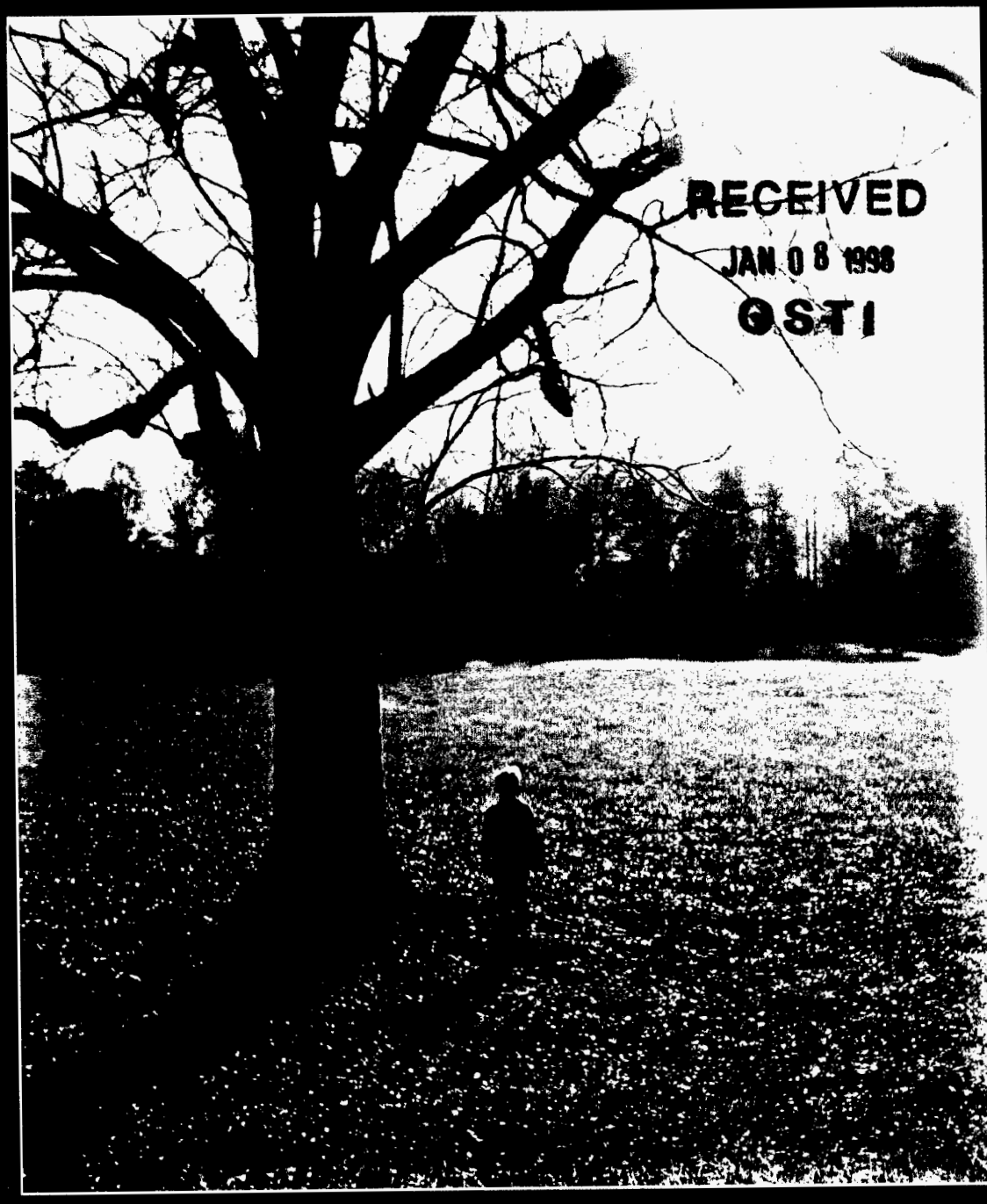
ES/ESH--73

OAK RIDGE Reservation

Annual Site Environmental Report for 1996



1996

— Looking Toward the Future —

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ES/ESH-73

Oak Ridge Reservation Annual Site Environmental Report for 1996

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http://www.ornl.gov/Env_Rpt/aser96/aser.htm

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ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
AOC	area of contamination
ARAP	Aquatic Resources Alteration Permit
ARAR	applicable or relevant and appropriate requirement
ASER	Annual Site Environmental Report
AVLIS	Atomic Vapor Laser Isotope Separation
BCK	Bear Creek kilometer
BCV	Bear Creek Valley
BMAP	Biological Monitoring and Abatement Program
BMP	best management practice
BOD	biological oxygen demand
CA	characterization area
CAA	Clean Air Act
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
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
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
dps	disintegrations per second
DUST	Division of Underground Storage Tanks
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
EM	environmental management
ELPAT	Environmental Lead Proficiency Analytical Testing Program
EMEF	Environmental Management and Enrichment Facilities
EML	Environmental Measurements Laboratory
EMP	*Environmental Monitoring Plan for the Oak Ridge Reservation*
EPA	U.S. Environmental Protection Agency
EPA-HQ	U.S. Environmental Protection Agency Headquarters
EPCRA	Emergency Planning and Community Right-To-Know Act
ER	environmental restoration
ESD	Environmental Sciences Division (ORNL)
ES&H	environment, safety, and health
ETTP	East Tennessee Technology Park
FDA	U.S. Food and Drug Administration
FFA	federal facilities agreement
FFCA	federal facilities compliance agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	finding of no significant impact
FY	fiscal year
GAAT	Gunite and Associate Tanks
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
HSWA	Hazardous and Solid Waste Amendments to RCRA (1984)
HV	high-volume
HVAC	heating, ventilating, and air-conditioning

I	intake
I/CDI	intake (estimated dose)/chronic daily intake
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
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
LLLW	liquid low-level (radioactive) waste
LLW	low-level (radioactive) waste
LMER	Lockheed Martin Energy Research Corporation
LMES	Lockheed Martin Energy Systems
MACT	maximum achievable control technology
MAP	Management Action Process
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	maximum contaminant level
MEK	Melton Branch kilometer
Mgd	million gallons per day
MIK	Mitchell Branch kilometer
MMES	Martin Marietta Energy Systems, Inc.
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
OHF	Old Hydrofracture Facility
ORAU	Oak Ridge Associated Universities
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
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)
REDC	Radionuclide Engineering Development Center
rem	roentgen equivalent man
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
R&D	research and development
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

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)
SMCL	secondary maximum contaminant level
SMO	Sample Management Office
SOP	standard operating procedure
SPCC	Spill Prevention Control and Countermeasures Plan
SPMD	semipermeable membrane device
S/RIDs	Standards/Requirements Identification Documents
ST	strong-tight
STP	Site Treatment Plan/Sewage Treatment Plant
SSSR	Site Specific Standard Request
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
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
TRK	Tennessee River kilometer
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSP	total suspended particulates
TSS	total suspended solids
TVA	Tennessee Valley Authority
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
WCK	White Oak Creek kilometer
WETF	West End Treatment Facility
WFPC	West Fork Poplar Creek
WIPP	Waste Isolation Pilot Plant
WMP	waste management program
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

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1. Site and Operations Overview

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, a government-owned, contractor-operated facility. Three sites compose the reservation: 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 produced (and continue to produce) radiological and hazardous wastes.

1.1 BACKGROUND

This document contains a summary of environmental monitoring activities on the Oak Ridge Reservation (ORR) and its 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 1996. The 1996 results are compiled in *Environmental Monitoring on the Oak Ridge Reservation: 1996 Results* (LMES 1997a). Reports are available on request from Oak Ridge National Laboratory (ORNL) Laboratory Records, P.O. Box 2008, Oak Ridge, TN 37831-6285.

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 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 approximately 34,516 acres of the contiguous land owned by DOE in the Oak Ridge area. A portion lies within the corporate limits of the city of Oak Ridge. The residential section of Oak Ridge forms the northern boundary of the reservation. The Tennessee 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 is about 798,925, with 5% of its labor force employed on the ORR (Fig. 1.3).

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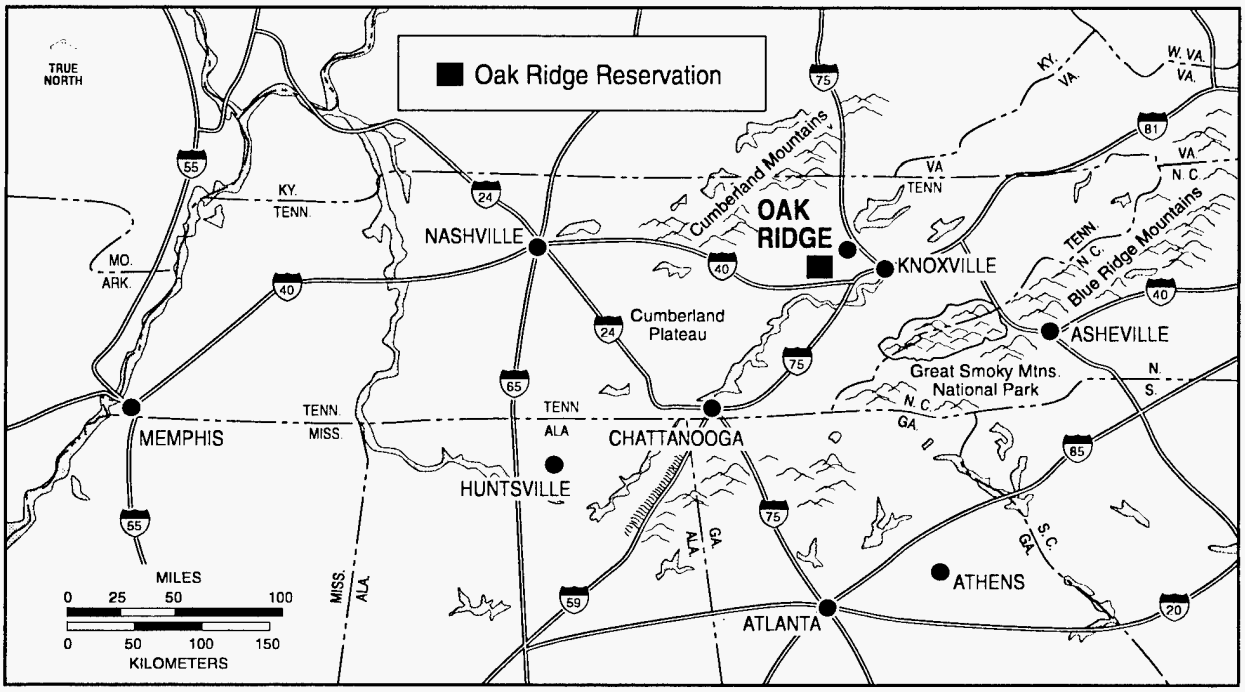

Fig. 1.1. Location of the city of Oak Ridge.

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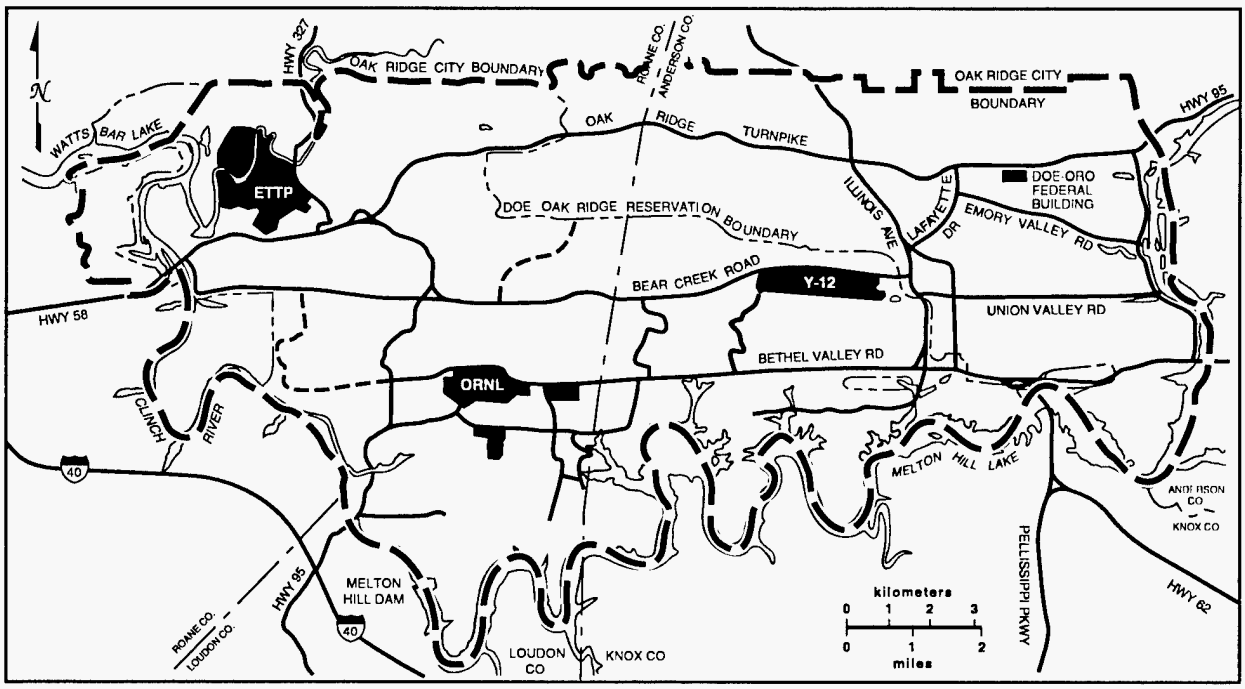

Fig. 1.2. The Oak Ridge Reservation.

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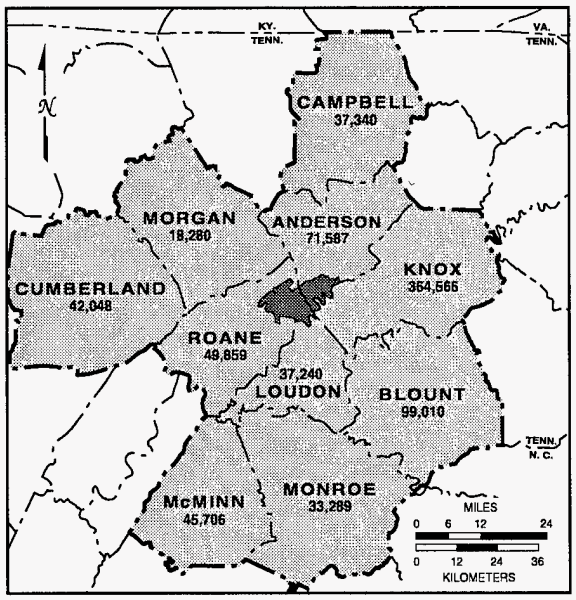

Fig. 1.3. The ten-county region surrounding the Oak Ridge Reservation. (Population figures are July 1, 1996, estimates taken from *Population Estimates for Tennessee Counties, 1990–1996* (TDECD 1996).

ORNL-DWG 87M-7054R5

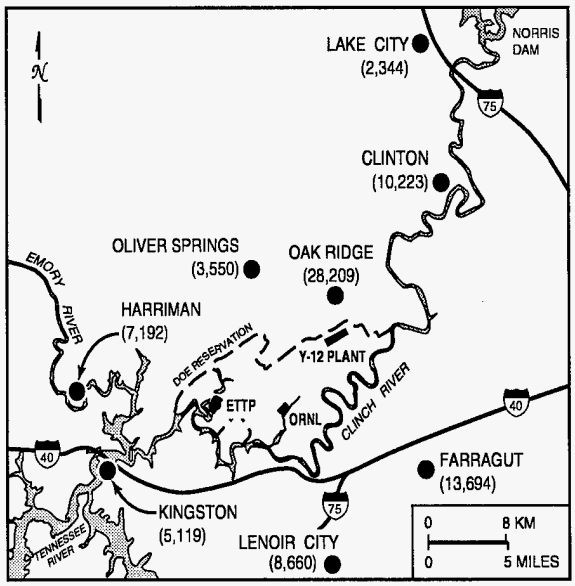

Fig. 1.4. Locations and populations of towns nearest to the Oak Ridge Reservation. (Population figures are July 1, 1994, estimates taken from *Population Estimates of Tennessee Cities, 1990–1994* (TDECD 1994).

Other towns in close proximity to the reservation include Oliver Springs, Clinton, 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 169,311 as reported in *Population Estimates of Tennessee Cities, 1990–1994* (TDECD 1994). Except for the city of Oak Ridge, the land within 8 km 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 occasionally dipping as low as –31°C (–24°F). July is typically 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).

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 as common as in 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 1977). Precipitation in 1996 was 169.0 cm (66.5 in.), about 30.5 cm (12 in.) above the annual average. 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, contractor-Operated 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 East Tennessee Technology Park (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, 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 numerous leased buildings housing about 7% 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. (LMES). 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 1996 LMES managed the Y-12 Plant, ETTP, and programs at the Paducah, Kentucky, facility 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).

1.4.2 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, inspection, 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. The technology transfer mission has as

Y-12 PHOTO 306208

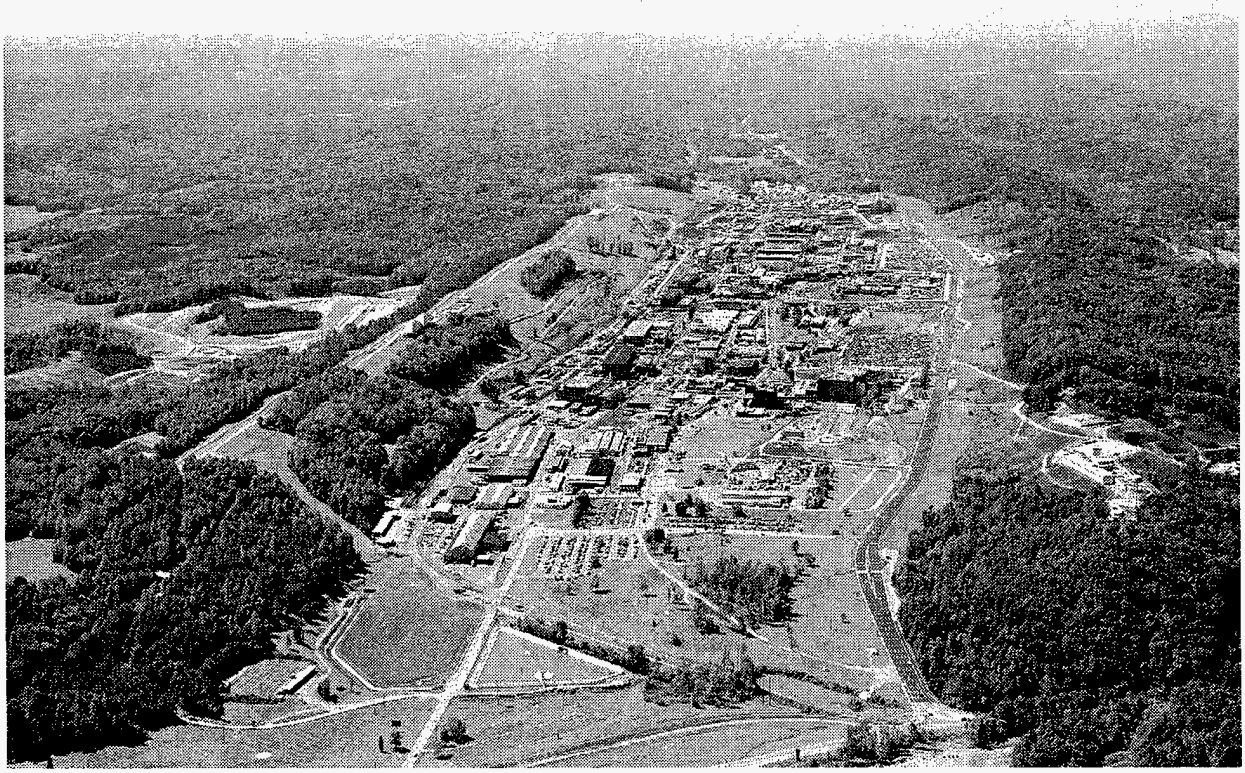

Fig. 1.5. The Oak Ridge Y-12 Plant.

its goal to apply 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.

The Oak Ridge Centers for Manufacturing Technology, 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 exist at the Y-12 Plant in 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 more than 3,000 companies 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, visit the Y-12 Plant home page on the World-Wide Web (http://www.ornl.gov/mmes-www/general/OverviewY12.html).

1.4.3 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.

DOE ORO 89-1063

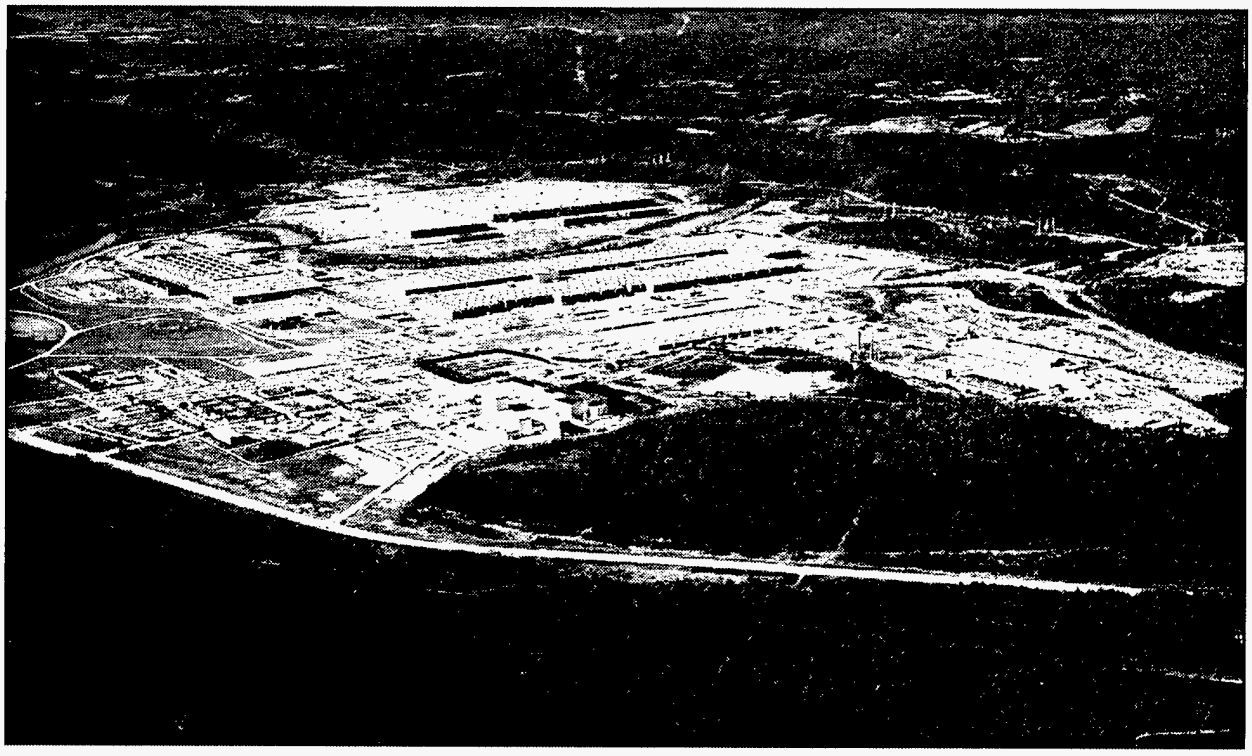

Fig. 1.6. The East Tennessee Technology Park (formerly the Oak Ridge K-25 Site).

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 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 Environmental Management and Enrichment Facilities business unit (EMEF).

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.

For more information, visit the ETTP home page on the World-Wide Web (http://www.ornl.gov/mmes-www/ERWM/erwmout.html).

1.4.4 Lockheed Martin Energy Research Corp.

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, which comprises 63.7% (almost 22,000 acres) of the reservation. Portions of the Park overlap areas of responsibility of 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).

1.4.5 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 in Oak Ridge, Tennessee. From its modest beginning as a war-time pilot plant, ORNL has grown to become one of the world's premier scientific research centers and home to 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 4,250 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 the entire reservation land as a Tennessee Wildlife Management Area.

ORNL's mission is to support DOE in six broad areas:

- energy production and conservation technologies—ORNL conducts applied R&D in energy technologies, conservation, renewable

DOE ORO 89-1216

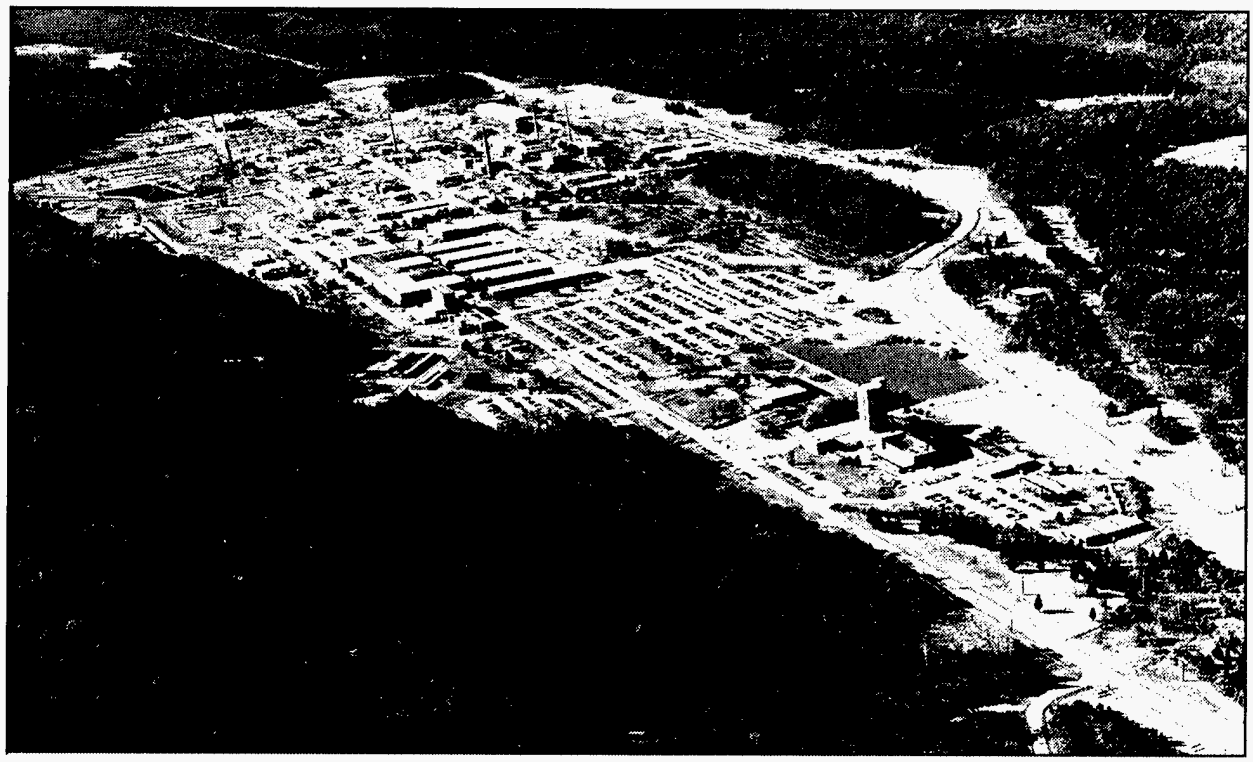

Fig. 1.7. The Oak Ridge National Laboratory.

energy sources, magnetic fusion, fission, and fossil energy;

- physical and life sciences—experimental and theoretical research is undertaken to investigate fundamental problems in physical, chemical, materials, computational, biomedical, earth, environmental, and social sciences;
- scientific and technological user facilities—ORNL designs, builds, and operates unique research facilities for the benefit of university, industrial, federal agency, and other national laboratory researchers, bringing together national and international research elements for important scientific and technical collaborations;
- environmental protection and waste management—ORNL develops new technologies to correct existing environmental problems, to prevent future problems, and to reduce waste generation by recycling, reusing, and substituting less deleterious materials;
- science and technology transfer—the transfer of science and technology to U.S. industries and universities, a key factor in increasing the nation's international economic competitiveness, is an integral component of ORNL's R&D activities; and
- education—ORNL helps to prepare the scientific and technical work force of the future by offering innovative and varied learning and R&D experiences to students and faculty members from the preschool level through high school to postdoctoral studies and by establishing new relationships with educational institutions by teaming, partnering, and establishing joint initiatives.

1.4.5.1 Oak Ridge National Environmental Research Park

The Oak Ridge National Environmental Research Park is a 21,980-acre "outdoor laboratory" with relatively undisturbed ecosystems

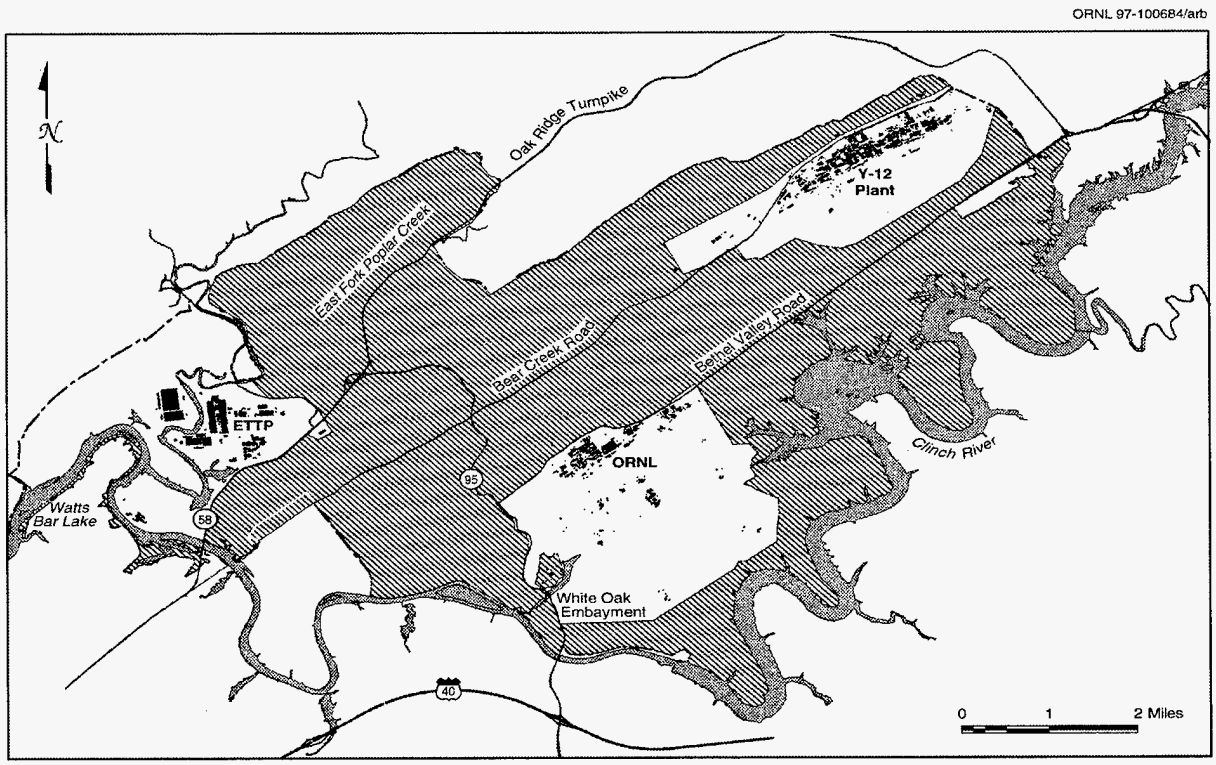

Fig. 1.8. The Oak Ridge National Environmental Research Park Covers 21,980 acres on the reservation.

(Fig. 1.8). The Research Park provides protected, biologically diverse land area for environmental research and education. It represents the eastern deciduous forest with more than 1,100 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 2.5 and 2.6). 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 diverseness 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 five 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.

1.4.6 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) currently occupies about 65 ha (162 acres) and 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.

ORISE received the DOE Pollution Prevention Award in 1994 for work in transforming three lagoons on the Scarboro Site into functional wetlands for the degradation of hazardous wastes into harmless constituents. 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

Abstract

It is the policy of the U.S. Department of Energy (DOE) 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), necessary and sufficient 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

Three of the most significant challenges faced by the DOE facilities in Oak Ridge are to maintain scientific and technical excellence, to increase productivity, and to cut costs, while doing so without compromising environmental, health, or safety protection. Toward that end, policy and strategy have been formulated at the national level, calling for contract reforms and stakeholder involvement in shaping the future of the DOE mission. At the local level, the DOE Oak Ridge Operations Office (DOE-ORO) and its contractors are redefining local missions and are refocusing technical capabilities and expertise to maintain the leadership role of the ORR facilities as premiere research institutes to better serve the nation.

Consistent with this initiative, there were significant changes at the ORR during 1996. A contract was signed with DOE, effective January 1, 1996, that transferred the responsibility for operating ORNL from LMES to the newly formed LMER. The Analytical Services Organization moved the sample preparation work for environmental radiochemistry and bioassay to a new building off the ORR. The laboratory is located in Union Valley just east of the Y-12 Plant and is known as the Union Valley Sample Preparation Facility. Other DOE operations on the ORR include the Scarboro Operations, managed by ORISE, and the operation of the Oak Ridge Water plant by Johnson Controls World Services, Inc.

In another move to reshape the ORR, DOE announced its intention to rebid the EMEF contract, which includes the ETTP and EMEF-funded activities at the ORNL, Y-12, Paducah, and Portsmouth facilities. Both LMES and LMER are DOE prime contractors.

DOE's operations on the reservation are required to be in conformance with environmental criteria 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 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 mixed 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 treatment, storage, or disposal facility. At the end of 1996, the Y-12 Plant had about 219 generator accumulation areas for hazardous or mixed waste. ORNL had about 350 generator accumulation areas, and the ETTP maintained 206.

The Union Valley Sample Preparation Facility managed by the Analytical Services Organization is also considered a large-quantity generator. At the end of 1996, 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 Valley Road is also classified as a conditionally exempt small-quantity generator. The Transportation Safeguards Division Garage, at present, is a small-quantity generator. However, because of recycling efforts and product replacements, the reduction of hazardous waste generation at this facility should allow its reclassification to a conditionally exempt small-quantity generator. ORNL's Walker Branch Watershed Laboratory is a conditionally exempt small-quantity generator.

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, the most recent version of which was approved in July 1991. 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 permit (TNHW-032) was issued by the TDEC on September 30, 1994, for tank storage units.

Three Class 1 permit modifications were submitted to the TDEC in 1996 for Permit TNHW-032. These modifications included updating the contingency plan; modifying the valves at the OD-9 unit; updating forms, attachments, and facility maps; updating inspection requirements for the tanks; installing a drum crusher at the OD-9 unit; and minor modifications to the language in the permit.

Permit TNHW-083 was issued by TDEC on September 28, 1995, for container storage units.

Four Class 1 and one Class 2 permit modifications were submitted to TDEC in 1996 for Permit TNHW-083. These modifications included updating the contingency plan, modifying signage requirements, updating the closure plan requirements, modifying the fire protection system and diking in Buildings 9720-9 and 9811-1 (OD-8), changing the marking requirements for containers in Building 9720-31, adding the capability to accept waste generated from DOE off-site facilities, and minor modifications to the language in the permit.

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
TNHW-092	Building 9720-32 Building 9720-59
	ORNL
TNHW-010A	Building 7507 Building 7507W Building 7651 Building 7653 Building 7654 Building 7668 Building 7669 Building 7934
TNHW-010	Building 7652
TNHW-027	Tank 7830A
	ETTP
TNHW-015	K-1435 Toxic Substances Control Act Incinerator
TNHW-015A	Storage of Waste at K-1435
TNHW-056	Container and tank storage
TNHW-057	Container and tank storage

Permit TNHW-084 was also issued by TDEC on September 28, 1995, for production-associated units.

Four Class 1 permit modifications were submitted to TDEC in 1996 for Permit TNHW-084. These modifications included updating the contingency plan; updating calculations for the Cyanide Treatment Unit; updating forms, attachments, and facility maps; updating inspection requirements; adding allowance of additional container sizes and types; moving and modifying storage racks within the headhouse of Building 9212; and minor modifications to the language in the permit.

Permit TNHW-092 was issued by TDEC on Sept. 3, 1996, for the production and classified waste storage areas, which include Buildings 9720-32 and 9720-59.

One Class 1 permit modification was submitted to the TDEC in 1996 for Permit TNHW-092. This modification included updating a facility map.

Four units at the Y-12 Plant operate under interim-status requirements. Eight wastewater treatment units operate under a RCRA exemption for wastewater treatment units already permitted under the Clean Water Act (CWA).

RCRA postclosure permits for the Y-12 Plant Kerr Hollow Quarry, Chestnut Ridge Security Pits, and New Hope Pond site were received in 1996. (See Sect. 2.2.2 for additional information.)

ORNL is registered as a large-quantity generator and a TSD facility under EPA ID Number TN1890090003. Two additional ORNL facilities (off site of the main ORNL facility) operated as small-quantity generators under EPA ID Numbers TN8981800008 and TN8891800007 in previous years, but in 1996 they did not generate hazardous wastes at levels to be regulated as small-quantity generators. One site generated no waste; the other site (Walker Branch Watershed Laboratory) generated less than 100 kg each month and was regulated as a conditionally exempt small-quantity generator.

ORNL's most recent Part A revision on August 9, 1996, included 34 units. Two units were removed from the Part A in that revision (proposed Building 7573, which will not be built, and Building 7860, which was closed). During 1996, 24 units operated as interim-status or permitted units, and another 10 units were proposed (new construction). Construction was essentially completed on three new storage units: 7668 for mixed wastes, 7883 for transuranic (TRU) mixed wastes, and 7572 for contact-handled TRU mixed waste storage. Wastes were not stored in those three units or in Building 7574 (awaiting final readiness review approval) during 1996.

ORNL has received three RCRA permits (see Table 2.1). During 1996, eight units continued to operate under a 1995 Part B Permit (TNHW-010A). Building 7652 continued to operate under a 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).

Six Class 2 permit modifications (two for each of the three permits) were submitted to TDEC in 1996 to incorporate F039 and the newly listed carbamate wastes; to add two portable-sampling handling units; and to update the Contingency Plan, Training Plan, and maps. TDEC issued a notice of deficiency (NOD) on the 1993 permit application for the TRU waste storage units in January 1996. ORNL responded to the NOD in February and issued a revised permit application in July that added seven additional units. TDEC action on that permit application is pending. On September 27, 1996, TDEC rescinded the Class 1a modification that they had approved in September 1995, eliminating the East Tennessee Economic Council and LMES as co-operators on the permit for Building 7652.

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.

1996 modifications to the ETTP RCRA permits include an update of contingency plan information, modifications to inspection schedules, the implementation of broader use of process knowledge, and repackaging activities.

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 HSWA permit for the ORR was issued 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. Many HSWA permit requirements have now been integrated into the ORR federal facilities 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 for DOE review. Lockheed Martin staff and DOE staff submitted comments and suggested changes on the draft permit for EPA consideration. EPA action is pending on that comment package.

At the Y-12 Plant, 26 RCRA units have been certified closed by TDEC since the mid-1980s. Closure of the 9409-5 Tank Storage Area was completed in 1996, as was the Uranium Treatment Unit. The Interim Reactive Waste Treatment Area is an additional RCRA unit requiring closure at the Y-12 Plant. A closure plan for the unit was submitted to TDEC on November 18, 1996.

The RCRA closure of the northern section of the Interim Drum Yard was completed in 1996; however, TDEC did not accept the closure certification package because legacy soil contamination was discovered at the site during closure activities. Further corrective action for this unit has been deferred by TDEC to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigation for the Upper East Fork Poplar Creek (UEFPC) Characterization Unit.

ORNL's Solid Waste Storage Area (SWSA) 6, which operated as a disposal facility for RCRA wastes, has not accepted RCRA wastes since 1986. SWSA 6 is currently undergoing RCRA/CERCLA closure. A revised Closure Plan for SWSA 6 (which included the disposal areas, the Hillcut Test Facility, and the Former Explosives Detonation Trench) was resubmitted in July 1995 to TDEC and EPA. The revisions focused on the integration of CERCLA remediation processes while still addressing 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 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.

Closure of the New Hydrofracture Surface Facility was completed in April 1996, and closure was approved by TDEC in May 1996. A revised Closure Plan for Building 7555 was submitted to TDEC in October 1996. TDEC approval of the Building 7555 Closure Plan is pending. TDEC approval of a Closure Plan for the Remote-Handled Transuranic Waste Burial Ground, which was submitted in September 1995, is still pending. ORNL is revising a Closure Plan for the Reactive Chemical Facility to incorporate new regulatory requirements. It will be resubmitted to TDEC in fiscal year (FY) 1997.

At the ETTP, closure of the K-1419 and K-1417-A units was completed, and certification of closure was submitted to TDEC in December 1996.

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 hazard-

ous 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 June 1992, negotiation was completed on a Federal Facilities Compliance Agreement (FFCA) to resolve the compliance issue of storing restricted waste for a period longer than is necessary to facilitate recovery, treatment, or disposal. The agreement contained a compliance schedule for submittal of strategies and plans for treatment of the backlog of restricted waste through a variety of treatment options. 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. A Tennessee commissioner's order signed on September 26, 1995, culminated negotiations between DOE and the state and established a schedule for treatment and disposal of DOE's mixed waste at Oak Ridge facilities.

2.2.2 RCRA-CERCLA Integration

The CERCLA and RCRA corrective action processes are similar. Each process has four steps with similar purposes (Table 2.2).

EPA, DOE, and TDEC have negotiated 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 and CERCLA.

For example, in April 1993, DOE, TDEC, and Martin Marietta Energy Systems, Inc., signed an agreed order regarding the RCRA postclosure permit for the S-3 Site at the Y-12 Plant, formally agreeing to proceed with CERCLA as the lead regulatory program and with RCRA as an applicable or relevant and appropriate requirement (ARAR), to the extent that postclosure maintenance and care of former interim-status units will be conducted in compliance with the terms of RCRA postclosure permits. Groundwater monitoring will be integrated with CERCLA programs, and corrective actions will be deferred to CERCLA. Reporting of groundwater-monitoring data will comply with RCRA postclosure permit conditions as well as CERCLA requirements.

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 former waste disposal areas at the Y-12 Plant. These are noted in Table 2.3.

Table 2.2. 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

Table 2.3. 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)	TNHW087
Chestnut Ridge	1. Chestnut Ridge Sediment Disposal Basin 2. Chestnut Ridge Security Pits 3. Kerr Hollow Quarry	TNHW088
Upper East Fork Poplar Creek	1. New Hope Pond 2. S-3 Pond site (east)	TNHW089

TDEC issued a Class 3 modification to the Chestnut Ridge Hydrogeologic Regime RCRA postclosure permit effective September 19, 1995, and issued the final Chestnut Ridge Security Pits modification to the Chestnut Ridge Hydrogeologic Regime RCRA postclosure permit on March 8, 1996. In addition, TDEC issued the Kerr Hollow Quarry modification to the Chestnut Ridge Hydrogeologic Regime RCRA postclosure permit on June 11, 1996. The Upper East Fork Poplar Creek Hydrogeologic Regime permit, which incorporates New Hope Pond and the eastern plume of the S-3 Pond, was issued on August 30, 1996.

2.2.3 Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA, also known as Superfund, was passed in 1980 and was amended in 1986 with passage of the Superfund Amendments and Reauthorization Act (SARA). Unlike the other basic regulatory programs summarized in this chapter (such as RCRA or CWA), CERCLA is a process to respond to environmental problems using other environmental laws and standards to guide the response action. Under CERCLA, abandoned or uncontrolled hazardous waste sites where a release has occurred or may have occurred are investigated, and a site is remediated if it poses significant risk to health or the environment. CERCLA requires that EPA place sites needing CERCLA response on the National Priorities List (NPL). The ORR was placed on the NPL in December 1989.

The DOE-Headquarters (DOE-HQ) Office of Environmental Restoration (EM-40) has initiated the Management Action Process (MAP) as a tool to assist DOE and contractor management and technical personnel, regulators, and stakeholders in capturing, evaluating, and documenting information essential for program planning, decision making, and implementation of environmental restoration at DOE facilities. Furthermore, DOE has developed a strategic plan to expedite the remediation of DOE facilities and to transition use of some of the facilities to the private sector.

In November 1996, DOE-ORO issued the *Environmental Restoration (ER) Program Management Action Process Document for the Oak Ridge Reservation* (DOE 1996a). This MAP document represents a concise "snapshot" of the Oak Ridge ER Program and includes a summary of past accomplishments; the status of the Oak Ridge ER Program; and future strategy, rationale, schedule, and funding requirements necessary to meet program objectives. It is important to note that the Oak Ridge ER Program is in transition. The program is moving from a contracting approach that was basically "level of effort" to an aggressive incentive approach. Goals have been established to transfer 60% of the ER Program projects to incentive task orders in FY 1997.

Based on discussions with both federal and state environmental regulators, the MAP document is expected to replace the *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program* (DOE 1995a).

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 was 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 included continued waste characterization for use, development, and/or modification of treatment technologies.

DOE-ORO and EPA signed the ORR-LDR FFCA on June 12, 1992, to allow storage of mixed wastes on the Reservation. As a result, the site treatment plan (STP) was provided to the EPA pursuant to the requirements contained in the ORR-LDR FFCA. To the extent possible, the STP designated specific facilities for the treatment of mixed waste and proposed schedules as set forth in the FFCA. If it was not possible to designate facilities or to adhere to schedules, the STP provided schedules for alternative activities, such as waste characterization and technology assessment. The main treatment strategies are as follows:

- Existing and modified on-site facilities will be used to treat mixed waste when possible.
- Off-site DOE capacity will be used when available and appropriate.
- When available and technically appropriate (based on factors such as risk and cost), commercial-sector resources will be used to treat mixed wastes. Waste types targeted for commercial treatment include inorganic sludges and soils.
- The minimum set of new on-site facilities will be built to treat those wastes for which commercial treatment is unavailable or unsuccessful.
- TRU mixed wastes will be treated only as necessary to meet the waste acceptance criteria of the Waste Isolation Pilot Plant (WIPP) in New Mexico.

The 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 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 WIPP. Nine existing on-site facilities will be used to treat inventoried low-level mixed waste. Construction of one new major on-site facility (the TPF) is proposed for the ORR, as described in the plan. The final configuration of new on-site facilities for mixed LLW streams will depend on the extent to which commercial resources are available.

The STP 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 (effective October 1, 1995) that requires compliance with the approved plan.

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

Semiannual progress reports will document the quantity of LDR mixed waste in storage at the end of the previous six-month period and the estimated quantity to be placed in storage for the

next five fiscal years. Descriptions will be provided of (1) the progress for treatment of each waste stream during the previous six-month period and (2) new treatment development. Additionally, the progress report will provide information such as addition or deletion of waste streams, funding activities, any needs involving changes in waste form or code, and any technology or capacity.

