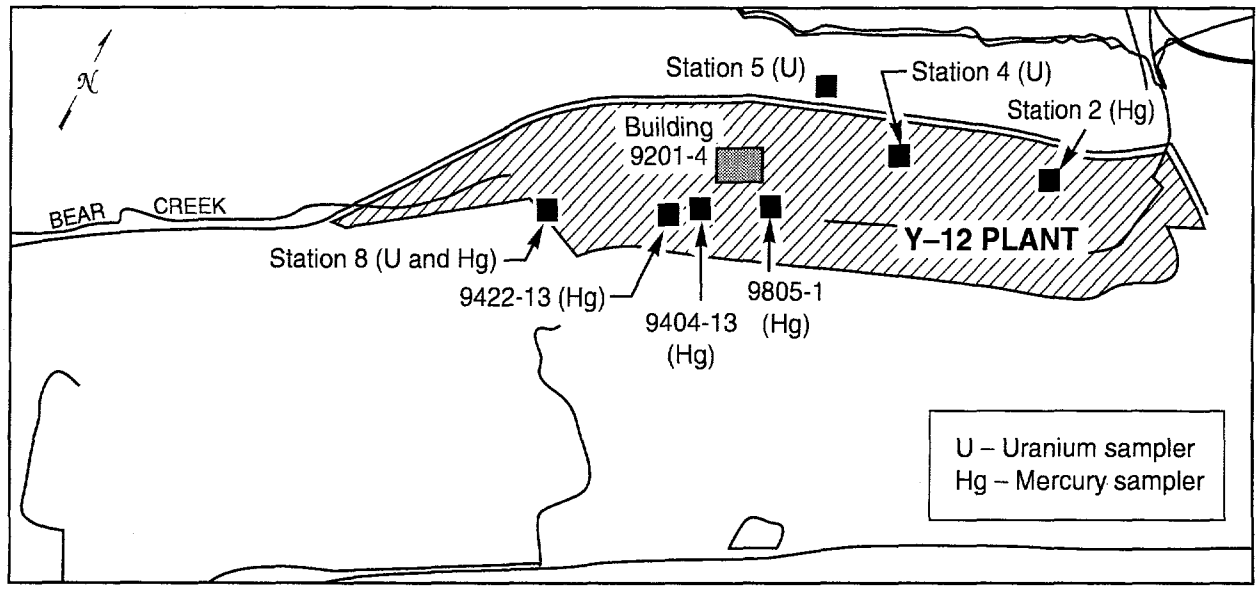

Fig. 5.4. Locations of ambient air monitoring stations at the Y-12 Plant.

5.4.2.1 Uranium

Samples for routine measurement of uranium particulate were collected by pulling ambient air through a 14-cm- (5.5-in.-) square filter, which was analyzed by the Y-12 Plant Analytical Services Organization for total uranium and for the percentage of ^{235}U. Prior to 1993, the samples were analyzed for gross alpha and beta and for activity levels of specific uranium isotopes; however, in 1993, the analysis program for radionuclides was revised as described in the EMP to obtain total uranium particulate and the percentage of ^{235}U. In this manner, uranium concentrations in ambient air could be better correlated to stack emission data, which are also measured as total uranium mass. For 1997, the average 7-day concentration of uranium at the three monitored locations ranged from a low of 0.0000062 $\mu g/m^3$ at Station 5 to a high of 0.00297 $\mu g/m^3$ at Station 4 (Table 5.4).

5.4.2.2 Mercury

The year 1997 represents the twelfth year of operation of the Oak Ridge Y-12 Plant monitoring program for measuring on-site mercury vapor concentrations in ambient air. Outdoor airborne mercury vapor at the Y-12 Plant is primarily the result of vaporization from mercury-contaminated soils, fugitive emissions from former mercury-use area buildings, and releases from coal burning at the Y-12 Steam Plant. The goals of the monitoring program have been to establish a historical data base of mercury concentrations in ambient air at the Y-12 Plant, identify spatial and temporal trends in mercury vapor concentrations at the Y-12 Plant, and demonstrate protection of the environment and human health from releases of mercury from the Y-12 Plant to the atmosphere.

Four outdoor ambient mercury monitoring stations (boundary stations) on the east and west ends of the plant and two stations near Building 9201-4, a former lithium isotope separation facility contaminated with mercury, were established at the Y-12 Plant in 1986. One of the original sites near Building 9201-4 was relocated in 1996 approximately 30 meters south and west of the old location to a site near Building 9422-13. A control or reference site was established in 1988 at Rain Gage No. 2 on Chestnut Ridge in the Walker Branch Watershed and monitored for a period of 20 months during 1988 and 1989 to establish background concentrations.

Table 5.4. Uranium mass in ambient air at the Y-12 Plant, 1997

Station No.	No. of samples	7-day concentration ($\mu g/m^3$)		
		Max	Min	Av
4	51	0.0029737	0.0000086	0.0001498
5	51	0.0011685	0.0000062	0.0000954
8	52	0.0007323	0.0000221	0.0000905

Because no established or EPA-approved method for measuring mercury vapor in ambient air existed when the program was initiated in 1986, staff of the ORNL Environmental Sciences Division developed a method to meet the needs of the monitoring program for the Y-12 Plant. At each of the monitoring sites, airborne mercury vapor is pulled through a Teflon filter and flow-limiting orifice before being adsorbed onto iodated charcoal packed in a glass sampling tube. The charcoal sampling tubes are routinely changed every 7 days. Average air concentration of mercury vapor for each 7-day sampling period is calculated by dividing the total quantity of mercury collected on the charcoal by the total volume of air pulled through the charcoal trap over the 7-day period.

During 1997, Tekran™ Model 2537A mercury vapor analyzers were operated at the two boundary locations, Ambient Station No. 2 and Ambient Station No. 8. The Tekran mercury vapor analyzers are self-calibrating, include mass-flow controllers, and can provide almost continuous analysis of mercury vapor in air at less than nanogram per cubic meter (sub-ng/m^3) levels at time intervals as short as 5 minutes, thus providing a means for determining the range and magnitude of short-term (i.e., minutes instead of days) mercury fluctuations. During 1997, the analyzers were operated at time intervals of 30 minutes, resulting in approximately 15,500 mercury concentration data points for Ambient Station No. 2 and over 10,000 data points for Ambient Station No. 8.

The Tekran analyzers at both Ambient Station No. 2 and Ambient Station No. 8 were run simultaneously throughout most of the year with the older monitoring system (i.e., the iodated charcoal traps) to verify comparability of the measurements. Figure 5.5 is a plot of mercury vapor concentrations recorded at 30-minute intervals by the Tekran analyzer at Ambient Station No. 2 during 1997. Overlain on top of it is the 7-day moving average of the Tekran data (comparable to the charcoal trap weekly results). The Tekran plot presents over 15,000 data points and provides important information on the magnitude of short-term fluctuations in mercury vapor concentration at Ambient Station No. 2. Figure 5.6 presents a plot of the charcoal trap results overlain on the Tekran 7-day moving average for the same time period (January through June 1997), illustrating good agreement between data collected by the two monitoring systems.

As reported in last year's annual ORR environmental report, analysis of data collected at the two Tekran sites has shown a strong correlation between wind direction and mercury vapor concentration, with peak mercury vapor concentrations measured at a site when the prevailing wind direction is from the former mercury-use areas at the Y-12 Plant. Data for 1997 continues to support this finding. Because the boundary sites are at opposite ends of the Y-12 Plant and opposite directions from the mercury-use areas, one would expect that when mercury vapor concentrations peak at one site, vapor concentrations would be low at the other boundary site. Tekran 30-minute interval results for the two sites support this (Fig. 5.7). Only mercury vapor concentrations greater than 0.01 $\mu g/m^3$ are shown in Fig. 5.7 so as to highlight differences between the two sites during periods when vapor concentrations are higher than average.

Annual average mercury vapor concentrations at the Y-12 Plant have declined since the early years of the monitoring program (1986 through 1988) with average concentrations at the two boundary sites currently comparable to those measured in 1988 and 1989 at the reference site (Table 5.5). Of the three sites operational since 1986, all three show significantly lower annual

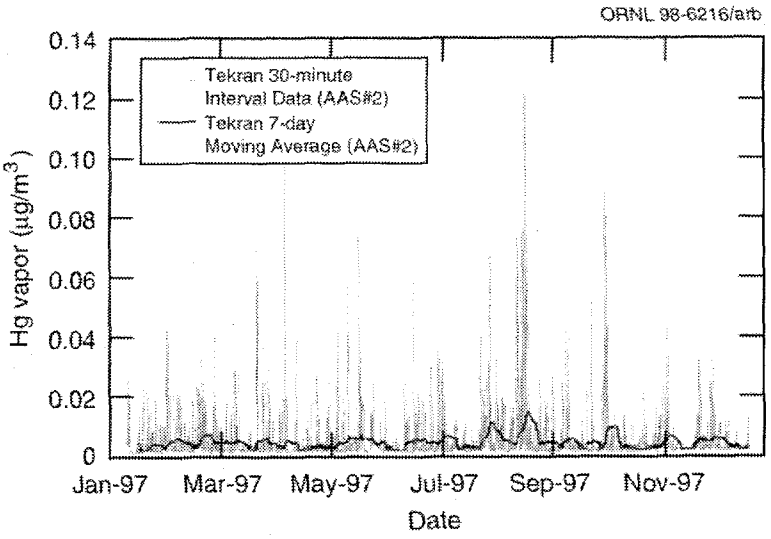

Fig. 5.5. Temporal trends in mercury vapor concentration at Ambient Station No. 2 from January through mid-December 1997 as measured by a Tekran Model 2537A mercury vapor analyzer. The 7-day moving average for the 15,444 data points overlays the 30-min Tekran data.

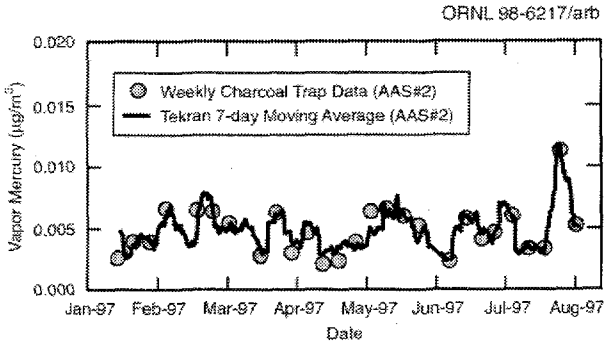

Fig. 5.6. Comparison of the Tekran 7-day moving average with the 7-day charcoal trap data for Ambient Station No. 2 during the first half of 1997.

averages (Student's *t*-test at the 1% level) for mercury vapor concentration when compared with the 1986 through 1988 average. Average mercury vapor concentrations in 1997 for the four sites currently monitored are comparable to those reported for the last two years in the annual environmental report (Table 5.5). The decrease in ambient vapor mercury recorded at the Y-12 sites since 1989 is thought to be related to the reductions in coal burning at the Y-12 Steam Plant beginning in 1989 and to the completion prior to 1989 of several major engineering projects [e.g., New Hope Pond closure, the Perimeter Intrusion Detection Assessment System (PIDAS), Reduction of Mercury in Plant Effluent (RMPE), and Utility Systems Restoration] that may have caused a temporary increase in mercury air concentrations because of disturbances to contaminated soil and sediment. More recently, mercury cleanup and closure activities have been conducted at several sites within the mercury-use areas including Building 9201-4.

Figure 5.8 illustrates temporal trends in mercury concentrations for the four active ambient air mercury monitoring sites since the inception of the program in 1986. Results for the newest site near Building 9422-13, which replaced the nearby site at Building 9404-13 in 1996, are overlain on the original plot for Building 9404-13. Seasonal increases in mercury concentrations in ambient air are recorded at all four sites during warm-weather months.

In 1997, although ambient mercury concentrations at the two monitoring sites near Building 9201-4 are still elevated above natural background, results indicate that concentrations of mercury vapor are well below the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value of 50 $\mu g/m^3$ (time-weighted average for 8-hour workday and 40-hour work week). Average concentrations at the two boundary monitoring sites located at the east and west end of the Y-12 Plant are comparable to levels measured at our reference site on Chestnut Ridge.

5.4.3 ORNL Ambient Air Monitoring

The objectives of the ORNL ambient air monitoring program are to collect samples at stations that are most likely to show impacts of airborne emissions from the operation of ORNL and to provide for emergency response capability.

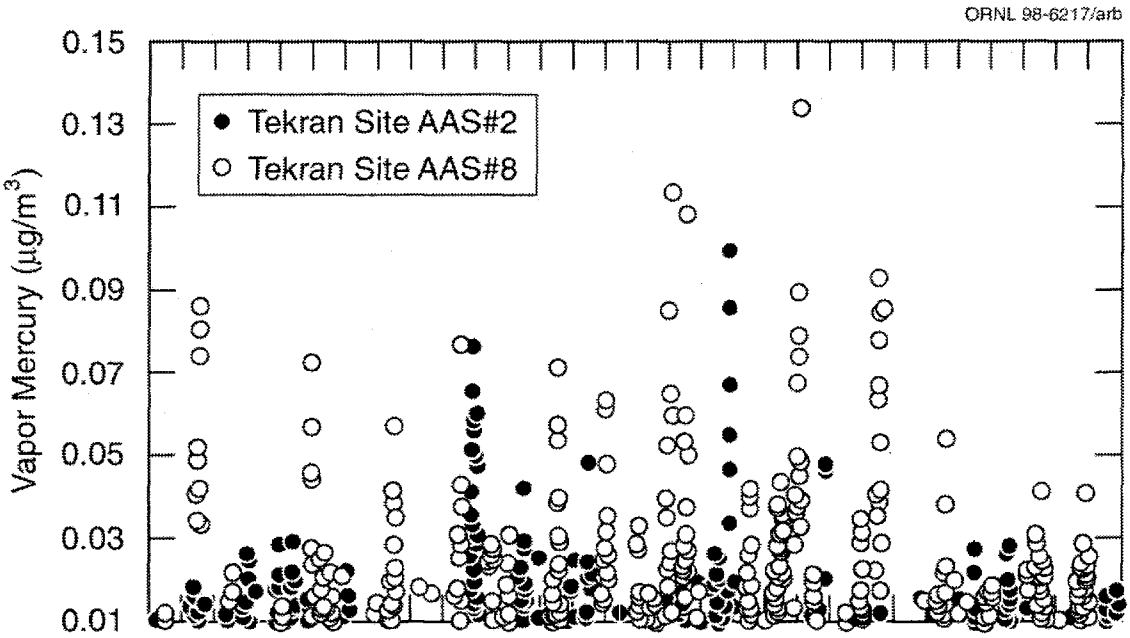

Fig. 5.7. Temporal comparison of peak (>0.01 µg/m³) mercury concentrations at Ambient Station No. 2 and Ambient Station No. 8 during a 2-month period in 1997.

Table 5.5. Results of the Y-12 Plant ambient air mercury monitoring program
The 1997 averages are calculated from results of both charcoal trap and Tekran monitoring

Ambient air monitoring site	Mercury vapor concentration (µg/m³)			
	1997 Average	1996 Average[a]	1995 Average[a]	1986–1988 Average[a]
Station No. 2 (east end of Y-12 Plant)	0.0048	0.004	0.005	0.010
Station No. 8 (west end of Y-12 Plant)	0.0065	0.006	0.007	0.033
Bldg. 9422-13 (SW of Bldg. 9201-4)	0.032[b]	0.030	N/A[c]	N/A[c]
Bldg. 9805-1 (SE of Bldg. 9201-4)	0.064[b]	0.058	0.066	0.099
Reference Site, Rain Gage No.2 (1988[d])	N/A	N/A	N/A	0.006
(1989[e])	N/A	N/A	N/A	0.005

[a]ACGIH 8-h workday/40-h work week threshold limit equals 50 µg/m³.
[b]Data for period from January 1 through September 30, 1997.
[c]Site established in late 1995.
[d]Data for period from February 9 through December 31, 1988.
[e]Data for period from January 1 through October 31, 1989.

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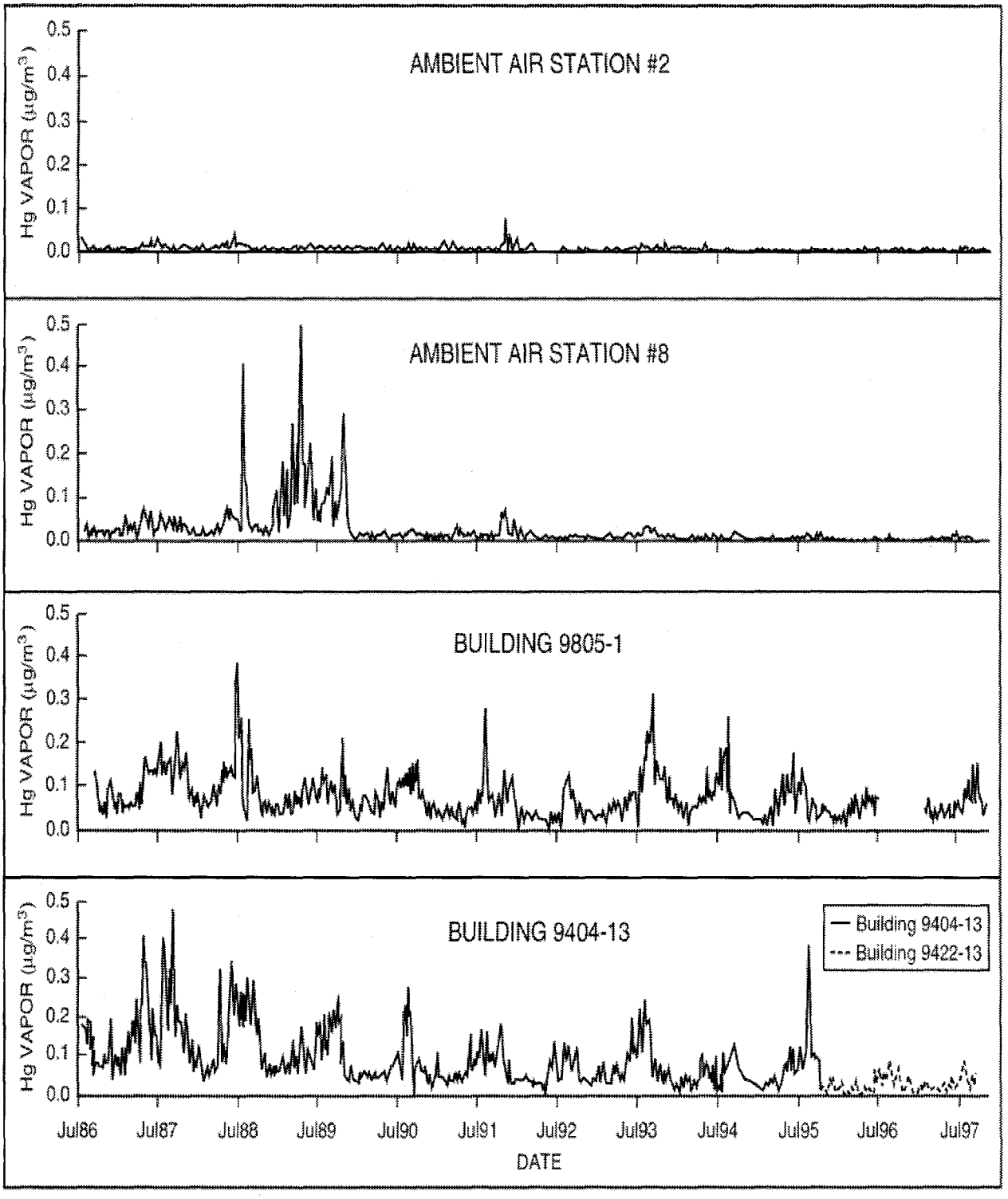

Fig. 5.8. Time trends in mercury vapor concentrations for the four active airborne mercury monitoring sites at the Oak Ridge Y-12 Plant (1986 through 1997). Note that the new site established in late 1995 at Building 9422-13 is overlain on the plot for Building 9404-13.

Four stations identified as stations 1, 2, 3, and 7 (Fig. 5.9) make up the ORNL network. Sampling is conducted at each ORNL station to quantify levels of adsorbable gases (e.g., iodine), and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.6).

The sampling system consists of a low-volume air sampler for particulate collection using a 47-mm glass fiber filter. The filters are collected biweekly, composited annually, then submitted to the laboratory for analysis. Following the filter is a charcoal cartridge used to collect adsorbable gases (e.g., iodine). The charcoal cartridges are analyzed biweekly using gamma spectroscopy for adsorbable gas quantification. A silica gel column is used for collection of tritium as tritiated water. These samples are collected biweekly or weekly. The silica gel from each station is composited each quarter then submitted to the laboratory for tritium analysis.

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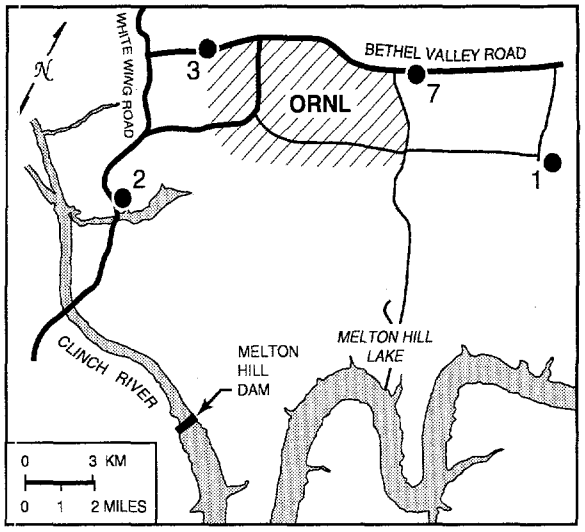

Fig. 5.9. Locations of ambient air monitoring stations at ORNL.

5.4.3.1 Results

The ORNL PAM stations are designed to provide data for collectively assessing the specific impact of ORNL operations on local air quality. Sampling data from the ORNL PAM stations (Table 5.6) is compared with air sampling data from the reference station (station 52) at Fort Loudoun.

5.4.4 ETTP Ambient Air Monitoring

DOE Order 5400.1 requires surveillance of ambient air to assess the impact of DOE operations on air quality off-site. In addition, airborne radionuclide monitoring is required for compliance with radionuclide NESHAP regulatory agreements. DOE Order 5400.5 also specifies locations for airborne radionuclide surveillance. The ETTP ambient air monitoring program is designed to monitor selected air contaminants for the ongoing monitoring of plant operations' impact on the immediate environment. Specific locations were selected to determine air contaminant concentrations in the prevailing directions, upwind and downwind of the site, and to obtain airborne radiological measurements in the direction of both the nearest and most exposed member of the public. The locations of these monitoring stations are shown in Fig. 5.10. The ETTP ambient air monitoring program complies with all requirements of DOE orders. National ambient air quality standards are referenced by DOE orders as guidance with respect to ambient air concentrations of certain air contaminants. These regulations specify 24-hour, quarterly, and annual standards for specific or criteria pollutants.

The ambient air program sampling schedule and monitoring capabilities for airborne particulate matter, uranium, and selected HAP metals are listed in Table 5.7. All parameters are chosen with consideration of existing and proposed regulations and the nature of operations in and around the ETTP. Changes in emissions, wind profile, site activities, or any other parameter that may alter the potential impact of ETTP activities on nearby communities or the enviroment may warrant periodic changes of air contaminants measured, number of stations, or relocation of existing stations.

During this reporting period, the network was modified with respect to ETTP operations. During the fourth quarter of 1997, a temporary high-

Table 5.6. Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 1997 (μCi/mL)[a]

Parameter	Station				
	1	2	3	7	52[b]
^{7}Be	1.6E–14	1.0E–14	9.8E–15	9.9E–15	*c*
^{137}Cs	3.1E–17	2.0E–17	5.2E–17	2.1E–17	2.3E–17
^{60}Co	3.0E–17	*c*	1.6E–17	*c*	1.1E–17
^{3}H	*c*	7.8E–11	*c*	2.6E–12	c
^{131}I	8.5E–16	1.5E–15	2.4E–15	9.4E–16	*d*
^{133}I	*c*	2.3E–15	2.6E–15	3.7E–15	*d*
^{135}I	7.6E–15	5.6E–14	1.5E–14	*c*	*d*
^{40}K	8.3E–16	9.1E–16	1.2E–15	9.3E–16	2.3E–15
^{234}U	3.0E–17	3.6E–17	2.9E–17	4.0E–17	4.1E–17
^{235}U	3.5E–18	*c*	*c*	*c*	3.6E–18
^{238}U	2.9E–17	2.6E–17	3.3E–17	3.0E–17	3.7E–17
Gross alpha	5.3E–15	4.5E–15	4.2E–15	6.3E–15	
Gross beta	1.1E–14	1.1E–14	1.0E–14	1.1E–14	

[a]1 μCi = 3.7E+04 Bq.
[b]Reference location.
[c]Not detected.
[d]Not applicable.

volume (HV) sampling station was activated in response to a scheduled demolition of buildings not within the existing perimeter ambient air monitoring network. Station KAFaD was activated prior to the start of activities to establish background levels of the air pollutants as identified in Table 5.7. All sampling was continuous with all procedures and schedules identical to the ETTP ambient air monitoring network operations with the exception that individual weekly samples are analyzed. The location of station KAFaD project is identified in Fig. 5.10.

HV sampling for uranium continues at stations K6 and K2, representing samples in the prevailing site upwind and downwind directions, respectively. Additional uranium monitoring coverage is supplied by ORR PAM stations 35 and 42. The PAM locations represent coverage in the direction of the nearest and the most exposed individuals as defined by DOE Order 5400.5. Sampling for HAP carcinogen metals and lead continues at stations K2 and K6.

5.4.4.1 Results

No standards were exceeded, and there were no significant elevations of pollutant concentrations associated with site operations. Sampling results assessing specific site activities' impact on air quality show that the ETTP and the project-specific operations did not have a measurable impact on local air quality. These data also support the state classification of this area, including the ETTP, as in attainment for PM10. Table 5.7 lists selected parameters measured during 1997.

5.4.4.2 Criteria Pollutant Levels

Daily PM10 analyses were performed on all 24-hour samples. A summary of all PM10 mea-

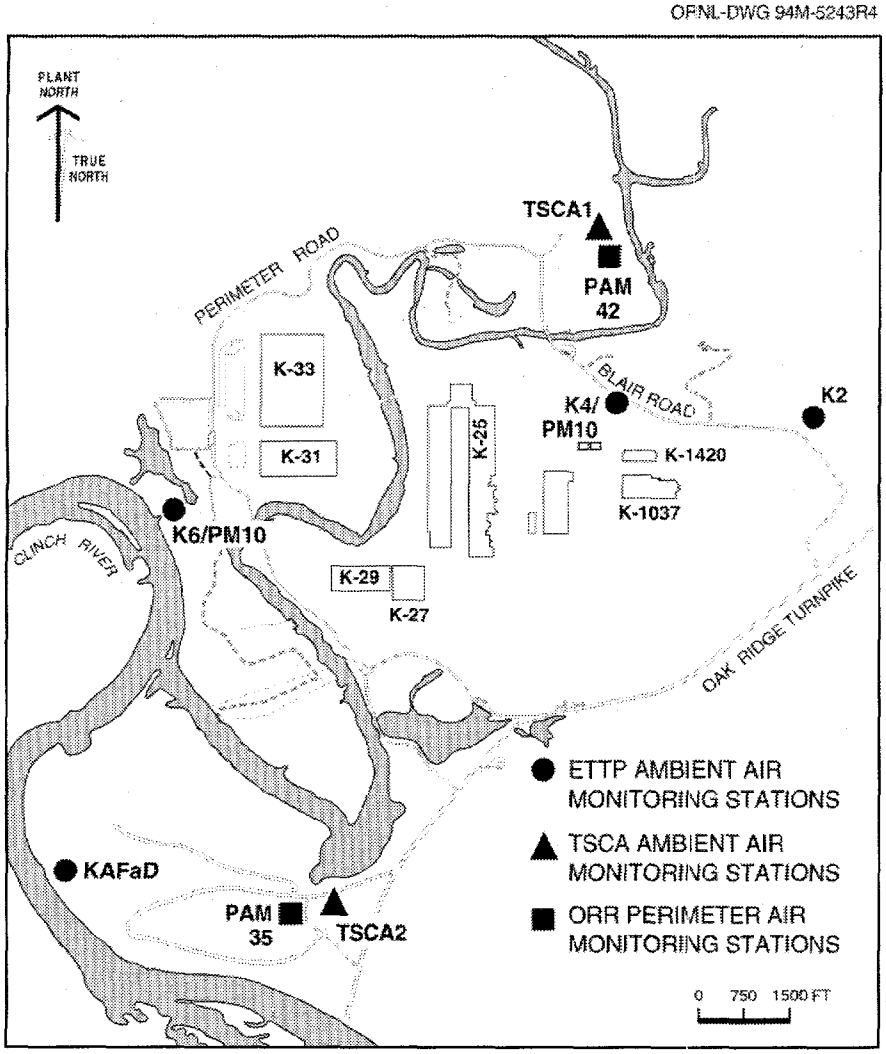

Fig. 5.10. Locations of ambient air monitoring stations at the ETTP.

surements is presented in Table 5.8. For 1997, the 24-hour PM10 concentrations ranged from 2.91 to 55.07 $\mu g/m^3$. The highest measured value was 36.7% of the Tennessee 24-hour primary and secondary standards (i.e., 150 $\mu g/m^3$). These levels are not an environmental concern.

Annual PM10 arithmetic averages of 24-hour measurements are presented in Table 5.8. The highest averaged PM10 annual result was 18.91 $\mu g/m^3$. This value was only 37.8% of the Tennessee and national annual primary and secondary standards for PM10 (i.e., 50 $\mu g/m^3$). Historical data show that this level is typical of annual measurements and is of no environmental concern (see Fig. 5.11 for 5-year PM10 trend).

Quarterly lead results were determined from analyses of both monthly composites of continuous weekly samples for stations K2 and K6 and weekly analyses of samples from the KAFaD project station. The total masses of lead were determined by the inductively coupled plasma mass spectrometry (ICP-MS) analytical technique. A summary of lead measurement results are presented in Table 5.9 and are compared with the Tennessee and national quarterly standard of 1.5 $\mu g/m^3$. There are no 24-hour, monthly, or annual ambient air criteria pollutant standards for lead. The maximum individual lead result was 0.008456 $\mu g/m^3$. This value was only 0.56% of the quarterly standard for lead. No lead concentration levels of environmental concern were measured (see Fig. 5.12 for 5-year lead trend).

5.4.4.3 Hazardous Air Pollutant Carcinogen Metal Levels

Analyses of HAP carcinogen metals (arsenic, beryllium, cadmium, and chromium) were performed on both monthly composites of continuous weekly samples from stations K2 and K6 and on each weekly sample from the KAFaD project station. The total mass of each selected metal was determined by the ICP-MS analytical technique. There are no Tennessee or national ambient air quality standards for HAP carcinogen metal. However, arsenic individual concentration results

Table 5.7. Summary of collection and analysis frequencies of samples collected at ETTP perimeter ambient air monitoring stations, 1997

Parameter	Sampling locations	Sampling period	Collection frequency	Analysis frequency[a]
		Criteria pollutants		
PM10	K4, 6	24 hour	Every sixth day[b]	Weekly
Lead	K2, 6	Continuous	Weekly	Monthly
	KAFaD[c]	Continuous	Weekly	Weekly
		Hazardous air pollutants carcinogen metals		
Arsenic	K2, 6	Continuous	Weekly	Monthly
	KAFaD	Continuous	Weekly	Weekly
Beryllium	K2, 6	Continuous	Weekly	Monthly
	KAFaD	Continuous	Weekly	Weekly
Cadmium	K2, 6	Continuous	Weekly	Monthly
	KAFaD	Continuous	Weekly	Weekly
Chromium (total)	K2, 6	Continuous	Weekly	Monthly
	KAFaD	Continuous	Weekly	Weekly
		Organic compounds		
PCBs	TSCA 1, 2	*d*	*d*	*d*
Furan	TSCA 1, 2	*d*	*d*	*d*
Dioxin	TSCA 1, 2	*d*	*d*	*d*
Hexachlorobenzene	TSCA 1, 2	*d*	*d*	*d*
		Radionuclides		
Uranium (total)	K2, 6	Continuous	Weekly	Monthly
	PAM-35, 42	Continuous	Weekly	Quarterly
	KAFaD	Continuous	Weekly	Weekly
	TSCA 1, 2	*d*	*d*	*d*

[a]"Weekly" frequency is analysis of each individual sample. "Monthly" and "quarterly" are composite sample analyses of all weekly samples over the identified period.

[b]24-hour sample every sixth day from midnight to midnight.

[c]Temporary sampling station during building demolition activities.

[d]Stations are activated automatically only if a TSCA Incinerator operational upset occurs. Identified samples are then immediately submitted for analysis.

for all measurement sites ranges from 0.000475 to 0.001160 $\mu g/m^3$. No beryllium measurement was above the established minimum detection limits of the analytical method. Cadmium concentration results ranged from 0.000190 to 0.001804 $\mu g/m^3$. Individual chromium measurements ranged from 0.000324 to 0.000966 $\mu g/m^3$. A summary of the HAP carcinogen metals measurements are in Table 5.10.

5.4.4.4 Radionuclide Levels

Of the radionuclides, only uranium was measured both as a monthly composite of continuous weekly samples from stations K2 and K6 and weekly samples from station KAFaD. The total uranium mass for each sample was determined by the ICP-MS analytical technique. The uranium concentrations for all measurement sites are

Table 5.8. PM10 particulates in ambient air at the ETTP, 1997

Station	Number of samples	Annual summary of PM10 concentrations ($\mu g/m^3$)			Max percentage of standard[a]	
		Annual av	24-h max	24-h min	Annual	24-h
K4	61	16.24	46.13	2.91	32.5	30.8
K6	58	18.91	55.07	4.96	37.8	36.7
All stations	119	17.57	55.07	2.91	35.1	36.7

[a]PM10 Tennessee and national primary and secondeary standards are 150 $\mu g/m^3$ per 24 hours and 50 $\mu g/m^3$ per year arithmetic average.

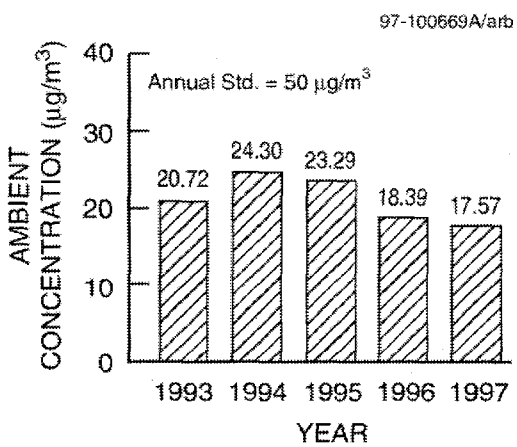

Fig. 5.11. Ambient air monitoring 5-year trend results for PM10 at the ETTP.

presented in Table 5.11 and ranged from a low of 0.000002 to 0.000621 $\mu g/m^3$. The highest results were measured at Station K2. Station K2 is in the prevailing downwind direction of the ETTP. The annual average values for all stations were less than 1% of the annual standard of 0.15 $\mu g/m^3$ (1.0E-1 pCi/m^3) for naturally occurring uranium. No uranium concentration levels of environmental concern were measured (see Fig. 5.13 for 5-year uranium trend).

5.4.4.5 Organic Compound Levels

Currently, measurements of selected semi-volatile organics are performed only during an operational upset of the TSCA Incinerator. No upsets occurred during waste burning operations in 1997 that activated the TSCA ambient air stations.

5.4.4.6 Five-Year Trends

Five-year summaries of ETTP ambient air monitoring data are shown in Figs. 5.11, 5.12, and 5.13 for PM10, lead, and uranium. Other measured pollutant trends are discussed in this section. Variations of PM10 measurements were insignificant and most likely reflect background concentration variations of air quality. Lead measurement variations from 1993 to 1994 were primarily caused by changes in analytical techniques. The minor changes are most likely a result of typical background variations of lead concentrations. Uranium levels reflect typical levels that can be associated with normal ETTP operations.

Arsenic, beryllium, and cadmium measurements were initiated in 1993, and chromium was initiated in 1986. Both arsenic and chromium measurement variations over the last 5 years have typically been indistinguishable from background levels except during the cooling tower demolition project activities in 1995 and 1996. All beryllium measurements, historical and current, have been at or near analytical detection limits. Cadmium concentration measurement variations have occurred coincidental to ground disturbance activities such as logging or bulldozing or in areas where large exposed earthen areas exist.

Table 5.9. Lead concentrations in ambient air at the ETTP, 1997

Station	Quarterly averages of monthly composites ($\mu g/m^3$)				Max individual result	Min individual result	Max percentage of quarterly standard[a,b]
	1	2	3	4			
K2	0.003653	0.004628	0.004523	0.003839	0.004628	0.003653	0.31
K6	0.003240	0.003318	0.003253	0.005670	0.005670	0.003240	0.38
KAFaD[c]				0.005038	0.008456	0.002437	0.56
Quarterly av	0.003446	0.003973	0.003888	0.004755	0.004755	0.003446	0.32
Quarterly max	0.003653	0.004628	0.004523	0.005670	0.005670	0.003653	0.38
Annual average for stations K2 and K6 = 0.004016 $\mu g/m^3$							

[a]Tennessee and national air quality standard for lead in 1.5 $\mu g/m^3$ quarterly arithmetic average.
[b]Conservative comparison of the maximum individual result (monthly or weekly) with the quarterly standard.
[c]K-25 Auxiliary Facility Demolition Project —Temporary station activated during the fourth quarter of 1997.

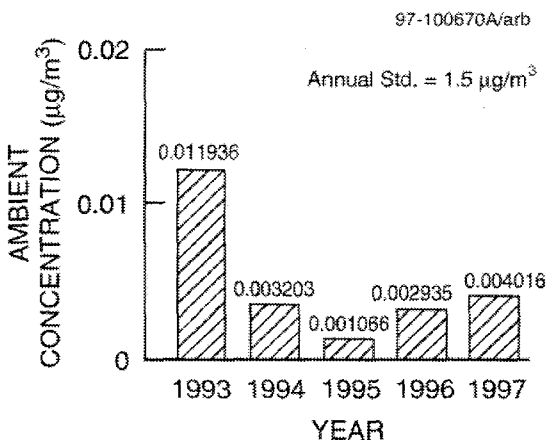

Fig. 5.12. Ambient air monitoring 5-year trend results for lead at the ETTP.

5.5 SURFACE WATER MONITORING

5.5.1 ORR Surface Water Monitoring

Under the ORR EMP, samples are collected and analyzed from 22 locations around the ORR to assess the impact of past and current DOE operations on the quality of local surface water. Sampling locations are on streams downstream of ORR waste sources, at reference points on streams and reservoirs upstream of waste sources, and at public water intakes (Fig. 5.14). Sampling locations include the following:

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

Table 5.10. HAP carcinogen metals in ambient air[a] at the ETTP, 1997

Parameter	Summary of K2 and K6 monthly composites of 32 samples (μg/m³)			Summary of KAFaD weekly results of 11 samples (μg/m³)		
	Annual av[b]	Monthly max	Monthly min	Fourth quarter av[c]	Weekly max	Weekly min
Arsenic	0.000603	0.000814	0.000475	0.000611	0.001160	0.000275
Beryllium	<0.000015	<0.000015	<0.000014	<0.000028	<0.000028	<0.000028
Cadmium	0.000273	0.000342	0.000190	0.000777	0.001804	0.000207
Chromium	0.000795	0.000966	0.000490	0.000534	0.000831	0.000324

[a]There are no Tennessee or national ambient air quality standards; however, EPA has identified arsenic, beryllium, cadmium, and chromium as HAP carcinogen metals.
[b]Average of all station K2 and K6 composites of weekly measurements.
[c]Average of station KAFaD weekly measurements.

Table 5.11. Uranium in ambient air at the ETTP, 1997

Station	Number of samples	Summary of composite analyses (μg/m³)		
		Annual av[a]	Max[b]	Min
K2	51	0.000186	0.000621	0.000025
K6	51	0.000034	0.000055	0.000019
PAM35	51	0.000023	0.000027	0.000021
PAM42	51	0.000018	0.000027	<0.000002
All stations	204	0.000065	0.000621	<0.000002
		Summary of weekly analyses (μg/m³)		
		Fourth quarter av	Max	Min
KAFaD	11	<0.000034	0.000069	<0.000017

[a]The annual standard for naturally occurring uranium is 1E–01 pCi/m³, which is equivalent to 0.15 μg/m³.
[b]Maximum individual composite result.

- WOC downstream from ORNL (WCK 2.6),
- WOC upstream from ORNL (WCK 6.8),
- Walker Branch prior to entering CRK 53.4 [Walker Branch kilometer (WBK) 0.1],
- McCoy Branch prior to entering CRK 60.3 [McCoy Branch kilometer (MCCBK) 1.8],
- Grassy Creek upstream of SEG and IT Corp. at CRK 23 [Grassy Creek kilometer (GCK) 3.6],
- Ish Creek prior to entering CRK 30.8 [Ish Creek kilometer (ICK) 0.7],
- Raccoon Creek sampling station prior to entering CRK 31 [Raccoon Creek kilometer (RCK) 2.0],
- Northwest Tributary prior to entering CRK 31 [Northwest Tributary kilometer (NWTK) 0.1],

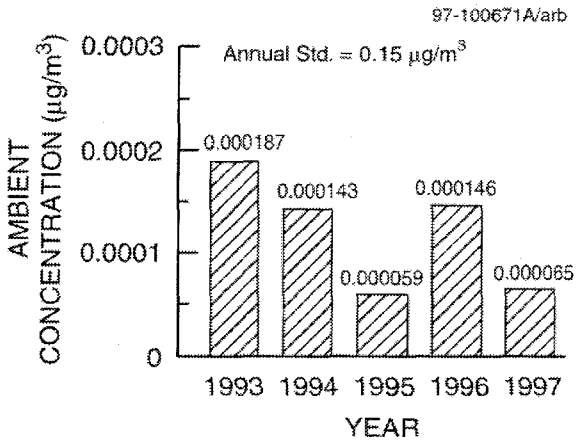

Fig. 5.13. Ambient air monitoring 5-year trend results for uranium at the ETTP.

- First Creek just upstream of NWT [First Creek kilometer (1STCK) 0.1], and
- Fifth Creek just upstream of White Oak Creek (ORNL) [Fifth Creek kilometer (FIFTHCK) 0.1].

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

Sampling frequency and parameters vary by site. Grab samples are collected and analyzed for general water quality parameters at all locations, and all are screened for radioactivity and analyzed for specific radionuclides when appropriate. A few sites also are checked for volatile organic compounds and/or PCBs. Table 5.12 lists the specific locations and their sampling frequencies and parameters.

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

Radionuclides were detected (statistically significant at a 95% confidence interval) at all of these surface water locations in 1997 except WBK 0.1 (Table D.3 in Appendix D). High levels of gross alpha, gross beta, and total radioactive strontium were detected at the First Creek (1STCK 0.1) location. Uranium isotopes, including ^{233}U, ^{234}U, ^{235}U, and ^{238}U were determined to be the primary alpha emitters. These phenomena are believed to be related to the findings at Corehole 8 and are being further investigated by Environmental Restoration. In June 1991, rock core drilling at Core Hole 8 revealed radiologically contaminated groundwater, referred to as the Core Hole 8 plume, in the uppermost portion of bedrock. The source of the plume was believed to be leakage to backfill and soil from underground radioactive waste storage Tank W-1A, which is located in the North Tank Farm within the main ORNL facilities complex. Because groundwater flows toward First Creek from the tank area, it is thought that radionuclides detected in those surface waters originate in soils surrounding Tank W-1A (DOE 1998a).

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

The few locations that were checked for volatile organic compounds either did not have any detected or what little was detected were either common laboratory contaminants, also present in the associated laboratory blanks, or were detected at low, estimated levels. PCBs were detected in some of the sampling events at WOD at low levels.

Two locations, Northwest Tributary (NWTK 0.1) and Raccoon Creek (RCK 2.0), also had elevated levels of gross beta and total radioactive strontium. Both of these locations have been sampled only three times because they are new to the program and are sampled semiannually. The

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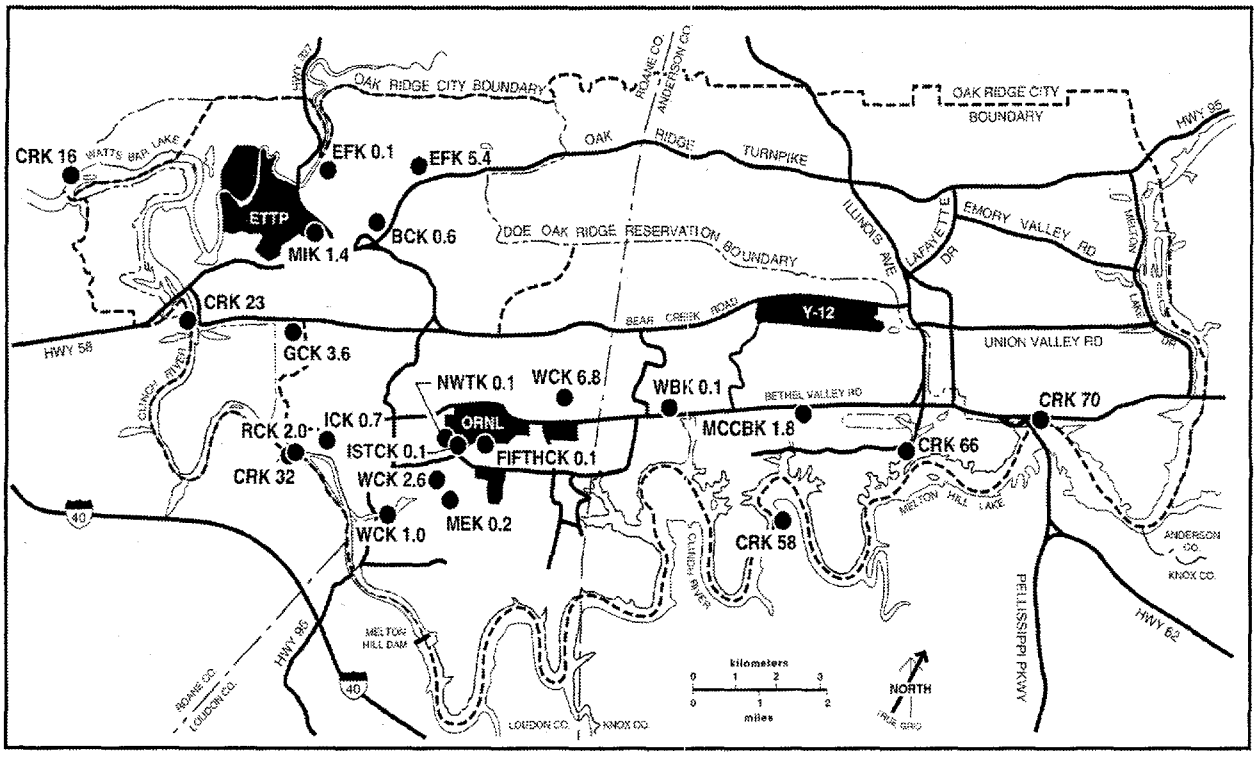

Fig. 5.14. Locations of ORR surface water surveillance sampling stations.

Raccoon Creek results appear to be seasonal, with the results from the two fall sampling events being higher than the one spring event. However, there are not enough data at this time to confirm this.

5.5.2 Y-12 Plant Surface Water Monitoring

Routine surface water surveillance monitoring, above and beyond that required by the NPDES permit, is performed as a BMP. (See Chap. 4 for results of radiological monitoring and NPDES monitoring at the Y-12 Plant.) The Y-12 Environmental Compliance 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. 5.15). Modifications were made to the routine BMP program (sampling frequency and number of parameters) in the fall of 1996 to meet budget constraints.

Monitoring is conducted in EFPC at Station 17 (9422-1) near the junction of Scarboro and Bear Creek roads. The current sampling program consists of two 48-hour composites plus a 3-day weekend composite. These samples are analyzed for mercury, ammonia-N, inductively coupled plasma (ICP) metals, and total suspended solids (TSS).

Monitoring is conducted in Bear Creek at BCK 4.55 (former NPDES station 304), which is at the western boundary of the Y-12 Plant area of responsibility. A surveillance sample (a 7-day composite sample) is collected monthly for analysis for mercury, anions (sulfate, chloride, nitrate, nitrite), ICP metals, total phenols, and TSS.

The exit pathway from the Chestnut Ridge regime is monitored via NPDES location S19 (former NPDES station 302) at Rogers Quarry. S19 is an in-stream location of McCoy Branch and is sampled monthly (a 24-h composite) for ICP metals. The NPDES requirement for this location is to monitor and report metals data only. As part of the surface-water BMP surveillance activity, data from this location, as well as that from Station 17 and BCK 4.55, are compared with state water quality criteria.

Table 5.12. Surface water sampling locations, frequencies, and parameters

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

Table 5.12 (continued)

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

[a]Dissolved oxygen, pH, temperature.

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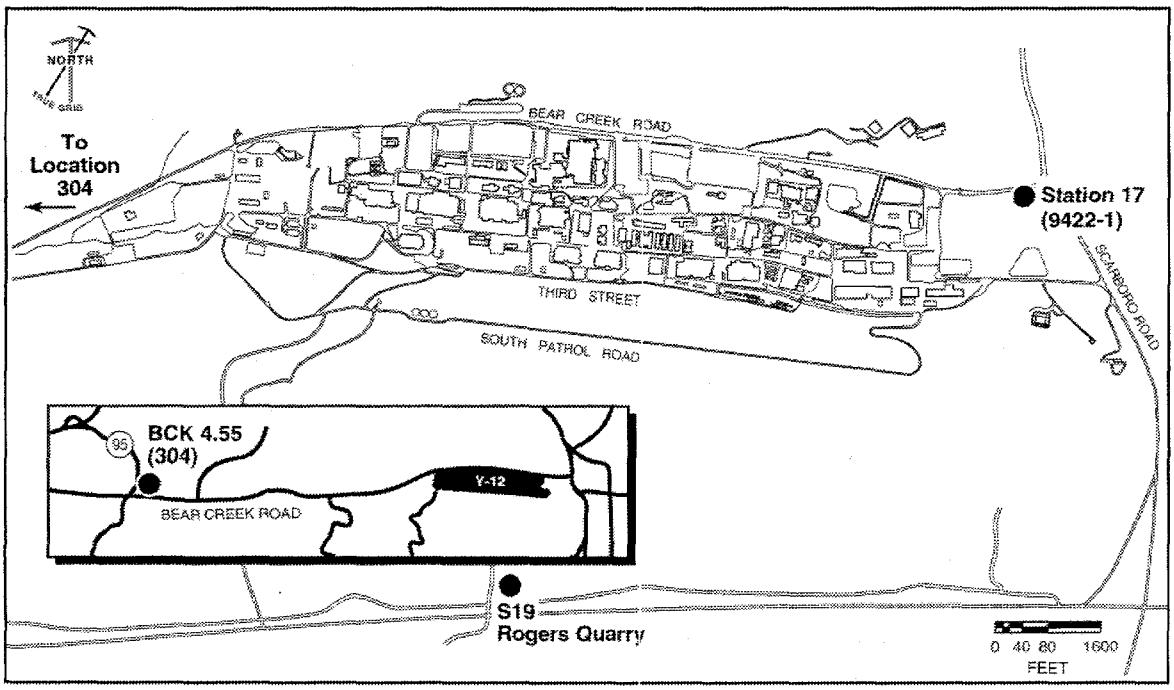

Fig. 5.15. Locations of Y-12 Plant surface water surveillance sampling stations.

In addition to these exit pathway locations, a network of real-time monitors is located at in-stream locations along UEFPC and at key points on the storm drain system that flows to the creek. The Surface Water Hydrological Information Support System (SWHISS) houses are available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 5.16. Not all stations are operated on a routine basis, but all are available as necessary and as available funding allows.

For nonradiological parameters that are sampled, and detected above the analytical method reporting detection limit, the data are compared with Tennessee water quality criteria. The most restrictive of either the freshwater fish and aquatic life "criterion maximum concentration" (CMC) or the "recreation concentration for organisms only" standard (10^{-5} risk factor for carcinogens) is used. This comparison serves as a record of water quality, and the comparison to state water quality criteria limits is for informational purposes only; as such, no attempt is made to achieve the lowest possible detection limit for all parameters.

More than 500 surface water surveillance samples were collected in 1997. Comparisons with Tennessee water quality criteria indicate that only silver, mercury and zinc, from samples collected at Station 17, were detected at values exceeding a criteria maximum. Results are shown in Table 5.13. Of all the parameters measured in the surface water as a BMP, mercury is the only demonstrated contaminant of concern (see "Reduction of Mercury in Plant Effluent: Phase II" in Sect. 4.2.2.2 for details on activities to reduce mercury discharges).

Additional surface-water sampling is conducted on Bear Creek in accordance with the Y-12 Plant Groundwater Protection Program (GWPP) to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Chap. 7).

5.5.3 ORNL Surface Water Monitoring at Reference Locations

The net impact of ORNL activities on surface waters is evaluated by comparing data from samples collected at background locations with information from samples collected downstream of the facility. Monthly surface water samples are collected at two reference sampling locations to determine contamination levels before the influence of WOC, the primary discharge point into Watts Bar Lake from the ORNL plant site. One sampling location is Melton Hill Dam above ORNL's main discharge point into the Clinch River. The other sampling location is WOC headwaters above any ORNL discharge points to WOC (Fig. 4.15).

Analyses were performed to detect radioactivity, conventional, and inorganic pollutants in the water. Conventional pollutants are indicated by

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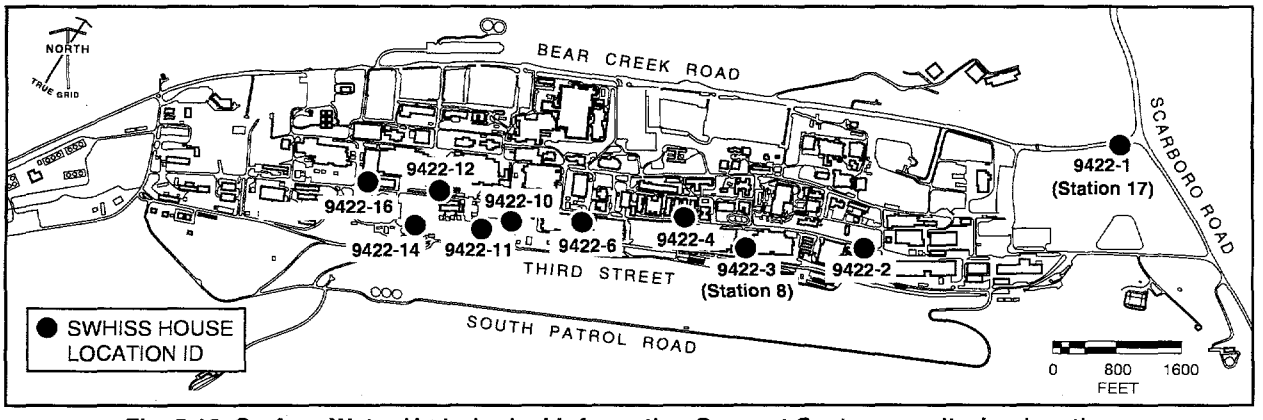

Fig. 5.16. Surface Water Hydrological Information Support System monitoring locations.

Table 5.13. Surface water surveillance measurements exceeding Tennessee water quality criteria at the Y-12 Plant, 1997

Parameter detected	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number of measurements exceeding criteria
			Detection limit	Max	Av		
Mercury	Station 17	408	0.0002	0.011	0.0007	0.00015	408
Silver	Station 17	158	0.006	0.01	<0.006	0.0041	1
Zinc	Station 17	158	0.01	0.15	0.04	0.117[a]	1

[a]The standard is a function of total hardness. This value corresponds to a total hardness value of 100 mg/L.

measurements of conductivity, temperature, turbidity, pH, TSS, and oil and grease. Inorganic parameters are indicated by analyses for metals and anions (Table 5.14).

In an effort to provide a basis for evaluation of analytical results and for assessment of surface water quality, Tennessee General Water Quality Criteria (TWQC) have been used as reference values. The TWQC for domestic water supply have been used at Melton Hill, whereas TWQC for fish and aquatic life have been used at WOC headwaters (see Appendix D, Table D.2 for TWQC for all parameters in water).

There is reasonably good agreement between parameters measured at WOC headwaters and those at Melton Hill Dam, the two reference locations. The average concentration is expressed as a percentage of the reference value when the parameter is a contaminant, the parameter is detected, and a reference value exists (Table 5.14). Eight metals met these criteria; the largest percentage of reference value was zinc at WOC headwaters at 11% of the reference value.

Radiological data are compared with DOE DCGs in Table 5.15. The average concentration for a radionuclide is expressed as a percentage of its DCG when a DCG exists and when the average concentration is significantly greater than zero. At the reference locations, only one average for 1997 met the criteria; the average concentration of ^{137}Cs at Melton Hill Dam was less than 1% of its DCG.

5.5.4 ETTP Surface Water Monitoring

Surface water surveillance is currently conducted at five locations at the ETTP (Fig. 5.17). Station K-1710 provides information on conditions upstream of ETTP. Station K-716 is located downstream from most ETTP operations and provides information on the cumulative effects of the ETTP as well as those upstream. The remaining sampling locations are at points where drainage in the major surface water basins converges before discharging to Poplar Creek (K-1007-B and K-1700) or to the Clinch River (K-901-A).

Samples are analyzed monthly for radionuclides and selected metals. Quarterly samples are collected and analyzed for general water quality parameters and for organic compounds. In addition, samples from K-1700 are analyzed quarterly for PCBs. Radionuclide results are compared with the DCGs. Nonradiological results are compared with Tennessee water quality standards (WQSs) for fish and aquatic life. The WQSs use the numeric values given in the TWQC, which are a subset of the WQSs.