Annual updates of the STP may contain requests for approval of changes. The requests may include, as appropriate, (1) proposed revisions or conditionally approved revisions, (2) proposed new milestones, and (3) other changes to the overall schedule. The first annual report covering CY 1995 was submitted as required in 1996.

The STP 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 an STP, 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 are regulated under RCRA, subtitle I, regulations (40 CFR 280); USTs that contain petroleum are regulated under Tennessee Rule 1200-1-15 (UST Program) in addition to being subject to 40 CFR 280.

ORNL has a total of 54 USTs registered with the TDEC Division of Underground Storage Tanks (DUST) under facility ID # 0-730089 (ORNL). Three of the six tanks remaining in service have been replaced or upgraded to meet the final 1998 standards for new tank installations and will continue in service for the remainder of their reasonable life expectancy. The other three tanks remaining in service are emergency generator fuel tanks (subject only to notification and release response requirements until December 22, 1998) and are scheduled for closure during CY 1997.

The other 48 registered USTs are out of service or are not subject to regulation by TDEC and fit into the following categories: 4 tanks closed after release of petroleum, site status monitoring required; 13 tanks closed with a clean site but have not received final closure letter from TDEC/DUST; 23 tanks closed by TDEC/DUST final closure letter or the tank was closed prior to 1988; 8 tanks registered with TDEC/DUST but not subject to regulation under 40 CFR 280 or TN 1200-1-15. The eight include five radwaste tanks, two heating oil tanks, and one waste water overflow tank.

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 at ORNL were never required to be registered because of their size or because they were closed prior to 1980. Table 2.4 presents the status of USTs on the ORR.

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,

Table 2.4. ORR UST status, 1996

	Y-12 Plant	ORNL	ETTP
Active/in-service	4	3	2
Closed	40	48[a]	14
Hazardous substance	3[b]	0	6[c]
Upgraded	0	3	0
Known or suspected sites	0	0	16
Total	47	54[d]	38

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

[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]Four USTs, one of which has been closed, 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 been placed into service.

[d]Typographical error last year gave total as 55.

and certificates are posted at the UST locations, enabling fuel delivery until March 31, 1998.

At four other former Y-12 Plant 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 the TDEC, the tank owner/operator is allowed to conduct semiannual groundwater monitoring in lieu of a remediation scenario.

TDEC approval for the site ranking for the 9201-1 and 9204-2 UST sites is in the second year of the monitoring-only program. Closure reports for these two sites were submitted in March 1997 to TDEC for final closure.

TDEC did not grant approval for 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 made 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.

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. Table 2.5 notes the types of NEPA activities conducted at the ORR during 1996.

LMES operates under a procedure that establishes administrative controls and provides requirements for project reviews and compliance with NEPA. Provisions apply (1) to the review of each proposed project, activity, or facility for its potential to result in significant impacts to the environment and (2) to the recommendation based on technical information of the appropriate level of NEPA documentation. The NEPA review process results in the preparation of NEPA documents, and federal, state, and local environmental regulations and DOE orders applicable to the environmental resource areas must be considered when preparing NEPA documents. These environmental resource areas include air, surface water, groundwater, terrestrial and aquatic ecology, threatened and endangered species, land use, and environmentally sensitive areas. Environmentally sensitive areas include floodplains, wetlands, prime farm land, habitats for threatened and endangered species, historic properties, and archaeological sites. Each ORR site NEPA program also maintains compliance with NEPA through the use of its site-level administrative and operational procedures. These procedures assist in establishing effective and responsive communications with program managers and project engineers with the goal of establishing NEPA as a key consideration in the formative stages of project planning.

ORNL has supported the preparation of an environmental assessment (EA). *Proposed Changes to the Sanitary Sludge Land Application Program on the Oak Ridge Reservation* (DOE 1996c) has been approved, and a finding of no significant impact (FONSI) has been issued.

Much of the NEPA activity at the ETTP during 1996 involved leasing land and facilities. A draft EA is being written with the following objectives: (1) to describe the baseline environmental conditions at the site, (2) to analyze potential generic impacts to the baseline environment from future tenant operations, and (3) to identify and characterize cumulative impacts of future industrial uses of the site. In addition, the EA will provide DOE with environmental information to be used in developing lease restrictions.

In 1996, DOE leased two facilities at the ETTP and one parcel of land on the ORR. Parcel ED-1 was leased by Community Reuse Organization of East Tennessee (CROET) for development

Table 2.5. NEPA activities during 1996

Types of NEPA documentation	Y-12 Plant	ORNL	ETTP	ORISE
Categorical exclusion (CX) recommendation	9	32[a]	8	
CX granted	9	16	8	
Approved under general CX documents	49	57	42	7
Environmental assessment	0	4	0	
Special environmental analysis	0	0	0	
Programmatic environmental assessment	0	1[b]	0	
Supplemental analysis	0	1[c]	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 under review by DOE-ORO.
[b]Reservation-wide programmatic waste management document in which ORNL had a supporting role; later withdrawn by DOE.
[c]Prepared by ORNL staff for LMES Waste Management Organization.

of an industrial park. An EA was prepared by ORNL personnel to evaluate the lease of Parcel ED-1, and a FONSI was issued in April 1996 (DOE 1996). Other leases at the ETTP included the ETTP Barge Facility (K-710) on the Clinch River, which was leased by CROET for receipt and dispatch of commercial products; and a machine shop in Building K-1401, which was leased for a small-scale metals recycling activity. Other leasing arrangements worked on under NEPA in 1996 involved machine shop operation, a portion of the K-1401 building, and the K-1036 building. Because the future use of these facilities would not change from previous use, the leases were categorically excluded [categorical exclusion (CX) A7, 10 CFR 1021] from NEPA review. Other leases may be approved under CXs if they meet specific criteria defined in 10 CFR 1021.410. The lease of K-1220 for use by a company to conduct equipment fabrication and assembly, a changed use for K-1220, was approved with an individual CX.

2.2.6.1 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 has seen to 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, ratified on May 6, 1994, outlines DOE-ORO's plan for the management of cultural and historical properties on the ORR. The programmatic agreement 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 within the ORR. A draft CRMP has been completed and reviewed by the SHPO and the Advisory Council. Comments are now being incorporated into the CRMP, and the CRMP is anticipated to be released for public comment in the near future.

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 two historical reviews in 1996, and the Y-12 Plant submitted six historical reviews requiring concurrence from the SHPO. Two of the six Y-12 historical reviews required concurrence from the Advisory Council. Three reviews were prepared for submittal in 1996 from the ETTP. The submittals dealt with leasing portions of property and/or land on the ORR.

A survey of the Y-12 Plant to identify sites eligible for inclusion in the *National Register* was completed in 1995, and the Y-12 Plant site archaeological survey was completed in 1996. Final reports for both surveys are expected by the end of 1997. 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 will be incorporated into the CRMP.

A historical consultant acceptable to the Tennessee SHPO was contracted to conduct a survey of all ORISE structures in order 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 LMER. 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.

2.2.6.2 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 NEPA review process. Protective buffer zones and application of best management practices (BMPs) are required for activities on the ORR. Coordination with TDEC, the U.S. Army Corps of Engineers, 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 Corps of Engineers, TVA, and/or the state.

The ORR implements protection of wetlands through the site NEPA program offices in accordance with 10 CFR 1022, "Floodplain/ Wetlands Environmental Review Requirements." Each of the sites has surveys for the presence of wetlands, and surveys are conducted on a project or program as-needed basis. Wetland surveys and delineations have been conducted on about 14,000 acres (5,668 ha) of the 34,500 acres (13,968 ha) that compose 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 (8,300 ha) are planned to be conducted only as needed.

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 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 area of responsibility was completed in October 1994. The first report surveys the Y-12

Plant and surrounding areas; the second report surveys additional areas for which ER activities are planned.

The Y-12 Plant, ORNL, and ETTP practice wetlands protection by requiring protective 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 according to 10 CFR 1022.

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. The plan required that a one-thousand-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. 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 NEPA 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. The wetlands that have been identified are protected when addressed under NEPA. A revised wetland assessment for site investigation activities at the ETTP was approved by DOE-ORO in December 1996.

In November 1995, TDEC issued a notice of violation (NOV) to DOE for an unpermitted wetland activity associated with pine beetle control reforestation activities at a site near Blair Road. A Wetland Restoration Plan was developed that calls for annual monitoring and reporting for five years. In April 1996, the wetland restoration was initiated at the site in accordance with the plan.

2.2.6.3 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, as part of the NEPA review and documentation process.

The *Floodplain Assessment and Statement of Findings for Site Characterization Activities at the ETTP Site* (DOE 1997a) was approved by DOE-ORO in December 1996.

2.2.6.4 Plant and Animal Species of Concern

Good stewardship, state laws, and federal laws 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.

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 2.6. 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). In particular, the reservation has not been sampled extensively for the several listed bats that may be present. 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. 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. 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.

Threatened and Endangered Plants

No federally listed plant species are currently known to occur on the ORR. Twenty-four plant species currently known to occur on the ORR are listed by the state of Tennessee, including the fen orchid, pink lady's slipper, and Canada lily (Table 2.7). 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. Current information is insufficient to determine whether these species may be appropriate for federal listing.

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.

2.2.6.5 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 actions not have the effect of excluding, denying, or discriminating on the basis of race, color, national origin, or income level. DOE, LMER, and LMES are continuing to work with EPA and other stakeholders to ensure that environmental justice issues are addressed when federal actions are taken on the ORR.

2.2.7 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 is currently managed by East Tennessee Mechanical Contractors in partnership with Johnson Controls World

Table 2.6. 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-breasted 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 2.7. Plant species found on the Oak Ridge Reservation and listed by state of Tennessee or federal agencies, 1995[a]

Species	Common name	Habitat on the ORR	Status
Aureolaria patula	Spreading false-foxglove	River bluff	*b, c*
Carex gravida	Heavy sedge	Varied	*d*
Carex howei	Howe sedge	Wetland	*e*
Cimicifuga rubifolia	Appalachian bugbane	River slope	*b, e*
Cypripedium acaule	Pink lady-slipper	Dry to rich woods	*f*
Delphinium exaltatum	Tall larkspur	Barrens and woods	*b, c*
Diervilla lonicera	Northern bush-honeysuckle	River bluff	*e*
Draba ramosissima	Branching whitlow-grass	Limestone cliff	*f*
Elodia nuttalii	Nuttall waterweed	Pond, embayment	*f*
Fothergilla major	Mountain witch-alder	Woods	*e*
Hydrastis canadensis	Golden seal	Rich woods	*e*
Juglans cinerea	Butternut	Slope near stream	*b, e*
Juncus brachycephalus	Small-head rush	Wetland	*f*
Lillium canadense	Canada lily	Moist woods	*e*
Liparis loeselli	Fen orchid	Forested wetland	*c*
Panax quinquifolius	Ginseng	Rich woods	*e*
Platanthera flava (*var. herbiola*)	Tuberculed rein-orchid	Forested wetland	*e*
Platanthera peramoena	Purple fringeless orchid	Wet meadow	*e*
Pycnanthemum verticillatum	Whorled Mountain-mint	Barrens, wet meadows	*c*
Rhynchospora colorata	White-topped sedge	Rocky edge of pond	*f*
Ruellia purshiana	Pursh's wild-petunia	Dry, open woods	*f*
Saxifraga careyana	Carey saxifrage	River bluff, sinkhole	*f*
Scirpus fluviatilis	River bulrush	Wetland	*f*
Spiranthes lucida	Shining ladies'-tresses	Wetland	*e*
Spiranthes ovalis	Lesser ladies'-tresses	Moist to dry woods	*f*
Viola tripartita (*var. tripartita*)	Three-parted violet	Rocky woods	*f*

[a]Other lists for the ORR have included *Lillium michiganense* and *Carex oxylepis var. pubescens;* they are excluded in this table because they have not been found in recent years.

[b]Under review for federal listing. Listed under the formerly used "C2" candidate designation. More information is needed to determine status.

[c]Endangered in Tennessee.

[d]Endangered in Tennessee because of commercial exploitation.

[e]Threatened in Tennessee.

[f]Special concern in Tennessee.

Services, Inc. Both ORNL and the Y-12 Plant are designated as non-transient, non-community 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 1996, the DOE water treatment plant met all of the Tennessee radiological and nonradiological standards.

ORNL's water system has qualified for triennial lead and copper sampling; the next assessment will be in 1997.

One Underground Injection Well permit application was submitted to the TDEC Division of Water Supply in 1996. A researcher within the Environmental Sciences Division (ESD) at ORNL intends to perform research in subsurface fate and transport of colloids.

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 non-transient, non-community 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 1996, the DOE water treatment plant met Tennessee radiological and nonradiological standards except for one exceedence of the maximum contaminant level (MCL) for dichloromethane. In accordance with Tennessee rules, a public notice was issued for this exceedence. However, since dichloromethane is a common laboratory contaminant and resampling indicated no detectable levels, it was concluded that the exceedence was a false result.

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 utilizes back-flow prevention devices and an engineering review and permitting process. As part of the program, an inventory of installed back-flow prevention devices is maintained, and inspection and maintenance of the devices are conducted in accordance with regulatory requirements.

2.2.8 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.

2.2.8.1 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 encompasses approximately 100 active point-source discharges or storm water monitoring locations requiring compliance monitoring that resulted in more than 9,000 laboratory analyses in 1996, in addition to numerous field observations. Monitoring of discharges demonstrates that the Y-12 Plant has achieved an NPDES permit compliance rate of more than 99%; 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 ten NPDES noncompliances in 1996, compared with six in 1995 (Fig. 2.1). Only four of the noncompliances during 1996 were because of events that exceeded the wastewater discharge limits.

The ORNL NPDES permit, renewed in December 1996, 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 1996, in addition to numerous field observations by ORNL field technicians. The NPDES permit limit compliance rate for all discharge points for 1996 was greater than 99% (Fig. 2.1). Most of ORNL's permit limit noncompliances for 1996 were for suspended solids in the storm water runoff from parking lots and construction activities.

The ETTP NPDES permit includes 4 major outfalls and 136 storm drain outfalls. From about 35,000 NPDES laboratory and field measurements completed in 1996, only 4 noncompliances occurred, indicating a compliance rate of more than 99% (Fig. 2.1).

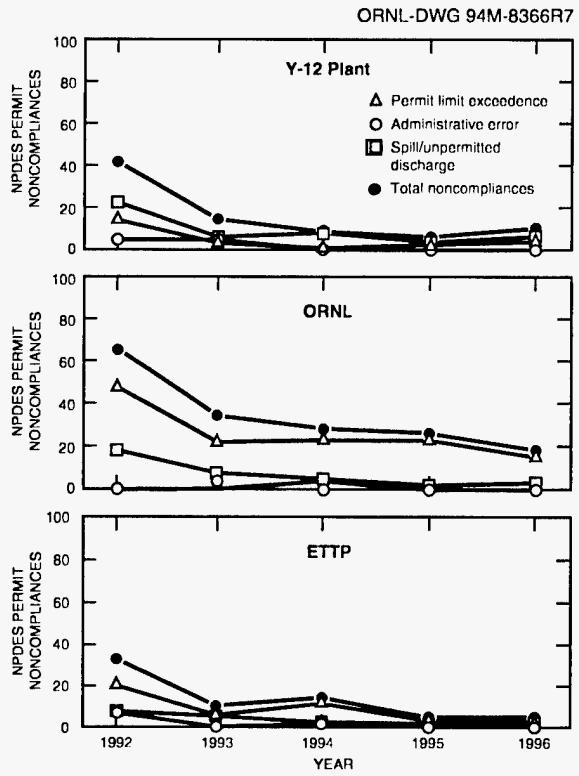

Fig. 2.1. Five-year summary of NPDES noncompliances.

2.2.8.2 Status of NPDES Permits

TDEC issued a new NPDES permit for the Y-12 Plant on April 28, 1995; it became effective on July 1, 1995. The previous Y-12 Plant NPDES permit (TN0002968) expired on May 23, 1990. The plant continued to operate through the first half of 1995 under the expired permit pending issuance of Tennessee Regulation 1200-4-1.05(5)(b). In May, 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 new permit addresses revisions that were in the renewal application, such as some previously unlisted miscellaneous outfalls. In addition, it requires storm water characterizations at selected monitoring locations in accordance with the Y-12 Plant Storm Water Pollution Prevention Plan, which was approved by TDEC April 26, 1996. Other documents submitted to TDEC in accordance with the new NPDES permit include the revised Radiological Monitoring Plan, the Biological Monitoring and Abatement Program (BMAP) Plan, and a report on the analysis of fecal coliform bacteria levels at selected storm water monitoring points.

ORNL is currently operating under NPDES Permit 0002941, which was renewed by TDEC on December 6, 1996, and went into effect February 3, 1997. Compared with the previous permit, the new 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 and modify the Radiological Monitoring Plan, develop and implement a Storm Water Pollution Prevention 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 is operating under NPDES Permit TN0002950, issued with an effective date of October 1, 1992. A major permit modification became effective June 1, 1995. As required by the permit, a Storm Water Pollution Prevention Plan was completed by October 1993. This plan (1) identifies areas having the potential to discharge pollutants to the receiving waters, (2) includes a pollutant control strategy to identify actions to minimize discharges of pollutants, and (3) outlines the development of annual sampling and analysis plans. Sampling as outlined in the FY 1996 Storm Water Pollution Prevention Sampling and Analysis Plan was initiated during the fourth quarter of 1995 and was completed in 1996. An evaluation of FY 1996 results was used to determine the scope of the FY 1997 Storm Water Pollution Prevention Sampling and Analysis Plan.

2.2.8.3 Sanitary Wastewater

The CWA includes pretreatment regulations for publicly owned treatment works (POTW). Sanitary wastewater for the Y-12 Plant is discharged to the city of Oak Ridge under an industrial and commercial user permit. The city of Oak Ridge staff performed its annual sanitary sewer compliance inspections on March 25, 1996, and September 9, 1996. No deficiencies of the Y-12 Plant Sanitary Sewer Compliance Program were noted during the inspections.

During 1996, the Y-12 Plant experienced two exceedences of the discharge permit issued by the city of Oak Ridge. Both exceedences were for mercury and occurred as a result of rehabilitation activities on the sanitary sewer. A multimillion dollar sanitary sewer upgrade project was initiated in 1996 and is expected to last through FY 1999.

As of this writing, the city of Oak Ridge is in the process of renewing its NPDES permit with TDEC. As a result, the city of Oak Ridge issued a six-month discharge permit for the Y-12 Plant until the state of Tennessee issues an NPDES permit to the city of Oak Ridge for the Oak Ridge Wastewater Treatment Plant. After the NPDES permit limits are established for the Oak Ridge Wastewater Treatment Plant, the city will in turn issue a new discharge permit for the Y-12 Plant.

Sanitary sewer radiological sample results at the Y-12 Plant are routinely reviewed to ensure compliance with DOE Order 5400.5. As sample results are received, they are compared with the derived concentration guides (DCGs) listed in the order. No radiological parameter that is monitored (including uranium) has exceeded a DCG. Typically, the results are three orders of magnitude below DCG limits. The current Y-12 Plant permit sets a discharge limit for uranium and incorporates DOE Order 5400.5 guidelines. The DOE has filed an appeal of the radiological limitations of the permit.

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 rain water 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 has, 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 disposed of in an ORNL SWSA. ORNL has received funding and is carrying out 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 sludge continues to decline.

ETTP domestic wastewater is treated at the K-1203 Sewage Treatment Plant and discharged pursuant to the NPDES permit. A sewer use

ordinance and an influent surveillance program are in effect to ensure that effluent from the K-1203 sewage treatment plant continues to meet all NPDES permit limits. The sewer lines have been relined and repaired to reduce rain water infiltration. The multiyear relining project was completed in July 1996.

2.2.8.4 Aquatic Resources Protection

The U.S. Army Corps of Engineers, 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 Corps of Engineers Section 404 dredge-and-fill permits, TDEC Aquatic Resources Alteration Permits (ARAPs), and TVA 26 approvals. (See Sect. 2.5, "Environmental Permits," for ARAP permits.)

2.2.8.5 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 Plan (SPCC) to minimize the potential for oil discharges. Currently, each facility implements a site-specific SPCC plan. This section 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 submitted to the EPA on February 17, 1995. 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.

2.2.9 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.

2.2.9.1 General CAA Compliance

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

CAA program staff routinely participate in regulatory inspections and internal compliance assessment audits to identify areas for improvement in the operation of air sources in conformance with regulations or permit conditions. All major sources of air emissions are appropriately permitted, and documentation of compliance is maintained at each site. A number of minor sources that are exempt from permitting requirements under state of Tennessee rules are identified for internal purposes as well. All major emission sources permitted by TDEC are operating in compliance with those permits. Programs for permitting, compliance inspection, and documentation of compliance are in place and have been effective in ensuring that all ORR operations remain in compliance with all federal and state air pollution control regulations.

2.2.9.2 Compliance with 1990 CAA Amendments

Under Title III—Hazardous Air Pollutants (HAPs), major emphasis has been on determining applicability of final rules promulgated by EPA during 1996. A final rule was promulgated pursuant to Section 112(r) for chemical accident release prevention. Evaluations were conducted as a

result of the rule to determine processes operated on the ORR that are covered or subject to the rule. Processes identified as covered were then placed on a schedule to comply with Risk Management Plan requirements of the rule by 1999.

Under Title V—Permits, EPA granted interim final approval of Tennessee's Title V Major Source Operating Permit Program. ETTP submitted a Title V application as part of Tennessee's early Title V submittal program. The other facilities continue to conduct permit hygiene in accordance with new air permit exemptions for major sources and process applications for submittal to TDEC as required in 1997. 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.

Under Title VI—Compliance activities consisted of maintenance of established programs for stratospheric ozone protection. These programs have been implemented at each facility for both motor vehicle air-conditioner and other refrigeration equipment that include elements for demonstrating compliance with equipment leak repair requirements, container labeling, regulated substances purchasing, and technician and equipment certifications.

2.2.9.3 National Emission Standards for Hazardous Air Pollutants for Radionuclides

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 was demonstrated by modeling emissions from major and minor point sources during periods of operation. The annual off-site effective dose equivalent (EDE) to the most-exposed member of the public for the ORR was 0.4 mrem in 1996, which is below the Rad-NESHAP compliance limit.

Continuous emissions monitoring is performed at the ETTP TSCA Incinerator, at seven stacks at ORNL, and at exhaust stacks serving uranium-processing areas at the Y-12 Plant. As of January 1, 1996, the Y-12 Plant had a total of 68 stacks, of which 60 were active and 8 were temporarily shut down. During 1996, four additional stacks were put into temporary shutdown at the Y-12 Plant. Therefore, monitored stacks at the Y-12 Plant went from 60 during the year to a low of 56 at the end of 1996. Grab samples and other EPA-approved estimation techniques are used on remaining minor emission points, grouped area sources, and fugitive emissions. All three facilities met the emission and test procedures of 40 CFR 61, Subpart H.

2.2.9.4 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 inspections, identification, monitoring, abatement, and disposal of asbestos materials. Two asbestos releases of reportable quantities under CERCLA were identified at the ETTP in 1996. Release quantities were small with no observable off-site migration. No reportable quantities (RQs) were reported at the Y-12 Plant or ORNL.

2.2.9.5 Other NESHAPs

On September 16, 1996, the Y-12 Plant Environmental Compliance Organization personnel initiated a request to DOE to discontinue beryllium stack sampling on the basis that continuous sampling is not required for regulatory compliance at the Y-12 Plant. The regulations require that the combined beryllium emissions from all beryllium sources be less than 10 grams over a 24-hour period. In addition, the regulations require that stack tests be conducted to determine emissions. This requirement was fulfilled for the Y-12 Plant in 1990 and 1991 when EPA Method 104 sampling, the regulatory required sampling, was conducted. Since that time, beryllium stack sampling has been conducted at the Y-12 Plant as a BMP. The BMP data indicated that combined emissions from monitored beryllium sources have been less than one gram per year. With DOE concurrence, BMP sampling for the beryllium stacks was discontinued on October 1, 1996.

2.2.9.6 State-Issued Air Permits

The Y-12 Plant has 52 active air permits covering 262 air emission points. There are 157 documented exempt minor sources and 328 exempt minor emission points.

ORNL has 26 active operating permits. During 1996, the state rescinded four of ORNL's operating permits as insignificant and issued one additional permit for a new source.

There were 239 active air emission sources at the ETTP at the end of 1996. The total includes 50 sources covered by 11 TDEC air operating permits. All remaining air emission sources are exempt from permitting requirements.

2.2.10 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 of both new and existing chemical substances, including polychlorinated biphenyls (PCBs).

2.2.10.1 Polychlorinated Biphenyls

TSCA specifically banned the manufacture, processing, and distribution in commerce of PCBs, but authorized the continued use of some existing PCBs and PCB equipment. TSCA also imposed 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 the 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 50 ppm in landfills. Additionally, PCB discharges into waterways are restricted by the state-regulated CWA and NPDES programs.

2.2.10.2 Authorized and Unauthorized Uses of PCBs

The 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 per 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.

The 1979, regulations did not anticipate the use of PCBs in many applications for which they were employed. 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 unauthorized 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.

2.2.10.3 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.

2.2.10.4 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 the treatment of hazardous wastes and to EPA Region 4 for the 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.

2.2.10.5 PCB Research and Development Approvals

EPA Region 4 has previously granted ORNL authorization to conduct R&D for development of alternative disposal techniques for PCBs. The approvals have authorized PCB R&D using stabilization/solidification techniques, base-catalyzed destruction processes, a chemically enhanced oxidation/reduction process, and a microbial degradation procedure. Final reports were submitted in 1996 for the stabilization/ solidification and the base-catalyzed destruction projects. Currently active R&D projects include the chemically enhanced oxidation/reduction process conducted by ESD and the microbial degradation procedure conducted by the Chemical Technology Division. Two additional PCB R&D approvals are being planned by the Chemical Technology Division. Upon initiation, these projects will operate under the criteria established in the ORR-PCB-FFCA.

2.2.11 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, ETTP, or ORNL. Safrotin®, used for the 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.

2.2.12 Emergency Planning and Community Right-To-Know Act

The Emergency Planning and Community Right-To-Know Act (EPCRA), also referred to as 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 (Table 2.8).

The ORR had no releases subject to Section 304 notification requirements during 1996. The Section 311 lists are updated frequently and are provided to the appropriate officials. The Section 312 inventories for 1996 identified 60 hazardous chemicals, documented their locations, and summarized the hazards associated with them. Of these Section 312 chemicals, 43 were located at the Y-12 Plant, 26 at ORNL, and 19 at the ETTP.

Under Section 313, four toxic chemicals were reported for 1996. Release data for 1995 and 1996 are summarized in Table 2.9. Compared with 1995 releases, there was a 27% reduction in total reportable toxic-chemical releases in 1996.

2.2.13 Environmental Occurrences

CERCLA requires notification of the National Response Center if a nonpermitted release of an RQ or more of a hazardous substance (including radionuclides) is released to the environment

Table 2.8. 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.

Table 2.9. EPCRA Section 313 toxic chemical release summary for the ORR

Chemical	Year	Quantity (lb)			
		Y-12 Plant[a]	ORNL	ETTP	Total
Methanol	1995	36,300	272	14	36,586
	1996	27,630	107	0	27,737
Hydrochloric acid	1995	1,170	81	69	1,320
	1996	870[b]		160	1,030
Lead	1995	14	5,948	19	5,981
	1996	9	3,355	69	3,433
Nitric acid	1995	222	1	0	223
	1996	161	1	0	162
Tetrachloroethene	1995	*c*	*c*	*c*	*c*
	1996	1	32	1	34
Total	1995	37,706	6,302	102	44,110
	1996	28,671	3,495	230	32,396

[a]Represents total releases to air 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]Tetrachloroethylene was below the threshold reporting value for 1995.

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 1996, 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.

During 1996, ORNL reported two incidents involving oil sheens, one on First Creek and one on WOC, both within the ORNL main plant area. The sheen on WOC (April 1, 1996) was caused by leakage from a private vehicle; the sheen on First Creek (December 5, 1996) was attributed to a vegetable oil spill. The National Response Center and TEMA were notified.

In 1996, two releases occurred at the ETTP that required notification of the National Response Center or TEMA. These involved the discovery of asbestos-containing material from plant steam lines on the ground.

2.3 DOE ORDER COMPLIANCE

In 1995 DOE implemented Standards/ Requirements Identification Documents (S/RIDs), which include all federal, state, and local requirements applicable to the Y-12 Plant, ETTP, and ORNL. The S/RIDs include mandatory contractor requirements from the DOE orders of primary interest to the Defense Nuclear Facilities Safety Board (DNFSB). 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 environment, safety, and health (ES&H) requirements rather than DOE orders.

In 1996, LMER and DOE implemented the "Necessary and Sufficient" process for ES&H. Standards identified during this process have replaced most of the S/RIDs for ORNL. LMES, with DOE, is also using the "Necessary and Sufficient" process and is working to have standards approved in 1997.

2.3.1 DOE Orders 5400.1, General Environmental Protection Program, and 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 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 is to be prepared, reviewed annually, and updated every three years or as needed. The *Environmental Monitoring Plan for the Oak Ridge Reservation* (EMP) (DOE 1995b) was reissued by DOE in May 1995 as a controlled document. 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. As of this writing, the EMP is being revised to reflect extensive monitoring changes during 1997. The three ORR sites are in compliance with DOE Order 5400.1. Selected requirements demonstrating compliance follow.

2.3.1.1 Pollution Prevention/Waste Minimization

The fundamental ORR pollution prevention function is to implement projects that result in the creation of less waste. This fundamental function is supported by three ancillary activities: (1) providing technical assistance (identifying and justifying opportunities for projects); (2) developing the overall program (awareness activities, planning, budgeting, reporting); and (3) administering the program (interfacing and communicating with site generator organizations, DOE, and outside organizations).

A central Pollution Prevention Information Management System has been created to integrate and synthesize information collected from tracking systems that have been developed at all three sites to track pollution prevention progress. Pollution prevention councils have been established at all three sites, with representation from each of the site organizations. The councils exchange information to promote pollution prevention activities. Responsibilities within the divisions at each site include the development of pollution prevention goals and implementation activities necessary to reduce both the amount and the toxicity of waste and environmental pollutants, communication of LMES pollution prevention

goals, documentation and communication of progress made toward implementation, and promotion of employee awareness.

During 1996, several source-reduction and recycling projects were completed. Projects include facility-specific activities as well as programmatic activities. Table 2.10 summarizes the results of selected recycling activities on the ORR during the past 5 years.

Three mechanisms have been developed and employed to fund pollution prevention implementation projects. Project proposals are submitted to the pollution prevention program. The proposals are evaluated and submitted to one of three funding avenues: (1) DOE hazard- quotient-(HQ-) funded high return on investment (ROI), (2) the reservation-funded High Investment Value (HiVal) System, or (3) the site-funded generator set-aside program. The generator set-aside fund is the newest funding mechanism; it taxes generated waste. The tax is accumulated for funding implementation projects.

2.3.1.2 Groundwater

The hydrogeologic system at the Y-12 Plant has been divided into three hydrogeologic regimes (or watersheds) based on topography, surface water, and groundwater flow patterns. Monitoring requirements specified by RCRA postclosure permits and CERCLA actions for each of the three regimes reflect the physical characteristics of these hydrogeologic units; monitoring objectives are defined accordingly. A fully integrated monitoring network (including springs and monitoring wells) has been established that meets RCRA postclosure, CERCLA, and DOE Order 5400.1 requirements to monitor flow from each hydrogeologic regime at the Y-12 Plant. These requirements specify the monitoring of plume-boundary and exit-pathway stations both east and west of the Y-12 Plant. Under the integrated program, two or more regulatory requirements are often satisfied by monitoring of one station because parameter lists are standardized and technical objectives between regulations frequently overlap. In addition, monitoring to detect any potential release of contaminants at uncontaminated waste management units is performed as specified in RCRA postclosure permits, CERCLA records of decision (RODs), and non-hazardous solid waste disposal facility (SWDF) operating permits. Limited monitoring continued in 1996 to evaluate the effectiveness of UST removals and corrective actions conducted primarily in the early 1990s.

Exit-pathway monitoring was initiated at ORNL in 1993. The program is designed to monitor groundwater and streams at four general locations that are thought to be likely exit pathways for ORNL groundwater. The ORNL waste area grouping (WAG) perimeter-monitoring network includes perimeter wells at ten WAGs.

Table 2.10. Results of selected Oak Ridge Reservation recycling activities for the past 5 years

Material	Quantity (tons)				
	1992	1993	1994	1995	1996
Aluminum cans	24.8	28.7	25.3	24	22.1
Cardboard	315.4	428.5	354.6	241.9	230.6
Paper	552.8	786.6	734.4	906.2[a]	851.9
Ash	*b*	*b*	*b*	15,294.7	14,209
Toner cartridges	*b*	*b*	*b*	10.5	8.4

[a]The ETTP combines cardboard and paper categories. Cardboard recycled at the ETTP is included in the paper total for 1996.

[b]Data not collected.

Exit-pathway monitoring at the ETTP is conducted at locations where groundwater flow from relatively large areas converges before discharging to surface water locations. The exit-pathway monitoring of groundwater quality in both the unconsolidated zone and the bedrock is supported by surface water monitoring at these convergence points. The responsibility for monitoring groundwater at the ETTP exit-pathway wells was assumed by the Integrated Water Quality Program in late 1996.

The 1996 annual TDEC RCRA groundwater compliance evaluation inspections were conducted in January and December at the Y-12 Plant and in October at ORNL. No findings or recommendations were issued as a result of the inspections.

2.3.2 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.

2.3.3 DOE Order 5820.2A, Radioactive Waste Management

DOE Order 5820.2A establishes the policies and minimum requirements for managing ORR radioactive wastes and the radioactive component of mixed wastes. The order requires that each DOE site prepare a waste management plan for radioactive waste generation and TSD operations. In previous years each site had prepared its own waste management plan. These plans have now been consolidated into one document, The *Oak Ridge Reservation Waste Management Plan* (MMES 1995).

ORNL manages TRU waste and LLW. Radioactive waste management activities at both the ETTP and Y-12 Plant are primarily related to LLW. Although material contaminated with TRU elements exists on the ETTP, the concentrations are less than the limits for TRU waste.

2.4 APPRAISALS AND SURVEILLANCES OF ENVIRONMENTAL PROGRAMS

Numerous appraisals, surveillances, and audits of the ORR environmental activities occurred during 1996 (see Tables 2.11, 2.12, and 2.13). These tables do not include internal LMES or Lockheed Martin corporate assessments.

2.4.1 Defense Nuclear Facilities Safety Board

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

Table 2.11. Summary of environmental audits and assessments conducted at the Y-12 Plant, 1996

Date	Reviewer	Subject	Issues
1/29–30	TDEC	RCRA Audit	0
2/7	EPA	EPA Audit	0
4/17–19	Wastren (for DOE)	Defense Programs Toxic Release Inventory Review	0
5/21	TDEC/DOE-O	Clean Air Compliance Inspections	0
6/24	EPA	EPA Visit	0
6/25	DOE	NPDES Sampling	0
6/26	TDEC	Y-12 Landfill VI	0
6/26	TDEC	Y-12 Landfill V	0
6/26	TDEC	Y-12 Landfill VII	0
6/28	TDEC/DOE-O	VEE of Stack 67	0
8/8–13	TDEC/DOE-O	Clean Air Compliance Inspections	0
11/22	TDEC	Y-12 Centralized Landfill II Postclosure Lane Inspection	0
12/3	TDEC	Y-12 Landfill IV	0

Table 2.12. Summary of environmental audits and assessments conducted at ORNL, 1996

Date	Reviewer	Subject	Issues
2/26	TDEC/DOE-O	Inspection of First Creek Riparian Corridor	0
3/12	TDEC/DOE-O	Opacity Evaluation Steam Plant	0
3/12–13	TDEC	Inspection of RCRA generator areas and treatment, storage and disposal operations	0
3/20–21	TDEC/DOE-O	Permitted emission sources	0
3/23–24	TDEC/DOE-O	Permitted emission sources	0
11/14	TDEC/DOE-O	Inspection of Process Waste Treatment Plant Upgrades Project	0
11/25	TDEC/DOE-O	Inspection of 4508 and 6000 Area Dechlorinators	0

was identified. As a result, a number of operations at the Y-12 Plant were curtailed. However, environmental management operations (compliance monitoring, reporting, and oversight) have continued operations, and there have been no environmental impacts as a result of the stand-down. Work continues at the Y-12 Plant to respond to recommendations from the board concerning formality of operations.

2.5 ENVIRONMENTAL PERMITS

Table 2.14 contains a summary of environmental permits for the three ORR sites.

Table 2.13. Summary of environmental audits and assessments conducted at the ETTP, 1996

Date	Reviewer	Subject	Issues
1/24	TDEC	SDWA Inspection	0
1/24	TDEC/DOE-O	CAA Inspection	0
1/30	TDEC	RCRA Inspection of Tech. Demo Area	0
2/15	TDEC, TDEC/DOE-O	Solid Waste Inspection	0
2/28	TDEC	RCRA Inspection of TSCA Incinerator	0
3/11	TDEC	CWA Inspection	0
3/25	TDEC, TDEC/DOE-O	RCRA Inspection	0
3/26	TDEC	RCRA Semiannual Inspection of TSCA Incinerator	0
5/10	Corps of Engineers	CWA Inspection of Wetland	0
7/24	Corps of Engineers	CWA Inspection of Bridge Project	0
7/24	TDEC	Solid Waste Inspection of Demolition Project	0
9/23	TDEC	Annual RCRA Inspection	0
9/26	TDEC	RCRA Semiannual Inspection of TSCA Incinerator	0
11/18	TDEC	Solid Waste Inspection of Demolition Project	0
12/11	TDEC, TDEC/DOE-O	CWA Inspection	0

2.6 NOTICES OF VIOLATIONS AND PENALTIES

On February 1, 1996, the Y-12 Plant received an order and assessment of civil penalty from TDEC for reported violations of the RCRA permit at the Waste Oil/Solvent Storage Unit (OD-9). However, TDEC later dismissed the order, and no penalty was assessed. In a like manner, EPA Region 4 issued a compliant and compliance order on September 24, 1996, for RCRA inspection deficiencies at the OD-9 facility. A fine of $22,500 was paid on November 22, 1996.

The Y-12 Plant received a NOV from TDEC on 2/7/96 for an NPDES permit noncompliance that occurred in December 1995. The noncompliance was reported by the Y-12 Plant to the TDEC as an exceedence of the permit limit for chlorine measured at monitoring location 201 in EFPC.

Tennessee State Landfill Permit IDL-01-103-0083 prohibits the 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 above which waste will be considered to be radioactively contaminated. In December 1996, on reviewing 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 Y-12's Landfill V between December 20, 1996, and January 27,

Table 2.14. Summary of permits as of December 1996

	Y-12 Plant	ORNL	ETTP
Resource Conservation and Recovery Act			
RCRA operating (part A and part B)	4[a]	3	4
Part B applications in process	1[b]	2	0
Postclosure	3[c]	1	0
Permit-by-rule units	45[d]	173	92
Solid waste landfills	6[e]	0	0
Annual petroleum UST facility certificate	2	1	1
Transporter permit	1	1	1
Clean Water Act			
NPDES	1[f]	1	1
Storm water	1[g]	1[g]	1[g]
Aquatic resource alteration/U.S. Army Corps of Engineers 404 permits	1	3	4
	0	0	0
General storm water construction	2[h]	0	2
Clean Air Act			
Operating air	52	26	11
Construction	0	0	2
Prevention of significant deterioration	0	0	0
Sanitary Sewer			
Sanitary sewer	1	0	0
Toxic Substances Control Act			
TSCA Incinerator	0	0	1
R&D for alternative disposal methods	0	3	0
Safe Drinking Water Act			
Class V Underground Injection Control Permit application in progress	0	1	0

[a]Four permits have been issued, representing 16 active units.

[b]One application is under review by TDEC, representing 3 active units.

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

[d]Includes tanks, sumps, and CWA-permitted TSD facilities.

[e]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.

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

[g]TDEC has incorporated into individual NPDES permits.

[h]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.

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 the two waste streams had been switched in error. Resolution of these exceedences is expected to continue into calendar year (CY) 1997.

In addition, ETTP received an NOV in 1996 for installation of culverts into waters of the state without a permit. The culverts were installed in tributaries to Grassy Creek along the powerline right-of-way between ETTP and ORNL.

ORNL received two TDEC NOVs in 1996 for NPDES permit limit excursions; one NOV was received in February 1996 and the other in September 1996. ORNL provided responses to TDEC as to corrective actions for each excursion maintained in the NOVs. No fines or penalties were assessed by TDEC.

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 must be provided to Friends of the Earth by mid-October 1997.

Friends of the Earth has asked the court to reconsider the order. At the time of this writing, a decision has not been issued by the court.

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 is 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. The moratorium for a given site will remain in effect until the site receives approval from DOE to resume off-site shipments using site-specific procedures that have been reviewed and approved by DOE.

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 DOE develops generic criteria for bulk contamination release. ORNL resumed activities for the off-site shipment of solid, hazardous/ toxic wastes following DOE's issuance of the partial lifting. ORNL received a further partial lifting of the moratorium in 1996 with DOE approval of a "no rad added" procedure. This allowed shipment of wastes that could be certified by process knowledge as nonradioactive.

2.7.3 Tennessee Oversight Agreement

On May 13, 1991, the state of Tennessee and DOE entered into a five-year monitoring and oversight agreement in which DOE agreed to provide the state financial and technical support for "independent monitoring and oversight" of DOE activities on the ORR. In June 1996, the state and DOE signed a five-year extension of the agreement that will expire in June 2001. The agreement provides the state of Tennessee $26.15 million over the five-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. During CY 1996, TDEC/DOE-O continued its Facility Survey Program by conducting 32 walk-through assessments of buildings on the ORR. The goal of this program is to provide an independent evaluation of the conditions of facilities on the ORR that can be used to support risk assessment.

TDEC/DOE-O has also initiated an environmental monitoring and sampling program. In December 1995, TDEC/DOE-O provided to DOE their CY 1996 Environmental Monitoring Plan. The plan addressed the state's intentions in the areas of sampling, site audits and inspections, review of sampling and analysis of data generated by DOE, review of plans, and oversight. Through these activities, the state intends to characterize and monitor chemical and radiological emissions

in the air, water, and soil, both on and off the ORR. TDEC/DOE-O also provided DOE with quarterly status reports of its environmental monitoring activities. It is anticipated that TDEC/DOE-O will soon provide DOE with its environmental monitoring report for CY 1996 activities and an environmental monitoring work plan for CY 1997. In October 1996, TDEC/DOE-O published a *Status Report to the Public* (TDEC 1997b), which presented its current findings and ways to improve public under-standing of the complex issues raised by federal facility cleanup.

3. Environmental Management and Reservation Activities

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; Martin Marietta Energy Systems, Inc., served as its managing and operating contractor. The following sections highlight (1) some of the environmental management activities for 1996 and (2) 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 1996 at ORNL. Several CERCLA removal actions were planned or performed at ORNL during this time period. Included in the removal actions taken at ORNL was the WAG 4 trench grouting project. The trench grouting project was conducted to reduce the amount of ^{90}Sr in the surface waters of ORNL. In addition, Building 3506 was demolished as a removal action to reduce risk to on-site workers and to provide sufficient work area for the Gunite and Associated Tanks (GAAT) Project, given the proximity of Building 3506 to the GAAT tanks in the South Tank Farm. Removal action activities continued at the Molten Salt Reactor Experiment (MSRE), and planning was performed in conjunction with the proposed removal action at 3001 Canal. An action memorandum was issued in 1996 for the removal of contaminated sludge from the old hydrofracture tanks.

The GAAT Project continued during 1996 with completion of project documentation and testing of tank dry wells for leakage. The GAAT

project is an interim remedial action that is to be taken by DOE. Activities associated with the GAAT CERCLA Treatability Study, conducted to determine the viability of using innovative sluicing and robotics technology, were continued during 1996. Among the activities associated with the Treatability Study was cold testing of sluicing technology that is to be used for removing sludge from the tanks.

Additionally, eight inactive liquid low-level waste (LLLW) tanks were remediated by removal, in situ grouting, and isolation. Remediation of the Inactive Liquid Low-Level Waste Tank System is not part of the scope of the GAAT Project, but is a separate project being performed under the aegis of the FFA.

WAG 6 CERCLA/RCRA groundwater monitoring continued under the auspices of the WAG 6 EMP (DOE 1995c). Continued characterization, modeling, and monitoring of groundwater at other sites within ORNL were performed during 1996.

The WOC Watershed remedial investigation was completed. Moreover, the remedial investigation/feasibility study (RI/FS) was issued for Surface Impoundments 3513 and 3524, located in the main plant area. The In Situ Vitrification project at WAG 7 was shut down because of an excursion of contaminants into the environment. The status of the project remains problematic.

3.3 OFF-SITE RESIDENTIAL DRINKING WATER QUALITY MONITORING PROGRAM

In 1996, responsibility for the Off-Site Residential Well Water Program was transferred from the ORR Surveillance Program to ER. The sampling program was incorporated into the Integrated Water Quality Program. No sampling took place in 1996. Sampling data from 1997 will be reported in the 1997 ASER.

3.4 THE DOE-ORO ENVIRONMENTAL MANAGEMENT RADIOLOGICAL SCRAP METAL PROGRAM

The DOE-ORO Environmental Management (EM) Scrap Metal Program has established a precedent-setting pursuit of commercial-sector recycling of its radioactive scrap metal. An estimated 1.46 billion lb of scrap metal may be produced during D&D of the three DOE gaseous diffusion plants. The prospect of this expanding inventory has prompted DOE-ORO to improve the scrap metal program by changing the approach from metal storage to aggressive recycling. The program focuses on environmental protection and recovery of the metal's value.

The program employs two methods: either decontamination, where possible, or smelting/forming the metals into items for use within the DOE complex. During FY 1996, 1,601,150 lb of ferrous and nonferrous contaminated scrap metals were shipped to commercial radioactive scrap metal processing companies. Of that, 513,150 lb were released for recycle or reuse following commercial decon-tamination, and 1,088,000 lb were commercially smelted and formed into shipping and storage containers for radioactive materials (Table 3.1).

Under the decontamination contract, title to the metal passes to the decontamination vendor, who decontaminates the metals and releases them to commercial scrap vendors. Secondary waste streams are disposed of by the decontamination vendor. A percentage of the proceeds from sales of the metal is recorded as credit with the vendor toward future shipments of scrap metal for decontamination and recycling.

Under the smelting contract, the metal remains the property of DOE and is reformed based on DOE specifications into a number of useful forms, such as shielding blocks, storage drums, or shielded containers. Slag from smelting operations is returned to DOE for disposal.

Table 3.1. DOE-ORO Environmental Management Radiological Scrap Metal Program summary of progress and relative cost

EM project	Recycling method	Amount recycled (lb)	Cost ($)		
			Recycling	Disposal[a]	Storage
Small-Scale Metals Recycle[b]	Smelting	1,072,000	1,565,763	1,338,447	1,608,000
Cooling-Tower Demolition[c]	Decontamination	459,000	605,880	573,120	688,500
K-1419 Batch Plant Demolition[d]	Decontamination	54,150	71,478	69,270	81,225
Tower Shielding Facility[e]	Smelting	16,000	23,370	24,135	24,000
Totals		1,601,150	2,266,491	2,004,973	2,401,725

[a]Disposal cost does not include associated costs, such as those from manifest preparation, disposal characterization such as the U.S. EPA toxicity characteristic leaching procedure (TCLP), or transportation facility capital recovery.

[b]Metals smelted and formed into sheets for fabrication of drums and strong-tight (ST) 90-ft^3 boxes.

[c]Metals decontaminated and released for private-sector use. Shipping and processing of an additional 150,000 lb of radiological scrap metal from this project await funding.

[d]Decontamination of metal in progress; it is anticipated to be free-released for private-sector use.

[e]Metal smelted into lead component of storage containers for use at the Idaho National Engineering and Environmental Laboratory (INEEL). INEEL provided an additional 26,000 lb of lead. Part of the High-Ranking Facilities Deactivation Project at ORNL, this work was funded through EM-60.

Recycling of radioactive scrap metal has saved money for DOE and has avoided the future costs that would have come from disposal of the material as low-level radioactive and/or hazardous waste. It has reduced the risk to human health and the environment and has reduced the amount of space occupied by the DOE radioactive scrap metal inventory. Competition among commercial vendors is expected to further reduce costs as the program expands locally and spreads across the DOE complex.

3.5 IN SITU VITRIFICATION PROJECT AT ORNL

DOE is treating the contaminated soil in Pit 1 in WAG 7 at ORNL by in situ vitrification. The pit was used for disposal of liquid radioactive waste in 1951. In 1981 it was filled with clean soil and capped with asphalt. The pit contains an estimated 38 Ci of radioactive material, primarily ^{137}Cs. Groundwater around the pit gives the contaminants a pathway out of the site.

The in situ vitrification technique fuses soil into a permanent, high-integrity glass in which radioactive contamination is fixed. Electrodes conduct electricity through the soil, which produces resistance heat, causing the soil to melt. A 25 × 25 × 15 ft plot would take about 10 days to reach 3,000°F and about a year to cool to normal temperatures.

The project at Pit 1 began in November 1992. Site preparation was completed in April 1995, and equipment installation was completed in February 1996. The initial melt began on April 3, 1996.

On April 21, 1996, an upheaval of steam and molten glass occurred on and around the off-gas

collection hood. No personnel were injured. The 15,000-lb, 50 × 50 × 6 ft hood was lifted, causing steam and some molten glass to be released. A fire began among combustible materials in the area of the upheaval. All electrical power to the equipment was turned off at the emergency switch, allowing firefighters access to the area; however, firefighting actions were not taken because of the potential for further steam releases. The intense heat dissipated quickly, and the small, smoldering fires self-extinguished within an hour.

Small, hairlike fibers of contaminated glass dispersed to the east and southeast of the hood, most of which were contained within the radiological boundaries of the project. Initial surveys of the personnel and firefighters at the site found no contamination. Loss of off-gas containment was minimal because of the high retention efficiency of the molten soil, the low contamination levels in the off-gas, and the brief time involved. Off-site and on-site uncontrolled release of contaminants was estimated at 0.2 μrem. An independent review board was assembled to conduct an investigation of the incident.

3.6 REMEDIATION UNDER WAY FOR THE MOLTEN SALT REACTOR EXPERIMENT FACILITY

Remediation of the MSRE facility continued during 1996. 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.

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

3.7 LAND APPLICATION OF SEWAGE SLUDGE

The city of Oak Ridge owns and operates a POTW that receives waste water from a variety of industrial, commercial, and residential generators in Anderson and Roane counties. One of the chief contributors is the Oak Ridge Y-12 Plant, which produces about 20% of the total influent. The POTW uses a standard activated-sludge process,

in which sludge from both primary and secondary sedimentation is 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 sludge as a soil conditioner and fertilizer. The city has been applying sludge at selected, state-approved sites on the ORR since 1983 (Fig. 3.1). The current sludge land-application program uses five sites totaling 160 acres on which about 224.6 tons (dry weight) of sewage sludge were applied in 1996. The sludge contains 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.

Elevated levels of mercury were detected in the sewage sludge in November 1995. As a result, the land application of sludge was suspended until May 14, 1996. Sludge in excess of established limits (Table 1 of 40 CFR 503.13) was dewatered and disposed of in the Y-12 Plant Sanitary Landfill V under a special waste permit issued by the TDEC Division of Solid Waste. Land application resumed with approval from the TDEC Division of Water Pollution Control on May 14, 1996, after mercury levels subsided and compliance was reestablished with the established EPA and TDEC sludge land application protocol. The highest detected levels of heavy metals detected in 1996 are compared with established limits in Table 3.2.

3.8 HUNTING ON THE OAK RIDGE RESERVATION

3.8.1 Background

The current deer population on the ORR is considered to be typical and good, if not excellent,

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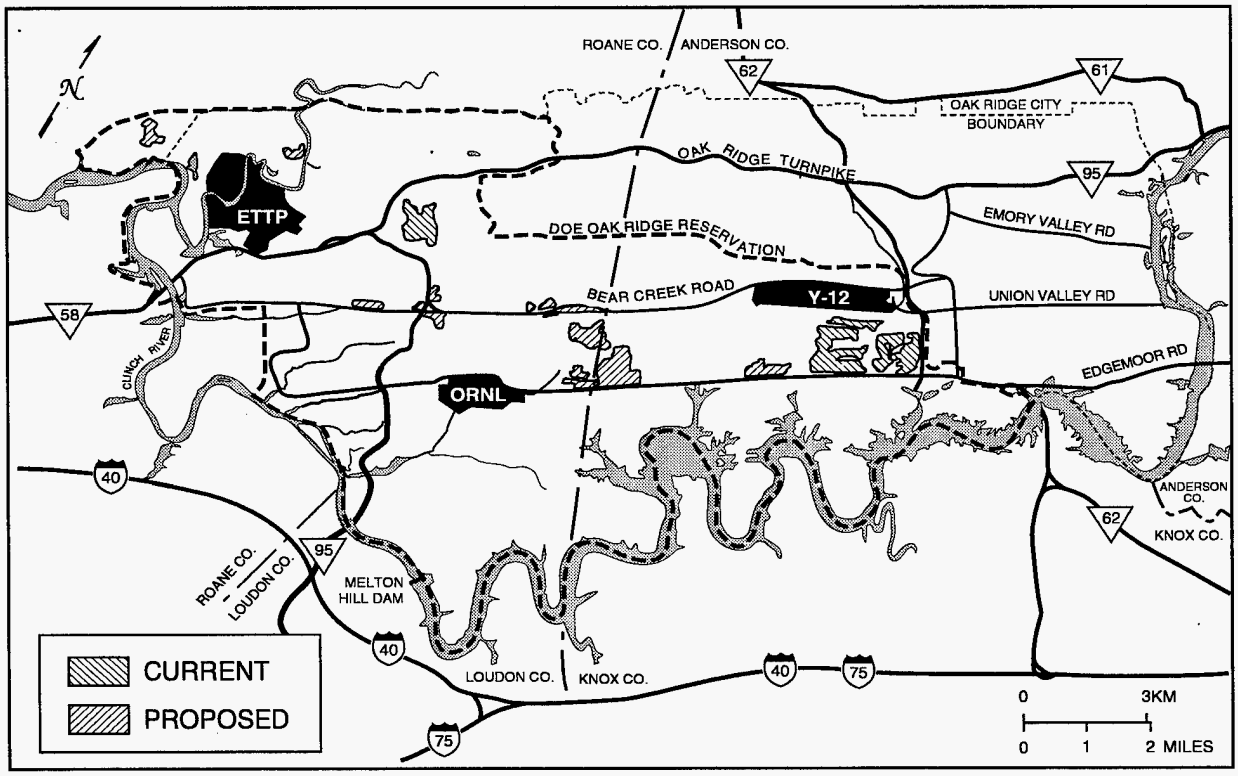

Fig. 3.1. Current and proposed sites for the land application of sewage sludge on the ORR.

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	Limits	
		40 CFR 503.13, Table 1	40 CFR 503.23, Table 1
Arsenic	12.8	75	73
Cadmium	19.40	85	—
Chromium	171.0	*a*	600
Copper	520.0	4300	—
Lead	74.0	840	—
Mercury	8.2	57	—
Molybdenum	54.0	*a*	—
Nickel	39.7	420	420
Selenium	18.2	100	—
Zinc	1610	7500	—

[a]This limit has been excised by EPA.

for the region in terms of numbers and health. Estimates of deer populations are based on road kills, hunt statistics, and field observations of animals and habitat condition. A change in those observations would indicate a change in population size or health. The most recent samples of stomach parasites (collected in 1995) from deer indicate a healthy and probably stable (i.e., not overpopulated) population.

The recent growth in numbers in the deer herd on the ORR is a continuation of a nationwide trend that began in the 1930s because of restocking and protection from hunting. Deer numbers were very low throughout the region (and the continent) by the 1850s because of overhunting.

The number of road-killed deer began to rise in 1978 (Fig. 3.2). Part of the rise is likely a result of increased automobile traffic and speeds as well as an increase in deer numbers. Annual hunts were started in an effort to reduce that number. It was thought that annual road kills might rise as high as 400 if something was not done. The annual hunt has almost certainly been the major factor in reducing deer collisions. Although the hunts have successfully reduced road kills to around 150, the number may increase again as land use changes; one possible consequence of leasing land for industrial development is increased problems with deer.

Decreasing hunting pressure, especially of does (females), would almost certainly result in an increase in the population and therefore would result in more collisions with vehicles as well as increased ecological damage to the habitat from overbrowsing.

3.8.2 Deer and Turkey Hunts

Deer hunts are held each fall on the ORR. The first turkey hunts on the ORR have been scheduled for the spring of 1997 and should continue in subsequent years. (Details of the turkey hunts will be published in the 1997 ASER.) Hunters are selected through the TWRA statewide drawing for quota hunts. To be eligible, hunters must submit an application and must have a valid license of the appropriate type. Hunters may indicate preferences for particular hunts, and there is a ranking scheme so that hunters who are not selected one year have a greater chance of being selected in

ORNL 97-100681/arb

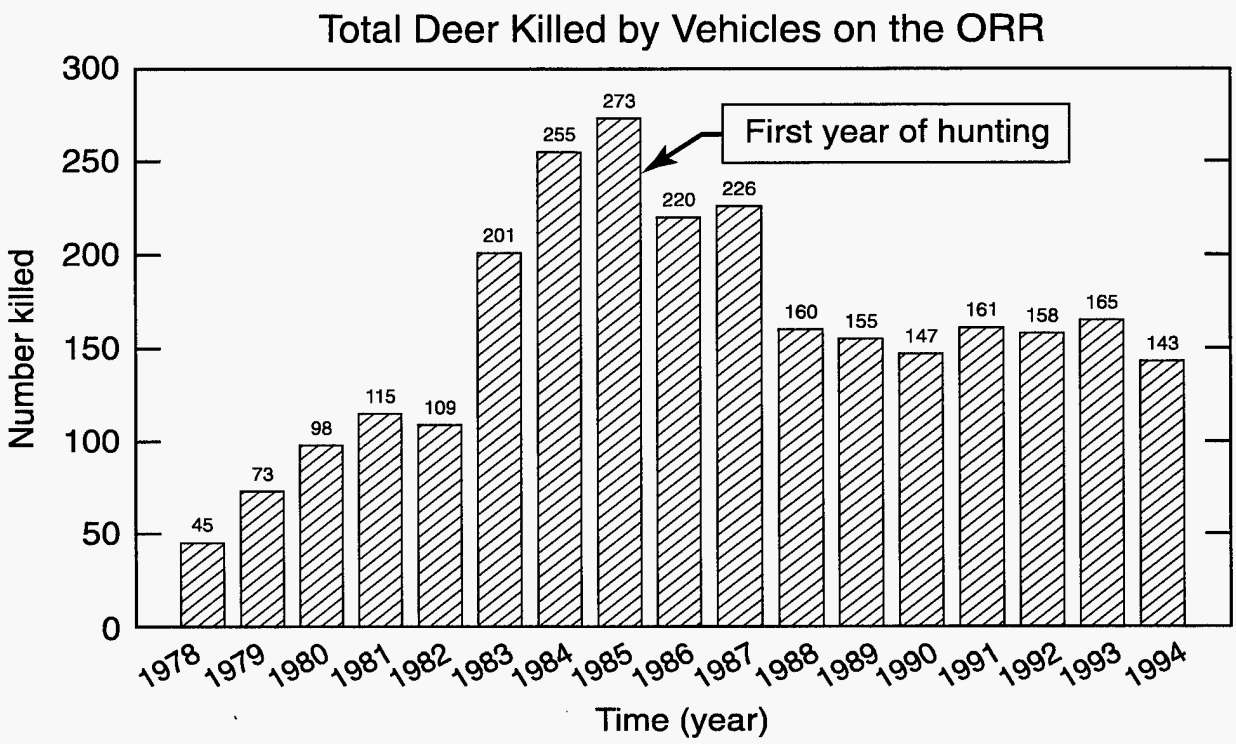

Fig. 3.2. Trend in road-killed deer on the Oak Ridge Reservation since 1978.

subsequent years. Selected hunters receive a color-coded map of the ORR, which shows the location of the checking station on Bethel Valley Road, delineates passable roads and the zones in which hunting is permitted, and has related information printed on the back. Maps for both hunts are similar and may be updated annually. Days are set aside for scouting before the scheduled hunts.

Successful hunters must bring their kill to the checking station. Deer should be field-dressed, and the liver should be retained. The weight, sex, and age of the animals are recorded. For deer, the number of antler points is also noted; for turkey, beard and spur length are measured. For deer, tissue samples (e.g., bone, liver, and muscle) are scanned on site. For turkey, a whole-body scan is conducted.

The checking procedure takes about 10 to 20 minutes, depending on the number of hunters in line. If an animal scans out at over the administrative limit for radioactive contamination, it is retained and the hunter is generally given another permit for a subsequent day or weekend. Confiscated animals are cut up, boxed, and sent to an incinerator.

Results of the 1996 hunts are detailed in Chap. 5. Dose information is detailed in Chap. 6. In addition to information about deer and turkeys, information is provided about migratory waterfowl (Canada geese) that may have visited the ORR.

3.9 PARTNERS IN FLIGHT SURVEY

Partners in Flight 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 three years as part of the Tennessee Partners in Flight program. The Tennessee Conservation League is coordinating data compilation for TWRA and will publish a three-year summary, probably later this year. A draft document has been written about birds of the ORR that contains some preliminary information about the Partners in Flight program. It is currently in review for publication in the journal *The Migrant*.

3.10 COMMUNITY HIKES BEGUN 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.

The hikes drew 75 participants in spite of limited publicity. Four groups of hikers were led by expert guides, two to observe birds at Freels Bend and two to observe wildflowers on the Walker Branch Watershed. Both the large turnout and the comments recorded by the participants on evaluation sheets demonstrate the public interest in the natural riches on the ORR. Future hikes have been planned for 1997.

3.11 ETTP COOLING TOWER PROJECT

The ETTP Cooling Tower project eliminated huge cooling towers built some 50 years ago, when the gaseous diffusion process first was used to enrich uranium for the Manhattan Project. The process generated great amounts of heat, which was dissipated through several immense cooling towers, large wooden structures resting on concrete basins more than 20 ft deep, 60 ft wide, and 300 ft long. After the enrichment process was put on permanent standby in 1987, the towers did nothing but make an imposing skyline. Without presence of water, the structures dried out and created a serious fire hazard.

The project to tear down the towers (including the removal of 85,000 ft^3 of sediment in the basins) presented an opportunity for the team to apply innovative methods and commercially recognized approaches. Begun in the spring of 1994, the task followed DOE's Environmental Management commitment to the development of cost-effective and results-oriented solutions to restoration projects.

By the project's end, a total of 17,000 yd^3 of wood and 2,500 yd^3 of asbestos-containing materials were disposed of and more than 11,000 drums and 116 ST-5 boxes (4 × 4 × 6 ft) of sediment and wood chips were removed. More than 200,000 work hours were logged with only one recordable injury and no NOVs or notices of deficiency from any state or federal regulatory agency.

3.12 PUBLIC INVOLVEMENT ACTIVITIES

Several major environmental cleanup decisions were reached in 1996 with stakeholders playing key roles. As part of its public involvement program, DOE continued to hold regular stakeholder meetings 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 include the following:

- meetings to discuss the proposed privatization of treatment and disposal of ORR low-level mixed waste;
- two environmental management general stakeholder meetings in Harriman, Tennessee, and Oak Ridge, Tennessee;
- workshop on Lower East Fork Poplar Creek Remediation Project;

- initiation of workshops on the Environmental management Ten-Year Plan, now known as *Accelerating Cleanup: Focus on 2006* (http://www.em.doe.gov/acc2006/orindex.html);
- brown bag lunches on topics such as the WIPP and UF_6 Management Program; and
- meeting on the preapplication status of the RCRA permit for the TSCA Incinerator.

Meetings were also held on a variety of other topics.

3.12.1 EnvironMENTAL Fair

Approximately 3000 sixth graders from Knox County and the Cherokee Reservation in North Carolina attended the Fifth Annual EnvironMENTAL Fair, held Thursday, September 26, on the grounds of the American Museum of Science and Energy. Numerous activities sponsored at the fair tied into its theme this year, "Pollution Prevention/Waste Management." The fair was sponsored by DOE, LMES, LMER, and the American Museum of Science and Energy (Fig. 3.3).

3.12.2 Site-Specific Advisory Board

The Oak Ridge Environmental management Site Specific Advisory Board, formed in 1995, continued to advise DOE on environmental management issues such as recommendations for

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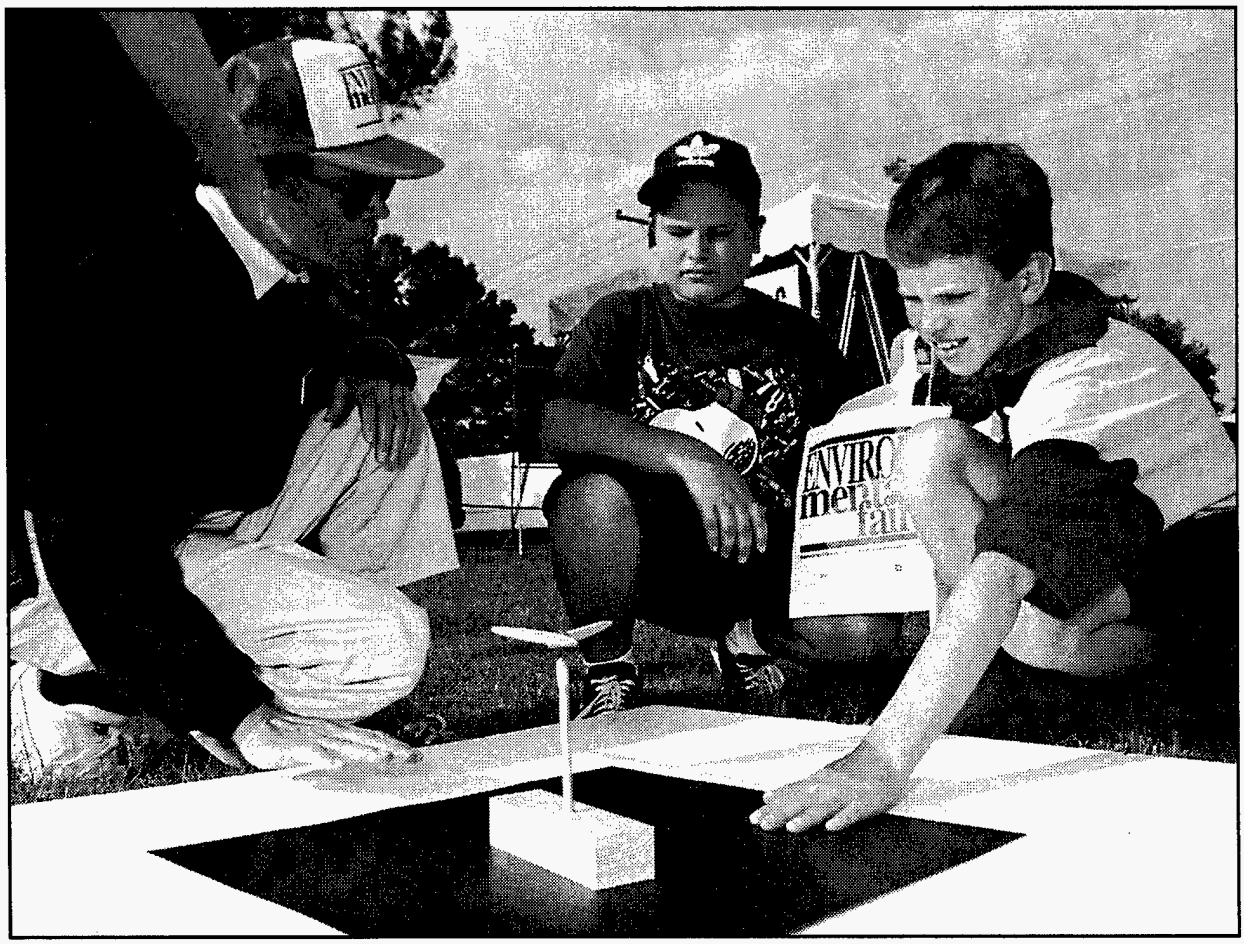

Fig. 3.3. The 1996 EnvironMENTAL Fair was fun as well as an educational experience for the sixth graders who attended.

cleanup levels, technology development, and long-term waste management issues.

3.13 SOME WEB SITES AND A NEW TOLL-FREE NUMBER

You can get the latest information on environmental cleanup and waste management in Oak Ridge, including the Public Involvement Calendar, 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 provides access to all ORNL home pages, plus home pages for the Y-12 Plant, 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 regulations issued by EPA, the TDEC Air Pollution Control Board, and DOE orders. Radioactive emissions are regulated by EPA Region 4 under the CAA, NESHAP, 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.

The NESHAP regulations limit the amount of annual radioactive exposure or dose to the nearest or most exposed member of the public. In December 1989, the EPA 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 compliance with the radionuclide NESHAP regulations. An updated Rad-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 if the source is otherwise operating normally.

Each ORR facility has a comprehensive air pollution control and monitoring program to ensure that airborne discharges meet regulatory requirements and do not adversely affect ambient air quality. Air pollution controls at the three Oak Ridge facilities include exhaust gas scrubbers, baghouses, and exhaust filtration systems designed to remove airborne pollution 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 1996, 55 of the Y-12 Plant's 68 stacks were judged to be major sources. Eight of these sources were not operational in 1996 because of work in progress on process and stack modifications. Twenty-one 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, 1996, the Y-12 Plant had a total of 68 stacks, 60 that were active and 8 that were temporarily shut down. During 1996, four additional stacks were placed into temporary shutdown. Thus, during the course of the year, 60 stacks were monitored, and there were 56 stacks being monitored at the end of 1996.

Radionuclides other than uranium are handled in millicurie quantities as part of ORNL and Y-12 Plant laboratory activities at facilities within the boundary of the Y-12 Plant. The releases from these activities are minimal, however, and have negligible impact on the total Y-12 Plant dose. Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to EPA-approved calculation methods.

Emissions from room ventilation systems are estimated from health physics 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 were included in the annual emission estimate.

4.1.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on 60 process exhaust stacks in 1996. Particulate matter (including uranium) was filtered from the stack sample; filters at each location were changed routinely, from one to five 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.

In 1996, 81 emission points were identified from unmonitored radiological processes and laboratories. In addition, one ventilation area from a building that houses depleted uranium operations and one ventilation area from a building that houses enriched uranium operations were identified from health physics data, where one or more average monthly concentrations exceeded 10% of the DAC. For the area, the annual average concentration is used, with design ventilation rates, to arrive at the annual emission estimate. No areas from buildings that house enriched uranium operations met these criteria.

4.1.1.2 Results

An estimated 0.02 Ci (9.7 kg) of uranium was released into the atmosphere in 1996 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 73% 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, 1996

Source of emissions	Quantity emitted	
	Ci[a]	kg
Enriched uranium		
Process exhaust (monitored)	0.014	0.21
Process and laboratory exhaust (unmonitored)	0.0003	0.0034
Room exhaust (from health physics data)	0.0024	0.016
Depleted uranium		
Process exhaust (monitored)	0.0016	3.0
Process and laboratory exhaust (unmonitored)	0.0022	4.0
Room exhaust (from health physics data)	0.0024	2.5
Total	0.023	9.7

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

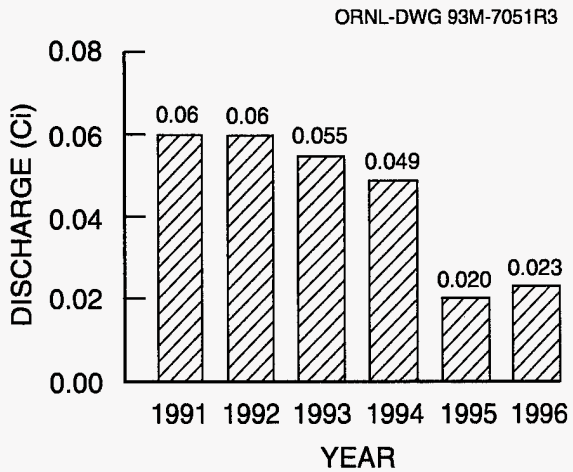

Fig. 4.1. Total curies of uranium discharged from the Y-12 Plant to the atmosphere, 1991–96.

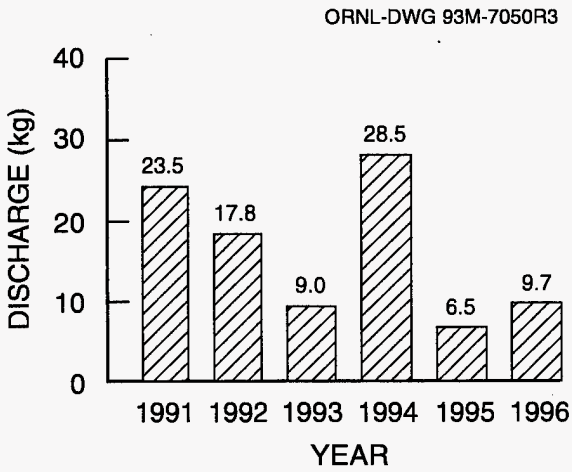

Fig. 4.2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1991–96.

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):

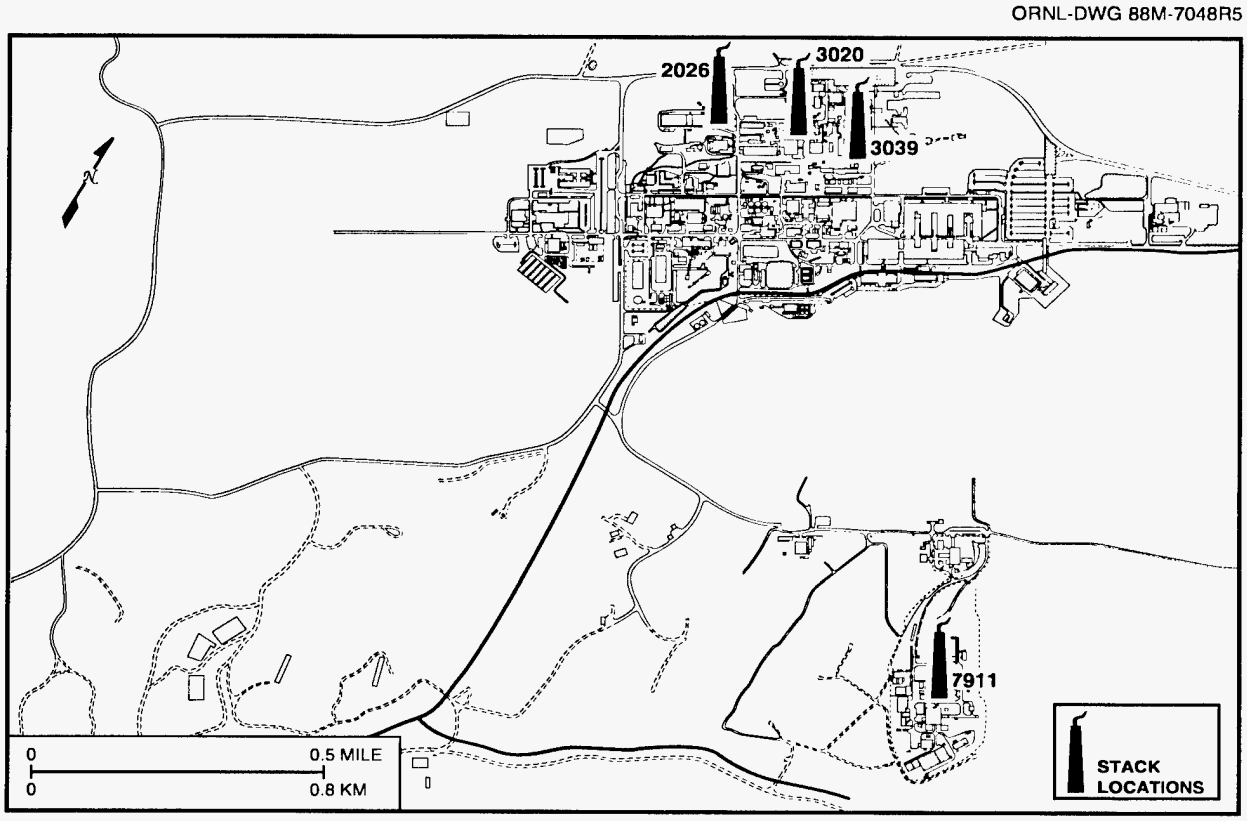

Fig. 4.3. Locations of major stacks (rad emission points) at ORNL.

- 2026 High Radiation Level Analytical Laboratory;
- 3020 Radiochemical Processing Plant;
- 3039 central off-gas 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 1996, there were 23 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, 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, lab 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 included in the NESHAP Compliance Plan for the ORR. These minor sources are evaluated on a one- to three-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.

4.1.2.2 Results

The charcoal cartridges, particulate filters, and silica gel traps were 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 was performed weekly. Particulate filters were held for eight 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 was conducted to better detect short-lived gamma isotopes. The weekly filters were 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 was rinsed, and the rinsate was 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 were compiled to give the annual emissions for each major source and some minor sources.

Annual radioactive airborne emissions for major sources 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 1996 totaled approximately 603 Ci (Fig. 4.4). The primary contributor was off-gas from Stack 7025 that vents the old Tritium Facility, even though it has been inoperative since 1989. The ^{131}I emission for 1996 is 0.28 Ci, which is higher than that of the past years (Fig. 4.5). The ^{3}H emissions are attributable to cleanup activities in April 1996 that exposed a small amount of tritium, which had adhered to the concrete walls and other solid surfaces as tritiated moisture. As the weather warmed up, this moisture was driven off slowly through the off-gas system.

4.1.3 ETTP Radiological Airborne Effluent Monitoring

Locations of airborne radionuclide point sources at the ETTP are shown in Fig. 4.6. 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.

Table 4.2. Major sources of radiological airborne emissions at ORNL, 1996 (in curies)[a]

Isotope	Stack			
	2026	3020	3039	7911
^{3}H	7.9E–01		8.1E+01	1.1E+02
^{7}Be	7.4E–07		2.2E–05	1.3E–06
^{40}K	4.2E–07			
^{41}Ar				2.0E+03
^{60}Co			2.1E–04	
^{85}Kr			1.0E+02	1.8E+02
^{85m}Kr				8.6E+00
^{87}Kr				2.0E+01
^{88}Kr				1.9E+01
^{89}Kr				9.9E+00
Total Sr	1.7E–06	3.4E–07	4.0E–05	3.1E–05
^{131}I	4.8E–06		4.3E–05	2.8E–01
^{132}I				1.5E–01
^{133}I	2.8E–07		8.3E–04	1.4E+00
^{135}I			2.2E–04	2.8E+00
^{131m}Xe				5.3E+00
^{133}Xe				1.1E+00
^{133m}Xe				7.4E–01
^{135}Xe	4.5E–06	9.1E–07	2.2E–04	1.6E+02
^{135m}Xe				1.2E+02
^{137}Xe				2.0E+02
^{138}Xe				8.0E+02
^{134}Cs				8.8E–06
^{137}Cs	1.4E–05	6.0E–07	1.2E–04	9.0E–06
^{138}Cs				2.9E+03
^{139}Ba				1.5E–01
^{140}Ba				7.9E–04
^{191}Os			1.2E–01	
^{212}Pb	1.3E–01	3.6E–01	9.6E–01	2.5E–01
^{228}Th	3.9E–08	1.5E–08	2.0E–08	3.0E–08
^{230}Th	4.4E–08	8.6E–08	2.0E–07	1.8E–07
^{232}Th	4.2E–09	1.3E–08	1.5E–08	3.5E–06
^{234}U	4.6E–07	2.7E–08	3.4E–07	1.6E–08
^{235}U	6.7E–09		3.6E–09	9.3E–09
^{238}U	1.2E–08	1.6E–08	6.0E–08	2.2E–08
^{238}Pu	1.5E–07	2.9E–09	4.8E–08	2.9E–09
^{239}Pu	4.7E–07	4.4E–08	8.2E–07	3.5E–08
^{241}Am	3.6E–07	5.9E–08	3.6E–07	8.1E–09
^{244}Cm	4.9E–06	6.1E–09	1.7E–07	1.7E–07
^{152}Eu			2.1E–06	
^{154}Eu			8.5E–07	
^{140}La				5.3E–06

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

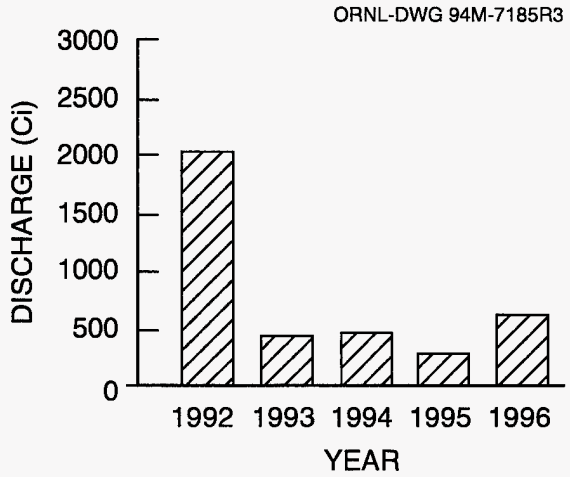

Fig. 4.4. Total discharges of ^{3}H from ORNL to the atmosphere, 1992–96.

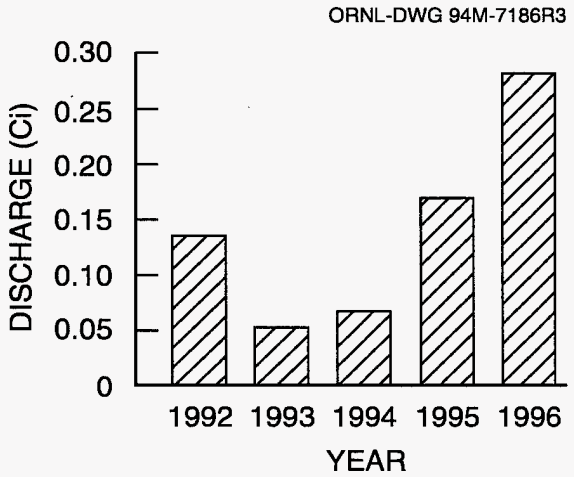

Fig. 4.5. Total discharges of ^{131}I from ORNL to the atmosphere, 1992–96.

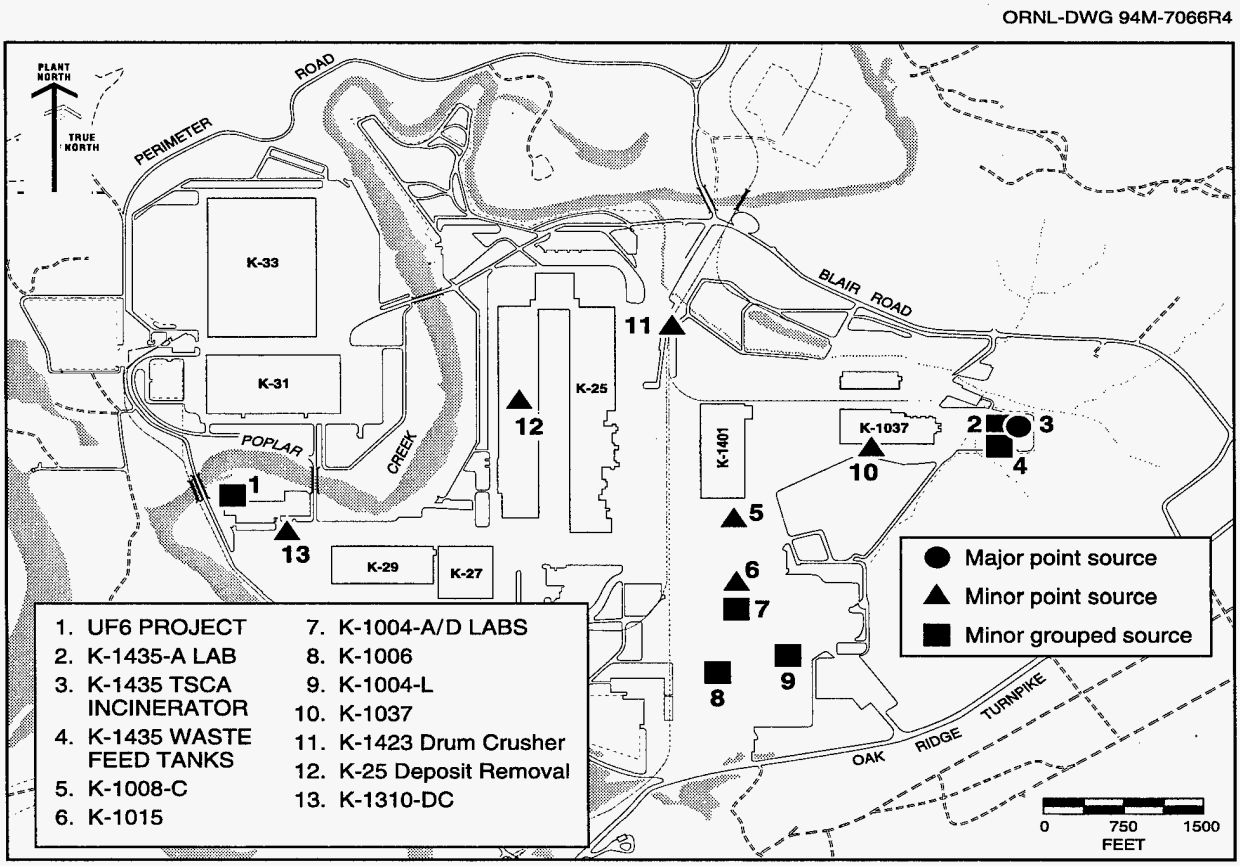

Fig. 4.6. ETTP active point sources of airborne radioactivity.

4.1.3.1 Sample Collection and Analytical Procedure

Routine emission estimates from the TSCA Incinerator were generated from the continuous stack sampling system. The TSCA Incinerator is the only operating major radionuclide emission source at the ETTP and is therefore the only stack that is continuously monitored. Estimates of TSCA Incinerator emissions were based on monthly composites of weekly stack samples.

Various techniques were used to determine all other radiological point source emissions. Representative grab sample techniques were used to generate emission estimates for the K-1015 Laundry. 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.

One new minor point source was approved for operation in 1996. 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 over-pressurization of breached cylinders during repairs.

The following minor sources were reactivated during 1996: 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 vacuums containing potentially contaminated debris.

4.1.3.2 Results

The ETTP 1996 radionuclide emissions from the TSCA Incinerator and minor emission sources are shown in Table 4.3. Additionally, Figs. 4.7 and 4.8 show a comparison of the total 1996 discharges of uranium with those of previous years. The total curies and mass of uranium discharged have decreased from the previous year. Variations are typically caused by changing levels of activities, waste burning, and uranium assay from year to year.

Table 4.3. ETTP radionuclide air emission totals, 1996 (in curies)[a]

Radionuclide	TSCA Incinerator	Minor sources
^{3}H	1.86E–07	5.41E–05
^{14}C	4.14E–09	7.00E–06
^{40}K	7.31E–05	
^{57}Co	7.14E–07	4.61E–08
^{60}Co	7.98E–04	3.15E–06
^{90}Sc		3.10E–06
^{99}Tc	6.57E–03	3.76E–04
^{131}I	2.49E–09	4.79E–07
^{137}Cs	8.54E–04	2.37E–05
^{203}Hg		9.00E–09
^{237}Np	7.55E–07	1.40E–05
^{238}Pu	2.94E–06	1.76E–05
^{239}Pu	4.70E–07	1.19E–05
^{228}Th	3.61E–06	1.24E–05
^{230}Th	7.40E–06	1.57E–05
^{232}Th	1.75E–06	1.04E–05
^{234}Th	4.66E–02	2.77E–04
^{234m}Pa	2.30E–01	5.69E–04
^{233}U		9.48E–07
^{234}U	6.59E–04	4.96E–04
^{235}U	1.18E–06	3.62E–05
^{236}U		9.86E–06
^{238}U	3.46E–03	9.07E–04
^{241}Am		5.83E–06
Totals	2.89E–01	2.85E–03

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

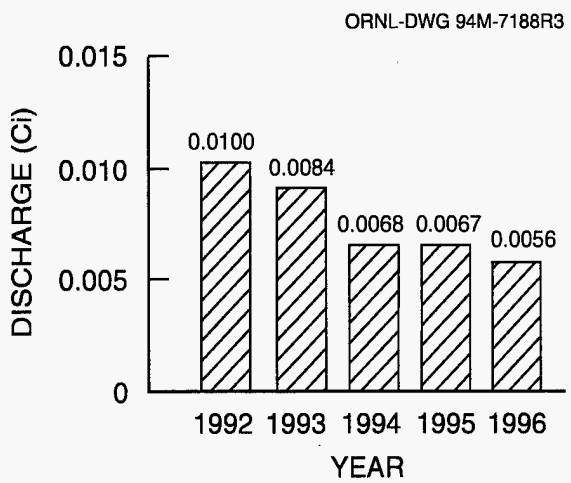

Fig. 4.7. Total curies of uranium discharged from the ETTP to the atmosphere, 1992–96.

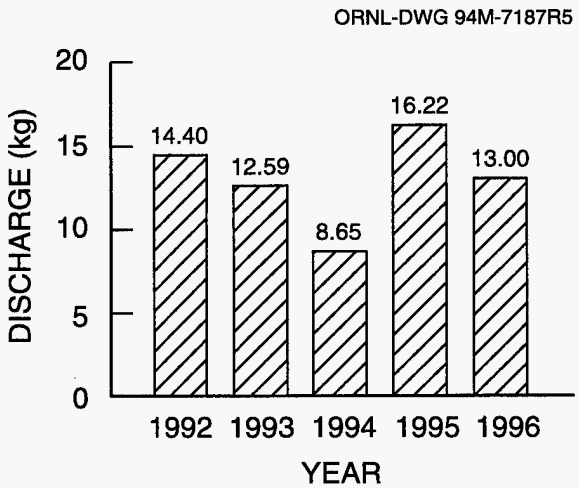

Fig. 4.8. Total kilograms of uranium discharged from the ETTP to the atmosphere, 1992–96.

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 of steam generation. Most process operations are served by ventilation systems that remove air contaminants from the workplace. TDEC has issued 52 air permits that cover 262 of these emission sources. The allowable level of air pollutant emissions from permitted emission sources in 1996 was approximately 10,345 tons per year of regulated pollutants. The actual emissions 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. Therefore, the annual emission fee is based on the sum of allowable air emissions of all regulated pollutants at the Y-12 Plant as defined in Chapter 1200-3-26 of the TDEC regulations.

The Y-12 Plant annual emission fee was calculated by TDEC personnel based on 10,199 tons per year of allowable emission of regulated pollutants, with an annual emission fee of $148,243.35, 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 4,000-ton cap is imposed for SO_2 and NO_x. The emission fee rate is based on $14.65 per ton of regulated pollutant allowable emissions.

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. The past practice of monitoring beryllium process air emissions, as a BMP, was discontinued in 1996 (see Chap. 2, Clean Air Act, other NESHAPs for details).

In anticipation of permitting requirements and implementation of maximum achievable control technology (MACT) standards under Title V of the CAA amendments, an effort is under way to improve the stack and vent survey, criteria pollutant emission inventory, and hazardous air pollutant emission inventory. The Oak Ridge Y-12 Plant Title V permit application is expected to be prepared in 1997.

Planning for continued compliance with anticipated and newly issued requirements under Title VI of the CAA amendments is a major

Table 4.4. Y-12 Plant nonradiological airborne emissions, 1996

Chemical	Quantity released		Major release source	Basis of estimate
	lb	kg		
SARA 313 chemicals[a]				
Hydrochloric acid	870	395	Chemical processing aid	Engineering calculation
Lead	1	0.5	Ancillary	Engineering calculations
Methanol	27,630	12,560	Cleaning/cooling	Engineering calculation
Nitric acid	145	66	Chemical processing aid	Engineering calculation
Tetrachloroethene	1	0.5	Storage	Engineering calculation
Other large-inventory chemicals[b]				
Freon 11	550	250	Refrigerant	Quarterly report
Freon 12	224	102	Refrigerant	Quarterly report
Freon 22	1235	561	Refrigerant	Quarterly report
Freon 13	6	3	Refrigerant	Quarterly report
Freon 114	1800	818	Refrigerant	Quarterly report
Freon 502	10	4	Refrigerant	Quarterly report
Steam plant emissions (all calculated emissions)[c]				
Particulates	29,783	13,538	Stack emission	Engineering calculations based on emission facts
SO_x	6,090,853	2,768,570	Stack emission	Engineering calculations based on emission facts
Carbon monoxide	46,933	21,333	Stack emission	Engineering calculations based on emission facts
Volatile organic compounds	3,655	1,661	Stack emission	Engineering calculations based on emission facts
NO_x	3,047,371	1,385,169	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.

effort. In accordance with the Y-12 Plant CAA implementation plan, a stratospheric ozone protection plan annual update 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.

The Y-12 Plant Environmental Compliance Organization personnel and refrigeration maintenance personnel successfully implemented work practices required to minimize releases of ozone-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 of new equipment that operates with "ozone-friendly" refrigerants or by retrofit of existing equipment with new compo-

nents 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 4.9 illustrates the five-year trend of fugitive CFC emissions as reported by the Y-12 Plant. Table 4.4 includes the 1996 estimated emissions of these ozone-depleting substances as a result of Y-12 Plant activities.