In most instances, results of the analyses for nonradiological parameters are well below the applicable standards. Heavy metals were occasionally detected but always in very low concentrations. In addition, natural conditions cause periodic exceedences of WQSs for dissolved

Table 5.14. 1997 analyses of ORNL background surface waters[a]

Parameter	No. detect/ No. total	Concentration			Standard error[d]	Reference value[e]	Percentage of reference value[f]
		Max[b]	Min[b]	Av[c]			
Melton Hill Dam							
Anions (mg/L)							
Sulfate, as SO_4	11/11	19	16	17	0.33	g	g
Field measurements							
Conductivity (mS/cm)	11/11	0.25	0.17	0.21	0.0086	g	g
Dissolved oxygen (mg/L)	11/11	13	5.8	8.6	0.61	g	g
Temperature (°C)	11/11	21	8.6	16	1.3	g	g
Turbidity (NTU)	11/11	68	3.0	15	5.4	g	g
pH (std. units)	11/11	8.1	7.5	7.8	0.060	g	g
Metals[h] (mg/L)							
Antimony, total	6/10	0.00070	<0.00010	~0.00019	0.000059	0.006	3.1
Arsenic, total	2/10	0.0020	<0.0010	~0.0011	0.00010	0.05	2.2
Cadmium, total	0/10	<0.00010	<0.00010	~0.00010	0	0.005	g
Chromium, total	8/10	0.0031	<0.00050	~0.0013	0.00026	0.1	1.3
Copper, total	8/10	0.0024	<0.0010	~0.0016	0.00015	g	g
Iron, total	0/10	<0.25	<0.25	~0.25	0	g	g
Lead, total	8/10	0.0010	<0.00010	~0.00044	0.000095	0.005	8.7
Nickel, total	7/10	0.0023	<0.0010	~0.0014	0.00013	0.1	1.4
Selenium, total	0/10	<0.0020	<0.0020	~0.0020	0	0.05	g
Silver, total	3/10	0.0046	<0.00010	~0.00055	0.00045	g	g
Zinc, total	10/10	0.011	0.0039	0.0067	0.00066	g	g
Others (mg/L)							
Oil and grease	0/11	<5.7	<5.5	~5.6	0.019	g	g
Physical (mg/L)							
Total suspended solids	7/11	19	<1.0	~3.5	1.7	g	g
White Oak Creek headwaters							
Anions (mg/L)							
Sulfate, as SO_4	11/11	4.1	1.8	2.8	0.22	g	g
Field measurements							
Conductivity (mS/cm)	11/11	0.23	0.087	0.15	0.015	g	g
Dissolved oxygen (mg/L)	11/11	13	7.2	9.8	0.46	g	g
Temperature (°C)	11/11	17	8.2	13	0.85	g	g
Turbidity (NTU)	11/11	90	3.0	15	7.6	g	g
pH (std. units)	11/11	8.2	7.0	7.8	0.11	g	g

Table 5.14 (continued)

Parameter	No. detect/ No. total	Concentration			Standard error[d]	Reference value[e]	Percentage of reference value[f]
		Max[b]	Min[b]	Av[c]			
Metals[h] (mg/L)							
Antimony, total	2/10	0.00040	<0.00010	~0.00013	0.000030	g	g
Arsenic, total	1/10	0.0024	<0.0010	~0.0011	0.00014	g	g
Cadmium, total	0/10	<0.00010	<0.00010	~0.00010	0	0.0039	g
Chromium, total	8/10	0.0036	<0.00050	~0.0016	0.00029	0.016	10
Copper, total	2/10	0.0014	<0.0010	~0.0011	0.000053	0.0177	6.1
Iron, total	7/10	0.94	<0.25	~0.48	0.079	g	g
Lead, total	10/10	0.0024	0.00014	0.0011	0.00025	0.0817	1.4
Nickel, total	7/10	0.0018	<0.0010	~0.0013	0.00010	1.418	0.089
Selenium, total	0/10	<0.0020	<0.0020	~0.0020	0	0.02	g
Silver, total	0/10	<0.00010	<0.00010	~0.00010	0	0.0041	g
Zinc, total	10/10	0.029	0.0060	0.013	0.0023	0.117	11
Others (mg/L)							
Oil and grease	0/11	<5.7	<5.5	~5.6	0.023	g	g
Physical (mg/L)							
Total suspended solids	11/11	100	15	38	7.4	g	g

[a]NPDES permit became effective on February 3, 1997; therefore, this table includes data for February–December 1997 to reflect the new permit.

[b]Prefix "<" indicates the value of a parameter (excluding organics) was not quantifiable at the analytical detection limit.

[c]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

[d]Standard error of the mean.

[e]Tennessee General Water Quality Criteria for Domestic Water Supply is used as a reference value for Melton Hill Dam; Tennessee General Water Quality Criteria for Fish and Aquatic Life is used as a reference value for White Oak Creek headwaters.

[f]Average concentration as a percentage of the reference value, calculated when a reference exists, the parameter is a contaminant, and the parameter is detected.

[g]Not applicable.

[h]Metals analyses began in March 1997.

oxygen. During 1997, Aroclor 1254 was detected at K-1700 on one occasion. This incident correlated with a very high suspended solids value, indicating that the Aroclor 1254 was adhering to sediment particles resuspended in the water column as a result of heavy rainfall and high streams flows.

Dissolved oxygen measurements regularly fall below the minimum WQS during the summer months because of increased temperature (and therefore lower solubility of the gas) and increased biological activity. Similarly, increased photosynthesis during the summer months causes an increase in the pH of area waterways, sometimes exceeding the maximum WQS. Water bodies in the vicinity of the ETTP are regularly inspected for signs of stress on aquatic organisms during these periods. No evidence that these conditions have a negative impact on the aquatic communities was discovered during 1997. For most of the analyses, results are below detection limits for the instrument and method. Moreover, analytical results for samples collected upstream of the ETTP are chemically similar in most respects to those collected below the ETTP.

The sum of the fractions of the DCGs for all locations remained below the annual limit, as required by DOE Order 5400.5 (Fig. 5.18). The highest sum of the fractions, 1.7% of the allowable sum of the fractions of the DCGs, was reported for sampling location K-1700. These results are still well below the conservative limits

Table 5.15. 1997 radionuclide concentrations in background surface waters above ORNL

Radionuclide	No. detect/ No. total	Concentration (pCi/L)			Standard error[c]	DCG[d]	Percentage of DCG[e]
		Max[a]	Min[a]	Av[b]			
			Melton Hill Dam				
^{60}Co	3/12	24*	–9.2	4.7	3.1	5,000	*f*
^{137}Cs	3/12	30*	–13	6.8*	3.7	3,000	0.23
Gross alpha	4/12	3.5*	–0.98	1.1*	0.40	*f*	*f*
Gross beta	4/12	8.5*	–1.8	2.1*	0.79	*f*	*f*
			White Oak Creek headwaters				
^{60}Co	2/12	18*	–17	3.8	2.8	5,000	*f*
^{137}Cs	3/12	18*	–19	2.2	3.2	3,000	*f*
Gross alpha	4/12	2.8*	–2.1	0.72*	0.35	*f*	*f*
Gross beta	6/12	6.3*	–6.5	2.1*	1.0	*f*	*f*

[a]Individual radionuclide concentrations significantly greater than zero are identified by an asterisk (*).
[b]Average radionuclide concentrations significantly greater than zero are identified by an *.
[c]Standard error of the mean.
[d]Derived concentration guide for ingestion of water. From DOE Order 5400.5.
[e]Average concentration as a percentage of the derived concentration guide (DCG), calculated only when a DCG exists and the average concentration is significantly greater than zero.
[f]Not applicable.

established by the order. The 1997 radiological data do not indicate any significant radiological effects from ETTP operations on perimeter surface waters.

5.5.5 Off-Site Monitoring

The ORNL program for assessing impacts to the Clinch and Tennessee rivers uses empirical data from samples taken at the Kingston and Gallaher potable water treatment plants (Fig. 5.19). In 1997, composite samples of treated water from Gallaher and untreated water from Kingston were collected monthly and analyzed quarterly for specific radionuclides.

Federal and state drinking water standards (DWSs) (40 CFR Parts 141 and 143 and TWQC for domestic water supply) were used as reference values. If a DWS for a radionuclide has not been established, then 4% of the DOE DCG for that radionuclide is used as the reference value. The average radionuclide concentration is expressed as a percentage of the reference value when a reference exists and when the average is significantly greater than zero. In 1997, ^{238}Pu and total uranium were the only parameters at the Gallaher Water Treatment Plant that met these criteria, with the largest being ^{238}Pu at 2.8% of the reference value. Only one parameter at the Kingston Water Treatment Plant met these criteria; total uranium was 0.88% of the reference value.

5.6 SOIL

Soil sampling at the plots located at the ambient air stations was discontinued in 1997. After four years of analyses, no evidence exists of increased radionuclide levels that can be attributed to deposition.

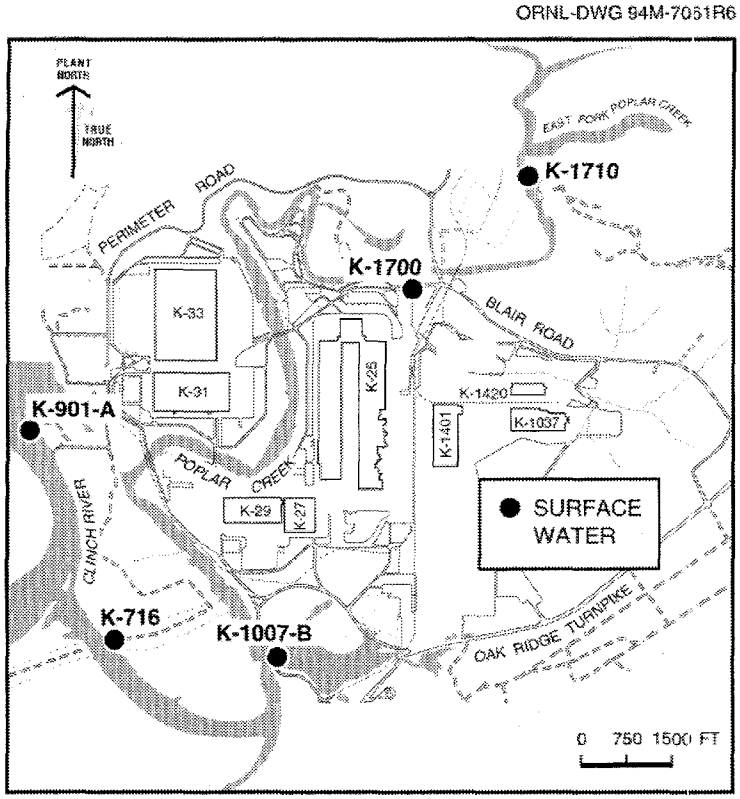

Fig. 5.17. Monitoring locations for surface water at the ETTP.

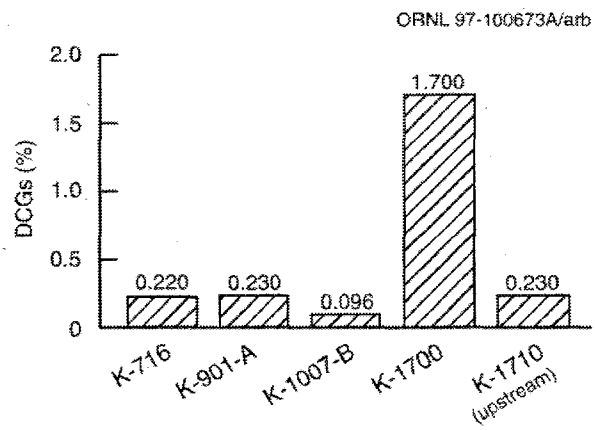

Fig. 5.18. Percentage of DCGs for ETTP surface water monitoring locations.

5.7 ORR SEDIMENT

Stream and lake sediments act as a record of some aspects of water quality by concentrating and storing certain contaminants. The program underwent reevaluation in 1996, which resulted in significant modification to the sampling locations and parameters of interest beginning with 1997. Sampling sites are the Clinch River downstream from all DOE inputs (CRK 16) and the Clinch River downstream from ORNL (CRK 32) and one background location, the Clinch River at the Solway Bridge upstream from all DOE inputs (CRK 70) (Fig. 5.20). The locations are sampled annually and, under the revised program, gamma scans were performed on the samples in 1997.

An additional sampling component was added to the program in 1997. Samples are collected on a semiannual basis in conjunction with a heavy rain event to characterize sediments that exit the ORR during a storm event. The sampling locations are Melton Branch upstream from ORNL (MEK 2.1), WOL at WOD (WCK 1.0), and WOC downstream from ORNL (WCK 2.6) (Fig. 5.20). These samples are filtered, and the residue (settleable solids) is analyzed for gross alpha emitters, gross beta emitters, and gamma emitters.

5.7.1 Results

Potassium-40 was the only radionuclide detected by the gamma scan at the upstream location (CRK 70). Downstream from ORNL at CRK 32, ^{60}Co, ^{137}Cs, ^{7}Be, and ^{40}K were all detected. At CRK 16, which is downstream from all DOE inputs, only ^{137}Cs and ^{40}K were detected by the gamma scan. Beryllium-7 and ^{40}K are naturally occurring radionuclides. None of the radionuclide concentrations at any of the three locations pose a problem for humans.

The heavy rain event sampling took place in March 1997. A second sample later in the year was analyzed using a different protocol because standard laboratory procedures were under development for this program. The second method produced results that did not reflect the purpose of the program. Cobalt-60 and ^{137}Cs were not de-

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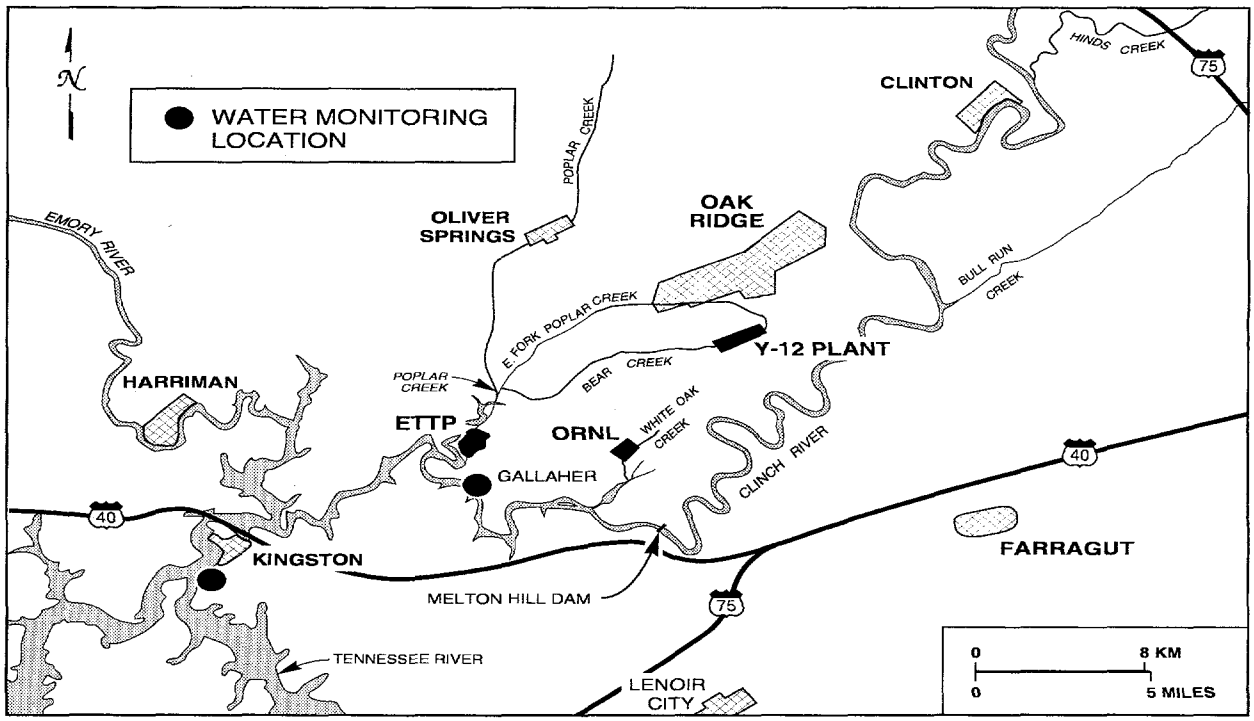

Fig. 5.19. ORNL off-site monitoring at the Gallaher and Kingston water treatment plants.

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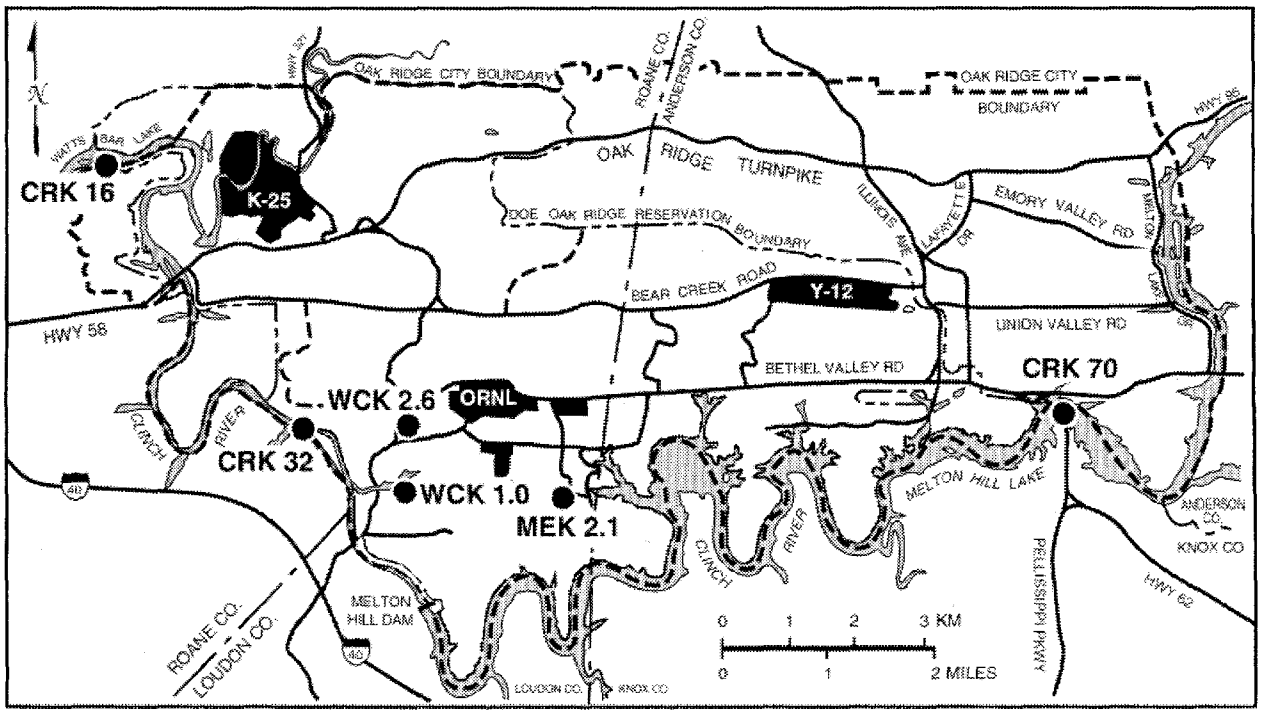

Fig. 5.20. ORR environmental monitoring plan sediment sampling locations.

tected in the settleable solids of the sample from the location upstream from ORNL; they were detected at the other two locations. Gross alpha and gross beta were detected at all three locations, with the upstream location having the least and WOL at WOD having the most. As more data are collected in future events, some conclusions may be drawn.

5.7.2 Y-12 Sediment Sampling

In 1997, revisions to the ORR EMP and the scope of ORR surveillance monitoring conducted by ORNL resulted in discontinuation of sediment sampling at the Y-12 Plant in EFPC and Bear Creek. However, historical data have shown that mercury, PCBs, and isotopes of uranium are present at detectable levels in the sediment. Therefore, as a best management practice, the Y-12 Plant maintains an annual sampling program to determine if these constituents are accumulating in the sediments of EFPC and Bear Creek as a result of Y-12 Plant discharges. Results of the 1997 monitoring activity are given in Table 5.16.

Table 5.16. 1997 results of Y-12 Plant sediment monitoring

	Station 17	BCK 9.4
^{226}Ra (pCi/g)	2.8	2.4
^{228}Th (pCi/g)	0.97	0.70
^{230}Th (pCi/g)	1.2	0.41
^{232}Th (pCi/g)	0.73	0.68
^{234}U (pCi/g)	2.6	3.6
^{235}U (pCi/g)	0.13	0.20
^{238}U (pCi/g)	2.9	6.3
Mercury µg/g	9.5	0.3
Total PCBs µg/kg	370J	350J

J—The J flag of the PCB data indicates an estimated value below the analytical method reporting limit.

5.8 FOOD

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

5.8.1 Hay

Hay is cut on the ORR and sold to area farmers for fodder. Six areas from which hay is cut have been identified as potential depositional areas for airborne materials from ORR sources (Fig. 5.21). Areas 1, 2, and 3 are within the predicted air plume for an ORNL source and could also be affected by the ETTP. Baled hay was collected from each of these three sites and composited for analysis. Areas 2, 4, 5, and 6 are within the predicted air plume for an ETTP, an ORNL, and a Y-12 Plant source. Baled hay was collected from each of these sites and composited for laboratory analysis. Area 6 best represents the combined plumes from all three sites; baled hay was collected from this site. Area 8, not shown on Fig. 5.21, represents a reference site near the Fort Loudoun ambient air monitoring station (Statio31n 52).

5.8.1.1 Results

Hay samples were collected during August 1997, and samples were analyzed for gross alpha and beta, and gamma emitters. Table 5.17 summarizes the results of the sampling effort. Composite samples from Areas 1, 2, and 3 and Areas 2, 4, and 5 had statistically significant concentrations of ^{137}Cs. Gross beta and ^{7}Be were statistically significant in the two composite samples (Areas 1, 2, and 3; and Areas 2, 4, and 5) and in the two individual locations, Area 6 and Area 8. Beryllium-7 is a naturally occurring isotope. There were no other significant radiological results in the 1997 hay samples.

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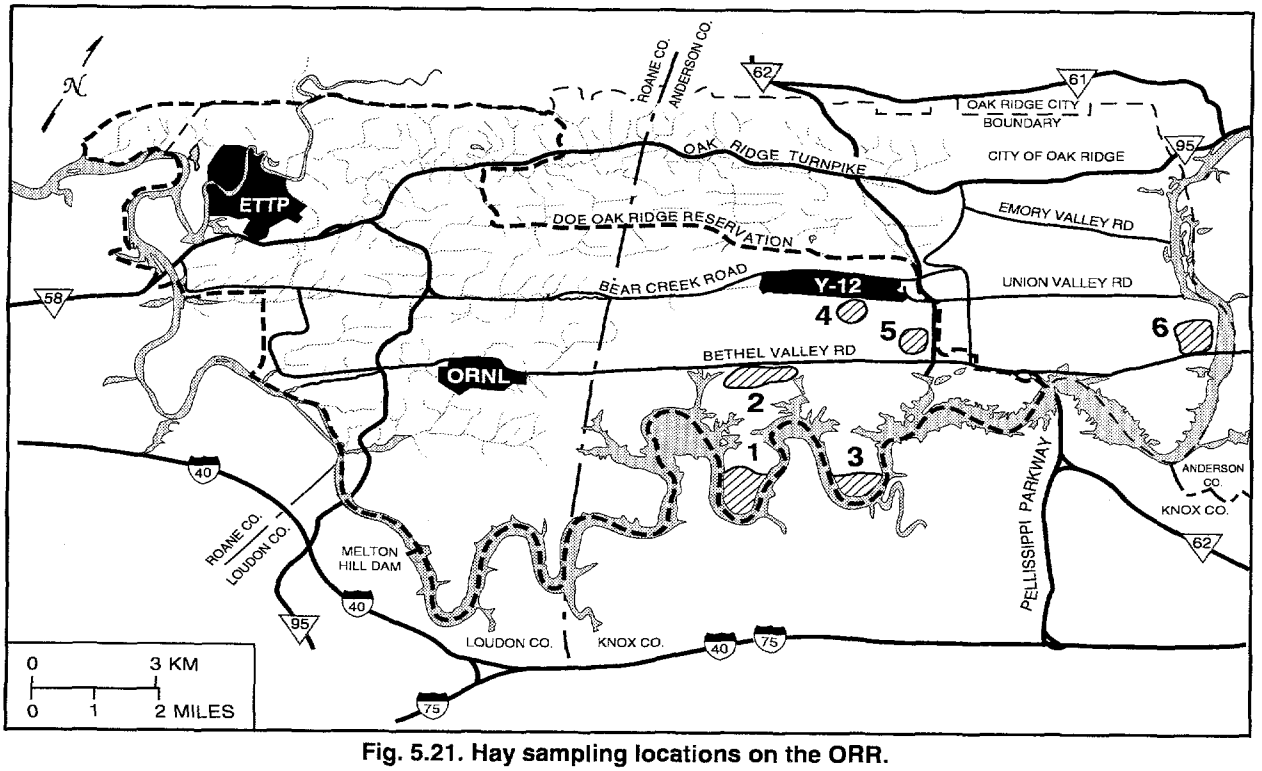

Fig. 5.21. Hay sampling locations on the ORR.

Table 5.17 Significant concentrations of radionuclides in hay from the ORR, 1997[a]

Analyte	Area			
	1,2,3	2,4,5	6	8
Gross beta	8500	4600	4400	5300
^{7}Be	5500	5500	3500	3600
^{137}Cs	34	19	*b*	*b*

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

5.8.2 Vegetables

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

5.8.2.1 Results

Samples were analyzed for gross alpha, gross beta, and gamma emitters. Table 5.18 summarizes the results of the sampling effort. Gross alpha was detected in one of the lettuce samples, and gross beta was detected in all of the samples. Cesium-137, ^{60}Co, ^{7}Be, and ^{40}K were detected by the gamma scan. Beryllium-7 and ^{40}K are naturally occurring radionuclides. Information regarding potential health impacts associated with chemical and radiological constituents detected in vegetables is discussed in Chap. 6.

5.8.3 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

Table 5.18. Radiological constituents in tomatoes and lettuce at sites near the ORR, 1997[a]

Location	^{7}Be	^{60}Co	^{137}Cs	^{40}K	Gross alpha	Gross beta
			Lettuce			
East of the Y-12 Plant	540	*b*	4.3	3800	*b*	2000
East of the Y-12 Plant, Claxton	350	*b*	*b*	3800	*b*	1900
Northeast of the Y-12 Plant, Scarboro	320	*b*	*b*	3800	*b*	1900
South of ORNL	460	*b*	*b*	4300	*b*	2700
West of the ETTP	510	*b*	3.2	3800	43	2300
			Tomatoes			
East of the Y-12 Plant	*b*	*b*	*b*	1800	*b*	1600
East of the Y-12 Plant, Claxton	*b*	4.8	*b*	2000	*b*	1300
Northeast of the Y-12 Plant, Scarboro	*b*	*b*	*b*	2200	*b*	1500
South of ORNL	*b*	3.4	*b*	1900	*b*	1700
West of the ETTP	*b*	*b*	*b*	1900	*b*	1700
			Turnips			
East of the Y-12 Plant	*b*	*b*	2.4	2500	*b*	2200
East of the Y-12 Plant, Claxton	*b*	*b*	*b*	2400	*b*	2500
Northeast of the Y-12 Plant, Scarboro	*b*	*b*	*b*	1800	*b*	1900
South of ORNL	*b*	5.7	*b*	2000	*b*	1600
West of the ETTP	*b*	*b*	*b*	2800	*b*	3200

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

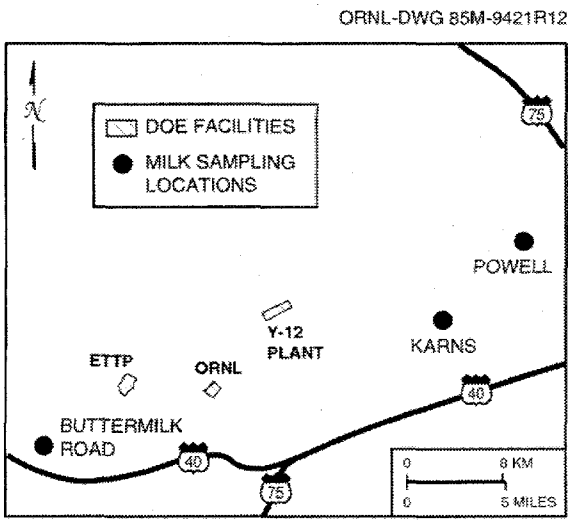

Fig. 5.22. Milk sampling locations in the vicinity of the ORR.

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 1997 milk sampling program consisted of grab samples collected every other month from three locations in the vicinity of the ORR (Fig. 5.22). Milk samples are analyzed at ORNL for radioactive iodine (^{131}I) by gamma spectrometry and for total radioactive strontium ($^{89}Sr + {}^{90}Sr$) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for tritium (^{3}H).

5.8.3.1 Results

Radioactivity measurements are reported as the net activity (the difference between the gross activity and instrument background). A 95%

confidence level is used to determine statistical significance. Concentrations of radionuclides detected in milk are presented in Table 5.19. There were no detected concentrations of ^{3}H. Average values for detected radionuclides were converted to EDEs and are presented in Chap. 6 of this report. Results are consistent with data from previous years.

5.8.4 Honey

Before 1995, honey from privately owned hives in the vicinity of the ORR was analyzed for radionuclides to determine whether a potential exposure pathway existed. In 1995, beehives were established on the reservation at strategic locations at the Y-12 Plant, ORNL, and the ETTP. Honey samples from the hives were analyzed in 1995 and 1996. Because of major changes in the ORR surveillance program (see Sect. 5.1 for changes), collection and analysis of honey samples on the ORR was discontinued in 1997.

5.8.5 Fish

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

The program was revised, which resulted in fewer sampling locations beginning in 1997. The river locations are on the Clinch River (see Fig. 5.23):

Table 5.19. Concentrations of radionuclides detected in raw milk, 1997[a]

Analysis	No. detected/ No. total	Detected concentration pCi/L			Standard error of mean
		Max[b]	Min[b]	Av[b]	
		Buttermilk Road			
^{131}I	1/6	84*	–41	15	18
^{40}K	2/2	32,000*	30,000*	31,000*	1,400
Total radioactive Sr	2/6	32*	0.11	14*	5.4
		Karns			
^{40}K	2/2	35,000*	32,000*	34,000*	1,400
Total radioactive Sr	4/6	68*	0.65	31*	11
		Powell			
^{40}K	2/2	35,000*	35,000*	35,000	0
		Network summary			
^{131}I	1/17	84	–46	3.9	8.5
^{40}K	6/6	35,000	30,000	33,000*	900
Total radioactive Sr	6/17	68	0.11	20*	4.7

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

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

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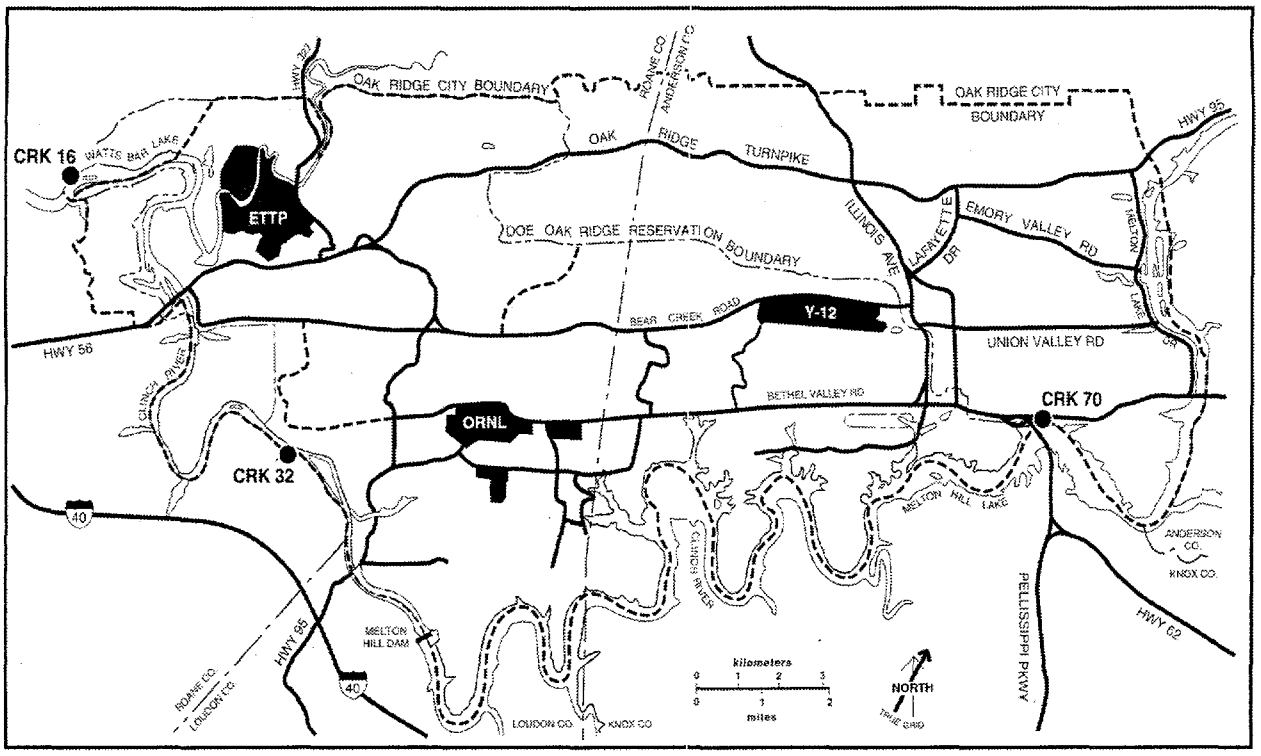

Fig. 5.23. Fish sampling locations for ORR environmental monitoring plan.

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

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

5.8.5.1 Results

In 1997, most parameters analyzed for in sunfish and catfish were undetected or detected in fewer than all samples. For PCBs, reported values for sunfish and catfish were below the U.S. Food and Drug Administration (FDA) tolerance of 2 ppm; for mercury, all reported values were below the FDA action level of 1 ppm. This has been true for all years of the program. When PCBs have been detected, they have been primarily Aroclor-1254 and Aroclor-1260, many at estimated low levels. Information regarding potential health impacts associated with chemical and radiological constituents detected in the sunfish and catfish is discussed in Chap. 6.

5.8.6 White-Tailed Deer

The 13th annual deer hunts managed by DOE and the TWRA were held on the ORR during the final quarter of 1997. ORNL staff, TWRA, and student members of the Wildlife and Fishery

Society (University of Tennessee Chapter) performed most of the necessary operations at the checking station.

The 1997 hunts were held on three weekends. Shotgun/muzzle loader hunts were held on October 18–19 (900 permitted hunters), November 8–9 (900 permitted hunters), and December 13–14 (900 permitted hunters). During the November 8–9 hunt, the Tower Shielding/Park City Road was opened for an archery-only hunt with 350 permitted hunters. A few areas are also designated as "archery only" during the gun hunts and do not require special permitting. A two-deer limit (no more than one antlered) was established for the December 13–14 shotgun/muzzle loader hunt as well as the archery-only hunt held the weekend of November 8–9 at the Tower Shielding/Park City Road area.

From the total harvest of 438 animals, 269 (61.4%) were bucks and 169 (38.6%) were does. The heaviest buck had nine antler points and weighed 169 lb. The greatest number of antler points (14) was found on a buck weighing 121 lb. The heaviest doe weighed 113 lb.

5.8.6.1 Results

Of the 438 deer harvested, nine were confiscated because they exceeded established release limits (5 pCi/g for ^{137}Cs and/or 20 pCi/g for ^{90}Sr). The average concentration of ^{137}Cs (based on field data) in the deer released to the public was 0.07 pCi/g (0.003 Bq/g). The deer confiscated during the 1997 hunt represent 2% of the total deer harvested. Since the hunts began in 1985, 6787 deer have been harvested; a total of 158 (2.3%) were retained because of radiological contamination.

5.8.7 Resident Canada Geese

One objective of the ORR waterfowl program is to determine concentrations of gamma-emitting radionuclides accumulated by waterfowl associated with waste disposal areas. Radioactive elements found in waste material are the primary types of contaminants associated with the ORR.

During 1997, whole-body scans were conducted in 83 geese. The geese were collected from ORNL (39), the ETTP (28), and Melton Hill Dam (16). Of the 83 geese screened, only 1 goose was retained.

The sampling areas are selected because of high geese congregation. The geese are highly mobile animals that range freely to sites on and off the reservation. For that reason, the results in this report should be taken as an indication of the possible overall impact that the reservation has on the geese rather than as an evaluation of the collection sites.

5.8.7.1 Results

The average ^{137}Cs concentration in the nonconfiscated geese was 0.07 pCi/g (3E-03 Bq/g). The highest ^{137}Cs concentration, 15 pCi/g (0.6 Bq/g), was found in a goose collected at ORNL, and this goose was retained. The average weight of the Canada geese screened during the roundup was about 4 kg (8.6 lb). The maximum goose weight was about 5.2 kg (11.4 lb).

5.8.8 Turkey Monitoring

Two wild turkey hunts managed by DOE and TWRA were held on the reservation on April 12–13, 1997, and on April 19–20, 1997. Hunting was open for both shotguns and archery. A total of 90 birds were harvested, and only 1 was retained because of elevated beta counts in the leg bone. Of the 90 birds harvested, 11 were juveniles and 79 were adults. The average turkey weight was 18.8 lb. The largest tom for the 1997 hunts weighed 23.5 lb, had 1.0-in. spurs, and had a 9.5-in. beard. The longest beard was on a tom weighing 21.3 lb, and it was 11.5-in.. The average ^{137}Cs concentration in the nonconfiscated turkeys was 0.1 pCi/g (0.004 Bq/g). The maximum ^{137}Cs concentration in the nonconfiscated turkeys was 0.6 pCi/g (0.0 Bq/g).

6. Dose

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Abstract

Activities on the ORR have the potential to release small quantities of radionuclides and hazardous chemicals to the environment. These releases could result in exposures of members of the public to low concentrations of radionuclides or chemicals. Monitoring of materials released from the reservation and environmental monitoring and surveillance on and around the reservation provide data that are used to show that doses from released radionuclides and chemicals are in compliance with the law; the calculated doses are compared with state and federal criteria.

6.1 RADIATION DOSE

Small quantities of radionuclides were released to the environment from operations at the ORR facilities during 1997. Those releases are quantified and characterized in Chaps. 4, 5, and 7. This chapter presents estimates of potential radiation doses to the public from the releases. The dose estimates, which use the monitored release and environmental monitoring and surveillance data, standard environmental transport codes, and exposure conditions that tend to maximize the calculated dose equivalents, are intended to demonstrate that during 1997, no member of the public received a dose in excess of that allowed by relevant regulatory authorities.

6.1.1 Terminology

Most doses associated with radionuclide releases to the environment are caused by interactions between radiation emitted by the radionuclides and human tissue. These interactions involve the transfer of energy from the radiation to tissue, a process that may damage the tissue. The radiation may come from radionuclides located outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (by inhalation, ingestion, and, in a few cases, absorption through the skin).

Exposures to radiation from nuclides located outside the body are called external exposures; exposures to radiation from nuclides deposited inside the body are called internal exposures. This distinction is important because external exposures occur only when a person is near or in a radionuclide-containing medium; internal exposures continue as long as the radionuclides remain inside the person. Also, external exposures may result in uniform irradiation of the entire body and all its components; internal exposures usually result in nonuniform irradiation of the body. (When taken into the body, most radionuclides deposit preferentially in specific organs or tissues and thus do not irradiate the body uniformly.)

A number of the specialized terms and units used to characterize exposures to ionizing radiation are defined in Appendix A. One of these is used repeatedly in this section, the EDE, which is a risk-based dose equivalent that can be used to estimate health effects or risks to exposed persons. It is a weighted sum of dose equivalents to specified organs and is expressed in rem or sieverts (1 rem = 0.01 Sv).

6.1.2 Methods of Evaluation

6.1.2.1 Airborne Radionuclides

The radiological consequences of radionuclides released to the atmosphere from ORR operations during 1997 were characterized by calculating, for each plant and for the entire ORR, EDEs to maximally exposed off-site individuals and to the entire population residing within 80 km (50 miles) of the center of the ORR. The dose calculations were made using the

CAP-88 package of computer codes (Beres 1990), which was developed under EPA sponsorship to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants: Radionuclides (Rad NESHAP), 40 CFR 61, Subpart H, which governs the emissions of radionuclides other than radon from DOE facilities. This package contains the EPA-approved version of the AIRDOS-EPA and DARTAB computer codes and the ALLRAD88 radionuclide data file. The AIRDOS-EPA computer code implements a steady-state Gaussian plume atmospheric dispersion model to calculate concentrations of radionuclides in the air and on the ground. It also uses Regulatory Guide 1.109 (NRC 1977) food-chain models to calculate radionuclide concentrations in foodstuffs (vegetables, meat, and milk) and subsequent intakes by humans.

The concentrations and human intakes are used by EPA's version of the DARTAB computer code to calculate EDEs from radionuclides released to the atmosphere. The dose calculations use the dose conversion factors (DCFs) contained in the ALLRAD88 data file (Beres 1990).

A total of 42 emission points, each of which includes one or more individual sources, on the ORR were modeled during 1997. This total includes 6 points at the Y-12 Plant, 25 points at ORNL, and 11 points at the ETTP. Table 6.1 is a list of the emission point parameter values and receptor locations used in the dose calculations.

Meteorological data used in the calculations were in the form of joint frequency distributions of wind direction, wind speed class, and atmospheric stability category. These data were derived from data collected during 1997 at the 60-m height on Tower MT6 for all sources at the Y-12 Plant; at the 100-m height on Tower MT2 for stacks X-2001, X-2026, X-2523, X-3018, X-3020, X-3039, X-3074, X-3544, X-3608, X-5505, X-7025, X-STP sludge drier, X-minor grouped sources, X-decommissioned lab hoods, X-Tank W-2X, X-GAAT tanks stack, and X-GAAT tanks vent at ORNL; at the 10-m height, with wind speeds adjusted to 30 m, on Tower MT4 for stacks X-7512, X-7567, X-7569, X-7830, X-7852, X-7860, X-7877, and X-7911 at ORNL; and at the 60-m height on Tower MT1 for all sources at the ETTP. During 1997, rainfall on the ORR was 132 cm (52 in.), as averaged over the four rain gauges located on the ORR. The average air temperature was 14°C (57°F), and the average mixing layer height was 1000 m (3280 ft).

The dose calculations are based on the assumptions that each person remained at home (actually, outside the house), unprotected, during the entire year and obtained food according to the rural pattern defined in the NESHAP background documents (EPA 1989). This pattern specifies that 70% of the vegetables and produce, 44.2% of the meat, and 39.9% of the milk consumed by each person are produced in the local area (e.g., a home garden). The remaining portion of each food is assumed to be produced within 80 km (50 miles) of the ORR. For collective EDE estimates, production of beef, milk, and crops within 80 km of the ORR was calculated using the state-specific production rates provided with CAP-88.

Results

Calculated EDEs from radionuclides emitted to the atmosphere from the ORR are listed in Tables 6.2 (maximum individual) and 6.3 (collective). The EDE received by the hypothetical maximally exposed individual for the ORR was calculated to be about 0.41 mrem (0.0041 mSv), which is well below the NESHAP standard of 10 mrem (0.10 mSv) and well below the 300 mrem (3 mSv) that the average individual receives from natural sources of radiation. The maximally exposed individual for the ORR is located about 12,200 m (7.6 miles) south-southwest of the Y-12 Plant release point, about 3720 m (2.3 miles) southwest of the X-7911 stack at ORNL, and about 6460 m (4.0 miles) southeast of the K-1435 (TSCA Incinerator) stack at the ETTP. The calculated collective EDE to the entire population within 80 km (50 miles) of the ORR (about 879,546 persons) was about 10 person-rem (0.10 person-Sv), which is approximately 0.004% of the 264,000 person-rem that this population could have received from natural sources of radiation.

The EDE received by the hypothetical maximally exposed individual for the Y-12 Plant was

Table 6.1. Emission point parameters and receptor locations used in the dose calculations

Source name	Type	Release height (m)	Diameter (m)	Gas exit velocity (m/s)	Gas exit temperature (°C)	Distance (m) and direction to maximally exposed individual			
						Plant		ORR	
X-2001	Point	15.24	0.66	8.32	Ambient	4,060	SSW	4,060	SSW
X-2026	Point	22.9	1.05	10.59	Ambient	4,060	SSW	4,060	SSW
X-2523	Point	7	0.3	5.96	Ambient	4,060	SSW	4,060	SSW
X-3018	Point	61	4.11	0.23	Ambient	4,060	SSW	4,060	SSW
X-3020	Point	61	1.96	6.39	Ambient	4,060	SSW	4,060	SSW
X-3039	Point	76.2	5.68	2.53	Ambient	4,060	SSW	4,060	SSW
X-3074	Point	4	0.26	10.2	Ambient	4,060	SSW	4,060	SSW
X-3544	Point	9.53	0.27	23.17	Ambient	4,060	SSW	4,060	SSW
X-3608	Point	10.97	2.44	0.57	Ambient	4,060	SSW	4,060	SSW
X-5505	Point	11	0.3	7.92	Ambient	4,060	SSW	4,060	SSW
X-7025	Point	3.96	0.3	13.66	Ambient	5,710	SW	5,710	SW
X-7512	Point	30.5	0.91	10.43	Ambient	3,720	SW	3,720	SW
X-7567	Point	3.81	0.31	2.01	Ambient	3,720	SW	3,720	SW
X-7569	Point	3.96	0.15	2.59	Ambient	3,720	SW	3,720	SW
X-7830	Point	4.55	0.21	12.51	Ambient	2,350	SW	2,350	SW
X-7852	Point	2.13	0.2	2.18	Ambient	2,350	SW	2,350	SW
X-7860	Point	18.29	0.305	3.9	Ambient	2,350	SW	2,350	SW
X-7877	Point	13.9	0.51	9.95	Ambient	2,350	SW	2,350	SW
X-7911	Point	76.2	3.43	2.85	Ambient	3,720	SW	3,720	SW
X-Decommissioned lab hoods	Point	15	NA	NA	Ambient	4,060	SSW	4,060	SSW
X-Minor grouped sources	Point	15	NA	NA	Ambient	4,060	SSW	4,060	SSW
X-STP sludge drier	Point	1.52	0.203	2.91	Ambient	3,500	SSW	3,500	SSW
XW-2X	Point	4.6	NA	NA	Ambient	3,470	SSW	3,470	SSW
X-GAAT tanks stack	Point	1	NA	NA	Ambient	4,060	SSW	4,060	SSW
X-GAAT tanks vent	Point	1	NA	NA	Ambient	4,060	SSW	4,060	SSW
Y-Monitored stacks	Point	20	NA	NA	Ambient	1,080	NNE	12,200	SSW

Table 6.1 (continued)

Source name	Type	Release height (m)	Diameter (m)	Gas exit velocity (m/s)	Gas exit temperature (°C)	Distance (m) and direction to maximally exposed individual			
						Plant		ORR	
Y-Minor processes	Point	20	NA	NA	Ambient	1,080	NNE	12,200	SSW
Y-Lab hoods	Point	20	NA	NA	Ambient	1,080	NNE	12,200	SSW
Y-ASO Union Valley	Point	9.75	0.8	10	Ambient	2,410	WSW	15,000	SW
Y-9207	Point	10	NA	NA	Ambient	700	NW	13,100	S
Y-9204-3	Point	20	NA	NA	Ambient	1,100	N	12,100	SSW
K-1435 Incinerator	Point	30.5	1.37	5.39	79.76	3,650	SSW	6,460	SE
K-1435 waste feed tanks	Point	18.29	NA	NA	Ambient	3,650	SSW	6,460	SE
K-1435-A lab hoods	Point	3.05	NA	NA	Ambient	3,650	SSW	6,460	SE
K-1008-C lab hood	Point	3.96	NA	NA	Ambient	3,200	S	6,720	SE
K-304-5 deposit removal room	Point	0	NA	NA	Ambient	3,420	S	7,330	SE
K-1004-A,-B,-C lab hoods	Point	8.5	NA	NA	Ambient	2,770	SSW	6,390	SE
K-1066-E Yard UF_6 cylinder venting	Point	0	NA	NA	Ambient	2,920	SSE	7,470	ESE
K-1310-DC Rad vacuum cleaning facility	Point	0	0.31	NA	Ambient	2,920	SSE	7,470	ESE
K-1423 Waste mgt. drum crusher	Point	6.1	0.15	NA	Ambient	3,590	S	7,230	SE
K-1775 TVS project	Point	15.24	0.26	1.89	55.06	3,370	SSE	7,830	SE
K-1006 lab hoods	Point	7.62	NA	NA	Ambient	2,680	SSW	6,410	SE

calculated to be 0.33 mrem (0.0033 mSv). This individual is located about 1080 m (0.7 miles) north-northeast of the Y-12 Plant release point. Inhalation and ingestion of uranium radioisotopes (i.e., ^{234}U, ^{235}U, ^{236}U, and ^{238}U) account for about 92% of the dose. The only other radionuclides contributing 1% or more to the dose are ^{239}Pu (1.9%) and ^{239}Np (1.4%). The contribution of Y-12 Plant emissions to the 50-year committed collective EDE to the population residing within 80 km of the ORR was calculated to be about 3.0 person-rem (0.030 person-Sv), which is approximately 30% of the collective EDE for the ORR.

The EDE received by the hypothetical maximally exposed individual for ORNL was calcu-

Table 6.2. Calculated radiation doses to maximally exposed off-site individuals from airborne releases during 1997

Plant	Total effective dose equivalents [mrem (mSv)]	
	Plant max	ORR max
ORNL	0.38 (0.0038)[a]	0.38 (0.0038)
ETTP	0.059 (0.00059)[b]	0.014 (0.00014)
Y-12 Plant	0.33 (0.0033)[c]	0.015 (0.00015)
Entire ORR	*d*	0.41 (0.0041)[e]

[a]The maximally exposed individual is located 4060 m (2.5 miles) SSW of X-3039 and 3720 m (2.3 miles) SW of X-7911.

[b]The maximally exposed individual is located 3650 m (2.3 miles) SW of K-1435.

[c]The maximally exposed individual is located 1080 m (0.7 miles) NNE of the Y-12 Plant release point.

[d]Not applicable.

[e]The maximally exposed individual for the entire ORR is the ORNL maximally exposed individual.

Table 6.3. Calculated collective EDEs from airborne releases during 1997

Plant	Effective dose equivalents[a]	
	(Person-rem)	(Person-Sv)
ORNL	5.8	0.058
ETTP	1.2	0.012
Y-12 Plant	3.0	0.030
Entire ORR	10.0	0.10

[a]Collective effective dose equivalents to the 879,546 persons residing within 80 km (50 miles) of the ORR.

lated to be 0.38 mrem (0.0038 mSv). This individual is located 4060 m (2.5 miles) south-southwest of the X-3039 stack and 3720 m (2.3 miles) southwest of the X-7911 stack. About 76% of this dose is from immersion in airborne ^{41}Ar. Other radionuclides contributing 1% or more to the dose include ^{138}Cs (17%) and ^{212}Pb (1.7%). The contribution of ORNL emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 5.8 person-rem (0.058 person-Sv), which is approximately 58% of the collective EDE for the ORR.

The EDE received by the hypothetical maximally exposed individual for the ETTP was calculated to be 0.059 mrem (0.00059 mSv). This individual is located about 3650 m (2.3 miles) south-southwest of the TSCA Incinerator (K-1435) stack. About 87% of this dose is from ingestion and inhalation of uranium radioisotopes, about 9.0% is from thorium radioisotopes, and about 1.3% is from plutonium. The contribution of ETTP emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 1.2 person-rem (0.012 person-Sv), which is approximately 12% of the collective EDE for the reservation.

The reasonableness of the calculated radiation doses can be inferred by comparison with radiation doses that could be received from measured air concentrations of radionuclides at the ORR PAMs and remote air monitoring station (RAM) (Fig. 5.3). Hypothetical individuals assumed to reside at the PAMs could have received EDEs between 0.11 and 0.32 mrem/year (0.0011 and 0.0032 mSv/year); these EDEs include contributions from naturally occurring (background) radionuclides, radionuclides released from the ORR, and radionuclides released from any other sources. An indication of doses from sources other than those on the ORR can be obtained from the EDE calculated at the RAM, which was 0.13 mrem/year (0.0013 mSv/year). Between 27 and 49% of the calculated EDEs at the PAMs are attributable to tritium, some of which was produced naturally.

Of particular interest is a comparison of doses calculated using measured air concentrations at PAMs located near the maximally exposed individuals for each plant and doses calculated to

those individuals using CAP-88 and measured emissions. PAM 46 is located near the maximally exposed individual for the Y-12 Plant. The EDE calculated at PAM 46 was 0.18 mrem/year (0.0018 mSv/year), which is about 55% of the 0.33 mrem/year (0.033 mSv/year) to the maximally exposed individual modeled by the CAP-88 code. PAM 39 is located at about the same distance as, but in a different wind direction from, the maximally exposed individual for ORNL. The EDE calculated at PAM 39 was 0.17 mrem/year (0.0017 mSv/year), which is about half the 0.38 mrem/year (0.0038 mSv/year) calculated for the maximally exposed individual. This result is not surprising because almost 80% of the dose from ORNL emissions is from emissions of noble gases, which would be not retained in the sampling media used at the PAMs. PAM 35 is located in the direction of, but much closer to, the emission points than is the maximally exposed individual for the ETTP. The EDE calculated at PAM 35 was 0.11 mrem/year (0.0011 mSv/year), which is about twice the 0.059 mrem/year (0.00059 mSv/year) modeled value to the maximally exposed individual.

Dose estimates based on calculated and measured radionuclide concentrations are in reasonable agreement given the differences in distances and directions between maximally exposed individuals and the monitoring stations and the fact that the CAP-88 model typically overestimates doses by a factor of 2.

6.1.2.2 Waterborne Radionuclides

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system by way of the Clinch River and various feeder streams. Discharges from the Y-12 Plant enter the Clinch River via Bear Creek and the East Fork of Poplar Creek, both of which enter Poplar Creek before it enters the Clinch River, and by discharges from Rogers Quarry into McCoy Branch and then into Melton Hill Lake. Discharges from ORNL enter the Clinch River via WOC and WOL. Discharges from the ETTP enter the Clinch River either directly or via Poplar Creek. This section discusses the potential radiological impacts of these discharges to persons who drink water; eat fish; and swim, boat, and use the shoreline at various locations along the Clinch and Tennessee rivers. For convenience of assessment, surface waters potentially affected by the ORR are divided into six segments that are distinguished by proximity to the ORR and by changes in water flow. These segments are Melton Hill Lake, Upper Clinch River (between Melton Hill Dam and the mouth of Poplar Creek), Lower Clinch River (between Poplar Creek and the Tennessee River), Upper Watts Bar Lake (the Kingston area), the Lower System (the rest of Watts Bar Lake and Chicamauga Lake), and Poplar Creek.

Two types of data are used to estimate potential radiation doses to the public. The first method uses radionuclide concentrations in water and fish that were determined by laboratory analyses of water and fish samples. The second method uses radionuclide concentrations in water and fish that were calculated from measured radionuclide discharges and known or estimated stream flows. The advantage of the first method is the use of measured concentrations of radionuclides in water and fish; disadvantages are the inclusion of naturally occurring radionuclides in total alpha- and beta-activity measurements, the possibility that some radionuclides of ORR origin might be present in quantities too low to be measured, and the possibility that the presence of some radionuclides might be overstated. (If the analytical laboratory looks for the presence of a given nuclide, a quantity will be reported for that nuclide even if the nuclide is not really present or is present at a quantity below the detection limit.) The advantages of the second method are that most, if not all, radionuclides discharged from the ORR will be quantified and naturally occurring radionuclides will not be considered; the disadvantage is the use of models to estimate the concentrations of the radionuclides in water and fish. Using the two methods should allow the potential radiation dose to be bracketed.

Drinking Water

There are several water treatment plants along the Clinch and Tennessee river systems that could

be affected by discharges from the ORR. For purposes of assessment, highly exposed individuals were assumed to drink 730 L of water during 1997; the average person, to drink 370 L.

Melton Hill Lake. The only water treatment plant located on Melton Hill Lake that could be affected by discharges from the ORR is a Knox County plant near CRK 58. Water from this plant is not sampled. However, the plant is located near EMP water sampling location CRK 58. A highly exposed individual could have received an EDE of about 0.096 mrem (0.00096 mSv) from drinking this water. The collective dose to the estimated 37,510 persons who drink this water could have been about 1.8 person-rem (0.018 person-Sv). These doses are about 300 times higher than those calculated from radionuclide discharges from the ORR to Melton Hill Lake. (These dose estimates may be high because they are based on water samples taken before processing in the plants.) Individuals drinking water that was sampled upstream of ORR radionuclide inputs could have received EDEs slightly higher than persons drinking water sampled at CRK 58.

Upper Clinch River. The ETTP (Gallaher) water plant draws water from this portion of the Clinch River. Based on water samples taken in the plant, a worker who drank 370 L (half of the worker's total annual water consumption) of this water could have received an EDE of about 0.15 mrem (0.0015 mSv), and the collective EDE to the approximately 2000 ETTP workers could have been about 0.29 person-rem (0.0029 person-Sv). Based on water samples taken from the Clinch River (CRK 23), the worker could have received an EDE of about 0.16 mrem (0.0016 mSv), and the collective EDE could have been about 0.31 person-rem (0.0031 person-Sv). Using radionuclide discharge data, the maximum individual EDE was estimated to be 0.025 mrem (0.00025 mSv); the collective EDE was 0.050 person-rem (0.00050 person-Sv).

Lower Clinch River. There are no water treatment plants that draw water from this segment.

Upper Watts Bar Lake. The Kingston municipal water plant is located near this segment; it draws water from the Tennessee River, just above its confluence with the Clinch River. Based on water samples taken in the plant, a highly exposed person could have received an EDE of about 0.40 mrem (0.0040 mSv), and the collective EDE to the estimated 7438 water users could have been about 1.5 person-rem (0.015 person-Sv). No water samples are taken from the Tennessee River near the water plant. Using radionuclide discharge data, the maximum individual EDE was estimated to be 0.015 mrem (0.00015 mSv); the collective EDE was 0.12 person-rem (0.0012 person-Sv). About half the EDEs from drinking sampled water are from ^{238}Pu. The source of this material is puzzling, especially because the Kingston water intake is on the Tennessee River, upstream from its convergence with the Clinch River.

Lower System. Several water treatment plants are located on tributaries of the remainder of Watts Bar Lake and Chicamauga Lake. Persons drinking water from these plants could not have received EDEs greater than about 0.014 mrem (0.00014 mSv). The estimated collective EDE, using discharge data, was about 1.4 person-rem (0.014 person-Sv).

Poplar Creek. There are no water treatment plants that draw water from this segment.

Fish

Fishing is quite common on the Clinch and Tennessee River systems. For purposes of assessment, avid fish eaters were assumed to have consumed 21 kg of fish during 1997; the average person, to have consumed 6.9 kg of fish. Measured concentrations of radionuclides in water and calculated concentrations from discharges were input to the LADTAP XL code to calculate EDEs from eating fish.

Melton Hill Lake. Samples of fish were collected at one location (CRK 70) on Melton Hill Lake. Based on analyses of these samples, an avid fish eater could have received an EDE of about 0.040 mrem (0.00040 mSv); the collective EDE could have been 0.017 person-rem (0.00017 person-Sv). Water samples were collected at three locations (CRKs 70, 66, and 58) on Melton Hill Lake. Based on analyses of these

samples, an avid fish eater could have received an EDE as high as 0.55 mrem (0.0055 mSv); the collective EDE could have been as high as 0.23 person-rem (0.0023 person-Sv). Based on radionuclide discharges to Melton Hill Lake, an avid fish eater could have received an EDE of 0.00042 mrem (0.0000042 mSv); the collective EDE could have been 0.00017 person-rem (0.0000017 person-Sv).

Upper Clinch River. Samples of fish were collected at one location (CRK 32) on the Upper Clinch River. Based on analyses of these samples, an avid eater could have received an EDE of about 0.034 mrem (0.00034 mSv); the collective EDE could have been 0.0098 person-rem (0.000098 person-Sv). Water samples were collected at two locations (CRK 32 and 23) on Upper Clinch River. Based on analyses of these samples, an avid fish eater could have received an EDE as high as 0.96 mrem (0.0096 mSv); the collective EDE could have been as high as 0.27 person-rem (0.0027 person-Sv). Based on radionuclide discharges to Melton Hill Lake, an avid fish eater could have received an EDE of 0.072 mrem (0.00072 mSv); the collective EDE could have been 0.020 person-rem (0.00020 person-Sv).

Lower Clinch River. Samples of fish were collected at one location (CRK 16) on the Lower Clinch River. Based on analyses of these samples, an avid fish eater could have received an EDE of about 0.045 mrem (0.00045 mSv); the collective EDE could have been 0.013 person-rem (0.00013 person-Sv). Water samples were collected at CRK 16. Based on analyses of these samples, an avid fish eater could have received an EDE as high as 0.31 mrem (0.0031 mSv); the collective EDE could have been as high as 0.088 person-rem (0.00088 person-Sv). Based on radionuclide discharges, an avid fish eater could have received an EDE of 0.068 mrem (0.00068 mSv); the collective EDE could have been 0.019 person-rem (0.00019 person-Sv).

Upper Watts Bar Lake. No fish or water samples were collected from this segment. Discharge data indicate that an avid fish eater could have received an EDE of about 0.020 mrem (0.00020 mSv); the collective EDE could have been 0.051 person-rem (0.00051 person-Sv).