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 1996. Both systems were taken out of service for annual calibration/recertification by Spectrum Systems Engineering, Inc., on April 19, 1996. The annual opacity calibration error test reports were submitted to TDEC in July 1996.

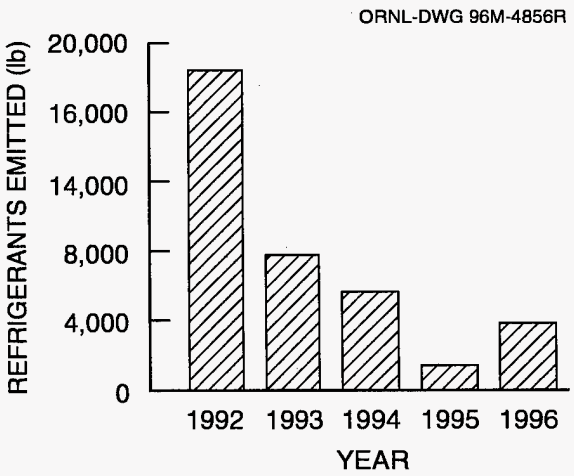

Fig. 4.9. Y-12 Plant CFC emissions, 1992–1996.

During 1996 there were a total of 14 six-minute periods of excess emissions and six 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 1996.

4.1.5 ORNL Nonradiological Airborne Emissions Monitoring

ORNL operates 26 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, 1995 through June 30, 1996, ORNL paid $75,925 in annual emission fees to TDEC. These fees are based on allowable emissions (actual emissions are lower than allowable emissions). In early 1996, TDEC inspected all permitted emission sources to ensure compliance; no noncompliances were noted.

The ORNL Title V permit application was finalized during 1996 and early 1997. To facilitate the preparation of this application, an existing survey of all emission points at ORNL was updated. This survey located all emission points and evaluated their compliance status. Survey results provided information regarding small sources that are currently exempt from air permit requirements. The survey will also assist with compliance efforts that may be required under CAA Title III, Hazardous Air Pollutants.

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 is the replacement or retrofit of large chiller systems that require Class I refrigerants.

4.1.6 ETTP Nonradiological Airborne Emissions Monitoring

The TDEC Division of Air Pollution Control has been delegated the authority by EPA to implement and enforce the sections of the CAA related to nonradiological air emissions in the state of Tennessee. As a result of TDEC rules promulgated pursuant to the CAA amendments of 1990, ETTP submitted a new operating air permit application package to TDEC for all major air emission sources in operation. The ETTP was one of many sources in the state that submitted applications early in the Title V Program as a participant in TDEC's early volunteer program. Development of the new permit application included an air emissions inventory of allowable and actual emissions from the ETTP.

To verify the annual air emission fee assessment, which is based on the ETTP's allowable limits for air pollutants, an inventory of potential emissions from the permitted sources at the ETTP is updated annually. Table 4.5 shows the allowable emissions of criteria pollutants from ETTP operations for the past five years. The ETTP paid annual emission fees based on allowable emissions in 1996 amounting to $14,635. An inventory of actual emissions from all permitted sources in operation at the ETTP was completed for 1996. Table 4.6 shows actual emissions from the ETTP during 1996.

Title VI of the CAA amendments addresses stratospheric ozone protection. This section authorizes 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 during the year with Class II HCFC-22 units. In addition to these, a large CFC-12 unit containing 2,700 lbs. of refrigerant was replaced with a HCFC-22 unit. Recovered CFC-12 from this project was sent to ORNL for reuse in lieu of disposal.

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. Boiler 4, a natural gas-fired unit, was abandoned in place and will no longer be used. The remain-

Table 4.5. Allowable emissions of criteria pollutants from ETTP, 1992–96

Pollutant	Allowable emissions (tons/year)				
	1992	1993	1994	1995	1996
Particulate matter	172	180	141	296	247
Volatile organic compounds	262	166	153	167	150
Sulfur dioxide	429	429	429	428	428
Nitrogen oxides	226	226	226	224	224
Carbon monoxide	157	157	157	157	157
Miscellaneous	291	291	145	149	0
Total	1537	1449	1251	1421	1206

ing units use natural gas as their primary fuel source, with No. 2 fuel oil used as backup during curtailment of natural gas supplies. Table 4.7 presents the actual and allowable emissions from the steam plant for 1996.

The TSCA Incinerator is also a major source of air emissions from the ETTP. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Actual emissions from the incinerator are significantly less than the permitted allowable emissions (Table 4.8).

Table 4.6. Actual emissions of criteria pollutants from ETTP, 1996

Pollutant	Actual emissions (tons/year)
Particulate matter	3.91
Volatile organic compounds	3.76
Sulfur dioxide	5.85
Nitrogen oxides	24.71
Carbon monoxide	30.08

4.2 LIQUID DISCHARGES

4.2.1 Radiological Liquid Discharges

DOE Order 5400.1 requires that effluent monitoring be conducted at all DOE sites. 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 International 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,

Table 4.7. Actual vs allowable air emissions from the K-1501 Steam Plant at ETTP, 1996

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate matter	1.99	143	1.4
Sulfur dioxide	5.43	389	1.4
Nitrogen oxides	17.48	191	9.2
Volatile organic compounds	1.16	9	12.9
Carbon monoxide	28.07	135	20.8

Table 4.8. Actual vs allowable air emissions from the TSCA Incinerator at ETTP, 1996

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Lead	0.00058	0.575	0.1
Beryllium	0.0000056	0.00037	1.5
Mercury	0.0030	0.088	3.4
Fluorine	0.0030	2.82	0.1
Chlorine	0.080	15.68	0.5
Sulfur dioxide	0.24	38.54	0.6
Particulate	0.044	13.14	0.3

as screening values for considering best available technology for treatment of liquid effluents, and for making dose comparisons. Radiological data are determined as percentages of the DCG for a given isotope. 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 Summary

Regulatory Requirements

At the Y-12 Plant, radiological monitoring of effluents and surface waters is also a component of the NPDES permit (TN002968). The permit, issued in 1995, required that the Y-12 Plant reevaluate the radiological monitoring plan and that it submit results from the monitoring program quarterly, as an addendum to the NPDES Discharge Monitoring Report. There were no discharge limits set by the new NPDES permit for radionuclides; the requirement is only to monitor and report. The *Radiological Monitoring Plan for the Y-12 Plant: Surface Water* (LMES 1995a) was revised and fully implemented in 1995 to better characterize the radiological components of plant effluents and to reflect changes in plant operations. The monitoring program was designed to monitor effluent at three types of locations: (1) treatment facilities, (2) other point and area source discharges, and (3) in-stream locations.

The following parameters are monitored routinely under the plan:

- alpha and beta activity,
- americium (^{241}Am),
- neptunium (^{237}Np),
- plutonium (^{238}Pu and $^{239/240}$Pu),
- radium (^{226}Ra and ^{228}Ra),
- strontium (^{90}Sr),
- technetium (^{99}Tc),
- thorium (^{228}Th, ^{230}Th, ^{232}Th, ^{234}Th, and total thorium),
- tritium (^{3}H), and
- uranium (^{234}U, ^{235}U, ^{236}U, ^{238}U, total uranium, and percentage of ^{235}U).

The 1995 revision to the radiological monitoring plan called for a routine gamma scan to be performed for a year and for an evaluation of the data at the end of the year. Review of that data supports eliminating gamma scans from routine sampling. However, gamma scans will continue as a BMP until such time that additional reviews would preclude continued monitoring.

In addition, 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. 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).

Results

Radiological monitoring plan sampling locations are noted in Fig. 4.10. Table 4.9 identifies the monitored locations, the frequency of monitoring, and the sum of DCG percentages for radionuclides measured in 1996. Radiological data for all locations were well below the allowable DCGs. The highest summed percentage of DCGs was from the in-stream location at Bear Creek kilometer (BCK) 11.97. Uranium (^{234}U and ^{238}U) and ^{237}Np were the major contributors of radioactivity there, contributing 4.0, 6.5, and 2.9%, respectively, to the total 14.3% of the sum of the percentages of the DCGs.

With the concurrence of TDEC personnel, the frequency of monitoring at BCK 11.97 was reduced from weekly to semiannually in August 1996 after evaluation of monitoring sites located on Bear Creek and to address ongoing budget reductions. Sampling in the upper Bear Creek area was initiated in 1983 as part of a memorandum of understanding between DOE, EPA, and the state

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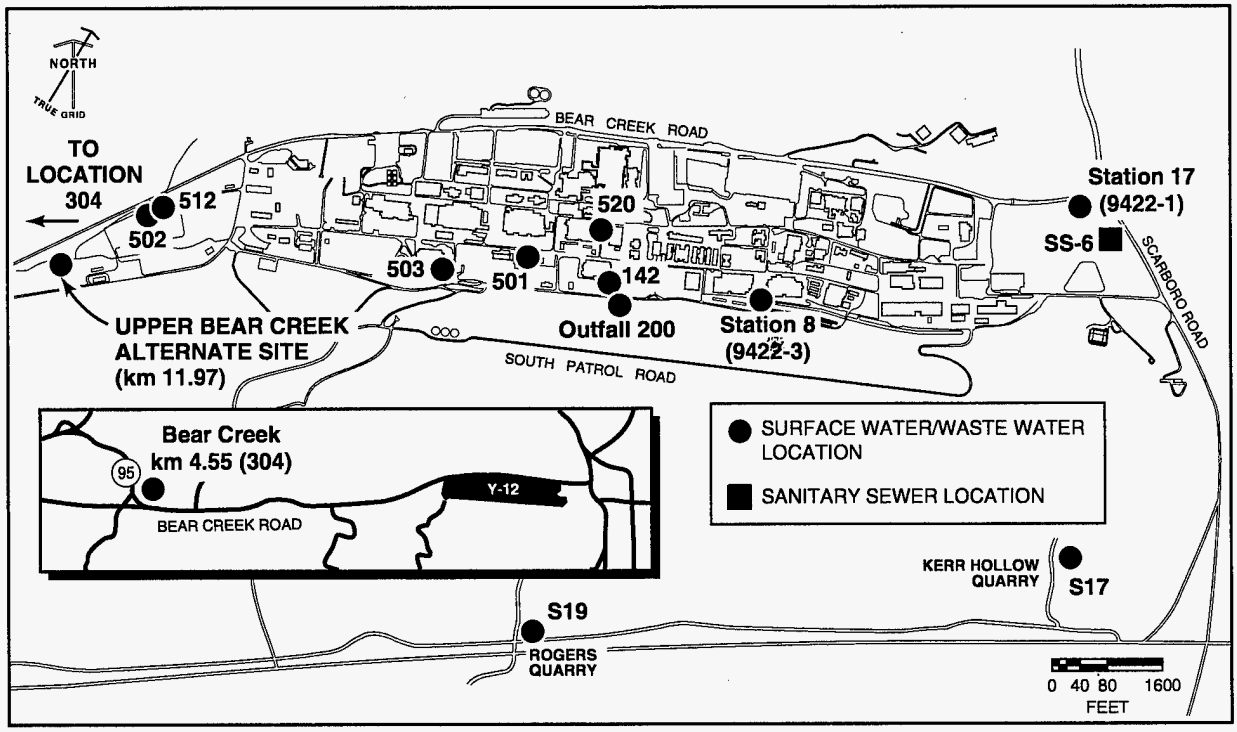

Fig. 4.10. Surface water and sanitary sewer radiological sampling locations at the Y-12 Plant.

of Tennessee to characterize effects of S-3 Pond discharges. This commitment has been satisfied; sampling of surface waters in the Bear Creek drainage area is now conducted at other locations to satisfy NPDES permit requirements and as part of remedial actions being conducted under CERCLA. This change in the monitoring program will be incorporated into the next update of the Radiological Monitoring Plan during 1997.

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. 4.11, which shows ^{238}U concentrations since 1989.

In 1996, 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 474 kg, or 0.284 Ci (1.05E+10 Bq) (Table 4.10). Figure 4.12 illustrates a 5-year trend of these releases.

The total release is calculated by multiplying the average concentration (grams/liter) times the average flow (million gallons/day). Converting units and multiplying by 365 days/year yields the calculated discharge. Heavy rainfall during 1996 contributed to increased creek flows and also contributed to increased calculated discharges in both EFPC and Bear Creek.

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. 4.10). Radionuclide discharge levels are established by DOE via DOE Order 5400.5.

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

Table 4.9. 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	–0.037
502	West End Treatment Facility	1/week	24-hour composite	–0.25
503	Steam Plant Wastewater Treatment Facility	1/week	24-hour composite	No flow
512	Groundwater Treatment Facility	1/week	24-hour composite	2.87
520 (402)[a]	Steam Condensate	1/week	Grab	No flow
	Other Y-12 Plant point and area source discharges			
142	Isotope Separation Process	1/month	24-hour composite	No flow
S17 (301)[a]	Kerr Hollow Quarry	1/month	24-hour composite	–0.70
S19 (302)[a]	Rogers Quarry	1/month	24-hour composite	–2.4
	Y-12 Plant in-stream locations			
BCK 4.55 (304)[a]	Bear Creek, Plant Exit (west)	1/week	7-day composite	2.4
Station 17	East Fork Poplar Creek, Plant Exit (east)	1/week	7-day composite	2.0
Station 8	East Fork Poplar Creek, Plant Site	1/week	7-day composite	3.3
200	North/South Pipes	1/week	24-hour composite	4.3
km 11.97	Bear Creek	1/week[b]	Grab	14.3

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

[b]Reduced to semiannually effective August 1996.

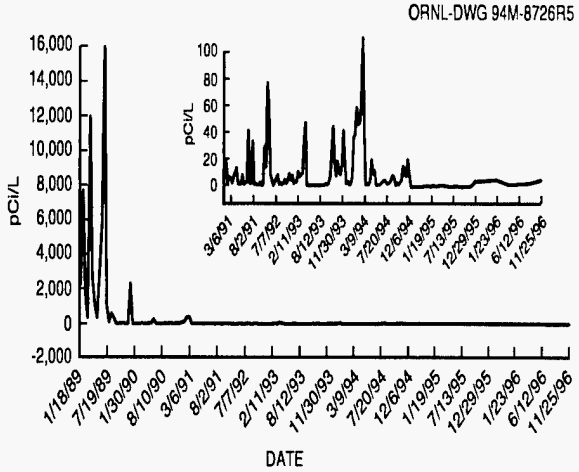

Fig. 4.11. Concentrations of ^{238}U at the Y-12 Plant Outfall 501, January 1989 through December 1996. The allowable DCG for ^{238}U is 600 pCi/L.

zero. Results of radiological monitoring were reported to the city of Oak Ridge with the quarterly monitoring report (Table 4.11).

Potential sources of radionuclides discharging to the sanitary sewer had been identified in previous studies at the Y-12 Plant as part of a BMP initiative to meet the ALARA goals of the Y-12 Plant. These data show that levels of radioactivity are orders of magnitude below regulatory levels established in DOE orders and are not thought to pose a safety or health risk. The radiological monitoring needs for the sanitary sewer will be reviewed and summarized in the 1997 update to the Radiological Monitoring Plan (RMP). Any recommendations or revisions to the radiological monitoring associated with the sanitary sewer will be documented in the RMP and implemented in 1997. Figure 4.13 illustrates the 5-year trend of

Table 4.10. Release of uranium from the Y-12 Plant to the off-site environment as a liquid effluent, 1991–96

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
	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

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

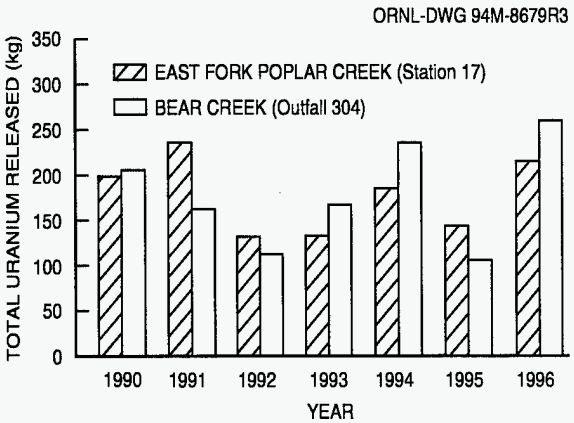

Fig. 4.12. Five-year trend of Y-12 Plant release of uranium to surface water.

total uranium discharges from the Y-12 Plant Sanitary Sewer.

4.2.1.2 ORNL Radiological Summary

ORNL Surface Waters Receiving Effluents

Under the RMP for the ORNL NPDES permit issued in 1986, sampling for radiological analyses was conducted at five NPDES stations and at six ambient stream locations around ORNL. The five NPDES stations were STP (X01), Nonradiological Wastewater Treatment Facility (NRWTF) (X12), Melton Branch 1 (X13), WOC (X14), and White Oak Dam (WOD) (X15). The six ambient stations were 7500 Road Bridge, First Creek, Fifth Creek, Melton Branch 2, Northwest Tributary, and Raccoon Creek (Fig. 4.14). In addition, water samples were collected for radiological analyses from the Clinch River at Melton Hill Dam and from WOC headwaters, two locations above ORNL discharge points that serve as references for other water sampling locations at the ORNL site.

DOE DCGs are used in this document 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. For 1996, only three radionuclides had an average concentration greater than 5% of the relevant DCG; they were ^{3}H, total radioactive strontium ($^{89}Sr + {}^{90}Sr$), and ^{137}Cs. The largest percentage was the total radioactive strontium concentration at NRWTF (X12), at 43% of the DCG (Fig. 4.15). 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 1996, the sum of DCG percentages at each effluent point and ambient water station was less than 100% and therefore within acceptable levels.

Table 4.11. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6, Radiological Summary (1/1/96–12/31/96)

Parameter	Number of samples	Concentration (pCi/L)						Standard error	Percentage of DCG	Total curies
		Max	+/–	Min	+/–	Median	+/–			
Alpha activity	53	22.0[a]	29	–10.0[a]	43	3.1[a]	3	0.7151	[b]	5.35E–03
Beta activity	53	20.0	8	–130.0[a]	99	5.2[a]	10	3.1536	[b]	1.91E–03
Gross gamma	53	460.0	57	–15.0[a]	31	23.0[a]	31	9.6637	[b]	4.52E–02
^{238}Plutonium	39	0.23[a]	20	–0.26[a]	19	0.017[a]	14	0.0171	0.0425	9.26E–06
$^{239/240}$Plutonium	39	0.2	23	–0.13[a]	15	0.0[a]	0	0.0093	0.0	–3.24E–06
^{234}Uranium	53	9.0	1	0.043	0.021	3.0	93	0.2397	0.6	4.02E–03
^{235}Uranium	53	0.44	40	–0.049[a]	0.098	0.13[a]	18	0.0163	0.0217	1.72E–04
^{236}Uranium	53	0.43	36	–0.14[a]	41	0.048[a]	0.097	0.0127	0.0096	7.00E–05
^{238}Uranium	53	18.0	3	0.014[a]	0.013	2.4	90	0.3611	0.4	3.40E–03

[a]Provisional data, result was below the minimum detectable activity.
[b]Not applicable.

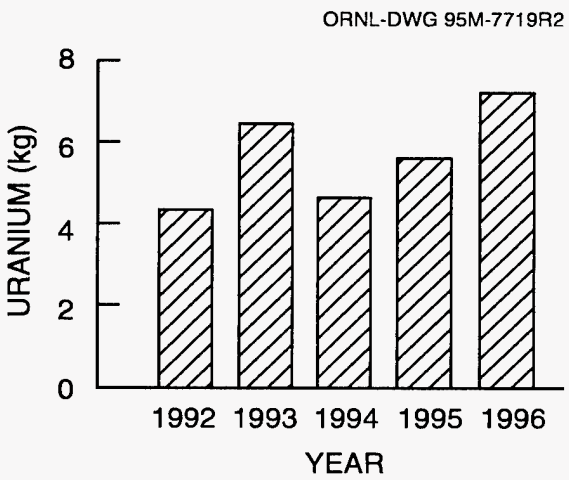

Fig. 4.13. Five-year trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

The discharge from ORNL of radioactive contaminants to the Clinch River is affected by stream flows. Clinch River flows are regulated by a series of TVA dams, one of which is Melton Hill Dam. In 1996, the monthly ratio of flow in WOC (measured at WOD) to flow in the Clinch River (measured at Melton Hill Dam) ranged from 0.00074 to 0.012, thus providing significant dilution of any radioactive contaminants released into the Clinch River from WOC.

Amounts of radioactivity released at WOD are calculated from concentration and flow. As shown in Figs. 4.16, 4.17, 4.18, 4.19, 4.20, and 4.21, the total discharges (or amounts) of radioactivity released at WOD during the past four years have remained in the same range of values.

Categories of Effluents

Under the RMP for the NPDES permit issued in 1986, monitoring was conducted quarterly at NPDES Category I and Category II outfalls. The permit defined Category I outfalls as storm drains and Category II outfalls as roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling-tower blowdown, condensate, and drains in the disposal demonstration area. Gross beta was measured at Category I and Category II outfalls in storm flow conditions. If a gross beta result exceeded a trigger level (810 pCi/L), then a total radioactive strontium analysis was conducted.

In 1996, none of the Category I or Category II gross beta results triggered a total radioactive strontium analysis. The maximum Category I

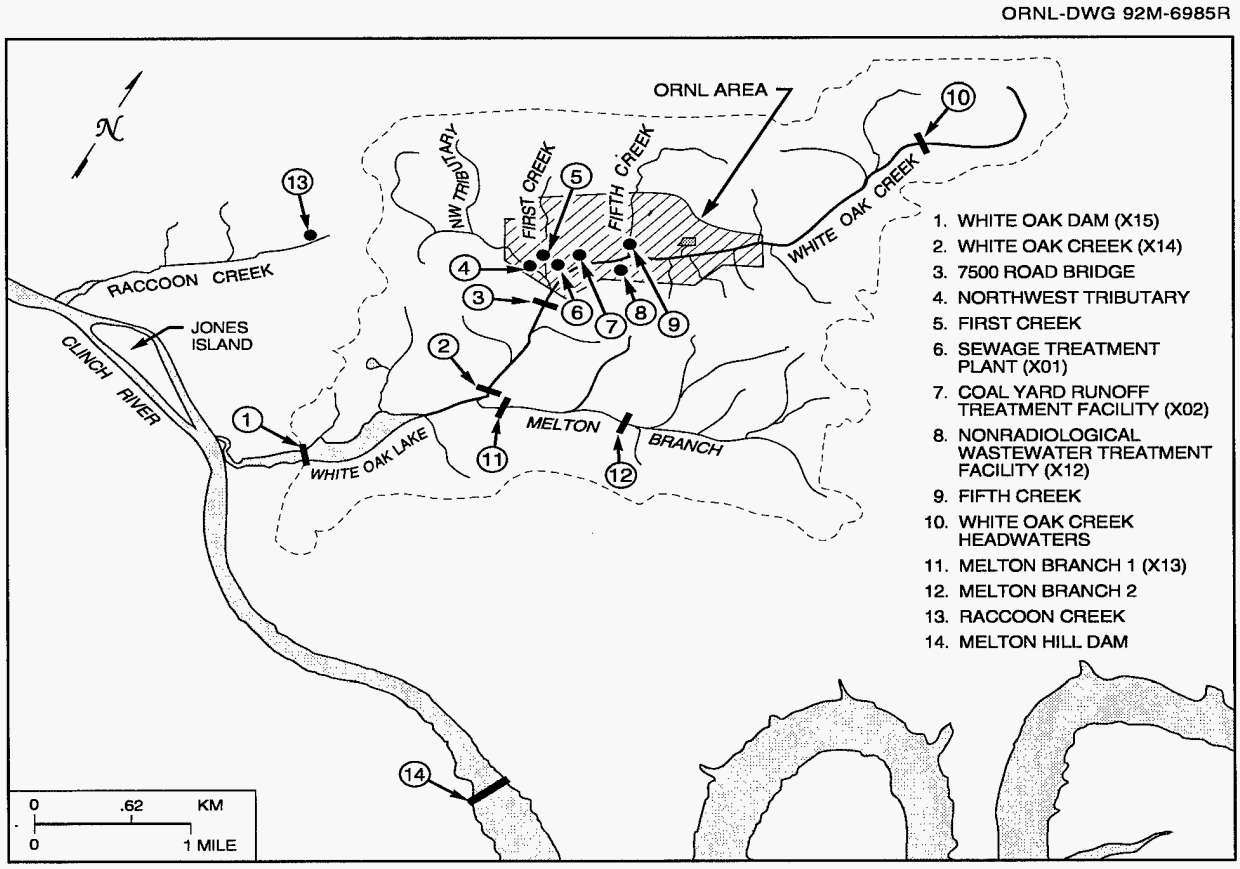

Fig. 4.14. ORNL surface water, NPDES, and reference sampling locations. Bars (**I**) indicate sampling locations that have weirs.

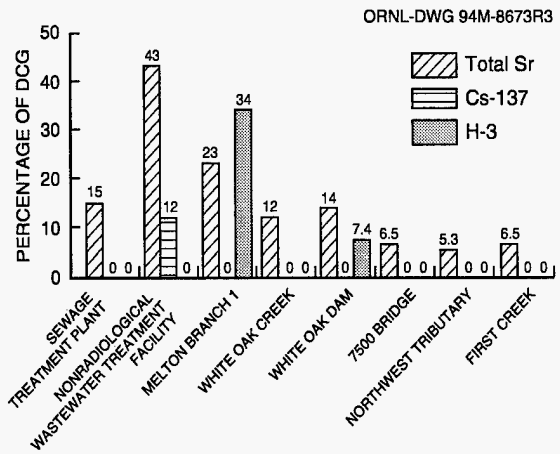

Fig. 4.15. Radionuclides at ORNL sampling sites having average concentrations greater than 5% of the relevant derived concentration guides in 1996.

gross beta value of 100 pCi/L occurred at Outfall 165, which discharges into Fifth Creek east of Building 3033. The maximum Category II gross beta value of 320 pCi/L occurred at Outfall 282, which discharges into WOC west of Building 7516.

4.2.1.3 ETTP Radiological 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.

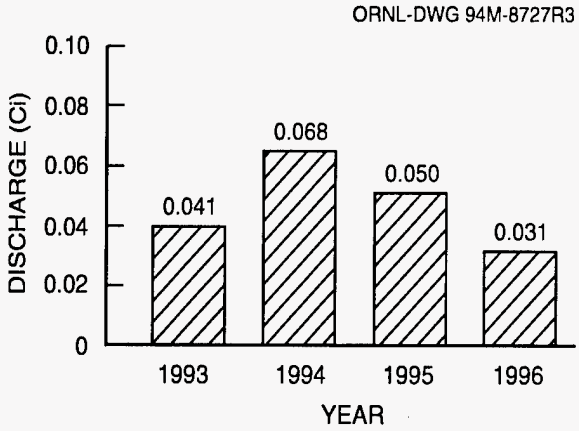

Fig. 4.16. Cobalt-60 discharges at White Oak Dam, 1993–96.

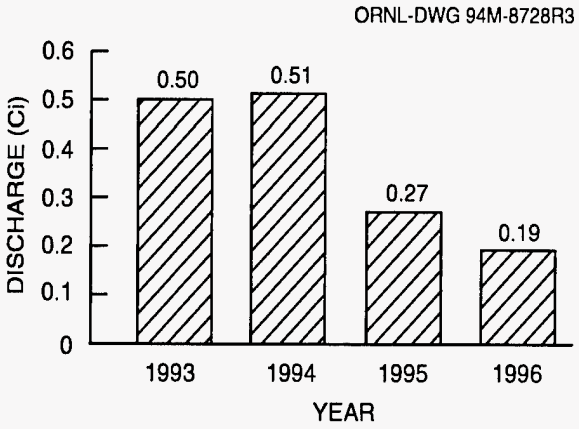

Fig. 4.17. Cesium-137 discharges at White Oak Dam, 1993–96.

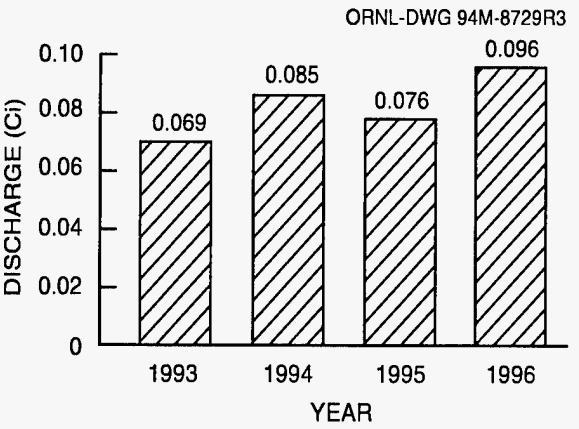

Fig. 4.18. Gross alpha discharges at White Oak Dam, 1993–96.

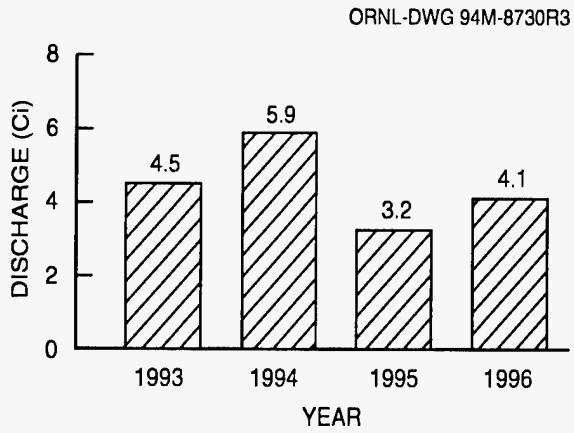

Fig. 4.19. Gross beta discharges at White Oak Dam, 1993–96.

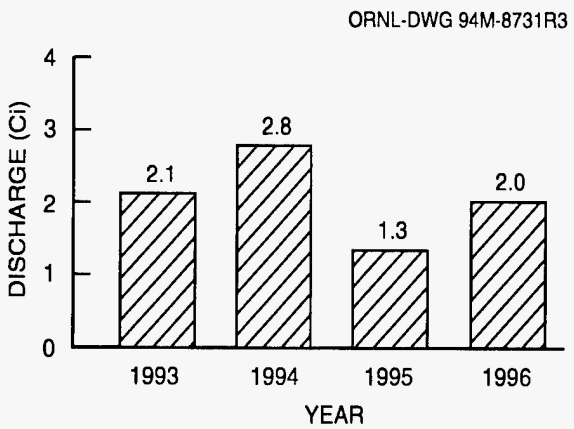

Fig. 4.20. Total radioactive strontium discharges at White Oak Dam, 1993–96.

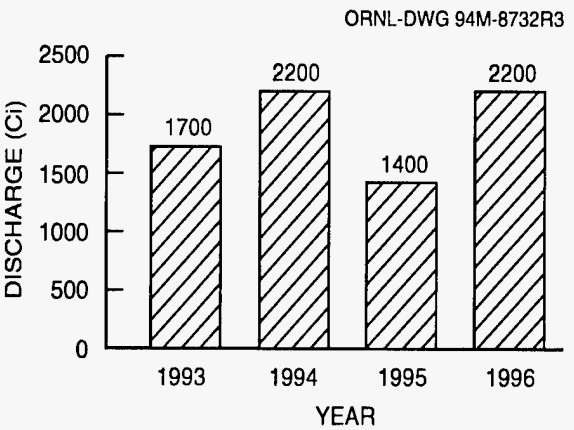

Fig. 4.21. Tritium discharges at White Oak Dam, 1993–96.

Sample Collection and Analytical Procedure

The ETTP monitored three major effluent discharge points for radiological parameters: the K-1203 STP discharge (Outfall 005), the treated effluent from the K-1407-J CNF (Outfall 014), and the K-1515-C filter backwash from the Sanitary Water Treatment Facility (Outfall 009) (Fig. 4.22). Weekly samples were collected from each of these locations. The weekly samples were composited into monthly samples and analyzed for radionuclides. Results of these sampling efforts were compared with the DCGs.

Results

The sum of the fractions of the DCGs at K-1407-J was calculated at 18% for CY 1996. The decrease in 1996 was determined to be caused by changes in TSCA Incinerator feed material. The sum of the fractions of the DCGs for effluent locations K-1203 and K-1515-C declined to less than 1%. Table 4.12 lists radionuclides discharged from the ETTP to off-site surface waters in 1996.

Uranium discharges to surface waters during a five-year period were investigated to observe their trend (Fig. 4.23). The effluent point having the greatest DCG percentage was the K-1407-J Outfall. Uranium isotopes contributed to this percentage (Fig. 4.24). The fluctuation in uranium discharges is attributed to TSCA Incinerator wastewater, which is sent to the Central Neutralization Facility (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

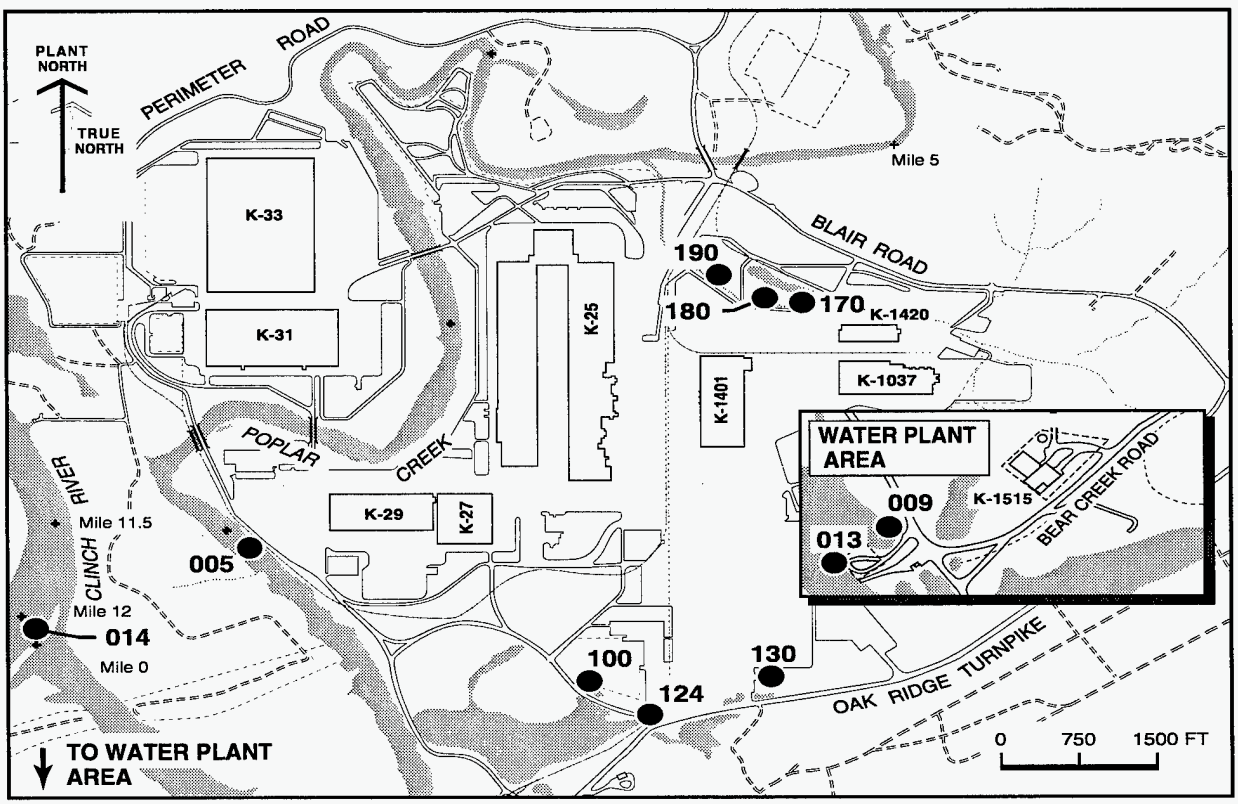

Fig. 4.22. ETTP NPDES major outfalls and Category I storm drain outfalls.

Table 4.12. Radionuclides released to off-site surface waters from the ETTP, 1996
Effluent discharge locations are K-1203, K-1407-J, and K-1515-C[a]

Isotope	Amount (Ci)[b]	Isotope	Amount (Ci)[b]
^{137}Cs	1.1E–04	^{234}Th	1.4E–03
^{237}Np	1.4E–05	^{234}U	4.6E–03
^{238}Pu	1.7E–04	^{235}U	3.7E–04
^{239}Pu	2.9E–05	^{236}U	5.2E–05
^{99}Tc	5.7E–02	^{238}U	6.1E–03

[a]Data collection for radionuclides at K-1515-C was discontinued in November.
[b]1 Ci = 3.7E+10 Bq.

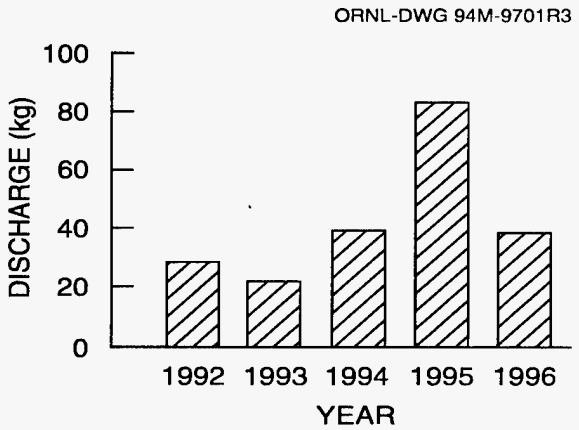

Fig. 4.23. Five-year trend of uranium releases to surface waters from the ETTP. Analysis includes discharge locations K-1203 and K-1407-J.

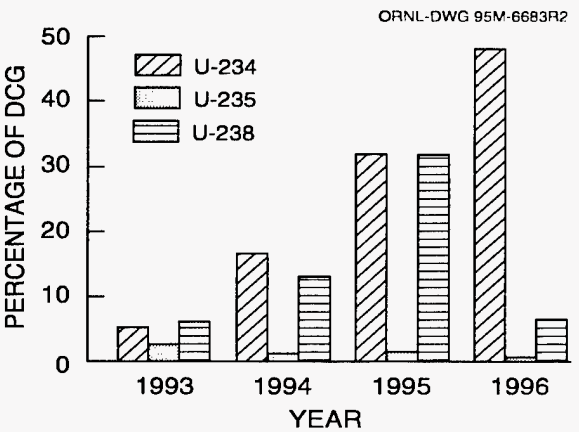

Fig. 4.24. Percentage of DCG for uranium isotopes from K-1407-J.

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 elimiate 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, 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 Control Act and according to the rules and regulations of the Tennessee Water Quality Control (QC) Board. DOE waste 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 1996, two outfalls (outfall S21 and 55A) were physically eliminated; two outfalls (outfall 550 and 551) were activated; and outfall 05A was added. During the previous three years, 49 outfalls were eliminated as part of a program to remove or consolidate outfall pipes on EFPC. Since the mid-1980s more than 250 untreated wastewater point sources that had previously discharged to surface waters have been either eliminated from direct discharge or routed to a wastewater treatment facility. Currently, the Y-12 Plant has outfalls and monitoring points in the following water drainage areas: EFPC, Bear Creek, an unnamed tributary to McCoy Branch, and two unnamed tributaries to the Clinch River. At the end of 1996, there were 61 outfalls discharging various types of wastewater (condensate, cooling water, groundwater, water from building sumps, treated process wastewaters, and other wastewaters) to EFPC. Of the 61 outfalls, nine discharge storm water only; three discharge steam condensate only; two discharge groundwater only; and two are potable water blowdowns. Twenty-seven storm water outfalls are actually in-stream monitoring locations throughout the Y-12 Plant area. Seven internal monitoring points 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 permitted discharges are compared with the appropriate NPDES limits when 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 the Clinch River. In past years, discharge of coal bottom ash slurry to the McCoy Branch Watershed 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).

1996 was the first 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 are as follows:

- toxicity limitation for the headwaters of EFPC,
- quarterly toxicity testing at the wastewater treatment facilities,
- a compliance schedule to reduce mercury in EFPC,
- a compliance schedule for chlorine limitations at outfalls containing cooling water,
- chlorine limitations based on water quality criteria at the headwaters of EFPC,
- a compliance schedule for correction of elevated ammonia concentrations discharged to EFPC from a groundwater spring,
- 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 the creek,
- sampling of storm water at a minimum of 25 locations per year,
- a storm water pollution plan, and
- in-stream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge.

4.2.2.2 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. Monitoring is conducted under the terms of the permit for a variety of organic and inorganic pollutants. During 1996, the wastewater flow in this system averaged about 854,000 gal/day (3,885,000 L/day).

Compliance sampling is conducted at the EESSMS (SS-6, Fig. 4.10) on a weekly basis. In addition, throughout 1996 mercury composite samples were obtained daily, Monday through Thursday, and a three-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.

Results

In 1996, the Y-12 Plant experienced an increase in NPDES excursions from six in 1995 to ten in 1996. Only four of the excursions were caused by exceedences of wastewater discharge limits. In 1996, 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. All Y-12 Plant NPDES permit excursions recorded in 1996 are summarized in Appendix F, Table F.1. Table 4.13 records the NPDES compliance monitoring requirements and the 1996 compliance record.

Monitoring of nonradiological parameters on Bear Creek at km 11.97 was reduced from weekly to semiannually in August 1996. Sampling in the upper Bear Creek area was initiated in 1983 as part of a memorandum of understanding between DOE, EPA, and the state of Tennessee to characterize effects of S-3 Pond discharges. This commitment has been satisfied: sampling of surface waters in the Bear Creek drainage area is now conducted at other locations to satisfy NPDES permit requirements and as part of remedial actions being conducted under CERCLA. Analytical data are reported to TDEC in an attachment to the discharge monitoring report required by NPDES. Surface water in the upper reaches of Bear Creek contains elevated trace metals and nitrate concentrations.

Table 4.14 summarizes Y-12 Plant contributions to the sanitary sewer system for 1996. During 1996, the Y-12 Plant experienced two exceedences of the discharge permit issued by the City of Oak Ridge. Both exceedences were for mercury and occurred as a result of rehabilitation activities on the sanitary sewer.

Progress in Implementing Corrective Actions and Significant Improvements

East Fork Poplar Creek Dechlorination

Two dechlorination systems that began operating in December 1992 continued to provide dechlorination for 75% of EFPC flow (20% of EFPC flow is estimated to be groundwater and 5% represents flows that do not require dechlorination). In-stream levels of total residual chlorine were typically about 0.01 mg/L during 1996 (outfall discharge levels before 1993 were about 0.3 to 1.0 mg/L). Fish populations and density have increased significantly. Additional dechlorination has been achieved by installation of tablet dechlorinators during 1993 through 1995 (which now total 42) at chlorine-discharge sources. Outfall 125, the next largest non-dechlorinated outfall, began treatment in 1995, following installation of a dechlorination system in late 1994.

Table 4.13. NPDES compliance monitoring requirements and record for the Y-12 Plant, January through December 1996

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 066	pH, standard units			*a*	9.0	100	5
Outfall 068	pH, standard units			*a*	9.0	100	12
Outfall 117	pH, standard units			*a*	9.0	100	7
Outfall 073	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
Outfall 077	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
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	12
	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	6
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			*a*	9.0	100	110
	Total residual chlorine				0.5	98	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 4.13 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (kg/d)	Daily max (kg/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	171
	Total residual chlorine				0.5	100	120
Outfall 201 (below the North/South pipes)	Total residual chlorine			0.011	0.019	100	160
	Temperature, °C			*a*	30.5	100	160
Outfall 200 (North/South pipes)	pH, standard units			10	8.5	99	160
	Oil and grease				15	100	160
Outfall 021	Total residual chlorine			0.080	0.188	100	158
	Temperature, °C			*a*	30.5	100	157
	pH, standard units				9.0	100	161
Outfall 017	pH, standard units			*a*	9.0	100	55
	Ammonia as N			32.4	64.8	100	52
Outfall 055	pH, standard units			*a*	9.0	100	110
	Mercury				0.004	100	106
	Total residual chlorine				0.5	100	110
Outfall 55A	pH, standard units			*a*	9.0	100	26
	Mercury				0.004	100	26
Outfall 550	pH, standard units			*a*	9.0	*b*	35
	Mercury			0.002	0.004	*b*	35
Outfall 551	pH, standard units				9.0	*b*	76
	Mercury				0.004	*b*	7
Outfall 051	pH, standard units			*a*	9.0	100	110
Outfall 501 (Central Pollution Control Facility)	pH, standard units			*a*	9.0	100	8
	Total suspended solids	0.16	0.4	31.0	40.0	100	8
	Total toxic organics	1.0	1.7	10	2.13	100	0[c]
	Oil and grease	1.2	2.0	0.075	15	100	8
	Cadmium	0.26	0.4	0.5	0.15	100	8
	Chromium	1.4	2.4	0.5	1.0	100	8
	Copper	0.14	0.26	0.10	1.0	100	8
	Lead	0.9	1.6	2.38	0.20	100	8
	Nickel	0.4	0.72	0.05	3.98	100	8

Table 4.13 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
	Silver			148	0.05	100	8
	Zinc			0.65	2.0	100	8
	Cyanide				1.20	100	8
	PCB				0.001	100	0[c]
Outfall 502 (West End Treatment Facility)	pH, standard units			[a]	9.0	100	39
	Total suspended solids	18.6	36.0	31.0	40.0	100	39
	Total toxic organics	0.16	0.4	100	2.13	100	5
	Nitrate/nitrite	1.0	1.7	10	150	100	39
	Oil and grease	1.2	2.0	0.075	15	100	39
	Cadmium	0.26	0.4	0.5	0.15	100	39
	Chromium	1.4	2.4	0.5	1.0	100	39
	Copper	0.14	0.26	0.10	1.0	100	39
	Lead	0.9	1.6	2.38	0.20	100	39
	Nickel	0.4	0.72	0.05	3.98	100	39
	Silver			1.48	0.05	100	39
	Zinc			0.65	2.0	100	39
	Cyanide				1.2	100	39
	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	0.83	0.83	0.075	0.15	*b*	0
	Chromium	4.17	4.17	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			1.0	1.0	*b*	0
Outfall 512 (Groundwater Treatment Facility)	pH			*a*	9.0	100	155
	Iron				1.0	99	157
	PCB				0.001	100	12
Outfall 520	pH, standard units				9.0	*b*	0

[a]Not applicable.
[b]No discharge.
[c]Last sample was July 1995 before a carbon column change. The next sample is due before the next carbon column change or before the end of the permit year, which is July 1997.

Table 4.14. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6, Nonradiological Summary (1/1/96–12/31/96)

Parameter	Number of samples	Concentration[a]			Reference value[b]	Number of values exceeding reference
		Max	Min	Av		
Flow, gpd[c]	366	2,601,718	227,610	852,312	*d*	*d*
pH, standard units	53	8.4	7.0	*d*	9/6[e]	0
Silver	53	0.027	<0.006	<0.007	0.1	0
Boron	53	0.05	<0.02	<0.03	*d*	*d*
Cadmium	53	<0.004	<0.004	<0.004	0.00024	0[f]
Cyanide	42	<0.01	<0.01	<0.01	0.007	0[f]
Chemical oxygen demand	42	170.0	25.0	56.6	*d*	*d*
Chromium	53	0.009	<0.006	<0.006	0.44	0
Ion chromium (Cr+6)	42	<0.01	<0.01	<0.01	0.002	0[f]
Copper	53	0.024	0.01	0.016	0.04	0
Iron	53	1.02	0.26	0.48	1.5	0
Mercury	249	0.066	0.0004	0.0056	0.1/0.035[g]	2
Manganese	53	0.141	0.028	0.057	1	0
Nitrogen as ammonia	39	9.1	1.7	6.0	*d*	*d*
Nickel	53	<0.008	<0.008	<0.008	0.1	0
Oil and grease	53	28.0	<2.0	<4.6321	50	0
Lead	53	<0.02	<0.02	<0.02	0.0016	0[f]
Phenols	42	0.26	<0.005	<0.0269	5	0
Selenium	53	<0.1	<0.1	<0.1	*d*	*d*
Total Kjeldahl nitrogen	53	28.0	5.2	11.9	90	0
Total suspended solids	53	100.0	<5.0	<45.6698	300	0
Zinc	53	0.23	0.09	0.13	2	0

[a]Units in mg/L unless otherwise indicated.
[b]Sanitary Sewer Industrial Users permit limits.
[c]Flow during operations and/or discharging.
[d]Not applicable.
[e]Maximum value/minimum value.
[f]The detection limit for this parameter is above the reference value.
[g]Reference value prior to April 14, 1996; reference value after April 14, 1996.

Ecological recovery of EFPC is continuing, and some significant recent trends have been observed. Pollution-intolerant fish species are being found below Lake Reality, and there has been substantial reduction in toxicity above Lake Reality. However, both fish and benthic macroinvertebrate communities in UEFPC are dominated by pollution-tolerant species, especially above Lake Reality. Additional recovery may occur in response to reductions in mercury levels in EFPC. Complete recovery may not occur because water temperatures remain elevated, inadvertent discharges/spills may occur, and availability of habitat is limited above Lake Reality.

Flow Management (or Raw Water) Project

Discharges to EFPC have decreased in volume from about 10 million gal/day (38 million L/day) in the early 1980s to about 3.5 million gal/day (13.2 million L/day) currently, primarily because of reductions in plant operations. These reductions have increased concern about maintaining water quality and stable flow in the upper reaches of EFPC. Accordingly, the current NPDES permit requires addition of Clinch River water to the headwaters of EFPC (North/South Pipe-Outfall 200 area) by March 1997 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. This project was completed in August 1996, when raw water began flowing at 3.5 million gal/day (13.2 million L/day), thus increasing flow in EFPC to the required minimum. In-stream water temperatures decreased approximately 5°C (from approximately 26°C at the headwaters).

Non-Point-Source Studies

Storm water runoff is required to be sampled periodically and analyzed for many contaminants according to the *Stormwater Pollution Prevention Plan for the Oak Ridge Y-12 Plant* (LMES 1995b). The plan was issued in September 1995 in accordance with provisions of the NPDES permit. The plan presents (1) programmatic and physical BMP controls implemented at the Y-12 Plant, (2) surveillance programs, and (3) a monitoring plan for characterizing storm water discharges. Storm water runoff data from previous years were analyzed and the *Feasibility Study of Best Management Practices for Non-Point Source Pollution Control at the Oak Ridge Y-12 Plant* (CDM 1993) was issued in 1993. Additional studies were initiated on the basis of this report. Sampling of parking lots, the metal scrap yard, and selected building roofs was completed in 1994. The data will help determine whether the areas are specific sources of contaminants observed in storm water flow in EFPC. These types of investigations will continue as necessary to ensure compliance with the NPDES permit and other regulatory requirements.

Drain Modifications and Reroutes

Extensive drain surveys conducted in years previous to 1993 identified incorrectly connected building drains 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 were designed and initiated in 1993 for 32 "major" buildings. Since that time, work has been completed in 29 buildings. Several changes were made to the initial plans because of the ongoing downsizing of the plant. The remaining buildings will be completed as funding appropriations permit.

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 by 1998. Further corrective actions will be taken as funding appropriations permit and as needs dictate.

Reduction of Mercury in Plant Effluent (RMPE): 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. The RMPE II program is structured to serve as a bridge between downstream remediation of EFPC and upstream remedial actions at the Y-12 Plant. These efforts are directed toward meeting the NPDES permit requirements of 5 g/day from the Y-12 Plant by December 31, 1998. Six projects (four building source elimination efforts and two treatment units) have been identified under the RMPE II program to reduce mercury contamination to UEFPC.

Significant progress toward reduction of mercury in discharges to EFPC has been achieved during the past three years. Construction and start-up of the Interim Mercury Treatment Unit (IHgTU) for Building 9201-2 was completed in September 1994. A study was initiated in 1995 to evaluate upgrading the IHgTU to a permanent system. The upgrade called the East End Mercury Treatment Facility (EEMTF) was completed in early 1996. The EEMTF, which continues to operate, treated more than 4.9 million gal (18.8 million L) of water in 1996. Some elimination work, consisting of rerouting pipes for buildings 9201-2, 9201-5, 9201-4, and 9204-4, was completed in early 1996, several months ahead of the required schedule.

To provide permanent mercury treatment capability, the Central Mercury Treatment System (CMTS) began operation on November 26, 1996. The facility is located in the existing Central Pollution Control Facility in Building 9623. Mercury-contaminated groundwater originating from sumps in buildings 9201-4, 9201-5, and 9204-4 is collected and piped or transported to CMTS for treatment. The discharge of the CMTS is through NPDES outfall 551.

Fish Kill Summary

During 1996, the Y-12 Plant reported no incidents to TDEC involving fish kills attributable to activities at the Y-12 Plant.

4.2.2.3 ORNL Nonradiological Summary

Effluents

ORNL NPDES permit TN0002941 was renewed on December 6, 1996, to become effective on February 3, 1997. Data collected for the NPDES permit are submitted to the state of Tennessee in the monthly *Discharge Monitoring Report*.

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. 4.14). ORNL operated during all of CY 1996 under the permit that expired on December 6, 1996. Under that permit, numeric and aesthetic effluent limits have been placed on the following locations:

- X01-STP;
- X02-Coal Yard Runoff Treatment Facility (CYRTF);
- X12-NRWTF;
- X13-Melton Branch;
- X14-WOC;
- X15-WOD;
- CAT1-Category I outfalls (storm drains);
- CAT2-Category II outfalls (roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling-tower blowdown, condensate, and disposal demonstration area);
- CAT3-Category III outfalls (drains that at one time included process and/or lab constituents); and
- COOLS-Cooling Systems (cooling water, cooling tower blowdown, and cleaning wastes originating at space-cooling facilities).

Permit limits and compliance are shown by location in Table 4.15. Compliance with the NPDES permit for the last three years is summarized by major effluent locations in Fig. 4.25. The figure provides a list of the effluent locations and the number of noncompliances at each location. Most permit limit excursions in 1996 occurred at

Table 4.15. 1996 NPDES compliance at ORNL

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	Ammonia, as N (summer)	3.5	5.2	4.0	6.0		0	92	100
(Sewage	Ammonia, as N (winter)	7.8	11.8	9.0	13.5		0	66	100
Treatment	Biochemical oxygen demand (summer)	8.7	13.1	10	15		0	92	100
Plant)	Biochemical oxygen demand (winter)	17.4	26.2	20	30		0	66	100
	Chlorine, total residual				0.5		0	157	100
	Dissolved oxygen					6.0	0	250	100
	Downstream pH (SU)				9.0	6.0	0	53	100
	Fecal coliform (col/100 mL)[b]			1000	5000		1	157	99
	Oil and grease	8.7	13.1	10	15		0	157	100
	pH (SU)				9.0	6.0	0	53	100
	Total suspended solids	26.2	39.2	30	45		0	158	100
X02	Chromium, total			0.2	0.2		0	52	100
(Coal Yard	Copper, total			1.0	1.0		0	52	100
Runoff	Downstream pH (SU)				9.0	6.0	0	52	100
Treatment	Iron, total			1.0	1.0		2	52	96
Facility)	Oil and grease			15	20		0	52	100
	pH (SU)				9.0	6.0	0	52	100
	Selenium, total			0.22	0.95		0	52	100
	Temperature (°C)				30.5		0	52	100
	Total suspended solids				50		0	52	100
	Zinc			1.0	1.0		0	52	100
X12	Cadmium, total	0.79	2.09	0.26	0.69		0	53	100
	Chromium, total	5.18	8.39	1.71	2.77		0	53	100
(Nonradiological	Copper, total	6.27	10.24	2.07	3.38		0	53	100
Wastewater	Cyanide, total	1.97	3.64	0.65	1.20		0	53	100
Treatment	Downstream pH (SU)				9.0	6.0	0	250	100
Facility)	Lead, total	1.30	2.09	0.43	0.69		0	53	100
	Nickel, total	7.21	12.06	2.38	3.98		0	53	100
	Oil and grease	30.3	45.4	10	15		0	53	100

Table 4.15 (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	pH (SU)				9.0	6.0	0	*c*	100
(Nonradiological	Silver, total	0.73	1.30	0.24	0.43		0	53	100
Wastewater	Temperature (°C)				30.5		0	250	100
Treatment	Total suspended solids	93.9	182	31	60		0	53	100
Facility)	Total toxic organics		6.45		2.13		0	53	100
	Zinc, total	4.48	7.91	1.48	2.61		0	53	100
Category I	Downstream pH (SU)				9.0	6.0	0	22	100
outfalls[d]	Oil and grease			10	15		0	22	100
	pH (SU)				9.0	6.0	0	22	100
	Temperature (°C)				30.5		0	22	100
	Total suspended solids			30	50		4	22	82
Category II	Downstream pH (SU)				9.0	6.0	0	148	100
outfalls	Downstream temperature (°C)[e]				30.5		0	39	100
	Oil and grease								
	pH (SU)			10	15		0	148	100
	Total suspended solids				9.0	6.0	0	148	100
				30	50		9	148	94
Cooling Systems	Chlorine, total residual				0.2		0	12	100
	Chromium, total				1.0		0	12	100
	Copper, total			0.5	1.0		0	12	100
	Downstream pH (SU)				9.0	6.0	0	12	100
	pH (SU)				9.0	6.0	0	12	100
	Temperature (°C)			35	38		0	12	100
	Zinc, total			0.5	1.0		0	12	100

[a]Percent compliance = 100 – [(number of noncompliances/number of samples) * 100].
[b]Colonies per 100 mL.
[c]pH monitoring is continuous.
[d]Category I outfalls are monitored annually by the NPDES permit year of April 1–March 31.
[e]Downstream temperature is monitored to check that the stream temperature standards stated in the General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee are not violated as a result of this discharge.

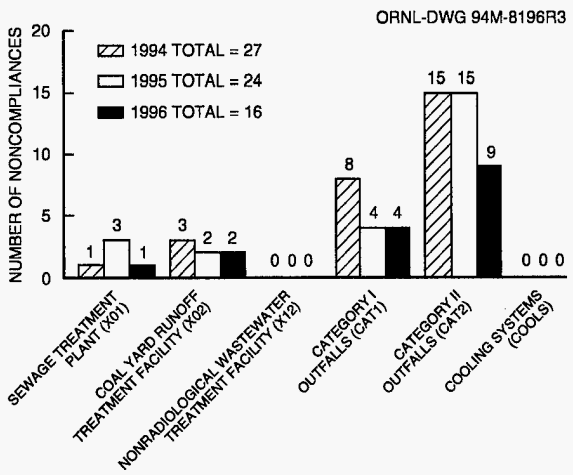

Fig. 4.25. ORNL NPDES limit compliance status comparison and locations of noncompliances, 1994–96.

the Category II outfalls. All Category II limit excursions in 1996 were associated with total suspended solids (TSS), typically residual dust or dirt particles, conveyed in storm water runoff.

ORNL Outfall X01, the STP, experienced one exceedence of the NPDES fecal coliform bacteria limit in July 1996. ORNL had received approximately 2.7 inches of rainfall on the day of the exceedence; however, other pertinent parameters that are monitored at STP, including chlorine, were within normal ranges. Therefore, no certain cause for the exceedence could be established. ORNL is currently in the process of installing an ozonation disinfection system for the STP, which should further enhance compliance with NPDES fecal coliform discharge limits in the future.

ORNL Outfall X02, the CYRTF, experienced two exceedences of the NPDES iron limit, one in May 1996 and one in August 1996. At the time of the May exceedence, ORNL personnel were in the process of removing accumulated sediment from the upper CYRTF settling basin. The sediment removal activity, which consisted of stabilizing the sediment with cement dust and removing the sediment with a mechanical loader, may have contributed to the concentration of effluent iron that was measured. No certain cause was established for the August iron exceedence. Previous ORNL investigations have shown that surface algae, which are abundant on the CYRTF discharge basin in late summer and early fall, tend to accumulate iron from the basin water. As no unusual circumstances were identified on the date of the iron exceedence, it is believed that algal accumulation of iron may have been a contributing factor. At X12, all parameters were 100% in compliance. All required NPDES monitoring and reporting were conducted on schedule. ORNL had no fish kills in 1996.

At the Category I and II outfalls, exceedences of limits on TSS were attributed to flushing of parking lots or streets by storm water runoff. Category I and II outfalls are not contaminated by any known activity, nor do they discharge through any oil-water separator, other treatment facility, or equipment. During rain events, waters from the parking lots and surrounding areas drain into these outfalls, carrying suspended solids and other residue. This situation may result in TSS exceedences. BMPs (including frequent street sweeping) are in place to help avoid these exceedences. In addition, a plan is currently being carried out to improve sampling points at selected outfalls. At the cooling systems, all parameters were 100% in compliance.

Mercury in the Aquatic Environment

The mercury-monitoring program at ORNL was conducted to comply with the CWA and Part III of the ORNL NPDES permit issued in 1986. Samples of surface water and stream sediment in Bethel and Melton valleys were collected semiannually and analyzed for mercury content.

Prior to the stringent regulations now in effect, some contaminants reached various streams primarily as the result of accidental spills or leakages. Most mercury spills occurred from 1954 through 1963, during a period when ORNL was involved with OREX and METALLEX separations processes. Most of this activity occurred in or around buildings 4501, 4505, and 3592 in the main plant area. These processes are no longer in operation at ORNL. During the time of operation, an unknown number of mercury spills occurred. The spills were cleaned up; however, some quantities of mercury escaped and reached the surrounding environment. Sampling

locations were selected in areas surrounding known mercury spills. Additional sampling locations were selected downstream from the outfalls and drains to determine mercury transport in surface water and sediment.

Locations for surface water samples are shown in Fig. 4.26. In 1996, a total of 78 samples were taken from 13 locations. Mercury was detected at 6 of the 13 sampling locations. The highest value reported was 0.55 μg/L near Outfall 207 in WOC, slightly higher than the 1995 high value of 0.44 μg/L at the same location. Average concentrations ranged from 0.13 to 0.36 μg/L. The Tennessee Water Quality Criteria for the protection of fish and aquatic life sets a maximum concentration of 2.4 μg/L for mercury in water. The highest concentration, near Outfall 207, was 23% of the reference value.

Locations for sediment sampling are shown in Fig. 4.27. In 1996, a total of 54 sediment samples were taken from nine stream locations. The highest value reported was 120 μg/g near Outfall 261 on Fifth Creek, considerably lower than the 1995 high value of 880 μg/L at the same site. Average values at the other sites ranged from 0.056 to 17 μg/g.

PCBs in the Aquatic Environment

The PCB monitoring program at ORNL was conducted to comply with the CWA and Part III of the ORNL NPDES permit issued in 1986. Samples of stream sediment were collected semiannually and analyzed for PCB Aroclor content. The program to collect water samples for PCB analysis was dropped in 1992, because PCB levels in the water samples had been below analytical detection limits for several years.

In 1996, duplicate samples of sediment were collected at ten locations in streams at and around ORNL (Figs. 4.28 and 4.29). Samples from each location were analyzed by the analytical laboratory for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Only three locations had results above detection limits. Six additional locations had laboratory-estimated values below the detection limit. The maximum concentration, 1900 μg/kg for Aroclor-1260, was reported at a

ORNL-DWG 92M-13528R2

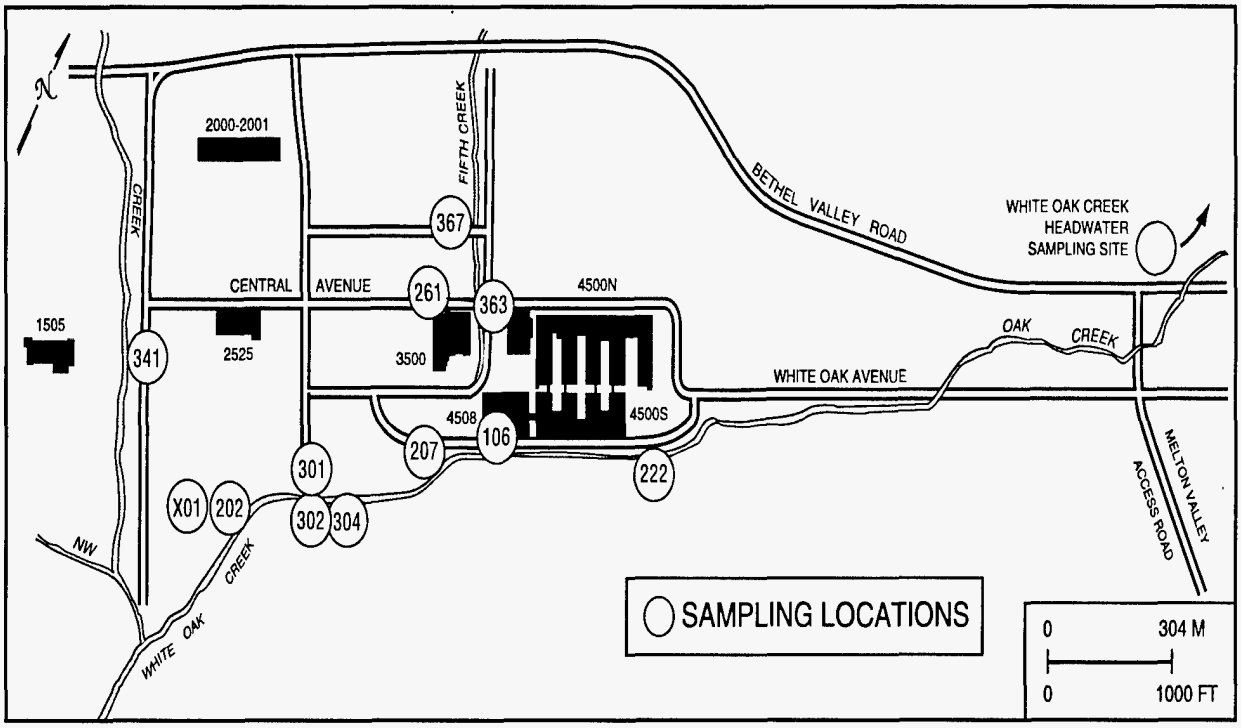

Fig. 4.26. ORNL sampling locations for mercury in water.

ORNL-DWG 92M-13531R2

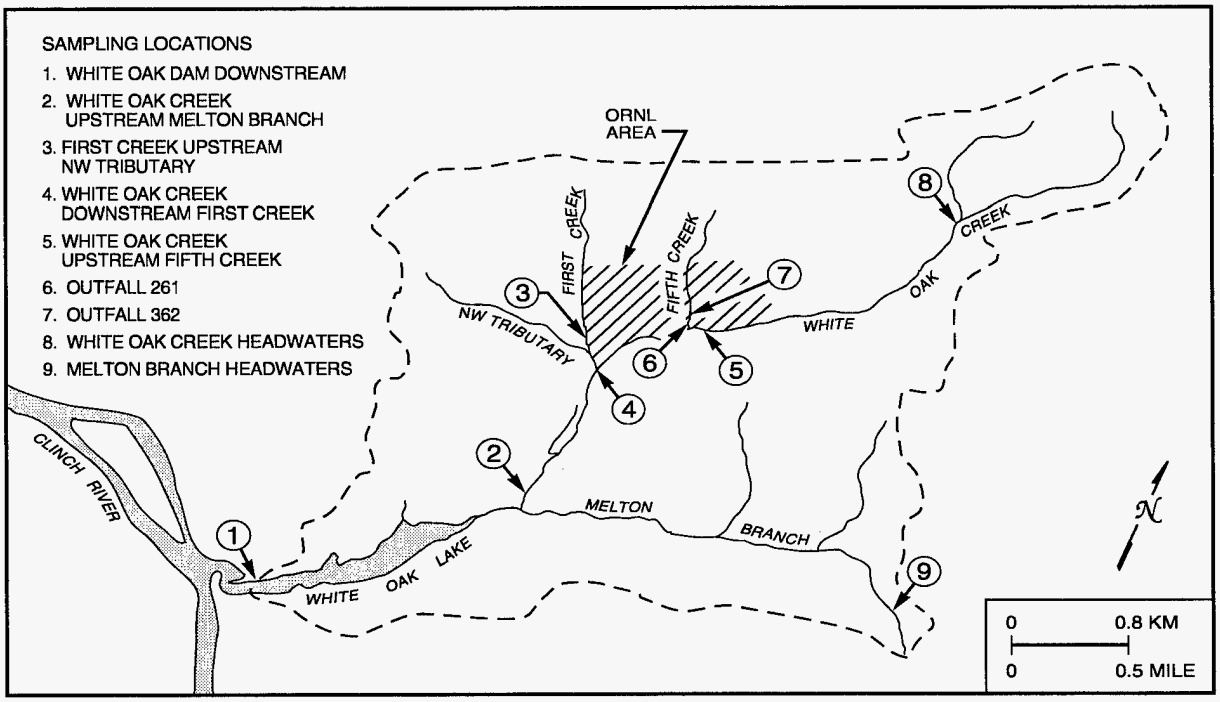

Fig. 4.27. ORNL sampling locations for mercury in sediment.

ORNL-DWG 92M-13529R2

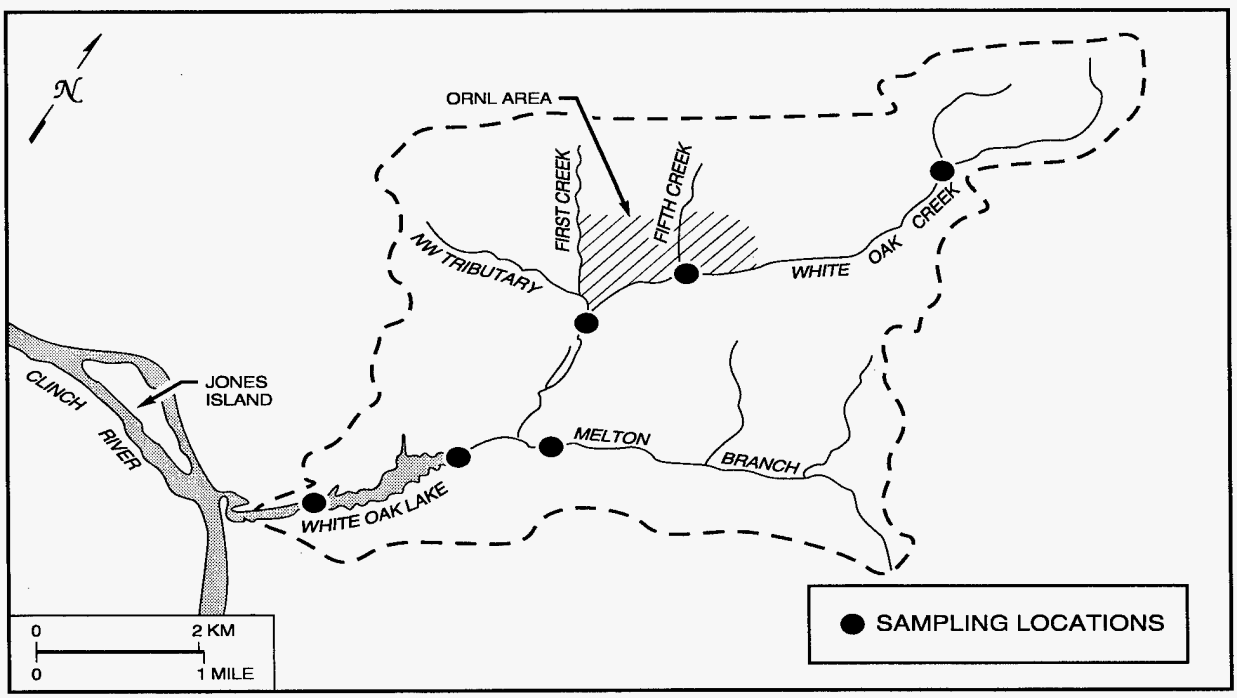

Fig. 4.28. ORNL sampling locations for polychlorinated biphenyls.

ORNL-DWG 92M-13530R

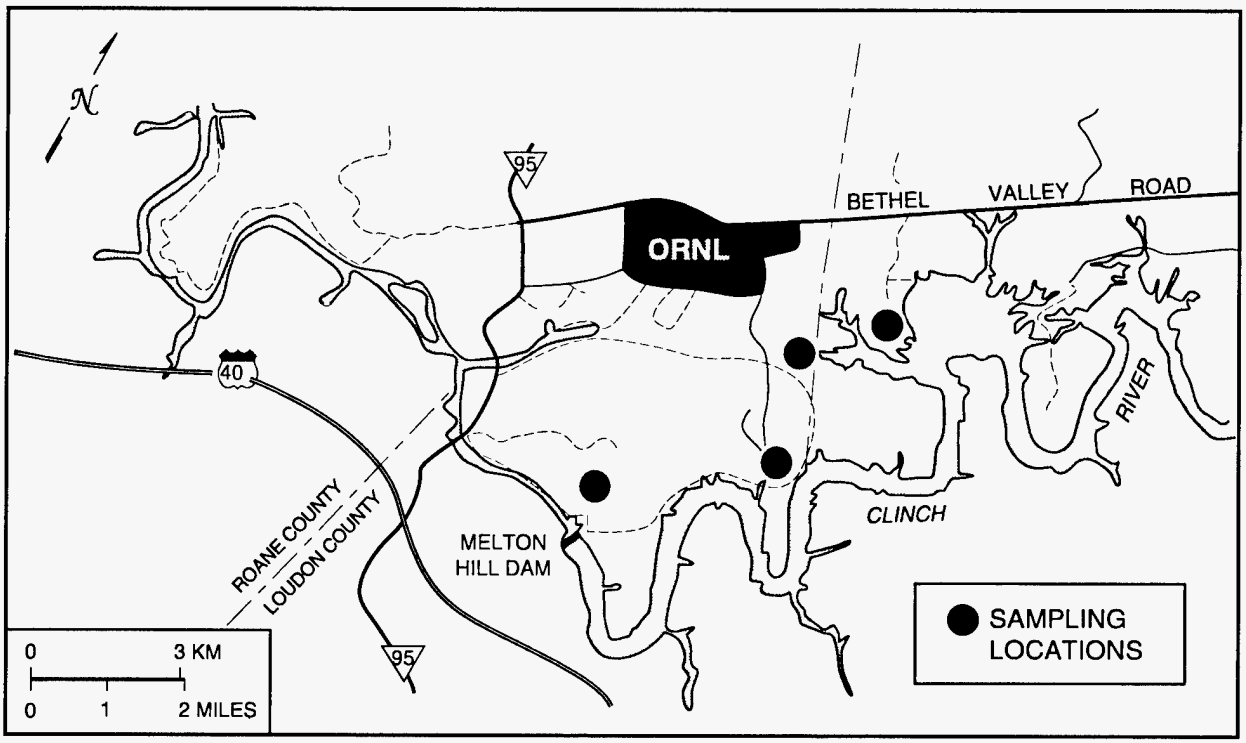

Fig. 4.29. Sampling locations for polychlorinated biphenyls in the greater ORNL area.

site on WOC, upstream of the weir at the 7500 Road Bridge. Results for most samples collected in 1996 were below analytical detection levels or were estimated by the laboratory 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 revision was issued effective June 1, 1995. The revision included the removal of inactive outfalls, the addition of effluent limits for new treatment technologies at CNF, the 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 four facility outfalls and 136 storm water outfalls. Compliance with the permit for the last five years is summarized by the major effluent locations in Fig. 4.30. Table 4.16 details the permit requirements and compliance records for all of the outfalls that discharged during 1996. The table provides a list of the discharge points, effluent analytes, permit limits, number of noncompliances, and the percentage of com-

ORNL-DWG 94M-8675R3

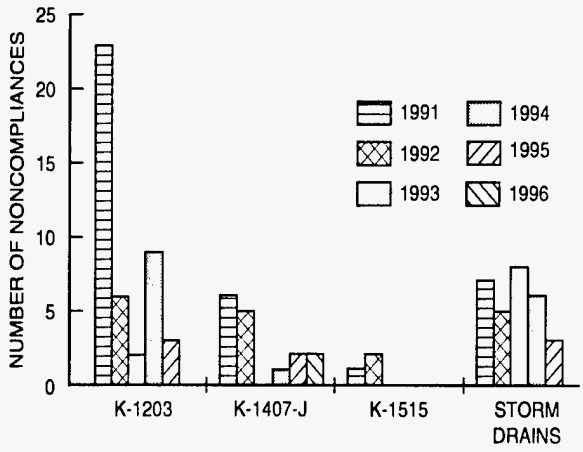

Fig. 4.30. ETTP NPDES compliance history by source of noncompliance.

Table 4.16. NPDES compliance at the ETTP, 1996

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	Ammonia nitrogen	5	7	12	17		100
(K-1203	Biochemical oxygen demand	15	20	37	49		100
Sewage	Chlorine, total residual	0.14	0.24				100
Treatment	Dissolved oxygen		5[b]				100
Facility)	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	Aluminum	1.0	2.0				100
(K-1515-C	Chlorine, total residual		1.0				100
Sanitary	Flow, Mgd	*d*	*d*				100
Water	pH, standard units		6.0–9.0				100
Plant)	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	1,1,1-Trichloroethane	*d*	*d*				100
(K-1407-J	Acetone	*d*	*d*				100
Central	Acetonitrile	*d*	*d*				100
Neutralization	Benzene	*d*	0.005				100
Facility to	Bromoform	*d*	*d*				100
Clinch River)	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 4.16 (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*	1	*f*
	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
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
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*	1	*f*
Category IV storm drains (to Poplar Creek)	Chlorine, total residual		0.14				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*		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.

pliance for 1996. Samples from these outfalls are collected and analyzed as specified in the NPDES permit.

The following are the four permitted major outfalls at the ETTP (Fig. 4.22):

- 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. Part I, Section E, of the permit required that CNF discharges through Outfall 011 cease and that CNF discharges through Outfall 014 be fully operational no later than April 30, 1996. This compliance schedule was completed in January 1996.

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 non-compliances during 1996.

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 1996.

The ETTP CNF, Outfall 014, has provisions for the 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.

In order 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. CNF had two NPDES noncompliances in 1996.

CNF experienced an exceedence of the NPDES permit limit for total petroleum hydrocarbons (TPH) in January 1996. The Outfall 014 permit limit for TPH was established as a technology-based limit contingent upon the upgrade of CNF to include organics waste treatment capabilities. This noncompliance occurred prior to the organic treatment system being brought on line. Since completion of the organics treatment upgrade, all TPH measurements have been below the NPDES permit limit.

In August 1996, CNF had an unpermitted discharge to the Clinch River. An improper alignment of the CNF valving configuration resulted in a bypass of the organics treatment system. Upon discovering the inappropriate valving configuration, the discharge was immediately halted. Organics samples taken of the wastewater treatment batch that was being discharged at that time revealed that all organic contaminants were below the NPDES permit limits. However, because the wastewater did not properly pass through the treatment system, the event was categorized as an unpermitted discharge. No adverse impacts to the receiving stream were observed as a result of this noncompliance. Automatic valving interlocks have been installed to prevent recurrence.

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, quar-

terly, 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 two ETTP NPDES noncompliances for 1996 occurred at storm water outfalls. These noncompliances occurred at Outfall 120 and Outfall 170.

In February 1996, a sewage bypass pump failed during a relining operation as part of the sanitary sewer upgrade project at the low point of the system, causing sewage to back up and overflow from a manhole. As a result, a small amount of raw sewage spilled onto a parking area and flowed into a nearby storm drain catch basin leading to Outfall 120. The bypass pump was immediately brought back on-line, and the sewage remaining in the parking area was cleaned up. A receiving stream inspection revealed no impacts.

In February 1996, there were discharges of sanitary sewage to Outfall 170 caused by damage to the sewage system that resulted from a freeze/thaw cycle related to extremely cold temperatures followed by warmer temperatures. Corrective actions were taken to protect storm drain catch basins, cease discharge of the sewage, and clean up residual wastes. Inspections of the receiving stream for outfall 170 revealed no impacts to the environment. Cold weather inspection checklists have been revised to include additional sanitary sewer checks.

The Storm Water Pollution Prevention (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 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 1995–1996 SWPP sampling effort, storm water outfalls at 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 ETTP, (2) knowledge of various processes and functions conducted at 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 outfalls 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.

Several outfalls were to be sampled at their discharge points and in critical points in their storm drainage piping networks. Network sampling locations were determined by using the sitewide storm drain camera survey that was conducted in FY 1994 and FY 1995. The storm drain network sampling was to be conducted during both wet and dry weather conditions in order to determine if groundwater infiltration contributed to the presence of pollutants in the storm water effluent from these locations.

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 ETTP, information obtained from the site-wide 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.

In addition, dry weather samples were taken from the outfalls that flow during the absence of rainfall. Dry weather samples were collected from outfalls that continued to flow at least 72 hours after the last qualifying rainfall event. Analysis of data collected during dry weather sampling of continuous flow storm water outfalls may (1) indicate contamination found in these drains, which can be attributed to groundwater infiltration into the storm drain system, (2) distinguish contaminants in storm water runoff from those found in groundwater that may be discharging through these storm drains, and (3) indicate the presence of sources of illicit or previously undetermined flows through the storm drain, such as chlorinated water from sanitary water line leaks and sanitary sewage from sewer line breaks.

As part of the FY 1996 SWPP sampling effort, semipermeable membrane devices (SPMDs) were utilized in locations upstream of the discharge point of selected storm drains associated with switchyards at ETTP. This was done in an effort to pinpoint specific sources of PCBs that might be entering the storm drain system. It is known from past sampling efforts and by process knowledge that the ETTP switchyards are possible sources of PCB-contaminated storm water discharges. The extent of the contamination of these discharges, the exact location of any significantly contaminated discharges, and the effectiveness of oil skimmers in the prevention of the discharge of PCBs to receiving waters were observed as part of this SPMD study.

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, page 39), a Biomonitoring Program that evaluates an EFPC in-stream monitoring location (Outfall 201), wastewater treatment system discharges, and four locations in the storm sewer system, are required. Table 4.17 is a summary of the results of biomonitoring tests conducted on effluent 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}s) during a 48-h 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 4.18 is a summary of the no-observed-effect concentrations (NOECs) and 96-h LC_{50}s for the in-stream monitoring location, Outfall 201. The NOEC is an NPDES-compliance limit and is the concentration of effluent which does not reduce survival, growth or reproduction of the biomonitoring test organisms. Thus, unlike the LC_{50}, the higher the value the less toxic an effluent.

Effluent from the Groundwater Treatment Facility was tested in January, April, July, and October, using *Ceriodaphnia dubia*. The effluent's 48-hour LC_{50}s were 64.0%, 48.2%, 42.4%, and 60.6%, respectively. The calculated IWCs (1.02%, 0.45%, 0.95%, and 0.15%, respectively) were below the LC_{50}s; therefore, it is unlikely that treated effluent from the Groundwater Treatment Facility adversely affected the aquatic biota in EFPC.

Table 4.17. Y-12 Plant Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 1996[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Groundwater Treatment Facility (Outfall 512)	1/11	*Ceriodaphnia*	64.0	1.02
9422-11 Storm Sewer	1/11	*Ceriodaphnia*	70.7	*d*
9422-12 Storm Sewer	1/11	*Ceriodaphnia*	70.7	*d*
9422-12 Storm Sewer (dechlorinated)	1/11	*Ceriodaphnia*	>100	*d*
9422-15 Storm Sewer	1/12	*Ceriodaphnia*	>100	*d*
9422-16 Storm Sewer	1/16	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (Outfall 501)	1/24	*Ceriodaphnia*	>100	0.10
9422-10 Storm Sewer	4/13	*Ceriodaphnia*	8.0	*d*
9422-10 Storm Sewer (dechlorinated)	4/13	*Ceriodaphnia*	66.9	*d*
9422-11 Storm Sewer	4/13	*Ceriodaphnia*	72.6	*d*
9422-12 Storm Sewer	4/16	*Ceriodaphnia*	70.7	*d*
9422-12 Storm Sewer (dechlorinated)	4/16	*Ceriodaphnia*	>100	*d*
Storm Sewer Drain E3305	4/16	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (Outfall 512)	4/17	*Ceriodaphnia*	48.2	0.45
Central Pollution Control Facility (Outfall 501)	6/7	*Ceriodaphnia*	>100	0.62
Storm Sewer Drain E3305	7/17	*Ceriodaphnia*	>100	*d*
9422-12 Storm Sewer	7/17	*Ceriodaphnia*	24.0	*d*
9422-12 Storm Sewer (dechlorinated)	7/17	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (Outfall 512)	7/18	*Ceriodaphnia*	42.4	0.95
9422-10 Storm Sewer	7/23	*Ceriodaphnia*	29.6	*d*
9422-10 Storm Sewer (dechlorinated)	7/23	*Ceriodaphnia*	40.9	*d*
9422-11 Storm Sewer	7/23	*Ceriodaphnia*	Invalid[e]	Invalid[e]
9422-11 Storm Sewer	7/30	*Ceriodaphnia*	66.6	*d*
West End Treatment Facility (Outfall 502)	8/15	*Ceriodaphnia*	11.2	0.23
West End Treatment Facility (Outfall 502)	10/2	*Ceriodaphnia*	39.4	0.16
Groundwater Treatment Facility (Outfall 512)	10/2	*Ceriodaphnia*	60.6	0.15
9422-12 Storm Sewer	10/2	*Ceriodaphnia*	64.8	*d*
9422-12 Storm Sewer (dechlorinated)	10/2	*Ceriodaphnia*	>100	*d*
9422-10 Storm Sewer	10/8	*Ceriodaphnia*	14.5	*d*
9422-10 Storm Sewer (dechlorinated)	10/8	*Ceriodaphnia*	51.4	*d*
9422-11 Storm Sewer	10/8	*Ceriodaphnia*	40.6	*d*
Storm Sewer Drain E3305	10/8	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (Outfall 501)	11/26	*Ceriodaphnia*	67.7	0.08
Central Mercury Treatment System (Outfall 551)	12/17	*Ceriodaphnia*	>100	0.14

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

[b]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 48 h.

[c]IWC = instream waste concentration. The calculated percentage of wastewater present when mixed with East Fork Poplar Creek. The IWC is based on actual flows at East Fork Poplar Creek, 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 July 30, 1996.

Table 4.18. Y-12 Plant Biomonitoring Program summary information for Outfall 201 for 1996[a]

Site	Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
Outfall 201	1/10	*Ceriodaphnia*	80	>100
		Fathead minnow	100	>100
Outfall 201	1/31	*Ceriodaphnia*	Terminated[d]	Terminated[d]
Outfall 201	2/14	*Ceriodaphnia*	80	>100
Outfall 201	4/12	*Ceriodaphnia*	100	>100
	4/13	Fathead minnow	100	>100
Outfall 201	7/17	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	10/2	*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 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.

[d]This test was terminated on February 2, 1996, because of inclement weather. More than 12 inches of ice and snow prevented sampling and toxicology laboratory personnel from continuing the test.

Effluent from the Central Pollution Control Facility was tested in January, June, and November, using *Ceriodaphnia*. In January and June, treated effluent from the Central Pollution Control Facility had 48-hour LC_{50}s of >100%. In November, the Central Pollution Control Facility effluent had a 48-hour LC_{50} of 67.7%. The calculated IWCs of Central Pollution Control Facility effluent were 0.10% in January, 0.62% in June, and 0.08% in November. 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 West End Treatment Facility was tested in August and October using *Ceriodaphnia*. The August 48-hour LC_{50} was 11.2% and the October 48-hour LC_{50} was 39.4%. The calculated IWCs (0.23% and 0.16%) were below the LC_{50}s; therefore, it is unlikely that treated effluent from the facility adversely affected the aquatic biota in EFPC.

Central Mercury Treatment System effluent was tested in December using *Ceriodaphnia*. The calculated IWC (0.14%) was less than the 48-hour LC_{50} (>100%); therefore, it is unlikely that treated effluent from the Central Mercury Treatment System adversely affected the aquatic biota in EFPC.

Toxicity testing of storm sewers was conducted at Buildings 9422-10, 9422-11, 9422-12, 9422-15, and 9422-16, which are monitoring locations in the storm system as part of the Surface Water Hydrologic Information Support System (SWHISS). Water from the storm sewer at Building 9422-10 was tested in April, July, and October using *Ceriodaphnia*. In April, water from the storm sewer at Building 9422-10 had a 48-hour LC_{50} of 8.0%. A portion of this water was treated by dechlorination before testing. The

48-hour LC_{50} of the dechlorinated water was 66.9%. In July, the 48-hour LC_{50} was 29.6%, and the 48-hour LC_{50} of dechlorinated water was 40.9%. In October, the 48-hour LC_{50} was 14.5%, and the 48-hour LC_{50} of dechlorinated water was 51.4%.

Storm sewer water from Building 9422-11 was tested in January, April, July, and October using *Ceriodaphnia*. The 48-hour LC_{50}s were 70.7%, 72.6%, 66.6%, and 40.6%, respectively. (A test of water at Building 9422-11, started on July 23, 1996, was invalid because of the unacceptable survival of control organisms. This location was retested on July 30, 1996.)

Storm sewer water at Building 9422-12 was tested in January, April, July, and October, using *Ceriodaphnia*. The 48-hour LC_{50} s were 70.7%, 70.7%, 24.0%, and 64.8%, respectively. The 48-hour LC_{50} s of dechlorinated storm sewer water were all >100%.

The storm sewer at Building 9422-16 was tested in January using *Ceriodaphnia*. The 48-hour LC_{50} was >100%. The storm sewer at Building 9422-15 was tested in January using *Ceriodaphnia*. The 48-hour LC_{50} was >100%.

The storm sewer at Drain E3305 (also known as 192N and 192S) was tested in April, July, and October. The 48-hour LC_{50} s were all >100% for *Ceriodaphnia*.

Water from the in-stream monitoring point, Outfall 201, was tested six times during 1996 using fathead minnow larvae and/or *Ceriodaphnia dubia*. On January 10, 1996, the NOEC was 80% for *Ceriodaphnia* and 100% for fathead minnows. The 96-hour LC_{50} was >100% for both *Ceriodaphnia* and fathead minnows. A confirmatory test started on January 31, 1996, was terminated on February 2, 1996, because of inclement weather. (More than 12 inches of ice and snow prevented sampling and toxicology laboratory personnel from continuing the test.) In February, the NOEC was 80% for *Ceriodaphnia*, and the 96-hour LC_{50} was >100%. For tests in 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 Toxicity Control and Monitoring Program

Under the TCMP, wastewaters from the STP, the CYRTF, and the NRWTF were evaluated for toxicity. In addition, two ambient in-stream sites were evaluated: one site is located on Melton Branch (NPDES permit point X13) and the other on White Oak Creek (permit point X14). The results of the toxicity tests of wastewaters from the three treatment facilities and the two ambient stream sites are given in Table 4.19. This table provides, for each wastewater and ambient water, the month the test was conducted, sample treatment (if any), the wastewater's NOEC for fathead minnows and *Ceriodaphnia*, and the IWC, if appropriate. The NOEC is the concentration that did not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 4.20.

During 1996, the CYRTF and the NRWTF were tested three times each, and the STP was tested nine times. The CYRTF wastewater's NOECs were 100% for fathead minnows and 25% and 12% for *Ceriodaphnia*. The corresponding wastewater's IWCs were 2.4% and 2.7%. Because the IWC was consistently lower than the NOEC, it is unlikely that wastewater from the CYRTF adversely affected the aquatic biota of WOC during 1996. Full-strength wastewater from the NRWTF was not toxic to *Ceriodaphnia* during April and October. A toxicity test conducted in October on samples split with TDEC resulted in no toxicity to fathead minnows. The NRWTF wastewater's NOECs were all 100%; therefore, no IWCs were calculated during 1996.

The STP wastewater's NOECs for *Ceriodaphnia* ranged from < 6% to 100% during 1996. The NOEC for the STP was <6% in July, September, and October; 25% in January and July; 50% in November; and 100% in March and May. Per guidelines in the NPDES permit, no fathead minnow tests were conducted for the STP.

Table 4.19. 1996 toxicity test results of ORNL wastewaters and ambient waters

Outfall	Test date	Treatment[a]	Fathead minnow NOEC[b] (%)	*Ceriodaphnia* NOEC[b] (%)	IWC[c] (%)
Coal Yard Runoff Treatment Facility (X02)	May	N	*d*	25	2.4
	Jun[e]	N	100	*f*	*g*
	Nov	N	100	12	2.7
Sewage Treatment Plant (X01)	Jan	N	*f*	25	21.5
	Mar	N	*f*	100	*g*
	May	N	*f*	100	*g*
	July	N	*f*	25	19.5
	Aug	N	*f*	<6	*g*
	Sep[e]	N	*f*	*e*	16.4
	Sep[d]	N	*f*	<6	*g*
	Oct[d]	N	*f*	<6	17.6
	Nov[d]	N	*f*	50	17.8
Nonradiological Wastewater Treatment Facility (X12)	Apr	N	*f*	100	*g*
	Oct	N	*f*	100	*g*
	Oct[h]	N	100	*f*	*g*
Melton Branch (X13)	Jan[d]	N	<80	*f*	
		UV	100	*f*	
	Feb	N	100	100	
		UV	100	*f*	
	Apr	N	100	100	
		UV	100	*f*	
	Jun	N	80	100	
		UV	100	*f*	
	Jun[d]	N	100	*f*	
		UV	100	*f*	
	Aug	N	100	100	
		UV	100	*f*	
	Oct	N	100	100	
		UV	100	*f*	
	Dec	N	100	<80	
		UV	100	*f*	
	Dec[d]	N	*f*	80	
		UV	*f*	*f*	

Table 4.19 (continued)

Outfall	Test date	Treatment[a]	Fathead minnow NOEC[b] (%)	*Ceriodaphnia* NOEC[b] (%)	IWC[c] (%)
White Oak Creek (X14)	Jan[e]	N	<80	*f*	
		UV	100	*f*	
	Feb	N	100	100	
		UV	100	*f*	
	Apr	N	100	100	
		UV	100	*f*	
	Jun	N	80	100	
		UV	100	*f*	
	Jun[e]	N	100	*f*	
		UV	100	*f*	
	Aug	N	100	100	
		UV	100	*f*	
	Oct	N	100	100	
		UV	100	*f*	
	Dec	N	100	100	
		UV	100	*f*	

[a]N = no sample pretreatment; UV = ultraviolet light pretreatment.
[b]No-observed-effect concentration.
[c]Mean in-stream waste concentration (based on critical low flow of White Oak Creek).
[d]Invalid test.
[e]Confirmatory test.
[f]Not tested.
[g]Not calculated.
[h]Split-sample test; tested concurrently with TDEC.