Lower System. No fish or water samples were collected from this segment. Discharge data indicate that an avid fish eater could have received an EDE as high as 0.019 mrem (0.00019 mSv); the collective EDE could have been 0.095 person-rem (0.00095 person-Sv).

Poplar Creek. No fish samples were collected from Poplar Creek. Water samples were taken from locations above and below the ETTP and from East Fork Poplar Creek, just before it joins Poplar Creek. Based on analyses of these samples, an avid fish eater could have received an EDE as high as 0.93 mrem (0.0093 mSv); the collective EDE could have been as high as 0.016 person-rem (0.00016 person-Sv). Based on radionuclide discharges, an avid fish eater could have received an EDE of 0.62 mrem (0.0062 mSv); the collective EDE could have been 0.018 person-rem (0.00018 person-Sv).

Other Uses

Other uses include swimming or wading, boating, and use of the shoreline. A highly exposed other user was assumed to swim or wade for 27 hours/year, boat for 63 hours/year, and use the shoreline for 67 hours/year. Measured and calculated concentrations of radionuclides in water and the LADTAP XL code were used to estimate potential EDEs from these activities. When compared to EDEs from eating fish from the same waters, the EDEs from these other uses are relatively insignificant.

Melton Hill Lake. Based on the water samples collected at CRKs 70, 66, and 58, a highly exposed other user could have received an EDE as high as 0.015 mrem (0.00015 mSv); the collective EDE could have been as high as 0.032 person-rem (0.00032 person-Sv). Based on radionuclide discharges to Melton Hill Lake, a user could have received an EDE of 0.0000030 mrem (0.000000030 mSv); the collective EDE could have been 0.0000014 person-rem (0.000000014 person-Sv).

Upper Clinch River. Based on the water samples collected at CRKs 32 and 23, a highly exposed other user could have received an EDE as high as 0.014 mrem (0.00014 mSv); the collective

EDE could have been as high as 0.0023 person-rem (0.000023 person-Sv). Based on measured radionuclide discharges from the ORR, a user could have received an EDE of 0.00014 mrem (0.0000014 mSv); the collective EDE could have been 0.000021 person-rem (0.00000021 person-Sv).

Lower Clinch River. Based on the water samples collected at CRK 16, a highly exposed other user could have received an EDE as high as 0.0040 mrem (0.000040 mSv); the collective EDE could have been as high as 0.0034 person-rem (0.000034 person-Sv). Based on measured radionuclide discharges from the ORR, a user could have received an EDE of 0.00012 mrem (0.0000012 mSv); the collective EDE could have been 0.00010 person-rem (0.0000010 person-Sv).

Upper Watts Bar Lake. No water samples were collected from this segment. Discharge data indicate that a highly exposed other user could have received an EDE of about 0.000035 mrem (0.00000035 mSv); the collective EDE could have been 0.00026 person-rem (0.0000026 person-Sv).

Lower System. No water samples were collected from this segment. Discharge data indicate that a highly exposed other user could have received an EDE of about 0.000034 mrem (0.00000034 mSv); the collective EDE could have been 0.0020 person-rem (0.000020 person-Sv).

Poplar Creek. Based on the water samples taken from Poplar Creek and from the lower end of East Fork Poplar Creek, a highly exposed other user could have received an EDE as high as 0.0033 mrem (0.000033 mSv); the collective EDE could have been as high as 0.000035 person-rem (0.00000035 person-Sv). Based on radionuclide discharges, a user could have received an EDE of 0.00061 mrem (0.0000061 mSv); the collective EDE could have been 0.000017 person-rem (0.00000017 person-Sv).

Summary

Table 6.4 is a summary of potential EDEs from waterborne radionuclide discharges. Adding worst-case EDEs for all pathways and all segments indicates that the maximum imaginable EDE could have been about 1.4 mrem (0.014 mSv): 0.4 mrem (0.004 mSv) from drinking Kingston water, plus 0.96 mrem (0.0096 mSv) from eating Upper Clinch River fish, plus 0.015 mrem (0.00015 mSv) from other uses on Melton Hill Lake. The maximum imaginable collective EDE to the 50-mile population was estimated to be about 5.7 person-rem (0.057 person-Sv). These are small percentages of individual and collective doses attributable to natural background radiation, 0.46% and 0.0022%, respectively.

6.1.2.3 Radionuclides in Other Environmental Media

The CAP-88 computer codes are used to calculate radiation doses from ingestion of meat, milk, and vegetables that contain radionuclides released to the atmosphere. These doses are included in the dose calculations for airborne radionuclides. However, some environmental media, including the three mentioned, are sampled as part of the surveillance program. The following dose estimates are based on environmental sampling results and may include contributions from radionuclides occurring in the natural environment, released from the ORR, or both.

Milk

Milk collected at three locations near the ORR was sampled for total strontium, ^{3}H, ^{40}K, and ^{131}I. Only strontium and ^{40}K were detected in the milk samples. All of these radionuclides are found in the natural environment, and all but ^{40}K are emitted from the ORR. The sampling results seem to be biased high this year, possibly as a result of a change in the method of reporting detection limits. Most of the strontium reported in the samples was below the detection limits and may not have actually been present in the milk. Nevertheless, the sample data were used to calculate potential EDEs to a hypothetical person who drank 310 L of sampled milk during the year.

This hypothetical person could have received an EDE between 0.66 and 1.5 mrem (0.0066 and 0.015 mSv); the average EDE could have been 0.95 mrem (0.0095 mSv) from strontium in milk.

Table 6.4. Summary of maximum individual EDEs (mrem)[a] from waterborne radionuclides

Type of sample	Drinking water	Eating fish	Other uses	Total of highest
		Melton Hill Lake		
Fish		0.040		
Water	0.096	0.55	0.015	0.66
Discharge	0.00032	0.00042	0.0000014	0.00074
		Upper Clinch River		
Drinking water	0.15			
Fish		0.034		
Water	0.16	0.96	0.014	1.1
Discharge	0.025	0.072	0.00014	0.12
		Lower Clinch River		
Fish		0.045		
Water		0.31	0.0040	0.31
Discharge		0.068	0.00012	0.068
		Upper Watts Bar Lake		
Drinking water	0.40			0.40
Discharge	0.015	0.020	0.000035	0.035
		Lower System (Lower Watts Bar Lake and Chicamauga Lake)		
Discharge	0.014	0.019	0.000034	0.033
		Poplar Creek		
Water		0.93	0.0033	0.93
Discharge		0.62	0.00061	0.62

[a]1 mrem = 0.01 mSv.

The average EDE associated with drinking milk in EPA Region 4 is about 0.09 mrem (0.0009 mSv) (EPA 1993a). However, drinking milk collected several tens of miles to the south, beyond the range of measurable influence of the ORR could have resulted in an EDE of about 2.6 mrem (0.026 mSv).

For perspective, the hypothetical person could have received an EDE of about 200 mrem (2.0 mSv) from the ^{40}K in milk. This EDE seems unrealistically high, largely because the reported concentrations of potassium seem too high when considered in terms of expected doses from naturally occurring radionuclides.

Honey

The honey sampling program was discontinued in 1997. Previous sampling campaigns indicated that any doses received from honey would be low. For example, a hypothetical person who consumed 1 kg (2.2 lb) of honey during 1996 could have received an EDE of between 0 and 0.06 mrem (0 and 0.0006 mSv) from radionuclides that could have been emitted from ORR facilities.

Food Crops

Samples of three types of vegetables (tomatoes, lettuce, and turnips) were collected from five representative gardens surrounding the ORR during 1997. These vegetable types are representative of fruit-bearing, leafy, and root vegetables. The sampling results were used to calculate potential EDEs to persons eating these foods.

Nationwide Food Consumption Survey (NFCS) data were used to estimate consumption rates and potential EDEs for eating home-produced foods (EPA 1997). A home gardener was assumed to have eaten 32 kg (71 lb) of homegrown tomatoes, 10 kg (22 lb) of homegrown leafy vegetables, and 37 kg (82 lb) of homegrown root vegetables during the year.

Based on the sampling data and the assumed food consumption rates, a typical home gardener who ate all three vegetable types could have received an EDE of about 3.4 mrem (0.034 mSv), about 1.2 mrem (0.012 mSv) from fruit-bearing vegetables, about 0.7 mrem (0.007 mSv) from leafy vegetables, and about 1.5 mrem (0.015 mSv) from root vegetables (Table 6.5). Essentially all (about 99.8%) of these doses result from the presence of ^{40}K, which is strictly a naturally occurring radionuclide in foods. Excluding the EDE from ^{40}K, the home gardener could have received an EDE of about 0.008 mrem (0.00008 mSv). This EDE is attributed to the other radionuclides detected in the vegetables, including ^{238}U, ^{7}Be, ^{60}Co, and ^{137}Cs. Although these radionuclides are measured in emissions from the ORR, the uranium isotopes and ^{7}Be also occur naturally in soil and fertilizers that are spread on gardens, and ^{60}Co and ^{137}Cs also are present in the environment because of weapons testing. No weapons testing has ever occurred in the Oak Ridge area. Most of the radioactivity found in the vegetables and the associated radiation doses may be attributable to radionuclides found in the environment, not radionuclides emitted by operations on the ORR.

Table 6.5. Average EDEs from ingesting vegetables grown at ORR ambient air monitoring stations, 1997

Vegetable	EDE [mrem (mSv)]	
	All reported radionuclides	Excluding ^{40}K
Tomatoes	1.2E+00 (1.2E–02)	3.0E-03 (3.0E–05)
Lettuce	7.0E–01 (7.0E–03)	1.9E-03 (1.9E–05)
Turnips	1.5E+00 (1.5E–02)	3.0E-03 (3.0E–05)
Total	3.4E+00 (3.4E–02)	8.0E-03 (8.0E–05)

Hay

Another environmental pathway that was evaluated using sampling data is eating beef and drinking milk obtained from bovines that ate hay harvested from the ORR. Hay was collected from one background location and from six ORR locations. Hay from six ORR locations were combined into three samples. Statistically significant concentrations were found only for ^{7}Be and ^{137}Cs. Beryllium-7 is a naturally occurring radionuclide, and ^{137}Cs may be present from previous weapons testing. (Note that no ^{137}Cs was found in sampled milk.) The EDE from drinking milk and eating beef during 1997 was estimated to be about 0.1 mrem (0.001 mSv), mostly from the presence of ^{137}Cs. In previous years, ^{40}K, a naturally occurring radionuclide that was not measured in 1997, was the primary contributor to the EDE from drinking milk and eating beef from bovines that consumed ORR-grown hay.

White-Tailed Deer

The TWRA conducted three 2-day deer hunts during 1997 on the Oak Ridge Wildlife Management Area, which is part of the ORR. A total of 438 deer were killed during these hunts and were brought to the TWRA checking station. At the station, a bone and a tissue sample were taken from each deer and were field-counted for radioactivity to ensure that the deer met release criteria; that is, they contained less than 20 pCi/g (0.74 Bq/g) of beta-particle activity in bone or 5 pCi/g

(0.19 Bq/g) of ^{137}Cs in edible tissue. Nine of the deer exceeded the limit for beta-particle activity in bone and were confiscated. The remaining 429 deer were released to the hunters.

The released deer had an average field-dressed weight of about 37 kg (82 lb). Because about 55% of the dressed weight is edible meat, the average deer would yield about 20 kg (44 lb) of meat. Therefore, based on the average weight, the total harvest of edible meat was about 8600 kg (18,960 lb).

The average ^{137}Cs concentration in tissue of the 429 released deer, as determined by field counting, was 0.07 pCi/g (0.003 Bq/g); the maximum ^{137}Cs concentration in a deer was 1.37 pCi/g (0.05 Bq/g). No tissue samples from the released deer were subjected to laboratory analysis, which is required to quantitatively determine ^{90}Sr concentrations in the tissue. Therefore, the maximum concentration of ^{90}Sr found in tissue samples from deer harvested during 1996 was used to estimate EDEs from eating deer harvested during 1997. This concentration was 0.002 pCi/g (0.00007 Bq/g).

An individual who consumed one average-weight deer containing the 1997 average concentration of ^{137}Cs (0.07 pCi/g) could have received an EDE of about 0.07 mrem (0.00007 mSv). The maximum likely EDE could be to a hunter who harvests and consumes two deer. During 1997, such a hunter could have received an EDE of about 1 mrem (0.01 mSv) from consuming two deer that had field-dressed weights of 80.5 and 85.5 lb (36.5 and 38.9 kg) and field-determined ^{137}Cs concentrations of 0.57 and 0.48 pCi/g (0.037 and 0.018 Bq/g). The maximum hypothetical EDE, about 3 mrem (0.03 mSv), would result from consuming a hypothetical deer, namely, the heaviest deer harvested containing the highest field-determined concentration of ^{137}Cs (1.37 pCi/g) and the maximum 1996 ^{90}Sr concentration.

The collective EDE from eating all the harvested deer meat with an 1997 average field-derived ^{137}Cs concentration of 0.07 pCi/g (0.003 Bq/g) is estimated to be about 0.03 person-rem (0.0003 person-Sv).

Canada Geese

During the 1997 goose roundup, 83 geese (39 from ORNL, 28 from the ETTP, and 16 from Melton Hill Dam) were weighed and subjected to whole-body gamma scans. Only one goose was retained. The average weight of the scanned geese was about 4 kg (9 lb); the heaviest goose weighed 5.2 kg (11.4 lb). Approximately half the weight of a goose is edible. The average ^{137}Cs concentration was 0.07 pCi/g (0.003 Bq/g); the maximum concentration was 0.69 pCi/g (0.03 Bq/g).

No ^{90}Sr analyses were performed during 1997. However, in 1995, 11 local geese and 6 geese from a background location were sacrificed and tissue, bone, and thyroid samples were collected and analyzed. The 1995 average ^{90}Sr concentration in tissue was approximately 7 pCi/g (0.3 Bq/g); the maximum concentration was 11 pCi/g (0.41 Bq/g).

If one person consumed an average-weight goose that contained the 1997 average concentration of ^{137}Cs and the 1995 average concentration of ^{90}Sr, that person could have received an EDE of about 2 mrem (0.02 mSv). The highest possible EDE, from eating a hypothetical goose (a combination of the heaviest goose and the maximum ^{137}Cs and ^{90}Sr concentrations), could have been about 4.5 mrem (0.045 mSv).

It is possible that one person could have eaten more than one goose that spent time on the ORR. If one person consumed nine average geese, that person could have received an EDE of about 18 mrem (0.18 mSv). This is a conservative assumption because most hunters harvest on average one to two geese per hunting season (USFWS 1995).

Goose harvest data for the 1997–1998 hunt season were not available from the state at the time of this report. Using average (1983 to 1996) goose harvest data for regions that include Anderson, Knox, Loudon, and Roane counties and weighting this data based on 1996 goose harvest per county, approximately 817 geese could have been harvested in the four counties (TWRA, 1997). Of the total number of geese harvested in

the four counties, it is possible that 302 of these geese could have spent time on the ORR. The collective EDE from consuming 302 average geese could have been about 0.60 person-rem (0.0060 person-Sv).

Eastern Wild Turkey

Two wild turkey hunts were held on the ORR during 1997. A total of 90 birds were harvested; 1 was retained. The average weight of the turkeys was 8.5 kg (19 lb), and their average ^{137}Cs concentration was 0.1 pCi/g (0.004 Bq/g). A person who ate an average turkey could have received an EDE of about 0.021 mrem (0.00021 mSv). The maximum weight of a released turkey was 10.7 kg (23.5 lbs), and the maximum ^{137}Cs concentration in a turkey (not the heaviest turkey) was 0.62 pCi/g (0.023 Bq/g). A person who ate a hypothetical turkey (a combination of the heaviest turkey and the highest ^{137}Cs concentration) could have received an EDE of about 0.17 mrem (0.0017 mSv).

In addition to the turkey hunt, a turkey roundup was conducted during January and February 1997 to provide baseline data prior to conducting the wild turkey hunt. Approximately 31 turkeys were whole-body gamma scanned, and tissue samples from 6 sacrificed turkeys were analyzed. The maximum concentrations of ^{137}Cs and ^{90}Sr measured in tissue samples were 0.12 pCi/g (0.044 Bq/g) and 0.22 pCi/g (0.0081 Bq/g), respectively. The heaviest roundup turkey weighed 9.9 kg (22 lb). A person who ate a hypothetical turkey (a combination of the heaviest turkey and the highest ^{137}Cs and ^{90}Sr concentrations) could have received an EDE of about 0.03 mrem (0.0003 mSv).

Direct Radiation

External exposure rates from background sources in the state of Tennessee average about 6.4 μR/hour and range from 2.9 to 11 μR/hour. These exposure rates translate into annual EDE rates that average 42 mrem/year (0.42 mSv/year) and range between 19 and 72 mrem/year, or 0.19 and 0.72 mSv/year (Myrick et al. 1981). External radiation exposure rates are measured at a number of locations on and off the ORR. The average exposure rate at PAMs around the ORR during 1997 was about 5.4 μR/hour. This rate corresponds to an EDE rate of about 36 mrem/year (0.36 mSv/year). Except for two locations, all measured exposure rates at or near the ORR boundaries are near background levels. The two exceptions are a stretch of bank along the Clinch River and a section of Poplar Creek that flows through the ETTP.

During 1997, external exposure rate measurements were taken along a 1.7-km (1.1-mile) length of Clinch River bank. Measured exposure rates along this stretch of bank averaged 8.4 μR/hour (down from 13 μR/hour in 1987) and ranged between 6.9 and 9.3 μR/hour (3.5 and 18 μR/hour in 1987). This corresponds to an average exposure rate of about 2 μR/hour (0.001 mrem/hour) above background.

A potential maximally exposed individual is a hypothetical fisherman who was assumed to have spent 5 hours/week (250 hours/year) near the point of average exposure. This hypothetical maximally exposed individual could have received an EDE of about 0.25 mrem (0.0025 mSv) during 1997.

The radiation field along Poplar Creek emanates from storage areas within the ETTP. The section of the creek affected by this area runs through the plant and is used at times by fishermen. Dose rate measurements taken at nine locations along the creek bank during 1997 ranged between 3.5 and 9.5 μR/hour, which corresponds to an EDE rate between 0.0026 to 0.0071 mrem/hour (between 0.000026 and 0.000071 mSv/hour). The average dose rate was about 6.1 μR/hour, which corresponds to an EDE rate of 0.0046 mrem/hour (0.000046 mSv/hour). A 4-hour fishing trip could have resulted in an EDE of 0.02 mrem (0.0002 mSv). If the hypothetical Clinch River fisherman is used, the 250-hour/year exposure time could have resulted in an EDE of about 1 mrem (0.01 mSv). It is extremely unlikely that anyone would fish this stretch of Poplar Creek for 250 hours/year.

6.1.3 Doses to Aquatic Biota

DOE Order 5400.5, Chapter II, sets an interim absorbed dose rate limit of 1 rad/day (0.01 Gy/day) to native aquatic organisms. To demonstrate compliance with this limit, absorbed dose rates to fish, crustacea (e.g., crayfish), and muskrats were calculated using the computer code CRITR2 (Baker and Soldat 1993). Fish and crustacea are considered to be primary aquatic organisms, those that reside in the aquatic ecosystem. Muskrats are considered to be secondary organisms, those that subsist on aquatic plants. Maximum and average concentrations of radionuclides measured in surface waters on and around the ORR are used to estimate dose rates from internal and external exposures. Internal dose rates are calculated using organism- and nuclide-specific bioaccumulation factors and absorbed energy fractions. External dose rates are calculated for submersion in water and irradiation from bottom sediments. Exposure to sediments is particularly meaningful for crawling or fixed organisms (such as crayfish and mollusks). Direct radiation doses from sediment are estimated from water concentrations using factors such as a geometry roughness factor, sediment deposition transfer factor, and nuclide-specific ground-surface irradiation dose factors. Table 6.6 lists average and maximum total dose rates to aquatic organisms from waterways at ORNL, the Y-12 Plant, and the ETTP.

At ORNL, doses to aquatic organisms are based on water concentrations at nine different sampling locations (see Table 6.6): Melton Branch (kilometer 0.2), WOC (kilometers 1.0, 2.6, and 6.8), First Creek, Fifth Creek, Raccoon Creek, Ish Creek, and Northwest Tributary. The results from these calculations indicate that absorbed dose rates to aquatic biota are less than 1 rad/day (0.01 Gy/day). At ORNL, the highest dose rates, which were associated with maximum concentrations of radionuclides in water, occurred at First Creek: 9E–3 rad/day (9E–5 Gy/day) to fish, 6E–3 rad/day (6E–5 Gy/day) to crustacea, and 4E–2 rad/day (4E–4 Gy/day) to muskrats. Even with maximum radionuclide concentrations at these locations, the absorbed doses were significantly less than the limit of 1 rad/day (0.01 Gy/day).

At the Y-12 Plant, doses to aquatic organisms were estimated from concentrations of radionuclides in water obtained from East Fork Poplar Creek at SWHISS 9422-1 (formerly Station 17), Bear Creek at BCK 4.55 (formerly Outfall 304), and Rogers Quarry discharge point S-19 (formerly Outfall 302). Maximum calculated dose rates to fish and muskrats were 7E–04 rad/day (7E–06 Gy/day) and 1E–1 rad/day (1E–3 Gy/day), respectively, at SWHISS 9422-1. The dominant radionuclide contributor to the muskrat dose was ^{228}Ra, a decay product of ^{232}Th, a naturally occurring radionuclide. The maximum calculated dose rate to crustacea was 4E–3 rad/day (4E–5 Gy/day) at BCK 4.55.

Similar analyses were conducted at the ETTP. The waterways evaluated were Mitchell Branch at K-1700, Poplar Creek at K-1007-B and K-1710 (upstream of the ETTP), Clinch River at K-901-A, East Fork Poplar Creek (kilometers 0.1 and 5.4), and at Bear Creek (BCK 0.6). At East Fork Poplar Creek (kilometer 5.4), the maximum dose rates to fish and muskrats were 1E–4 rad/day (1E–6 Gy/day) and 2E–2 rad/day (2E–4 rad/day), respectively. At Mitchell Branch (K-1700) the maximum dose rate to crustacea was estimated to be 4E–4 rad/day (4E–6 Gy/day). Even with maximum radionuclide concentrations at these locations, the absorbed doses were less than the limit of 1 rad/day (0.01 Gy/day).

Absorbed doses estimated from maximum radionuclide water concentrations determined on the ORR resulted in doses that were less than the 1 rad/day (0.01 Gy/day) limit prescribed in DOE Order 5400.5.

6.1.4 Current-Year Summary

A summary of the maximum EDEs to individuals by pathway of exposure is given in Table 6.7 It is very unlikely (if not impossible) that any real person could have been irradiated by all of these sources and pathways for the duration of 1997; however, if someone was, that person could have received a total EDE of about 2.8 mrem (0.028 mSv): 0.41 mrem (0.0041 mSv) from

Table 6.6. 1997 total dose rate for aquatic organisms (rad/day)[a,b]

Measurement location	Fish		Crustacea		Muskrat	
	Av	Max	Av	Max	Av	Max
		ORNL				
Melton Branch (K 0.2)	1E–3	2E–3	3E–4	6E–4	3E–3	6E–3
White Oak Creek (K 1.0)	8E–4	2E–3	3E–4	5E–4	2E–3	3E–3
White Oak Creek (K 2.6)	4E–4	7E–4	1E–4	2E–4	1E–3	2E–3
White Oak Creek (K 6.8)	7E–8	1E–7	7E–8	1E–7	1E–7	2E–7
First Creek	7E–3	9E–3	6E–3	6E–3	3E–2	4E–2
Fifth Creek	6E–5	8E–5	1E–5	1E–5	2E–4	3E–4
Northwest Tributary	2E–4	4E–4	6E–5	1E–4	7E–4	1E–3
Raccoon Creek	9E–5	2E–4	2E–5	3E–5	3E–4	6E–4
Ish Creek	2E–5	3E–5	4E–5	6E–5	5E–6	8E–6
		Y-12 Plant				
East Fork Poplar Creek (SWHISS 9422-1)	1E–4	7E–4	5E–4	3E–3	1E–2	1E–1
Bear Creek (BCK 4.55)[c]	2E–4	6E–4	9E–4	4E–3	3E–2	9E–2
Rogers Quarry (Outfall S19)[d]	4E–5	3E–4	2E–4	1E–3	4E–3	8E–2
		ETTP				
Mitchell Branch (K-1700)	2E–5	5E–5	1E–4	4E–4	1E–4	2E–4
Poplar Creek (K-1007B)	2E–6	4E–6	3E–5	1E–4	6E–6	1E–5
Poplar Creek (K-1710) upstream of the ETTP	3E–6	9E–6	5E–6	8E–5	1E–5	4E–5
Clinch River (K-901-A)	5E–6	1E–5	8E–5	2E–4	1E–5	3E–5
East Fork Poplar Creek (K0.1)	3E–5	4E–5	7E–5	7E–5	6E–3	6E–3
East Fork Poplar Creek (K5.4)	1E–4	1E–4	2E–4	2E–4	2E–2	2E–2
Bear Creek (BCK 0.6)	3E–5	4E–5	5E–5	6E–5	9E–5	1E–4

[a]Total dose rate includes the contribution of internally deposited radionuclides, sediment exposure (derived from water concentrations), and water immersion.

[b]To convert from rad/day to Gy/day divide by 100.

[c]Formerly NPDES Outfall 304.

[d]Formerly NPDES Outfall 302.

Table 6.7. Summary of maximum potential radiation dose equivalents to an adult during 1997 and locations of the maximum exposures

Pathway	Location	Effective dose equivalent (mrem)[a]
Gaseous effluents: Inhalation, immersion, direct radiation from ground, and food chains	Maximally exposed resident to	
	Y-12 Plant	
	ORNL	0.33
	ETTP	0.38
	ORR	0.059
		0.41
Liquid effluents		
Drinking water	Kingston Water Plant	0.40
Eating fish	Clinch River, CRK 23	0.96
	Clinch River, CRK 58	
Other activities		0.015
Eating deer		3.0[b]
Eating geese		4.5[c]
Eating turkey		0.2[d]
Direct radiation	Clinch River shoreline	0.25
	Poplar Creek (ETTP)	1.0

[a]1 mrem = 0.01 mSv.

[b]Hypothetical deer = the heaviest deer containing highest measured concentrations of ^{137}Cs and ^{90}Sr.

[c]Hypothetical goose = the heaviest goose containing highest measured concentration of ^{137}Cs and ^{90}Sr.

[d]Hypothetical turkey = the heaviest turkey containing highest measured concentration of ^{137}Cs.

airborne emissions, 0.40 mrem (0.0040 mSv) from drinking water from the Kingston plant, 0.96 mrem (0.0096 mSv) from eating fish from Upper Clinch River, 1 mrem (0.01 mSv) from fishing on Poplar Creek inside the ETTP, and 0.015 mrem (0.00015 mSv) from other water uses on Melton Hill Lake. This dose is about 0.93% of the annual dose [300 mrem (3 mSv)] from background radiation. If this person also was the person who received the highest EDEs from eating wildlife harvested on the ORR, that person could not have received an additional committed EDE greater than about 7.7 mrem (0.077 mSv).

DOE Order 5400.5 limits to no more than 100 mrem (1 mSv) the EDE that an individual may receive from all exposure pathways from all radionuclides released from the ORR during one year. As described in the preceding paragraph, the 1997 maximum EDE could not have exceeded about 10.5 mrem (0.105 mSv), or about 10.5% of the limit given in DOE Order 5400.5. For further information, see Table A.2, which provides a summary of dose levels associated with a wide range of activities.

The total collective EDE to the population living within a 50-mile (80-km) radius of the ORR was estimated to be about 17 person-rem (0.17 person-Sv). This dose is about 0.0064% of the 264,000 person-rem (2640 person-Sv) that this population received from natural sources during 1997.

6.1.5 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years from 1993 to

Table 6.8. Trends in total effective dose equivalent for selected pathways

Pathway	Effective dose equivalent (mrem)[a]				
	1993	1994	1995	1996	1997
All air	1.4	1.7	0.5	0.45	0.41
Fish consumption	0.2	1.6	0.9	1.2	0.96
Drinking water (Kingston)	0.07	0.04	0.15	0.32	0.40
Direct radiation (Clinch River)	1[b]	1[b,c]	1[b,c]	1[b,c]	0.25[b]
Direct radiation (Poplar Creek)	1[b]	1[b]	1[b]	1[b]	1[b]

[a]1 mrem = 0.01 mSv.

[b]These values have been corrected by removing the contribution of natural background radiation and by using International Commission on Radiological Protection recommendations for converting external exposure to effective dose equivalent.

[c]This is an overestimate of the potential dose because the source of the direct radiation was remediated during 1993 and 1994.

1997 are given in Table 6.8. The variations in values over this 5-year period likely are not statistically significant. The dose estimates for direct irradiation along the Clinch River have been corrected for background.

6.1.6 Potential Contributions from Off-Site Sources

Four off-site facilities could contribute to radiation doses received by members of the public around the ORR. These facilities include a waste processing facility located on Bear Creek Road, a depleted uranium processing facility located on Illinois Avenue, a decontamination facility located on Flint Road in Oak Ridge, and a waste processing facility located on Gallaher Road in Kingston.

These facilities submit annual reports to demonstrate compliance with NESHAPs regulations. These reports indicate that no individual located in the vicinity of the ORR should have received in EDE in excess of 0.20 mrem (0.0020 mSv) because of airborne emissions from these facilities. When combined with doses that could have been caused by emissions from the ORR, no individual should have received an EDE in excess of EPA or DOE annual limits. No information was obtained about waterborne releases, if any, from these facilities.

6.1.7 Findings

The maximally exposed off-site individual could have received a 50-year committed EDE of about 0.41 mrem (0.0041 mSv) from airborne effluents from the ORR. This dose is below 10 mrem (0.10 mSv) per year, the limit specified in the CAA for DOE facilities. No individual EDE was calculated that even approaches the 100-mrem/year (1.0-mSv/year) limit prescribed by the DOE. The estimated collective committed EDE to the about 880,000 persons living within 50 miles (80 km) of the ORR was about 10 person-rem (0.10 person-Sv) for 1997 airborne emissions. This represents about 0.004% of the 264,000 person-rem (2640 person-Sv) that the surrounding population would receive from all sources of natural radiation.

6.2 CHEMICAL DOSE

6.2.1 Terminology

The following terms are pertinent to the understanding of chemical exposure. See Appendix B for further explanation of terms and methodology.

- Slope factor (SF). A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The SF is used to estimate an upper-bound probability of an individual developing cancer as a result of lifetime exposure to a particular level of a potential carcinogen. Units are expressed as mg kg^{-1} day^{-1}.
- Maximum contaminant level (MCL). EPA National Interim Primary and National Primary Drinking Water regulation concentrations that apply to all community or public water systems.
- Reference dose (RfD). An estimate of the daily exposure to the human population, including sensitive individuals, that is likely to be without an appreciable risk of deleterious effects during a lifetime.
- Secondary maximum contaminant level (SMCL). EPA National Secondary Drinking Water regulation concentrations that apply to public water systems. The EPA SMCLs are unenforceable criteria that apply to aesthetic water quality; however, Tennessee SMCLs, which are the same as the federal SMCLs, are enforceable.

RfDs, which are used to evaluate potential health effects from noncarcinogens, are derived from doses of chemicals that result in no adverse effect or the lowest dose that showed an adverse effect on humans or laboratory animals. (See Appendix B.) The EPA maintains the Integrated Risk Information System (IRIS) data base, which contains verified RfDs and SFs and up-to-date health risk and EPA regulatory information for numerous chemicals.

For chemicals for which RfDs are not available, MCL and SMCL concentrations, expressed in milligrams per liter, are converted to RfD values by multiplying by 2 L (the average daily adult water intake) and dividing by 70 kg (the reference adult body weight). The result is a dose expressed in mg kg^{-1} day^{-1}. Table 6.9 lists the RfDs and SFs used in this analysis.

SFs are used to evaluate carcinogenic impacts. The SF converts the estimated daily intake averaged over a lifetime exposure to the incremental risk of an individual developing cancer. Because it is unknown whether a threshold (a dose below which no adverse effect occurs) exists for carcinogens, units for carcinogens are set in terms of risk. For potential carcinogens at the ORR, a risk of developing cancer during a human lifetime of 1 in 100,000 (10^{-5}) was used to establish acceptable levels of exposure. That is, the EPA estimates that a certain concentration of a chemical, if ingested, could cause a risk of one additional cancer case for every 100,000 exposed persons.

6.2.2 Methods of Evaluation

6.2.2.1 Airborne Chemicals

Research and facility operations result in the release of small quantities of chemicals to the atmosphere. These releases are allowed under air pollution control rules and do not pose a threat to human health or the environment. (See Sect. 4.1, Airborne Discharges.)

6.2.2.2 Waterborne Chemicals

Current risk assessment methodologies use the term "hazard quotient" (HQ) to evaluate noncarcinogenic health effects. Intakes, calculated in mg kg^{-1} day^{-1} in the HQ methodology, are expressed in terms of dose. For carcinogens, the estimated dose or intake (I) from ingestion of water or fish is divided by the chronic daily intake (CDI), which corresponds to a 10^{-5} lifetime risk of developing cancer. See Appendix B for a more detailed discussion.

Table 6.9. Chemical reference doses and slope factors used in drinking water and fish intake analysis

Chemical	Reference dose or slope factor[a]	Reference[b]
Acetone	1.0E–01	RfD
Aldrin	1.7E+01	SF
Aluminum	5.7E–03	SMCL
Antimony	4.0E–04	RfD
Aroclor-1016	7.0E–05	RfD
Aroclor-1221	1.25E–08	TN WQC
Aroclor-1232	1.25E–08	TN WQC
Aroclor-1242	1.25E–08	TN WQC
Aroclor-1248	1.25E–08	TN WQC
Aroclor-1254	2.0E–05	RfD
Aroclor-1260	1.25E–08	TN WQC
Arsenic	3.0E–04	RfD
Barium	7.0E–02	RfD
Beta-BHC	4.0E–06	TN WQC
Beryllium	2.0E–03	RfD
Boron	9.0E–02	RfD
2-Butanone	6.0E–01	RfD
Cadmium	5.0E–04	RfD
Carbon disulfide	1.0E–01	RfD
Chlordane (alpha, gamma)	5.0E–04	RfD
Chloride	7.1E+00	SMCL
Chromium (VI)	5.0E–03	RfD
Copper	3.7E–02	MCL
4,4′-DDD	2.4E–01	SF
4,4′-DDE	3.4E–01	SF
4,4′-DDT	5.0E–04	RfD
Dieldrin	1.6E+01	SF
Endosulfan I, II	6.0E–03	RfD
Endosulfan sulfate	3.1E–03	TN WQC
Endrin	3.0E–04	RfD
Endrin aldehyde	2.2E–05	TN WQC
Fluoride	6.0E–02	RfD
Heptachlor	5.0E–04	RfD
Heptachlor epoxide	1.3E–05	RfD
Iron	8.6E–03	SMCL
Lead	4.0E–04	MCL

Table 6.9 (continued)

Chemical	Reference dose or slope factor[a]	Reference[b]
Manganese	4.7E–02	RfD
Mercury	5.7E–05	MCL
Methoxychlor	5.0E–03	RfD
Nickel (soluble salts)	2.0E–02	RfD
Nitrate	1.6E+00	RfD
PCBs (mixed)	2.0E+00	SF
Selenium	5.0E–03	RfD
Silver	5.0E–03	RfD
Strontium	6.0E–01	RfD
Sulfate	1.4E+01	MCL
Thallium	8.0E–05	RfD
Toluene	2.0E–01	RfD
Toxaphene	1.1E+01	SF
Uranium (soluble salts)	3.0E–03	RfD
Vanadium	7.0E–03	RfD
Xylene	2.0E+00	RfD
Zinc	3.0E–01	RfD

[a]RfD = reference dose (mg kg^{-1} day^{-1}); SF: slope factor (risk per mg kg^{-1} day^{-1}).
[b]The maximum contaminant level (MCL), secondary maximum contaminant level (SMCL), and Tennessee Water Quality Criteria (TN WQC) are in units of mg/L. To convert the concentration to an RfD (mg kg^{-1} day^{-1}), the concentration was multiplied by the consumption rate (2 L/day) and divided by the mass of a reference man, 70 kg.

Drinking Water

HQ ratios for chemical concentrations found in surface water are summarized in Table 6.10. The tilde (~) indicates that estimated values and/or detection limits were used to estimate the average concentration of a chemical in water. This symbol is listed beside the estimated HQ ratio to indicate the type of data used.

To evaluate the drinking water pathway, HQs were estimated for upstream and downstream of the ORR discharge points. Upstream of all DOE discharge point is CRK 70. The Gallaher Water Station (CRK 23), a current drinking water supply intake location for the ETTP, is below the ORNL effluent discharge point, and CRK 16 is a location downstream of all DOE discharge points.

Measured aluminum, antimony, iron, lead, thallium, and vanadium surface water concentrations resulted in HQ values greater than 1 (HQs less than 1 are desirable). HQs greater than 1 for aluminum, iron, lead, and vanadium were observed in both upstream and downstream locations. The derivation of the reference dose for both aluminum and iron were the SMCLs. The SMCLs control contaminants in drinking water that primarily affect aesthetic qualities, such as taste and odor. Elevated aluminum and iron HQs were estimated both upstream and downstream of the ORR. Tildes associated with HQs shown in Table 6.10 indicate that estimated values and/or detection limits were used in the calculation of these surface water chemical concentrations.

Table 6.10. 1997 chemical hazard quotients for drinking water[a]

Chemical	Hazard quotient		
	CRK 70[b]	CRK 23[c]	CRK 16[d]
	Metals		
Aluminum	~1.3	~1.4	~2.1
Antimony		~3.2	
Barium	~3E–2	~3E–2	4E–2
Boron	6E–3	7E–3	7E–3
Chromium	~5E–2	~5E–2	~5E–2
Copper	~4E–3	~7E–3	
Iron	~1.2	~1	1.6
Lead	~3E+1	~3	
Manganese	~4E–2	3E–2	4E–2
Stronium	4E–3	4E–3	4E–3
Thallium	~2E+1		
Uranium	~4E–3	~4E–3	~4E–3
Vanadium	~1.3	~1.3	
Zinc	~3E–3	~2E–3	~2E–3
	Volatile organics		
Acetone	~2E–3	~2E–3	~2E–3
2-Butanone	~4E–4	~4E–4	~4E–4
Toluene	~6E–4		
Xylene	~6E–5		

[a]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation, and a blank space indicates the parameter was undetected.
[b]Melton Hill Reservoir above city of Oak Ridge input.
[c]Water supply intake for the ETTP.
[d]Clinch River downstream of all DOE inputs.

Fish Consumption

Chemicals in water can be accumulated by aquatic organisms that may be eaten by humans. Sunfish and catfish collected from the Clinch River were analyzed for a number of metals, pesticides, and PCBs. Table 6.11 is a summary of the HQs and I/CDI ratios derived from average concentrations of chemicals detected in fish samples taken both upstream and downstream from the ORR.

Antimony, arsenic, and lead concentrations in catfish tissue resulted in HQs greater than 1. HQs greater than 1 for these metals were found in catfish collected both upstream and downstream of the ORR. An HQ greater than 1 was found for mercury in sunfish collected at CRK 16, which is downstream from the ORR. HQs greater than 1 were estimated for benzene hexachloride (BHC) and Aroclors (-1221, -1232, -1242, -1248, -1254, and -1260) in sunfish samples collected at CRK 16. HQs greater than 1 for Aroclor-1260 were also

Table 6.11. 1997 chemical hazard quotients (HQs) for metals and estimated dose/chronic daily intake (I/CDIs) for carcinogens in fish[a]

Parameters	Sunfish			Catfish		
	CRK 70[b]	CRK 32[c]	CRK 16[d]	CRK 70[b]	CRK 32[c]	CRK 16[d]
HQs for metals						
Antimony				<3E+0	<3E+0	<3E+0
Arsenic				<4E+0	<4E+0	<4E+0
Beryllium				<4E–3	<4E–3	<4E–3
Cadium				<1E–1	<2E–1	<1E–1
Chromium	~4E–2		~7E–2	<5E–2	<5E–2	<5E–2
Copper	7E–3	8E–3	5E–3			
Lead				<3E+0	<3E+0	<3E+0
Mercury	~6E–1	6E–1	2E+0			
Nickel			~8E–3	<1E–2	<1E–2	<1E–2
Selenium		~2E–1		<2E–1	<3E–1	<2E–1
Silver				<3E–2	<3E–2	<3E–2
Zinc	4E–2	4E–2	5E–2			
HQs for pesticides and Aroclors						
Chlordane			1E–1			
Benzine hexachloride (alpha, beta)			~1E+0			
Gamma BHC			~6E–1			
4,4′-DDT			~2E–2			
Endosulfan I			~7E–4			
Endosulfan II			~1E–3			
Endosulfan sulfate			~3E–3			
Endrin			~3E–2			
Endrin aldehyde			~4E–1			
Heptachlor			~8E–3			
Heptachlor epoxide			~3E–1			
Methoxychlor			~8E–3			
Aroclor-1016			~7E–1			
Aroclor-1221			~4E+3			
Aroclor-1232			~4E+3			
Aroclor-1242			~4E+3			
Aroclor-1248			~4E+3			
Aroclor-1254			~3E+0			
Aroclor-1260	~2E+3	~1E+3	~2E+3			
I/CDIs for carcinogens						
Aldrin			~7E+0			
4,4′-DDD			~2E–1			
4,4′-DDE			~3E–1			
Dieldrin			~1E+1			
Toxaphene			~7E+0			

[a]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation, and a blank space indicates the parameter was undetected.

[b]Melton Hill Reservoir, above Oak Ridge city input.

[c]Clinch River, downstream of ORNL.

[d]Clinch River, downstream of all DOE inputs.

determined in sunfish collected upstream of the ORR. None of these chemicals were detected in catfish samples. However, more sunfish samples were collected than catfish samples. In many cases, the hazard quotients, especially for pesticides and Aroclors, were estimated using concentrations estimated at or below the analytical detection limit. Because of analytical detection limitations, the actual fish tissue concentrations are unknown.

For carcinogens, I/CDI ratios greater than 1 indicate a risk greater than 10^{-5}. In sunfish collected downstream of ORR, I/CDIs greater than 1 were estimated for aldrin, dieldrin, and toxaphene (Table 6.11). Because of analytical detection limitations, the actual fish tissue concentrations are unknown.

7. Groundwater

S. B. Jones and R. S. Loffman

Abstract

Most residents in the Oak Ridge area do not rely on groundwater for potable supplies, although suitable water is available. Local groundwater provides some domestic, municipal, farm, irrigation, and industrial uses, however, and must be viewed as both a potential pathway for exposure to hazardous wastes and as a means for contaminant transport. Statutes codified into regulations by EPA specifically target the protection of groundwater from contamination by hazardous wastes. The regulations guide groundwater monitoring at the DOE plants in Oak Ridge. Monitoring programs established on the ORR assess groundwater contamination and transport on and off the reservation and are intended to comply with established regulatory requirements.

7.1 INTRODUCTION

The groundwater monitoring programs at the ORR are designed to gather information to determine the effects of DOE operations on groundwater quality in compliance with all applicable requirements.

The location and movement of groundwater must be determined to identify the extent of contamination in groundwater and to predict the possible fate of contaminants. To make this determination, an understanding is required of how groundwater moves in general and how that movement will be influenced by the geological setting.

7.1.1 Geological Setting

The ORR is located in the Tennessee portion of the Valley and Ridge Province, which is part of the southern Appalachian fold and thrust belt. As a result of thrust faulting and varying erosion rates, a series of parallel valleys and ridges have formed that trend southwest-northeast.

Two geologic units on the ORR, designated as the Knox Group and the Maynardville Limestone of the Conasauga Group, both consisting of dolostone and limestone, constitute the Knox Aquifer. A combination of fractures and solution conduits in this aquifer control flow over substantial areas, and relatively large quantities of water may move relatively long distances. Active groundwater flow can occur at substantial depths in the Knox Aquifer [300 to 400 ft (91.5 to 122 m) deep]. The Knox Aquifer is the primary source of groundwater to many streams (base-flow), and most large springs on the ORR receive discharge from the Knox Aquifer. Yields of some wells penetrating larger solution conduits are reported to exceed 1000 gal/min (3784 L/min).

The remaining geologic units on the ORR (the Rome Formation, the Conasauga Group below the Maynardville Limestone, and the Chickamauga Group) constitute the ORR Aquitards, which consist mainly of siltstone, shale, sandstone, and thinly bedded limestone of low to very low permeability. Nearly all groundwater flow in the aquitards occurs through fractures. The typical yield of a well in the aquitards is less than 1 gal/min (3.8 L/min), and the base flows of streams draining areas underlain by the aquitards are poorly sustained because of such low flow rates.

7.1.2 Hydrogeological Setting

7.1.2.1 Groundwater Hydrology

When rain falls, a portion of the rainwater accumulates as groundwater by soaking into the ground, infiltrating soil and rock. The accumulation of groundwater in pore spaces of sediments and bedrock creates sources of usable water, which flows in response to external forces. Groundwater eventually reappears at the surface

in springs, swamps, stream and river beds, or pumped wells. Thus, groundwater is a reservoir for which the primary input is recharge from infiltrating rainwater and whose output is discharge to springs, swamps, rivers, streams, and wells.

Water infiltrates by percolating downward through the pore spaces between sediment grains and also through fractures in bedrock. The smaller the pore spaces or fractures, the slower the flow of water through the subsurface. The physical property that describes the ease with which water may move through the pore spaces and fractures in a given material is called permeability, and it is largely determined by the volume and size of these features and how well they are connected.

As water infiltrates the earth, it travels down through the unsaturated zone, where the pore spaces and fractures are partly filled with water and partly filled with air. Water moving down through the unsaturated zone will eventually reach the saturated zone, where the pore spaces and fractures are completely filled with water. The boundary between the unsaturated and the saturated zones is known as the water table, which generally follows, in subtle form, the contour of the surface topography. Springs, swamps, and beds of streams and rivers are the outcrops of the water table, where groundwater is discharged to the surface.

Because the earth's permeability varies greatly, groundwater flowing through subsurface strata does not travel at a constant rate or without impediment. Strata that transmit water easily (such as those composed primarily of sand) are called aquifers, and strata that restrict water movement (such as clay layers) are called aquitards. An aquifer with an aquitard lying above and beneath it is termed a confined aquifer. Groundwater moves through aquifers toward natural exits, or discharge points, to reappear at the surface.

The direction of groundwater flow through an aquifer system is determined by the permeability of the strata containing the aquifer and by the hydraulic gradient, which is a measure of the difference in hydraulic head over a specified distance. The driving force for groundwater movement through the saturated zone comprises differences in hydraulic head. The hydraulic head at any given point in an aquifer is a function of the energy associated with the water's elevation above sea level and the pressures exerted on it by surrounding water. Because hydraulic head is not solely a function of elevation, downgradient is not necessarily synonymous with downhill. The downgradient direction will have a horizontal and vertical component, just as a household drain moves wastewater both horizontally and vertically, seeking the lowest point of exit. Aquitards deflect groundwater movement just as drain pipe walls control the direction of wastewater movement. In an aquifer constrained by aquitards such as horizontal clay layers, the downgradient direction tends to be more horizontal than vertical.

Groundwater on the ORR occurs both in the unsaturated zone as transient, shallow subsurface stormflow and within the saturated zone. An unsaturated zone of variable thickness separates the stormflow zone and water table. Adjacent to surface water features or in valley floors, the water table is found at shallow depths and the unsaturated zone is thin. Along the ridge tops or near other high topographic areas, the unsaturated zone is thick, and the water table often lies at considerable depth [50 to 175 ft (15 to 50 m) deep]. In low-lying areas where the water table occurs near the surface, the stormflow zone and saturated zone are indistinguishable.

Several distinct flow intervals occur within the aquifer: the uppermost water table interval, the intermediate interval, the deep interval, and the aquiclude. The divisions within the saturated zone grade into one another vertically and are not separated by distinct boundaries but reflect an overall decrease in the rate of groundwater flow with depth. Within the ORR aquitards, the greatest groundwater flow rates occur in the stormflow zone and the smallest within the deep zone. Water does not flow in the aquiclude, which is defined by a transition to saline water (Fig. 7.1). In the Knox Aquifer, the greatest groundwater flow is in the water table and intermediate intervals [depths to approximately 300 ft (91.5 m)].

As noted earlier, two broad hydrologic units are identified on the ORR: the Knox Aquifer and

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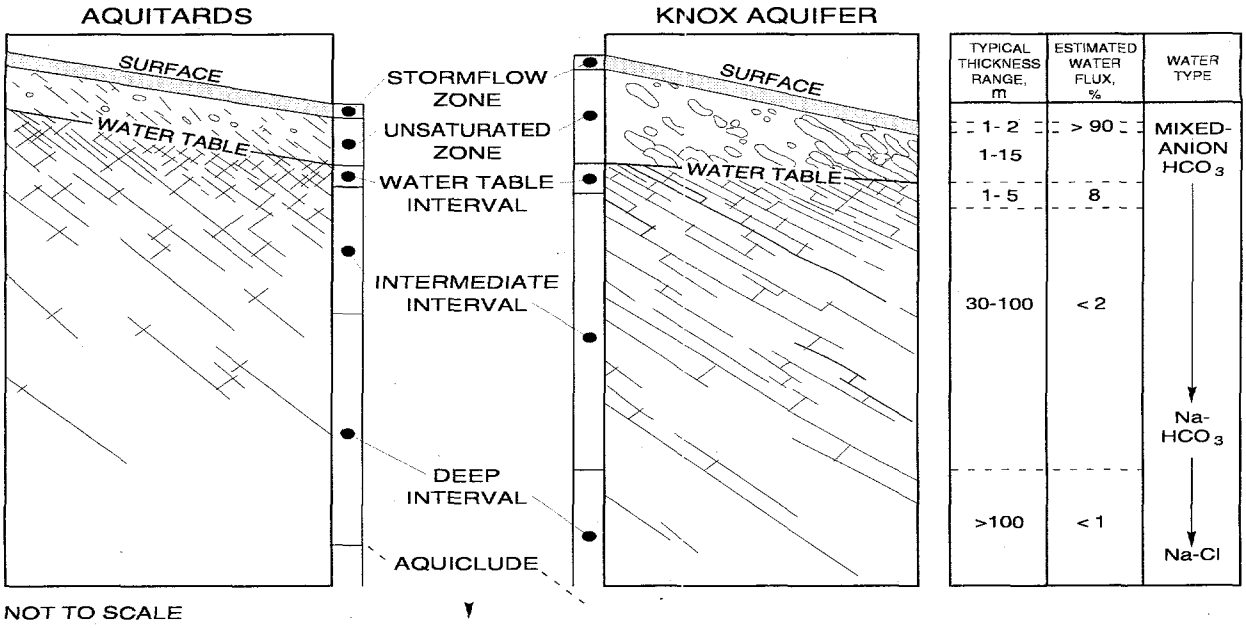

Fig. 7.1. Vertical relationships of flow zones of the ORR: estimated thicknesses, water flux, and water types.

the ORR Aquitards, which consist of less permeable geologic units. Figure 7.2 is a generalized map showing surface distribution of the Knox Aquifer and the ORR Aquitards. Many waste areas on the ORR are located in areas underlain by the ORR Aquitards.

7.1.2.2 Unsaturated Zone Hydrology

In undisturbed, naturally vegetated areas on the ORR, about 90% of the infiltrating precipitation does not reach the water table but travels through the 1- to 2-m-deep stormflow zone, which approximately corresponds to the root zone. Because of the permeability contrast between the stormflow zone and the underlying unsaturated zone, the stormflow zone partially or completely saturates during rainfall events, and then water flows laterally, following very short flow paths to adjacent streams. When the stormflow zone becomes completely saturated, flow of water over the land occurs. Between rainfall events, as the stormflow zone drains, flow rates decrease dramatically and water movement becomes nearly vertical toward the underlying water table.

The rate at which groundwater is transmitted through the stormflow zone is attributed to large pores (root channels, worm bores, and relict fractures). Stormflow is primarily a transport mechanism in undisturbed or vegetated areas, where it intersects shallow waste sources. Most buried wastes are below the stormflow zone; however, in some trenches a commonly observed condition known as "bathtubbing" can occur, in which the excavation fills with water and may overflow into the stormflow zone. All stormflow ultimately discharges to streams on the ORR.

7.1.2.3 Saturated Zone Hydrology

As shown in Fig. 7.1, the saturated zone on the ORR can be divided into four vertically distinct flow zones: an uppermost water table interval, an intermediate zone, a deep zone, and an aquiclude. Available evidence indicates that most water in the saturated zone in the aquitards is transmitted through a 3- to 20-ft (1- to 6-m) thick layer of closely spaced, well-connected fractures near the water table (the water table interval) as shown in Fig. 7.3.

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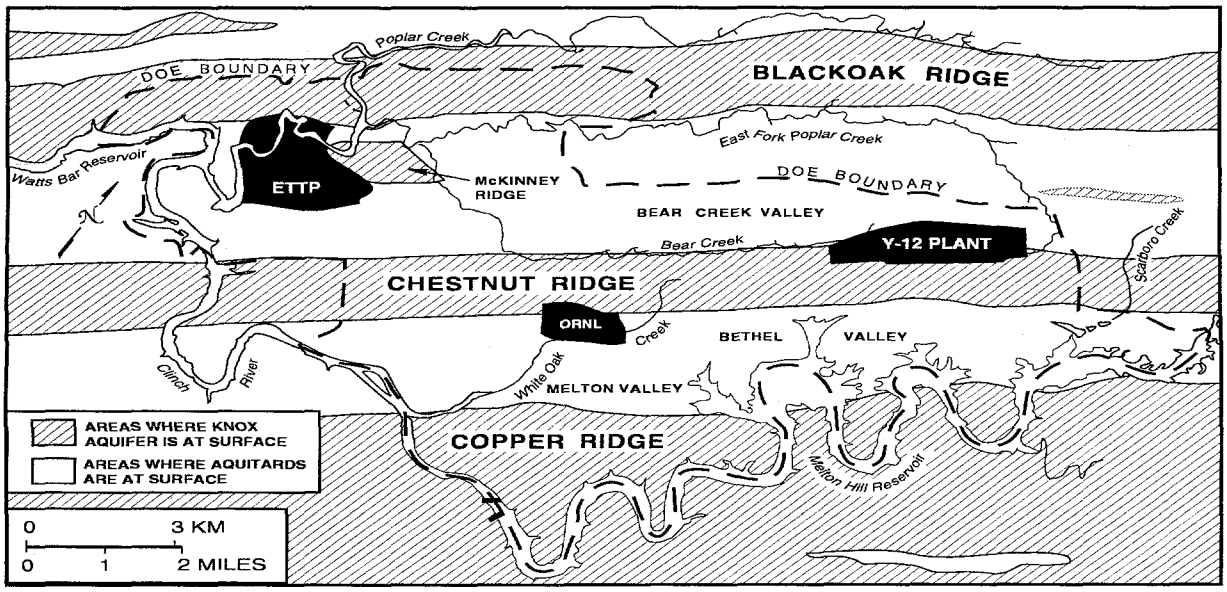

Fig. 7.2. The Knox Aquifer and the aquitards on the Oak Ridge Reservation.

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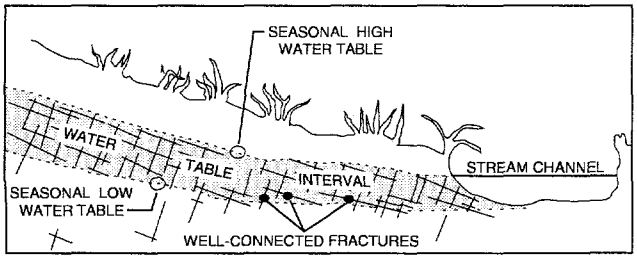

Fig. 7.3. Water table interval.

As in the stormflow zone, the bulk of groundwater in the saturated zone resides within the pore spaces of the rock matrix. The rock matrix typically forms blocks that are bounded by fractures. Contaminants migrating from sources by way of the fractures typically occur in higher concentrations than in the matrix; thus, the contaminants tend to move (diffuse) into the matrix. This process, termed diffusive exchange, between water in matrix pores and water in adjacent fractures reduces the overall contaminant migration rates relative to groundwater flow velocities. For example, the leading edge of a geochemically nonreactive contaminant mass such as tritium may migrate along fractures at a typical rate of 3 ft/day (1 m/day); however, the center of mass of a contaminant plume typically migrates at a rate less than 0.2 ft/day (0.66 m/day).

In the aquitards, chemical characteristics of groundwater change from a mixed-cation-HCO_3 water type at shallow depth to a Na-HCO_3 water type at deeper levels (about 100 ft). This transition, not marked by a distinct change in rock properties, serves as a useful marker and can be used to distinguish the more active water table and intermediate groundwater intervals from the sluggish flow of the deep interval. There is no evidence of similar change with depth in the chemical characteristics of water in the Knox Aquifer; virtually all wells are within the monitoring regime of Ca-Mg-HCO_3 type water. Although the mechanism responsible for this change in water types is not quantified, it most likely is related to the amount of time the water is in contact with a specific type of rock.

Most groundwater flow in the saturated zone occurs within the water table interval. Most flow is through weathered, permeable fractures and matrix rock and within solution conduits in the Knox Aquifer. The range of seasonal fluctuations

of water table depth and rates of groundwater flow varies significantly across the reservation. In areas underlain by the Knox Aquifer, seasonal fluctuations in water levels average 17 ft (5.3 m) and mean discharge from the active groundwater zone is typically 85 gal/min (322 L/min) per square mile. In the aquitards of Bear Creek Valley (BCV), Melton Valley, East Fork Valley, and Bethel Valley, seasonal fluctuations in water levels average 5 ft (1.5 m) and typical mean discharge is 26 gal/min (98 L/min) per square mile.

In the intermediate interval, groundwater flow paths are a product of fracture density and orientation. In this interval, groundwater movement occurs primarily in permeable fractures that are poorly connected. In the Knox Aquifer, a few cavity systems and fractures control groundwater movement in this zone, but in the aquitards, the bulk of flow is through fractures along which permeability may be increased by weathering.

The deep interval of the saturated zone is delineated by a change to a Na-Cl water type. Hydrologically active fractures in the deep interval are significantly fewer in number and shorter in length than in the other intervals, and the spacing is greater. Wells finished in the deep interval of the ORR aquitards typically yield less than 0.3 gal/min (1.1 L/min) and thus are barely adequate for water supply.

In the aquitards, saline water characterized by total dissolved solids ranging up to 2.75×10^5 mg/L and chlorides generally in excess of 5×10^4 mg/L (ranging up to 1.63×10^5 mg/L) lies beneath the deep interval of the groundwater zone, delineating an aquiclude. Chemically, this water resembles brines typical of major sedimentary basins, but its origin is not known. The chemistry suggests extremely long residence times (i.e., very low flow rates) and little or no mixing with shallow groundwater.

The aquiclude has been encountered at depths of 400 and 800 ft (125 and 244 m) in Melton and Bethel valleys, respectively (near ORNL), and it is believed to approach 1000 ft (305 m) in portions of BCV (near the Y-12 Plant) underlain by aquitard formations. Depth to the aquiclude in areas of the Knox Aquifer is not known but is believed to be greater than 1200 ft (366 m); depth to the aquiclude has not been established in the vicinity of the ETTP.

7.1.3 Groundwater Flow

Many factors influence groundwater flow on the ORR. Topography, surface cover, geologic structure, and rock type exhibit especially strong influence on the hydrogeology. Variations in these features result in variations of the total amount of groundwater moving through the system (flux). (Average flux ratios for the aquitards and the Knox Aquifer formations are shown in Fig. 7.1.) As an example, the overall decrease in open fracture density with depth results in a decreased groundwater flux with depth.

Topographic relief on the ORR is such that most active subsurface groundwater flow occurs at shallow depths. U.S. Geological Survey modeling (Tucci 1992) suggests that 95% of all groundwater flow occurs in the upper 50 to 100 ft (15 to 30 m) of the saturated zone in the aquitards. As a result, flow paths in the active-flow zones (particularly in the aquitards) are relatively short, and nearly all groundwater discharges to local surface water drainages on the ORR. Conversely, in the Knox Aquifer, it is believed that solution conduit flow paths may be considerably longer, perhaps as much as 2 miles (3.2 km) long in the along-strike direction. No evidence at this time substantiates the existence of any deep, regional flow off the ORR or between basins within the ORR in either the Knox Aquifer or the aquitards. Data collected in CY 1994 and 1995, however, have demonstrated that groundwater flow and contaminant transport occur off the ORR in the intermediate interval of the Knox Aquifer, near the east end of the Y-12 Plant.

Migration rates of contaminants transported in groundwater are strongly influenced by natural chemical and physical processes in the subsurface (including diffusion and adsorption). Peak concentrations of solutes, including contaminants such as tritium moving from a waste area, for instance, can be delayed for several to many decades in the aquitards, even along flow paths as short as a few hundred feet. The processes that

naturally retard contaminant migration and store contaminants in the subsurface are less effective in the Knox Aquifer than in the aquitards because of rapid flow along solution features allowing minimal time for diffusion to occur.

7.1.4 Groundwater Monitoring Considerations

Because of the complexity of the hydrogeologic framework on the ORR, groundwater flow and, therefore, contaminant transport are difficult to predict on a local scale. Consequently, individual plume delineation is not always feasible on the ORR. Stormflow and most groundwater discharge to the surface water drainages on the ORR. For that reason, monitoring springs, seeps, and surface water quality is one of the best ways to assess the extent to which groundwater from a large portion of the ORR transports contaminants; however, contaminant transport may occur at depth as well. The center of mass of the volatile organic compound (VOC) plume in the Maynardville Limestone east of the Y-12 Plant lies at a depth of 300 ft (91.5 m). Transport of the highest VOC concentrations occurs in this interval because many VOCs are more dense than water, and there is little dilution.

7.1.5 Groundwater Monitoring Programs on the ORR

The groundwater surveillance monitoring programs implemented at the DOE facilities have been designed to obtain full compliance with regulatory requirements and to meet technical objectives. Site-specific regulatory monitoring programs are supported technically by site characterization and regional studies of the geohydrologic and chemical aspects of the flow system. Monitoring at the Y-12 Plant and ORNL is coordinated through site-level groundwater programs. The site-level programs provide oversight for surveillance and effluent monitoring and coordination of monitoring required under CERCLA drivers. The IWQP has been established at the DOE level to track and prioritize CERCLA monitoring across all of the ORR facilities.

7.2 GROUNDWATER MONITORING AT THE Y-12 PLANT

7.2.1 Background and Regulatory Setting

Most of the groundwater monitoring at the Y-12 Plant is conducted within the scope of a single, comprehensive groundwater monitoring program, which included the following elements in 1997:

- monitoring to comply with requirements of RCRA postclosure regulations,
- monitoring to support CERCLA remedial investigation/feasibility study (RI/FS) efforts and RODs,
- compliance with TDEC solid waste management (SWM) regulations, and
- monitoring to support DOE Order 5400.1 requirements (exit pathway and surveillance monitoring).

Through incorporation of these multiple considerations, the comprehensive monitoring program at the Y-12 Plant addresses multiple regulatory considerations and technical objectives. It eliminates redundancy between different regulatory programs and ensures consistent data collection and evaluation.

More than 200 sites have been identified at the Y-12 Plant that represent known or potential sources of contamination to the environment as a result of past waste management practices. These sites are being addressed either by the ER Program under exclusively CERCLA programs or a combination of CERCLA and RCRA regulations. The ER Program and Y-12 Plant management share responsibilities for sites regulated under dual CERCLA and RCRA drivers.

In 1992, a number of the inactive waste management sites were grouped into operable units (OUs) under CERCLA as part of an FFA

negotiated between EPA, TDEC, and DOE. Two types of OUs were identified: (1) source OUs consisting of sites or groups of sites that were known sources of contamination to the environment and (2) integrator OUs consisting of media, such as groundwater, soils, and/or surface water, that had been impacted by the source OUs. An agreement was reached among regulatory agencies and DOE in 1994 to proceed with an integrated RI/FS strategy. In the integrated strategy, former source OUs and integrator OUs are addressed concurrently in a characterization area (CA) defined by physical limits, such as watershed boundaries and/or groundwater flow regimes (Fig. 7.4). Specific sites or locations of high risk or concern within the CA are targeted for focused, rapid remedial actions, while a general remedial strategy and/or administrative controls for other sites in the CA progress. Individual focused action sites are designated as OUs and documented under separate RODs.

Two CAs incorporating 27 known source units have been established for the Y-12 Plant, the UEFPC CA and the BCV CA.

In addition, four individual source OUs remain on Chestnut Ridge, where available data indicate that contamination from each unit is distinct and separable. The remaining sites have been grouped into Y-12 Plant study areas that constitute lower-priority units that will be investigated under CERCLA as preliminary assessment/site investigations (PA/SIs). New OUs or additions to existing CAs will be made if the degree of contamination determined by the PA/SI warrants further study under an RI/FS.

Postclosure maintenance, monitoring, and reporting requirements of RCRA also apply to seven inactive CERCLA-regulated units that meet the definition of RCRA hazardous waste TSD facilities. These units include the S-3 Site, portions of the Bear Creek Burial Grounds, the Oil Landfarm, New Hope Pond, the Chestnut Ridge Security Pits, the Chestnut Ridge Sediment Disposal Basin, and Kerr Hollow Quarry. Postclosure requirements are now outlined in RCRA postclosure permits issued by TDEC. These requirements are integrated with CERCLA programs. Corrective actions addressing contaminant

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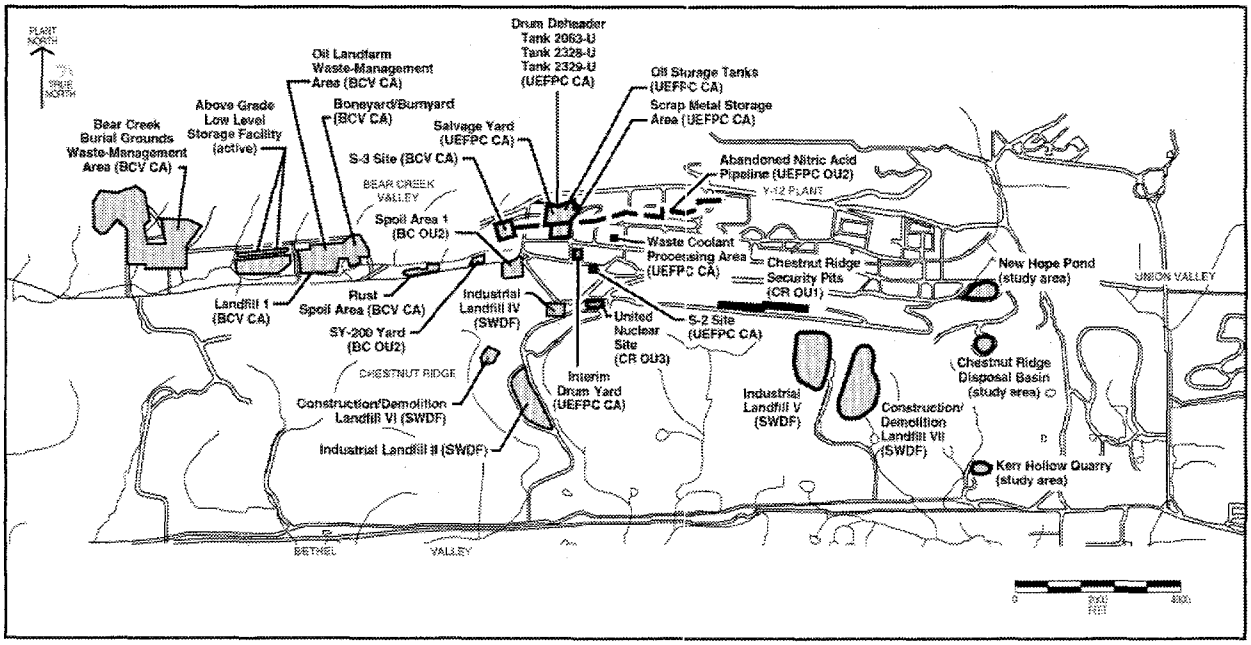

Fig. 7.4. Y-12 Plant inactive regulated units, study areas, and active facilities for which groundwater monitoring was conducted in CY 1997.

releases will be deferred to the CERCLA RI/FS process. While corrective actions are progressing, the permits require focused monitoring of selected exit pathways and compliance boundaries.

An additional primary regulatory driver for groundwater monitoring at the Y-12 Plant is the TDEC regulations governing nonhazardous solid waste disposal facilities (SWDFs). Two facilities (Centralized Sanitary Landfill II and Industrial Landfill IV) have been subject to groundwater monitoring under the SWDF regulations since the late 1980s. Construction of three additional landfill facilities was completed between 1993 and 1994 (Industrial Landfill V, Construction/ Demolition Landfill VI, and Construction/Demolition Landfill VII). All of the landfill sites are now under a semiannual detection monitoring program.

Specific regulatory requirements do not address all groundwater monitoring concerns at the Y-12 Plant. Selected areas, from which contamination is most likely to migrate to potential exposure points off the ORR, are monitored as part of DOE Order 5400.1 requirements for exit pathway monitoring. Also, monitoring is performed as part of DOE 5400.1 surveillance monitoring in areas not specifically regulated and not representing specific exit pathways off the reservation, such as a large part of the industrialized portion of the Y-12 Plant. Surveillance monitoring is conducted to monitor contaminant plume boundaries and to trend contaminant concentrations specifically to augment regulatory and exit pathway monitoring programs.

7.2.2 Hydrogeologic Setting and Summary of Groundwater Quality

In the comprehensive monitoring program, the Y-12 Plant is divided into three hydrogeologic regimes delineated by surface water drainage patterns, topography, and groundwater flow characteristics. The regimes are further defined by the waste sites they contain. These regimes include the Bear Creek Hydrogeologic Regime (Bear Creek regime), the Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork regime), and the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge regime) (Fig. 7.5). Most of the Bear Creek and East Fork regimes are underlain by the ORR aquitards. The extreme southern portion of these two regimes is underlain by the Maynardville Limestone, which is part of the Knox Aquifer. The entire Chestnut Ridge regime is underlain by the Knox Aquifer.

In general, groundwater flow in the water table interval follows topography. Shallow groundwater flow in the Bear Creek and East Fork regimes is divergent from a topographic and groundwater table divide located near the western end of the Y-12 Plant. The flow directions of shallow groundwater east and west of the divide are predominantly easterly and westerly, respectively. This divide defines the boundary between the Bear Creek and Upper East Fork Poplar Creek

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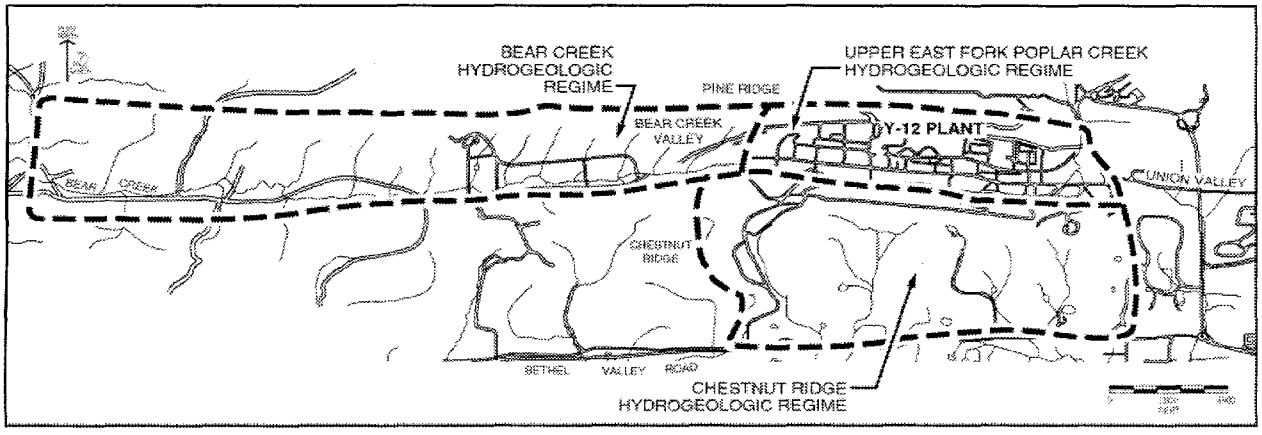

Fig. 7.5. Hydrogeologic regimes at the Y-12 Plant.

regimes. In addition, flow converges toward the primary surface streams from Pine Ridge to the north and Chestnut Ridge to the south of the Y-12 Plant. In the Chestnut Ridge regime, a groundwater table divide exists that approximately coincides with the crest of the ridge. Shallow groundwater flow, therefore, tends to be toward either flank of the ridge, with discharge primarily to surface streams and springs located in Bethel Valley to the south and BCV to the north.

In BCV, groundwater in the intermediate and deep intervals moves predominantly through fractures in the ORR aquitards, converging toward and moving through fractures and solution conduits in the Maynardville Limestone. Karst development in the Maynardville Limestone has a significant impact on groundwater flow paths in the water table and intermediate intervals. In general, groundwater flow parallels geologic strike. Groundwater flow rates in BCV vary widely; they are very slow within the deep interval of the ORR aquitards but can be quite rapid within solution conduits in the Maynardville Limestone.

The rate of groundwater flow perpendicular to geologic strike from the ORR aquitards to the Maynardville Limestone has been estimated to be very slow below the water table interval. Most contaminant migration appears to be via surface tributaries to Bear Creek or along utility traces and buried tributaries in the East Fork regime. Recent data obtained as part of hydrologic studies in the Bear Creek regime suggest that strike-parallel transport of some contaminants can occur within the ORR aquitards for significant distances. Continuous elevated levels of nitrate within the ORR aquitards are now known to extend west from the S-3 Site for a distance of about 3000 ft, approximately twice the previous estimates. VOCs at source units in the ORR aquitards, however, tend to remain close to source areas because they tend to adsorb to the bedrock matrix, diffuse into pore spaces within the matrix, and degrade prior to migrating to exit pathways, where rapid transport for long distances can occur.

Groundwater flow in the Chestnut Ridge regime is almost exclusively through fractures and solution conduits in the Knox Group. Discharge points for intermediate and deep flow are not well known. Groundwater is currently presumed to flow primarily toward BCV to the north and Bethel Valley to the south. Groundwater from intermediate and deep zones may discharge at certain spring locations along the flanks of Chestnut Ridge. Along the crest of the ridge, water table elevations decrease from west to east, demonstrating an overall easterly trend in groundwater flow.

Historical monitoring efforts have shown that groundwater quality at the Y-12 Plant has been affected by four types of contaminants: nitrate, VOCs, metals, and radionuclides. Of these, nitrate and VOCs are the most widespread, although data obtained since 1988 show that the extent of some radionuclides, particularly ^{99}Tc is also significant, particularly in the Bear Creek regime. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low-pH groundwater at the west end of the Y-12 Plant, in the vicinity of the S-3 Site. Historical data have shown that plumes from multiple source units have mixed with one another and that contaminants (other than nitrate and possibly ^{99}Tc) are no longer easily associated with a single source.

7.2.3 1997 Well Installation and Plugging and Abandonment Activities

A number of monitoring devices are routinely used for groundwater data collection at the Y-12 Plant. Monitoring wells are permanent devices used for collection of groundwater samples; these are installed according to established regulatory and industry specifications. Piezometers are primarily temporary devices used to measure groundwater table levels and are often constructed of PVC or other low-cost materials. Other devices or techniques are sometimes employed to gather data, including well points and push probes.

No new monitoring wells were installed in CY 1997 for compliance monitoring. However, a total of 52 characterization wells and piezometers were installed in the vicinity of the S-3 Site and

the east end of the plant near Upper East Fork Poplar Creek. Twelve wells at the S-3 Site were installed to assess the performance of a CERCLA treatability study, and 16 of the wells along Upper East Fork Poplar Creek were installed to meet data needs for the CERCLA UEFPC remedial investigation (RI) preparation. The other 24 piezometers were installed along UEFPC in support of the Reduction of Mercury in Plant Effluent (RMPE) Program to evaluate mercury transport in the shallow groundwater system.

Under the Y-12 Plant GWPP, well plugging and abandonment activities are conducted as part of an overall program to maintain the Y-12 Plant monitoring well network. Wells that are damaged beyond rehabilitation, that interfere with planned construction activities, or from which no useful data can be obtained, are selected for plugging and abandonment. In 1997, no wells were plugged and abandoned.

7.2.4 1997 Monitoring Program

Groundwater monitoring in 1997 addressed multiple requirements from regulatory drivers and DOE orders. Table 7.1 contains a summary of monitoring activities conducted by the Y-12 Plant GWPP, as well as the programmatic requirements that apply to each monitored site.

Figure 7.6 shows the locations of ORR perimeter groundwater monitoring stations as specified in the EMP.

Detailed data reporting for monitoring activities conducted by the Y-12 Plant GWPP is contained within the annual groundwater monitoring reports for each hydrogeologic regime (LMES 1998b, 1998c, and 1998d). Details of small-scale monitoring efforts performed outside the scope of the comprehensive monitoring program specifically for CERCLA OUs are published in RI reports. Other groundwater monitoring in support of CERCLA activities is performed by the IWQP (DOE 1998b). Information about IWQP monitoring is reported in annual Remediation Effectiveness Reports.

7.2.5 Y-12 Plant Groundwater Quality

7.2.5.1 Upper East Fork Poplar Creek Hydrogeologic Regime

The 1997 monitoring locations and waste management sites in the East Fork regime that are addressed in this document are shown in Fig. 7.7. Regulatory status of waste management sites in the East Fork Regime is summarized in Fig. 7.4. Brief descriptions of the waste management sites are presented in Table 7.2. Detailed operational histories of these sites have been published in previous ORR ASERs.

The East Fork Regime contains the UEFPC CA, which consists of source units, surface water, and groundwater components of the hydrogeologic system within the East Fork regime and Union Valley to the east of the Y-12 Plant. Numerous sources of contamination to both surface water and groundwater exist within the plant area. Chemical constituents from the S-3 Site dominate groundwater contamination in the western portion of the UEFPC CA. In addition to potential surface water and groundwater contamination sources identified as OUs, a majority of the Y-12 Plant study areas are within the East Fork regime. Potential surface-water contamination associated with the storm sewer system and East Fork mercury use areas is of primary interest and will also be addressed in the UEFPC CA RI/FS.

Discussion of Monitoring Results

The objectives of the 1997 groundwater monitoring program in the East Fork regime were to (1) further define contaminant nature and extent; (2) evaluate potential contaminant exit pathways for CERCLA RI, RCRA postclosure, and DOE Order technical objectives; and (3) trend contaminant levels over time. Locations of monitoring stations are shown in Fig. 7.7.

Table 7.1. Summary of the comprehensive groundwater monitoring program at the Y-12 Plant, 1997[a]

Hydrogeologic regime/waste disposal site	Requirements[b]	Number of wells/locations
Bear Creek Hydrogeologic Regime		
Bear Creek Springs	EXP	3
Bear Creek surface water	EXP	7
Maynardville Limestone	EXP/RCRA-CM	19
Oil Landfarm	RCRA-CM/SMP	7
Rust Spoil Area	SMP	1
S-3 Site	RCRA-CM	4
Spoil Area I	SMP	1
Y-12 Burial Grounds	RCRA-CM/SMP	13
East Fork Poplar Creek Hydrogeologic Regime		
Maynardville Limestone	EXP/RCRA-CM	15
Scarboro Road north of the Y-12 Plant	EXP	3
S-3 Site Eastern Plume	RCRA-CM	1
Y-12 Plant	SMP/BMP/RIFS	24
–Active facilities		
–S-2 Site		
–Fire Training Facility		
–Beta-4 Security Pits		
–Grid network		
New Hope Pond	RCRA-CM/SMP	5
UEFPC diversion channel	RIFS	1
Chestnut Ridge Hydrogeologic Regime		
Springs	EXP	2
Surface water	ROD	1
Chestnut Ridge Security Pits	RCRA-CM	3
Kerr Hollow Quarry	RCRA-DM	5
Landfill II	SWDF	3
Landfill IV	SWDF	5
Landfill V	SWDF	5
Landfill VI	SWDF	5
Landfill VII	SWDF	4
Sediment Disposal Basin	RCRA-DM	4
United Nuclear Site	ROD	6

[a]Baseline analytical parameters include ICP metals scan: U (total), thallium, Pb, and As by plasma mass spectroscopy; Hg; VOCs; major anions; gross alpha; gross beta; pH; conductance; TSS; TDS; turbidity; and standard field parameters, including dissolved oxygen, water level, pH, temperature, conductance, and redox potential. RCRA corrective action monitoring in the Bear Creek regime includes ^{241}Am, ^{129}I, ^{237}Np, ^{238}Pu, total radium, total strontium, ^{99}Tc, ^{3}H, ^{234}U, ^{235}U, and ^{238}U. SWDF monitoring required by TDEC Rule 1200-1-7-.04 includes chemical oxygen demand, cyanide, total organic carbon (TOC), total organic halides (TOX), ammonia (as N), gamma activity, and additional VOC list required by TDEC Rule 1200-1-7-.04. Analyte lists for some sites were tailored to meet specific programmatic, technical, or regulatory requirements.

[b]BMP = best management practices monitoring; EXP = exit-pathway or perimeter monitoring under DOE Order 5400.1; RCRA-DM = RCRA Detection Monitoring; RCRA-CM = RCRA postclosure corrective action monitoring; SMP = DOE Order 5400.1 surveillance monitoring; SWDF = monitoring for solid waste disposal facilities under TDEC Rule 1200-1-7.04; ROD = CERCLA record of decision postclosure monitoring; RIFS = CERCLA remedial investigation monitoring.

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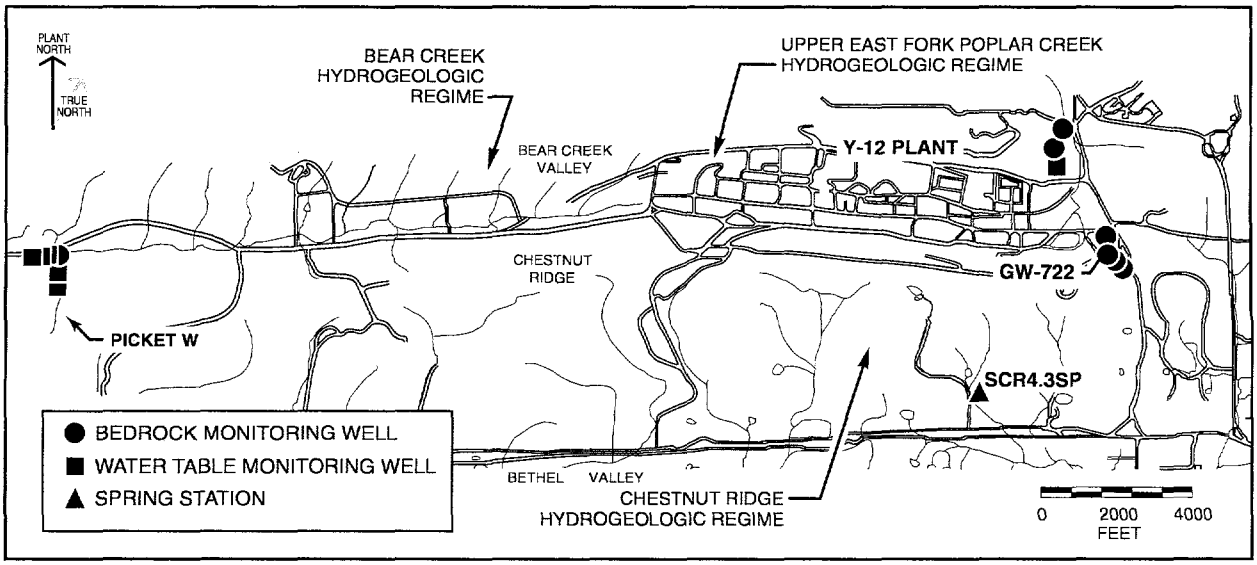

Fig. 7.6. Locations of ORR perimeter surveillance wells and multiport monitoring wells specified in the *Environmental Monitoring Plan (Rev. 1)*. Well GW-722 is a multiport monitoring well that is also designated as a perimeter surveillance well.

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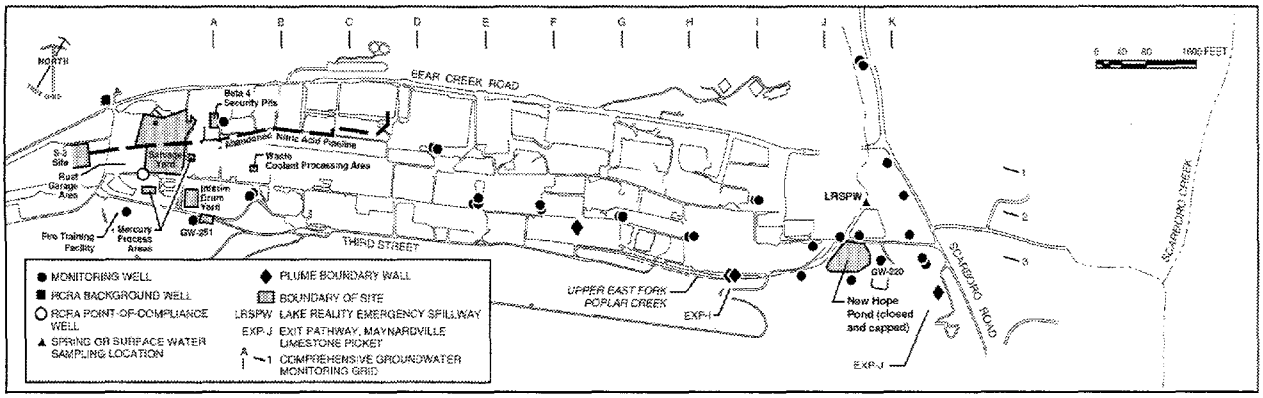

Fig. 7.7. Locations of waste management sites and monitoring wells sampled during 1997 in the Upper East Fork Poplar Creek Hydrogeologic Regime.

Plume Delineation

As denoted in previous ORR ASERs, the primary groundwater contaminants in the East Fork regime are nitrate, VOCs, trace metals, and radionuclides. Sources of nitrate, trace metals, and radionuclides monitored during 1997 are the S-2 Site, the Abandoned Nitric Acid Pipeline, and the S-3 Site. Although it is located west of the current hydrologic divide that separates the East Fork regime from the Bear Creek regime, the S-3 Site has contributed to groundwater contamination in the western part of the regime during its operation. Sources of VOCs in the East Fork regime include the S-3 Site, several sites located within the Y-12 Salvage Yard, the Waste Coolant Processing Area, petroleum USTs, and process/production buildings in the plant.

Table 7.2. Regulatory status and operational history of waste management units and underground storage tanks included in the 1997 Comprehensive Groundwater Monitoring Program; *Upper East Fork Poplar Creek Hydrogeologic Regime*

Site	Historical/current regulatory classification[a]	Historical data
New Hope Pond	TSD/Study Area	Built in 1963. Regulated flow of water in UEFPC before exiting the Y-12 Plant grounds. Sediments include PCBs, mercury, and uranium but not hazardous according to toxicity characteristic leaching procedure. Closed under RCRA in 1990.
Abandoned Nitric Acid Pipeline	SWMU/UEFPC OU2	Used from 1951 to 1983. Transported liquid nitric acid wastes and dissolved uranium from Y-12 Plant process areas to the S-3 Site. Leaks were the release mechanisms to groundwater. A CERCLA ROD has been issued.
Salvage Yard Scrap Metal Storage Area	SWMU/UEFPC CA	Used from 1950 to present for scrap metal storage. Some metals contaminated with low levels of depleted or enriched uranium. Runoff and infiltration are the principal release mechanisms to groundwater.
Salvage Yard Oil/ Solvent Drum Storage Area	SWMU/UEFPC CA	Primary wastes included waste oils, solvents, uranium, and beryllium. Both closed under RCRA. Leaks and spills represent the primary contamination mechanisms for groundwater.
Salvage Yard Oil Storage Tanks	SWMU/UEFPC CA	Used from 1978 to 1986. Two tanks used to store PCB-contaminated oils, both within a diked area.
Salvage Yard Drum Deheader Facility	SWMU/UEFPC CA	Used from 1959 to 1989. Sump tanks 2063-U, 2328-U, and 2329-U received residual drum contents. Sump leakage is a likely release mechanism to groundwater.
S-2 Site	SWMU/UEFPC CA	Used from 1945 to 1951. An unlined reservoir received liquid wastes. Infiltration is the primary release mechanism to groundwater.
Waste Coolant Processing Area	SWMU/UEFPC CA	Former biodegradation facility used to treat waste coolants from various machining processes. Closed under RCRA in 1988.
Building 81-10 Area	NA/UEFPC CA	Staging facility. Potential historical releases to groundwater from leaks and spills of liquid wastes or mercury.
Coal Pile Trench	SWMU/UEFPC CA	Located beneath the current steam plant coal pile. Disposals included solid materials (primarily alloys). Trench leachate is a potential release mechanism to groundwater.

Table 7.2 (continued)

Site	Historical/current regulatory classification[a]	Historical data
Interim Drum Yard	SWMU/Study Area	Diked outdoor storage area once used to store drums of liquid and solid wastes. Partially closed under RCRA in 1988 and 1996. Further action deferred to CERCLA.
Beta-4 Security Pits	SWMU/Study Area	Used from 1968 to 1972 for disposal of classified materials, scrap metals, and liquid wastes. Site is closed and capped. Primary release mechanism to groundwater is infiltration.
Rust Garage Area	UST/Study Area	Former vehicle and equipment maintenance area, including four former petroleum USTs. Petroleum product releases to groundwater are documented.
Garage Underground Tanks	SWMU/Study Area	Fuel USTs used from 1944 to 1978. Converted to waste oil storage in 1978; removed in 1989. Petroleum and waste oil leaks represent probable releases to groundwater. The unit was clean-closed under RCRA in 1995.

[a]Regulatory status before the 1992 Federal Facility Agreement: TSD-RCRA—regulated, land-based treatment, storage, or disposal unit; SWMU—RCRA-regulated solid waste management unit; and UST—petroleum underground storage tank. Current regulatory status: study area—Y-12 Plant study area; UEFPC OU2—Upper East Fork Poplar Creek Operable Unit 2; UEFPC CA—Upper East Fork Poplar Creek Characterization Area.

Nitrate

Nitrate concentrations in groundwater at the Y-12 Plant exceed the 10 mg/L maximum drinking water contamination level (a complete list of DWSs is presented in Appendix D) in a large part of the western portion of the East Fork regime (Fig. 7.8). Groundwater containing nitrate concentrations as high as 10,000 mg/L occurs in the unconsolidated zone and at shallow bedrock depths just east of the S-3 Site.

The extent of the nitrate plume is essentially defined in the unconsolidated zone and the shallow bedrock zone. In both zones of the aquitards, the nitrate plume extends about 4000 ft (1219 m) eastward from the S-3 Site. Nitrate has traveled farthest, approximately 5000 ft (1524 m), in groundwater in the Maynardville Limestone. Although the nitrate plume is dispersing and moving eastward, concentrations near the source have been trending downward since disposal operations ceased and the site was closed and capped in the late 1980s.

Trace Metals

Concentrations of barium, cadmium, chromium, lead, nickel, and thallium exceeded MCLs during 1997 in samples collected from various monitoring wells at the S-2 Site, the S-3 Site, central and eastern plant grid locations, exit pathway wells, and upgradient of New Hope Pond. Elevated concentrations of these metals were most commonly reported for groundwater samples collected from monitoring wells in the unconsolidated zone. A definable plume of elevated metals contaminants is not present; metals above maximum contaminant levels tend to occur adjacent to the source units.

Volatile Organic Compounds

Because of the many source areas, VOCs are the most widespread groundwater contaminants in the East Fork regime. Dissolved VOCs in the regime generally consist of two types of compounds: chlorinated solvents and petroleum hydrocarbons. The highest concentrations of dissolved chlorinated solvents (about 12 mg/L)

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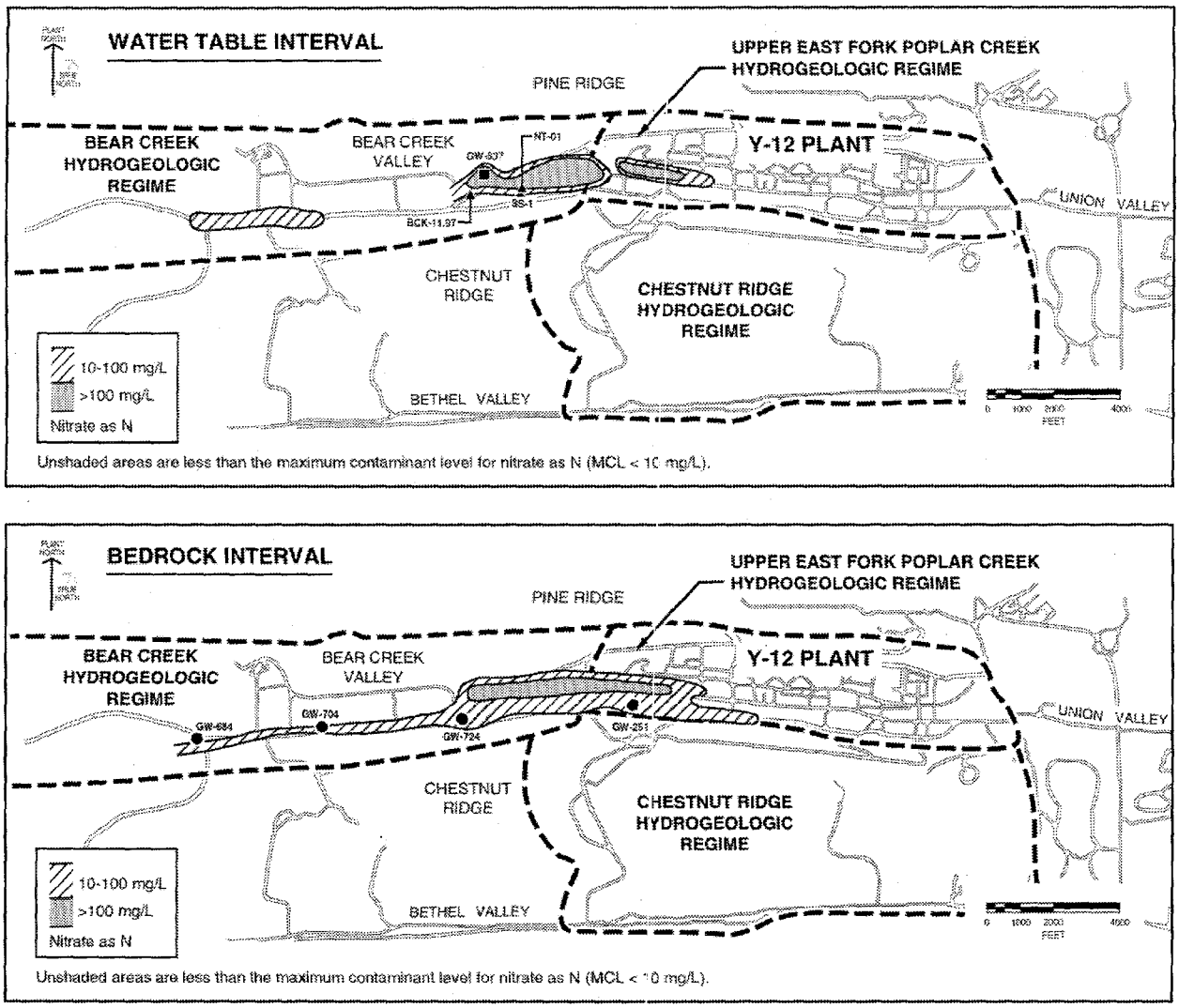

Fig. 7.8. Nitrate (as N) observed in groundwater at the Y-12 Plant.

are found at the Waste Coolant Processing Area and Y-12 Salvage Yard. The highest dissolved concentrations of petroleum hydrocarbons (about 60 mg/L) occur in groundwater near the Rust Garage Area.

Concentrations of chlorinated VOCs in the vicinity of source areas have remained relatively constant or have decreased since 1988 (Fig. 7.9). Within the exit pathway on the east end of the regime, some monitoring locations (e.g., GW-220) east of New Hope Pond have shown increasing VOC concentrations, indicative of an easterly movement of part of the plume (Fig. 7.10). Some wells south and west of New Hope Pond (e.g., GW-606 and GW-153) show a shallow decreasing concentration trend, while wells located farther to the east (GW-733 and GW-170) show a static or stable trend. Data show that VOCs are the most extensive in shallow groundwater; however, when contaminants migrate into the Maynardville Limestone, they tend to concentrate at depths between 100 and 500 ft. The highest VOC concentrations appear to be between 200 and 500 ft, as exemplified by vertical carbon tetrachloride distribution at the east end of the Y-12 Plant (Fig. 7.11).

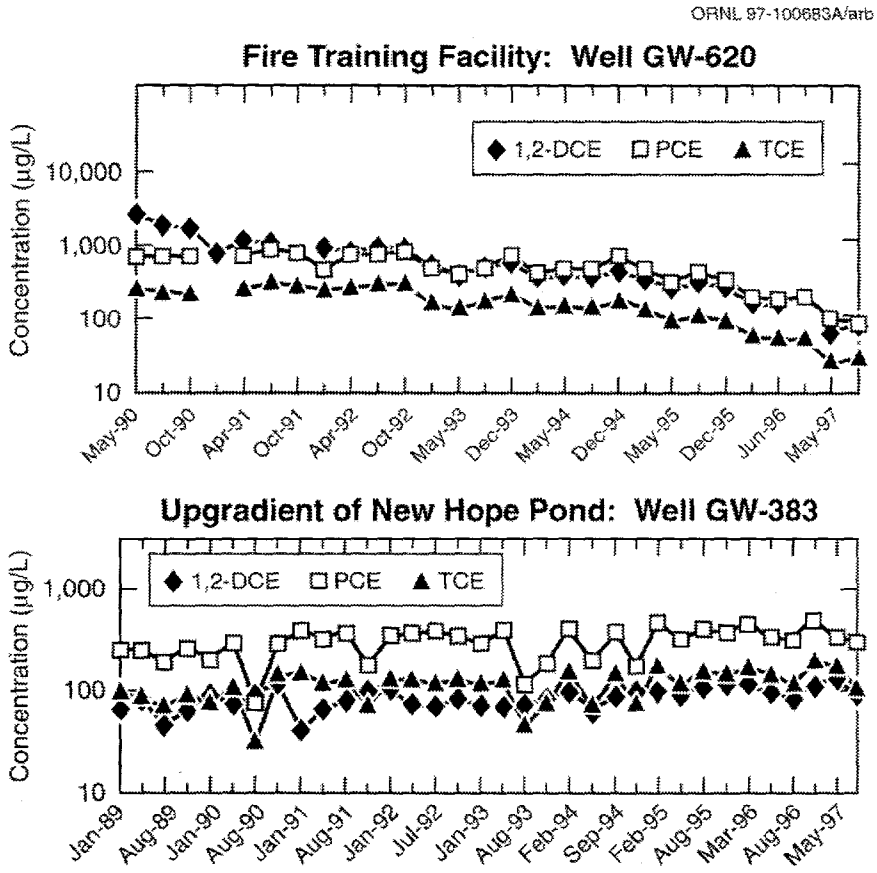

Fig. 7.9. VOC concentration in groundwater in selected wells in the East Fork regime.

The 1997 monitoring results generally confirm findings from the previous 6 years of monitoring. A continuous dissolved VOC plume in groundwater in the bedrock zone extends eastward from the S-3 Site over the entire length of the regime (Fig. 7.12). The primary sources are the Waste Coolant Processing Facility, the Building 9754 and 9754-2 fuel facilities, and process areas in the central portion of the plant.

Chloroethene compounds (tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride) tend to dominate the VOC plume composition in the western and central portions of the Y-12 Plant. However, tetrachloroethene and isomers of dichloroethene are almost ubiquitous throughout the extent of the VOC plume, indicating many source areas. Chloromethane compounds (carbon tetrachloride, chloroform, and methylene chloride) are the predominant VOCs in the eastern and southeastern portions of the plant.

Radionuclides

As in the Bear Creek regime, the primary alpha-emitting radionuclides found in the East Fork regime are isotopes of uranium, radium, neptunium, and americium. The primary beta-emitting radionuclide is technetium.

Groundwater with gross alpha activity greater than 15 pCi/L occurs in scattered areas throughout the East Fork regime (Fig. 7.13). Historical data show that gross alpha activity that consistently exceeds the MCL for drinking water (annual average activity level of 15 pCi/L) is most extensive in groundwater in the unconsolidated zone in the western portion of the Y-12 Plant near the S-3 Site. Surveillance data also show that gross beta activity levels remained elevated well above the MCL in the western portion of the plant. An area of elevated gross alpha activity is also present west of New Hope Pond. Sporadic gross alpha activity was also observed in several shallow wells scattered across the East Fork regime. Erratic data distribution, coupled with high turbidity and TSS content in samples from most of the wells, indicates that these sporadic values are false positives.

Elevated gross beta activity in groundwater in the East Fork regime shows a pattern similar to that observed for gross alpha activity (Fig. 7.14). In general, gross beta activity consistently exceeds the annual average MCL of 50 pCi/L in groundwater in the western portion of the regime, with the primary source being the S-3 Site.

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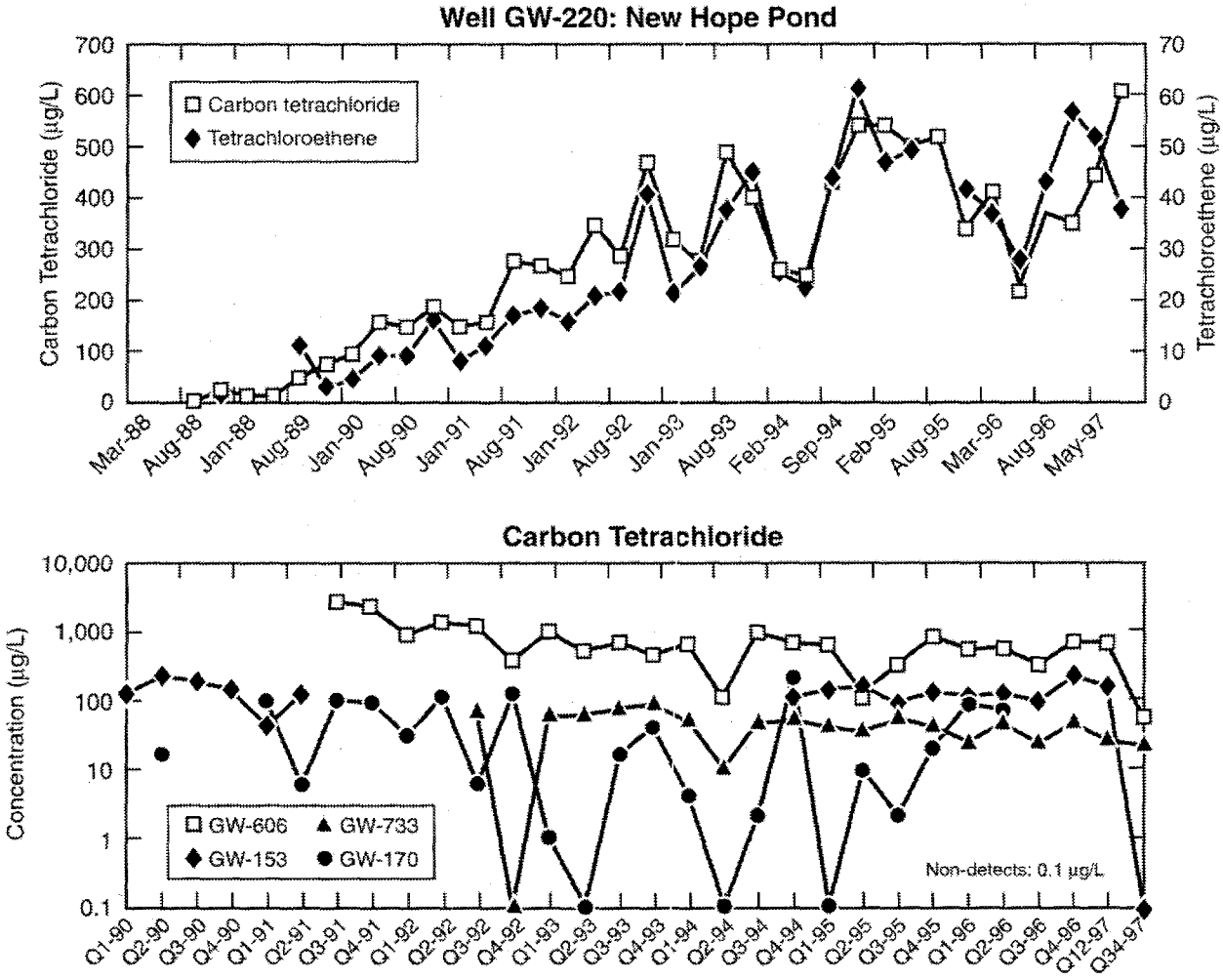

Fig. 7.10. VOC concentrations in selected wells near New Hope Pond and exit pathway wells.

Exit Pathway and Perimeter Monitoring

Exit pathway groundwater monitoring activities in the East Fork regime in 1997 involved continued collection and trending of data from exit pathway monitoring stations. In addition, data collected under the scope of the UEFPC RI were integrated into evaluations of contaminant exit-pathways. The RI effort included sampling of springs, seeps, surface water, and wells in Union Valley and a few selected locations within the Y-12 Plant. Surface water quality in UEFPC is regularly monitored in accordance with NPDES permits, and the results are summarized in Chap. 4.

Data collected to date indicate that VOCs are the primary class of contaminants that are migrating through the exit pathways in the East Fork regime. The VOCs are migrating predominantly at depths between 200 and 500 ft and appear to be restricted to the Maynardville Limestone. An aerial distribution of VOCs is shown in Fig. 7.12. A vertical profile of VOC contamination is depicted in Fig. 7.11. Concentrations of VOCs are typically higher at depth because most dilution and mixing with rainfall occurs in the shallow portions of the Maynardville limestone. In addition, the majority of the VOCs are more dense than water; therefore, they tend to migrate downward within the subsurface. The deep fractures

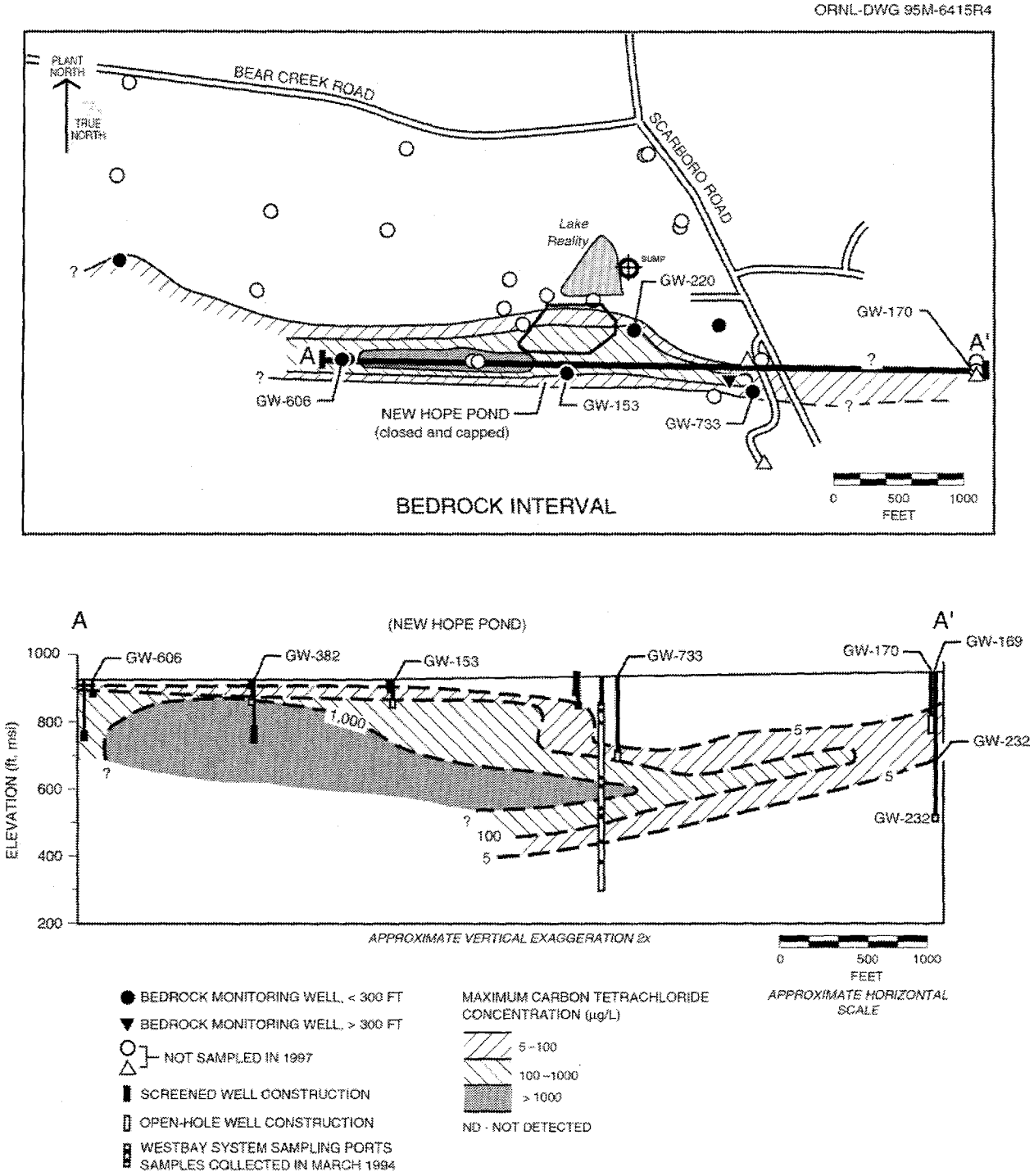

Fig. 7.11. Maximum carbon tetrachloride concentrations in Maynardville Limestone at depths between 200 and 500 ft, 1997.

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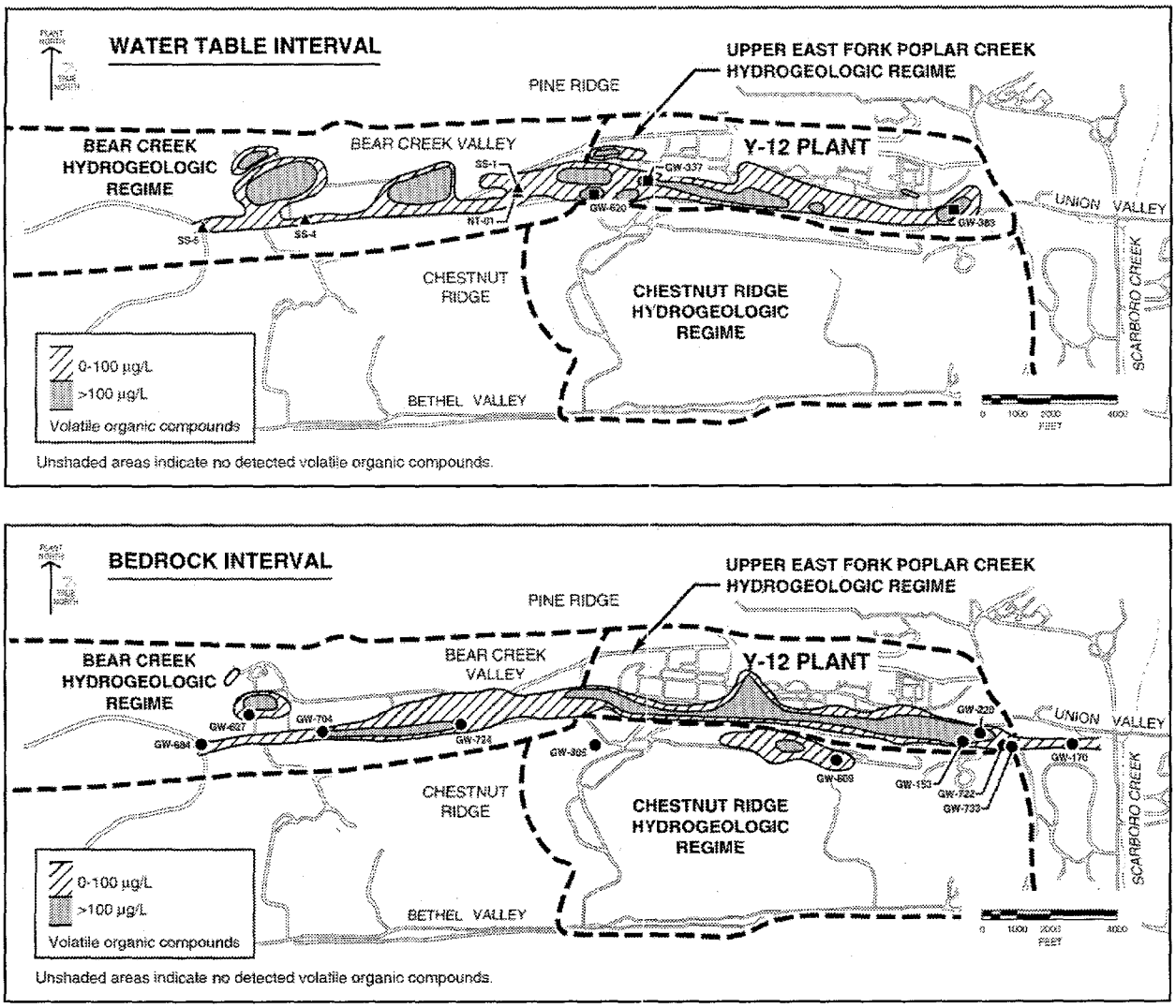

Fig. 7.12. Summed volatile organic compounds in groundwater at the Y-12 Plant.

and solution channels that constitute flowpaths within the Maynardville Limestone appear to be well connected. The characteristics of the flowpaths combined with the chemical characteristics of the contaminants have resulted in migration for substantial distances off the ORR into Union Valley to the east of the Y-12 Plant. The EMP specifies monitoring of three wells near the eastern ORR boundary for this exit pathway (Fig. 7.6).

In addition to the deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval in the vicinity of New Hope Pond, Lake Reality, and Upper East Fork Poplar Creek is also monitored. Historically, VOCs have been observed in the vicinity of Lake Reality from wells, a dewatering sump, and the Lake Reality spillway (LRSPW). In this area, shallow groundwater flows north-northeast through the water table interval east of New Hope Pond and Lake Reality, following the path of a diversion channel for Upper East Fork Poplar Creek.

Groundwater movement and contaminant migration along the diversion channel also appear to be accelerated by the effects of Lake Reality

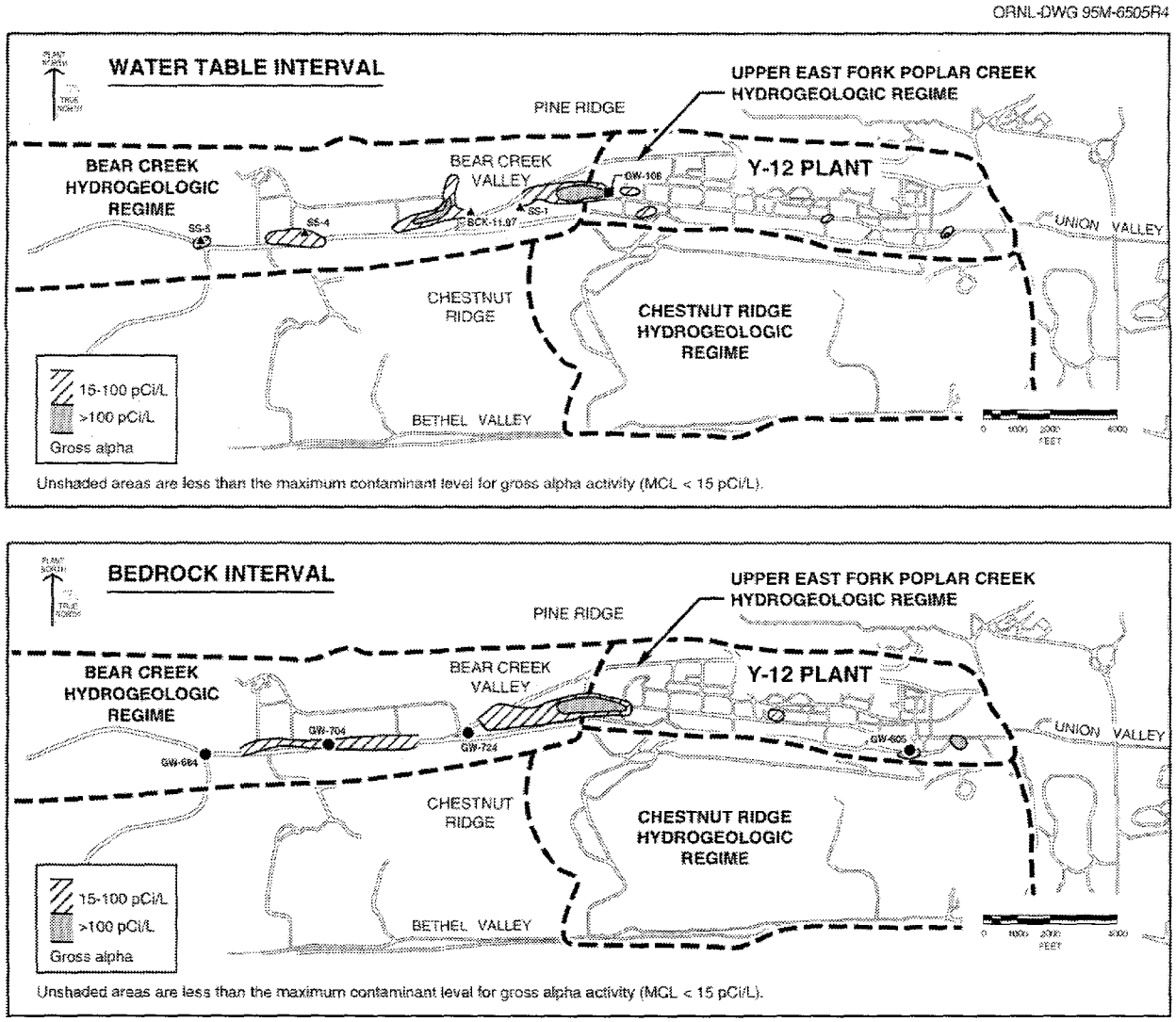

Fig. 7.13. Gross alpha activity in groundwater at the Y-12 Plant.

underdrain dewatering activities. At the dewatering sump (Fig. 7.11), groundwater is pumped from a drainage layer to relieve hydraulic pressure that periodically raises the synthetic liner in Lake Reality. Past studies have shown that when the dewatering sump is activated, groundwater table levels are lowered over a large area and contaminant levels in the sump discharge increase over time. Thus, operation of the dewatering sump has been kept to minimal levels with monitoring of discharge when operation is required. During 1997, a decrease in VOCs at LRSPW was observed.

Three wells, located in the large gap in Pine Ridge through which UEFPC exits the Y-12 Plant, are used to monitor shallow, intermediate, and deep groundwater intervals. These wells are monitored under the scope of the EMP. Shallow groundwater moves through this exit pathway, and very strong upward vertical flow gradients exist; two of the three wells located in this area are strongly artesian. Monitoring of these wells since about 1990 has not shown that any contaminants are moving via this exit pathway.