A Toxicity Control Plan developed and implemented for the STP in 1995 was continued through 1996, with toxicity testing for this facility conducted every other month.

During 1996, the Melton Branch (X13) site was tested nine times, and the WOC (X14) site was tested eight times. Water from X13 and X14 reduced fathead minnow survival on two occasions (January and June). Follow-up confirmatory tests conducted in June showed the water from X13 and X14 to be nontoxic to fathead minnows; thus the toxicity appeared to be transient. To determine whether fathead minnow mortality in the ambient water samples might be caused by a fungal or bacterial pathogen, water from X13 and X14 was exposed to ultraviolet (UV) light for a 20-minute period. Tests of water from sites X13 and X14 showed improved fathead minnow survival in water treated with UV light (NOECs were 100%). Water from X13 reduced *Ceriodaphnia* reproduction in December. A confirmatory test conducted in December again reduced *Ceriodaphnia* reproduction. Water from X14 was not toxic to *Ceriodaphnia*.

4.3.3 ETTP Toxicity Control and Monitoring Program

The NPDES permit requires that toxicity testing be performed at Outfall 005. Accordingly, toxicity testing was conducted at Outfall 005 bimonthly until 1995, when the outfall was placed on a biannual sampling schedule.

The results of the toxicity tests of wastewaters conducted during 1996 are given in Table 4.21. This table provides the wastewater's no-observed-effect level (NOEL) and 96-hour LC_{50} for fathead minnows and *Ceriodaphnia* for

Table 4.20. 1996 average water quality parameters measured during toxicity tests of ORNL wastewaters and ambient waters.

Values are for full-strength wastewater for each test (N = 1 or 7) or averages of full-strength ambient water for each test (N = 7)

Outfall	Test date	pH[a]	Conductivity[b]	Alkalinity[c]	Hardness[c]
Coal Yard Runnoff Treatment Facility (X02)	May	7.55	4080	20	1760
	June	7.38	3340	19	1980
	Nov	7.39	3690	28	722
Sewage Treatment Plant (X01)	Jan	7.67	494	92	164
	Mar	7.84	438	88	152
	May	8.05	416	93	145
	Jul	7.92	392	78	141
	Aug	7.88	384	89	140
	Sep	7.97	402	95	145
	Sep	7.96	406	94	152
	Oct	7.95	417	100	152
	Nov	7.98	421	100	159
Nonradiological Wastewater Treatment Facility (X12)	Apr	8.05	435	85	91
	Oct	7.96	511	91	82
	Oct	8.03	431	94	100
Melton Branch (X13)	Jan	7.67	281	72	124
	Feb	8.02	361	91	161
	Apr	8.02	366	101	171
	Jun	8.16	371	149	180
	Jun	8.18	459	157	223
	Aug	7.91	745	100	351
	Oct	8.07	479	183	229
	Dec	8.01	299	126	145
	Dec	7.77	256	83	123
White Oak Creek (X14)	Jan	7.89	284	98	121
	Feb	8.16	332	105	140
	Apr	8.11	320	109	136
	Jun	8.14	278	114	129
	Jun	8.15	339	127	141
	Aug	8.04	394	119	159
	Oct	8.04	379	127	145
	Dec	8.04	320	122	138

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

Table 4.21. 1996 ETTP NPDES Permit Number TN 0002950 toxicity tests results

ETTP Outfall	Test date	Species	NOEL[a] (%)	LC_{50}[b] (%)	IWC[c] (%)
K-1203 (Outfall 005)	January	Fathead minnow	100	>100	2.91
		Ceriodaphnia	100	>100	2.91
	July	Fathead minnow	100	>100	1.99
		Ceriodaphnia	100	>100	1.99

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

each test. Average water quality measures obtained during each toxicity test are shown in Table 4.22.

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 NOELs were 100% and the LC_{50}s were >100%.

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 1986 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 in the UEFPC watershed— flow management and a partial bypass of Lake Reality—were initiated during 1996. Flow management, which began in the summer of 1996 and reached full implementation in the fall, could have influenced some BMAP results in 1996 but is expected to exert its full influence during 1997. Testing for the bypass of Lake Reality did not begin until mid-December 1996, so this change almost certainly did not affect any of the BMAP tasks during the year.

4.4.1.1 Toxicity monitoring

Toxicity monitoring uses EPA-approved methods with *Ceriodaphnia dubia* (an invertebrate "water flea") and fathead minnow (fish) larvae to assess the toxicity of stream water to aquatic life. Toxicity monitoring is 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) are tested quarterly. No evidence for toxicity was found during tests conducted in 1996.

4.4.1.2 Bioaccumulation studies

Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are

Table 4.22. 1996 ETTP average water quality parameters measured during toxicity tests of ETTP wastewaters
Values are averages of full-strength wastewater for each test (N = 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	7.97	465	102	162
	July	8.00	374	69	148

associated with discharges from the Y-12 Plant. Redbreast sunfish (*Lepomis auritus*) are collected twice annually from seven sites along the length of EFPC to evaluate spatial and temporal trends in mercury and PCB contamination. The forage fish species (stoneroller, *Campostoma anomalum*) is collected once annually to evaluate PCB contamination in the food of fish-eating wildlife.

In spring 1996, the mean mercury concentrations in fish sampled from EFPC ranged from five to fifteen 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 continue to be an important source of mercury in fish in the upper reaches of EFPC. There was some indication that mercury concentrations may be decreasing in fish from sites downstream of Lake Reality compared with those of previous years.

PCB concentrations in sunfish sampled from EFPC during 1996 fell within ranges typical of past monitoring efforts at these sites. Mean PCB concentrations were highest in Lake Reality and the reaches of EFPC above Lake Reality, and decreased downstream of Lake Reality. Stonerollers contained much higher concentrations of PCBs than sunfish, with the greatest average concentration (12 mg/kg) at EFK 23.4, immediately downstream from the Lake Reality discharge. A sharp decrease occurred between that site and EFK 18.2. These data suggest that the use of PCB concentrations in sunfish fillets to directly estimate ecological risk to fish-eating wildlife in the EFPC floodplain could result in underestimating actual risk by several fold.

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) has identified kingfishers as being highly at risk on all ORR streams. In 1996, BMAP researchers began to study kingfishers in the EFPC floodplain. No nest sites were identified during 1996, but preparations are under way for further investigations during the 1997 nesting season.

Another special study under the bioaccumulation task of the Y-12 Plant BMAP involves the deployment in EFPC of a number of SPMDs. SPMDs are passive sampling devices that provide a time-integrated measurement of dissolved (bioavailable) PCB concentrations. The goal of this work is to determine the significance of releases from the Y-12 Plant to the overall flux of PCBs in local surface waters and to the total budget of PCB releases from DOE facilities in Oak Ridge. Highest concentrations of PCBs were observed in the reaches of EFPC within the Y-12 Plant, ranging from approximately 26–32 ng/L. Concentrations decreased to 5 ng/L PCBs at Turtle Park (near EFK 13.8), but then increased to almost 9 ng/L farther downstream, possibly reflecting additional downstream sources of contamination.

4.4.1.4 Biological indicator studies

The bioindicator 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. The health of individual sunfish in EFPC upstream of Bear Creek continues to differ signifi-

cantly from fish at reference sites. Female sunfish collected during 1996 from these upper reaches were more emaciated than fish from downstream sites in EFPC or from reference sites, and continued to exhibit characteristically high incidences of oocyte atresia (death of immature eggs). Water sampled throughout the length of EFPC during 1996 remained toxic to developing fish embryos in the medaka test. Preliminary tests suggest that medaka embryos are very sensitive to mercury contamination, offering one potential explanation for the observed toxicity.

4.4.1.5 Ecological surveys and fish kill results

Periphyton monitoring in EFPC occurs four times a year. Algal biomass and photosynthetic rates were generally within the range of measurements made over the past eight years, but areal-specific photosynthetic rates and chlorophyll-specific photosynthetic rates were somewhat lower than previous years. Nutrient concentrations in EFPC were found to be 1 to 2 orders of magnitude higher during 1996 than in reference streams (such as BFK 7.6), and both nitrogen and phosphorus were likely to be growth-saturating for periphyton in EFPC. Ammonia levels were elevated at EFK 24.4 (0.3 mg/L), suggesting continuing influence from the legacy area source near Outfall 017.

Overall, periphyton biomass and photosynthesis in 1996 were roughly similar to that measured previously. However, photosynthesis and chlorophyll-specific photosynthesis at EFK 24.4 were lower in fall than in spring, suggesting that photosynthesis in the upper reaches of EFPC may have been diminished by flow management activities. If this trend continues, then growth and reproduction of the current major fish species in upper EFPC could eventually be adversely affected by flow management activities.

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 fish communities in EFPC continued during 1996. Two sensitive species, the northern hog sucker and the snubnose darter, were observed at EFK 23.4, and the redline darter persisted at EFK 13.8. Further improvement in species diversity at sites downstream of Lake Reality is expected in association with decreases in stream temperatures accompanying the flow management activities in upper EFPC. The new temperature regime in upper EFPC now approximates 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 current siphon bypass arrangement used to shunt water around the lake.

Fish kill investigations are conducted in response to chemical spills, unplanned water releases, or when dead fish are observed in EFPC. The basic procedure for fish kill investigations is a survey of upper EFPC (above Bear Creek Road to the N/S 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. No fish kills were observed in EFPC during the period of January to March, 1996. From March through May, a total of 299 dead fish were recorded, of which 275 were stonerollers and 64% were in spawning condition. Thereafter, the average dead per survey decreased to less than 1 fish, a value similar to background mortality levels.

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 1996. However, subtle but persistent increases in total richness and the richness of pollution tolerant taxa at these sites indicate some improvement in water quality. The benthic macroinvertebrate community at sites further downstream (i.e., EFK 13.8) appear only minimally impacted relative to reference conditions.

4.4.2 Oak Ridge National Laboratory BMAP

4.4.2.1 Toxicity monitoring

Toxicity monitoring involves the use of EPA-approved methods with *Ceriodaphnia dubia* and fathead minnow larvae to assess the toxicity of stream water to aquatic life. Toxicity monitoring was conducted three times in 1996 at three sites in the WOC watershed [Fifth Creek, First Creek and WOC (WCK 3.4)]. No evidence for toxicity was found during tests conducted in 1996.

4.4.2.2 Bioaccumulation studies

Monitoring of mercury contamination in sunfish and largemouth bass continued in 1996. Redbreast sunfish were collected in the spring of 1996 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 and decreased with distance downstream. The present level of mercury contamination in WOC sunfish is approximately three times higher than concentrations observed in fish from reference streams or reservoirs in east Tennessee. Mercury concentrations in largemouth bass appear to have stabilized since much higher concentrations were observed during the 1991–93 time period; mercury concentrations in bass from the 1994–96 period are about half the levels observed from the 1991–93 period.

In 1996, 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. 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.

Forage fish collected from WCK 3.9 and WCK 2.9 in 1996 were also analyzed for a suite of metals and PCBs. Cadmium, copper, mercury, selenium, zinc, and PCBs in forage fish from WOC proper were clearly elevated in comparison with fish from the reference site. Differences between WOC sites and the reference stream ranged from approximately a factor of two to three (for cadmium, copper, selenium, and zinc) to greater than two orders of magnitude for PCBs. High concentrations of PCBs in forage fish at WCK 3.9 near the main ORNL complex, with lower levels in fish collected 1 km downstream, are consistent with the presence of continuing PCB inputs upstream of WCK 3.9.

4.4.2.3 Ecological surveys

Periphyton monitoring in WOC was conducted three times in 1996 at two sites located upstream of ORNL discharges to WOC (WCK 6.8 and WCK 5.1) and three sites located downstream of ORNL discharges (WCK 3.9, WCK 3.4, and WCK 2.3). Algal biomass and photosynthetic rates were generally within the range of measurements made since 1992, indicating little change in conditions. Algal biomass and chlorophyll-specific photosynthetic rates tend to be higher downstream of ORNL discharges than upstream. Samples for nutrient analyses were taken in April 1996. Nitrate and soluble reactive phosphorus increased steadily with distance downstream in WOC. High nutrient concentrations contribute to high photosynthetic rates in WOC and are at least partly responsible for the herbivore- (stoneroller-) dominated fish assemblages in unshaded portions of the stream.

Quantitative samples at established biomonitoring sites in the WOC watershed in the spring and fall of 1996 were collected under the fish community task. Total density and biomass values for the fall were similar to those for previous years with the exception of the site located downstream on First Creek. Total density and biomass values at this site were at the lowest levels in fall 1996 since sampling began in 1985. Total density and biomass at WCK 3.9 continues to decline from the peak values in fall 1992 following the start-up of the NRWTF in March 1990. This decline may be part of the normal fluctuations that will occur in fish populations when new habitat is opened for occupation. In the fall sampling, two fish species were collected at two separate sites

for the first time. The redbreast sunfish was collected for the first time in lower First Creek (FCK 0.1), and the spotted bass (*Micropterus punctulatus*) was collected for the first time at WCK 3.9.

The benthic macroinvertebrate communities were sampled at nine sites in the WOC watershed during the spring and fall of 1996. Results of the April sampling periods through 1995 continued to show that ORNL operations are having adverse ecological effects on First Creek, Fifth Creek, Melton Branch, and WOC. The most severely affected site continued to be WCK 3.9, where pollution-intolerant species are rare. Total richness (i.e., the mean number of different kinds of taxa per sample) increased substantially at WCK 3.9 after 1989 and then stabilized. Conditions further downstream at WCK 2.3 appear unchanged since 1986. The macroinvertebrate community of lower Fifth Creek (FFK 0.2) exhibited strong evidence of gradual improvement through 1993 and then appears to have stabilized through 1995. A reduction in total richness may indicate that FFK 0.2 experienced an additional perturbation after the 1993 sampling; results of the spring 1996 samples will be used to determine whether a persistent decline has occurred in ecological conditions or if the decline is a result of natural temporal variability.

4.4.3 East Tennessee Technology Park 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 one of six tests. Full-strength effluent from SD190 reduced *Ceriodaphnia* survival or reproduction in five of six tests. Effluent from SD180 was evaluated for toxicity three times in 1996; 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 1996, caged clams were used to evaluate potential PCB sources to ETTP waters, and in November, resident fish were collected from Mitchell Branch, the K-1007-P1 pond, and the K901-A pond to evaluate the potential human-health risks associated with fish ingestion. 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 (11.16 μg/g). The average PCB concentration in clams placed for four weeks at the K901-A outlet (0.30 μg/g) was approximately two 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 (1.3 and 1.4 μg/g, respectively). The mean PCB concentrations (μg/g wet wt., mean ± S.E.) in resident sport fish were as follows: 1.63 ± 0.48 in redbreast sunfish from Mitchell Branch, 26.19 ± 5.59 in largemouth bass from the K-1007-P1 pond, and 0.64 ± 0.12 in largemouth bass from the K-901-A pond (n = 4 fish/site). Considered together, the clam and fish studies in 1996 indicate that Mitchell Branch and the K-1007-P1 pond are the major ETTP sources of PCBs to downstream waters and would provide the greatest potential risk (if these sites were accessible to the public) to human consumers.

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. In 1996, Canada geese were "whole-body counted" for gamma radiation and averaged 0.08 pCi/g, a level comparable with that of geese collected at other sites in the area. Since 1993, more than 300 geese captured on or near the ORR have undergone such "whole body counts." Only five of these geese (< 2%) had gross gamma activity ≥ 0.5pCi/g. Three of these, however, occurred in 1996, and all five were captured at ORNL. ORR Canada goose observations continued to decline in 1996 (down 27% from 1995), while non-goose waterfowl observations increased 46% during the same period.

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 Ephemeroptera, Plecoptera, and Trichoptera (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, indicating that no further detectable improvements have occurred.

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 has generally increased at MIK 0.71 as represented in both spring and fall samples from 1991 through spring 1996. A total of ten fish species has been collected at MIK 0.71. In contrast, total estimated fish density has shown an overall decline at MIK 0.45 from fall 1991 through spring 1996. A total of seven fish species has been collected at MIK 0.45; however, the fish population at MIK 0.45 consists of relatively stable populations of only two species, blacknose dace and creek chub. Compared with the reference stream, Mitchell Branch is lacking stable populations of several fish species.

4.4.6 BMAP Trends on the ORR

Several tasks were common to each of the three ORR BMAPs during 1996, and these provide some basis for examining trends in environmental quality for the ORR. The receiving streams for discharges from each facility were consistently nontoxic in standardized fish- and invertebrate-based laboratory tests conducted during 1996, although water from EFPC (the only receiving stream tested by this procedure) continued to be toxic to fish embryos in the medaka embryo test. Mercury and PCBs remained elevated in fish downstream of each facility, but there was some indication of mercury decreases in fish downstream of Lake Reality on EFPC. 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 1996 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

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Abstract

Annual environmental surveillance is a major activity on the ORR. Environmental surveillance consists of the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from the reservation and its surroundings. External radiation is also measured. Samples are analyzed for chemical content and for the presence of radioisotopes. 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 (if any) on the local population and the environment.

5.1 ANTICIPATED ENVIRONMENTAL SURVEILLANCE PROGRAM CHANGES

As noted in Chap. 2, the EMP is in the midst of significant revision. The revisions will be implemented in 1997. Consequently, many of the programs described in the following sections will change, and information reported in the 1997 *Oak Ridge Reservation Annual Site Environmental Report for 1997* (ASER) will differ from this year's report.

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 32.8 ft 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

ORNL-DWG 87M-7052R5

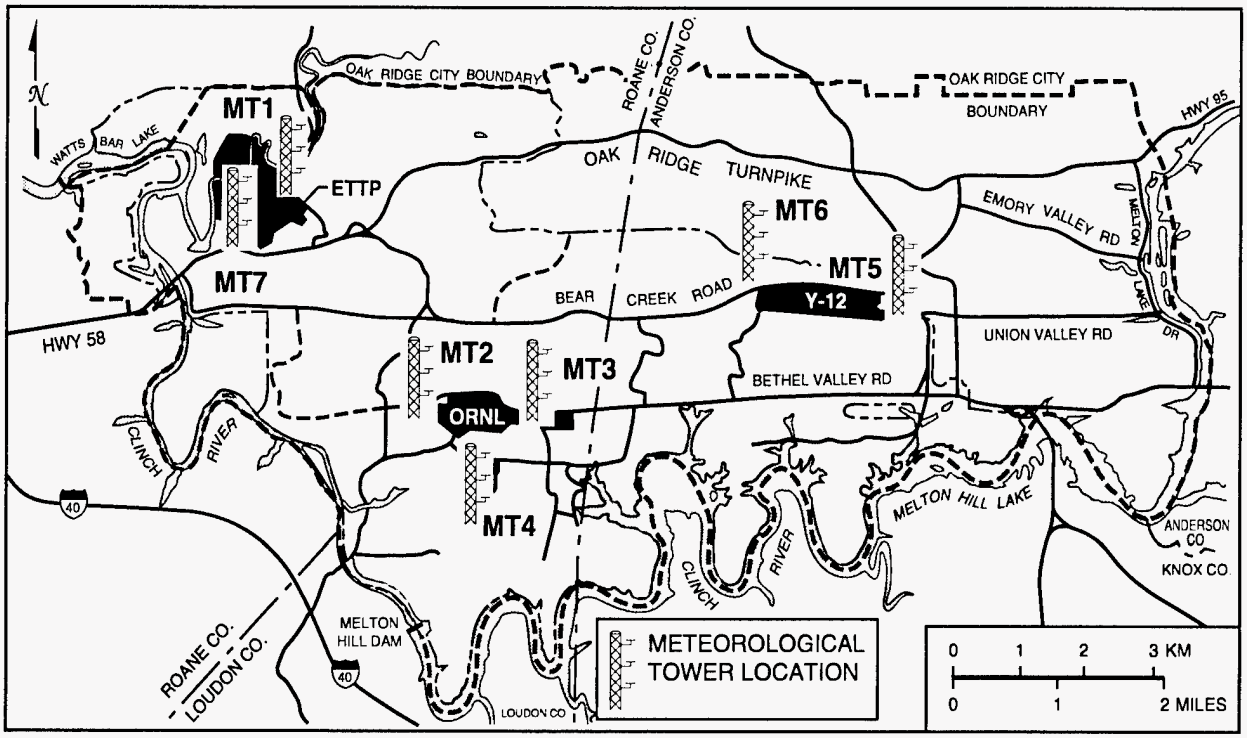

Fig. 5.1. The ORR meteorological monitoring network.

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 97.6% in 1996. The maximum data recovery was 99.7% at Y-12 MT5 at 100 m, and the minimum was 88.7% at ETTP MT1 at 60 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 presents the following data for individual stations: number of data values collected, maximum value, minimum value, average value, and standard error of the mean. The median value for the ORR in 1996 was 7.7μR/hour, while the median value for cities in the United States during 1989 was 9.3 μR/hour (EPA 1990). Any contribution to the external gamma signature by the DOE facilities is not distinguishable at the ORR perimeter air monitoring station (PAM) locations.

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 remote locations. The ORR PAM network includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 5.3); the remote air monitoring (RAM) network that provides reference information consists of stations 51 (Norris Dam) and 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 1996 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides and tritium.

Atmospheric dispersion modeling was used to select appropriate sampler locations. The locations selected are those most likely to be affected

ORNL-DWG 93M-10027R2

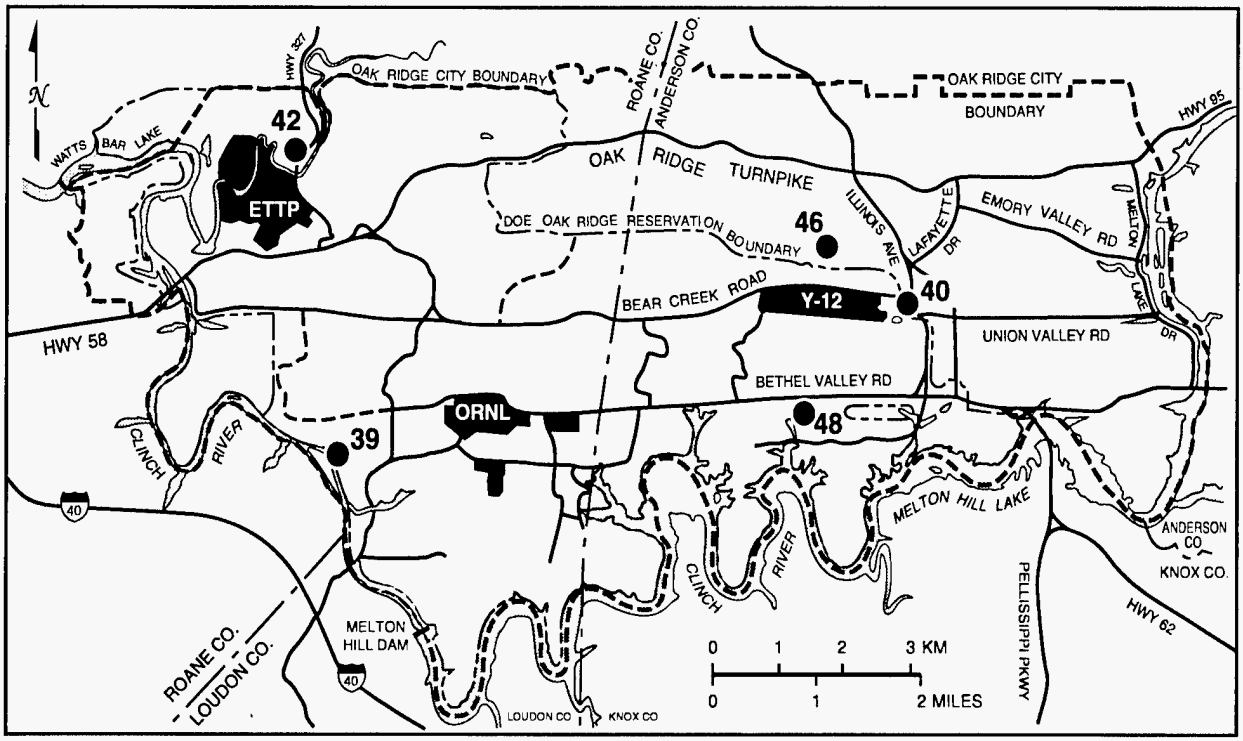

Fig. 5.2. External gamma radiation monitoring locations on the ORR. Location 51, at Norris Dam, 26 miles northeast of ORNL, is not shown on this map.

Table 5.1. External gamma averages, 1996

Location	Number of data values collected	Measurement (μR/hour)[a]			Standard error of mean
		Min	Max	Mean	
39	50	6.1	10.4	8.4	0.74
40	52	2.8	14.5	7.5	1.49
42	53	0.1	8.4	6.3	1.92
46	52	0.1	13.6	7.9	1.94
48	52	0.1	20.1	7.2	2.30
51	51	2.3	34.4	8.5	4.56

[a]To convert microroentgens per hour to milliroentgens per year, multiply by 8.760.

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, two additional stations are located at sites not affected by releases from the ORR.

The sampling system consists of two separate instruments. The particulates are captured using a high-volume air sampler on glass fiber filters. The filters are collected weekly, composited every

ORNL-DWG 92M-5318R2

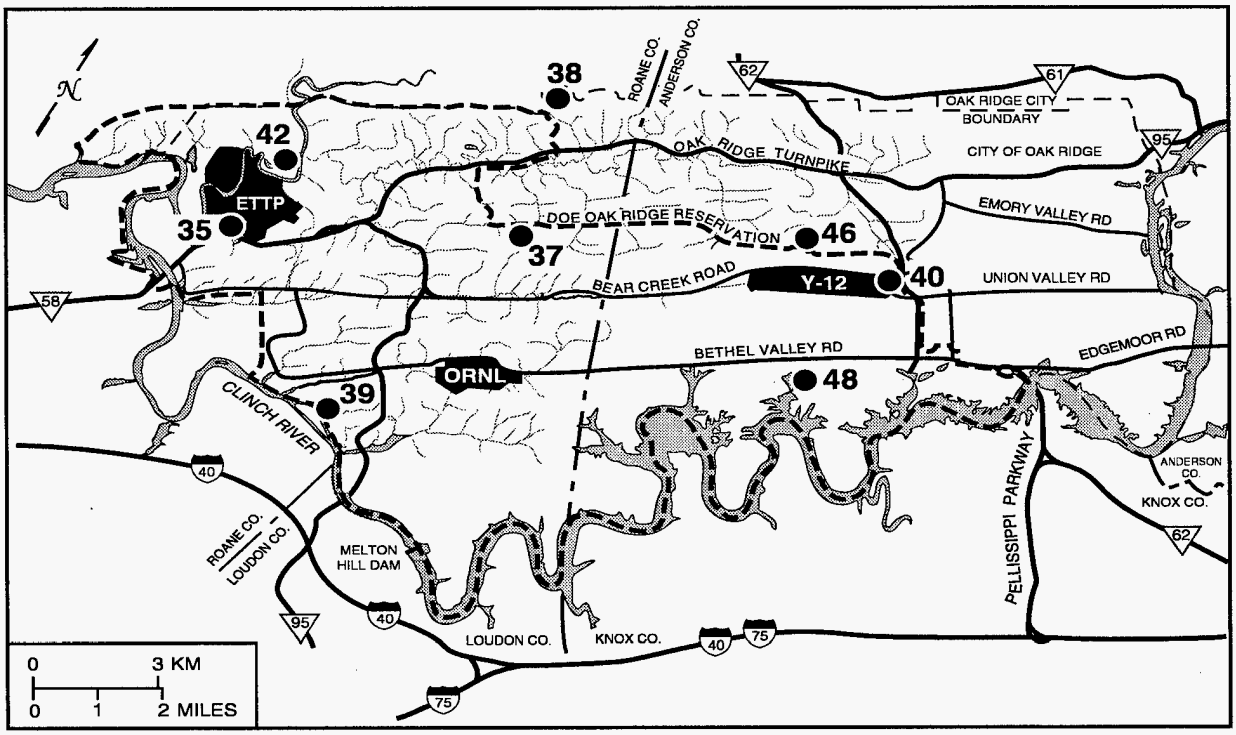

Fig. 5.3. Location of ORR perimeter air monitoring stations.

filters are collected weekly, composited every 4 weeks, 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, composited monthly, then submitted to the laboratory for tritium analysis.

The ORR 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 RAM stations provide information on reference concentrations of radionuclides and gross parameters for the region. A comparison of ORR PAM station sampling data with those from the RAM stations shows that ORR operations do not significantly affect local air quality (Tables 5.2 and 5.3).

Table 5.4 represents the average concentration of three isotopes of uranium at each station for sampling years 1993, 1994, 1995, and 1996.

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 the DOE and TDEC in reviewing the ambient air program for applicability and useful-

Table 5.2. ORR environmental surveillance multimedia by station[a,b]

Media	^{7}Be	^{60}Co	^{137}Cs	^{40}K	^{3}H	^{234}U	^{235}U	^{238}U	Gross alpha	Gross beta
					Station 35					
Air filter	1.6E–13	1.1E–16	1.6E–16	*c*	1.0E–11	2.2E–17	1.3E–18	3.4E–17	2.8E–15	6.3E–15
Tomatoes	*c*	8.1E–03	*c*	3.0E+00	*c*	*c*	*c*	*c*	*c*	1.7E+00
Lettuce	*d*	*d*	*d*	3.2E+00	*c*	*c*	*c*	6.8E–07	*d*	1.7E+00
Turnips	*d*	*d*	*d*	2.4E+00	*c*	*c*	*c*	*c*	*d*	1.6E+00
Soil	*c*	*d*	*d*	1.4E+01	*c*	5.4E–01	*d*	5.4E–01	1.8E+00	*d*
					Station 37					
Air filter	1.6E–13	8.3E–17	1.3E–16	*c*	9.3E–12	2.0E–17	7.2E–19	2.1E–17	2.8E–15	5.7E–15
Tomatoes	*d*	*d*	*d*	2.2E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
Lettuce	*d*	*d*	*d*	3.4E+00	*c*	5.1E–07	*c*	4.9E–07	*d*	1.8E+00
Turnips	*d*	*d*	*d*	2.6E+00	*c*	*c*	*c*	*c*	*d*	2.2E+00
Soil	*c*	*d*	*d*	1.7E+01	*c*	5.3E–01	*d*	8.5E–01	3.0E+00	*d*
					Station 38					
Air filter	1.5E–13	2.3E–17	4.1E–17	*c*	3.7E–12	1.6E–17	9.2E–19	2.0E–17	2.4E–15	5.5E–15
Tomatoes	*d*	*d*	*d*	3.2E+00	*c*	*c*	*c*	*c*	*d*	2.1E+00
Lettuce	*d*	*d*	*d*	2.8E+00	*c*	9.7E–07	6.5E–07	1.3E–06	5.1E–02	1.6E+00
Turnips	*d*	*d*	2.0E–03	2.3E+00	*c*	*c*	*c*	*c*	*d*	2.0E+00
Soil	*c*	*d*	*d*	1.8E+01	*c*	*d*	*d*	*d*	2.6E+00	*d*
					Station 39					
Air filter	1.2E–13	3.3E–17	4.6E–17	*c*	7.5E–12	1.4E–17	6.2E–19	1.2E–17	2.2E–15	4.2E–15
Tomatoes	*d*	*d*	*d*	3.8E+00	*c*	*c*	*c*	*c*	*d*	1.9E+00
Lettuce	*d*	*d*	*d*	3.4E+00	*c*	*c*	*c*	1.1E–06	*d*	1.9E+00
Turnips	*d*	4.1E–03	*d*	3.1E+00	*c*	*c*	*c*	*c*	*d*	2.5E+00
Soil	*c*	*d*	*d*	1.7E+01	*c*	3.5E–01	*d*	3.7E–01	2.3E+00	*d*
					Station 40					
Air filter	1.6E–13	9.1E–17	5.2E–17	*c*	9.2E–12	4.6E–17	1.8E–18	1.7E–17	2.8E–15	5.7E–15
Tomatoes	*d*	*d*	*d*	2.7E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
Lettuce	*d*	6.5E–03	3.8E–03	3.3E+00	*c*	7.3E–07	*c*	7.0E–07	4.6E–02	2.1E+00
Turnips[c]	*d*	*d*	*d*	2.1E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
Soil	*c*	*d*	*d*	1.9E+01	*c*	*d*	*d*	1.1E+00	2.5E+00	*d*

Table 5.2 (continued)

Media	^{7}Be	^{60}Co	^{137}Cs	^{40}K	^{3}H	^{234}U	^{235}U	^{238}U	Gross alpha	Gross beta
					Station 42					
Air filter	1.3E–13	1.8E–17	2.9E–17	*c*	5.2E–12	1.8E–17	1.3E–18	2.0E–17	2.2E–15	4.6E–15
Tomatoes	*d*	*d*	*d*	3.0E+00	*c*	*c*	*c*	*c*	*d*	1.7E+00
Lettuce	*d*	8.9E–03	*d*	3.2E+00	*c*	1.0E–06	*c*	1.7E–06	4.3E–02	2.1E+00
Turnips	*d*	*d*	*d*	2.2E+00	*c*	*c*	*c*	*c*	*d*	1.7E+00
Soil	*c*	*d*	*d*	1.5E+01	*c*	3.3E–01	4.9E–01	8.7E–01	*d*	*d*
					Station 46					
Air filter	1.5E–13	5.7E–17	1.3E–16	*c*	1.0E–11	2.3E–17	1.1E–18	1.9E–17	2.3E–15	4.9E–15
Tomatoes	*d*	*d*	*d*	2.7E+00	*c*	*c*	*c*	*c*	*d*	1.7E+00
Lettuce	*d*	*d*	*d*	2.8E+00	*c*	*c*	*c*	*d*	*d*	1.6E+00
Turnips	*d*	*d*	6.2E–03	2.2E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
Soil	*c*	*d*	*d*	1.5E+01	*c*	5.0E–02	*d*	3.0E–01	3.0E+00	*d*
					Station 48					
Air filter	1.6E–13	3.3E–17	5.4E–17	*c*	8.2E–12	2.8E–17	6.9E–19	1.3E–17	2.7E–15	5.6E–15
Tomatoes	*d*	*d*	*d*	3.2E+00	*c*	*c*	*c*	*c*	*d*	1.6E+00
Lettuce	*d*	5.1E–03	*d*	3.6E+00	*c*	4.1E–07	*c*	1.6E–06	*d*	2.3E+00
Turnips	*d*	*d*	3.8E–03	2.0E+00	*c*	*c*	*c*	*c*	3.2E–02	1.7E+00
Soil	*c*	*d*	*d*	1.7E+01	*c*	3.8E–01	*d*	9.5E–01	1.9E+00	*d*
					Station 51					
Air filter	1.6E–13	7.4E–17	2.2E–17	*c*	9.2E–12	8.5E–18	3.8E–19	7.2E–18	2.7E–15	5.2E–15
Tomatoes	*d*	*d*	*d*	3.0E+00	*c*	*c*	*c*	*c*	*d*	2.1E+00
Lettuce	*d*	*d*	*d*	3.2E+00	*c*	4.9E–07	*c*	*d*	*d*	1.9E+00
Turnips	*d*	*d*	*d*	2.9E+00	*c*	*c*	*c*	*c*	*d*	1.6E+00
Soil	*c*	*d*	*d*	1.6E+01	*c*	*d*	*d*	*d*	2.3E+00	*d*
					Station 52					
Air filter	1.5E–13	5.0E–17	1.1E–17	*c*	6.6E–12	9.4E–18	1.4E–18	9.3E–18	1.8E–15	4.7E–15

[a]All values represent the mean number for each of the media and each isotope.
[b]Values for air filters are given in microcuries per milliliter. Values for all other media are given in picocuries per gram.
[c]Not applicable.
[d]Not detected.
[e]Flag.

Table 5.3. ORR environmental surveillance multimedia by media[a,b]

Station	^{7}Be	^{60}Co	^{137}Cs	^{40}K	^{3}H	^{234}U	^{235}U	^{238}U	Gross alpha	Gross beta
					Air filters (μCi/mL)					
35	1.6E–13	1.1E–16	1.6E–16	*c*	1.0E–11	2.2E–17	1.3E–18	3.4E–17	2.8E–15	6.3E–15
37	1.6E–13	8.3E–17	1.3E–16	*c*	9.3E–12	2.0E–17	7.2E–19	2.1E–17	2.8E–15	5.7E–15
38	1.5E–13	2.3E–17	4.1E–17	*c*	3.7E–12	1.6E–17	9.2E–19	2.0E–17	2.4E–15	5.5E–15
39	1.2E–13	3.3E–17	4.6E–17	*c*	7.5E–12	1.4E–17	6.2E–19	1.2E–17	2.2E–15	4.2E–15
40	1.6E–13	9.1E–17	5.2E–17	*c*	9.2E–12	4.6E–17	1.8E–18	1.7E–17	2.8E–15	5.7E–15
42	1.3E–13	1.8E–17	2.9E–17	*c*	5.2E–12	1.8E–17	1.3E–18	2.0E–17	2.2E–15	4.6E–15
46	1.5E–13	5.7E–17	1.3E–16	*c*	1.0E–11	2.3E–17	1.1E–18	1.9E–17	2.3E–15	4.9E–15
48	1.6E–13	3.3E–17	5.4E–17	*c*	8.2E–12	2.8E–17	6.9E–19	1.3E–17	2.7E–15	5.6E–15
51	1.6E–13	7.4E–17	2.2E–17	*c*	9.2E–12	8.5E–18	3.8E–19	7.2E–18	2.7E–15	5.2E–15
52	1.5E–13	5.0E–17	1.1E–17	*c*	6.6E–12	9.4E–18	1.4E–18	9.3E–18	1.8E–15	4.7E–15
					Tomatoes (pCi/g)					
35	*c*	8.1E–03	*c*	3.0E+00	*c*	*c*	*c*	*c*	*c*	1.7E+00
37	*d*	*d*	*d*	2.2E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
38	*d*	*d*	*d*	3.2E+00	*c*	*c*	*c*	*c*	*d*	2.1E+00
39	*d*	*d*	*d*	3.8E+00	*c*	*c*	*c*	*c*	*d*	1.9E+00
40	*d*	*d*	*d*	2.7E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
42	*d*	*d*	*d*	3.0E+00	*c*	*c*	*c*	*c*	*d*	1.7E+00
46	*d*	*d*	*d*	2.7E+00	*c*	*c*	*c*	*c*	*d*	1.7E+00
48	*d*	*d*	*d*	3.2E+00	*c*	*c*	*c*	*c*	*d*	1.6E+00
51	*d*	*d*	*d*	3.0E+00	*c*	*c*	*c*	*c*	*d*	2.1E+00
					Lettuce (pCi/g)					
35	*d*	*d*	*d*	3.2E+00	*c*	*c*	*c*	6.8E–07	*d*	1.7E+00
37	*d*	*d*	*d*	3.4E+00	*c*	5.1E–07	*c*	4.9E–07	*d*	1.8E+00
38	*d*	*d*	*d*	2.8E+00	*c*	9.7E–07	6.5E–07	1.3E–06	5.1E–02	1.6E+00
39	*d*	*d*	*d*	3.4E+00	*c*	*c*	*c*	1.1E–06	*d*	1.9E+00
40	*d*	6.5E–03	3.8E–03	3.3E+00	*c*	7.3E–07	*c*	7.0E–07	4.6E–02	2.1E+00
42	*d*	8.9E–03	*d*	3.2E+00	*c*	1.0E–06	*c*	1.7E–06	4.3E–02	2.1E+00
46	*d*	*d*	*d*	2.8E+00	*c*	*c*	*c*	*d*	*d*	1.6E+00
48	*d*	5.1E–03	*d*	3.6E+00	*c*	4.1E–07	*c*	1.7E–06	*d*	2.3E+00
51	*d*	*d*	*d*	3.2E+00	*c*	4.9E–07	*c*	*d*	*d*	1.9E+00

Table 5.3 (continued)

Station	^{7}Be	^{60}Co	^{137}Cs	^{40}K	^{3}H	^{234}U	^{235}U	^{238}U	Gross alpha	Gross beta
					Turnips (pCi/g)					
35	*d*	*d*	*d*	2.4E+00	*c*	*c*	*c*	*c*	*d*	1.6E+00
37	*d*	*d*	*d*	2.6E+00	*c*	*c*	*c*	*c*	*d*	2.2E+00
38	*d*	*d*	2.0E–03	2.3E+00	*c*	*c*	*c*	*c*	*d*	2.0E+00
39	*d*	4.1E–03	*d*	3.1E+00	*c*	*c*	*c*	*c*	*d*	2.5E+00
40	*d*	*d*	*d*	2.1E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
42	*d*	*d*	*d*	2.2E+00	*c*	*c*	*c*	*c*	*d*	1.7E+00
46	*d*	*d*	6.2E–03	2.2E+00	*c*	*c*	*c*	*c*	*d*	1.5E+00
48	*d*	*d*	3.8E–03	2.0E+00	*c*	*c*	*c*	*c*	3.2E–02	1.7E+00
51	*d*	*d*	*d*	2.9E+00	*c*	*c*	*c*	*c*	*d*	1.6E+00
					Soil (pCi/g)					
35	*c*	*d*	*d*	1.4E+01	*c*	5.4E–01	*d*	5.4E–01	1.8E+00	*d*
37	*c*	*d*	*d*	1.7E+01	*c*	5.3E–01	*d*	8.5E–01	3.0E+00	*d*
38	*c*	*d*	*d*	1.8E+01	*c*	*d*	*d*	*d*	2.6E+00	*d*
39	*c*	*d*	*d*	1.7E+01	*c*	3.5E–01	*d*	3.7E–01	2.3E+00	*d*
40	*c*	*d*	*d*	1.9E+01	*c*	*d*	*d*	1.1E+00	2.5E+00	*d*
42	*c*	*d*	*d*	1.5E+01	*c*	3.3E–01	4.9E–01	8.7E–01	*d*	*d*
46	*c*	*d*	*d*	1.5E+01	*c*	5.0E–02	*d*	3.0E–01	3.0E+00	*d*
48	*c*	*d*	*d*	1.7E+01	*c*	3.8E–01	*d*	9.5E–01	1.9E+00	*d*
51	*c*	*d*	*d*	1.6E+01	*c*	*d*	*d*	*d*	2.3E+00	*d*

[a]All values represent the mean number for each of the media and each isotope.
[b]Values for air filters are given in microcuries per milliliter. Values for all other media are given in picocuries per gram.
[c]Not applicable.
[d]Not detected.

Table 5.4. Uranium concentrations in ambient air on the ORR

Isotope	Concentration (10^{-15} μCi/mL)			
	1993	1994	1995	1996
		Station 35		
^{234}U	4.2E–02	3.5E–02	1.5E–02	2.2E–02
^{235}U	1.1E–02	3.0E–03	4.4E–04	1.3E–03
^{238}U	2.2E–02	2.4E–02	1.8E–02	3.4E–02
		Station 37		
^{234}U	5.4E–02	3.5E–02	1.3E–02	2.0E–02
^{235}U	9.0E–03	3.0E–03	1.4E–03	7.2E–04
^{238}U	1.8E–02	1.9E–02	1.3E–02	2.1E–02
		Station 38		
^{234}U	3.7E–02	2.9E–02	1.1E–02	1.6E–02
^{235}U	7.0E–03	4.0E–03	2.7E–04	9.2E–04
^{238}U	1.7E–02	1.6E–02	1.1E–07	2.0E–02
		Station 39		
^{234}U	4.1E–02	2.7E–02	1.1E–02	1.4E–02
^{235}U	1.0E–02	5.0E–03	1.1E–03	6.2E–04
^{238}U	1.6E–02	9.0E–03	9.1E–03	1.2E–02
		Station 40		
^{234}U	1.1E–01	8.9E–02	5.1E–02	4.6E–02
^{235}U	1.0E–03	9.0E–03	3.4E–03	1.8E–03
^{238}U	2.1E–02	1.6E–02	1.6E–02	1.7E–02
		Station 42		
^{234}U	2.5E–02	1.9E–02	1.1E–02	1.8E–02
^{235}U	3.0E–03	2.0E–03	1.3E–03	1.3E–03
^{238}U	2.2E–02	1.5E–02	1.1E–02	2.0E–02
		Station 46		
^{234}U	1.0E–01	4.4E–02	2.6E–02	2.3E–02
^{235}U	1.2E–02	6.0E–03	1.7E–03	1.1E–03
^{238}U	1.8E–02	1.5E–02	1.1E–02	1.9E–02
		Station 48		
^{234}U	5.2E–02	2.3E–02	1.3E–02	2.8E–02
^{235}U	1.0E–02	1.0E–03	1.0E–03	6.9E–04
^{238}U	2.1E–02	1.1E–02	9.5E–03	1.3E–02
		Station 51		
^{234}U	4.3E–02	1.0E–02	7.2E–03	8.5E–03
^{235}U	9.0E–03	2.0E–03	2.7E–03	3.8E–04
^{238}U	1.4E–02	6.0E–03	5.9E–03	7.2E–03
		Station 52		
^{234}U	3.3E–02	1.6E–02	1.2E–02	9.4E–03
^{235}U	7.0E–03	2.0E–02	2.2E–03	1.4E–03
^{238}U	1.6E–02	6.0E–03	8.9E–03	9.3E–03

ness 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 the emission of enriched and depleted uranium are equipped with stack samplers that have been reviewed and approved by the 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 1996 but may be curtailed in the near future because of decreasing monitoring budgets.

In 1996, 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.

5.4.2.1 Uranium

Samples for routine measurement of uranium particulate were collected by pulling ambient air through a square 14-cm (5.5-in.) 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 1996, the average 7-day concentration of uranium at the three monitored locations ranged from a low of 0.000002 $\mu g/m^3$ at Station 5 to a high of 0.00157 $\mu g/m^3$ at Station 4 (Table 5.5).