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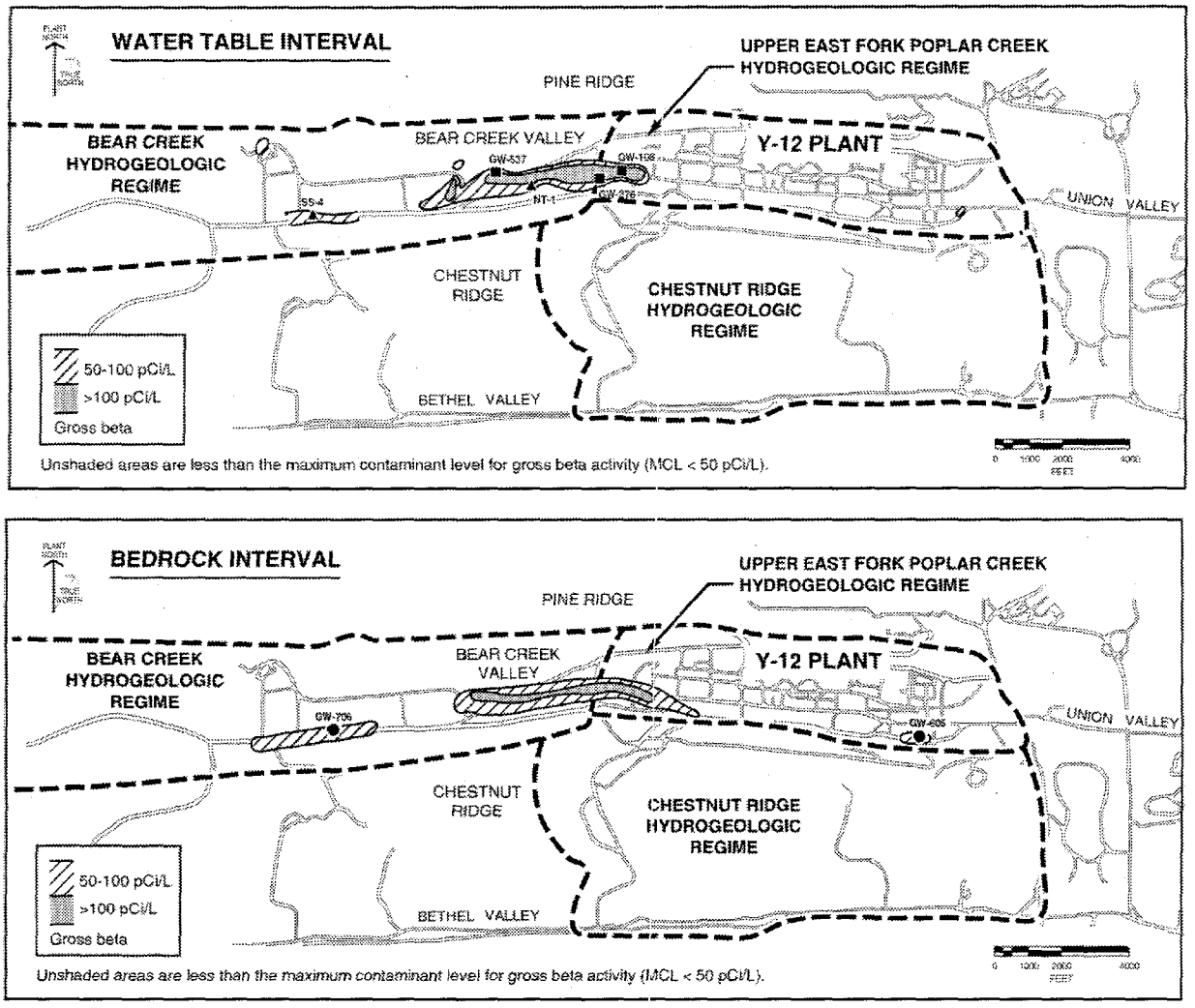

Fig. 7.14. Gross beta activity in groundwater at the Y-12 Plant.

7.2.5.2 Union Valley Focus Study

Groundwater monitoring data obtained in 1993 provided the first strong indication that VOCs were being transported off the ORR through the deep Maynardville Limestone exit pathway. The 1995 ASER provided a discussion of the nature and extent of the VOCs and short-term response actions taken. In 1997, monitoring of locations in Union Valley continued under the IWQP (DOE 1998b). These data showed no significant changes in the types and concentrations of contaminants comprising the groundwater contaminant plume in Union Valley.

The current conceptual model for Union Valley suggests that Scarboro Creek (Fig. 7.12) functions as a shallow (and possible intermediate) groundwater divide. Contaminants appear to be upwelling under the influence of vertical gradients and discharging at low concentrations to several springs and possibly within the creek channel itself. Under the terms of an interim proposed plan, administrative controls, such as restriction of potential future groundwater use, have been established. Long-term remedial actions in this area will be addressed along with those for the entire UEFPC CA in conjunction with DOE, TDEC, EPA, and the public.

7.2.5.3 Bear Creek Hydrogeologic Regime

Located west of the Y-12 Plant in BCV, the Bear Creek regime is bounded to the north by Pine Ridge and to the south by Chestnut Ridge. The regime encompasses the portion of BCV extending from the west end of the Y-12 Plant to Highway 95. Figures 7.15 and 7.16 show the Bear Creek regime, locations of stations sampled in 1997, and the locations of its waste management sites. The BCV CA lies within the regime and includes all source units, groundwater, surface water, and soils/sediments, with the exception of the SY-200 Yard and Spoil Area I, which are separate actions (Fig. 7.4; Table 7.3).

Characterization of the nature and extent of contamination in the regime is essentially complete. A CERCLA RI report has been finalized and approved by TDEC and EPA. The RI report contains a detailed description of site history, nature and extent of contamination, and human health and ecological risk assessments and is now available for public use.

As the next step in the CERCLA process, remedial actions under the scope of a feasibility study will be evaluated and initiated where sufficient data exist to identify acceptable alternatives. Where data gaps exist preventing full evaluation of remedial alternatives, focused studies with limited scopes and short durations will be completed to obtain the specific data required to fully evaluate potential remedial actions.

Currently, the focus of monitoring efforts is RCRA postclosure corrective action monitoring, exit pathway monitoring, and surveillance of contaminant plume boundaries. These objectives were met by sampling of a monitoring network of

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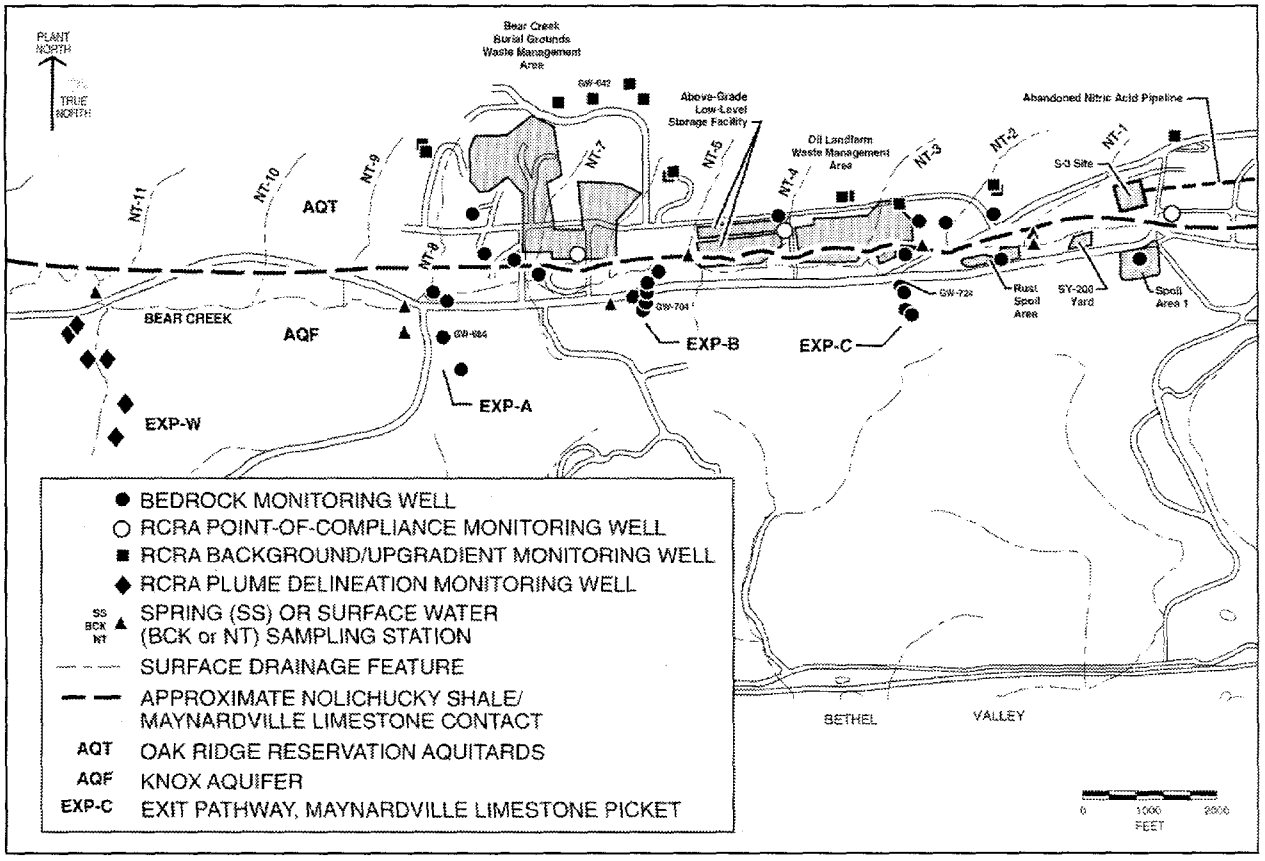

Fig. 7.15. Locations of waste management sites and monitoring wells sampled during 1997 in the Bear Creek Hydrogeologic Regime.

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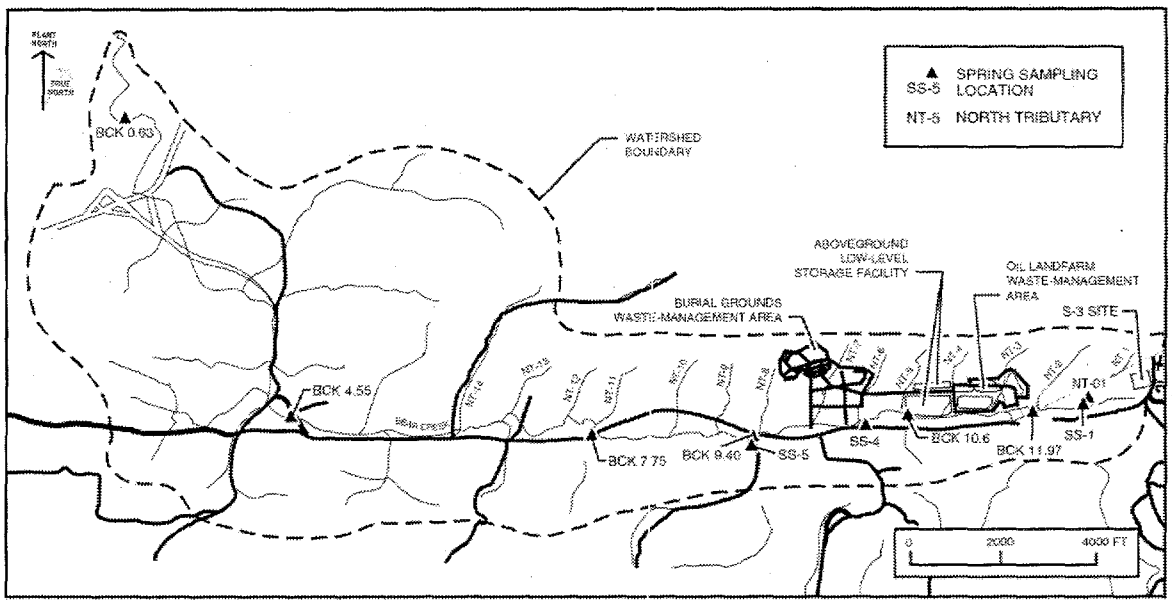

Fig. 7.16. Surface water and spring stations sampled during 1997 in the Bear Creek Hydrogeologic Regime.

45 wells, 3 springs, and 7 surface water locations specified by the RCRA postclosure permit, the ORR EMP, and primary exit pathway and surveillance-monitoring points. The network was sampled at a baseline semiannual frequency. Any future monitoring requirements dictated by CERCLA RODs issued for the BCV CA will be integrated into the long-term corrective action/surveillance-monitoring network for the regime.

Discussion of Monitoring Results

Groundwater monitoring in the Bear Creek regime during 1997 was conducted (1) to maintain surveillance of contaminant plumes (both extent and concentration of contaminants); (2) to conduct trending within contaminant exit pathways in the Maynardville Limestone using existing monitoring locations; and (3) to conduct corrective action monitoring at point-of-compliance sites, exit pathways, and background wells in accordance with the Bear Creek regime RCRA postclosure permit.

Plume Delineation

The primary groundwater contaminants in the Bear Creek regime are nitrate, trace metals, VOCs, and radionuclides. The S-3 Site is the primary source of nitrate, radionuclides, and trace metals. Sources of VOCs include the S-3 Site, the Rust Spoil Area, the Oil Landfarm waste management area, and the Bear Creek Burial Grounds waste management area; the latter two sites are the principal sources. Dense nonaqueous phase liquids (DNAPLs) exist at a depth of 270 ft below the Bear Creek Burial Grounds. The DNAPLs consist primarily of tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, and high concentrations of PCBs.

Contaminant plume boundaries are essentially defined in the bedrock formations that directly underlie many waste disposal areas in the Bear Creek regime, particularly the Nolichucky Shale. The elongated shape of the contaminant plumes in the Bear Creek regime is the result of preferential transport of the contaminants parallel to strike in both the Knox Aquifer and the ORR Aquitards. A review of historical data suggests that contaminant

Table 7.3. Regulatory status and operational history of waste management units included in the 1997 Comprehensive Groundwater Monitoring Program; Bear Creek Hydrogeologic Regime

Site	Historical/current regulatory classification[a]	Historical data
S-3 Site	TSD/TSD-BCV CA	Four unlined surface impoundments constructed in 1951. Received liquid nitric acid/uranium-bearing wastes via the Nitric Acid Pipeline until 1984. Closed and capped under RCRA in 1988. Infiltration was the primary release mechanism to groundwater.
Oil Landfarm	TSD/TSD-BCV CA	Operated from 1973 to 1982. Received waste oils and coolants tainted with metals and PCBs. Closed and capped under RCRA in 1989. Infiltration was the primary release mechanism to groundwater.
Boneyard	SWMU/BCV CA	Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood.
Burnyard	SWMU/BCV CA	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches.
Hazardous Chemical Disposal Area	SWMU/BCV CA	Built over the burnyard. Handled compressed gas cylinders and reactive chemicals. Residues placed in a small, unlined pit.
Sanitary Landfill I	SWMU/BCV CA	Used from 1968 to 1982. TDEC-permitted, nonhazardous industrial landfill. May be a source of certain contaminants to groundwater. Closed and capped under TDEC requirements in 1983.
Bear Creek Burial Grounds: A, C, and Walk-in Pits	TSD/TSD-BCV CA	A and C received waste oils, coolants, beryllium and uranium, various metallic wastes, and asbestos into unlined trenches and standpipes. Walk-in Pits received chemical wastes, shock-sensitive reagents, and uranium saw fines. Activities ceased in 1981. Final closure certified for A (1989), C (1993), and the Walk-in Pits (1995). Infiltration is the primary release mechanism to groundwater.
Bear Creek Burial Grounds: B, D, E, J, and Oil Retention Ponds 1 and 2	SWMUs/BCV CA	Burial Grounds B, D, E, and J, unlined trenches, received depleted uranium metal and oxides and minor amounts of debris and inorganic salts. Ponds 1 and 2, built in 1971 and 1972, respectively, captured waste oils seeping into two Bear Creek tributaries. The ponds were closed and capped under RCRA in 1989. Certification of closure and capping of Burial Grounds B and part of C was granted 2/95.

Table 7.3 (continued)

Site	Historical/current regulatory classification[a]	Historical data
Rust Spoil Area	SWMU/BCV CA	Used from 1975 to 1983 for disposal of construction debris, but may have included materials bearing solvents, asbestos, mercury, and uranium. Closed under RCRA in 1984. Site is a source of VOCs to shallow groundwater according to CERCLA RI.
Spoil Area I	SWMU/BC OU 2	Used from 1980 to about 1987 for disposal of construction debris and other stable, nonrad wastes. Permitted under TDEC solid waste management regulations in 1986; closure began shortly thereafter. Soil contamination is of primary concern. CERCLA ROD issued in 1996.
SY-200 Yard	SWMU/BC OU 2	Used from 1950s to 1986 for equipment and materials storage. No documented waste disposal at the site occurred. Leaks, spills, and soil contamination are concerns. CERCLA ROD issued in 1996.
Above-Grade LLW Storage Facility	Active	Constructed in 1993. Consists of six above-grade storage pads used to store inert, low-level radioactive debris and solid wastes packaged in steel containers.

[a]Regulatory status before the 1992 Federal Facilities Agreement: TSD—RCRA regulated, land-based treatment, storage, or disposal unit; SWMU—RCRA-regulated solid waste management unit; NA—not regulated. Current regulatory status: BCV CA—Bear Creek Valley Characterization Area; BC OU 02—Bear Creek Operable Unit 02; active—active waste storage facility.

concentrations near source areas within the ORR Aquitards have remained relatively constant since 1986. However, one well west of the Bear Creek Burial Grounds has exhibited a shallow increase in VOCs, indicating some movement parallel to strike (Fig. 7.17). As detailed in previous ORR ASERs, certain contaminants at specific sites, such as nitrate levels adjacent to the S-3 site, have shown decreasing concentration trends. Other constituents, such as gross alpha, exhibit upward trends. In exit pathway wells located in the Bear Creek regime (Fig. 7.18), slight increases or decreases are observed for selected contaminants, depending on mobility of the contaminants and relative location of the monitoring station with respect to source areas.

Nitrate

Unlike most of the other groundwater contaminants, nitrate moves easily with the groundwater. The limits of the nitrate plume probably define the maximum extent of subsurface contamination in the Bear Creek regime.

Data obtained during 1997 indicate that nitrate concentrations exceed the 10 mg/L MCL in an area that extends west from the S-3 Site for approximately 12,000 ft down BCV (Fig. 7.8). Nitrate concentrations greater than 100 mg/L extend about 3000 ft (915 m) west of the S-3 Site. Data obtained since 1986 suggest that the nitrate plume extends more than 600 ft (183 m) below the ground surface within the ORR aquitards at the S-3 Site. Historically, the highest nitrate concentrations are observed adjacent to the S-3 Site in groundwater in the unconsolidated zone and at shallow depths [less than 100 ft (30.5 m) below the ground surface] in the Nolichucky Shale. During 1997, no monitoring was performed immediately adjacent, and downgradient of the S-3 Site. However, the closest well to the S-3 Site, which monitors the water table interval of the Nolichucky Shale (Oil Landfarm well GW-537), did have the highest nitrate concentrations during

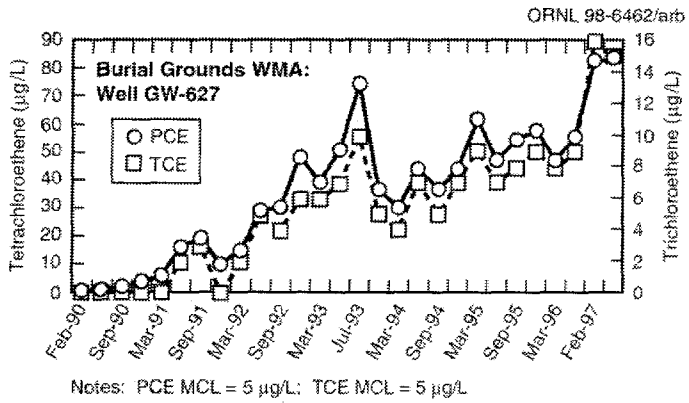

Fig. 7.17. VOC concentrations in Bear Creek Burial Grounds well GW-627.

this year. Monitoring location NT-1 was closer than well GW-537, but nitrate concentrations were diluted by surface water influences.

The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper to intermediate part of the aquifer [less than 300 ft (91 m) below the ground surface]. Data obtained from exit pathway monitoring wells indicate that the nitrate plume in groundwater within bedrock in the Maynardville Limestone has not migrated appreciably during the past year and concentrations remain relatively constant or are slightly decreasing.

Trace Metals

Barium, cadmium, chromium, lead, and mercury have been identified from previous monitoring as the principal trace metal contaminants in groundwater in the Bear Creek regime. Historically, the concentrations of these metals exceeded MCLs or natural (background) levels primarily in low-pH groundwater at shallow depths near the S-3 Site. Disposal of acidic liquid wastes at this site reduced the pH of the groundwater, which allows the metals to remain in solution. Elsewhere in the Bear Creek regime, where relatively high pH conditions prevail, only sporadic occurrences of elevated trace metal concentrations are evident.

Other trace metal contaminants in the Bear Creek regime are beryllium, boron, cobalt, copper, nickel, strontium, and uranium. Concentrations of these metals have commonly exceeded background levels in groundwater near the S-3 Site, the Bear Creek Burial Grounds, and the Oil Landfarm waste management areas. Selected stream and spring locations and exit pathway study wells also have exhibited total uranium and strontium concentrations above background values.

Volatile Organic Compounds

Like nitrate, VOCs are widespread in groundwater in the Bear Creek regime (Fig. 7.12). The primary compounds are tetrachloroethene, trichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethane, and 1,1-dichloroethane. In most areas, the VOCs are dissolved in the groundwater, but nonaqueous phase accumulations of tetrachloroethene and trichloroethene occur in bedrock more than 250 ft (76 m) below the Bear Creek Burial Grounds waste management area.

Groundwater in the unconsolidated zone overlying the aquitards that contains detectable levels of VOCs occurs primarily within about 1000 ft (305 m) of the source areas. The highest VOC concentrations (greater than 10,000 mg/L) in the unconsolidated zone occur at the Bear Creek Burial Grounds waste management area. The extent of the dissolved VOC plumes is slightly greater in the underlying bedrock. Well GW-627, which is downgradient of the Bear Creek Burial Grounds waste management area has exhibited an increase in VOC concentration (Fig. 7.17). This indicates that some strike parallel migration through the aquitards is occurring in the intermediate bedrock interval.

Significant transport of VOCs has occurred in the Maynardville Limestone. Data obtained from exit pathway monitoring locations show that in the vicinity of the water table, an apparently continuous dissolved VOC plume extends for about 12,000 ft (3660 m) westward from the S-3 Site to just west of the Bear Creek Burial Grounds waste management area. The highest levels of VOCs in the Bear Creek regime occur in bedrock, just south of the Bear Creek Burial Grounds waste

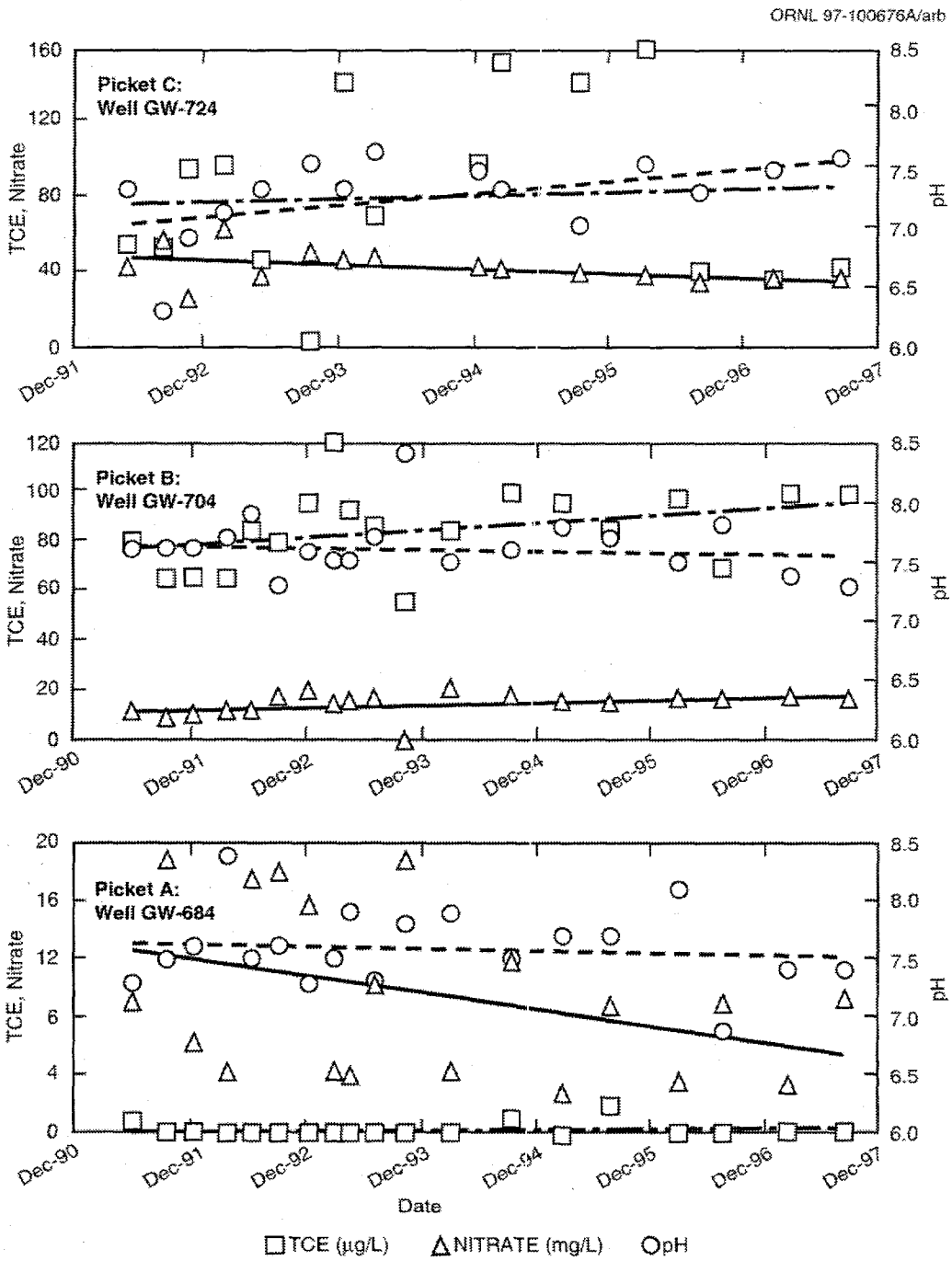

Fig. 7.18. Concentrations of selected contaminants in exit pathway monitoring wells GW-724, GW-704, and GW-684 in the Bear Creek Hydrogeologic Regime.

management area. Historical levels have been as high as 7000 mg/L in groundwater near the source area. Typical VOC levels in the exit pathway (Maynardville Limestone) range from about 160 μg/L in the eastern part of the regime to less than detectable levels in the western part of the regime.

During 1997, VOC concentrations have been highest in exit pathway transect Picket B. Well GW-704 at this transect has exhibited a shallow increasing trend in trichloroethene since the early 1990s. All other exit pathway transect wells display a decrease in this VOC. The increase in VOCs in Picket B wells indicates that the Oil Landfarm waste management area is still a significant contributing source of VOCs.

Radionuclides

As in the East Fork regime, uranium, neptunium, americium, and naturally occurring isotopes of radium have been identified as the primary alpha-particle-emitting radionuclides in the Bear Creek regime. Technetium is the primary beta-particle-emitting radionuclide in the regime, but tritium and isotopes of strontium are also present in groundwater near the S-3 Site.

Evaluations of the extent of these radionuclides in groundwater in the Bear Creek regime during 1997 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from a well exceeded 15 pCi/L (the MCL for gross alpha activity), then one (or more) of the alpha-emitting radionuclides was assumed to be present in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded 50 pCi/L.

As shown in Fig. 7.13, groundwater with elevated levels of gross alpha activity occurs in the water table interval in the vicinity of the S-3 Site, the Bear Creek Burial Grounds, and the Oil Landfarm waste management areas. In the bedrock interval, gross alpha activity exceeds 15 pCi/L in groundwater in the Nolichucky Shale near the S-3 Site, east of the Oil Landfarm waste management areas and the southern side of the Bear Creek Burial Grounds. Data obtained from exit pathway monitoring stations show that gross alpha activity in groundwater in the Maynardville Limestone exceeds the MCL for 10,000 ft (3050 m) west of the S-3 Site.

The distribution of gross beta radioactivity in groundwater in the unconsolidated zone is similar to that of gross alpha radioactivity (Fig. 7.14). During 1997, gross beta activity exceeded 50 pCi/L within the water table interval in the Maynardville Limestone from south of the S-3 Site to the Oil Landfarm waste management area. Within the intermediate bedrock interval in the Maynardville Limestone, the elevated gross beta activity extends as far west as does gross alpha activity, just to the west of the Bear Creek Burial Grounds waste management area.

Exit pathway and Perimeter Monitoring

Exit pathway monitoring began in 1990 to provide data on the quality of groundwater and surface water exiting the Bear Creek regime. The Maynardville Limestone is the primary exit pathway for groundwater. Bear Creek, which flows across the Maynardville Limestone in much of the Bear Creek regime, is the principal exit pathway for surface water. Various studies have shown that surface water in Bear Creek, springs along the valley floor, and groundwater in the Maynardville Limestone are hydraulically connected. The western exit pathway well transect (Picket W) serves as the ORR perimeter wells for the Bear Creek Regime (Fig. 7.6).

Exit pathway monitoring consisted of continued monitoring at four well transects (pickets) and selected springs and surface water stations. Groundwater quality data obtained during 1997 from the exit pathway monitoring wells confirmed previous data indicating that contaminated groundwater does not seem to occur much beyond the western side of the Bear Creek Burial Grounds waste management area. However, low levels of nitrate (1 to 4 mg/L) have been observed in surface water and one Picket W well west of the burial grounds (LMES 1998a).

Surface water and spring samples collected during CY 1997 (Fig. 7.16) indicate that spring discharges and water in upper reaches of Bear Creek contain many of the compounds found in the groundwater; however, the concentrations in the creek and spring discharges decrease rapidly with distance downstream of the waste disposal sites (Fig. 7.19).

7.2.5.4 Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge regime is south of the Y-12 Plant and is flanked to the north by BCV and to the south by Bethel Valley Road (Fig. 7.5). The regime encompasses the portion of Chestnut Ridge extending from Scarboro Road east of the Y-12 Plant to an unnamed drainage basin on the ridge located just west of Centralized Sanitary Landfill II. Figure 7.20 shows the approximate boundaries of the regime and locations of waste management units and monitoring wells sampled in 1997.

Four categories of sites are located within the Chestnut Ridge regime: (1) RCRA-regulated TSD units, (2) RCRA 3004(u) SWMUs and solid waste disposal units, (3) TDEC-permitted SWDFs, and (4) CERCLA OUs. The Chestnut Ridge Security Pits is the only documented source of groundwater contamination in the regime. No integrating CA has been established for the regime because contamination from the Security Pits is distinct and is not mingled with plumes from other sources. Table 7.4 summarizes the regulatory status and operational history of waste management units in the regime. Detailed discussions of these sites have been included in previous ASERs.

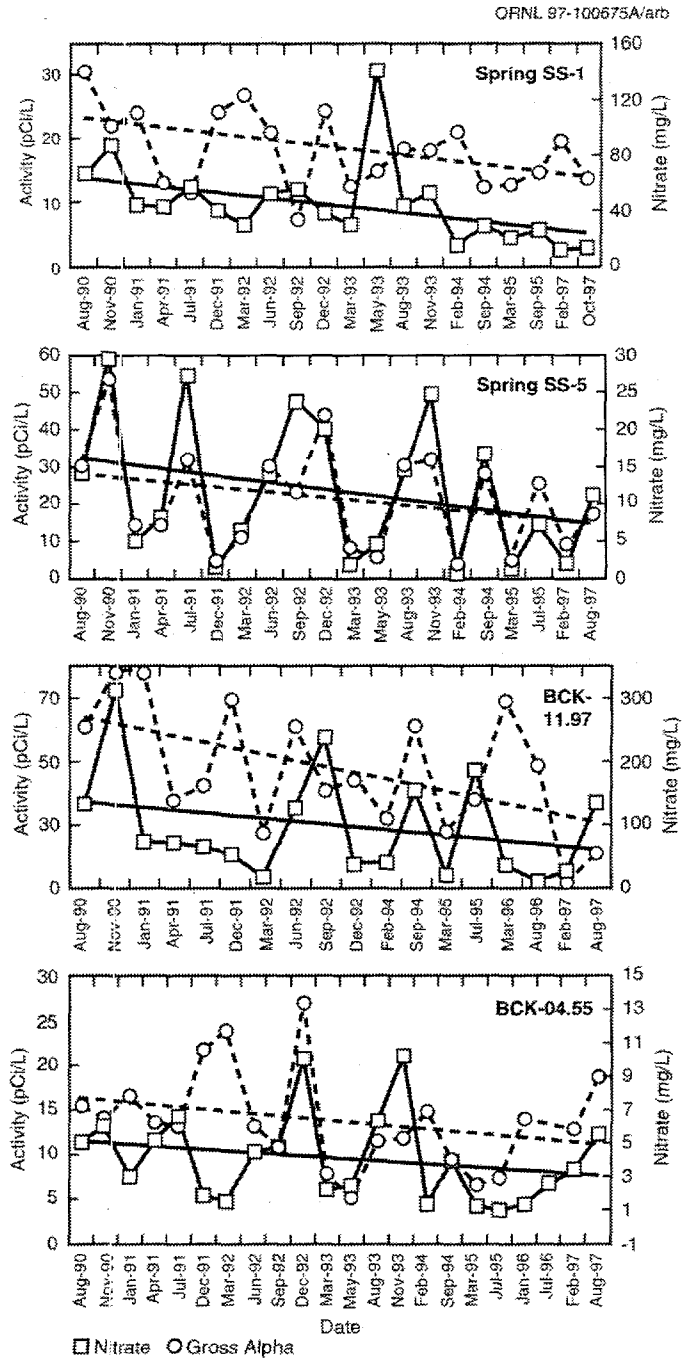

Fig. 7.19. Concentrations of selected groundwater contaminants in springs and surface water in the Bear Creek Hydrogeologic Regime. Refer to Fig. 7.16 for sampling locations.

Discussion of Monitoring Results

A more comprehensive suite of analytical tests is applied to most sites in the Chestnut Ridge regime because of various permitting requirements. Volatile organics and trace metals are the only categories that currently consistently exceed background levels, and these are predominantly associated with the Chestnut Ridge Security Pits. Gross alpha and beta activities have sporadically exceeded screening levels in the past in samples taken from wells at the

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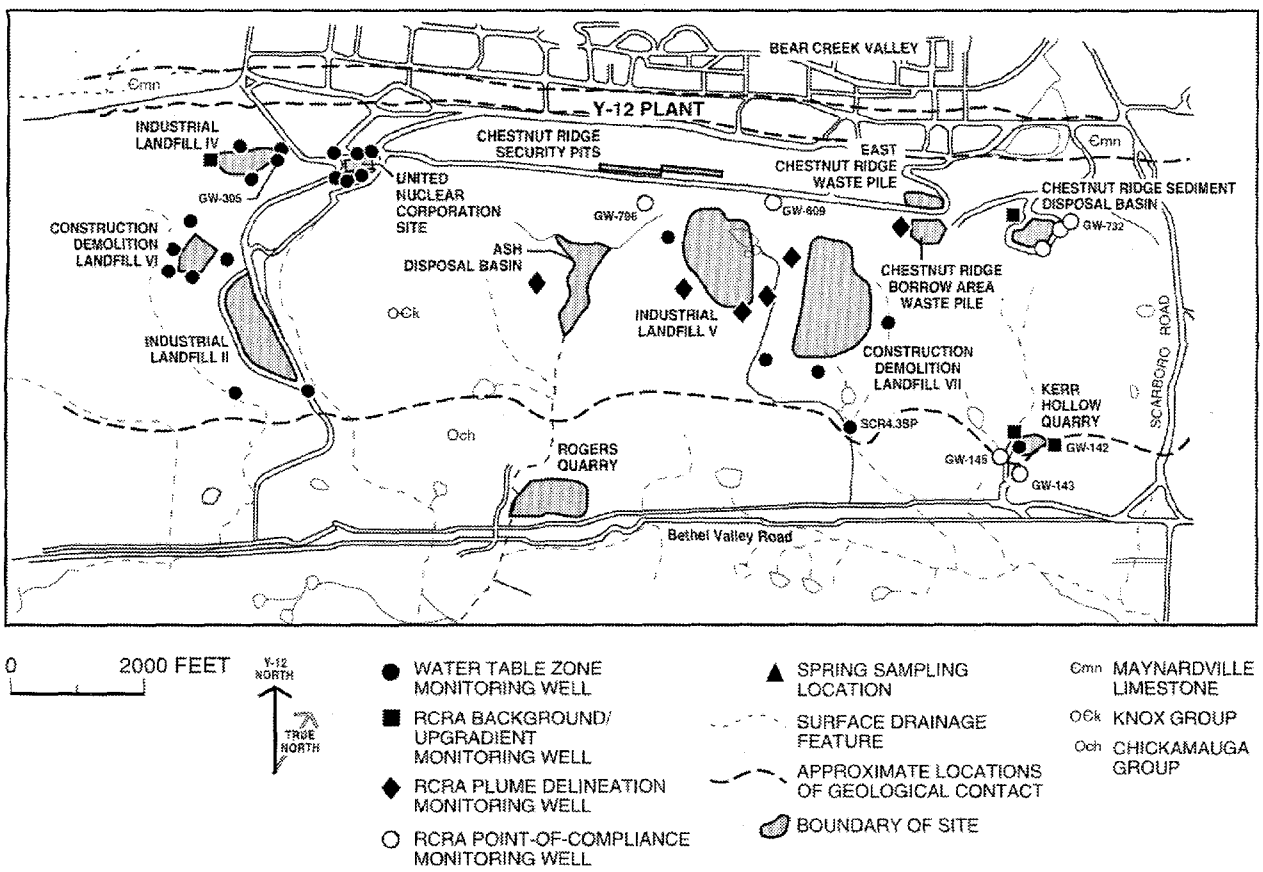

Fig. 7.20. Locations of waste management sites and monitoring wells sampled during 1997 in the Chestnut Ridge Hydrogeologic Regime.

Chestnut Ridge Sediment Disposal Basin, United Nuclear Site, Industrial Landfill IV, and Kerr Hollow Quarry, although no discernable pattern or consistency to the data has been determined.

Monitored units in the Chestnut Ridge regime, with the exception of the Chestnut Ridge Security Pits and the United Nuclear Site, are under a regulatory detection monitoring program. The Chestnut Ridge Security Pits are monitored in accordance with RCRA postclosure corrective action requirements. The United Nuclear Site is monitored under the provisions of a CERCLA ROD. In 1997, no releases of contaminants to groundwater were determined for those units under formal detection monitoring programs (Table 7.1). No observable changes of groundwater quality relative to past years were noted for units monitored under surveillance practices or a CERCLA ROD. Plume delineation and contaminants of interest are discussed in the following sections. Four additional issues are also discussed. These four issues include the occurrence of trace levels of (1) VOCs, total strontium, and total uranium at Kerr Hollow Quarry; (2) total uranium at the Sediment disposal Basin; (3) VOCs in one well located at Industrial Landfill IV; and (4) nickel in one well located at Centralized Sanitary Landfill II.

Plume Delineation

The horizontal extent of the VOC plume at the Chestnut Ridge Security Pits is reasonably well defined in the water table and shallow bedrock zones (Fig. 7.12). Groundwater quality data obtained during 1997 continue to indicate that the

Table 7.4. Regulatory status and operational history of waste management units included in the 1997 Comprehensive Groundwater Monitoring Program; Chestnut Ridge Hydrogeologic Regime

Site	Historical/current regulatory classification[a]	Historical data
Chestnut Ridge Sediment Disposal Basin	TSD/TSD-Study Area	Operated from 1973 to 1989. Received soil and sediment from New Hope Pond and mercury-contaminated soils from the Y-12 Plant. Site was closed under RCRA in 1989. Not a documented source of groundwater contamination.
Kerr Hollow Quarry	TSD/TSD-Study Area	Operated from 1940s to 1988. Used for the disposal of reactive materials, compressed gas cylinders, and various debris. RCRA closure (waste removal) was conducted between 1990 and 1993. Certification of closure with some wastes remaining in place was approved by TDEC 2/95.
Chestnut Ridge Security Pits	TSD/TSD-CR OU 1	Operated from 1973 to 1988. Series of trenches for disposal of classified materials, liquid wastes, thorium, uranium, heavy metals, and various debris. Closed under RCRA in 1989. Infiltration is the primary release mechanism to groundwater.
United Nuclear Corporation Site	SWMU/CR OU 3	Received about 29,000 drums of cement-fixed sludges and soils demolition materials, and low-level radioactive contaminated soils. Closed in 1992; CERCLA ROD has been issued.
Centralized Sanitary Landfill II	TDEC-permitted Class II industrial SWDF	Central sanitary landfill for the ORR. Detection monitoring under postclosure plan has been ongoing since 1996.
Industrial Landfill V	TDEC-permitted Class II industrial SWDF	New facility completed and initiated operations 4/94. Baseline groundwater monitoring began 5/93 and was completed 1/95. Currently under TDEC-SWM detection monitoring.
Industrial Landfill IV	TDEC-permitted Class II industrial SWDF	Permitted to receive only, nonhazardous industrial solid wastes. Detection monitoring under TDEC-SWM regulations has been ongoing since 1988.

Table 7.4 (continued)

Site	Historical/current regulatory classification[a]	Historical data
Construction/Demolition Landfill VI	TDEC-permitted Class IV construction/demolition SWDF	New facility completed and initiated operations 12/93. Baseline groundwater quality monitoring began 5/93 and was completed 12/93. Currently under permit-required detection monitoring per TDEC.
Construction/Demolition Landfill VII	TDEC-permitted Class IV construction/demolition SWDF	New facility; construction completed in 12/94. TDEC granted approval to operate 1/95. Baseline groundwater quality monitoring began in 5/93 and was completed in 1/95. Permit-required detection monitoring per TDEC was temporarily suspended 10/97 pending closure of construction/demolition Landfill VI.

[a]Regulatory classification before the 1992 Federal Facilities Agreement: TSD—RCRA regulated, land-based treatment, storage, or disposal facility; SWMU—RCRA-regulated solid waste management unit. Current regulatory status: study area—Y-12 Plant study area; CR OU 1—Chestnut Ridge Operable Unit 1; CR OU 2—Chestnut Ridge Operable Unit 2; CR OU 3—Chestnut Ridge Operable Unit 3; CR OU 4—Chestnut Ridge Operable Unit 4; SWDF—solid waste disposal facility (active landfill).

lateral extent of the VOC plume at the site is increasing slightly, as evidenced by detectable signature VOCs in wells GW-609, and GW-796. Concentrations of tetrachloroethene have been steadily decreasing in well GW-609 since monitoring began in 1990.

There are two distinct VOCs in groundwater at the security pits. In the western portion of the site, the VOC plume is characterized by high concentrations of 1,1,1-trichloroethane. Tetrachloroethene is a principal component of the VOC plume in the eastern portion of the site. The distinct difference in the composition of the plume is probably related to differences in the types of wastes disposed of in the eastern and western trench areas.

Nitrate

Nitrate concentrations were well below the DWS of 10 mg/L at all monitoring stations.

Trace Metals

Beryllium, chromium, lead, and nickel concentrations sporadically exceeded DWSs in a number of wells during 1997. Most of the elevated results were attributable to elevated turbidity and suspended solids in the samples. Verification sampling required under detection monitoring programs was performed for a number of the exceedences.

Total strontium and total uranium levels continued to be elevated above background levels at wells GW-142, GW-143, and GW-145 at Kerr Hollow Quarry. These two constituents do not appear to have a radiogenic source in that isotopic and gross activity analyses remained well below applicable DWSs and 4% of the DCGs during 1997. Additionally, in accordance with RCRA Postclosure Permit requirements, confirmatory sampling of Kerr Hollow Quarry wells was performed because of elevated concentrations of boron and strontium in the initial sampling event.

The confirmatory sampling event showed that no release of boron or strontium occurred.

An increase in total uranium above background concentrations was observed in well GW-732 at the Chestnut Ridge Sediment Disposal Basin. This exceedence is attributed to modifications in the background value calculation procedure and the increased turbidity of samples, not to a contaminant release from the facility. Confirmatory sampling has been deferred to the next sampling event in 1998.

The confirmatory sampling of well GW-539 at Centralized Sanitary Landfill II did verify the elevated concentrations of nickel above the DWS. Well GW-539 is upgradient of Centralized Sanitary Landfill II and downgradient of Construction/Demolition Landfill VI. The elevated nickel concentrations are not attributed to a release from Construction/Demolition Landfill VI but to degradation in well performance and corrosion of well materials.

Volatile Organic Compounds

Well GW-305 located immediately to the east of Industrial Landfill IV continues to exhibit an increasing trend in VOCs (Fig. 7.21) since the first quarter of 1992 (exclusively 1,1,1-trichloroethane until the fourth quarter of 1996). Concentrations of the VOCs have remained below applicable DWSs. The source of the VOCs in this well was originally thought to be the Chestnut Ridge Security Pits. However, evaluation of water table levels in wells in the area have shown that the water table at Industrial Landfill IV is typically about 10 feet higher than that at the Security Pits. Therefore, a connection with the Security Pits is not the most feasible explanation. Additional monitoring data are being reviewed and collected in the area to attempt to establish the source of the VOCs.

Efforts to delineate the extent of VOCs in groundwater attributable to the security pits (previously discussed) have been in progress since 1987. A review of historical data suggests that VOC concentrations in groundwater at the site have generally decreased since 1988 (Fig. 7.22). Low levels of VOCs have also been observed at a few additional monitoring locations in 1997. Of particular note, trace levels of VOCs continued to be observed in Kerr Hollow Quarry monitoring wells.

Radionuclides

Only three samples exceeded the gross alpha DWS of 15 pCi/L (LMES 1998a); no well has demonstrated consistent radiological contamination. Gross beta activities were below the DWS of 50 pCi/L at all locations.

Exit pathway and Perimeter Monitoring

Contaminant and groundwater flow paths in the karst bedrock underlying the Chestnut Ridge regime have not been well characterized using conventional monitoring techniques. Dye-tracer studies have been used in the past to attempt to identify exit pathways. Based on the results of dye-tracer studies to date, no springs or surface streams that represent discharge points for groundwater have been conclusively identified for water quality monitoring. Future dye-tracer studies are possible. TDEC/DOE-OR conducted a small-scale tracer study east of the Sediment Disposal Basin in 1995; the results indicated preferential migration of groundwater along strike with discharge to a spring located off the ORR along Scarboro Creek in Union Valley. Off-site locations, including the spring, are monitored as part of the Union Valley focus study (Sect. 7.2.5.2).

Monitoring of one large spring south of Industrial Landfill V and Construction/Demolition Landfill VII was continued in 1997 as required under the EMP. Periodically, additional springs within the Chestnut Ridge regime will be sampled as part of overall exit pathway monitoring for the regime.

7.2.5.5 Special Studies

Planning or initiation of a number of special projects related to groundwater occurred in 1997. These special projects may be divided into three general categories: technical studies, characteriza-

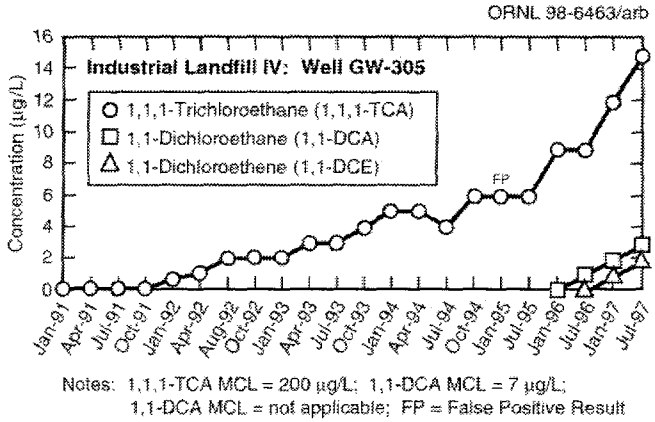

Fig. 7.21. VOC concentrations in Industrial Landfill IV well GW-305.

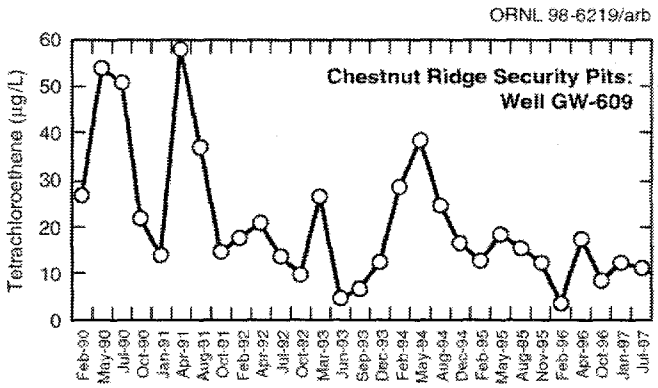

Fig. 7.22. Tetrachloroethene concentrations in Chestnut Ridge Security Pits well GW-609.

tion activities, and technology feasibility studies/demonstrations.

Technical Studies

Another large effort was initiated in 1996 to review the distribution of major utility lines within the Y-12 Plant that may act as preferential pathways for shallow groundwater flow and contaminant transport. This effort was initiated because several instances had been previously documented in which utility pipeline traces acted as either preferential flowpaths or truncated shallow groundwater contaminant plumes. This effort was completed in 1997 and revealed that underground utilities do, in many cases, act as flowpaths for shallow groundwater and contaminants. This information was incorporated into characterizations efforts of the UEFPC RI.

Characterization Activities

During 1997, several projects were undertaken to provide data for the UEFPC CERCLA RI. It was determined that the additional field activities were required to resolve gaps in the existing data. These projects included characterization of groundwater, surface water, fish, and sediments. The groundwater-related activities performed consisted of the installation and sampling of 16 temporary shallow wells and the sampling of other existing wells, stormdrains, and basement sumps.

In support of the RMPE Program, 24 shallow piezometers were installed along UEFPC in late 1997. These piezometers will be monitored in 1998 to evaluate mercury mobilization and transport in the shallow groundwater system.

Technology Feasibility Studies/ Demonstrations

Planning activities began in 1996 to design a groundwater capture and treatment system for the VOC plume emanating from the plant and moving eastward along exit pathways as far as Union Valley. One phase of this feasibility study involves the installation of a deep well [approximately 500 ft (152 m)] on the ORR near the east end of the Y-12 Plant. This well will target the mass of contamination (carbon tetrachloride in particular) in the intermediate and deep intervals of the Maynardville Limestone. Pumping and tracer tests will be performed on this well to assess geologic and hydrologic characteristics of the bedrock for system design and feasibility determinations. In addition, a gravel underdrain system beneath the concrete diversion channel of UEFPC is being considered as part of the groundwater capture system, specifically for shallow groundwater. The underdrain will function as a capture trench. The underdrain system traverses a large portion of the east end of the Y-12 Plant and is already known to transmit large quantities of

shallow groundwater. The combined pumping of these two capture systems will theoretically intercept the VOC plume both in the shallow and deeper flow systems. Planning and design of the deep well was deferred until 1997. Installation and testing of the well will begin in early 1998. If the feasibility study indicates the design is successful, groundwater extraction and treatment may be considered as a long-term remedial action.

A multiphase treatability study within the Bear Creek regime continued in 1997. This effort involved evaluation of remedial technologies for contaminated groundwater and surface water, with particular focus on the primary S-3 Site contaminants. The initial phase of the feasibility study was conducted in 1996 and early 1997 and involved laboratory-scale testing of various types of treatment methods for contaminated groundwater. In addition, remediation of contaminants in surface water using wetlands and biological uptake methods was tested using field-scale experiments. The second phase, which began in 1997, involved the collection of focused hydrologic data around the S-3 Site and the installation of capture trenches and wells for shallow groundwater extraction and treatment. One well was drilled at approximately 45% from vertical (200 linear feet) to intersect a permeable flow zone beneath north tributary 1.

An additional special study (termed technology demonstration) of the applicability of groundwater and soils remedial technologies continued during 1997. The technology demonstration involved the installation of a trench capture and treatment system for shallow groundwater contamination. This technology consists of a treatment cell located between two subsurface impermeable barrier walls downgradient of a collection trench (funnel and gate). The treatment cell contains experimental treatment media housed in removable cartridges for easy maintenance. The entire system is approximately 300 ft (91 m) long and 25 ft (7.6 m) deep (or to bedrock), and installation was completed in late 1997. Monitoring of treatment effectiveness will be continued into 1998.

7.3 GROUNDWATER MONITORING AT THE OAK RIDGE NATIONAL LABORATORY

7.3.1 Background

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes and (2) piezometer wells used to characterize groundwater flow conditions. The EMEF Program, formerly the ER Program, provides comprehensive cleanup of sites where past and current research, development, and waste management activities may have resulted in residual contamination of the environment. Individual monitoring and assessment is assumed to be impractical for each of these sites because their boundaries are indistinct and because there are hydrologic interconnections between many of them. Consequently, the concept of WAGs was developed to facilitate evaluation of potential sources of releases to the environment. A WAG is a grouping of multiple sites that are geographically contiguous and/or that occur within hydrologically (geohydrologically) defined areas. WAGs allow establishment of suitably comprehensive groundwater and surface water monitoring and remediation programs in a far shorter time than that required to deal with every facility, site, or SWMU individually. Some WAGs share boundaries, but each WAG represents a collection of distinct small drainage areas, within which similar contaminants may have been introduced. Monitoring data from each WAG are used to direct further groundwater studies aimed at addressing individual sites or units within a WAG as well as contaminant plumes that extend beyond the perimeter of a WAG.

In 1996, DOE established the Integrated Water Quality Program (Sect. 3.3) to implement a comprehensive and integrated environmental

assessment program for the ORR and minimize duplication of field, analytical, and reporting efforts (DOE 1998b). Under the IWQP, there was a shift away from the use of the WAG concept to more of a watershed approach to remediation, which resulted in the assignment of two watersheds to ORNL, Bethel Valley Watershed and Melton Valley Watershed. Because the ORNL WAGs were already naturally located either in Bethel or Melton valleys, the change did not significantly affect the way monitoring or remediation was viewed at ORNL. Therefore, to provide continuity with previous ASER reports and to allow comparison of activities and sampling results, the following discussions continue to use the WAG concept.

At ORNL, 20 WAGs were identified by the RCRA Facility Assessment (RFA) conducted in 1987. Thirteen of these have been identified as potential sources of groundwater contamination. Additionally, there are a few areas where potential remedial action sites are located outside the major WAGs. These individual sites have been considered separately (instead of expanding the area of the WAG). Water quality monitoring wells have been established around the perimeters of the WAGs determined to have a potential for release of contaminants. Figure 7.23 shows the location of each of the 20 WAGs.

Groundwater quality monitoring wells for the WAGs are designated as hydraulically upgradient or downgradient (perimeter), depending on their location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Downgradient wells are positioned along the perimeter of the site to detect possible groundwater contaminant migration from the site. There are no groundwater quality monitoring wells installed for the WAG 10 grout sheets.

A summary of the ORNL groundwater surveillance program is presented in Table 7.5, in which the WAGs are identified as within Bethel or Melton valleys. The program was reviewed in 1996, and modifications included transfer of monitoring responsibility for some of the WAGs to IWQP. ORNL retained WAGs that have the potential for groundwater contamination because of ongoing ORNL activities. In its current program, groundwater quality wells are sampled by ORNL on a rotational basis (Table 7.5).

WAG 6 has been monitored under RCRA auspices for a number of years. RCRA assessment data for WAG 6 were submitted to TDEC in March 1997. As part of the WAG 6 RCRA/CERCLA integrated monitoring approach, RCRA assessment groundwater monitoring continued from 1995 through 1997 under the auspices of the *Environmental Monitoring Plan for WAG 6 at ORNL* (DOE 1995), a CERCLA-driven monitoring plan, agreed to in principle by DOE, EPA, and TDEC in June 1994. Baseline groundwater monitoring under the plan was initiated in October 1994 and ended in September 1995. All 24 RCRA groundwater monitoring wells were sampled during that time (8 quarterly and 16 semiannually). Routine groundwater monitoring conducted

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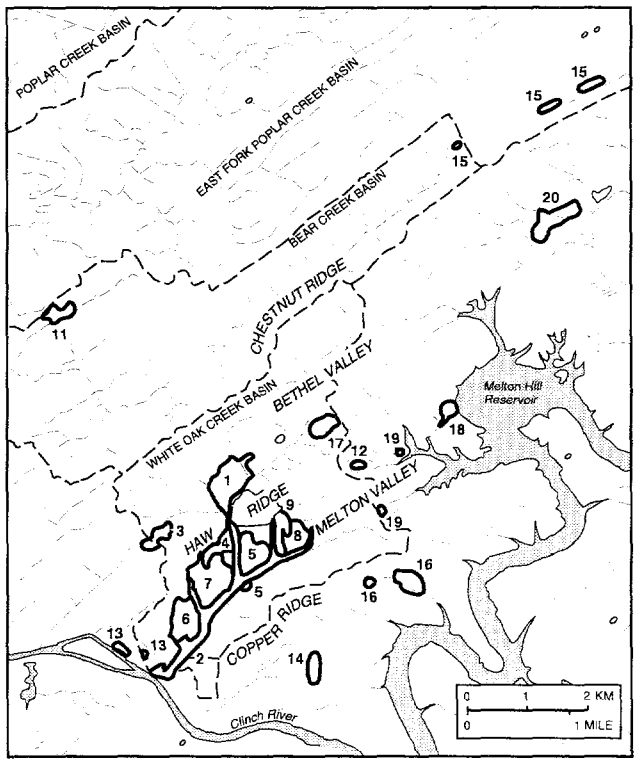

Fig. 7.23. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5.)

Table 7.5. Summary of the groundwater surveillance program at ORNL, 1997

WAG	Regulatory status	Wells		Frequency and last date sampled in 1997	Locations	Parameters
		Upgradient	Downgradient			
			Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	Rotation May 1997	4 wells	Radionuclides[a] and field measurements[b]
3	DOE Orders 5400.1 and 5400.5	3	12	*c*	*c*	*c*
17	DOE Orders 5400.1 and 5400.5	4	4	Rotation Aug 1997	All wells	Volatile organics, radionuclides,[a] and field measurements[b]
			Melton Valley			
2	CERCLA and DOE Orders 5400.1 and 5400.5	12	8	Rotation Feb Apr 1997	4 wells 16 wells	Full set[d] and field measurements[b] radionuclides[a] and field measurements[b]
4	CERCLA and DOE Orders 5400.1 and 5400.5	4	11	*c*	*c*	*c*
5	CERCLA and DOE Orders 5400.1 and 5400.5	2	20	*c*	*c*	*c*
6	RCRA/CERCLA and DOE Orders 5400.1 and 5400.5	7	17	*e*	*e*	*e*

Table 7.5 (continued)

WAG	Regulatory status	Wells		Frequency and last date sampled in 1997	Locations	Parameters
		Upgradient	Downgradient			
7	CERCLA and DOE Orders 5400.1 and 5400.5	2	14	*c*	*c*	*c*
8 and 9	DOE Orders 5400.1 and 5400.5	2	9	Jan–Feb 1997	All wells	Radionuclides[a] and field measurements[b]
			White Wing Scrap Yard			
11	DOE Orders 5400.1 and 5400.5	6	5	*c*	*c*	*c*

[a]Gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.
[b]Standard field measurements: pH, conductivity, turbidity, oxidation/reduction potential, temperature, and dissolved oxygen.
[c]Sampling transferred to IWQP (see DOE 1998b for data and results).
[d]Volatile organics, metals, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.
[e]Sampled by ER and data reported in the 1997 Groundwater Quality Assessment Report for ORNL's Solid Waste Storage Area 6.

under the plan was initiated in October 1995 and continued into 1997. A subset of 12 RCRA groundwater monitoring wells were sampled on a semiannual basis during 1997 under the routine monitoring scenario. The nine downgradient wells involved in routine monitoring are 835, 837, 841, 842, 843, 844, 4315, 4316, and 4317. The remaining wells are located upgradient of the hazardous waste disposal area. These wells are 846, 857, and 858. VOCs and radionuclides were monitored during routine monitoring.

The ORNL exit pathway program is designated to monitor groundwater at locations that are thought to be likely exit pathways for groundwater affected by activities at ORNL. The program was initiated in 1993 and was reviewed in 1996, which resulted in WOC/Melton Valley being the focus of the program (Fig. 7.24). A summary of the current program is presented in Table 7.6.

Groundwater monitoring for the ORNL WAG perimeter monitoring network and the ORNL plant perimeter surveillance during 1997 involved approximately 45 sampling events. In a few cases, no samples could be collected because the wells were dry.

Four of the 10 wells identified by the ORR EMP represent ORNL's exit pathway and are also part of the WAG perimeter monitoring program (WAG 2). As a result, 1997 data from sampling conducted under the WAG perimeter program were used for the exit pathway monitoring plan program. The surface water location (WOC at WOD) was sampled in the fall of 1997. The results of the plant perimeter monitoring program are discussed as part of the discussions below.

Groundwater quality is regulated under RCRA by referring to the SDWA standards. The standards are applied when a site undergoes RCRA permitting. None of the ORNL WAGs are under RCRA permits at this time; therefore, no permit standards exist with which to compare sampling results. In an effort to provide a basis for evaluation of analytical results and for assessment of groundwater quality at ORNL WAGs, federal DWSs and Tennessee water quality criteria for domestic water supplies were used as reference values in the following discussions. When no federal or state standard has been established for

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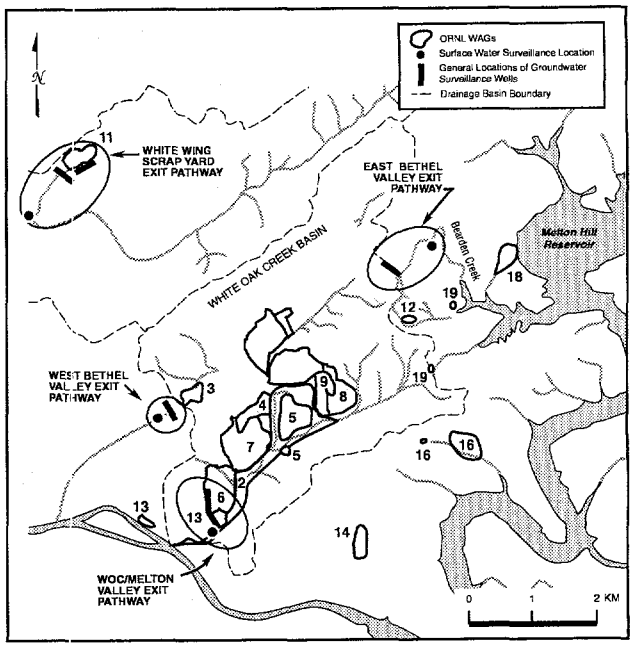

Fig. 7.24. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by Oak Ridge operations.

a radionuclide, then 4% of the DOE DCG has been used. Although DWSs are used, it is unrealistic to assume that members of the public are going to drink groundwater from ORNL WAGs. There are no groundwater wells furnishing drinking water to personnel at ORNL.

7.3.1.1 Bethel Valley

Bethel Valley, which is located in the southeastern portion of the ORR, lies between two prominent, parallel, northeast-southwest trending ridges, Chestnut Ridge to the north and Haw Ridge to the south. It has been an industrial site for 50 years and contains the main ORNL facilities complex, including buildings, reactors, surface impoundments, and buried waste tank farms with transfer pipelines. In most instances, groundwater in the valley flows northeast-southwest (i.e., parallel to the strike direction) and contaminant plumes generally enter the surface water system (DOE 1998b), where contaminants are readily monitored (Chap. 5).

Table 7.6. Summary of the plant perimeter surveillance program at ORNL, 1997

Exit pathway	WAG	Number of wells	Surface water locations	Parameters
White Oak Creek/ Melton Valley	6 and 2[a]	10	White Oak Creek at White Oak Dam	Volatile organics, ICP metals, tritium, total radioactive strontium, gross alpha and beta, ^{60}Co and ^{137}C

[a]Four wells are part of the ORNL WAG 2 perimeter network.

WAG 1 Area

WAG 1, the ORNL main plant area, contains about one-half of the remedial action sites identified to date by the EMEF Program. WAG 1 lies within the Bethel Valley portion of the WOC drainage basin. The boundaries of the basin extend to the southeast and northeast along Chestnut Ridge and Haw Ridge. The WAG boundary extends to the water gap in Haw Ridge. The total area of the basin in Bethel Valley is about 2040 acres. Bedrock beneath the main plant area is limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group.

Many of the WAG 1 sites were used to collect and to store LLW in tanks, ponds, and waste treatment facilities, but some sites also include landfills and contaminated sites resulting from spills and leaks occurring over the last 50 years. Because of the nature of cleanup and repair, it is not possible to determine which spill or leak sites still represent potential sources of release. Most of the SWMUs are related to ORNL's waste management operations. Recent EMEF activities within WAG 1 include several CERCLA actions associated with sources of contamination [e.g., a treatability study associated with the GAAT remedial action, the demolition of the Waste Evaporator Facility (Building 3506) via a CERCLA removal action, and completion of the non-time-critical removal action for stabilization of the 3001 canal].

WAG 1 Results

In 1997, under the revised program, four wells were sampled for radionuclides only. These four wells are in the southwest area of WAG 1. Gross alpha activity ranged from below detection to 3.7 pCi/L, and tritium ranged from below detection to 20,000 pCi/L. None of the other targeted radionuclides were detected. All four wells' results were consistent with historical data.

WAG 3 Area

WAG 3 is located in Bethel Valley about 0.6 mile (1 km) west of the main plant area. WAG 3 is composed of three SWMUs: SWSA 3, the Closed Scrap Metal Area (1562), and the Contractors' Landfill (1554).

SWSA 3 and the Closed Scrap Metal Area are inactive landfills known to contain radioactive solid wastes and surplus materials generated at ORNL from 1946 to 1979. Burial of solid waste ceased at this site in 1951; however, the site continued to be used as an aboveground scrap metal storage area until 1979. Sometime during the period from 1946 to 1949, radioactive solid wastes removed from SWSA 2 were buried at this site. In 1979, most of the scrap metal stored above ground at SWSA 3 was either transferred to other storage areas or buried on site in a triangular-shaped disposal area immediately south of SWSA 3.

Records of the composition of radioactive solid waste buried in SWSA 3 were destroyed in a fire in 1961. Sketches and drawings of the site

indicate that alpha and beta-gamma wastes were segregated and buried in separate areas or trenches. Chemical wastes were probably also buried in SWSA 3 because there are no records of disposal elsewhere. Although the information is sketchy, the larger scrap metal equipment (such as tanks and drums) stored on the surface at this site was also probably contaminated. Because only a portion of this material is now buried in the closed Scrap Metal Area, it is not possible to estimate the amount of contamination that exists in this SWMU.

The Contractors' Landfill was opened in 1975 and is now closed. It was used to dispose of various uncontaminated construction materials. No contaminated waste or asbestos was allowed to be buried at the site. ORNL disposal procedures required that only non-RCRA, nonradioactive solid wastes were to be buried in the Contractors' Landfill.

WAG 3 Results

Groundwater monitoring in WAG 3 was transferred to IWQP in 1996. Monitoring results for 1997 are available in the IWQP annual report (DOE 1998b).

WAG 17 Area

WAG 17 is located about 1 mile (1.6 km) directly east of the ORNL main plant area (Fig. 7.23). This area has served as the major craft and machine shop area for ORNL since the late 1940s. The area includes the receiving and shipping departments, machine shops, carpenter shops, paint shops, lead-melting facilities, garage facilities, welding facilities, and material storage areas that are needed to support ORNL's routine and experimental operations. It is composed of 18 SWMUs. A former septic tank is now used as a sewage collection/pumping station for the area. Photographic waste tanks have been removed. Only two tanks are currently registered to store oil.

WAG 17 Results

WAG 17 is located on a northwest-facing slope, with its upgradient wells on the eastern border and downgradient wells on the western border. Although none of the wells had radiological levels above any DWSs, the data for wells along the eastern and western boundaries show evidence of radioactivity, including gross alpha activity and ^{3}H. In the past, gross alpha activity has exceeded the DWS at two wells; however, this has not occurred in the past four sampling events. The highest gross alpha activity was 10 pCi/L, and ^{3}H was 6200 pCi/L. Gross beta and total radioactive strontium were not detected.

The data for the wells along the southeastern and southwestern boundaries show evidence of VOCs. The contamination has consistently been located primarily in one well (Well 1201) (LMES 1998a). The pollutants include trichloroethene, vinyl chloride, tetrachloroethene, 1,1-dichloroethene and benzene.

7.3.1.2 Melton Valley

Melton Valley is one of two valleys that make up ORNL; the other is Bethel Valley, which is separated from Melton Valley by Haw Ridge. Melton Valley is of primary importance on the ORR because it is one of the major waste storage areas on the reservation. In addition to surface structures, it is the location of shallow waste burial trenches and auger holes, landfills, tanks, impoundments, seepage pits, hydrofracture wells and grout sheets, and waste transfer pipelines and associated leak sites. As with Bethel Valley, groundwater plumes within Melton Valley generally enter the surface water system (DOE 1998b), where contaminants are frequently encountered (Chap. 5).

WAG 2 Area

WAG 2 is composed of WOC discharge points and includes the associated floodplain and subsurface environment. It represents the major drainage system for ORNL and the surrounding facilities.

In addition to natural drainage, WOC has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the NRWTF, the STP, and a variety of process waste holdup ponds throughout the ORNL main plant area (WAG 1). It also receives groundwater discharge and surface drainage from WAGs 1, 4, 5, 6, 7, 8, and 9.

There is little doubt that WAG 2 represents a source of continuing contaminant release (radionuclides and/or chemical contaminants) to the Clinch River. Although it is known that WAG 2 receives groundwater contamination from other WAGs, the extent to which WAG 2 may be contributing to groundwater contamination has yet to be determined. Recent EMEF activities include continued monitoring and support of the WAG 5 seeps removal action, as well as performing an RI of the WOC watershed.

WAG 2 Results

At WAG 2, most of the downgradient wells are to the west and downstream. The upgradient wells are to the east and upstream. As a major drainage system, WAG 2 is influenced by other WAGs, and this seems to be reflected in the analytical results. Major contributors of ^{3}H and total radioactive strontium to WAG 2 (in order of contribution) are WAGs 5, 8, 9, 4, 1, 6, and 7 (see Fig. 7.23).

For example, four of the WAG 2 wells that exhibited high levels of ^{3}H are located south of and downgradient of WAGs 5, 6, and 8. All of the WAG 2 wells show evidence of radioactivity, including gross alpha and gross beta activity and ^{3}H (LMES 1998a). Gross beta activity above primary DWSs was detected at one well south of WAG 6. The elevated levels of ^{3}H and total radioactive strontium in the perimeter wells at WOD are believed to be the result of surface-water underflow at the dam, not groundwater contamination. Gross alpha activity at WAG 2 ranged from not detected to 15 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not detected to 530 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not detected to 170 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 350,000 pCi/L (the DWS is 20,000 pCi/L) (LMES 1998a).

Chromium and lead were detected above DWS at one well south of WAG 6. Chromium has been found to be above the DWS in the past five sampling events at this well (LMES 1998a).

WAG 4 Area

WAG 4 is located in Melton Valley about 0.5 mile (0.8 km) southwest of the main ORNL plant site. It comprises the SWSA 4 waste disposal area, LLLW transfer lines, and the experimental Pilot Pit Area (Area 7811).

SWSA 4 was opened for routine burial of solid radioactive wastes in 1951. From 1955 to 1963, Oak Ridge was designated by the Atomic Energy Commission as the Southern Regional Burial Ground; as such, SWSA 4 received a wide variety of poorly characterized solid wastes (including radioactive waste) from about 50 sources. These wastes consisted of paper, clothing, equipment, filters, animal carcasses, and related laboratory wastes. About 50% of the waste was received from sources outside of Oak Ridge facilities. Wastes were placed in trenches, shallow auger holes, and in piles on the ground for covering at a later date.

From 1954 to 1975, LLLW was transported from storage tanks at the main ORNL complex to waste pits and trenches in Melton Valley (WAG 7), and later to the hydrofracture disposal sites, through underground transfer lines. The Pilot Pit Area (Area 7811) was constructed for use in pilot-scale radioactive waste disposal studies from 1955 to 1959; three large concrete cylinders containing experimental equipment remain embedded in the ground. A removal action was initiated at WAG 4 during 1995 to grout in place sources of ^{90}Sr contamination emanating from selected trenches located within the WAG. A control building and asphalt pad have been used for storage through the years.

WAG 4 Results

Groundwater monitoring in WAG 4 was transferred to IWQP in 1996. Monitoring results for 1997 are available in the IWQP annual report (DOE 1998b).

WAG 5 Area

WAG 5 contains 33 SWMUs, 13 of which are tanks that were used to store LLLW prior to disposal by the hydrofracture process. WAG 5 also includes the surface facilities constructed in support of both the old and new hydrofracture facilities. The largest land areas in WAG 5 are devoted to TRU waste in SWSA 5 South and SWSA 5 North. The remaining sites are support facilities for ORNL's hydrofracture operations, two LLLW pipeline leak/spill sites, and an impoundment in SWSA 5 used to dewater sludge from the original Process Waste Treatment Facility. Currently, LLW tanks at the New Hydrofracture Facility are being used to store evaporator concentrates pending a decision regarding ultimate disposal of these wastes.

SWSA 5 South was used to dispose of solid LLW generated at ORNL from 1959 to 1973. From 1959 to 1963, the burial ground served as the Southeastern Regional Burial Ground for the Atomic Energy Commission. At the time SWSA 5 burial operations were initiated, about 10 acres of the site was set aside for the retrievable storage of TRU wastes.

The WAG 5 boundary includes the Old and New Hydrofracture Facilities. Because Melton Branch flows between the Old and New Hydrofracture Facilities, the New Hydrofracture Facility has a separate boundary. Studies of the contents of several tanks at the Old Hydrofracture Facility (OHF) were performed in preparation for a removal action. The scope of the removal action is to remove the contents of the tanks. The documentation for the non-time-critical removal action for the OHF tanks was completed in 1997. A CERCLA removal action was initiated in 1994 to remove ^{90}Sr from Seeps C and D, located along the southern boundary of WAG 5, and continued during 1997.

WAG 5 Results

Groundwater monitoring in WAG 5 was transferred to the IWQP in 1996. Monitoring results for 1997 are available in the IWQP annual report (DOE 1998b) and also as an independent report by ESD (Stafford and McCarthy 1998) published as Appendix B in the IWQP annual report (DOE 1998b). The ESD 1997 results indicate 5- to 10-fold higher levels of gross alpha activity in groundwater in SWSA 5-N than had been previously reported.

WAG 6 Area

WAG 6 consists of four SWMUs: (1) SWSA 6, (2) Building 7878, (3) the explosives detonation trench, and (4) Building 7842. SWSA 6 is located in Melton Valley, northwest of WOL and southeast of Lagoon Road and Haw Ridge. The site is about 1.2 miles (2 km) south of the main ORNL complex. Waste burials at the 68-acre site were initiated in 1973 when SWSA 5 was closed. Various radioactive and chemical wastes were buried in trenches and auger holes. SWSA 6 is the only currently operating disposal area for LLW at ORNL. The emergency waste basin was constructed in 1961 to provide storage of liquid wastes that could not be released from ORNL to WOC. The basin is located northwest of SWSA 6 and has a capacity of 15 million gal, but has never been used. Radiological sampling of the small drainage from the basin has shown the presence of some radioactivity. The source of this contamination is not known.

WAG 6 was among the first WAGs to be investigated at ORNL by the EMEF Program. WAG 6 is an interim-status RCRA unit because of past disposal of RCRA-regulated hazardous waste. Environmental monitoring is carried out under CERCLA and RCRA. A proposed CERCLA remedial action, which involved capping WAG 6, was abandoned after a public meeting in which members of the community objected to the high cost of capping. Groundwater monitoring continues to be carried out under the auspices of the EMP for WAG 6 at ORNL, which was

implemented after abandonment of the remedial action chosen at WAG 6.

WAG 6 Results

Information about WAG 6 monitoring results in 1997 are available in both the IWQP annual report (DOE 1998b) and the 1997 groundwater quality assessment report for ORNL's Solid Waste Storage Area 6 (DOE 1998c)

WAG 7 Area

WAG 7 is located in Melton Valley about 1 mile (1.6 km) south of the ORNL main plant area. The major sites in WAG 7 are the seven pits and trenches used from 1951 to 1966 for disposal of LLLW. WAG 7 also includes a decontamination facility, three leak sites, a storage area containing shielded transfer tanks and other equipment, and seven fuel wells used to dispose of acid solutions primarily containing enriched uranium from Homogeneous Reactor Experiment fuel. WAG 7 has been used to demonstrate the efficacy of in situ vitrification technology to immobilize radioactive waste streams buried in the WAG. However, because of a release of fission products (^{137}Cs) during testing of the in situ vitrification technology, the project was placed in shutdown mode.

WAG 7 Results

Groundwater monitoring in WAG 7 was transferred to IWQP in 1996. If monitoring results for 1997 are available, they would be in the IWQP annual report (DOE 1998b).

WAGs 8 and 9 Area

WAG 8, located in Melton Valley, south of the main plant area, is composed of 36 SWMUs that are associated with the reactor facilities in Melton Valley. The SWMUs consist of active LLLW collection and storage tanks, leak/spill sites, a contractors' soils area, radioactive waste ponds and impoundments, and chemical and sewage waste treatment facilities. WAG 8 includes the MSRE facility, the HFIR, and the REDC. A removal action was initiated at the MSRE during 1995 to remove filtration devices contaminated with uranium. The CERCLA actions (time-critical removal action, non-time-critical removal action, and remedial action) for MSRE continued in 1997 (see Sect. 3.5 for details).

Radioactive wastes from WAG 8 facilities are collected in on-site LLLW tanks and are periodically pumped to the main plant area (WAG 1) for storage and treatment. The waste includes demineralizer backwash, regeneration effluents, decontamination fluids, experimental coolant, and drainage from the compartmental areas of filter pits.

WAG 9 is located in Melton Valley about 0.6 miles (1 km) southeast of the ORNL main plant area and adjacent to WAG 8. WAG 9 is composed of eight SWMUs, including the Homogeneous Reactor Experiment pond, which was used from 1958 to 1961 to hold contaminated condensate and shield water from the reactor, and LLLW collection and storage tanks, which were used from 1957 to 1986.

Because of the small number of groundwater monitoring wells in WAG 8 and WAG 9, they are sampled together. The analytical results for the two WAGs are also reported together.

WAGs 8 and 9 Results

The two upgradient wells are located north of the WAGs, two of the downgradient wells are located northwest of the WAGs, two are located south of WAG 8, and the remaining five are in WAG 8 west of WAG 9 and in WAG 9. The analytical results for 1997 are comparable to results from the previous years.

All of the perimeter wells show evidence of radioactivity. The data indicate that the gross beta activity is attributable to total radioactive strontium. The two wells on the northwestern perimeter exceeded DWSs: one well with respect to ^{3}H contamination and the other with respect to gross beta activity and total radioactive strontium contamination. Gross alpha activity ranged from not detected to 2.3 pCi/L (the DWS is 15 pCi/L);

beta activity ranged from not detected to 2000 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not detected to 810 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 59,000 pCi/L (the DWS is 20,000 pCi/L). Total radioactive strontium and gross beta activity levels exceeded the DWSs at the westernmost WAG 8 well.

WAG 10 Area

WAG 10 consists of the OHF grout sheets, the New Hydrofracture Facility, and the New Hydrofracture Facility grout sheets. The surface facilities are associated with WAGs 5, 7, and 8.

Hydrofracture Experiment Site 1 is located within the boundary of WAG 7 (south of Lagoon Road) and was the site of the first experimental injection of grout (October 1959) as a testing program for observing the fracture pattern created in the shale and for identifying potential operating problems. Injected waste was water tagged with ^{137}Cs and ^{141}Ce. Grout consisted of diatomaceous earth and cement.

Hydrofracture Experiment Site 2 is located about 0.8 km (0.5 mile) south of the 7500 (experimental reactor) area (WAG 8). The second hydrofracture experiment was designed to duplicate, in scale, an actual disposal operation; however, radioactive tracers were used instead of actual waste. Cement, bentonite, and water tagged with ^{137}Cs were used in formulating the grout.

The OHF is located about 1.6 km (1.0 mile) southwest of the main ORNL complex near the southwest corner of WAG 5. The facility, commissioned in 1963, was used to dispose of liquid radioactive waste in impermeable shale formations at depths of 800 to 1000 ft by hydrofracture methods. Wastes used in the disposal operations included concentrated LLLW from the gunite tanks in WAG 2, ^{90}Sr, ^{137}Cs, ^{244}Cm, TRU, and other, unidentified radionuclides.

The New Hydrofracture Facility is located 900 ft southwest of the OHF on the south side of Melton Branch. The facility was constructed to replace the OHF. Wastes used in the injections were concentrated LLLW and sludge removed from the gunite tanks, ^{90}Sr, ^{137}Cs, ^{244}Cm, TRU, and other nuclides. Plans to plug and abandon several deep injection wells at WAG 10 were made in 1995.

WAG 10 Results

No groundwater monitoring wells were installed in WAG 10.

Exit Pathway Results

In the Melton Valley exit pathway, WOC at WOD had gross beta activity (260 pCi/L) and total radioactive strontium (100 pCi/L). One of the wells also had gross beta activity, total radioactive strontium, and ^{3}H concentrations detected above DWSs. This is consistent with historical data. No VOCs were detected above DWSs in either the wells or the surface-water location.

7.3.1.3. White Wing Scrap Yard

White Wing Scrap Yard (WAG 11) Area

The White Wing Scrap Yard (WAG 11), a largely wooded area of about 30 acres, is located in the McNew Hollow area on the western edge of East Fork Ridge. It is 1.4 km (0.9 miles) east of the junction of White Wing Road and the Oak Ridge Turnpike. Geologically, the White Oak thrust fault bisects WAG 11. Lower-Cambrian-age strata of the Rome Formation occur southwest of the fault and overlie the younger Ordovician-age Chickamauga Limestone northeast of the fault. There is only one SWMU in WAG 11.

The White Wing Scrap Yard was used for aboveground storage of contaminated material from ORNL, the ETTP, and the Y-12 Plant. The material stored at the site by ORNL consisted largely of contaminated steel tanks; trucks; earth-moving equipment; assorted large pieces of steel, stainless steel, and aluminum; and reactor cell vessels removed during cleanup of Building 3019. An interim ROD was agreed to by TDEC, EPA, and DOE requiring surface debris to be removed from the site. This work was completed in 1994.

The area began receiving material (primarily metal, glass, concrete, and trash with alpha, beta,

and gamma contamination) in the early 1950s. Information regarding possible hazardous waste contamination has not been found. The precise dates of material storage are uncertain, as is the time when the area was closed to further storage. In 1966, efforts were begun to clean up the area by disposing of contaminated materials in ORNL's SWSA 5 and by the sale of uncontaminated material to an outside contractor for scrap. Cleanup continued at least into 1970, and removal of contaminated soil began the same year. Some scrap metal, concrete, and other trash is still located in the area. Numerous radioactive areas, steel drums, and PCB-contaminated soil were identified during surface radiological investigations conducted during 1989 and 1990 at WAG 11. The amount of material or contaminated soil remaining in the area is not known.

White Wing Scrapyard (WAG 11) Results

Groundwater monitoring in WAG 11 was transferred to IWQP in 1996. If monitoring results for 1997 are available, they would be in the IWQP annual report (DOE 1998b).

7.3.2 Well Plugging and Abandonment at ORNL

The purpose of the ORNL well plugging and abandonment program is to remove unneeded wells and boreholes as possible sources of cross contamination of groundwater from the surface or between geological formations. Because of the complex geology and groundwater pathways at ORNL, it has been necessary to drill many wells and boreholes to establish the information base needed to predict groundwater properties and behavior. However, many of the wells that were established before the 1980s were not constructed satisfactorily to serve current long-term monitoring requirements. Where existing wells do not meet monitoring requirements, they become candidates for plugging and abandonment.

7.3.2.1 Wells Plugged During 1997

No wells were plugged and abandoned at ORNL during 1997. A total of 232 wells have been recommended for plugging and abandonment as soon as funds are available.

7.3.2.2 Methods Used

Plugging and abandonment are accomplished by splitting the existing well casing and filling the casing and annular voids with grout or bentonite to create a seal between the ground surface and water-bearing formations and between naturally isolated water-bearing formations.

Splitting and abandoning the well casing in place also minimize the generation of waste that would be created if other methods were used. Special tools were developed to split the casings of different sizes and material. A down-hole camera was used during development of the splitting tools to evaluate their effectiveness.

Detailed procedures have been developed and documented regarding the use of specific grout materials in different well environments. These procedures were tested and evaluated during the 1993 plugging and abandonment activities.

7.4 GROUNDWATER MONITORING AT THE ETTP

7.4.1 Background and Hydrogeologic Setting

Groundwater effluent monitoring at the ETTP is focused primarily on investigating and characterizing sites for remediation under CERCLA. As a result of the FFA and certification of closure of the K-1407-B and -C Ponds, the principal driver at the ETTP is CERCLA.

The cleanup strategy described in the site management plan has been developed to accelerate the transition of areas of concern from characterization to remediation by making decisions at the watershed scale based on recommended land use. The watershed is a surface drainage basin that

includes an area of concern or multiple areas of concern to be investigated and/or remediated. This approach allows for the systematic monitoring and evaluation of contaminant sources and migration through the use of integrated surface-water and groundwater monitoring.

ETTP Groundwater Protection Program requirements were incorporated into the IWQP in FY 1997 so that there is no longer a site-level program. The IWQP, which was established to provide a consistent approach to watershed monitoring across the ORR, will be responsible for conducting groundwater surveillance monitoring at the ETTP. Six watersheds have been designated at the ETTP for monitoring and reporting groundwater quality data. The watershed designations and associated areas of concern are described in the following section.

Unlike the other ORR facilities, where many source areas are located in relatively undeveloped areas of the reservation, most source areas at the ETTP are located within the highly industrialized areas of the site. The surface topography has been considerably altered as a result of site construction. Large areas have been excavated or filled to yield the present, low-relief landscape. As much as 60 ft of materials have been excavated locally, with equal amounts of fill placed in adjacent low areas. These filled areas may represent primary pathways for contaminant migration when located below the water table. A number of sinkholes have been identified on historic aerial photos that are not visible on the surface today. Many of these have been filled during site construction, and buildings (such as K-33) have been erected directly above them.

The storm drain network discharges to either Mitchell Branch, the K-1007-P1 pond, the K-901-A pond, or directly to Poplar Creek and the Clinch River. Storm drain video surveys show both infiltrating and exfiltrating water along the lines, suggesting that the storm drains may serve as groundwater sinks (where located below the water table) or sources in other areas of the plant. In addition, at least ten buildings have been determined to have basements with sumps below the seasonal low water table. Water that accumulates in the sumps is discharged either to the sanitary sewer or CNF system, storm drains, or, on rare occasions, to the ground. All of these systems have been active since building construction in the 1940s.

Bedrock underlying the ETTP can be broadly categorized as carbonate (Knox and Chickamauga groups) or clastic (Rome Formation and possibly the Conasauga Group). The carbonates underlie most of the main plant area, including the K-27/29 Peninsula, K-1070-A Burial Ground, the K-25 Building, and the K-1004 laboratory area. The eastern portion of the site, including the K-1070-C/D site and much of the Mitchell Branch area, is underlain by clastics of the Rome formation and possibly the Conasauga Group. The structural geology of the ETTP is perhaps the most complicated on the ORR and includes "map-scale" folds and faults and "outcrop-scale" fractures, folds, and faults. Complex faulting, fracturing, and folding in the clastic bedrock preclude definition of simple bedding geometry. Therefore, groundwater flow paths cannot be predicted in this area of the site.

Cavities have been encountered in 39% of all subsurface penetrations at the ETTP. Cavity heights are typically greater in the Knox Group carbonates. During recent drilling in the vicinity of the K-1070-A Burial Ground, cavernous bedrock with cavities up to 22 ft (6.7 m) in height has been encountered; however, based on camera and sonar surveys, the lateral extent of these cavities appears limited. Although large cavities have been reported in some locations in the Chickamauga bedrock, typical cavity heights are generally less than 5 ft (1.5 m).

Groundwater occurs in both the unconsolidated zone and bedrock, primarily as a single water table aquifer. Perched water may be of local significance. With few exceptions, the water table occurs in the overburden above bedrock across the site, with saturated overburden thickness ranging up to 70 ft. Because bedrock is exposed along the bottom of the Clinch River and Poplar Creek, the unconsolidated zone flowpaths are truncated at these boundaries. Water level data indicate that groundwater flows radially from higher elevations toward the bounding surface water features; however, the sumps and drains that lie below the

seasonal low water table affect the configuration of the water table surface and thus affect the contaminant flow directions.

Groundwater flow in the unconsolidated zone is expected to be in the direction of the mapped hydraulic gradients. In the carbonate bedrock, groundwater flow is expected to be controlled by hydraulic gradients and geologic strike. In the Rome Formation, groundwater flow directions cannot be predicted with any certainty. Recent studies have shown that hydraulic gradients are steepest (and consequently, overall flux is greatest) during the wet season and low pool stage periods. Much of the site is paved or otherwise covered, reducing direct recharge by groundwater; however, leaking underground utilities and storm drains are likely to recharge the groundwater substantially.

Few perennial springs have been identified along Poplar Creek or the Clinch River. Wet-season springs located along the exposed low pool stage shores of Poplar Creek and the Clinch River do not appear consistently from year to year. In general, both springs and seeps at the ETTP are characterized by moderate to low flow rates.

7.4.2 Watersheds

Six watersheds, each defined as a geographic area that encompasses a surface water drainage basin, have been defined at the ETTP. These watersheds are described in the following sections and are indicated on Fig. 7.25.

7.4.2.1 K-1007-B Watershed

The K-1007-B Watershed encompasses the southern area of the ETTP. Areas of concern in this watershed include the K-1004-J Vaults, the K-1004-L UST, the K-1004-L recirculating cooling water (RCW) lines, the K-1004 cooling tower basin, the K-1004 laboratory drain, the K-1007-P1 Pond, the K-1007 UST, and the K-1200 Centrifuge complex. Potential contaminants include heavy metals, acids, organic solvents, other organic chemicals, and radioactivity.

7.4.2.2 Mitchell Branch Watershed

The Mitchell Branch Watershed encompasses the northeastern portion of the ETTP and includes the K-1407-A Neutralization Pit, the former K-1407-B and C Ponds, the K-1407-C soil, the K-1700 stream (Mitchell Branch), the K-1070-B Old Classified Burial Ground, the K-1401 acid line, the K-1401 degreasers, the K-1401 basement, the K-1413 neutralization pit, the K-1420 building process lines, the K-1420 oil storage area, the K-1420 incinerator, the K-1413 treatment tanks, the K-1413 building and process lines, the K-1070-C/D Classified Burial Ground, the K-1070 concrete pad, the K-1070-D storage dikes, the K-1070 pits, and the K-1414 Garage. The potential contaminants include organic solvents, waste oils, heavy metals, PCBs, and radioactivity.

7.4.2.3 Ungaged Watershed

The Ungaged Watershed encompasses areas where groundwater and surface water discharge directly to Poplar Creek and includes the western half of the K-25 Building, the K-1064 peninsula, the K-27/29 peninsula, the K-31 Building, and the eastern half of the K-33 Building. Areas of contamination in this watershed include the K-1066-J cylinder storage yard; the K-1024 dilution pit; the K-1064 drum storage and burn area; the K-1064 drum deheading facility; the K-802-B, K-802-H, K-832-H, K-892-G, K-892-H, K-892-J, and K-862-E cooling tower basins; the K-31 and K-33 RCW lines; the K-732, K-762, and K-792 switchyards; the K-27 and K-29 RCW lines; the K-1410 neutralization pit; the K-1131 facility; the K-1232 chemical recovery facility lagoon; and the K-1231 facility. Potential contaminants include waste oils, heavy metals, organic solvents, PCBs, and radioactivity.

7.4.2.4 K-901/K-1070-A Watershed

The K-901/K-1070-A Watershed encompasses the northwestern portion of the ETTP. The areas of concern include the K-1070-A burial ground, the K-1070-A landfarm, the K-901-A

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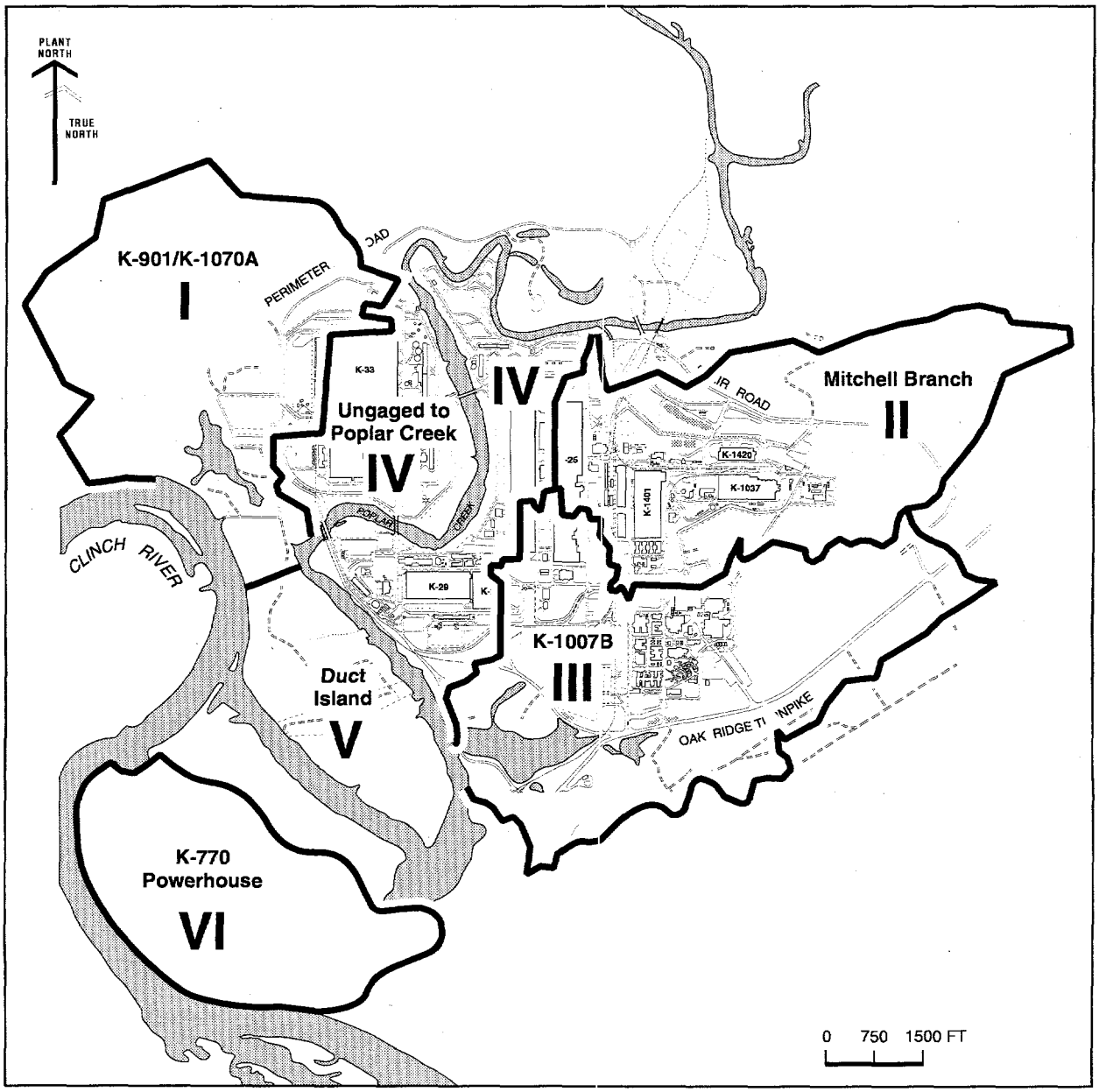

Fig. 7.25. ETTP watershed areas.

holding pond, the K-901 north and south disposal areas, the K-895 cylinder destruct facility, and the K-1066-K cylinder storage yard. Potential contaminants are organics, heavy metals, PCBs, and radioactivity.

7.4.2.5 Duct Island Watershed

The Duct Island Area consists of the K-1070-F peninsula on Poplar Creek and contains the K-1070-F contractors' burial ground, the K-900 bottle smasher, and the Duct Island Road. Potential contaminants are heavy metals, organics, and uranium.

7.4.2.6 K-770/Powerhouse Watershed

The K-770/Powerhouse Watershed borders the Clinch River in the southwestern portion of the ETTP. Areas of concern included in this watershed are the K-770 Scrap Yard, the K-725 Beryllium Building, the K-720 ash pile, the F-05 laboratory, the K-709 switchyard, the K-710 sludge beds and Imhoff tanks, and the K-1085 Firehouse Burn Area. The potential contaminants are waste oils, organics, heavy metals, PCBs, and radioactivity.

7.4.3 Groundwater Monitoring Results

The IWQP annual report (DOE 1998b) contains groundwater data results received for the ETTP for 1997. Results related to the effectiveness and protectiveness of implemented environmental restoration remedies are presented in the context of operational and regulatory history in the IWQP Annual Remediation Effectiveness Report, which is an FFA-required report.

8. Quality Assurance

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Abstract

The overall goal of a well-designed and well-implemented sampling and analysis program is to measure accurately what is really there. Environmental decisions are made on the assumption that analytical results are, within known limits of accuracy and precision, representative of site conditions. Many sources of error exist that could affect the analytical results. Factors to consider as sources of error include improper sample collection, handling, preservation, and transport; inadequate personnel training; and poor analytical methods, data reporting, and record keeping. A quality assurance program is designed to minimize these sources of error and to control all phases of the monitoring process.

8.1 INTRODUCTION

The application of a quality assurance/quality control (QA/QC) program for environmental monitoring activities at the ORR is essential to generating data of known and defensible quality. Each aspect of the environmental monitoring program, from sample collection to data management, must address and meet applicable quality standards.

The 1997 QA/QC results for the three sites have been compiled into a summary that represents the performance of the reservation as a whole. Before 1996, the results were reported separately for each of the three site analytical laboratories. In 1995, the three site service laboratories were combined into a single entity, the Analytical Services Organization. The 1997 results are based on data from the Analytical Services Organization, ESD, the ORNL Industrial Hygiene Department, and the ETTP Technical Division.

8.2 FIELD SAMPLING QUALITY ASSURANCE

Field sampling QA encompasses many practices that minimize error and evaluate sampling performance. Some key quality practices include the following:

- use of standard operating procedures (SOPs) for sample collection and analysis;
- use of chain-of-custody and sample-identification procedures;
- instrument standardization, calibration, and verification;
- technician and analyst training;
- sample preservation, handling, and decontamination; and
- use of QC samples such as field and trip blanks, duplicates, and equipment rinses.

Because of changing technologies and regulatory protocols, training of field personnel is a continuing process. To ensure that qualified personnel are available for the array of sampling tasks to be accomplished, training programs by EPA as well as private contractors have been used to supplement internal training. Examples of topics addressed include the following:

- planning, preparation, and record keeping for field sampling;
- well construction and groundwater sampling;
- surface water, leachate, and sediment sampling;
- soil sampling;
- stack sampling;
- decontamination procedures; and
- health and safety considerations.

8.3 ANALYTICAL QUALITY ASSURANCE

The Lockheed Martin analytical laboratories have well-established QA/QC programs, well-trained and highly qualified staff, and excellent equipment and facilities. Current, approved analytical methodologies employing good laboratory and measurement control practices are used routinely to ensure analytical reliability. The analytical laboratories conduct extensive internal QC programs with a high degree of accuracy, participate in several external QA programs, and use statistics to evaluate and to continuously improve performance. Thus, QA and QC are daily responsibilities of all employees.

8.3.1 Internal Quality Control

Analytical activities are supported by the use of standard materials or reference materials (e.g., materials of known composition that are used in the calibration of instruments, methods standardization, spike additions for recovery tests, and other practices). Certified standards from the National Institute of Standards and Technology (NIST), EPA , or other DOE laboratories are used for such work. The laboratories operate under specific QA/QC criteria at each installation. Additionally, separate QA/QC documents relating to analysis of environmental samples associated with regulatory requirements are developed.

QA/QC measurement control programs external to the sample analysis groups have single-blind control samples submitted to the analytical laboratories to monitor performance. The results of such periodic measurement programs are statistically evaluated and reported to the laboratories and their customers. Most reports are issued quarterly, and some laboratories compile annual summary reports. These reports assist in evaluating the adequacy of analytical support programs and procedures. If serious deviations are noted by the QC groups, the operating laboratories are promptly notified so that corrective actions can be initiated and problems can be resolved. QC data are stored in an easily retrievable manner so that they can be related to the analytical results they support.

8.3.2 External Quality Assurance

In addition to the internal programs, all Lockheed Martin analytical laboratories are directed by DOE and are expected by EPA to participate in external QA programs. The QA programs generate data that are readily recognizable as objective packets of results. The external QA programs typically consist of the Lockheed Martin laboratories analyzing a sample of unknown composition provided by various QA organizations. The organizations know the true composition of the sample and provide the Lockheed Martin laboratories with a data report on their analytical performance. The sources of these programs are laboratories in EPA, DOE, and the commercial sector. Lockheed Martin participates in ten such programs (Table 8.1). The following sections describe the external QA programs in which Lockheed Martin participates.

8.3.2.1 EPA Contract Laboratory Program

The Contract Laboratory Program (CLP) is an EPA-administered QA element used to evaluate laboratory analytical proficiency in comparison with an analyte and the current state of work. The program operates from the EPA Contract Laboratory Analytical Services Support office at Alexandria, Virginia, in cooperation with the EPA regional offices. This program evaluates laboratories for the determination of organic and inorganic contaminants in aqueous and solid hazardous waste materials and enforces stringent QA/QC requirements to ensure comparable data. This program scores on additional criteria other than an "acceptable-unacceptable" evaluation of the measurement result. By the CLP scoring algorithm, performance of 75% or better indicates acceptable performance. Values below this score indicate that deficiencies exist and that the participant has failed to demonstrate the capability to meet the contract requirements.

Table 8.1. QA/QC results for the Oak Ridge Reservation, 1997

Program	Total number of analytes	Acceptable	
		Total	Percentage
EPA Contract Laboratory Program (CLP)[a,b]			95.90
EPA Water Supply Laboratory Performance Quality Control Program (Water Supply)	128	119	92.97
EPA Water Pollution Performance Evaluation Quality Control Program (Water Pollution)[c] and Discharge Monitoring Quality Assurance Study[c]	278	258	92.81
AIHA Proficiency Analytical Testing Program[d]	240	237	98.75
EPA National Exposure Research Laboratory Intercomparison Radionuclide Control Program	114	109	95.61
AIHA Environmental Lead Proficiency Analytical Testing Program (ELPAT)	64	64	100
DOE Mixed Analyte Performance Evaluation Program (MAPEP)	92	90	97.83
DOE Environmental Measurements Laboratory (EML) Quality Assessment Program	185	174	82.70
Proficiency Environmental Testing Program (PET)	1152	1134	98.44

[a]The CLP scores its results on other factors besides quantitation. An average score was determined by averaging each site's average score from the CLP.

[b]Not all data available.

[c]Includes toxicology data from the ORNL Environmental Sciences Division in addition to the Analytical Services Organization.

[d]Includes asbestos data from the ETTP Technical Division and organics and asbestos data from the ORNL Industrial Hygiene Department, as well as data from the Analytical Services Organization.

8.3.2.2 EPA Water Supply Laboratory Performance Quality Control Program

This program is administered by EPA and is used by the state of Tennessee to certify laboratories for drinking water analysis. To maintain a certification, a laboratory must meet a specified set of criteria relating to technical personnel, equipment, work areas, QA/QC operating procedures, and successful analysis of QA samples. In addition, inclusion on the state of Tennessee's UST approved listing may be granted as a result of successful participation in this program. This program is also used by other states as part of their certification programs.

8.3.2.3 Combined EPA Water Pollution Performance Evaluation Quality Control Program and EPA Discharge Monitoring Report Quality Assurance Study

During 1996, the EPA Water Pollution Performance Evaluation Quality Control Program was combined with the EPA Discharge Monitor-

ing Report Quality Assurance Study, although they are two separate distinct programs.

The Water Pollution Performance Evaluation Quality Control Program is used by EPA to evaluate laboratories engaged in analysis of polluted water samples at existing and former DOE sites. It is administered by the EPA laboratory in Cincinnati, Ohio, (Region 5) and is used by some states as part of their laboratory certification process.

EPA conducts the national Discharge Monitoring Report Quality Assurance Study in support of the NPDES permits. Use of the program is mandatory for major permit holders. EPA supplies the QA samples and furnishes the evaluated results to the permittee, who is required to report the results and any necessary corrective actions to the state or regional coordinator.

8.3.2.4 American Industrial Hygiene Association Proficiency Analytical Testing Program

The American Industrial Hygiene Association (AIHA) administers the Proficiency Analytical Testing Program as part of its AIHA accreditation process for laboratories performing analyses of industrial hygiene air samples.

8.3.2.5 EPA Intercomparison Radionuclide Control Program

The EPA Intercomparison Radionuclide Control Program is administered by the National Exposure Research Laboratory at Las Vegas (NERL-LV). Samples are composed of a water matrix. The state of Tennessee requires participation for drinking water certification of radionuclide analysis. This program is also used by other states as part of their laboratory certification process. The NERL-LV program calculates a normalized standard deviation for each laboratory based on all reported results. By its criteria, any reported value above three standard deviations is considered unacceptable.

8.3.2.6 AIHA Environmental Lead Proficiency Analytical Testing Program

The Environmental Lead Proficiency Analytical Testing Program (ELPAT) is administered by AIHA. It was established by AIHA in 1992 to evaluate analysis of environmental lead samples in different matrices. The matrices evaluated are paint, soil, and dust wipes. The participating laboratory can analyze each matrix at four levels. In addition, a laboratory may request to become accredited for lead analysis in this program.

8.3.2.7 DOE Mixed Analyte Performance Evaluation Program

The Mixed Analyte Performance Evaluation Program (MAPEP) is a program set up by the DOE Radiological and Environmental Sciences Laboratory in conjunction with the Laboratory Management Division of the Office of Technology Development to evaluate analysis of mixed-waste samples. MAPEP is evaluated by Argonne National Laboratory. Participation is required by DOE for laboratories that perform environmental analytical measurements in support of EM activities.

8.3.2.8 DOE Environmental Measurements Laboratory Quality Assessment Program

Participation in the radionuclide Quality Assessment Program, administered by the DOE Environmental Measurements Laboratory (EML) in New York, is required by DOE Order 5400.1. Various matrices, such as soil, water, air filters, and vegetation, are submitted semiannually for analysis of a variety of radioactive isotopes. All matrices, except air filters, are actual materials obtained from the environment at a DOE facility. A statistical report is submitted to the sites by EML for each study.

8.3.2.9 Proficiency Environmental Testing Program

The Proficiency Environmental Testing Program is a service purchased from an outside vendor and is used by all Lockheed Martin analytical laboratories and the DOE laboratory at Fernald, Ohio, to meet the need for a QA program for all environmental analyses. The samples are supplied by the commercial company at two concentration levels (high and low). All data from each of the laboratories are reported to the supplier. The commercial supplier provides a report on the evaluated data to the site QA/QC managers. The report includes a percentage recovery of the referenced value, deviation from the mean of all reported data, specific problems in a site laboratory, and other statistical information. A corporate report is also provided that compares the data from the Lockheed Martin laboratories with those of other corporate laboratories.

8.3.3 Quality Assessment Program for Subcontracted Laboratories

A buy/make assessment has been established for each project that requires analytical work. Based on the results of this assessment, work is managed in-house or is placed with a subcontractor through the DOE Sample Management Office (SMO). A competitive award system has been established to place analytical work. The SMO provides single-source sample management for the reservation by supporting several organizations, including Jacobs Engineering, Bechtel National, and the EM section of EMEF at LMES. The SMO anticipates placing work with 13 commercial laboratories on a yearly basis. Laboratories approved by the SMO are required to comply with the requirements set forth in the Analytical Support Agreement terms and conditions. Oversight of subcontracted commercial laboratories is performed by DOE, which is supported by the SMO. DOE, SMO, and subcontractors conduct on-site laboratory reviews and monitor the performance of all subcontracted laboratories.

8.4 DATA MANAGEMENT, VERIFICATION, AND VALIDATION

Verification and validation of environmental data are performed as components of the data collection process, which includes planning, sampling, analysis, and data review. Verification and validation of field and analytical data collected for environmental monitoring and restoration programs are necessary to ensure that data conform with applicable regulatory and contractual requirements. Validation of field and analytical data is a technical review performed to compare data with established quality criteria to ensure that data are adequate for intended use. The extent of project data verification and validation activities is based on project-specific requirements.

Over the years, the environmental data verification and data validation processes used by ORR environmental programs have evolved to meet continuing regulatory changes and monitoring objectives. For routine environmental effluent monitoring and surveillance monitoring, data verification activities may include processes of checking whether (1) data have been accurately transcribed and recorded, (2) appropriate procedures have been followed, (3) electronic and hard-copy data show one-to-one correspondence, and (4) data are consistent with expected trends. For example, the requirements for self-monitoring of surface-water and wastewater effluents under the terms of an NPDES permit require the permittee to conduct the analyses as defined in 40 CFR 136 and to certify that the data reported in the monthly discharge monitoring report are true and accurate.

Typically, routine data verification actions alone are sufficient to document the truthfulness and accuracy of the discharge monitoring report. For restoration projects, routine verification activities are more contractually oriented and

include checks for data completeness, consistency, and compliance against a predetermined standard or contract.

Certain projects may perform a more thorough technical validation of the data as mandated by the project's data quality objectives. For example, sampling and analyses conducted as part of a remedial investigation to support the CERCLA process may generate data that are needed to evaluate risk to human health and the environment, to document that no further remediation is necessary, or to support a multimillion-dollar construction activity and treatment alternative. In that case, the data quality objectives of the project may mandate a more thorough technical evaluation of the data against predetermined criteria. For example, EPA has established functional guidelines for validation of organic and inorganic data collected under the protocol of the EPA's CLP. These guidelines are used to offer assistance to the data user in evaluating and interpreting the data generated from monitoring activities that require CLP performance.

The validation process may result in identifying data that do not meet predetermined QC criteria (in flagging quantitative data that must be considered qualitative only) or in the ultimate rejection of data from its intended use. Typical criteria evaluated in the validation of CLP data include the percentage of surrogate recoveries, spike recoveries, method blanks, instrument tuning, instrument calibration, continuing calibration verifications, internal standard response, comparison of duplicate samples, and sample holding times.

Integration of compliance-monitoring data for the ORR with sampling and analysis results from remedial investigations is a function of the Oak Ridge Environmental Information System (OREIS). OREIS is necessary to fulfill requirements prescribed in both the FFA and TOA and to support data management activities for DOE. The FFA, a tripartite agreement between DOE, EPA Region 4, and the state of Tennessee, requires DOE to maintain one consolidated database for environmental data generated at DOE facilities on the ORR. According to the FFA, the consolidated database is to include data generated pursuant to the FFA as well as data generated under federal and state environmental permits. The TOA further defines DOE staff obligations to develop a quality assured, consolidated data base of monitoring information that will be shared electronically on a near-real-time basis with the state staff.

OREIS is the primary component of the data management program for restoration projects, providing consolidated, consistent, and well-documented environmental data and data products to support planning, decision making, and reporting activities. OREIS provides a direct electronic link of ORR monitoring and remedial investigation results to EPA Region 4 and TDEC/DOE-ORO.

Appendix A: Radiation

Appendix A: Radiation

This appendix presents basic facts about radiation. The information is intended to be a basis for understanding the potential doses associated with releases of radionuclides from the Oak Ridge Reservation (ORR), not as a comprehensive discussion of radiation and its effects on the environment and biological systems.

Radiation comes from natural and human-made sources. People are exposed to naturally occurring radiation constantly. For example, cosmic radiation; radon in air; potassium in food and water; and uranium, thorium, and radium in the earth's crust are all sources of radiation. The following discussion describes important aspects of radiation, including atoms and isotopes; types, sources, and pathways of radiation; radiation measurement; and dose information.

ATOMS AND ISOTOPES

All matter is made up of atoms. An atom is "a unit of matter consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (ANS 1986). The number of protons in the nucleus determines an element's atomic number or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the neutrons may vary in number among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element that have different numbers of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights (Fig. A.1).

For example, the element uranium has 92 protons. All isotopes of uranium, therefore, have 92 protons. However, each uranium isotope has a different number of neutrons. Uranium-238 has 92 protons and 146 neutrons; uranium-235 has 92 protons and 143 neutrons; and uranium-234 has 92 protons and 142 neutrons.

Some isotopes are stable, or nonradioactive; some are radioactive. Radioactive isotopes are called radionuclides, or radioisotopes. In an attempt to become stable, radionuclides "throw away," or emit, rays or particles. This emission of rays and particles is known as radioactive decay. Each radioisotope has a "radioactive half-life," which is the average time that it takes for half of a specified number of atoms to decay. Half-lives can be very short (fractions of a second) or very long (thousands of years), depending on the isotope (Table A.1).

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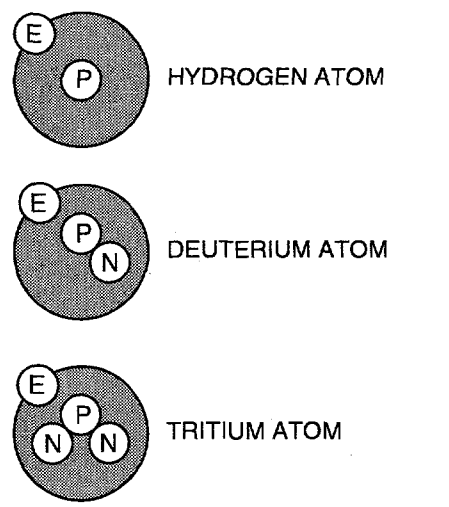

	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1
TRITIUM	1	2

Fig. A.1. The hydrogen atom and its isotopes.

Table A.1. Radionuclide nomenclature

Radionuclide	Symbol	Half-life	Radionuclide	Symbol	Half-life
Americium-241	^{241}Am	432.2 years	Plutonium-238	^{238}Pu	87.75 years
Americium-243	^{243}Am	7.38E+3 years	Plutonium-239	^{239}Pu	2.41E+4 years
Antimony-125	^{125}Sb	2.77 years	Plutonium-240	^{240}Pu	6.569E+3 years
Argon-41	^{41}Ar	1.827 hours	Potassium-40	^{40}K	1.2777E+9 years
Beryllium-7	^{7}Be	53.44 days	Promethium-147	^{147}Pm	2.6234 years
Californium-252	^{252}Cf	2.639 years	Protactinium-234*m*	^{234}mPa	1.17 minutes
Carbon-14	^{14}C	5.730E+3 years	Radium-226	^{226}Ra	1.6E+3 years
Cerium-141	^{141}Ce	32.50 days	Radium-228	^{228}Ra	5.75 years
Cerium-143	^{143}Ce	1.38 days	Ruthenium-103	^{103}Ru	39.35 days
Cerium-144	^{144}Ce	284.3 days	Ruthenium-106	^{106}Ru	368.2 days
Cesium- 134	^{134}Cs	2.062 years	Strontium-89	^{89}Sr	50.55 days
Cesium-137	^{137}Cs	30.17 years	Strontium-90	^{90}Sr	28.6 years
Cobalt-58	^{58}Co	70.80 days	Technetium-99	^{99}Tc	2.13E+5 years
Cobalt-60	^{60}Co	5.271 years	Thorium-228	^{228}Th	1.9132 years
Curium-242	^{242}Cm	163.2 days	Thorium-230	^{230}Th	7.54E+4 years
Curium-244	^{244}Cm	18.11 years	Thorium-232	^{232}Th	1.405E+10 years
Iodine-129	^{129}I	157E+7 years	Thorium-234	^{234}Th	2.41E+1 day
Iodine-131	^{131}I	8.04 days	Tritium	^{3}H	12.28 years
Krypton-85	^{85}Kr	10.72 years	Uranium-234	^{234}U	2.445E+5 years
Krypton-88	^{88}Kr	2.84 hours	Uranium-235	^{235}U	7.038E+8 years
Manganese-54	^{54}Mn	312.7 days	Uranium-236	^{236}U	2.3415E+7 years
Neptunium-237	^{237}Np	2.14E+6 days	Uranium-238	^{238}U	4.468E+9 years
Niobium-95	^{95}Nb	35.06 days	Xenon-133	^{133}Xe	5.245E+9 years
Osmium-185	^{185}Os	93.6 days	Xenon-135	^{135}Xe	9.11 hours
Phosphorus-32	^{32}P	14.29 days	Yttrium-90	^{90}Y	64.1 hours
Polonium-210	^{210}Po	138.378 days	Zirconium-95	^{95}Zr	64.02 days

Source: DOE 1989. Radioactive Decay Data Tables: A Handbook of Decay Data for Application to Radioactive Dosimetry and Radiological Assessments, DOE/TIC-11026.

RADIATION

Radiation, or radiant energy, is energy in the form of waves or particles moving through space. Visible light, heat, radio waves, and alpha particles are examples of radiation. When people feel warmth from the sunlight, they are actually absorbing the radiant energy emitted by the sun.

Electromagnetic radiation is radiation in the form of electromagnetic waves. Examples include gamma rays, ultraviolet light, and radio waves. Particulate radiation is radiation in the form of particles. Examples include alpha and beta particles. Radiation also is characterized as ionizing or nonionizing because of the way in which it interacts with matter.

Ionizing Radiation

Normally, an atom has an equal number of protons and electrons; however, atoms can lose or gain electrons in a process known as ionization. Some forms of radiation (called ionizing radiation) can ionize atoms by "knocking" electrons off atoms. Examples of ionizing radiation include alpha, beta, and gamma radiation.

Ionizing radiation is capable of changing the chemical state of matter and subsequently causing biological damage. By this mechanism, it is potentially harmful to human health.

Nonionizing Radiation

Nonionizing radiation bounces off or passes through matter without displacing electrons. Examples include visible light and radio waves. At this time it is unclear whether or not nonionizing radiation is harmful to human health. In the discussion that follows, the term radiation is used to describe ionizing radiation.

SOURCES OF RADIATION

Radiation is everywhere. Most occurs naturally; a small percentage is human-made. Naturally occurring radiation is known as background radiation.

Background Radiation

Many materials are naturally radioactive. In fact, this naturally occurring radiation is the major source of radiation in the environment. Although people have little control over the amount of background radiation to which they are exposed, this exposure must be put into perspective. Background radiation remains relatively constant over time and is present in the environment today much as it was hundreds of years ago.

Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Background radiation is categorized as cosmic, terrestrial, or internal, depending on its origin.

Principal Radiation Types Emitted by Radionuclides

Alpha

A particle consisting of two protons and two neutrons emitted from the nucleus.

Low penetration: the mean range of a 5-MeV alpha particle in air is about 3.5 cm; in tissue its range is about 44 μm.

For environmental dosimetry, particularly important as an internal emitter, especially in the respiratory passages, on bone surfaces, and in red marrow. Its energy is concentrated along short paths and can deliver high localized doses to sensitive surface regions.

Beta

An electron emitted from the nucleus.