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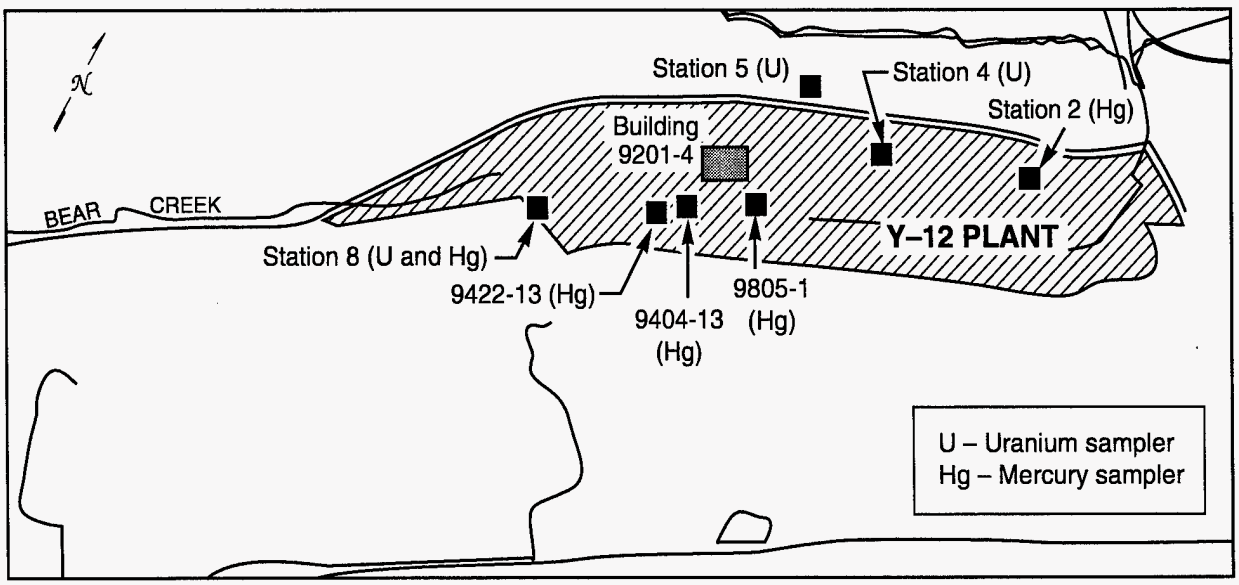

Fig. 5.4. Locations of ambient air monitoring stations at the Y-12 Plant.

Table 5.5. Uranium mass in ambient air at the Y-12 Plant, 1996

Station No.	No. of samples	7-day concentration ($\mu g/m^3$)		
		Max	Min	Av
4	51	0.00157	0.000004	0.00009
5	51	0.00029	0.000002	0.00006
8	52	0.00091	0.000020	0.00009

5.4.2.2 Mercury

In 1986, the Oak Ridge Y-12 Plant established a monitoring program to measure 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, releases from burning coal at the Y-12 Steam Plant, and fugitive emissions from Building 9201-4, a former lithium isotope separation facility contaminated with mercury. When originally established, the goals of the monitoring program were to establish a historical data base of mercury concentration 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. With the purchase and installation in late 1995 of near-continuous mercury vapor monitors that provide mercury vapor data for periods as short as five minutes, a goal of developing a better understanding of the nature and sources of fugitive mercury emissions at the Y-12 Plant was added.

Four outdoor ambient mercury monitoring stations (stations on the east and west ends of the plant and two stations near Building 9201-4) were established at the Y-12 Plant in 1986. All are presently still operating except for one of the sites near Building 9201-4. This site, formerly located near Building 9404-13, was relocated in 1996 to a site approximately 30 meters south and west of the old location. The new site was chosen in order to have access to a nearby instrument shed, Building 9422-13, for housing a mercury vapor analyzer. A control, or reference site, was established in 1988 at Rain Gage No. 2 on Chestnut Ridge in the Walker Branch Watershed. This reference site was discontinued after collecting data for approximately 20 months to establish background concentrations and a seasonal pattern.

Because no established or EPA-approved method for measuring mercury vapor in ambient air existed when the program was initiated in 1986, ESD staff 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 seven days. Average air concentration of mercury vapor for each seven-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 seven-day period.

In late 1995, Tekran™ Model 2537A Mercury Vapor Analyzers were installed at Ambient Station No. 8 and Building 9422-13 and in September, 1996, at Ambient Station No. 2. The analyzer at Building 9422-13 was removed in early 1996 until recurrent computer and analyzer problems could be solved. These new Tekran mercury vapor analyzers are self-calibrating, include mass-flow controllers, and can provide almost continuous analysis of mercury vapor in air at levels less than 1 ng/cm^3 at time intervals as short as five minutes. Plans (pending available funding) are for a Tekran analyzer to be reinstalled at the Building 9422-13 location and a for fourth analyzer to be installed at a not-yet-determined location near the present charcoal trap monitoring site at Building 9805-1.

The new analyzers at both Ambient Station No. 2 and Ambient Station No. 8 are presently being operated simultaneously with the existing monitoring system (i.e., the iodated charcoal traps) to verify comparability of the measurements. As the reliability and comparability of data of the Tekrans is established, the use of the

iodated charcoal traps will be phased out. The Tekran monitors provide data on demand and, because of their high sensitivity, provide data averaged over much shorter time intervals than the charcoal trap data (i.e., minutes instead of days). Figure 5.5 shows a plot of mercury vapor concentrations recorded by a Tekran analyzer at 30-min intervals over a three-month period in 1996 at Ambient Station No. 2. This plot represents approximately 4000 data points and provides important temporal information. This information, when combined with synoptic meteorologic data (i.e., wind speed and direction), could be used to better understand the nature and location of fugitive mercury emissions. Preliminary analysis of data collected at the two existing Tekran sites has already shown a strong correlation between wind direction and mercury vapor concentration with higher mercury vapor concentrations measured at a site when the prevailing wind direction is from the former mercury-use areas at the Y-12 Plant.

Preliminary results given in Table 5.6 show average mercury vapor concentration for the same time period during which both monitoring methods were operational. The average concentration recorded by the two Tekran analyzers is slightly higher than that calculated using the charcoal trap method, although a paired *t*-test analysis of the Station No. 2 data demonstrates that the means are not significantly different. A paired *t*-test analysis of the Station No. 8 averages, however, indicated a significant difference in the means at this site. The volume of air sampled by the Tekran analyzers, which have mass flow controllers, is corrected to standard temperature and pressure, unlike the charcoal traps. This could explain the small though significant difference between the two means. A statistical comparison of data collected by the two monitoring methods is being continued into 1997 for these two sites. Plans are to do a similar comparison at one of the sites located south of Building 9201-4, where mercury vapor levels are significantly higher.

As reported in previous ORR ASERs, annual average mercury vapor concentrations have declined in recent years when compared with concentrations measured during the early years of the monitoring program (1986 through 1988). This trend continues through 1996 (see Table 5.7). Of the three sites still operational since 1986, all three recorded significantly lower annual averages (Student's *t*-test at the 1% level) for mercury vapor concentration when compared with the 1986 through 1988 average. In addition, 1996 averages for the three sites are lower, although not significantly, than those recorded for 1995. Mercury vapor concentrations recorded at Building 9422-13 are approximately half of concentrations recorded previously at the Building 9404-13 site that it replaced. The decrease in ambient mercury recorded at the Y-12 site since 1989 is thought to be related to the reduction in coal burned 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

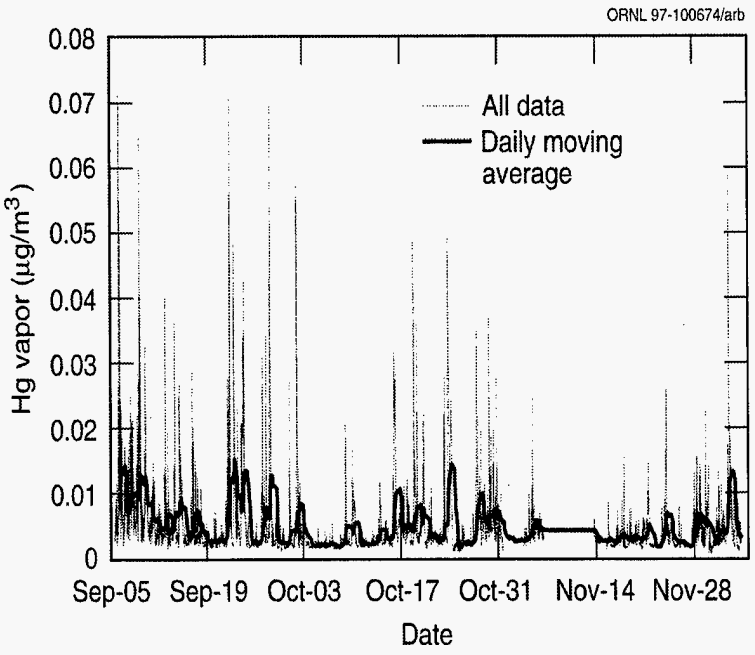

Fig. 5.5. Time trends in mercury vapor concentration at Ambient Station No. 2 from September through early December 1996, as measured by a Tekran Model 2537A Mercury Vapor Analyzer.

Table 5.6. Comparison of average mercury vapor concentrations at the two Y-12 Plant monitoring sites with both Tekran and charcoal trap monitoring systems[a]

Ambient air monitoring site	N	Average mercury vapor concentration (μg/m³)	
		Tekran analyzer	Iodated charcoal traps
Ambient Station No. 2	15	0.0049	0.0046
Ambient Station No. 8	49	0.0067	0.0059

[a]The two averages for a site are calculated from data collected by the Tekran analyzer and charcoal traps for the same time period.

Table 5.7. 1996 results of the Y-12 Plant ambient air mercury monitoring program compared with average results from 1995 and 1986–88

Ambient air monitoring site	No.	Mercury vapor concentration (μg/m³)				
		1996 max	1996 min	1996 av[a]	1995 av[a]	1986–88 av[a]
Station No. 2 (east end of Y-12 Plant)	51	0.010	<0.002	0.004	0.005	0.010
Station No. 8 (west end of Y-12 Plant)	52	0.016	<0.002	0.006	0.007	0.033
Bldg. 9422-13 (SW of Bldg. 9201-4)	51	0.100	0.008	0.030	N/A[b]	N/A[b]
Bldg. 9805-1 (SE of Bldg. 9201-4)	28[c]	0.112	0.006	0.058	0.066	0.099
Reference site, rain gage No. 2 (1988[d])	47	0.016	0.002	0.006	0.006	N/A
(1989[e])	47	0.015	<0.001	0.005	0.005	N/A

[a]The NESHAP 30-day average standard equals 1 μg/m³. The American Conference of Governmental Industrial Hygienists 8-hour day, 40-hour work week standard equals 50 μg/m³.
[b]New site.
[c]Electrical outage during utility upgrades (e.g., transformer replacement).
[d]Data for February 9 through December 31, 1988.
[e]Data for January 1 through October 31, 1989.

Perimeter Intrusion Detection Assessment System (PIDAS), RMPE, and Utility Systems Restoration] that may have caused a temporary increase in mercury air concentrations when contaminated soil and sediment were disturbed. More recently, mercury cleanup and closure activities have been conducted at several sites within the mercury-use areas, including Building. 9201-4. Table 5.7 presents average mercury vapor data for 1995 and 1996, data from the1986 through 1988 period, and data from the reference or control site collected using the charcoal trap monitoring method.

Figure 5.6 shows the trends in mercury concentrations for the four active ambient air mercury monitoring sites since the inception of the program in 1986. (The results for the new site at Building 9422-13 are combined with the results for Building 9404-13.)

Ambient mercury concentrations at the two monitoring sites near Building 9201-4 continue to

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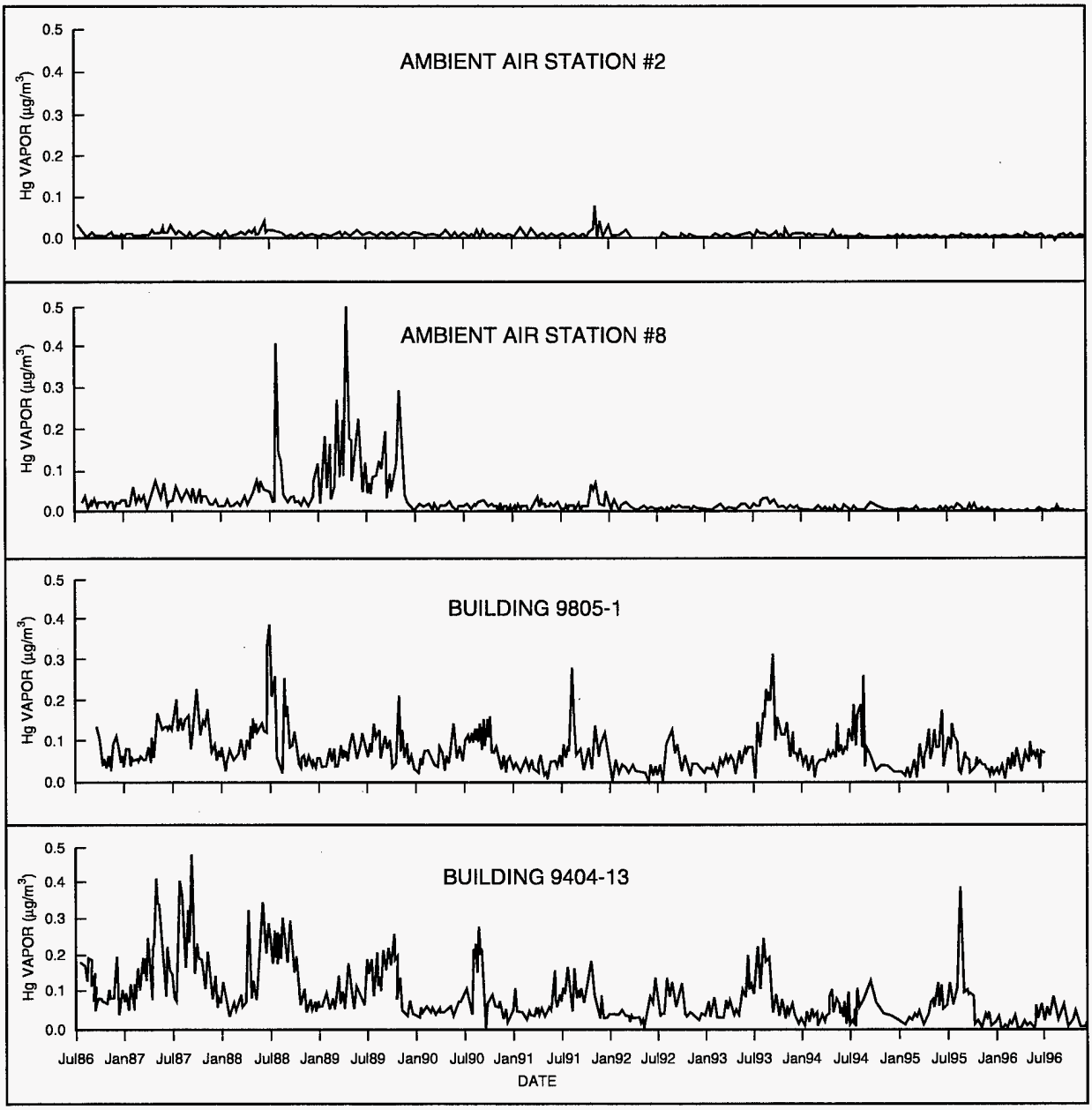

Fig. 5.6. Time trends in mercury vapor concentrations (iodated charcoal trap monitoring method) for the four active airborne mercury monitoring sites at the Oak Ridge Y-12 Plant (1986 through 1996). Results for the new site established in 1996 at Bldg. 9422-13 are combined with results for Building 9404-13.

be elevated above natural background in 1996 (see Fig. 5.4); however, results indicate that the concentrations of mercury vapor are well below the NESHAP guideline of 1 µg/m^3 (30-day average) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value of 50 µg/m^3 (time-weighted average for 8-hour workday and 40-hour work week). Average concentrations at the two monitoring sites located at the east and west end of the Y-12 Plant are

presently as low as levels measured at the 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. The specific stations associated with these objectives are 1, 2, 3, and 7 (Fig. 5.7). Sampling is conducted at each ORNL station to quantify levels of adsorbable gas (e.g., iodine); beryllium; and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.8).

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 isotopic 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 the collection of tritium as tritiated water. These samples are collected biweekly. The silica gel is composited each four weeks, then submitted to the laboratory for tritium analysis.

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 5.8) is compared with air sampling data from the reference stations at Norris Dam (51) and Fort Loudoun (52) (Table 5.2). Comparison of the data in

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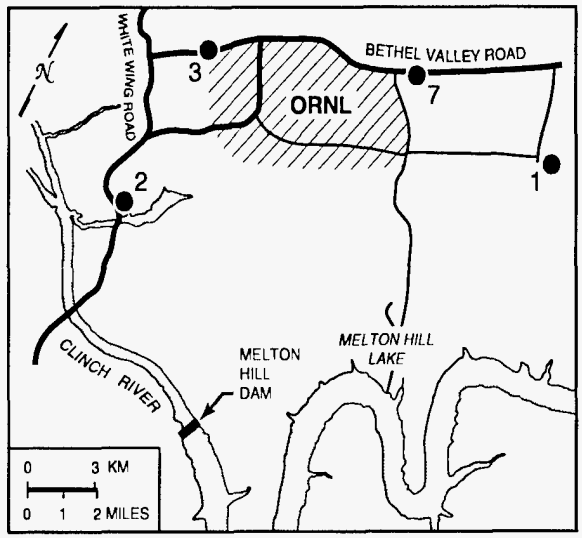

Fig. 5.7. Locations of ambient air monitoring stations at ORNL.

Table 5.8. Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 1996 (μCi/mL)[a]

Parameter	Station			
	1	2	3	7
^{241}Am	*b*	*b*	9.3E−18	4.9E−18
^{7}Be	1.2E−14	9.4E−15	1.5E−14	1.1E−14
^{244}Cm	*b*	9.4E−18	*b*	*b*
^{60}Co	*b*	*b*	*b*	*b*
^{137}Cs	5.7E−17	*b*	2.6E−17	*b*
^{3}H	4.3E−11	6.6E−11	1.5E−11	5.7E−11
^{131}I	4.0E−15	4.1E−15	1.4E−15	1.3E−15
^{133}I	*b*	3.2E−15	3.5E−15	2.7E−15
^{135}I	5.3E−14	*b*	2.5E−14	9.7E−14
^{212}Pb	*b*	*b*	3.0E−14	*b*
^{238}Pu	9.9E−18	4.5E−18	*b*	*b*
^{239}Pu	*b*	*b*	4.4E−18	4.1E−18
^{90}Sr	*b*	*b*	*b*	*b*
^{228}Th	5.4E−16	1.4E−16	3.6E−16	1.5E−16
^{230}Th	2.1E−15	7.0E−16	8.2E−16	5.8E−16
^{232}Th	4.3E−16	1.5E−16	2.2E−16	4.9E−16
^{234}U	3.0E−17	2.4E−17	2.5E−17	3.3E−17
^{235}U	5.1E−18	*b*	*b*	*b*
^{238}U	3.0E−17	2.6E−17	3.3E−17	4.5E−17

[a] 1 μCi = 3.7E+4 Bq.
[b] Not detected.

the two tables shows that ORNL has not had a significant impact on local air quality.

5.4.4 ETTP Ambient Air Monitoring

The ETTP ambient air monitoring program is designed to monitor selected pollutants for the ongoing monitoring of plant operations' impact on the immediate environment. Specific locations were selected to determine pollutant concentrations in the prevailing site upwind and downwind directions and to obtain 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. 5.8.

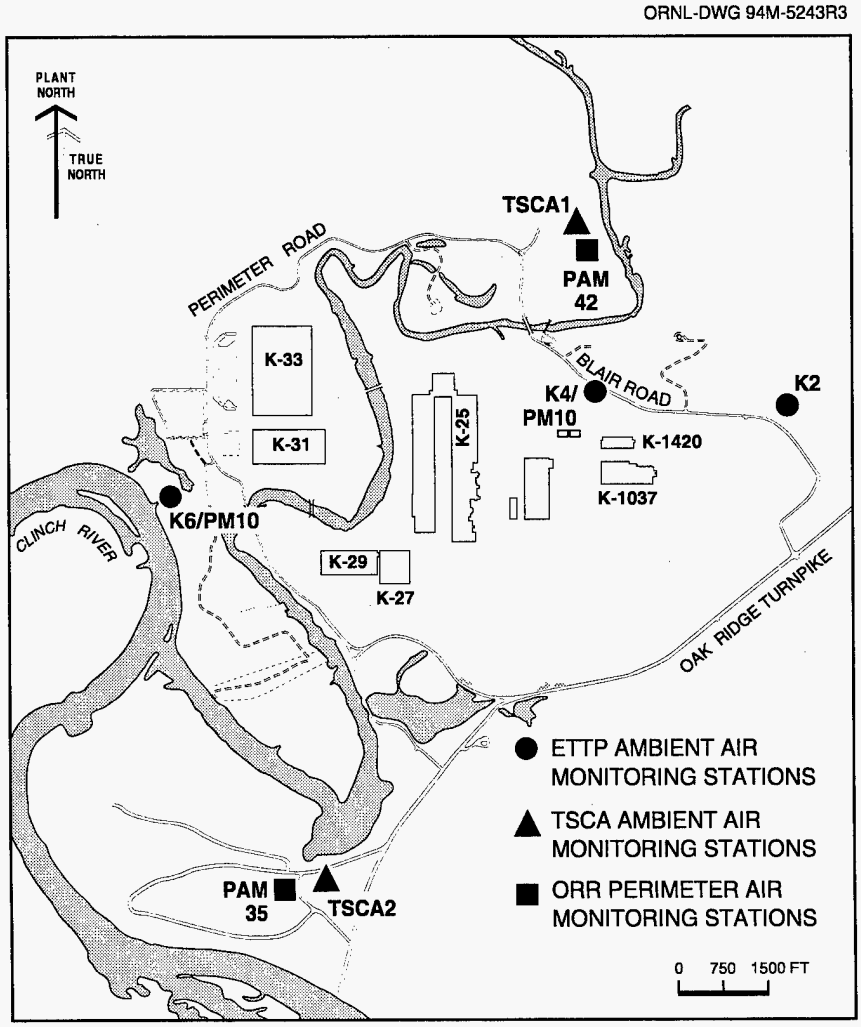

Fig. 5.8. Locations of ambient air monitoring stations at the ETTP.

The ETTP ambient air monitoring program complies with all requirements of DOE orders. The CAA regulations 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 defined pollutants.

The ambient air program sampling schedule and monitoring capabilities for airborne particulate matter, uranium, and metals are listed in Table 5.9. 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 the environment or community may warrant periodic changes of pollutants measured, number of stations, or relocation of existing stations.

During this reporting period, the network was modified with respect to ETTP operations. All sampling was discontinued at stations K1, K3, K5, and K7. Additionally, all high-volume (HV) sampling for TSP was discontinued to reflect the state and federal withdrawal of TSP ambient air quality standards. To supplement the existing sampling for particulate matter smaller than 10 microns in diameter (PM10) at station K4, a second PM10 sampler was installed at station K6. The two PM10 samplers are located in the prevailing upwind and downwind directions with respect to the ETTP, and operate on the same 24-hour sample every sixth day schedule.

HV sampling for uranium continues at stations K2 and K6, representing samples in the prevailing wind direc-

Table 5.9. Summary of collection and analysis frequencies of samples collected at ETTP perimeter ambient air monitoring stations, 1996

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
		Hazardous air pollutants carcinogen metals		
Arsenic	K2, 6	Continuous	Weekly	Monthly
Beryllium	K2, 6	Continuous	Weekly	Monthly
Cadmium	K2, 6	Continuous	Weekly	Monthly
Chromium (total)	K2, 6	Continuous	Weekly	Monthly
		Organic compounds		
PCBs	TSCA 1, 2	*c*	*c*	*c*
Furan	TSCA 1, 2	*c*	*c*	*c*
Dioxin	TSCA 1, 2	*c*	*c*	*c*
Hexachlorobenzene	TSCA 1, 2	*c*	*c*	*c*
		Radionuclides		
Uranium (total)	K2, 6	Continuous	Weekly	Monthly
	PAM-35, 42	Continuous	Weekly	Quarterly
	TSCA 1, 2	Continuous	*c*	*c*

[a]"Weekly" frequency is analysis of each 24-hour 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]Activated automatically only if a TSCA Incinerator operational upset occurs. Samples are then immediately submitted for analysis.

tions. Additional uranium monitoring coverage is supplied by the 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. The HV sampling schedule was modified at the beginning of this reporting period to correspond with PAM operations. This includes changing from the previous periodic grab sampling to continuous sampling with samples collected on a weekly basis.

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 have a measurable but not a significant impact on local air quality. These data also support the state classification of this area, including the ETTP, as in attainment for PM10. Table 5.9 lists selected parameters measured during 1996.

5.4.4.2 Criteria Pollutant Levels

Daily PM10 analyses were performed on all 24-hour samples. A summary of all PM10 measurements is presented in Table 5.10. For 1996, the 24-hour PM10 concentrations ranged from 1.79 to 47.11 $\mu g/m^3$. The highest measured value was 31.4% 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 5.10. The highest averaged PM10 annual result was 18.65 $\mu g/m^3$. This value was only 37.3% 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. 5.9 for five-year PM10 trend).

Quarterly lead results were determined from analyses of monthly composites of continuous weekly samples for each station. The total masses of lead were determined by the inductively coupled plasma mass spectrometry (ICP-MS) analytical technique. This technique was initiated in 1993, replacing a graphite furnace atomic absorption method (thus simplifying all metals analyses to one method). A summary of lead measurement results are presented in Table 5.11 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 monthly lead result was 0.007641 $\mu g/m^3$. This value was only 0.51% of the quarterly standard for lead. No lead concentration levels of environmental concern were measured (see Fig. 5.10 for five-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 a monthly composite of continuous weekly samples from each station. The total mass of each selected metal was determined by ICP-MS analytical technique. This technique was initiated in 1993, replacing a flame atomic absorption method. The ICP-MS analytical technique simplified all chemical analyses to one method. There are no Tennessee or national ambient air quality standards for HAP carcinogen metals. However, monthly composite arsenic concentration results for all measurement sites ranged from 0.000238 to 0.000611 $\mu g/m^3$. Monthly composite beryllium concentration results ranged from less than 0.000012 to 0.000075 $\mu g/m^3$. Monthly composite cadmium concentration results for all measurement sites ranged from 0.000090 to 0.001331 $\mu g/m^3$. Monthly composite chromium concentration results for all measurement sites ranged from less than 0.000148 to 0.004855 $\mu g/m^3$. An annual summary of all HAP carcinogen metals measurement results are in Table 5.12.

Table 5.10. PM10 particulates in ambient air at the ETTP, 1996

Station	Number of samples	Annual summary of PM10 concentrations ($\mu g/m^3$)			Max percentage of standard[a]	
		Annual av	24-hour max	24-hour min	Annual	24-hour
K4	51	18.13	46.97	1.79	36.3	31.3
K6	55	18.65	47.11	5.89	37.3	31.4
All stations	106	18.39	47.11	1.79	36.8	31.4

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

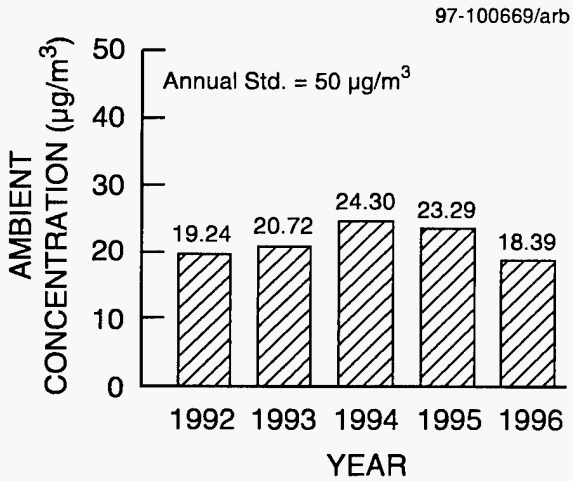

Fig. 5.9. Ambient air monitoring five-year trend results for PM10 at the ETTP.

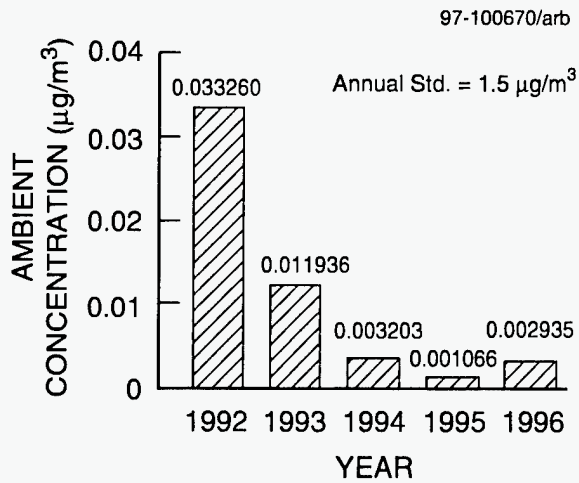

Fig. 5.10. Ambient air monitoring 5-year trend results for lead at the ETTP.

Table 5.11. Lead concentrations in ambient air at the ETTP, 1996

Station	Quarterly averages of monthly composites (µg/m³)				Max monthly result	Min monthly result	Max percentage of quarterly standard[a,b]
	1	2	3	4			
K2	0.004483	0.002316	0.003066	0.001588	0.006763	0.001588	0.45
K6	0.004942	0.002355	0.003119	0.001608	0.007641	0.001608	0.51
Quarterly av	0.004712	0.002335	0.003092	0.001598	0.007202	0.001598	0.48
Quarterly max	0.004942	0.02355	0.003119	0.001608	0.007641	0.001588	0.51
	Annual average for all stations = 0.002935 µg/m³						

[a]Tennessee and national air quality standard for lead is 1.5 µg/m³ quarterly arithmetic average.
[b]Conservative comparison of the maximum monthly result with the quarterly standard.

5.4.4.4 Radionuclide Levels

Of the radionuclides, only uranium was measured as a monthly composite of continuous weekly samples from each station. The total uranium mass for each composite sample was determined by ICP-MS analytical technique. The uranium concentration for all measurement sites ranged from a low of 0.000014 to 0.001295 $\mu g/m^3$ at Station K2 (Table 5.13). 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. 5.11 for five-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. Four

Table 5.12. HAP carcinogen metals in ambient air[a] at the ETTP, 1996

Parameter	Number of samples (all stations)	Annual summary of monthly composites (μg/m³)		
		Annual av[b]	Monthly max	Monthly min
Arsenic	51	0.000474	0.000811	0.000238
Beryllium	51	0.000024	0.000075	<0.000012
Cadmium	51	0.000411	0.001331	0.000090
Chromium	51	0.001082	0.004855	0.000148

[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 measurements.

Table 5.13. Uranium in ambient air at the ETTP, 1996

Station	Number of samples	Annual summary of monthly composite sampling (μg/m³)		
		Annual av	Monthly max[a]	Monthly min[a]
K2	53	0.000386	0.001295	0.000015
K6	52	0.000083	0.000394	0.000013
PAM35	47	0.000069	0.000258	0.000023
PAM42	48	0.000044	0.000107	0.000014
All stations	200	0.000146	0.001295	0.000014

[a]The annual standard for natural occurring uranium is 1E-01 pCi/m³, which is equivalent to 0.15 μg/m³.

upsets occurred during waste burning operations in 1996 that activated the TSCA ambient air stations. The upsets resulted in three measurements of PCBs, furans, dioxin, and hexachlorobenzene. Sampling and analytical results showed that there was no detectable off-site impact as a result of these events beyond that which would result from normal background levels. Ambient air samples for one event were not analyzed because the incinerator was not feeding waste at the time of the operational upset.

5.4.4.6 Five-Year Trends

Five-year summaries of ETTP ambient air monitoring data are shown in Figs. 5.9, 5.10, and 5.11 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 1992 through 1993 were primarily caused by changes in analytical techniques. From 1993 to the present, lead levels have been declining and most likely reflect the

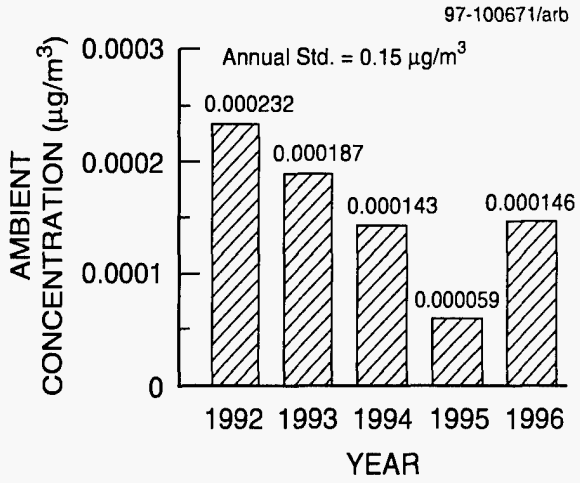

Fig. 5.11. Ambient air monitoring five-year trend results for uranium at the ETTP.

reduction of lead and lead compounds in motor vehicle fuels. No variations caused by ETTP activities could be differentiated from background levels of this pollutant. Arsenic, beryllium, and cadmium measurements were initiated in 1993. Arsenic variations in 1995 and 1996 were coincidental to demolition activities that affected structural materials treated with arsenic compounds. Measurements of beryllium have been at or near analytical detection limits. Cadmium concentration variations occurred during 1992 and 1995. Variations of chromium measurements from 1992 through 1994 show no identifiable ETTP contribution. Changes in analytical techniques were responsible for most of the variations up to 1994. Chromium variations in 1995 and 1996 were coincidental to demolition activities that affected structural materials that had long-term exposure to chromium compounds.

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. Sample locations are on streams downstream of ORR waste sources, at reference points on streams and reservoirs upstream of waste sources, on reference streams off site, and at public water intakes (Fig. 5.12). Sampling locations include the following:

- Bear Creek downstream from Y-12 Plant inputs (BCK 0.6),
- Bear Creek downstream from Y-12 Plant burial grounds (BCK 9.4),
- 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),
- Melton Hill Reservoir at Oak Ridge Marina (CRK 80),
- Melton Hill Reservoir above all DOE inputs at the Anderson County Filtration Plant (CRK 84),
- EFPC downstream from floodplain (EFK 5.4),
- EFPC downstream from Y-12 Plant (EFK 23.4),
- Hinds Creek (reference site for EFPC) (HC),
- Melton Branch downstream from ORNL [Melton Branch kilometer (MEK) 0.2],
- Melton Branch upstream from ORNL (MEK 2.1),
- Mitchell Branch downstream from ETTP Site [Mitchell Branch kilometer (MIK) 0.1],
- Mitchell Branch upstream from ETTP (MIK 1.4),
- Poplar Creek downstream from ETTP [Poplar Creek kilometer (PCK) 2.2],
- Poplar Creek upstream from ETTP and EFPC (PCK 22),
- water supply intake for city of Kingston [Tennessee River kilometer (TRK) 915],
- WOL at WOD [White Oak Creek kilometer (WCK) 1.0],

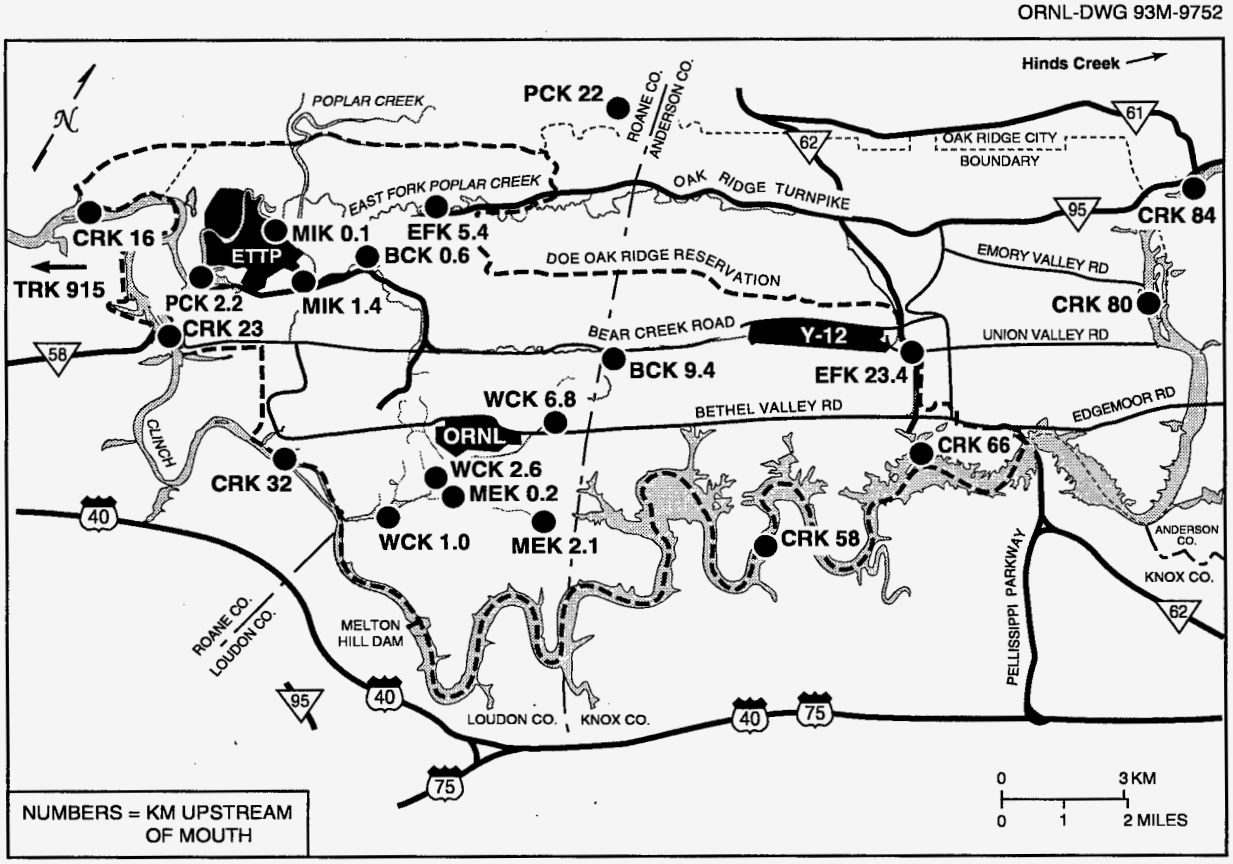

Fig. 5.12. Locations of ORR surface water surveillance sampling stations.

- WOC downstream from ORNL (WCK 2.6), and
- WOC upstream from ORNL (WCK 6.8).

Water quality measurements serve as guides to the general health of the environment. The sampling and analysis in this program are conducted in addition to requirements mandated in 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.

Sampling frequency under the EMP is bimonthly, with half of the sites being sampled one month and the other half in the following month. Grab samples are collected and analyzed for general water quality parameters, total metals, and volatile organics. They are also screened for radioactivity and analyzed for specific radionuclides when appropriate.

In 1994, the collection of semiannual composite samples from WOC at WOD (WCK 1.0) and the Clinch River downstream from all DOE inputs (CRK 16) was implemented. These samples are analyzed for isotopic uraniums, thoriums, and transuranics. This program was discontinued in 1996; samples were collected one time in June.

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. Out of the 79 parameters analyzed at each of the 22 locations, chromium at WOD (WCK 1.0), arsenic at the Melton Hill Reservoir at the Oak Ridge Marina (CRK 80), zinc at WOC upstream from

ORNL (WCK 6.8), and mercury at the water supply intake for Knox County (CRK 58) are the only parameters that exceeded a reference value in 1996. Of these, chromium at WOD has been historically detected at elevated levels.

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 1996. The following observations are made from examining three years of historic data. Bear Creek downstream from the Y-12 Plant Burial Grounds (BCK 9.4) has consistently had the highest levels of gross alpha activity and, associated with the alpha activity, total uranium and uranium isotopes. BCK 9.4 also has elevated levels of gross beta activity. The highest levels of gross beta, total radioactive strontium, and tritium have been 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 the processes or legacy activities nearby or upstream from these locations. The results for the June composites at CRK 16 and WCK 1.0 are consistent with the bimonthly samples collected from these locations.

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. 5.13). Modifications were made to the routine BMP program (sampling frequency and number of parameters) in the fall of 1996 to meet budget constraints.

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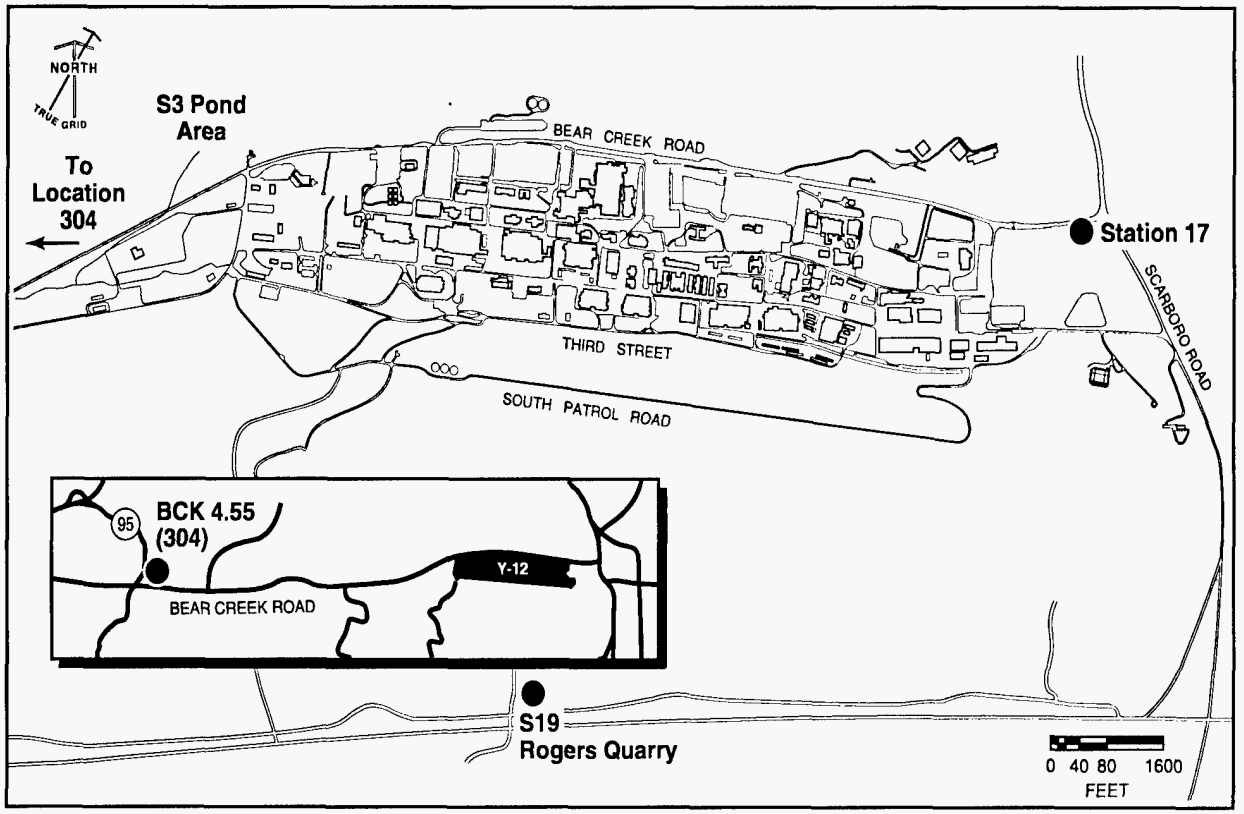

Fig. 5.13. Locations of Y-12 Plant surface water surveillance sampling stations.

Monitoring is conducted in EFPC at Station 17 (9422-1) near the junction of Scarboro and Bear Creek roads. The present sampling program consists of two 48-hour composites plus a three-day weekend composite. These samples are analyzed for mercury, ammonia-N, inductively coupled plasma (ICP) metals, and 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 seven-day composite sample) is collected monthly for mercury, anions (sulfate, chloride, ortho-phosphate, nitrate, nitrite), metals by ICP, 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-hr 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 Bear Creek km 4.55, are compared with state water quality criteria.

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 stations are available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 5.14. 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 fresh water 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 200 surface water surveillance samples were collected in 1996. Comparisons with Tennessee water quality criteria indicate that only mercury and zinc, from samples collected at Station 17, were detected at values exceeding a criteria maximum. Results are shown in Table 5.14. Of all the parameters measured in the surface water as a BMP, mercury is the only demonstrated contaminant of concern (see Chap. 4, "RMPE: Phase II," for details on activities to reduce mercury discharges).

Six zinc measurements from Station 17 exceeded the fish and aquatic life standard (0.117 mg/L) in 1996 as opposed to twenty-six measurements in 1995. The source of the zinc is believed to be a zinc additive present in once-through cooling water. The contribution of

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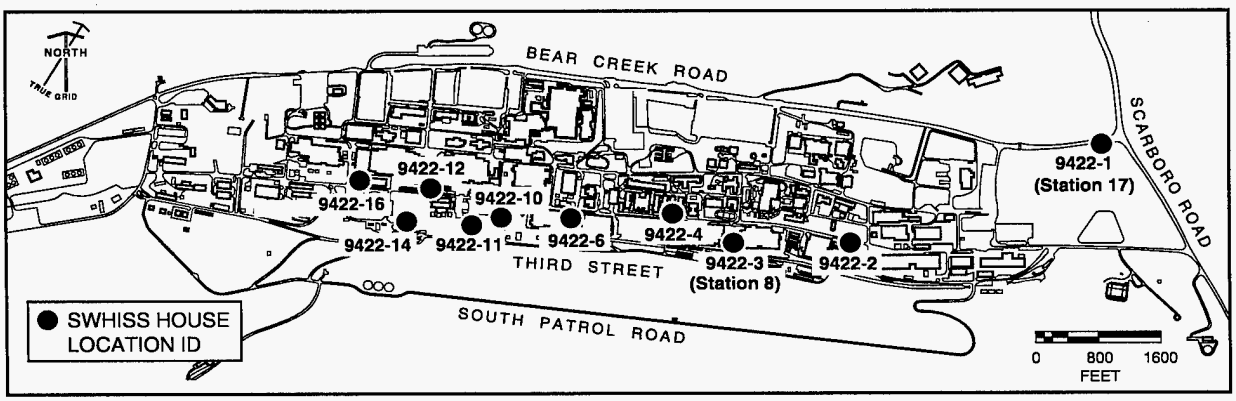

Fig. 5.14. Surface Water Hydrological Information Support System monitoring locations.

Table 5.14. Surface water surveillance measurements exceeding Tennessee Water Quality Criteria at the Y-12 Plant, 1996[a]

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	526	0.0002	0.0066	<0.0008	0.00015	526
Zinc	Station 17	218	0.01	0.18	0.05	0.117[b]	6

[a]Appendix G, Errata, contains a revised version of this table for the 1995 ASER. The water quality value for thallium (0.0063 mg/L) was inadvertently applied to zinc in the 1995 report.