The average range of a 1-MeV beta particle is about 3 m in air but only about 3 mm in tissue.

For environmental dosimetry, of primary concern as an internal emitter. Because of their relatively short range in tissue, beta particles principally irradiate the organs in which they originate.

Gamma and X rays

Electromagnetic radiation, emitted as energy packets called photons, similar to light and radio waves but from a different energy region of the electromagnetic spectrum. X rays originate in the orbital electron field surrounding the nucleus; gamma rays are emitted from the nucleus.

Gamma radiation: to absorb 95% of the gamma energy from a ^{60}Co source, 6 cm of lead, 10 cm of iron, or 33 cm of concrete would be needed.

For environmental dosimetry, gamma and X rays important both for internal and external exposure. Gamma emitters deposited in one organ of the body can significantly irradiate other organs.

Cosmic Radiation

Energetically charged particles from outer space continuously hit the earth's atmosphere. These particles and the secondary particles and photons they create are called cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. In other words, a person in Denver, Colorado, is exposed to more cosmic radiation than a person in New Orleans, Louisiana.

Terrestrial Radiation

Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn), radon progeny (the relatively short-lived decay products from the decay of radon ^{222}Rn), potassium (^{40}K), isotopes of thorium (Th), and isotopes of uranium (U) are the elements responsible for most terrestrial radiation.

Internal Radiation

Radionuclides in the environment enter the body with the air people breathe and the foods they eat. They also can enter through an open wound. Natural radionuclides that can be inhaled and ingested include isotopes of uranium and its progeny, especially radon (^{222}Rn) and its progeny, thoron (^{220}Rn) and its progeny, potassium (^{40}K), rubidium (^{87}Rb), and carbon (^{14}C). Radionuclides contained in the body are dominated by ^{40}K and ^{210}Po; others include rubidium (^{87}Rb) and carbon (^{14}C) (NCRP 1987).

Human-Made Radiation

In addition to background radiation, there are human-made sources of radiation to which most people are exposed. Examples include consumer products, medical sources, fallout from atmospheric atomic bomb tests, and industrial by-products. No atmospheric testing of atomic weapons has occurred since 1980 (NCRP 1987).

Consumer Products

Some consumer products are sources of radiation. The radiation in some of these products, such as smoke detectors and airport X-ray baggage inspection systems, is essential to the performance of the device. In other products, such as televisions and tobacco products, the radiation occurs incidentally to the product function.

Medical Sources

Radiation is an important tool of diagnostic medicine and treatment and is the main source of exposure to the public from human-made radiation. Exposure is deliberate and directly beneficial to the patients exposed. In general, medical exposures from diagnostic or therapeutic X rays result from beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Nuclear medicine examinations and treatments involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body. Radiation and radioactive materials also are used in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves.

Other Sources

Radioactive fallout, the by-product of nuclear-weapon testing in the atmosphere, is a source of radiation. Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; transportation of radioactive materials; and emissions from mineral-extraction facilities.

PATHWAYS OF RADIONUCLIDES

People can be exposed to radionuclides in the environment through a number of routes (Fig. A.2). Potential routes for internal and/or external exposure are referred to as pathways. For example, radionuclides in the air could fall on a pasture. The grass then could be eaten by cows, and the radionuclides deposited on the grass would show up in milk. People drinking the milk would be exposed to this radiation. People also could simply inhale airborne radionuclides. Similarly, radionuclides in water could be ingested by fish, and people eating the fish would also ingest the radionuclides in the fish tissue. People swimming in the water would be exposed also.

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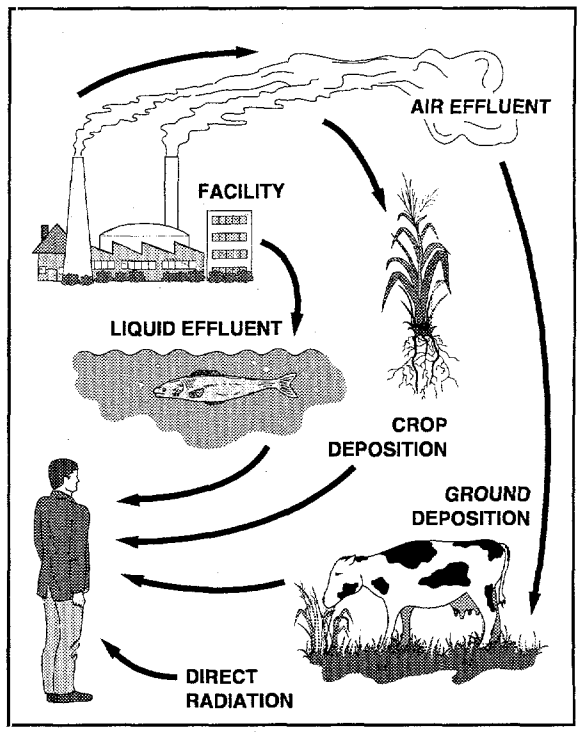

Fig. A.2. Examples of radiation pathways.

MEASURING RADIATION

To determine the possible effects of radiation on the health of the environment and people, the radiation must be measured. More precisely, its potential to cause damage must be ascertained.

Activity

When we measure the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among the various radioisotopes. For that reason, one gram of a radioactive substance may contain the same amount of activity as several tons of another material. This activity is expressed in a unit of measure known as a curie (Ci). More specifically, one curie equals 3.7×10^{10} (37,000,000,000) atomic disintegrations per second (dps). In the international system of units, 1 dps equals 1 becquerel (Bq).

Absorbed Dose

The total amount of energy absorbed per unit mass of the exposed material as a result of exposure to radiation is expressed in a unit of measure known as a rad. In this case, it is the effect of the absorbed energy (the biological damage that it causes) that is important, not the actual amount. In the international system of units, 100 rad equals 1 gray (Gy).

Dose Equivalent

The measure of potential biological damage to specific body organs or tissues caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem. One rem of any type of radiation has the same total damaging effect. Because a rem represents a fairly large dose equivalent, dose equivalents are usually expressed as millirem (mrem), which is 1/1000 of a rem. In the international system of units, 1 sievert (Sv) equals 100 rem; 1 millisievert (mSv) equals 100 mrem. Specific types of dose equivalents are defined as follows:

- committed dose equivalent—the total dose equivalent to an organ during the 50-year period following intake.
- effective dose equivalent (EDE)—the weighted sum of dose equivalents to a specified list of organs. The organs and weighting factors are selected on the basis of risk to the entire body. "EDE" is the unit used in the *Annual Site Environmental Report*.
  - — committed effective dose equivalent: the total effective dose to specified organs in the human body during the 50-year period following intake.
  - — collective effective dose equivalent: the sum of effective dose equivalents of all members of a given population.

Units of Radiation Measure

To comply with DOE orders, this report will present results using the current system followed by Système International (SI) units in parentheses. For example, the dose from a typical chest X ray is 10 mrem (0.10 mSv).

Current System	SI System	Conversion
Activity		
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
Absorbed dose		
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
Dose equivalent		
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Converting Dose Equivalent

Because a rem represents a fairly large dose of radiation, dose is best expressed as a millirem, or 1/1000 of a rem. The same is true of sieverts. Dose is expressed in millisieverts (mSv). Because 1 mrem equals 0.01 mSv, converting from millirem to millisieverts is simply a matter of moving the decimal point two places to the left. For example, 267 mrem equals 2.67 mSv.

Dose Determination

Determining dose is an involved process in which complex mathematical equations based on several factors, including the type of radiation, the rate of exposure, weather conditions, and typical diet, are used. Basically, radioactive decay, or activity, generates radiant energy. People absorb some of the energy to which they are exposed. The effect of this absorbed energy is responsible for an individual's dose. Whether radiation is natural or human-made, it has the same effect on people.

Many terms are used to report dose. The terms take several factors into account, including the amount of radiation absorbed, the organ absorbing the radiation, and the effect of the radiation over a 50-year period. The term "dose," in this report, means the committed EDE, which is the total effective dose equivalent that will be received during a specified time (50 years) from radionuclides taken into the body in the current year, and the EDE attributable to penetrating radiation from sources external to the body.

Dose Conversion Factor

A dose conversion factor (DCF) is defined as the dose equivalent received from exposure to a unit quantity of a radionuclide by way of a specific exposure pathway. Two types of DCFs exist. One type gives the committed dose equivalent (rem) resulting from intake (by inhalation and ingestion) of a unit activity (1.0 μCi) of a radionuclide. The second gives the dose equivalent rate (millirem per year) per unit activity (1.0 μCi) of a radionuclide in a unit (cubic or square centimeters) of an environmental compartment (air volume or ground surface). All DCFs used in this report were approved by DOE or by EPA (DOE 1988a; DOE 1988b; EPA 1993).

Comparison of Dose Levels

Table A.2 presents a scale of dose levels, with an example of the type of exposure that may cause such a dose, or the special significance of such a dose. This information is intended to help the reader become familiar with a range of doses that various individuals may receive.

The maximally exposed person living near the ORR area could receive an annual EDE of about 4.1 mrem (0.041 mSv) from radionuclides released from the ORR during 1997.

Dose from Cosmic Radiation

The average annual dose equivalent to people in the United States from cosmic radiation is about 27 mrem (0.27 mSv) (NCRP 1987). The average dose equivalent caused by cosmic radiation in Tennessee is about 45 mrem per year (0.45 mSv per year) (Tsakeres 1980). When shielding and the time spent indoors are considered, the dose for the surrounding population is reduced to 80%, or about 36 mrem (0.36 mSv) per year.

Dose from Terrestrial Radiation

The average annual dose from terrestrial gamma radiation is about 28 mrem (0.28 mSv) in the United States but varies geographically across the country (NCRP 1987). Typical reported values are about 16 mrem (0.16 mSv) on the Atlantic and Gulf coastal plains and about 63 mrem (0.63 mSv) on the eastern slopes of the Rocky Mountains. The average external gamma exposure rate in the vicinity of the ORR is about 7.8 μR/h, which results in an equivalent dose of about 51 mrem per year (0.51 mSv per year).

Dose from Internal Radiation

The major contributors to the annual dose equivalent for internal radionuclides are the short-lived decay products of radon, which contribute an average dose of about 200 mrem (2.00 mSv) per year. This dose estimate is based on an average radon concentration of about 1 pCi/L (0.037 Bq/L) (NCRP 1987).

The average dose from other internal radionuclides is about 39 mrem (0.39 mSv) per year, which is predominantly attributed to the naturally occurring radioactive isotope of potassium, ^{40}K. The concentration of radioactive potassium in human tissues is similar in all parts of the world (NCRP 1987).

Dose from Consumer Products

The U.S. average annual dose to an individual from consumer products is about 10 mrem (0.10 mSv) (NCRP 1987); however, not all members of the U.S. population are exposed to all of these sources.

Table A.2. Comparison and description of various dose levels

Dose level	Description
1 mrem	Approximate daily dose from natural background radiation, including radon
2.5 mrem	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles
10 mrem	Annual exposure limit set by the U.S. Environmental Protection Agency (EPA) for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants, uranium mines, and mills
45 mrem	Average yearly dose from cosmic radiation received by people in the Paducah area
46 mrem	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear accident
66 mrem	Average yearly dose to people in the United States from human-made sources
100 mrem	Annual limit of dose from all U.S. Department of Energy (DOE) facilities to a member of the public who is not a radiation worker
110 mrem	Average occupational dose received by U.S. commercial radiation workers in 1980
244 mrem	Average dose from an upper gastrointestinal diagnostic X-ray series
300 mrem	Average yearly dose to people in the United States from all sources of natural background radiation
1 to 5 rem	Level at which EPA Protective Action Guidelines state that public officials should take emergency action when this is a probable dose to a member of the public from a nuclear accident
5 rem	Annual limit for occupational exposure of radiation workers set by the U.S. Nuclear Regulatory Commission and DOE
10 rem	Estimated level at which an acute dose would result in a lifetime excess risk of death from cancer of 0.8%
25 rem	EPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency
75 rem	EPA guideline for maximum dose to emergency workers volunteering for lifesaving work
50 to 600 rem	Level at which doses received over a short period of time produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people will die within 60 days

Adapted from Westinghouse Savannah River Company 1994. *Savannah River Site Environmental Report for 1993, Summary Pamphlet*, WSRC-TR-94-076.

Dose from Medical Sources

Nuclear medicine examinations, which involve internal administration of radiopharmaceuticals, generally account for the largest portion of dose from human-made sources. However, the radionuclides used for specific tests are not distributed uniformly throughout the body. In these cases, the concept of EDE, which relates the significance of exposures of organs or body parts to the effect on the entire body, is useful in making comparisons. The average annual EDE from medical examinations is 53 mrem (0.53 mSv), including 39 mrem (0.39 mSv) for diagnostic X rays and 14 mrem (0.14 mSv) for nuclear medicine procedures (NCRP 1989). The actual doses to individuals who receive such medical exams are much higher than these values, but not everyone receives such exams each year (NCRP 1989).

Dose from Other Sources

A few additional sources of radiation contribute minor doses to individuals in the United States. The dose to the general public from nuclear fuel cycle facilities, such as uranium mines, mills, fuel-processing plants, nuclear power plants, and transportation routes, has been estimated at less than 1 mrem (0.01 mSv) per year (NCRP 1987).

A comprehensive U.S. Environmental Protection Agency report projected an average occupational dose to monitored radiation workers in medicine, industry, the nuclear fuel cycle, government, and miscellaneous industries to be 105 mrem (1.05 mSv) per year for 1985, down slightly from 110 mrem (1.10 mSv) per year in 1980 (Kumazawa et al. 1984).

Small doses to individuals occur as a result of radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive materials from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to the average dose to an individual (NCRP 1987).

Appendix B: Chemicals

Appendix B: Chemicals

This appendix presents basic facts about chemicals. The information is intended to be a basis for understanding the dose or relative toxicity assessment associated with releases from the Oak Ridge Reservation (ORR), not a comprehensive discussion of chemicals and their effects on the environment and biological systems.

PERSPECTIVE ON CHEMICALS

The lives of modern humans have been greatly improved by the development of chemicals such as pharmaceuticals, building materials, housewares, pesticides, and industrial chemicals. Through the use of chemicals, we can increase food production, cure diseases, build more efficient houses, and send people to the moon. At the same time, we must be cautious to ensure that our own existence is not endangered by uncontrolled and overexpanded use of chemicals (Chan et al. 1982).

Just as all humans are exposed to radiation in the normal daily routine, humans are also exposed to chemicals. Some potentially hazardous chemicals exist in the natural environment. In many areas of the country, soils contain naturally elevated concentrations of metals such as selenium, arsenic, or molybdenum, which may be hazardous to humans or animals. However, exposures to many more hazardous chemicals result from the direct or indirect actions of humans. Building materials used for the construction of homes may contain chemicals such as formaldehyde (in some insulation materials), asbestos (formerly used in insulations and ceiling tiles), and lead (formerly used in paints and gasoline). Some chemicals are present as a result of application of pesticides and fertilizers to soil. Other chemicals may have been transported long distances through the atmosphere from industrial sources before being deposited on soil or water.

PATHWAYS OF CHEMICALS FROM THE ORR TO THE PUBLIC

Pathways refer to the route or way in which a person can come in contact with a chemical substance. Chemicals released to the air may remain suspended for long periods of time, or they may be deposited on plants, soil, and water. Chemicals may also be released as liquid wastes called effluents, which can enter streams and rivers.

People are exposed to chemicals by inhalation (breathing air), ingestion (eating exposed plants and animals or drinking water), or by direct contact (touching the soil or swimming in water). For example, fish that live in a river that receives effluents may take in some of the chemicals present. People eating the fish would then be exposed to the chemical. Less likely would be exposure by directly drinking from the stream or river.

The public is not normally exposed to chemicals on the ORR because access to the reservation is limited. However, chemicals released as a result of ORR operations can move through the environment to off-site locations, resulting in potential exposure to the public.

DEFINITIONS

Toxicity

Chemicals have varying types of effects. Generally, when considering human health, chemicals are divided into two broad categories: chemicals that cause health effects but do not cause cancer (noncarcinogens) and chemicals that cause cancer (carcinogens). The potential health effects of noncarcinogens range from irritation to life-shortening. Carcinogens cause or increase the incidence of malignant neoplasms or cancers.

Toxicity refers to an adverse effect of a chemical on human health. Not all chemicals are toxic: every day we ingest chemicals in the form of food, water, and sometimes medications. Even those chemicals that are usually considered toxic are usually nontoxic or harmless below a certain concentration.

Concentration limits or advisories are set by government agencies for some chemicals that are known or are thought to have an adverse effect on human health. These concentration limits can be used to calculate a chemical dose that would not harm even individuals who are particularly sensitive to the chemical.

Dose Terms for Noncarcinogens

Reference Dose

A reference dose (RfD) is an estimate (with uncertainty spanning an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Units are expressed as milligrams per kilogram per day (mg kg^{-1} day^{-1}).

Values for RfDs are derived from doses of chemicals that result in no adverse effect or the lowest dose that showed an adverse effect on humans or laboratory animals. Because these doses are in most cases derived from animal studies, safety factors are added for application to humans. Safety factors range from 10 to 1000 (i.e., safe doses for humans are set at 10 to 1000 times lower than doses showing no effect or a non-life-threatening effect in animals). This is thought to protect the most sensitive individuals. The EPA maintains the Integrated Risk Information System (IRIS) data base (EPA 1991), which contains verified RfDs and slope factors and up-to-date health risk and EPA regulatory information for numerous chemicals.

Primary and secondary maximum contaminant level

For chemicals for which RfDs are not available, national primary drinking water regulation concentrations [maximum contaminant levels (MCLs)] and secondary drinking water regulation concentrations [secondary MCLs (SMCLs)], expressed in milligrams per liter, are converted to RfD values by multiplying by 2 L (the average daily adult water intake) and dividing by 70 kg (the reference adult body weight). The result is a "derived" reference dose expressed in milligrams per kilogram per day (mg kg^{-1} day^{-1}).

Dose Term for Carcinogens

Slope Factor

A slope factor (SF) is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical during a lifetime. The SF is used to estimate an upper-bound probability of an individual

developing cancer as a result of a lifetime exposure to a particular level of a potential carcinogen. Units are expressed as risk per dose (mg kg^{-1} day^{-1}).

The SF converts the estimated daily intake averaged over a lifetime exposure to the incremental risk of an individual developing cancer. Because it is unknown whether a threshold (a dose below which no adverse effect occurs) exists for carcinogens, units for carcinogens are set in terms of risk factors. For potential carcinogens at the ORR, a specific risk of developing cancer over a human lifetime of 1 in 100,000 (10^{-5}) was used to establish acceptable levels of exposure. That is, EPA estimates that a certain concentration in food or water could cause a risk of one additional cancer case for every 100,000 exposed persons.

MEASURING CHEMICALS

Environmental samples are collected in areas surrounding the ORR and are analyzed for chemical constituents that are most likely to be released from the ORR. Typically, chemical concentrations in liquids are expressed in terms of milligrams or micrograms of chemical per liter of water; concentrations in solids (soil and fish tissue) are expressed in terms of milligrams or micrograms of chemical per gram or kilogram of sample material.

The instruments used to measure chemical concentrations are very sensitive; however, they have limits below which they cannot detect the chemicals of interest. Concentrations that are below the detection limits of the instruments are recorded as "less-than" (<) values or with tildes (~). Exposure calculations are given "less-than" values unless at least one sample exceeds the detection limit. The tilde indicates that estimated values and/or detection limits were used in estimating the average concentration of a chemical.

RISK ASSESSMENT METHODOLOGY

Exposure Assessment

To evaluate an individual's exposure by way of a specific exposure pathway, the intake amount of the chemical must be determined. For example, chemical exposure by drinking water and eating fish from the Clinch River is assessed in the following way. It is assumed that individuals outside the ORR boundary are exposed to statistically significant concentrations of contaminants. It is also assumed that they drink 2 L (0.53 gal) of water per day directly from the river, which amounts to 730 L (193 gal) per year, and that they eat 94 g of fish per day (34 kg per year), which is based on a survey of recreational freshwater anglers about their fish consumption rates (EPA 1995). Estimated daily intakes or estimated doses to the public can be calculated by multiplying measured concentrations in water by 2 L or those in fish by 94 g. This intake is first multiplied by the exposure duration (30 years) and exposure frequency (350 days/year), and then divided by an averaging time (30 years for noncarcinogens and 70 years for carcinogens). These assumptions are conservative, and in many cases they result in higher estimated intakes and doses than an actual individual would receive.

Dose Estimate

When the contaminant oral daily intake via exposure pathways has been estimated, the dose can be determined. For chemicals, the dose to humans is measured as milligrams per kilogram per day (mg kg^{-1} day^{-1}). In this case, the "kilogram" refers to the body weight of an adult individual. When a chemical dose is calculated, the length of time an individual is exposed to a certain concentration is important. To assess

off-site doses, it is assumed that the exposure duration occurs over 30 years. Such exposures are called "chronic" in contrast to short-term exposures, which are called "acute."

Calculation Methodology

In previous annual environmental reports, the "calculated daily intakes," based on chemical concentrations in water or fish, were divided by the "acceptable daily intake," which was based on the RfD. Both intakes were expressed in milligrams per day by multiplying by 70 kg for body weight. Current risk assessment methodologies use the term hazard quotient (HQ) to evaluate noncarcinogenic health effects. Therefore, in this environmental report the HQ methodology is used. Because intakes are calculated in milligrams per kilogram per day in the HQ methodology, they are expressed in terms of dose. The HQ is a ratio that compares the estimated exposure dose or intake (I) to the RfD as follows:

$$HQ = \frac{I}{RfD} \quad ,$$

where

HQ = hazard quotient (unitless),
I = estimated dose (mg kg^{-1} day^{-1}),
RfD = reference dose (mg kg^{-1} day^{-1}).

HQ values of less than 1 indicate an unlikely potential for adverse health effects, whereas HQ values greater than 1 indicate a concern for adverse health effects or the need for further study.

To evaluate carcinogenic risk, SFs are used instead of RfDs. In this report, the estimated dose from ingesting water or fish from rivers and streams surrounding ORR is compared to the chronic daily intake (CDI) derived from assuming a human lifetime risk of developing cancer of 10^{-5} (1 in 100,000). The SF is converted to a CDI as follows:

$$CDI = \frac{1 \times 10^{-5}}{SF} \quad ,$$

where

CDI = chronic daily intake (mg kg^{-1} day^{-1}),
SF = slope factor, oral (risk per mg kg^{-1} day^{-1}).

In typical risk assessments, risks are generally derived; however, in this report 10^{-5} is assumed as the level of acceptable risk. To estimate the risk of inducing cancers, from ingestion of water and fish, relative to the risk of 10^{-5}, the estimated dose or intake (I) is divided by the CDI. A ratio greater than 1 indicates a risk greater than 10^{-5} and a value less than 1 indicates a risk less than 10^{-5}. The tilde, "~," indicates that estimated values and/or detection limits were used in estimating the average concentrations of a chemical. This symbol is listed beside the estimated HQ or I/CDI values to indicate the type of data used.

Appendix C: Air Permits

Table C.1. Air permits at the Y-12 Plant

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
		Part I—operating permits at Y-12 Plant		
Y-9201-1-A	01-0020-15	730303P	582	Weld booths sanders and grinders
			583	Metal sanders and grinders
			584	Plasma torch
Y-9201-1-B	01-0020-59	730310P	586	Tool grinding machine shop
Y-9201-1-C	01-0020-17	036057P	278	Graphite carbon machine shop
			279	Graphite carbon machine shop
Y-9201-1W-A	01-0020-99	036129P	272	Paint spray booth
Y-9201-5-F	–	–	821	Lindberg Furnaces
			822	Lindberg Furnaces
Y-9201-5-G	01-0020-44	730308P	412	DeVilbiss hood
			413	Acid pickling tanks
			75	Arc melt
			76	Scrap metal recycle
Y-9201-5-H	01-0020-16	026019P	600	Vapor blasters
			762	Mixing process material
			763	Setup and sample area
			764	Vapor blaster
			765	Nickel plating tank exhaust
			766	Material handling
			767	Material handling
			768	Glovebox and blending station
			769	Inspection house vacuum
Y-9201-5E-B	01-0020-21	730305P	72	Chip vacuum system
Y-9201-5N-A	01-1020-18	730314P	67	Machine shop exhaust
Y-9201-5N-B	01-0020-30	030484P	239	Plating tanks and hoods
			240	Plating tanks and hoods
			241	Plating tanks and hoods
			242	Incinerator
			243	Grit blaster
			244	Grit blaster and area exhaust
			245	Process hoods
			454	Plating hoods
Y-9202-A	01-0020-06	031696P	160	Laboratory beryllium
			161	Laboratory beryllium

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9204-2-B	01-0020-71	025954P	313	Caustic scrubber stack exhaust
			314	Caustic scrubber exhaust
			317	Lithium metal wash station
			318	Lithium cell pan wash station
Y-9204-2-D	01-1020-57	730327P	342	Salvage vats
			344	Lithium chloride crystallizer
			345	Lithium chloride crystallizer
			346	Neutralizer
			347	Process tank
			348	Salvage crystallizer
			349	Reactor wash station
			350	Reactor wash station
Y-9204-2-E	01-1020-55	730325P	357	Glove box and oven
			359	Machine dust dumping station
			361	Gloveboxes
			363	Glovebox and four ovens
			364	Dry powder process
9204-2-E1	01-1020-55	730325P	351	Rotary dryer
			358	Gloveboxes, sonic sifter
			360	Rotary dryer
			362	Glovebox
Y-9204-2-G	01-1020-79	730329P	371	Metal working machine shop
			372	Metal working machine shop
Y-9204-2E-A	01-0020-68	730312P	101	Lathes
			436	Exhaust hoods
			439	Hood exhaust
Y-9204-4-A	01-1020-56	032416P	415	Wash tank
			416	Exhaust from press pit area
			417	Dye penetrant hood exhaust
			85	Vent from two grit blasters
			86	Exhaust from press pit area
			87	Exhaust from press pit area
			88	Exhaust from press pit area
			91	Exhaust from ingot cooler
			93	Dust removal exhaust
			95	Salt baths

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9206-B	01-0020-03	731689P	13	South stack incinerator
			15	West stack
			17	Steam cleaning hoods
			209	HF purge vent
			211	Hood 29 and 30
Y-9212-A	01-1020-72	036942P	111	Reduction fluid bed
			112	Conversion fluid beds
			132	Decontamination facility
			134	B-Wing and C-1 Wing exhaust
			141	Reduction fluid bed
			142	Conversion fluid beds
			19	Filter exhaust
			21	Centrifuges
			22	Reduction salvage crusher
			24	Calciner and dry vacuum system enclosure
			25	Denitrator area and fluid bed room enclosure
			27	D-Wing room 1010 hoods
			28	Reduction shear and room
			33	Headhouse equipment incinerator
			40	B-1 sampling lab hood
			430	HF dock cylinder/vaporizer
			431	N_2O_4 cylinder purge vent
			432	Muffle furnaces (2) vent room 229
			518	HF dock cylinder/vaporizer
			519	Potassium hydroxide storage
			520	Potassium hydroxide storage
Y-9212-B	01-0020-02	730301P	110	U metal and U metal alloy
			38	U metal drying and briquetting process
			43	Exhaust from machine shop
			48	Chip washing and drying
Y-9212-C	01-0020-05	025984P	113	Dissolver trays/scrubber
			114	Shear and hacksaw hood
			128	Precipitation process
			26	Drum receiving/sampling hood and glovebox
			290	Tube furnace/gas purge vent
			44	Leaching and dissolving hoods
			45	Muffle furnace dry hoods
			46	Tray dissolver hoods
			47	Dissolver tray hoods/room 1

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9212-M	01-0020-21	730305P	1083	Air bearing operations
Y-9215-A	01-0020-37	731839P	3	Machine shop hood exhaust
Y-9215-B	01-1020-51	732125P	1	O-wing metal working operations
			2	Abar water quench vacuum
			4	O-wing metal working operations
			6	Base of rolling mill
Y-9215-C	01-1020-52	730323P	6	Base of rolling mill
			7	Metal process area
Y-9215-D	01-1020-53	025966P	10	Roll mill exhaust
			11	Furnace/quench tank/conveyor exhaust
			12	Hydraulic shear exhaust
			9	Rolling mill/salt bath
Y-9401-2-A	01-0020-88	730286P	205	Plating equipment
			220	Plating equipment
			221	Plating equipment
			222	Plating equipment
			223	Plating equipment
			224	Plating equipment
			225	Plating equipment
			226	Plating equipment
			227	Plating equipment
			228	Plating equipment
			229	Plating equipment
			230	Plating equipment
			231	Plating equipment
			232	Plating equipment
			233	Plating equipment
			234	Plating equipment
			235	Plating equipment
Y-9401-3-A	01-1020-31	034809P	170	Coal or natural gas fired boiler
Y-9401-3-B	01-1020-32	034809P	170	Coal or natural gas fired boiler
Y-9401-3-C	01-1020-33	034809P	171	Coal or natural gas fired boiler
Y-9401-3-D	01-1020-34	034809P	171	Coal or natural gas fired boiler
Y-9401-5-A	–	–	109	Uranium chip oxidixer
Y-9404-9-C	01-1020-19	730315P	324	Urethane warming ovens
			325	Urethane warming oven #3
			326	PVC oven #4
			327	PVC oven #5

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9720-32-C	01-1020-99	742886I	435	Classified paper waste incinerator
Y-9738-A	01-0020-14	036776P	576	Sand blaster
			577	Hood with fan
Y-9767-13-A	01-0020-35	036292P	00	Chilled water circulating system
Y-9767-4-B	01-0020-38	036293P	00	Chilled water circulating system
Y-9811-6-A	01-1020-82	029415P	377	Dry ash handling system
			378	Dry ash handling system
Y-9815-A	01-0020-11	025895P	780	Vent from dissolvers
Y-9825-1-A	–	–	127	Oxide storage vault
Y-9825-2-A	–	–	127	Oxide storage vault
Y-9998-A	01-0020-13	038154P	60	5 swagging machines
			61	Foundry operations
			62	Hood
			64	Nitric acid pickling tank
			812	Swagging machines
			813	Sintering furnaces
Y-9998-B	01-1020-84	025984P	172	Machining beryllium source
Part II—Construction permits at Y-12 Plant				
Y-9201-1-A	01-0020-15	730303P	582	Weld booths, sanders and grinders
			583	Metal sanders and grinders
			584	Plasma torch
Y-9201-1-B	01-0020-59	730310P	586	Tool grinding machine shop
Y-9201-5-G	01-0020-44	730308P	412	DeVilbiss hood
			413	Acid pickling tanks
			75	Arc melt
			76	Scrap metal recycle
Y-9201-5E-B	01-0020-21	730305P	72	Chip vacuum system
Y-9201-5N-A	01-1020-18	730314P	67	Machine shop exhaust
Y-9204-2-D	01-1020-57	730327P	342	Salvage vats
			344	Lithium chloride crystallizer
			345	Lithium chloride crystallizer
			346	Neutralizer
			347	Process tank
			348	Salvage crystallizer
			349	Reactor wash station
			350	Reactor wash station

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9204-2-E	01-1020-55	730325P	351	Glove box and oven
			359	Machine dust dumping station
			361	Gloveboxes
			363	Glove box and four ovens
			364	Dry powder process
Y-9204-2-E1	01-1020-55	730325P	351	Rotary dryer
			358	Glove boxes, sonic sifter
			360	Rotary dryer
			362	Glove box
Y-9204-2-G	01-1020-79	730329P	371	Metal working machine shop
			372	Metal working machine shop
Y-9204-2E-A	01-0020-68	730312P	101	Lathes
			436	Exhaust hoods
			439	Hood exhaust
Y-9206-B	01-0020-03	731689P	13	South stack incinerator
			15	West stack
			17	Steam cleaning hoods
			209	HF purge vent
			211	Hood 29 and 30
Y-9212-A	01-1020-72	743807P	111	Reduction fluid beds
			112	Conversion fluid beds
			132	Decontamination facility
			134	B-wing and C-1 wing exhaust
			141	Reduction fluid beds
			142	Conversion fluid beds
			19	Filter exhaust
			21	Centrifuges
			22	Reduction salvage crusher
			24	Calciner and dry vacuum system enclosure
			25	Denitrator area and fluid bed room enclosure
			27	D-wing room 1010 hoods
			28	Reduction shear and room
			33	Headhouse equipment incinerator
			40	B-1 sampling lab hoods
			430	HF dock cylinder/vaporizer
			431	N2O4 cylinder purge vent
			432	Muffle furnaces (2) vent room 229

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			518	HF dock cylinder/vaporizer
			519	Potassium hydroxide storage
			520	Potassium hydroxide storage
Y-9212-B	01-0020-02	730301P	110	U metal and U metal alloy
			38	U metal drying and briquetting process
			43	Exhaust from machine shop
			48	Chip washing and drying
Y-9212-M	01-0020-21	730305P	1083	Air bearing operations
Y-9215-A	01-0020-37	731839P	3	Machine shop hood exhaust
Y-9215-B	01-1020-51	732125P	1	O-wing metal working operations
			2	Abar water quech vacuum
			4	O-wing metal working operations
			6	Base of rolling mill
Y-9215-C	01-1020-52	730323P	6	Base of rolling mill
			7	Metal process area
Y-9401-2-A	01-0020-88	730286P	205	Plating equipment
			220	Plating equipment
			221	Plating equipment
			222	Plating equipment
			223	Plating equipment
			224	Plating equipment
			225	Plating equipment
			226	Plating equipment
			227	Plating equipment
			228	Plating equipment
			229	Plating equipment
			230	Plating equipment
			231	Plating equipment
			232	Plating equipment
			233	Plating equipment
			234	Plating equipment
			235	Plating equipment
Y-9404-9-C	01-1020-19	730315P	324	Urethane warming ovens
			325	Urethane warming oven #3
			326	PVC oven #4
			327	PVC oven #5
Y-9720-32-C	01-1020-99	742886I	435	Classified paper waste incinerator
Y-9815-A	01-0020-11	7432133P	780	Vent from dissolver

Table C.2. ORNL air permits

ORNL Source Number	Emission Source Reference Number	TDEC Permit Number	Source Description
X-2519-1/5	73-0112-03	030284P	Steam plant
X-2525-SV11	73-0112-49	035026P	Electroplating shop
X-3039	73-0112-93	739974P	Off-gas and hot cell ventilation
X-3502	73-0112-05	947267P	Manipulator boot shop
X-3544-SV1	73-0112-70	730468P	Process waste treatment plant
X-3587-SV1	73-0112-56	029830P	Printed circuit board facility
X-3608-01	73-0112-37	730489P	Nonrad wastewater treatment plant, air stripper column
X-4508-SV8	73-0112-61	040077P	Acid etching process
X-4508-SV9	73-0112-55	024306P	Sandblaster
X-7007	73-0112-09	743190P	Paint shop
X-7015-03	73-1106-47	947142P	Plasma arc torch
X-7021-00	73-0112-58	038357P	Grinding shop and sandblaster
X-7600-01	73-0112-20	017930P	Nuclear fuel reprocessing
X-7602-01	73-0112-24	027090F	Boiler, hot water
X-7603-01	73-0112-25	740219F	Steam boiler
X-7667-0	6007	6007	Chemical detonation facility
X-7877-SV1	73-0112-71	043761P	Liquid waste solidification project
X-7911-00	73-0112-82	034381P	High flux isotope reactor, 7920 and 7930
X-7934-SV2	73-0112-53	024912P	Silver recovery system
X-7935-SV1	73-0112-78	027393P	Equipment cleaning facility
X-FE	73-0112-97	029660P	Fugitive emission source

Table C.3. ETTP air permits

ETTP source number	Emission source reference number	Permit number	Source description	Permit type
K1037AVLISPRODCON	73-1106-36	935597P	Products conversion demonstration	Permit to construct
K1095PS1234	73-0106-14	734461P	Paint spray operation, one oven, two spray booths, and one silk screen degreaser	Operating
K1202ST1	73-1106-20	033203P	Tank stores waste oils and solvents for incinerator	Operating
K1202ST2	73-1106-41	034392P	Tank stores waste oils and solvents for incinerator	Operating
K1420AI	73-0106-82	034619P	Flammable materials storage tank	Operating
K1425WOSC	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSA	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSD	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1425WOSB	73-0106-11	029895P	Waste oil and solvent storage tanks	Operating
K1435TSCAINCIN	73-0106-78	0324491	TSCA Incinerator	Operating
K1435CTANKFARM	73-0106-75	037460P	Tank farm for hazardous liquid wastes	Operating
K1501BOILER7	73-0106-17	042076F	Gas/oil boiler	Operating
K1501BOILER8	73-0106-12	937114F	Gas/oil boiler	Operating
K1501BOILER9	73-0106-12	038751F	Gas/oil boiler	Operating
K1407CNFAIRSTRIPPER	73-0106-90	045253P	Air stripper for removing VOCs at CNF	Operating
K1775TVS	73-0106-91	944465P	LLMW vitrification system	Permit to construct
ETTPFUGITIVEEMISSIONS	73-1106-38	043016P	Number of sources logged into permit	Operating

Table C.4. Periods of excess emissions and out-of-service conditions for Y-12 Plant Steam Plant east and west opacity monitors in 1997

Date	Stack	Condition	Comments
February 24	West	One six-minute period of excess emissions.	Bag failure in Compartment 4 of Baghouse 1.
February 25	West	One six-minute period of excess emissions.	Bag failure in Compartment 5 of Baghouse 1.
April 22 and 23	East and West	Opacity monitoring equipment was out of service.	Annual calibration of the opacity monitors.
April 23	West	One six-minute period of excess emissions.	Bag failure (bad bags) in Baghouse 2.
May 14	West	One six-minute period of excess emissions.	Start-up of fans on Boiler 1 after overhaul.
June 10	East and West	Monitoring system inoperative.	Shutter alarm/monitor malfunction.
June 11	West	Five six-minute periods of excess emissions.	Baghouse 1 malfunction.
June 15	East	One six-minute period of excess emissions.	High inlet temperature causing Baghouse 3 bypass dampers to open.
June 16	West	Two six-minute periods of excess emissions.	Operators cleaning the steam generating tubes on Boiler 2 after overhaul.
September 24	West	Two six-minute periods of excess emissions.	Start-up of fans and restart of fans after tachometer failure on Boiler 2 following overhaul.
December 19 and 20	West	Opacity monitoring equipment was out of service.	West opacity monitor stack blower malfunction.

Appendix D: Reference Standards and Data for Water

Table D.1. Reference standards for radionuclides in water (pCi/L)

Parameter[a]	National primary drinking water standard[b]	4% of DCG[c]	DCG[d]
^{241}Am		1.2	30
^{214}Bi		24,000	600,000
^{109}Cd		400	10,000
^{143}Ce		1,200	30,000
^{60}Co		200	5,000
^{51}Cr		40,000	1,000,000
^{137}Cs		120	3,000
^{155}Eu		4,000	100,000
Gross alpha[e]	15		
Gross beta (mrem/yr)	4		
^{3}H	20,000[f]	80,000	2,000,000
^{131}I		120	3,000
^{40}K		280	7,000
^{237}Np		1.2	30
^{234m}Pa		2,800	70,000
^{238}Pu		1.6	40
$^{239/240}$Pu		1.2	30
^{226}Ra	5[g]	4	100
^{228}Ra	5[g]	4	100
^{106}Ru		240	6,000
^{90}Sr	8[f]	40	1,000
^{99}Tc		4,000	100,000
^{228}Th		16	400
^{230}Th		12	300
^{232}Th		2	50
^{234}Th		400	10,000
Thorium, natural		2	50
^{234}U		20	500
^{235}U		24	600
^{238}U		24	600
Uranium, natural		24	600
Uranium, total[h]		20	500

[a]Only the radionuclides sought on the Oak Ridge Reservation are listed.

[b]40 CFR Part 141 National Primary Drinking Water Regulations Subparts B and G.

[c]Four percent of the DCG represents the DOE criterion of 4 mrem effective dose equivalent from ingestion of drinking water.

[d]U.S. DOE Order 5400.5 Chapter III Derived Concentration Guides for Air and Water.

[e]Excludes radon and uranium.

[f]These values are not MCLs, but are concentrations that result in the effective dose equivalent (EDE) of the MCL for gross beta emissions, which is 4 mrem/year.

[g]Applies to combined ^{226}Ra and ^{228}Ra.

[h]Minimum of uranium isotopes.

Table D.2. Reference standards for chemicals and metals in water

Parameter	National drinking water standards		Tennessee water quality criteria[c]			
	Primary[a]	Secondary[b]	Domestic water supply	Fish and aquatic life CMC	Recreation: Organisms	Recreation: Water and organisms[d]
Anions (mg/L)						
Chloride		250				
Fluoride	4	2				
Nitrate	10					
Nitrite	1					
Sulfate, as SO_4		250				
Base/neutral/acid extractable organics (µg/L)						
1,2-Dichlorobenzene (*ortho*)	600		600		17,000	2,700
1,2,4-Trichlorobenzene	70		70			
1,3-Dichlorobenzene (*meta*)					2,600	400
1,4-Dichlorobenzene (*para*)	75		75		2,600	400
2,4-Dinitrophenol					14,000	70
2,4-Dinitrotoluene					91	1.1
2,4,6-Trichlorophenol					65	21
2-Methyl-4,6-Dinitrophenol					765	13.4
3,4-Benzo(b)fluoranthene					0.49	0.044
Benzo(k)fluoranthene					0.49	0.044
Acenaphthylene					2,700	1,200
Anthracene					110,000	9,600
Benzo(a)anthracene					0.49	0.044
Benzo(a)pyrene	0.2		0.2		0.49	0.044
bis-(2-chloroethyl)ether					14	0.31
bis-(2-ethylhexyl)phthalate	6	6			59	18
Di-n-butyl phthalate					12,000	2,700
Diethyl phthalate					120,000	23,000
Dimethyl phthalate					2,900,000	313,000
Fluoranthene					370	300
Fluorene					14,000	1,300
Hexachlorobenzene	1		1		0.0077	0.0075
Hexachlorocyclopentadiene	50		50		17,000	240
Hexachloroethane					89	19
Nitrobenzene					1,900	17
Pentachlorophenol (pH 7.8)	1		1	20	82	2.8
Pyrene					11,000	960
Field measurements						
Chlorine, mg/L				19		
Dissolved oxygen, mg/L				5		
Temperature, °C			30.5		30.5	30.5
Turbidity, JTU[e]	1					
pH, standard units		(6.5, 8.5)	(6.0, 9.0)	(6.5, 8.5)	(6.0, 9.0)	(6.0,9.0)

Table D.2 (continued)

Parameter	National drinking water standards		Tennessee water quality criteria[c]			
	Primary[a]	Secondary[b]	Domestic water supply	Fish and aquatic life	Recreation: Organisms	Recreation: Water and organisms[d]
Metals (mg/L)						
Aluminum		0.05-0.2				
Antimony	0.006		0.006		4.30	0.014
Arsenic	0.05		0.05	360 (III)	0.0014	0.00018
Barium	2		2			
Beryllium	0.004		0.004			
Cadmium	0.005		0.005	0.0039[f]		
Chromium, total	0.1		0.1			
Chromium (hexavalent)				0.016		
Copper	1.3[g]	1		0.0177[f]		
Iron		0.3				
Lead	0.015[g]		0.005	0.0817[f]		
Manganese		0.05				
Mercury	0.002		0.002	0.0024	0.00015	0.00014
Nickel	0.1[h]		0.1	1.418[f]	4.6	0.61
Selenium	0.05		0.050	0.02		
Silver		0.1		0.0041[f]		
Thallium	0.002		0.002		0.0063	0.0017
Zinc		5		0.117[f]		
Others						
Asbestos (fibers/L)	7,000,000					
Coliform bacteria[i]						
Color (color units)		15				
Cyanide (mg/L)	0.2		0.2	0.022	220	0.7
Odor (T.O.N.)		3				
Total dissolved solids (mg/L)		500	500			
Pesticides/herbicides/PCBs (µg/L)						
2,3,7,8-TCDD (Dioxin)	0.00003		0.00003		0.000001	0.000001
2,4-D	70		70			
2,4,5-TP (Silvex)	50		50			
4,4'-DDT				1.1	0.0059	0.0059
4,4'-DDE					0.0059	0.0059
4,4'-DDD					0.0084	0.0083
Alachlor	2		2			
Aldrin				3	0.0014	0.0013
Atrazine	3		3			
Carbofuran	40		40			
Chlordane	2		2	2.4	0.0059	0.0057
Dalapon	200		200			

Table D.2 (continued)

Parameter	National drinking water standards		Tennessee water quality criteria[c]			
	Primary[a]	Secondary[b]	Domestic water supply	Fish and aquatic life	Recreation	
					Organisms	Water and organisms[d]
1,2-Dibromo-3-chloropropane	0.2		0.2			
Di(ethylhexyl)adipate	400		400			
Di(ethylhexyl)phthalate[j]						
Dinoseb	7		7			
Diquat	20		20			
a-Endosulfan				0.22	159	74
b-Endosulfan				0.22	159	74
Endothall	100		100			
Endrin	2		2	0.18	0.81	0.76
Ethylene dibromide	0.05		0.05			
Glyphosate	700		700			
Heptachlor	0.4		0.4	0.52	0.0021	0.0021
Heptachlor epoxide	0.2		0.2	0.52	0.0011	0.001
g-BHC (Lindane)	0.2		0.2	2	0.63	0.19
Methoxychlor	40		40			
Oxamyl (Vydate)	200		200			
PCB-1242					0.00045	0.00044
PCB-1254					0.00045	0.00044
PCB-1221					0.00045	0.00044
PCB-1232					0.00045	0.00044
PCB-1248					0.00045	0.00044
PCB-1260					0.00045	0.00044
PCB-1016					0.00045	0.00044
PCB, total	0.5		0.5		0.00045	0.00044
Picloram	500		500			
Simazine	4		4			
Toxaphene	3		3	0.73	0.0075	0.0073
Volatile organics (μg/L)						
1,1,1-Trichloroethane	200		200			
1,1-Dichloroethene	7		7		32	0.57
1,1,2-Trichloroethane	5		5		420	6
1,1,2,2-Tetrachloroethane					110	1.7
1,2-Dichloroethane	5		5		990	3.8
1,2-Dichloroethene[k]						
cis-1,2-Dichloroethene	70		70			
trans-1,2-Dichloroethene	100		100			700
1,2-Dichloropropane	5		5		39	0.52
cis-1,3-Dichloropropene					1,700	10
trans-1,3-Dichloropropene					1,700	10

Table D.2 (continued)

Parameter	National drinking water standards		Tennessee water quality criteria[c]			
	Primary[a]	Secondary[b]	Domestic water	Fish and aquatic life	Recreation	
					Organisms	Water and organisms[d]
Acrolein					780	320
Acrylonitrile					6.6	0.59
Benzene	5		5		710	12
Bromodichloromethane	100[l]				220	2.7
Bromoform	100[l]				3,600	43
Carbon tetrachloride	5		5		44	2.5
Chlorobenzene	100				21,000	680
Chloroform	100[l]				4,700	57
Dibromochloromethane	100[l]				340	4.1
Ethylbenzene	700		700		29,000	3,100
Methylene chloride (Dichloromethane)	5		5		16,000	47
Styrene	100		100			
Tetrachloroethene	5		5		88.5	8
Toluene	1,000		1,000		200,000	6,800
Trichloroethene	5		5		810	27
Trihalomethanes, total	100					
Vinyl chloride	2		2		5,250	20
Xylene, total	10,000		10,000			

[a]40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.

[b]40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.

[c]Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended. CMC= criterion maximum concentration.

[d]These criteria, for the protection of public health, pertain to the consumption of water and organisms. They are applied only to waters designated for *both* recreation and domestic water supply.

[e]Jackson turbidity unit (JTU) and nephelometric turbidity unit (NTU) are roughly equivalent in the range of 25 to 1000 JTU.

[f]The standard is a function of total hardness. The values in this table correspond to a total-hardness value of 100 mg/L.

[g]"Action level" for initiation of corrosion control studies and treatment techniques, applicable to community water systems and non-transient, non-community water systems.

[h]EPA has deleted the MCL for nickel from the *Code of Federal Regulations*. The state of Tennessee currently still retains the MCL, but plans to delete it. The state of Tennessee also has a water quality criterion for nickel of 100 μg/L, which protects domestic water supplies.

[i]Standard no longer numeric, but based on presence or absence in sample.

[j]See bis(2-ethylhexyl)phthalate.

[k]See *cis*-Dichlorethene and *trans*-Dichloroethene.

[l]Limit for total trihalomethanes (bromodichloromethane + bromoform + chloroform + dibromochloromethane).

Table D.3. 1997 surface water analyses at ORR surface water locations[a]

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
First Creek just upstream of Northwest Tributary (1STCK)						
Field measurements						
Dissolved oxygen (ppm)	2/2	10	8.4	9.4	0.95	*f*
pH (SU)	2/2	8.2	7.7	8.0	0.25	*f*
Temperature (°C)	2/2	17	16	16	0.90	*f*
Radionuclides (pCi/L)[g]						
^{60}Co	1/2	3.1*	–1.9	0.60	2.5	200
Gross alpha	3/3	83*	3.0*	56	26	*f*
Gross beta	3/3	1,800*	38*	870	510	*f*
^{3}H	1/2	540*	–380	81	460	80,000
Total rad Sr	2/2	900*	19*	460	440	40
Total uranium	1/1	1.2*	1.2*	1.2	*f*	20
$^{233/234}U$	1/1	2,200*	2,200*	2,200	*f*	*f*
^{234}U	1/1	1.0*	1.0*	1.0	*f*	20
^{235}U	1/2	0.090*	0.014	0.052	0.038	24
^{238}U	2/2	1.4*	0.20*	0.80	0.60	24
Bear Creek downstream from all possible DOE inputs (BCK 0.6)						
Field measurements						
Dissolved oxygen (ppm)	2/2	9.7	9.6	9.7	0.050	*f*
pH (SU)	2/2	8.3	7.5	7.9	0.40	*f*
Temperature (°C)	2/2	14	14	14	0.30	*f*
Radionuclides (pCi/L)[g]						
^{60}Co	1/2	2.2*	1.4	1.8	0.42	200
Gross alpha	2/2	9.2*	5.1*	7.2	2.0	*f*
Gross beta	2/2	8.9*	7.1*	8.0*	0.91	*f*
Total uranium	1/1	5.9*	5.9*	5.9	*f*	20
^{234}U	2/2	4.1*	2.7*	3.4	0.70	20
^{238}U	2/2	6.5*	3.0*	4.7	1.8	24
Clinch River downstream from all DOE inputs (CRK 16)						
Field measurements						
Dissolved oxygen (ppm)	11/11	9.1	6.7	7.9	0.26	*f*
pH (SU)	11/11	8.4	7.5	7.9	0.095	*f*
Temperature (°C)	11/11	23	9.8	17	1.5	*f*
Metals (mg/L)						
Aluminum, total	10/11	1.8	<0.10	~0.44	0.16	*f*
Barium, total	2/11	<0.10	0.039	~0.090	0.0070	*f*
Boron, total	1/1	0.023	0.023	0.023	*f*	*f*

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
Calcium, total	11/11	38	23	31	1.4	*f*
Chromium, total	1/11	<0.010	0.0013	~0.0087	0.00091	*f*
Cobalt, total	1/11	<0.10	0.00029	~0.073	0.014	*f*
Iron, total	11/11	1.5	0.059	0.49	0.14	*f*
Magnesium, total	11/11	10	6.3	8.6	0.39	*f*
Manganese, total	11/11	0.14	0.027	0.065	0.0094	*f*
Potassium, total	9/11	2.0	1.4	~1.6	0.073	*f*
Sodium, total	11/11	4.9	2.1	3.7	0.28	*f*
Strontium, total	1/1	0.081	0.081	0.081	*f*	*f*
Uranium, total	1/5	<0.0010	<0.00010	~0.00048	0.00015	*f*
Zinc, total	4/11	0.032	<0.0095	~0.021	0.0020	*f*
		Radionuclides (pCi/L)[g]				
^{7}Be	1/6	15*	–4.9	4.2	3.4	40,000
^{60}Co	3/11	2.1*	–3.4	0.44	0.47	200
^{137}Cs	2/11	2.3*	–1.5	0.057	0.33	120
Gross alpha	5/11	1.8*	–0.16	0.56*	0.21	*f*
Gross beta	6/11	4.1*	0	1.9*	0.42	*f*
^{40}K	1/4	36*	–1.0	12	8.5	280
		Volatile organics (μg/L)				
2-Butanone	1/3	U10	JB7.0	~9.0	1.0	*f*
Acetone	1/3	U10	JB4.0	~8.0	2.0	*f*
		Water supply intake for the K-25 Site (CRK 23)				
		Field measurements				
Dissolved oxygen (ppm)	12/12	10	5.8	8.4	0.38	*f*
pH (SU)	12/12	8.2	7.8	8.0	0.042	*f*
Temperature (°C)	12/12	24	9.9	16	1.4	*f*
		Metals (mg/L)				
Aluminum, total	10/12	1.6	<0.10	~0.30	0.12	*f*
Antimony, total	1/13	<0.051	0.00011	~0.046	0.0038	0.014
Barium, total	4/13	<0.10	0.029	~0.079	0.0092	*f*
Boron, total	1/1	0.024	0.024	0.024	*f*	*f*
Calcium, total	12/12	37	30	33	0.62	*f*
Chromium, total	1/12	<0.010	0.00089	~0.0087	0.00087	*f*
Cobalt, total	1/12	<0.10	0.00020	~0.068	0.014	*f*
Copper, total	2/13	<0.070	0.0016	~0.0095	0.0051	*f*
Iron, total	12/13	1.7	0.051	~0.31	0.12	*f*
Lead, total	1/13	<0.051	0.00036	~0.042	0.0052	*f*
Magnesium, total	12/12	10	8.1	9.2	0.18	*f*
Manganese, total	13/13	0.20	0.025	0.056	0.013	*f*

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
Potassium, total	9/12	<2.0	1.1	~1.6	0.090	*f*
Sodium, total	12/12	5.1	3.5	4.3	0.14	*f*
Strontium, total	1/1	0.085	0.085	0.085	*f*	*f*
Uranium, total	2/6	<0.0010	<0.00010	~0.00042	0.00013	*f*
Vanadium, total	2/11	<0.51	<0.0020	~0.32	0.076	*f*
Zinc, total	4/13	0.021	0.0076	~0.017	0.0014	*f*
Radionuclides (pCi/L)[g]						
^{60}Co	6/12	3.4*	–0.97	1.2*	0.41	200
^{137}Cs	2/12	4.1*	–0.20	1.1*	0.32	120
Gross alpha	6/12	1.8*	–0.40	0.57*	0.17	*f*
Gross beta	9/12	14*	–0.40	3.0*	1.1	*f*
^{3}H	4/12	1,100*	–27	270*	98	80,000
Total rad Sr	3/12	2.9*	–2.5	0.66	0.45	40
Volatile organics (μg/L)						
2-Butanone	1/4	U10	JB8.0	~9.5	0.50	*f*
Acetone	1/4	U10	JB4.0	~8.5	1.5	*f*
Clinch River downstream from ORNL (CRK 32)						
Field measurements						
Dissolved oxygen (ppm)	12/12	10	6.2	8.3	0.44	*f*
pH (SU)	12/12	8.2	7.6	7.9	0.071	*f*
Temperature (°C)	12/12	22	9.0	16	1.3	*f*
Radionuclides (pCi/L)[g]						
^{7}Be	1/6	16*	–1.3	4.2	2.6	40,000
^{60}Co	1/12	4.1*	–1.9	0.52	0.47	200
^{137}Cs	2/12	3.3*	–1.3	0.62	0.37	120
Gross alpha	3/12	1.2*	–1.1	0.048	0.18	*f*
Gross beta	11/12	11*	1.1	4.6*	0.73	*f*
^{3}H	7/12	5,400*	–1,100	870	490	80,000
^{212}Pb	1/1	7.1*	7.1*	7.1	*f*	120
Total rad Sr	3/12	4.9*	–2.1	0.95	0.57	40
Water supply intake for Knox County (CRK 58)						
Field measurements						
Dissolved oxygen (ppm)	12/12	13	7.0	9.3	0.50	*f*
pH (SU)	12/12	8.4	7.4	7.8	0.096	*f*
Temperature (°C)	12/12	25	8.7	16	1.7	*f*
Radionuclides (pCi/L)[g]						
^{7}Be	1/6	14*	–9.3	3.0	3.3	40,000
^{60}Co	6/12	3.5*	–1.0	1.5*	0.44	200
^{137}Cs	1/12	2.1*	–0.50	0.59*	0.24	120

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
Gross alpha	4/12	0.86*	–1.4	0.16	0.17	*f*
Gross beta	7/12	2.6*	0.20	1.3*	0.26	*f*
^{40}K	1/5	58*	–34	9.6	18	280
Melton Hill Reservoir above City of Oak Ridge water intake (CRK 66)						
Field measurements						
Dissolved oxygen (ppm)	12/12	11	7.4	9.2	0.40	*f*
pH (SU)	12/12	8.4	6.9	7.6	0.12	*f*
Temperature (°C)	12/12	25	8.7	16	1.7	*f*
Radionuclides (pCi/L)[g]						
^{60}Co	3/12	3.0*	–1.4	0.80*	0.38	200
Gross alpha	3/12	1.5	–0.23	0.41*	0.17	*f*
Gross beta	8/12	3.4*	0.80	2.2*	0.26	*f*
^{40}K	2/5	140*	–50	30	32	280
^{208}Tl	1/1	3.8*	3.8*	3.8	*f*	*f*
Clinch River (Solway Bridge) upstream from all DOE inputs (CRK 70)						
Field measurements						
Dissolved oxygen (ppm)	12/12	11	6.5	8.6	0.36	*f*
pH (SU)	12/12	8.3	6.5	7.2	0.16	*f*
Temperature (°C)	12/12	24	9.1	16	1.6	*f*
Metals (mg/L)						
Aluminum, total	10/12	1.2	<0.10	~0.27	0.089	*f*
Barium, total	3/12	<0.10	0.028	~0.082	0.0092	*f*
Boron, total	1/1	0.021	0.021	0.021	*f*	*f*
Calcium, total	11/12	38	<0.050	~31	2.9	*f*
Chromium, total	1/12	<0.010	0.0011	~0.0088	0.00086	*f*
Cobalt, total	1/12	<0.10	0.00030	~0.068	0.014	*f*
Copper, total	2/13	<0.0070	<0.0040	~0.0049	0.00036	*f*
Iron, total	11/12	1.9	<0.050	~0.37	0.15	*f*
Lead, total	1/12	<0.050	0.00091	~0.046	0.0041	*f*
Lithium, total	1/1	0.0055	0.0055	0.0055	*f*	*f*
Magnesium, total	11/12	10	<0.020	~8.4	0.79	*f*
Manganese, total	11/12	0.25	<0.010	~0.067	0.017	*f*
Potassium, total	8/12	<2.0	<0.60	~1.5	0.12	*f*
Sodium, total	11/12	4.9	<0.050	~3.7	0.39	*f*
Strontium, total	1/1	0.088	0.088	0.088	*f*	*f*
Thallium, total	1/10	<0.20	<0.00050	~0.060	0.022	0.0017
Uranium, total	2/6	<0.0010	<0.00010	~0.00041	0.00014	*f*
Vanadium, total	1/11	<0.50	<0.0020	~0.32	0.075	*f*
Zinc, total	3/12	0.18	0.012	~0.033	0.013	*f*

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
			Radionuclides (pCi/L)[g]			
^{7}Be	1/6	24*	−18	0	6.5	40,000
^{60}Co	3/12	2.3*	−1.1	1.0*	0.29	200
^{137}Cs	1/12	2.1*	−3.0	−0.0026	0.39	120
Gross alpha	3/12	1.0*	−1.5	0.17	0.20	*f*
Gross beta	5/12	3.1*	−0.22	1.3*	0.26	*f*
^{3}H	1/12	830*	−430	31	97	80,000
Total rad Sr	1/12	5.0	−1.3	0.76	0.47	40
			Volatile organics (μg/L)			
2-Butanone	1/4	U10	JB8.0	~9.5	0.50	*f*
Acetone	1/4	U10	JB4.0	~8.5	1.5	*f*
Toluene	1/11	U5.0	J1.0	~4.6	0.36	6,800
Xylene, total	1/4	U5.0	J1.0	~4.0	1.0	*f*
			East Fork Poplar Creek prior to entering Poplar Creek (EFK 0.1)			
			Field measurements			
Dissolved oxygen (ppm)	2/2	11	9.1	9.9	0.75	*f*
pH (SU)	2/2	8.5	7.6	8.1	0.45	*f*
Temperature (°C)	2/2	17	13	15	1.9	*f*
			Radionuclides (pCi/L)[g]			
^{60}Co	1/2	1.9*	0.65	1.3	0.63	200
Gross alpha	2/2	3.0*	2.2*	2.6*	0.39	*f*
Gross beta	2/2	4.1*	3.1*	3.6*	0.48	*f*
^{131}I	1/1	41*	41*	41	*f*	120
			East Fork Poplar Creek downstream from floodplain (EFK 5.4)			
			Field measurements			
Dissolved oxygen (ppm)	2/2	9.6	9.4	9.5	0.10	*f*
pH (SU)	2/2	8.5	7.4	8.0	0.55	*f*
Temperature (°C)	2/2	17	15	16	1.0	*f*
			Radionuclides (pCi/L)[g]			
^{7}Be	1/1	20*	20*	20	*f*	40,000
^{60}Co	1/2	2.1*	0.41	1.3	0.85	200
^{137}Cs	1/2	1.8*	1.1	1.4	0.34	120
Gross alpha	2/2	3.5*	2.4*	3.0	0.56	*f*
Gross beta	2/2	4.9*	3.0*	3.9	0.96	*f*
^{131}I	1/1	130*	130*	130	*f*	120
Total uranium	1/1	3.2*	3.2*	3.2	*f*	20
^{234}U	1/1	1.3*	1.3*	1.3	*f*	20
^{238}U	1/1	2.0*	2.0*	2.0	*f*	24

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
Fifth Creek just upstream of White Oak Creek at ORNL (FIFTHCK 0.1)						
Field measurements						
Dissolved oxygen (ppm)	2/2	9.7	9.2	9.5	0.25	*f*
pH (SU)	2/2	8.1	7.8	8.0	0.15	*f*
Temperature (°C)	2/2	18	17	17	0.35	*f*
Radionuclides (pCi/L)[g]						
Gross alpha	2/2	0.92*	0.65*	0.79	0.13	*f*
Gross beta	2/2	36*	23*	29	6.5	*f*
^{3}H	1/2	700*	–54	320	380	80,000
Total rad Sr	2/2	22*	11*	17	5.3	40
Grassy Creek upstream of SEG and IT Corp. at CRK 23 (GCK 3.6)						
Field measurements						
Dissolved oxygen (ppm)	1/1	10	10	10	*f*	*f*
pH (SU)	1/1	8.0	8.0	8.0	*f*	*f*
Temperature (°C)	1/1	14	14	14	*f*	*f*
Radionuclides (pCi/L)[g]						
Gross beta	1/1	1.2*	1.2*	1.2	*f*	*f*
Ish Creek prior to entering CRK 30.8 (ICK 0.7)						
Field measurements						
Dissolved oxygen (ppm)	2/2	11	9.2	10	1.1	*f*
pH (SU)	2/2	7.7	7.4	7.6	0.15	*f*
Temperature (°C)	2/2	16	11	14	2.9	*f*
Radionuclides (pCi/L)[g]						
^{60}Co	1/2	4.0*	0.59	2.3	1.7	200
^{40}K	1/1	240*	240*	240	*f*	280
McCoy Branch prior to entering CRK 60.3 (MCCBK 1.8)						
Field measurements						
Dissolved oxygen (ppm)	2/2	10	6.8	8.5	1.7	*f*
pH (SU)	2/2	8.0	7.1	7.6	0.45	*f*
Temperature (°C)	2/2	15	11	13	1.9	*f*
Radionuclides (pCi/L)[g]						
Gross alpha	1/2	0.67*	–0.14	0.27	0.40	*f*
Gross beta	1/2	1.8*	0.76	1.3	0.52	*f*
^{40}K	1/1	60*	60*	60	*f*	280

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
Melton Branch downstream from ORNL (MEK 0.2)						
Field measurements						
Dissolved oxygen (ppm)	6/6	14	8.7	10	0.77	*f*
pH (SU)	6/6	8.2	7.7	7.9	0.091	*f*
Temperature (°C)	6/6	22	8.4	15	2.3	*f*
Radionuclides (pCi/L)[g]						
^{7}Be	1/3	15*	–13	–3.0	9.0	40,000
^{60}Co	3/6	2.9*	0.99	1.8*	0.31	200
Gross alpha	3/6	2.5*	–0.027	1.1*	0.46	*f*
Gross beta	6/6	700*	350*	490*	63	*f*
^{3}H	6/6	900,000*	320,000*	470,000*	90,000	80,000
Total rad Sr	6/6	430*	160*	250*	41	40
Mitchell Branch upstream from the K-25 Site (MIK 1.4)						
Field measurements						
Dissolved oxygen (ppm)	4/4	9.9	7.0	8.4	0.71	*f*
pH (SU)	4/4	8.2	7.9	8.0	0.075	*f*
Temperature (°C)	4/4	21	8.6	13	2.8	*f*
Radionuclides (pCi/L)[g]						
Gross alpha	2/4	1.0*	–0.18	0.61	0.27	*f*
Gross beta	3/4	2.9*	–0.60	1.6	0.77	*f*
Northwest Tributary prior to entering 1st Creek at ORNL (NWTK 0.1)						
Field measurements						
Dissolved oxygen (ppm)	2/2	10	7.7	8.9	1.2	*f*
pH (SU)	2/2	8.1	7.8	8.0	0.15	*f*
Temperature (°C)	2/2	16	15	15	0.25	*f*
Radionuclides (pCi/L)[g]						
^{60}Co	1/2	2.5*	0.97	1.7	0.74	200
Gross beta	2/2	240*	17*	130	110	*f*
^{3}H	1/2	810*	70	440	370	80,000
Total rad Sr	2/2	100*	7.2*	54	46	40
Raccoon Creek sampling station prior to entering CRK 31 (RCK 2.0)						
Field measurements						
Dissolved oxygen (ppm)	2/2	10	6.1	8.1	2.0	*f*
pH (SU)	2/2	7.9	7.2	7.6	0.35	*f*
Temperature (°C)	2/2	14	14	14	0.20	*f*

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
Radionuclides (pCi/L)[g]						
Gross alpha	1/2	1.6*	0.65	1.1	0.46	*f*
Gross beta	2/2	66*	16*	41	25	*f*
^{3}H	1/2	500*	–81	210	290	80,000
Total rad Sr	2/2	47*	4.3*	26	21	40
Walker Branch prior to entering CRK 53.4 (WBK 0.1)						
Field measurements						
Dissolved oxygen (ppm)	2/2	12	7.1	9.6	2.5	*f*
pH (SU)	2/2	7.0	6.8	6.9	0.10	*f*
Temperature (°C)	2/2	15	9.4	12	2.9	*f*
White Oak Lake at White Oak Dam (WCK 1.0)						
Field measurements						
Dissolved oxygen (ppm)	12/12	10	5.1	7.6	0.43	*f*
pH (SU)	12/12	8.5	7.5	8.0	0.075	*f*
Temperature (°C)	12/12	29	7.2	17	2.0	*f*
PCBs						
Aroclor-1254	5/12	U1.0	J0.027	~0.36	0.087	*f*
Total aroclors	3/6	U0.50	J0.027	~0.27	0.10	*f*
Radionuclides (pCi/L)[g]						
^{57}Co	1/1	23*	23*	23	*f*	4,000
^{60}Co	7/12	6.0*	–0.30	2.3*	0.49	200
^{137}Cs	11/11	74*	6.5*	23*	5.8	120
Gross alpha	12/12	9.5*	2.4*	6.3*	0.67	*f*
Gross beta	12/12	430*	200*	280*	19	*f*
^{3}H	12/12	190,000*	47,000*	99,000*	12,000	80,000
^{212}Pb	1/2	19*	0.77	9.9	9.1	120
Total rad Sr	12/12	180*	97*	130*	8.3	40
Total uranium	3/3	7.6*	7.0*	7.2*	0.18	20
$^{233/234}U$	2/2	9.4*	7.4*	8.4*	1.0	*f*
^{234}U	5/5	8.0*	3.2*	5.8*	0.76	20
^{235}U	4/7	0.12*	0*	0.038*	0.017	24
^{238}U	7/7	1.8*	0.67*	1.2*	0.16	24
White Oak Creek downstream from ORNL (WCK 2.6)						
Field measurements						
Dissolved oxygen (ppm)	6/6	10	7.1	8.8	0.52	*f*
pH (SU)	6/6	8.4	7.7	8.0	0.11	*f*
Temperature (°C)	6/6	22	10	16	2.0	*f*

Table D.3 (continued)

Parameter	N det/ N total	Max[b]	Min[b]	Av[c]	Standard error[d]	TWQC[e]
			Radionuclides (pCi/L)[g]			
^{60}Co	1/6	4.8*	–1.8	0.79	1.0	200
^{137}Cs	6/6	28*	5.4*	16*	3.4	120
Gross alpha	6/6	4.3*	2.3*	3.5*	0.36	*f*
Gross beta	6/6	270*	120*	180*	20	*f*
^{3}H	6/6	27,000*	14,000*	18,000*	2,000	80,000
^{40}K	1/2	63*	0.18	32	31	280
Total rad Sr	6/6	110*	55*	82*	7.7	40
Total uranium	1/1	8.1*	8.1*	8.1	*f*	2
$^{233/234}U$	1/1	3.6*	3.6*	3.6	*f*	*f*
^{234}U	1/1	6.5*	6.5*	6.5	*f*	20
^{238}U	2/2	1.5*	0.56*	1.0	0.48	24
			White Oak Creek upstream from ORNL (WCK 6.8)			
			Field measurements			
Dissolved oxygen (ppm)	4/4	10	8.3	9.4	0.44	*f*
pH (SU)	4/4	8.2	7.0	7.6	0.35	*f*
Temperature (°C)	4/4	18	11	14	1.6	*f*
			Radionuclides (pCi/L)[g]			
^{7}Be	1/2	20*	6.0	13	7.0	40,000
Gross alpha	2/4	0.94*	–0.96	0.068	0.43	*f*
Gross beta	1/4	1.6	0.48	1.1*	0.25	*f*
^{3}H	1/4	430	34	230*	84	80,000

[a]All values were included in the calculations. Only parameters that have one or more samples detected are listed in the table.The sampling and analysis plan contains a complete list of analyses performed.

[b]Prefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; "U" indicates the value for an organic parameter was undetected at the analytical detection limit; "J" indicates the value was estimated at or below the analytical detection limit by the laboratory; and "JB" indicates the value was estimated at or below the analytical detection limit and was found in the laboratory blank.

[c]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

[d]Standard error of the mean.

[e]Tennessee General Water Quality Criteria for Recreation and Domestic Use, as amended (CRK 16, CRK 23, CRK 32, CRK 58, CRK 66, CRK 70) or Tennessee General Water Quality Criteria for Freshwater Fish and Aquatic Life, as amended (BCK 0.6, EFK 0.1, EFK 5.4, MEK 0.2, WCK 1.0, WCK 2.6, WCK 6.8). 4% of DOE DCG used for radionuclides, whereapplicable.

[f]Not applicable.

[g]Individual and average radionuclide concentrations significantly greater than zero are identified by an *.

Appendix E: Underground Storage Tank Data

Table E.1. Underground storage tanks (USTs) at the Y-12 Plant

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation	Environmental assessment ( ) date to regulatory agency	Corrective action
					Petroleum USTs				
9722-6	2312-U	1987	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	Closure approval (6/96)
9722-5	2313-U	1987	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	Closure approval (6/96)
9999-7	2316-U	1986	1994	550	Diesel	Inert filled 2/95	CR (4/95)	NA	Closure approval (6/96)
9999-5	2320-U	1986	1994	550	Diesel	Removed 2/95	CR (4/95)	NA	Closure approval (6/96)
9722-4	2333-U	1988	1994	550	Diesel	Inert filled 3/95	CR (4/95)	NA	Closure approval (6/96)
9714	2334-U	1987	In use	6,000	Gasoline	Full compliance	Site check	NA	Case closed (6/97)
9714	2335-U	1987	In use	10,000	Diesel	Full compliance	Site check	NA	Case closed (6/97)
9754-3	2396-U	1993	In use	10,000	Diesel	Full compliance	NA	NA	NA
9754-3	2397-U	1993	In use	20,000	Gasoline	Full compliance	NA	NA	NA
9712	0084-U	1958	1988	500	Used oil	Removed 6/88	CERCLA	TBD	TBD
9204-2	0134-U	1966	1982	117	Gasoline	Removed 8/88	ISCR,FPRR	SIR (3/92)	EAR/CAP (8/92), CAP approval (5/93), CR (4/94), SRF (1/95), CR (3/97), CR (3/97). Closure approval (6/97)
9754-2	0439-U	1978	1989	20,000	Gasoline	Removed 9/89	IAR, ISCR, FPRR	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754-2	0440-U	1978	1989	10,000	Diesel	Removed 9/89	IAR, ISCR, FPRR	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2073-U	1944	1979	1,000	Gasoline	Removed 10/93	SI	SIR/CAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation	Environmental assessment ( ) date to regulatory agency	Corrective action
9754	2074-U	1944	1979	1,000	Gasoline	Removed 10/93	SI	SIRCAP (3/91)	CAP (7/92), CAP approval (5/93), BMR (3/94), SSSR (4/94)
9754	2075-U	1944	1979	1,000	Diesel	Removed 10/93	SI	SIRCAP (3/91)	CAP (7/92), CAP approval 5/93), (BMR (3/94), SSSR (4/94)
9754-1	1219-U	1964	1988	12,000	Diesel	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95), CERCLA
9754-1	1222-U	1968	1988	12,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95), CERCLA
9720-15	2068-U	1968	1980	1,000	Gasoline	Removed 2/90	EA/FPRR	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95), CERCLA
9754-1	2082-U	1981	1988	8,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRF (2/94), SRF approval (3/94), SSSR (9/94), SSSR revised (1/95), CERCLA
PRW	2310-U	1975	1989	200	Gasoline	Removed 11/89	ISCR	SIR/CAP (7/91)	EAR/CAP (3/93), CAP approval (12/93), OE (4/94,5/94), CR (7/94), Closure approval (9/95)

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation	Environmental assessment ( ) date to regulatory agency	Corrective action
9201-1	2331-U	1973	1988	560	Gasoline	Removed 12/88	ISCR, FPRR	SIR (3/92)	EAR/CAP (7/92), CAP approval (12/93), BMR (3/94), SRF (4/94), SRF approval (5/94), CR (3/97), Closure approval (6/97)
9401-3	0713-U	1955	1988	10,500	No. 2 fuel oil	Removed 11/88	NI	NA	NA
9754	0836-U	1944	1989	10,000	Used oil	Removed 10/89	RCRA closure approved 9/95	RCRA	RCRA
9204-3	0928-U	1966	1989	200	Gasoline	Removed 5/89	RIR, closure approved 8/92	NA	NA
9995	2078-U	1965	1979	110	Gasoline	Inert filled 1979	Exempt	CERCLA	CERCLA
9995	2079-U	1965	1979	55	Gasoline	Inert filled 1979	Exempt	CERCLA	CERCLA
9996	2080-U	1971	1987	560	Gasoline	Removed 12/88	RIR closure approved 9/95	NA	NA
9212	208 1 -U	1958	1970	280	Gasoline	Removed 4/91	ISCR	NA	OE/CR (12/91) Closure approval (5/97)
9201-5	2099-U	1971	1989	560	Gasoline	Removed 7/89	IAR, RIR, closure approved 3/90	NA	NA
9929-1	2117-U	1971	1983	550	No. 2 fuel oil	Removed 10/88	NI	NA	NA
9204-4	2130-U	1960	1992	550	Gasoline	Removed 12/92	RIR, closure approved 9/95	NA	NA
9999	2293-U	1954	1974	58	Gasoline	Removed 1974	NI	NA	NA
9999	2294-U	1954	1974	58	Gasoline	Removed 1974	NI	NA	NA
9998	2305-U	1956	1990	55	Diesel	Removed 10/90	RIR, closure approved 1/95	NA	NA
PRE	2315-U	1960	1988	64	Gasoline	Removed II 11/89	ISCR	EAR/CAP (2/91)	OE/CAR (12/92). Closure approval 1/95

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation	Environmental assessment ( ) date to regulatory agency	Corrective action
9769	2330-U	1949	1988	5,000	No. 2 fuel oil	Inert filled 4/88	NI	NA	NA
Chestnut Ridge	2336-U	1981	1991	550	Gasoline	Removed 5/91	RIR, closure approved 1/95	NA	NA
Buff. Mtn.	2337-U	1972	1990	250	Gasoline	Removed 3/90	IAR, ISCR	SIR (5/91), SIR Phase II (1/92)	Closure approval (2/95)
9720-13	2338-U	1970	1984	200	Used oil	Removed 7/90	RIR	TBD	Closure approval (5/97)
9219	2395-U	1964	1977	2,000	No. 2 fuel oil	Removed 6/93	NI	NA	NA
SYDD	2063-U	1959	1989	130	Oil/ solvent	Removed 7/89	IAR, ISCR/ FPRR	CERCLA	CERCLA
SYDD	2328-U	1959	1989	475	Oil/ solvent	Removed 7/89	TAR, ISCR/ FPRR	CERCLA	CERCLA
SYDD	2329-U	1959	1989	475	Oil/ solvent	Removed 7/89	IAR, ISCR/ FPRR	CERCLA	CERCLA
					Hazardous Substance USTs				
9767-13	2102-U	1987	1992	7,500	Methanol	Removed 1/93	CR	NA	NA
9418-3	2072-U	1943	1960	45,000	Solid uranium oxide	Exempt	CERCLA	CERCLA	CERCLA
9825-1	2129-U	1984	In use	240,000	Solid uranium oxide	Exempt	NA	NA	NA

Notes

BMR	baseline monitoring report
CAP	corrective action plan
CAR	corrective action report
CERCLA	conducted under the Comprehensive Environmental Response, Compensation, and Liability Act
CR	closure report
EA	environmental assessment
EAR	environmental assessment report
FPRR	free product removal report
IAR	initial abatement report
ISCR	initial site characterization report
NA	not applicable
NI	not investigated
OE	overexcavation
RCRA	conducted under Resource Conservation and Recovery Act, Subtitle C
RIR	release investigation report
SIR	site investigation report
SRF	site ranking form
SSSR	site-specific standard request
SYDD	salvage yard drum deheader
TBD	to be determined

Table E.2. Underground storage tanks (USTs) at the ETTP

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation	Environmental assessment ( ) date to regulatory agency	Corrective action
					Hazardous USTs				
K-720-B	No. 2	1949	1981	~75	Methyl mercaptan	Removed 7/12/96	NA Regulated under the Pipeline Safety Act	NA	NA
K-720-C1	No. 3	1949	1981	~175	Methyl mercaptan	Removed 7/11/96	NA Regulated under the Pipeline Safety Act	NA	NA
K-720-C2	No. 4	1949	1981	~175	Methyl mercaptan	Removed 7/11/96	NA Regulated unde the Pipeline Safety Act	NA	NA
K-721	No. 5	1949	1981	~175	Methyl mercaptan	Removed 1987	NA Regulated under the Pipeline Safety Act	NA	NA
K-1414	No. 8	1975	NA	12,600	85% methanol, 15% gasoline	Removed 5/8/97	CR (7/16/97)	NA	NA
K-1134	A	1983	NA	1,000	Installed for spill and overfill protection	Never used	NA	NA	NA
					Petrolum USTs				
K-1652	No. 1	1983	4/1/96	285	Diesel	Inert filled 7/16/96	CR (8/96)	NA	NA
K-1414	No. 6	1949	2/90	500	Used oil	Inert filled 5/23/91	CR (8/7/91)	NA	NA
K-1414	No. 7	1956	5/14/93	22,000	Gasoline	Inert filled 6/28/94	CR (7/26/94)	NA	NA
K-1414	No. 9	1953	2/87	1,500	Diesel	Removed 3/387	CERCLA	TBD	TBD
K-1220-NE	No. 10	1979	4/90	970	Diesel	Removed 4/23/91	CR (8/7/91)	EA (8/6/93)	NA
K-1220-SE	No. 11	1979	4/90	970	Diesel	Removed 4/25/91	CR (8/7/91)	NA	NA
K-1210-N	No. 12	1977	8/89	1,500	Diesel	Removed 8/29/89	CR (3/25/91)	NA	NA

Table E.2 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation	Environmental assessment ( ) date to regulatory agency	Corrective action
K-1210-A	No. 13	1977	8/89	1,500	Diesel	Removed 8/25/89	CR (3/25/91)	NA	NA
K-1200	No. 14	1974	8/89	500	Diesel	Removed 8/23/89	CR (3/25/91)	NA	NA
K-33	No. 15	1955	3/90	12,000	Diesel	Removed 3/23/90	CR (2/19/91)	NA	NA
K-1650	No. 16	1980	3/27/96	250	Diesel	Inert filled 7/16/96	CR (8/15/96)	NA	NA
K-1402	No. 17	1944	12/16/91	275	Diesel	Removed 10/6/92	CR (1/12/95)	SIR 11/92	NA
K-1007	No. 18	Unknown	8/28/86	1,000	Gasoline	Removed 8/86–10/86	NA	NA	NA
K-806	No. 19	1978	1/18/95	250	Gasoline	Removed 11/14/95	CR (12/22/95)	NA	NA
K-1414	No. 20	1992	NA	20,000	Gasoline	In use, full compliance	NA	NA	NA
K-1414	No. 21	1992	NA	6,000	Diesel	In use, full compliance	NA	NA	NA

Notes:

CERCLA	conducted under the Comprehensive Environmental Response, Compensation, and Liability Act
CR	closure report
EA	environmental assessment
NA	not applicable
SIR	site investigation report
TBD	to be determined
TOU	temporarily out of use

Table E.3. Underground storage tanks (USTs) at ORNL

ORNL #	TDEC #	Installed	Out of service	Capacity gallons	Contents	Status	Comments	Correspondence (most recent)	Corrective action
0902	1	1964	1980	50	Gasoline	Closed in place	V<110 gal (deferred from regulation)	ANF 1996	NA
1505	2	1977	1997	1000	Diesel	Closed in place	Emergency generator	PCR 1997	NA
2009	3	Unknown	1989	345	Gasoline	Excavated	Emergency generator	NFARL 1991	NA
2011	4	1973	1994	285	Diesel	Excavated	Emergency generator	NFARL 1995	Removed soil
2026	5	1964	1992	285	Diesel	Excavated	Emergency generator	NFARL 1997	Removed soil; GW monitored
2088	6	1975	1996	285	Diesel	Excavated	Emergency generator	PCR 1996	Removed soil
2519A	8	1964	1992	500	Gasoline	Closed in place	SSS approved	NFARL 2/98	GW monitored
2519B	9	1975	1992	750	Diesel	Excavated	SSS approved	NFARL 2/98	Removed soil; GW monitored
2521	10	1974	1997	285	Diesel	Closed in place	Emergency generator	PCR 1997	NA
2572A	11	1980	1997	285	Diesel	Closed in place	Emergency generator	PCR 1997	NA
2572B	7	1965	1985	110	Gasoline	Closed in place	V = 110 gal (deferred from regulation)	ANF 1996	NA
3019B	13	1952	1992	100	Gasoline	Excavated	V<110 gal (deferred from regulation)	NFARL 1993	Removed soil
3029/ 3032	14	1985	1995	250	Diesel	Closed in place	Emergency generator	PCR 1995	NA
3042	15	1960	1995	3000	Diesel	Closed in place	Emergency generator	PCR 1995	NA
3047A	16	1973	1995	285	Diesel	Closed in place	Emergency generator	PCR 1995	NA
3047B	17	1965	1989	50	Diesel	Closed in place	V<110 gal (deferred from regulation)	ANF 1996	NA

Table E.3 (continued)

ORNL #	TDEC #	Installed	Out of service	Capacity gallons	Contents	Status	Comments	Correspondence (most recent)	Corrective action
3123	18	1972	1994	285	Diesel	Excavated	Emergency generator	NFARL 1995	Removed soil
3125	19	1973	1988	1000	Diesel	Excavated	Emergency generator	NFARL 1995	Removed soil; GW monitored
3130	20	1982	1997	550	Diesel	Closed in place	Emergency generator	PCR 1997	NA
3131	21	1979	1995	1000	Diesel	Closed in place	Emergency generator	PCR 1995	NA
3132	22	1979	1995	1000	Diesel	Excavated	Emergency generator	PCR 1995	Removed soil
3146	12	1985	1995	550	Diesel	Excavated	Emergency generator	PCR 1995	Removed soil
3598	23	1962	1994	400	Diesel	Closed in place	SRS approved	SSMR 1997	GW monitored
4500N	24	1975	1995	5000	Diesel	Excavated	Emergency generator	PCR 1995	Removed soil
4500S	25	1960	1989	1000	Diesel	Excavated	Emergency generator	NFARL 1995	Removed soil; GW monitored
4500N "B"	54	1995	NA	1000	Diesel	In use	New UST installed 9/95	Annual fee–1998	NA
4501	26	1960	1984	325	Diesel	Closed in place	Closed prior to 12/22/88 but after 1/1/74	ANF 1996	NA
4514	27	1986	1997	1000	Diesel	Closed in place	Last UST closed (11/97)	PCR 1997	NA
6554	28	1977	1990	3000	Ethylene glycol	Excavated	Hazardous Substance UST	PCR to EPA 1992	NA
7002A	29	1948	1989	300	PCB, Rad Waste oil	Excavated	RCRA SWMU; PCB UST; Tank decon approved by EPA in 1994	PCR 1989	Removed soil
7002B	30	1947	1977	8000	Gasoline	Closed in place	Closed prior to 12/22/88 but after 1/1/74	ANF 1996	NA

Table E.3 (continued)

ORNL #	TDEC #	Installed	Out of service	Capacity gallons	Contents	Status	Comments	Correspondence (most recent)	Corrective action
7009	32	1975	1990	5000	Waste oil	Excavated	PCB UST: Tank decon approved by EPA in 1994	NFARL 1991 for the UST site	Removed soil
7063	31	1964	1989	50	Gasoline	Closed in place	V<110 gal (deferred from regulation)	ANF 1996	NA
7069A	33	1956	1989	8500	Diesel	Excavated	Old Gas Station UST	PCR 1991	NA
7069B	34	1956	1986	8300	Gasoline	Excavated	Old Gas Station UST: SSS approved	NFARL 1997	Removed soil; GW monitored
7069C	35	1956	1989	4000	Gasoline	Excavated	Old Gas Station UST	PCR 1991	NA
7069D	36	1972	1990	10000	Diesel	Excavated	Old Gas Station UST	PCR 1991	Removed soil; GW monitored
7069E	37	1988	NA	6000	Diesel	In Use	New Gas Station UST: SSS approved	Annual fee–1998	GW monitored
7069F	38	1988	NA	15000	Gasoline	In use	New Gas Station UST: SSS approved	Annual fee–1998	GW monitored
7075	39	1982	1994	4200	Waste oil	Closed in place	RCRA Subtitle C	NA	Closure under Subtitle C
7560	40	Unknown	1997	1000	LLLW	Closed in place	FFA Category D	NA	Closure by FFA Program
7562	41	Unknown	1997	12000	LLLW	Closed in place	FFA Category D	NA	Closure by FFA Program
7600	42	1960	1996	24000	Heating oil	Closed in place	Excluded from regulation	NA	NA
7602	43	Unknown	Unknown	13000	Wastewater	In use	Deferred from regulation	ANF 1996	NA
7605	44	1962	1989	1000	Diesel	Excavated	Emergency generator	NFARL 1991	NA
7606	45	1960	1993	1000	Heating oil	Excavated	Excluded from regulation	NA	Soil removed

Table E.3 (continued)

ORNL #	TDEC #	Installed	Out of service	Capacity gallons	Contents	Status	Comments	Correspondence (most recent)	Corrective action
7615	46	1962	1989	280	Paint Solvents	Excavated	Hazardous Substance UST	PCR to EPA 1992	NA
7618	47	1980	1995	2000	Diesel	Excavated	Emergency generator	PCR 1995	NA
7830A	48	1981	NA	5000	Rad Waste Oil	In Use	RCRA Subtitle C	NA	Permitted under Subtitle C
7860A	49	1983	1992	3700	Waste oil	Excavated	RCRA Subtitle C	NA	Closure under Subtitle C
7860B	50	1982	1993	500	Diesel	Closed in place	Emergency generator	NFARL 1994	NA
7901	51	1962	1996	4000	Diesel	Closed in place	Emergency generator	PCR 1996	NA
7921	52	1966	1996	500	Diesel	Closed in place	Emergency generator	PCR 1996	NA
7931	53	1967	1996	550	Diesel	Excavated	Emergency generator; SRS approved; GW monitoring expected to be completed 8/99.	SSMR 2/98	Removed soil; GW monitored
2572C	NA	Unknown	1973	Unknown	Gasoline	Closed in place	Not registered since closed prior to 1/1/74.	NA	NA
3001C	NA	1942	1970	50	Oil	Closed in place	Not registered since closed prior to 1/1/74.	NA	NA
5500A	NA	Unknown	1970	200	Gasoline	Closed in place	Not registered since closed prior to 1/1/74.	NA	NA
7740B	NA	Unknown	1973	Unknown	Gasoline	Closed in place	Not registered since closed prior to 1/1/74.	NA	NA
"Parcel A/Bethel Valley UST-1	1	Unknown	1989	800	Gasoline	Excavated	Registered to 2-730089.	NFARL 1991	NA

Table E.3 (continued)

ORNL #	TDEC #	Installed	Out of service	Capacity gallons	Contents	Status	Comments	Correspondence (most recent)	Corrective action
Rogers Quarry	1	Unknown	1991	250	Gasoline	Excavated	Registered to 0-730180.	NFARL 1995	NA
Clinch River Breeder Reactor	1	1971	1991	250	Gasoline	Excavated	Registered to 0-730179.	NFARL 1995	NA

Notes

ANF = Amended Notification Form
APC = Application for Permanent Closure
EPA = Environmental Protection Agency
FFA = Federal Facilities Agreement
GW = Ground Water
LLLW = Low-Level Liquid Waste
NA = Not Applicable
NFARL = No Further Action Required Letter
PCR = Permanent Closure Report
RCRA = Resource Conservation and Recovery Act
SRS = Site Ranking System
SSMR = Site Status Monitoring Report
SSS = Site Specific Standard
SWMU = Solid Waste Management Unit
TDEC = Tennessee Department of Environment and Conservation

Appendix F: NPDES Noncompliances

Table F.1. Summary of Y-12 Plant NPDES excursions, 1997

Date	Location	Excursion	Explanation	Corrective action
3/19/97	Outfall 014	Oil sheen	An oil sheen was observed flowing from Outfall 014 on the north bank of East Fork Poplar Creek (EFPC) behind Building 9720-4. The sheen resulted from a diesel fuel spill during filling of an underground tank at the Y-12 fuel station, Building 9754-3. It is estimated that less than 10 gal was spilled	The pavement upon which the diesel fuel spilled was cleaned using absorbal. Booms were installed at the Lake Reality outlets to prevent off-site release. Most of the sheen was captured in Lake Reality, and absorbent diapers were used to clean the oil sheen from EFPC and Lake Reality. Booms were also installed on EFPC at Outfall 14 and downstream of Lake Reality. A Best Management Practice plan will be implemented in future fuel station transfer operations to prevent future spills to the storm drain system.
4/22/97	Outfall 501	Permit limit exceedence	A grab sample of the Central Pollution Control Facility (CPCF) effluent indicated pH to be 9.2, which is outside the permitted pH range of 6.0 to 9.0.	CPCF personnel modified operation of the pH adjustment unit, and the effluent was brought well within permissible range. This was verified by same-day resampling of the effluent, with pH sample results at 8.3.
7/24/97	Outfall 055	Permit limit exceedence	A localized storm released nearly 6 inches of rain within 2 hours during the evening of July 22–23, 1997, flooding Building 9201-2. The East End Mercury Treatment Facility (EEMTF), which is located in this building, treats contaminated sump waters from the basement. During the flood event, a power outage rendered the sumps that feed the EEMTF inoperable. Emergency pumping was implemented per EEMTF bypass procedures, resulting in contaminated water being discharged through NPDES Outfall 55. Analysis of a grab sample taken at this location resulted in a mercury reading of 0.0047 mg/L. This is above the permitted value of 0.004 mg/L.	Operation of the treatment unit resumed after flood waters subsided

Table F.1 (continued)

Date	Location	Excursion	Explanation	Corrective action
7/29/97	Outfall 055	Permit limit exceedence	Pumping operations in Building 9201-2 continued from the flood event of July 22–23, 1997. A grab sample of Outfall 55, from which contaminated waters bypassing the EEMTF flowed, resulted in a mercury reading of 0.010 mg/L. This is above the permitted value of 0.004 mg/L.	Operation of the treatment unit resumed after flood waters subsided.
9/4/97	Outfall 501	Permit limit exceedence	A sample taken of the CPCF effluent indicated nitrates (as nitrogen) present in the amount of 290 mg/L. This exceeds the permit limit of 100 mg/L.	Lower influent content of nitrates at CPCF.
9/24/97	Outfall 501	Permit limit exceedence	A sample taken of the CPCF effluent indicated nitrates (as nitrogen) present in the amount of 193 mg/L. This exceeds the permit limit of 100 mg/L.	Eliminate high-nitrate wastewater from system and treat at West End Treatment Facility. Lower influent content of nitrates at CPCF.
9/30/97	Station 17	Permit limit exceedence	The monthly average of the daily flow of water at Station 17 was 6.9 million gpd, which is less than the requirement of 7 million gpd. This was a result of a drier (less rainfall) than normal month and the unavailability of the north raw water feed line. The south line can supply a maximum of about 4.5 mgd.	Increase the amount of raw water released in EFPC, as necessary. Monitor and periodically remove debris and gravel to relieve submergence of the flume at the Station 17 monitoring location. Work with the USGS to identify impacts of obstructions in the creek on the accuracy of EFPC flow measurements. A funding request has been made for repair to the north line.

Table F.2. Summary of ORNL NPDES excursions, 1997

Outfall	Date	Excursion	Explanation	Corrective action
081	2/10/97	Total residual oxidant	Outfall 081 discharges street and parking lot runoff, roof runoff, and dechlorinated once-through cooling water from the Radiochemical Engineering Development Center area (7920/7930) to an unnamed tributary to Melton Branch. At the time of the TRO excursion on February 10, 1997, the dechlorinated cooling water sources were not in operation. The flow rate of the effluent on that date was approximately 6 gal/minute.	ORNL personnel investigated to determine and correct the source of the chlorine-bearing water that is being released via Outfall 081. As an interim corrective measure, one of the existing dechlorination systems associated with Outfall 081 was put into operation. The source of the chlorinated water was determined to be once-through cooling for steam condensate. A recirculating cooling system has been designed and is being installed to eliminate the need for once-through cooling water at the facility.
281	2/17/97	Total residual oxidant	Outfall 281 is a Category IV cooling tower blowdown outfall that also conveys stormwater from the ORNL 7900 (High Flux Isotope Reactor, HFIR) area to an unnamed Melton Branch tributary. The main source of chlorine in Outfall 281 effluent is the chlorinated process supply water that is used as makeup water in the HFIR cooling tower.	To reduce the chlorine concentration in Outfall 281 effluent, HFIR cooling tower operators have revised the manner in which makeup water is cycled through the tower. This revision reduced the amount of makeup water that was required to operate the tower and was successfully controlling the chlorine concentration of Outfall 281 below the effective permit limit of 0.050 mg/L for several months after the February 17, 1997, excursion.
081	2/28/97	Total residual oxidant	This is a calculated, monthly average limit excursion that derived from the daily maximum concentration limit excursion on 2/10/97.	
281	2/28/97	Total residual oxidant	This is a calculated, monthly average limit excursion that derived from the daily maximum concentration limit excursion on 2/17/97.	
X01	3/24/97	Total residual chlorine	It was determined that dechlorination systems at the ORNL Steam Plant, which dechlorinate Steam Plant noncontact cooling water as well as Sewage Treatment Plant (STP) effluent, were not operating optimally at the time of the excursion.	The STP manager revised the STP operating practices to include more frequent operational checks, and adjustments whenever necessary, of the dechlorination systems that serve the ORNL Steam Plant cooling water and the STP effluent.

Table F.2 (continued)

Outfall	Date	Excursion	Explanation	Corrective action
081	4/21/97	Total residual oxidant	Outfall 081 is a Category IV outfall that discharges street and parking lot runoff, roof runoff, and dechlorinated once-through cooling water from the Radiochemical Engineering Development Center area (7920/7930) to an unnamed Melton Branch tributary. At the time of the TRO excursion on April 21, 1997, dechlorinated water was being discharged through Outfall 081 at a flow rate of approximately 14 gal/min.	At the time of the excursion, one of the existing tablet-feeder dechlorination systems associated with Outfall 081 were in operation. Upon discovery of the excursion, the water level in the tablet feeder was adjusted to provide a greater degree of effluent dechlorination.
281	4/21/97	Total residual oxidant	Outfall 281 is a Category IV stormwater and cooling tower blowdown outfall at the ORNL 7900 (High Flux Isotope Reactor, HFIR) area that discharges to an unnamed Melton Branch tributary. The main source of chlorine in Outfall 281 effluent is the chlorinated process supply water that is used as makeup water in the HFIR cooling tower. The effluent flow rate from Outfall 281 was approximately 90 gal/min.	HFIR cooling tower operators had previously revised the manner in which makeup water is cycled through the tower to reduce the chlorine concentration in Outfall 281 effluent. This revision reduced the amount of makeup water that is required to operate the tower and had successfully controlled the chlorine concentration of Outfall 281 without additional chemical feed until the excursion. As a result of the excursion, operators installed a dechlorination system at the tower as an additional NPDES permit compliance measure.
081	4/30/97	Total residual oxidant	The excursion of the daily maximum limit on 4/21/97 caused the monthly average limit to also be exceeded based on calculations that are performed at the end of the month.	
281	4/30/97	Total residual oxidant	The excursion of the daily maximum limit on 4/21/97 caused the monthly average limit to also be exceeded based on calculations that are performed at the end of the month.	

Table F.2 (continued)

Outfall	Date	Excursion	Explanation	Corrective action
X01	7/10/97	Total residual chlorine	It was determined that an STP dechlorination system pump had experienced a loss of suction, which prevented an adequate feed rate of the dechlorination chemical, sodium metabisulfite.	The system was adjusted, and subsequent chlorine measurements that were made at 1:17 p.m. and at 3:45 p.m. on July 10, 1997, confirmed that the system was working properly. The STP manager had revised STP operating practices to include more frequent operational checks, and adjustments whenever necessary, of the STP dechlorination system. The revised practices include frequent routine checks of dechlorination systems and keeping a log record of various dechlorinator operating parameters to ensure proper operation of the systems and an adequate dechlorination chemical feed rate. No additional chlorine excursions have been measured at the STP since July 10, 1997.
267	7/22/97	Unpermitted discharge	On July 22, 1997, an underground potable water supply pipeline was accidentally breached during utility work on underground pipe fittings, allowing the release of approximately 4000 gal of potable (chlorinated) water to Fifth Creek via Outfall 267. The release occurred within a utility excavation; therefore, considerable turbidity was also conveyed to Fifth Creek.	The damaged pipe was valved off for repair within 15 minutes, stopping the release, and erosion control measures were taken at the site. A stream survey that was conducted shortly after the release indicated no impact on fish in Fifth Creek.
X16	9/8/97	Total residual oxidant	The TRO was attributed to water effluent from Outfall 241, a storm drain outfall that originates near Building 1503. No impacts on aquatic life in First Creek were noted at the time of the exceedence, or thereafter.	Investigation of the water effluent from Outfall 241 indicated the source to be a nearby leaking underground potable water supply pipe. The location of the leak was determined, and the pipe was excavated and repaired. No additional chlorine excursions have been measured at X16 since September 8, 1997.

Table F.2 (continued)

Outfall	Date	Excursion	Explanation	Corrective action
X16	9/30/97	Total residual oxidant	The single exceedence of the daily maximum limit on 9/8/97 also caused a calculated exceedence of the monthly average limit of 0.011 mg/L, even though no other measurements during September actually indicated the presence of TRO at monitoring point X16.	
X01	10/9/97	Carbonaceous biochemical oxygen demand	Aqueous sodium metabisulfite is used at the Sewage Treatment Plant, which discharges through Outfall X01, to dechlorinate the effluent and has the secondary effect of an additional oxygen demand if overfed into the effluent stream. The additional oxygen demand placed by the sodium metabisulfite was interfering with the CBOD5 measurement required for the STP effluent.	The chemical discharge tube from the dechlorination evaluation system has been relocated to a point below where the CBOD5 composite sample intake is located, yet where adequate dechlorination will occur. The chlorine disinfection and dechlorination evaluation system will be supplemented with an ozone disinfection system. The Tennessee Department of Environment and Conservation has approved plans for this ozone system, and equipment is currently being procured for installation. This is an excursion of the daily maximum concentration limit.
X01	10/9/97	Carbonaceous biochemical oxygen demand	This is a daily maximum amount excursion that was calculated using the daily maximum concentration from and the average daily flow for October 9, 1997.	
281	10/20/97	Total residual oxidant	Diagnosis of this event indicated this excursion occurred when the aqueous sodium metabisulfite dechlorination chemical crystallized in the delivery line during a period when the cooling tower was not operating.	Immediate corrective measures included air purging the chemical delivery line to remove the blockage. An additional TRO measurement later that day verified that delivery of the chemical had been restored. Other planned corrective measures included installation of an in-line flow meter and an air purge system.

Table F.2 (continued)

Outfall	Date	Excursion	Explanation	Corrective action
281	10/23/97	Total residual oxidant	Additional monitoring was initiated on October 23, 1997, to further verify the corrective measure; however, an additional TRO excursion was measured. Further investigations by HFIR personnel revealed that the dechlorination chemical was not being delivered to the blowdown water and that the inconsistent dechlorination chemical delivery was related to air binding in the feed line.	Planned corrective measures included reconfiguration of the piping to eliminate air traps, installation of a high-point vent, installation of a flow meter for routine system performance checks, installation of a poly-tank (to provide inherent level indication for tank inventory), and incorporation of daily operational checks. To implement all of the corrective measures discussed above, a backup dechlorination system, which used sodium metabisulfite tablets, was activated and the aqueous sodium metabisulfite system was deactivated.
281	10/27/97	Total residual oxidant	Additional monitoring on October 27, 1997, resulted in an additional TRO excursion being measured. This excursion is attributed to the poor performance of the sodium metabisulfite tablets in the backup dechlorination system. It was observed that the tablets had incompletely dissolved and did not allow fresh tablets to drop into the flow of water.	The tablets were immediately adjusted to restore maximum water contact with fresh tablets. The liquid feed system was returned to service during the evening of October 27, 1997, after the corrective measures discussed above were completed. Additional monitoring results during the week showed the corrective measures to be effective in reducing the TRO levels below the detection limit.
281	10/31/97	Total residual oxidant	This excursion, which was calculated on the final day of the reporting period, is the average of all daily maximum TRO concentrations for October at Outfall 281.	Additional daily monitoring after the October 27, 1997, excursion indicated that the corrective measures had been successfully implemented and that the dechlorination capabilities of the system were being maintained. No subsequent excursions occurred in 1997.

Table F.2 (continued)

Outfall	Date	Excursion	Explanation	Corrective action
302	11/10/97	pH	pH was measured at Outall 302 during an investigation of a newly discovered source of water near the lower reach of the storm drain network that feeds Outfall 302. A measurement of the newly discovered water source also had a high pH.	ORNL personnel investigated the newly discovered source of water. Monitoring upstream in the 302 storm drain network revealed pH values within the expected range of 6.0–9.0 SU. Potential nearby sources of water leakage were isolated and cut off. No specific source, has been identified, but actions to find a source, including installation of an inflatable plug, have decreased the flow and pH of the water source and several subsequent pH measurement at Outfall 302 were within the allowable range.

Table F.3. Summary of ETTP NPDES excursions, 1997

Date	Location	Excursion	Explanation	Corrective action
3/17/97	Outfall 014 (CNF)	Total petroleum hydrocarbon	TPH measurement of 1.64 mg/L exceeded maximum permitted level of 0.1 mg/L.	Reviewed all operating records, lab procedures, and TPH levels in influent streams.
9/24/97	Storm Drain Outfall SD-124	Total residual chlorine	TRC measurement of 0.18 mg/L exceeded maximum permitted level of 0.14 mg/L.	SD-124 drainage area walked down, smoke testing conducted at catch basins, maps and video tape survey reviewed, daily surveillance of flow patterns conducted, declorination tablets placed in catch basin.
10/1/97	Storm Drain Outfall SD-100	Unpermitted discharge	Liquid solution of absorbent material used by private industrial firm leasing building at ETTP entered storm drain system.	BMPs to prevent occurrences were recommended to private industrial firm.
10/2/97	Storm Drain Outfall SD-500	Failure to obtain required sample	Category I Storm drain outfall was not sampled for flow and pH during 6 month reporting period of 3/1/97 through 9/30/97 as required by permit.	Existing tracking system for storm drain sampling reviewed and determined to be satisfactory. Sampling personnel were counseled to emphasize attention to detail.

Appendix G: Errata

Appendix G: Errata

The following corrections pertain to LMES 1997. *Oak Ridge Reservation Annual Site Environmental Report for 1996,* ES/ESH-73, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Replace Table 3.2 of the 1996 ASER with the following:

Table 3.2. Highest levels of heavy metals detected in 1996 at the city of Oak Ridge POTW compared with limits established in 40 CFR 503.13 and 40 CFR 503.23

Heavy metal	Highest level detected in sludge (mg/kg)[a]	Limits (mg/kg)[a]	
		40 CFR 503.13, Table 1	40 CFR 503.23, Table 1
Arsenic	12.8	75	73
Cadmium	19.40	85	—
Chromium	171.0	*b*	600
Copper	520.0	4300	—
Lead	74.0	840	—
Mercury	8.2	57	—
Molybdenum	54.0	*b*	—
Nickel	39.7	420	420
Selenium	18.2	100	—
Zinc	1610	7500	—

[a]Dry-weight basis.
[b]This limit has been excised by EPA.

Page 4-25: Units for Table 4.13, columns 3 and 4 (Effluent limits, Daily av and Daily max), should be lb/d rather than kg/d.

Page 4-49: Section 4.4.1.3 was omitted through a numbering error; no material is absent.

Appendix H: Glossary

Glossary of Environmental Terms

AA — See atomic absorption spectrometry.

absorption — The process by which the number and energy of particles or photons entering a body of matter is reduced by interaction with the matter.

accuracy — The closeness of the result of a measurement to the true value of the quantity.

aliquot — The quantity of sample being used for analysis.

alkalinity — Alkalinity is a measure of the buffering capacity of water, and because pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality.

alpha particle — A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air — The surrounding atmosphere as it exists around people, plants, and structures.

analytical detection limit — The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

analyte — A constituent or parameter that is being analyzed.

anion — A negatively charged ion.

aquifer — A saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard — A geologic unit that inhibits the flow of water.

ash — Inorganic residue remaining after ignition of combustible substances.

assimilate — To take up or absorb into the body.

atom — Smallest particle of an element capable of entering into a chemical reaction.

atomic absorption spectrometry (AA) — Chemical analysis performed by vaporizing a sample and measuring the absorbance of light by the vapor.

Atomic Energy Commission (AEC) — A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian application. It was abolished by the Energy Reorganization Act of 1974 and succeeded by the Energy Research and Development Administration (now part of the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission).

base/neutral and acid extractables (BNA) — A group of organic compounds analyzed as part of Appendix IX of 40 CFR 264 and the EPA list of priority pollutants.

beta particle — A negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

biota — The animal and plant life of a particular region considered as a total ecological entity.

blank — A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. In such cases, the measured value or signal for the substance being analyzed is believed to be a result of artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. EPA does not permit the subtraction of blank results in EPA-regulated analyses.

calibration — Determination of variance from a standard of accuracy of a measuring instrument to ascertain necessary correction factors.

carcinogen — A cancer-causing substance.

cation — Positively charged ion.

CERCLA-reportable release — A release to the environment that exceeds reportable quantities as defined by CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act).

chain-of-custody — A form that documents sample collection, transport, analysis, and disposal.

chemical oxygen demand — Indicates the quantity of oxidizable materials present in a water and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

chlorocarbons — Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethene, etc. They are among the most significant and widespread environmental contaminants. Classified as hazardous wastes, chlorocarbons may have a tendency to cause detrimental effects, such as birth defects.

closure — Specifically, closure of a hazardous waste management facility under RCRA requirements.

compliance — Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

concentration — The amount of a substance contained in a unit volume or mass of a sample.

conductivity — A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

confluence — The point at which two or more streams meet; the point where a tributary joins the main stream.

contamination — Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation — Ionizing radiation with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

count — The signal that announces an ionization event within a counter; a measure of the radiation from an object or device.

curie (Ci) — A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

kilocurie (kCi) — 10^3 Ci, one thousand curies; 3.7×10^{13} disintegrations per second.

millicurie (mCi) — 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.

microcurie (Ci) — 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.

picocurie (pCi) — 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

daughter — A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive — The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

dense nonaqueous phase liquid (DNAPL) — The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethene and trichloroethene.

derived concentration guide (DCG) — The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The guides for radionuclides in air and water are given in DOE Order 5400.5.

desorption — The process of removing a sorbed substance by the reverse of adsorption or absorption.

dilution factor — The mathematical factor by which a sample is diluted to bring the concentration of an analyte in a sample within the analytical range of a detector (e.g., 1 mL sample + 9 mL solvent = 1:10 dilution, or a dilution factor of 10).

disintegration, nuclear — A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dissolved oxygen — A desirable indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. Dissolved oxygen prevents the chemical reduction and subsequent leaching of iron and manganese from sediments.

dose — The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

absorbed dose — The quantity of radiation energy absorbed by an organ, divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 Gy).

dose equivalent — The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

committed dose equivalent — The calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).

committed effective dose equivalent — The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

effective dose equivalent — The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.

collective dose equivalent/collective effective dose equivalent — The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

dosimeter — A portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry — The theory and application of principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with using various types of radiation instruments to make measurements.

downgradient — In the direction of decreasing hydrostatic head.

downgradient well — A well that is installed hydraulically downgradient of a site and may be capable of detecting migration of contaminants from a site.

drinking water standards (DWS) — Federal primary drinking water standards, both proposed and final, as set forth by EPA.

duplicate samples — Two or more samples collected simultaneously into separate containers.

duplicate result — A result derived by taking a portion of a primary sample and performing the identical analysis on that portion as is performed on the primary sample.

effluent — A liquid or gaseous waste discharge to the environment.

effluent monitoring — The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures of members of the public, and demonstrating compliance with applicable standards.

Environmental Restoration — A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities contaminated with waste as a result of nuclear-related activities.

exposure (radiation) — The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation that takes place during a person's working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation — Exposure to ionizing radiation when the radiation source is located outside the body.

fecal coliform — The coliform group comprises all of the aerobic, non-spore-forming, rod-shaped bacteria. Testing determines the presence or absence of coliform organisms.

formation — A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

friable asbestos — Asbestos that is brittle or readily crumbled.

gamma ray — High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to X rays except for the source of the emission.

gamma spectrometry — A system consisting of a detector, associated electronics, and a multichannel analyzer that is used to analyze samples for gamma-emitting radionuclides.

genotoxicology — The study of the effects of chemicals or radioactive contaminants on the genetics of individual animals or plants.

grab sample — A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

groundwater, unconfined — Groundwater exposed to the unsaturated zone.

half-life, biological — The time required for a biological system, such as that of a human, to eliminate by natural processes half the amount of a substance (such as a radioactive material) that has entered it.

half-life, radiological — The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

halogenated compound — An organic compound bonded with one of the five halogen elements (astatine, bromine, chlorine, fluorine, and iodine).

halomethane — Any compound that includes a methane group (CH_3) bonded to a halogen element (astatine, bromine, chlorine, fluorine, or iodine).

hardness — Water hardness is caused by polyvalent metallic ions dissolved in water. In fresh water, these are mainly calcium and magnesium, although other metals such as iron, strontium, and manganese may contribute to hardness.

heavy water — Water in which the molecules contain oxygen and deuterium, an isotope of hydrogen that is heavier than ordinary hydrogen.

herbaceous — Having little or no woody tissue.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

hydrogeology — Hydrologic aspects of site geology.

in situ — In its original place; field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

internal dose factor — A factor used to convert intakes of radionuclides to dose equivalents.

internal radiation — Internal radiation occurs when natural radionuclides enter the body by ingestion of foods, milk, and water, and by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion — An atom or compound that carries an electrical charge.

ion exchange — Process in which a solution containing soluble ions is passed over a solid ion exchange column that removes the soluble ions by exchanging them with labile ions from the surface of the column. The process is reversible so that the trapped ions are removed (eluted) from the column and the column is regenerated.

irradiation — Exposure to radiation.

isotopes — Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

long-lived isotope — A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than 3 years).

short-lived isotope — A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is 2 days or less).

lower limit of detection (LLD) — The smallest concentration/amount of analyte that can be reliably detected in a sample at a 95% confidence level.

maximally exposed individual — A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

mercury — A silver-white, liquid metal solidifying at -38.9°C to form a tin-white, ductile, malleable mass. It is widely distributed in the environment and biologically is a nonessential or nonbeneficial element. Human poisoning from this highly toxic element has been clinically recognized.

microbes — Microscopic organisms.

migration — The transfer or movement of a material through the air, soil, or groundwater.

millirem (rem) — The dose equivalent that is one one-thousandth of a rem.

milliroentgen (mR) — A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable activity — The smallest activity of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

monitoring — Process whereby the quantity and quality of factors that can affect the environment and/or human health are measured periodically in order to regulate and control potential impacts.

natural radiation — Radiation arising from cosmic and other naturally occurring radionuclide sources (such as radon) present in the environment.

nuclide — An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

outfall — The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

parts per million (ppm) — A unit measure of concentration equivalent to the weight/volume ratio expressed as milligrams per liter.

parts per billion (ppb) — A unit measure of concentration equivalent to the weight/volume ratio expressed as micrograms per liter or nanograms per milliter.

person-rem — Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

pH — A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 through 6, basic solutions have a pH > 7, and neutral solutions have a pH = 7.

piezometer — An instrument used to measure the potentiometric surface of the groundwater. Also, a well designed for this purpose.

precision — The closeness of approach of a value of similar or replicate results to a common value in a series of measurements.

priority pollutants — A group of approximately 130 chemicals (about 110 are organics) that appear on a U. S. Environmental Protection Agency list because they are toxic and relatively common in industrial discharges.

process water — Water used within a system process.

process sewer — Pipe or drain, generally located underground, used to carry off process water and/or waste matter.

purge — To remove water prior to sampling, generally by pumping or bailing.

quality assurance (QA) — Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC) — The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

quality factor — The factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad — The unit of absorbed dose deposited in a volume of material.

radioactivity — The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

radioisotopes — Radioactive isotopes.

radionuclide — An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reclamation — Recovery of wasteland, desert, etc., by ditching, filling, draining, or planting.

reference material — A material or substance with one or more properties that is sufficiently well established and used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

regression analysis — A collection of statistical techniques that serve as a basis for drawing inferences about relationships among quantities in a scientific system.

release — Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem — The unit of dose equivalent (absorbed dose in rads x the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

remediation — The correction of a problem. See Environmental Restoration.

RFI Program — RCRA Facility Investigation Program; EPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

RFI/RI Program — RCRA Facility Investigation/Remedial Investigation Program; on the ORR, the expansion of the RFI Program to include CERCLA and hazardous substance regulations.

roentgen — A unit of exposure from X or gamma rays. One roentgen equals 2.58×10^{-4} coulombs per kilogram of air.

screened interval — In well construction, the section of a formation that contains the screen, or perforated pipe, that allows water to enter the well.

seepage basin — An excavation that receives wastewater. Insoluble materials settle out on the floor of the basin, and soluble materials seep with the water through the soil column where they are removed partially by ion exchange with the soil. Construction may include dikes to prevent overflow or surface runoff.

self-absorption — Absorption of radiation by the sample itself, preventing detection by the counting instrument.

sensitivity — The capability of methodology or instruments to discriminate between samples with differing concentrations or containing varying amounts of analyte.

settleable solids — Material settling out of suspension within a defined period.

settling basin — A temporary holding basin (excavation) that receives wastewater, which is subsequently discharged.

sievert (Sv) — The SI (International System of Units) unit of dose equivalent, 1 Sv = 100 rem.

slurry — A suspension of solid particles (sludge) in water.

specific conductance — The ability of water to conduct electricity; this ability varies in proportion to the amount of ionized minerals in the water.

spike — The addition of a known amount of reference material containing the analyte of interest to a blank sample.

spiked sample — A sample to which a known amount of some substance has been added.

split sample — A sample that has been portioned into two or more containers from a single sample container or sample-mixing container.

stable — Not radioactive or not easily decomposed or otherwise modified chemically.

stack — A vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard deviation — An indication of the dispersion of a set of results around their average.

standard reference material (SRM) — A reference material distributed and certified by the National Institute of Standards and Technology.

storm water runoff — Surface streams that appear after precipitation.

strata — Beds, layers, or zones of rocks.

substrate — The substance, base, surface, or medium in which an organism lives and grows.

surface water — All water on the surface of the earth, as distinguished from groundwater.

temperature — The thermal state of a body considered with its ability to communicate heat to other bodies.

terrestrial radiation — Ionizing radiation emitted from radioactive materials, primarily potassium-40, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

total activity — The total quantity of radioactive decay particles that are emitted from a sample.

total dissolved solids — Dissolved solids and total dissolved solids are terms generally associated with freshwater systems and consist of inorganic salts, small amounts of organic matter and dissolved materials.

total organic halogens — A measure of the total concentration of organic compounds that have one or more halogen atoms.

total solids — The sum of total dissolved solids and suspended solids.

total suspended particulates — Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transect — A line across an area being studied. The line is composed of points where specific measurements or samples are taken.

transmissive zone — A zone of sediments sufficiently porous and permeable to allow the flow of groundwater through the zone.

transuranic waste — Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

transuranium elements — Elements with higher atomic weights than uranium; all 13 known transuranic elements are radioactive and are produced artificially.

trip blank — A sample container of deionized water that is transported to the well sample location, treated as a well sample, and sent to the laboratory for analysis; trip blanks are used to check for contamination resulting from transport, shipping, and site conditions.

tritium (^3H) — The hydrogen isotope with one proton and two neutrons in the nucleus. It emits a low-energy beta particle (0.0186 MeV maximum) and has a half-life of 12.5 years.

t-test — Statistical method used to determine if the means of groups of observations are equal.

turbidity — A measure of the concentration of sediment or suspended particles in solution.

unconsolidated zone — Soil zone located above the water table.

uncontrolled area — Any area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials.

upgradient — In the direction of increasing hydrostatic head.

volatile organic compounds — Used in many industrial processes, the levels of these carcinogenic compounds must be kept to a minimum. They are measured by volatile organic analyses content. Common examples include trichloroethane, tetrachloroethene, and trichloroethene.

watershed — The region draining into a river, river system, or body of water.

wetlands — Lowland areas, such as a marshes or swamps, inundated or saturated by surface water or groundwater sufficiently to support hydrophytic vegetation typically adapted for life in saturated soils.

wind rose — A diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

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