[b]The standard is a function of total hardness. This value corresponds to a total hardness value of 100 mg/L.

zinc to the toxicity of the stream is being evaluated as part of the Toxicity Identification Evaluations (toxicity tests with *Ceriodaphnia dubia*) in order to achieve the NPDES toxicity limitations for the headwaters for EFPC.

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 Reference Surface Water Monitoring

The net impact of ORNL activities on surface waters is evaluated by comparing data from samples collected at reference 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. 4.14).

Analyses were performed to detect radioactivity and conventional, inorganic, and organic pollutants in the water. Conventional pollutants are indicated by measurements of conductivity, temperature, turbidity, pH, total dissolved solids, TSS, and oil and grease. Inorganic parameters are indicated by analyses for metals and anions. The presence of organic pollutants is indicated by results from total organic carbon analysis.

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 criteria for Fish and Aquatic Life have been used at WOC headwaters.

There is reasonably good agreement between parameters measured at WOC headwaters and those at Melton Hill Dam. 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. Only one parameter met these criteria; zinc at WOC headwaters was 11% of the reference value.

Radiological data are compared with DOE DCGs. 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 1996 met the criteria: the average concentration of ^{60}Co at Melton Hill Dam was less than 1% of its DCG.

5.5.4 ORNL Radiological Liquid Effluent Monitoring Program Under the EMP

In 1994 monitoring for gamma activity and tritium was added at the ORNL NPDES Category I and Category II outfalls. Category I outfalls are storm drains; Category II outfalls are storage area drains, once-through cooling water, cooling-tower blowdown, and condensate drains. With the exception of total radioactive strontium at the Category II outfalls (reported in Sect. 4.2.1.2), radionuclides detected at the remaining outfalls in 1996 were <1% of the DCG for the respective radionuclide.

5.5.5 ETTP Surface Water Monitoring

Surface water surveillance is currently conducted at five locations at the ETTP (Fig. 5.15). In late 1996, an internal review of results obtained from ETTP sampling locations was conducted. Because of this review, a sixth location at West Fork Poplar Creek (WFPC) was deleted from the monitoring program. Because both K-1710 and WFPC are located upstream of the ETTP, the K-1710 location was chosen to be used as the single upstream reference point. Monitoring at WFPC ceased in November 1996. Station K-716 is located downstream from most ETTP operations and provides information on the cumulative effects of 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. Quarterly samples are collected and analyzed for general water quality parameters, selected metals, and organic compounds. In addition, samples from K-901-A and K-1007-B are analyzed monthly for PCBs. Samples from the remaining locations 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 oxygen. During 1996, Aroclor 1254 was detected at K-1007-B, K-901-A, and K-1700 on several occasions. However, in all cases the reported values were below the lowest calibration point for the analytical method. No other PCBs were detected at these or any other ETTP surface water surveillance monitoring locations.

Dissolved oxygen measurements regularly fall below the minimum WQS during the summer months because of increased temperature (and

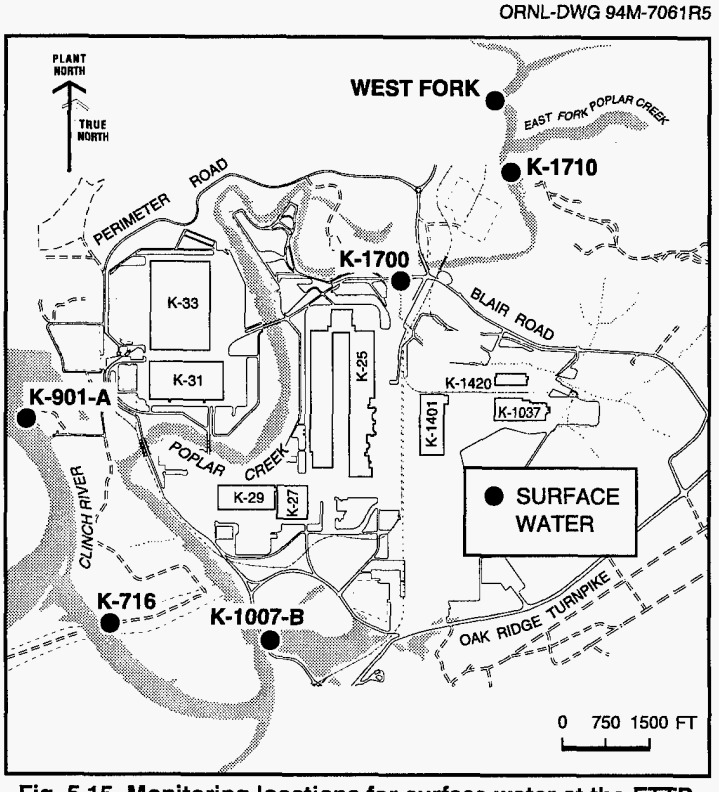

Fig. 5.15. Monitoring locations for surface water at the ETTP.

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 1996. 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. 5.16). The highest sum of the fractions, 1.4% 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 established by the order. The 1996 radiological data do not indicate any significant radiological effects from ETTP operations on perimeter surface waters.

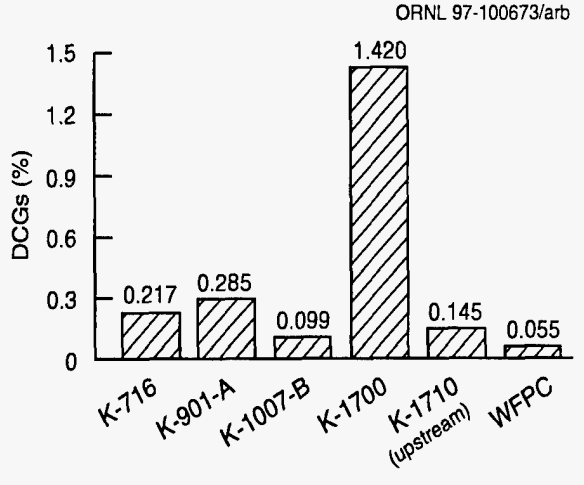

Fig. 5.16. Percentage of DCGs for ETTP surface water monitoring locations. (Results for January through October.)

5.5.6 Off-Site Treated Water 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. 5.17). In 1996, composite samples of treated water samples were collected monthly and analyzed quarterly for total uranium and 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 1996, there were no average radionuclide concentrations greater than 4% of reference values at the Kingston Water Treatment Plant and none greater than 25% of reference values at the Gallaher Water Treatment Plant. The laboratory method used for total uranium does not permit a test of significance for the maximum and minimum, but the average concentrations of uranium at both Gallaher and Kingston were <0.9% of the gross alpha standard (15 pCi/L). The total uranium measurement is converted to an activity by assuming natural abundance of uranium isotopes ^{234}U, ^{235}U, and ^{238}U.

5.6 SOIL

Soil is an integrating medium that can contain pollutants originally released to the air and can thus provide a measure of pollutant deposition from the atmosphere. Soil sampling and analysis are used to evaluate long-term accumulation trends.

Soil plots consisting of a known mixture of soil were erected at nine of the ambient air stations in the fall of 1992 (eight perimeter stations

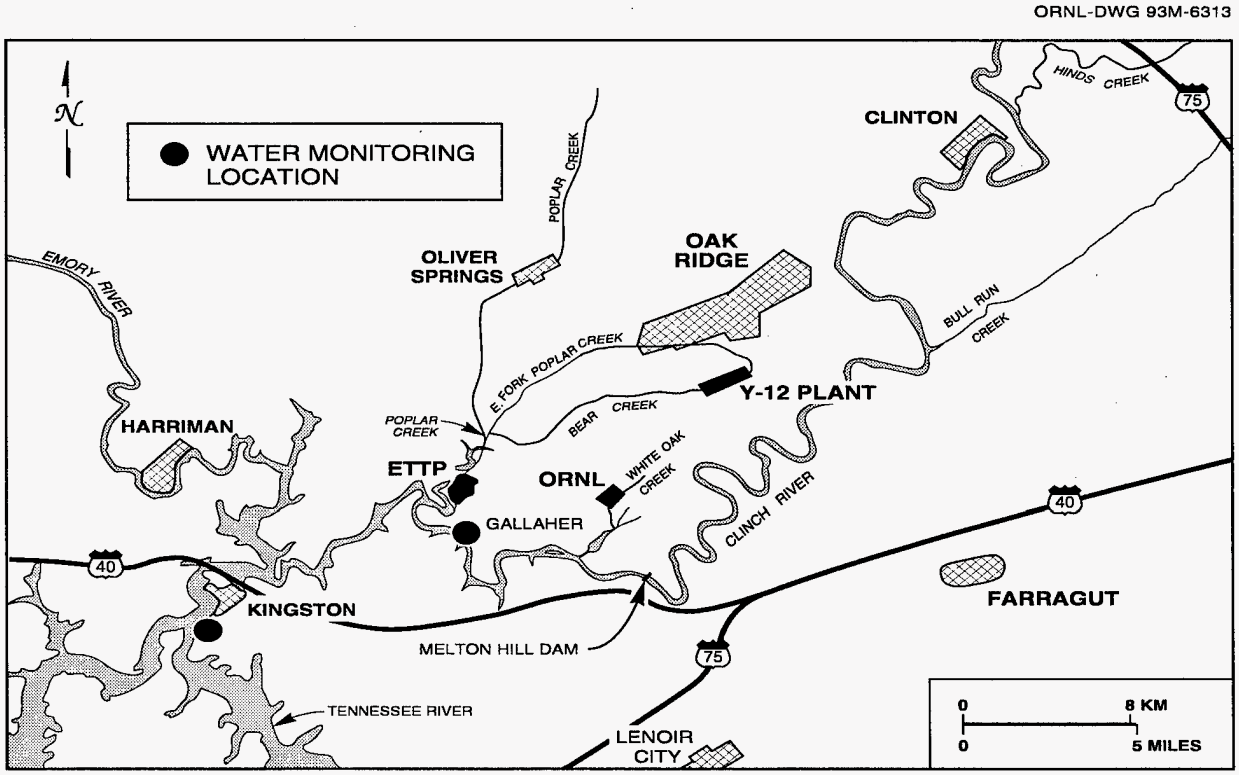

Fig. 5.17. Sampling locations for off-site treated water.

and the remote station at Norris Dam; see Fig. 5.3). These soil plots eliminate the differences in the mechanics of transport in the different types of soil found naturally on the ORR. The soil plot program is described in detail in the EMP.

Vertical composite samples were collected at the nine stations once during 1996. Samples were analyzed for gross alpha and beta activity, gamma emitters, and uranium. Soil sampling results are presented in Tables 5.2 and 5.3.

5.7 ORR SEDIMENT

Stream and lake sediments act as a record of some aspects of water quality by concentrating and storing certain contaminants. Annually, under the EMP, sediment samples are collected at 16 sites near surface water and biological monitoring locations in and around the reservation (Fig. 5.18). The sampling sites are as follows:

- Bear Creek downstream from all DOE inputs (BCK 0.6),
- Bear Creek downstream from Y-12 Plant burial grounds (BCK 9.4),
- Clinch River downstream from all DOE inputs (CRK 16),
- Clinch River downstream from ORNL (CRK 32),
- Melton Hill Reservoir at Oak Ridge Marina (CRK 80),
- Melton Hill Reservoir above all DOE inputs at the Anderson County Filtration Plant (CRK 84),
- EFPC downstream from floodplain (EFK 5.4),
- EFPC downstream from the Y-12 Plant (EFK 23.4),
- Hinds Creek (reference site for EFPC) (HC),
- Melton Branch upstream from ORNL (MEK 2.1),
- Mitchell Branch downstream from ETTP (MIK 0.1),

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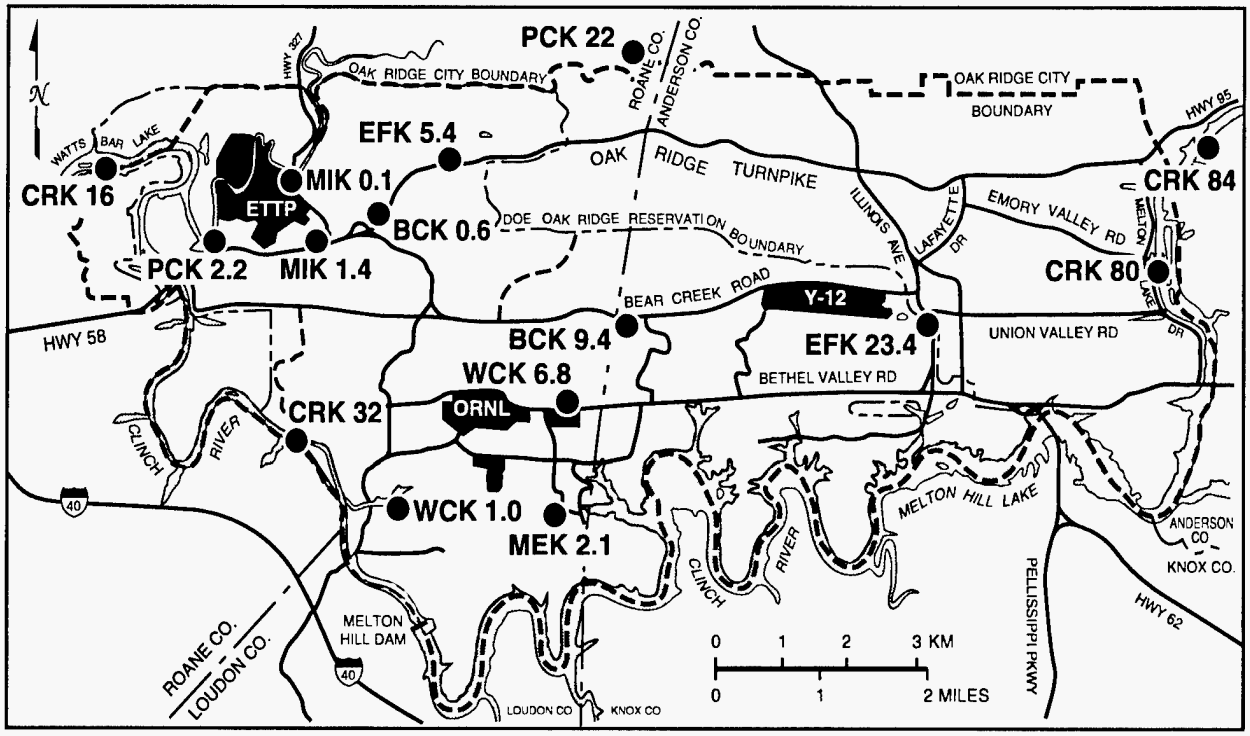

Fig. 5.18. ORR environmental monitoring plan sediment sampling locations.

- Mitchell Branch upstream from ETTP (MIK 1.4),
- Poplar Creek downstream from ETTP (PCK 2.2),
- Poplar Creek upstream from ETTP and EFPC (PCK 22),
- White Oak Lake at White Oak Dam (WCK 1.0), and
- White Oak Creek upstream from ORNL (WCK 6.8).

Sediments are effective at concentrating and storing contaminants that have a high affinity for organic and inorganic surfaces, but they also contain naturally occurring organic and inorganic chemicals. In analytical measurements, the naturally occurring chemicals in sediment lead to higher backgrounds and less sensitivity than those found in water samples. Sediments are best analyzed for substances that are concentrated and retained in sediment, resulting in sensitive, time-integrated measurements of contamination. The program was initiated in 1993, and the locations are sampled annually. Samples were analyzed for total metals, chlorinated pesticides, PCBs, semivolatile organic compounds, and selected radionuclides.

By examining the four years' worth of data available from this program, a few observations may be made. There is no evidence of PCBs at the Clinch River locations (CRK 16, 32, 80, and 84), the Melton Branch location (MEK 2.1), and Poplar Creek upstream from the ETTP and EFPC (PCK 22). PCBs, in particular Aroclor-1254 and Aroclor-1260, have consistently been detected downstream from the Y-12 Plant at EFK 23.4, and lower levels of PCBs have been detected at EFK 5.4. In general, estimated levels have been detected at the remaining sediment sampling locations. In 1996, Aroclor-1254 was detected at BCK 0.6 (140 μg/kg), BCK 9.4 (230 μg/kg), HC (110 μg/kg), MIK 0.1 (2600 μg/kg), and WCK 6.8 (230 μg/kg); in previous years, this has either not been detected or detected at estimated levels at these locations.

Metals have been detected at all of the locations. Those that are especially higher at a particular location are mercury at EFK 23.4 and EFK 5.4 and barium at MEK 2.1.

The locations where radionuclides have been detected at consistently higher concentrations are WCK 1.0 (^{60}Co and ^{137}Cs) and MIK 0.1 (gross alpha and beta, ^{99}Tc, and alpha-emitting isotopes of plutonium, neptunium, and uranium). In 1996, the radionuclide concentrations at MIK 0.1 were noticeably less than those in previous years. It is possible that nearby remediation efforts are responsible for these reductions; however, one sampling event is not enough to support a definitive conclusion.

In most cases, these observations reflect the processes occurring nearby or upstream of the particular sampling location, which is what one would expect.

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. 5.19). 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 the 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 7, not shown on Fig. 5.19, represents a reference site near the Norris Dam ambient air station (Station 51).

5.8.1.1 Results

Hay samples were collected during June 1996, and samples were analyzed for gross alpha and beta, gamma emitters, iodine, and fluorides. Table 5.15 summarizes the results of the sampling effort. There was one statistically significant gross beta result of 7.3E-09 pCi/kg in the composite for Areas 1, 2, and 3 and one of 6.0E–09 in the Areas 2, 4, and 5 composite. There were no other significant radiological results in the 1996 hay samples.

5.8.2 Vegetables

Tomatoes, lettuce, and turnips were grown in nine soil plots established at the ORR ambient air stations as shown in Fig. 5.3.

5.8.2.1 Results

Samples were analyzed for gross alpha emitters, gross beta emitters, gamma emitters, and isotopic uranium. Table 5.2 summarizes the results of the sampling effort. The analytical results indicate that overall radionuclide concentrations in tomatoes, lettuce, and turnips do not vary significantly when compared with samples collected at reference Station 51.

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 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 1996 milk sampling program consisted of monthly grab samples collected from five locations in the vicinity of the ORR (Fig. 5.20). Milk

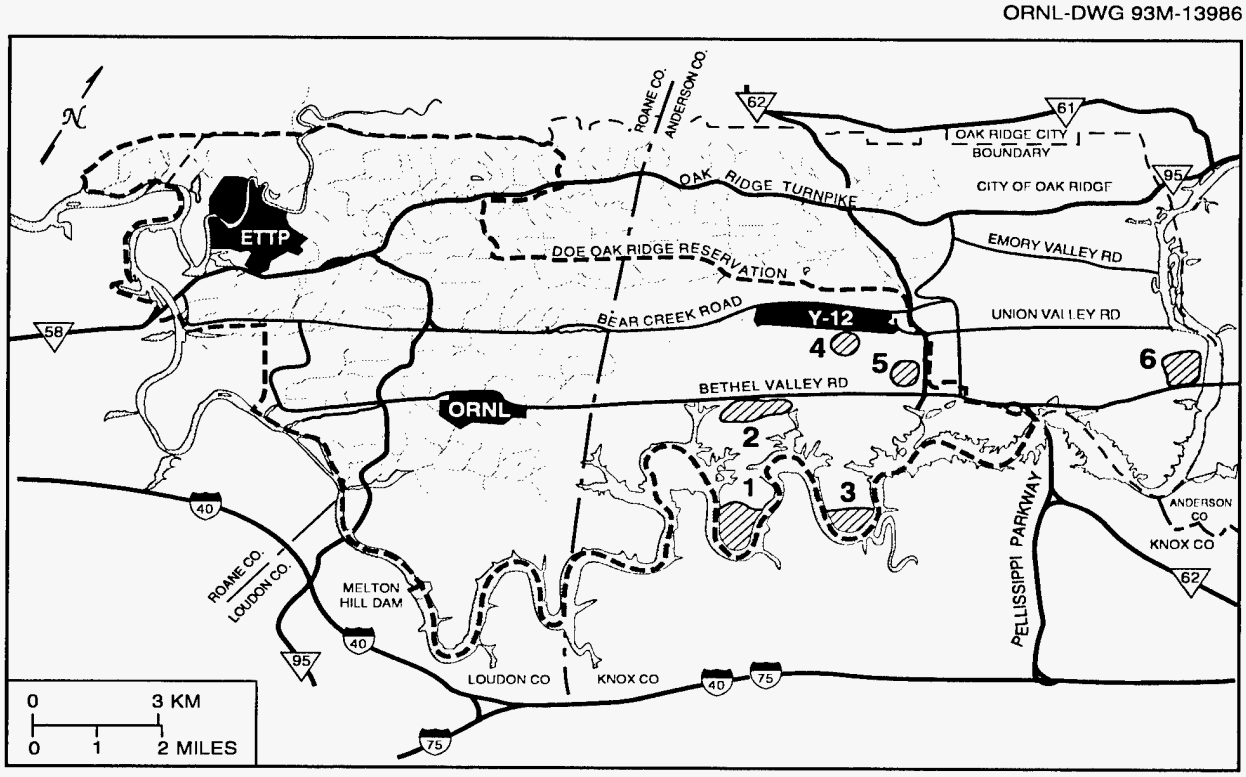

Fig. 5.19. Hay sampling locations on the ORR.

Table 5.15 Concentrations of radionuclides and fluoride in hay from the ORR, 1996[a]

	Area		
Analyte	1,2,3	2,4,5	6
Gross beta	7.3E–09	6.0E–09	*b*
Fluoride	3.1E+00	3.0E+00	3.2E+00

[a]All radionuclide data are given in picocuries per kilogram (1 pCi = 3.7E-02 Bq). Fluoride data are given in micrograms per gram.
[b]No significant result.

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 total radioactive strontium detected in milk are presented in Table 5.16. There were no detected concentrations of ^{131}I or ^{3}H. Average values for radioactive strontium 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. The results of the radiological

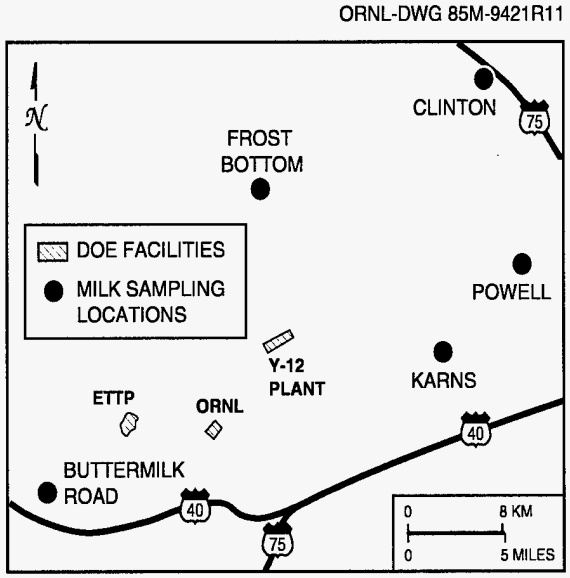

Fig. 5.20. Milk sampling locations in the vicinity of the ORR.

analysis of honey collected in 1996 from sites on the ORR are summarized in Table 5.17.

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 six locations annually and analyzing edible fish flesh. Sampling takes place at six river locations. Because of the limited number and size of fish available for sampling on creek locations, different fish-processing and analytical procedures are used. Only results from sampling at river locations are presented in this report.

The river locations include five sites on the Clinch River and one location on Poplar Creek (Fig. 5.21):

- Melton Hill Reservoir above all DOE inputs at Anderson County Filtration Plant (CRK 84),
- Melton Hill Reservoir at Oak Ridge Marina (CRK 80),
- Melton Hill Reservoir above the city of Oak Ridge water intake (CRK 66),
- Clinch River downstream from ORNL (CRK 32),
- Clinch River downstream from all DOE inputs (CRK 16), and
- Poplar Creek downstream from the ETTP (PCK 2.2).

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) are collected from each of the six 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 at the CRK 16 and CRK 32 locations, 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 1996, 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 further discussed in Chap. 6.

5.8.6 White-Tailed Deer

The twelfth annual deer hunts managed by DOE and the TWRA were held on the ORR during the final quarter of 1996. ORNL staff, TWRA, and student members of the Wildlife and

Table 5.16. Concentrations of total radioactive strontium (^{89}Sr + ^{90}Sr) in raw milk, 1996 (pCi/L)[a]

Station	No. detected/ No. of samples	Concentration using all samples			Standard error of mean
		Max[b]	Min[b]	Av[b]	
Buttermilk Road	5/12	2.4*	–0.22	0.95*	0.21
Powell	7/11	3.2*	–3.5	1.3*	0.55
Clinton	8/10	3.0*	0.65	1.9*	0.22
Frost Bottom	6/11	4.1*	0.70	2.1*	0.35
Karns	10/12	4.6*	0.38	1.9*	0.35
Network summary	36/56	4.6	–3.5	1.6*	0.17

[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 (*).

Table 5.17. Significant radiological results for honey sampled from hives on the ORR, 1996 (pCi/kg)[a]

Parameter	No. detected/ No. of samples	Concentration using all samples			Standard error of mean
		Max[b]	Min[b]	Av[b]	
^{137}Cs	2/3	1.8*	0.59	1.4*	0.40
Gross alpha	1/3	22*	–11	3.7	9.5
Gross beta	3/3	460*	240*	320*	72
^{40}K	3/3	920*	460*	700*	130

[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 (*).

Fishery Society (University of Tennessee Chapter) performed most of the necessary operations at the checking station.

The 1996 hunts were held on three weekends. Shotgun/muzzle loader hunts were held on October 19–20 (1000 permitted hunters), November 9–10 (800 permitted hunters), and December 14–15 (1000 permitted hunters). During the November 9–10 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 14–15 shotgun/muzzle loader hunt as well as the archery-only hunt held the weekend of November 9–10 at the Park City Road/Tower Shielding area.

From the total harvest of 464 animals, 240 (51.7%) were bucks and 224 (48.3%) were does. The heaviest buck had ten antler points and weighed 172 lb. The greatest number of antler points (14) was found on a buck weighing 141 lb. The heaviest doe weighed 113 lb.

ORNL-DWG 93M-5468R

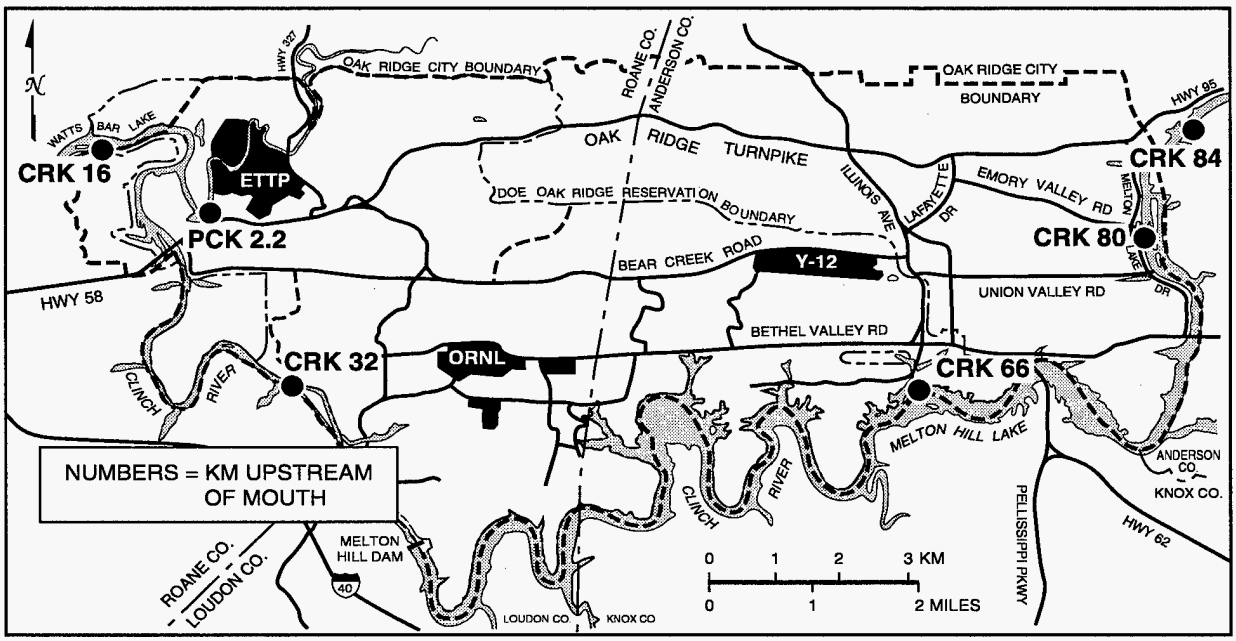

Fig. 5.21. Fish sampling locations along the Clinch River.

During the statewide juvenile hunt held November 9–10, a deer harvested from Jones Island was brought into the deer-checking station and was found to contain elevated beta activity in the bone and was voluntarily retained from the hunter.

5.8.6.1 Results

Of the 464 deer harvested, only two 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 0.19 pCi/g (7E-03 Bq/g). The deer confiscated during the 1996 hunt represent 0.4% of the total deer harvested. Since the hunts began in 1985, 6,349 deer have been harvested; a total of 149 (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.

The annual roundup of Canada geese took place June 25 and 26, 1996. During the roundup, whole-body gamma scans were conducted on 83 geese: 18 from ORNL, 42 from the ETTP, and 23 from Melton Hill Dam. Of the geese screened, only one was confiscated because ^{60}Co was detected. Of the nonconfiscated geese, 56 were released at Kentucky Lake, 23 were returned to Melton Hill Dam, one was released in the Solway area, and two died during the roundup.

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 0.12 pCi/g (4.4E-03 Bq/g). The highest ^{137}Cs concentration, 1.8 pCi/g (0.07Bq/g), was found in a goose collected at ORNL. The average weight of the Canada geese screened during the roundup was about 3 kg (8 lb). The maximum goose weight was about 4 kg (9 lb).

5.8.8 Turkey Monitoring

Wild turkeys on the ORR have not been considered a potential pathway for radiation exposure to humans because in the past there have been no permitted hunts on the reservation or in the surrounding areas. However, two hunts on the reservation were approved for 1997, and hunts for surrounding counties have also been approved. During the first quarter of 1996, TWRA trapped eight wild turkeys on the reservation for relocation to Roane County in the Paint Rock area. Prior to relocation, a whole-body gamma scan of each turkey was conducted. In order to evaluate this pathway, studies to determine radionuclide concentrations in tissue, bone, and organs from wild turkeys on the ORR will be implemented in 1997.

6. Dose

Abstract

Activities on the Oak Ridge Reservation have the potential to release small quantities of radioisotopes and hazardous chemicals to the environment. Releases of radioisotopes or chemicals represent potential exposures (doses) to the public. Environmental monitoring and surveillance on the reservation provide data from which radiological and chemical assessments are performed. To ensure 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 1996. Those releases are quantified and characterized in Chaps. 4, 5, and 7. This chapter presents estimates of the potential radiation doses to the public from the releases and describes the methods used to make the estimates.

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 effective dose equivalent (EDE), which is a risk-based dose equivalent that can be used to estimate health-effects risks to exposed persons. It is a weighted sum of dose equivalents to specified organs, expressed in rem or sieverts (1 rem = 0.01 Sv).

6.1.2 Methods of Evaluation

6.1.2.1 Airborne Radionuclides

Characterization of the radiological consequences of radionuclides released to the atmosphere from ORR operations during 1996 was accomplished 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 Radionuclide-National Emission Standards for Hazardous Air Pollutants (Rad-NESHAP), 40 CFR 61, Subpart H. 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 47 emission points, each of which includes one or more individual sources, on the ORR were modeled during 1996. This total includes 7 points at the Y-12 Plant; 27 points at ORNL; and 13 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 1996 at the 60-m height on MT6 for all sources at the Y-12 Plant; at the 100-m height on MT2 for stacks 2000, 2026, 2523, 3018, 3020, 3039, 3074, 3544, 3608, 3610-T, 5505, 7025, the sludge drier, the minor lab hoods, LA-104, and the inactive lab hoods at ORNL; at the 30-m height on MT4 for stacks 7512, 7567, 7569, 7830, 7852, 7860, 7877, 7911, the In Situ Vitrification project, the lysimeter project, and the vial crusher at ORNL; and at the 10-m height, with wind speeds adjusted to 60-m, on MT1 for all sources at the ETTP. Average rainfall on the ORR during 1996, based on the four functioning rain gauges, was 154 cm (61 in.). The average air temperature was 14°C (56°F), and the average mixing layer height was 1000 m (3280 ft).

The dose calculations are based on the assumption 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 0.45 mrem (0.0045 mSv), which is 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 is located about 1080 m (0.7 miles) north-northeast of the Y-12 Plant release point, about 9300 m (5.8 miles) northeast of the 3039 stack at ORNL, and about 13,000 m (8.1 miles) east-northeast 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 9.9 person-rem (0.099 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 calculated to be 0.40 mrem (0.0040 mSv). This individual is located about 1080 m (0.7 miles) north-northeast of the Y-12 Plant release point. Essentially, all (93%) of this dose is from ingestion and inhalation of uranium, primarily ^{234}U, ^{235}U, and ^{238}U, and about 3% of the dose is attributed to ^{239}Pu. 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 4.4 person-rem (0.044 person-Sv), which is approximately 44% of the collective EDE for the ORR.

The EDE received by the hypothetical maximally exposed individual for ORNL was calcu-

Table 6.1. Emission point parameters and receptor locations used in the dose calculations

Source name	Type	Release height (m)	Inner diameter (m)	Gas exit velocity (m/s)	Gas exit temperature (°C)	Distance (m) and direction to maximally exposed individual			
						Plant		ORR	
				Y-12 Plant					
Minor process sources	Point	20			Ambient	1,080	NNE	1,080	NNE
Monitored stacks	Point	20			Ambient	1,080	NNE	1,080	NNE
Unmonitored room exhausts	Point	20			Ambient	1,080	NNE	1,080	NNE
Lab hoods	Point	20			Ambient	1,080	NNE	1,080	NNE
9207	Point	20			Ambient	700	NW	700	NW
9204-3	Point	20			Ambient	1,100	N	1,100	N
ASO	Point	9.75	0.8	10	Ambient	2,410	WSW	2,410	WSW
				ORNL					
2000	Point	15.24	0.66	8.32	Ambient	4,970	SW	9,300	NE
7025	Point	3.96	0.3	13.74	Ambient	6,910	SW	7,550	NNE
2523	Point	7	0.3	7.5	Ambient	4,970	SW	9,300	NE
LA-104	Point	1			Ambient	4,970	SW	9,300	NE
3074	Point	4	0.26	10.2	Ambient	4,970	SW	9,300	NE
7860	Point	18.29	0.31	3.9	Ambient	3,860	WSW	10,990	NNE
7852	Point	2.13	0.2	2.18	Ambient	3,860	WSW	10,990	NNE
2026	Point	22.9	1.05	10.41	Ambient	4,970	SW	9,300	NE
In Situ Vitrification Project	Point	0			Ambient	3,370	SW	10,920	NE
3020	Point	61	1.96	6.29	Ambient	4,970	SW	9,300	NE
3039	Point	76.2	5.68	2.53	Ambient	4,970	SW	9,300	NE
7512	Point	30.5	0.91	7.96	Ambient	5,160	WSW	9,640	NNE
7911	Point	76.2	3.43	2.85	Ambient	5,160	WSW	9,640	NNE
5505	Point	11	0.3	7.92	Ambient	4,970	SW	9,300	NE
3018	Point	61	4.11	0.2	Ambient	4,970	SW	9,300	NE
3544	Point	9.53	0.27	28.18	Ambient	4,970	SW	9,300	NE
Inactive lab hoods	Point	15			Ambient	4,970	SW	9,300	NE
7830	Point	4.55	0.21	12.86	Ambient	3,860	WSW	10,990	NNE
7567	Point	3.81	0.31	2.01	Ambient	5,160	WSW	9,640	NNE
7569	Point	3.96	0.15	2.59	Ambient	5,160	WSW	9,640	NNE
7877	Point	13.9	0.51	11.4	Ambient	3,860	WSW	10,990	NNE
3608	Point	10.97	2.44	0.57	Ambient	4,970	SW	9,300	NE
STP sludge drier	Point	1.52	0.2	2.91	Ambient	4,460	SW	9,760	NE
3610-T	Point	0.61			Ambient	4,970	SW	9,300	NE

Table 6.1 (continued)

Source name	Type	Release height (m)	Inner diameter (m)	Gas exit velocity (m/s)	Gas exit temperature (°C)	Distance (m) and direction to maximally exposed individual			
						Plant		ORR	
Lysimeter project	Point	0			Ambient	3,160	WSW	11,330	NNE
7654 vial crusher	Point	1.2			Ambient	3,860	WSW	10,990	NNE
Minor lab hoods	Point	15			Ambient	4,970	SW	9,300	NE
				ETTP					
K1435 incinerator	Point	30.5	1.37	5.46	80.55	5,180	WSW	13,000	ENE
K1435-A	Point	3.05			Ambient	5,180	WSW	13,000	ENE
K1435 Tanks	Point	2			Ambient	5,180	WSW	13,000	ENE
K1004-L	Point	13.41			Ambient	4,340	W	14,000	ENE
K1006	Point	7.62			Ambient	4,240	W	14,000	ENE
K1008-C	Point	3.96			Ambient	4,360	WSW	13,900	ENE
K1015	Point	3.7			Ambient	4,340	WSW	14,000	ENE
K1037	Point	10.5	1.07	6.34	Ambient	4,820	WSW	13,250	ENE
K1423	Point	6.1	0.1524		Ambient	4,270	WSW	14,000	ENE
K1310-DC	Point	1	0.305		Ambient	3,160	WSW	15,060	ENE
K304-5	Point	1			Ambient	3,900	WSW	14,300	ENE
UF_6 cylinder project	Point	1			Ambient	3,160	WSW	15,060	ENE
K1004 A-D	Point	8.5			Ambient	4,340	W	14,000	ENE

lated to be 0.24 mrem (0.0024 mSv). This individual is located 4970 m (3.1 miles) southwest of the 3039 stack and 5160 m (3.2 miles) west-southwest of the 7911 stack. About 48% of this dose is from ingestion and inhalation of ^{138}Cs and about 29% is from immersion in noble gases (primarily ^{41}Ar). Other nuclides contributing 1% or more to the dose include ^{131}I (5.7%), ^{3}H (5.4%), ^{185}W (5.4%), and ^{212}Pb (3.3%). The contribution of ORNL emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 3.1 person-rem (0.031 person-Sv), which is approximately 32% of the collective EDE for the ORR.

The EDE received by the hypothetical maximally exposed individual for the ETTP was calculated to be 0.056 mrem (0.00056 mSv). This individual is located about 5180 m (3.2 miles) west-southwest of the TSCA Incinerator (K-1435) stack. About 95% of this dose is from ingestion and inhalation of uranium, about 2.0% is from thorium, and about 1.1% 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 2.4 person-rem (0.024 person-Sv), which is approximately 24% 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 RAMs (Fig. 5.3). Hypothetical individuals assumed to reside at the PAMs could have received EDEs between 0.11 and 0.19 mrem/year (0.0011 and 0.0019 mSv/year); these EDEs in-

Table 6.2. Calculated radiation doses to maximally exposed off-site individuals from airborne releases during 1996

Plant	Total effective dose equivalents [mrem (mSv)]	
	Plant max	ORR max
ORNL	2.4E–01 (2.4E–03)[a]	3.6E–02 (3.6E–04)
ETTP	5.6E–02 (5.6E–04)[b]	1.1E–02 (1.1E–04)
Y-12 Plant	4.0E–01 (4.0E–03)[c]	4.0E–01 (4.0E–03)
Entire ORR	*d*	4.5E–01 (4.5E–03)[e]

[a]The maximally exposed individual is located 4970 m (3.1 miles) SW of the 3039 stack and 5160 m (3.2 miles) WSW of the 7911 stack.
[b]The maximally exposed individual is located 5180 m (3.2 miles) WSW of the K-1435 stack.
[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 Y-12 Plant maximally exposed individual.

Table 6.3. Calculated collective EDEs from airborne releases during 1996

Plant	Effective dose equivalents[a]	
	Person-rem	Person-Sv
ORNL	3.1	0.031
ETTP	2.4	0.024
Y-12 Plant	4.4	0.044
ORR	9.9	0.099

[a]The collective effective dose equivalents to the 879,546 persons residing within 80 km (50 miles) of the ORR.

clude 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 EDEs calculated at the two RAMs, which averaged 0.080 mrem/year (0.00080 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 and the entire ORR. The EDE calculated at PAM 46 was 0.17 mrem/year (0.0017 mSv/year), which is about 38% of the 0.45 mrem/year (0.045 mSv/year) to the maximally exposed individual modeled by the CAP-88 code. PAM 39 is located near the maximally exposed individual for ORNL. The EDE calculated at PAM 39 was 0.12 mrem/year (0.0012 mSv/year), which is about half the 0.24 mrem/year (0.0024 mSv/year) based on CAP-88 code modeling. PAM 35 is located near the maximally exposed individual for the ETTP. The EDE calculated at PAM 35 was 0.19 mrem/year (0.0019 mSv/year), which is about three times higher than the 0.056 mrem/year (0.00056 mSv/year) modeled value to the maximally exposed individual.

Dose estimates based on calculated and measured nuclide concentrations for the Y-12 Plant and ORNL are in good agreement, given that the CAP-88 model typically overestimates doses by a factor of 2. The dose estimate based on measured nuclide concentrations near ETTP is somewhat higher than would be expected with respect to the estimate based on calculated concentrations.

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 by way of Bear Creek and EFPC, both of which enter Poplar Creek before it enters the Clinch River, and by direct discharge from Rogers Quarry into Melton Hill Lake. Discharges from ORNL enter the Clinch River by way of WOC and WOL. Discharges from the ETTP enter the Clinch River by way of Poplar Creek. This section discusses the potential radiological impacts of these discharges to persons who drink water, eat fish, swim, boat, and use the shoreline at various locations along the Clinch and Tennessee rivers.

Measured, annual-average concentrations of radionuclides in water samples taken at the ETTP (Gallaher) water plant and at the Kingston municipal water plant were used to calculate potential maximum individual EDEs from drinking water. A worker who drank 365 L (half of the worker's total water consumption) of ETTP water during 1996 could have received an EDE of about 0.22 mrem (0.0022 mSv); a person who drank 730 L of Kingston water could have received about 0.32 mrem (0.0032 mSv).

There are other water treatment plants that are not sampled along the Clinch and Tennessee river systems. Six plants are located above Melton Hill Dam, and others are located on tributaries of Watts Bar and Chicamauga lakes. Three of the upstream plants draw water from near sampling points CRK 84, CRK 66, and CRK 58. Two draw water from unsampled areas near CRK 120 and CRK 74. The remaining plant draws water from Bull Run Creek. Persons drinking 730 L of water per year from the three plants near sampling points could receive EDEs of 0.12, 0.24, and 0.24 mrem (0.0012, 0.0024, and 0.0024 mSv), respectively. (These dose estimates may be high because they are based on water samples taken before processing in the plants.) Persons drinking water from the Watts Bar and Chicamauga plants should receive EDEs lower than the 0.32 mrem calculated for the Kingston water treatment plant.

A program initiated during 1993 involves collecting samples of water and fish at selected locations along the Clinch River, Poplar Creek, and near the intake of the Kingston city water plant on the Tennessee River. The results of this sampling program were used to illustrate potential radiation doses from radionuclides found in waters above and below inputs from the ORR.

Measured concentrations of radionuclides in water at the selected locations were input to the LADTAP XL computer code to calculate potential EDEs to maximally exposed individuals who are assumed to eat 21 kg of fish/year, to swim or wade for 27 hours/year, to boat for 63 hours/year, and to use the shoreline for 67 hours/year at the sampled location. Also, fish sampling data were used to calculate maximum individual EDEs from eating 21 kg of fish. Table 6.4 is a summary of the potential EDEs. Eating fish and shoreline usage are the only significant contributors to potential EDEs. Doses attributable to swimming or wading and boating are negligibly small.

EDEs from eating fish also are estimated using measured concentrations of radionuclides in fish. Because of differences in the radionuclides reported as present, doses calculated using concentrations in water exceeded those calculated using concentrations in fish tissue. The results are presented in Table 6.4.

Calculated EDEs ranged from 0.20 to 1.0 mrem (0.0020 to 0.010 mSv) per year. High and low dose estimates are found both above and below DOE inputs. Dose estimates for eating fish range from 0.0002 to 0.99 mrem (0.000002 to 0.0099 mSv) per year, and doses resulting from shoreline exposures ranged from 0.000031 to 0.030 mrem (0.00000031 to 0.00030 mSv) per year. The highest EDEs were calculated at a location (CRK 16) downstream from all DOE inputs.

An alternative method to estimate potential EDEs from radionuclides discharged to surface waters is to use measured discharge quantities and water body flow rates in the LADTAP code. The highest individual EDE calculated by using this method was 1.2 mrem (0.012 mSv) to an individual eating 21 kg of fish caught from lower Poplar Creek. All other individual EDEs were less than 0.15 mrem (0.0015 mSv). The collective EDE from drinking water, eating fish, swimming, boating, and using the shoreline from Melton Hill Lake to Chicamauga Dam was estimated to be 2.0 person-rem (0.020 person-Sv).

Table 6.4. Potential maximum individual EDEs (mrem)[a,b] from use of off-site waters based on measured radionuclide concentrations

Location	Eating fish	Swimming or wading	Boating	Using shoreline	Total
Clinch River above all DOE input (CRK 84)	1.6E–1 1.9E–4	3.7E–5	3.9E–5	3.0.E–2	1.6E–1
Clinch River at Oak Ridge Marina (CRK 80)	3.1E–1 3.4E–4	2.0E–4	2.0E–4	1.5E–2	3.2E–1
Clinch River above Oak Ridge city water intake (CRK 66)	2.5E–1 1.8E–4	1.4E–4	1.5E–4	1.2E–2	2.6E–1
Clinch River at Knox County water intake (CRK 58)	5.1E–1	1.5E–4	1.6E–4	1.3E–2	5.1E–1
Clinch River below ORNL (CRK 32)	2.8E–1 3.3E–2	1.4E–5	2.1E–7	3.1E–5	2.8E–1
Clinch River at ETTP water intake (CRK 23)	4.9E–1	1.7E–4	1.4E–4	1.1E–2	5.0E–1
Clinch River below all DOE inputs (CRK 16)	9.9E–1 4.1E–4	2.4E–4	2.3E–4	1.8E–2	1.0E+0
Tennessee River at Kingston Water Plant intake (TRK 915)	2.8E–1	1.5E–5	1.6E–5	1.4E–3	2.8E–1
Poplar Creek above union with East Fork Poplar Creek (PCK 22)	1.9E–1	*c*	9.4E–5	7.1E–3	2.0E–1
Poplar Creek below the ETTP (PCK 2.2)	3.5E–1 3.0E–4	*c*	2.3E–7	3.6E–5	3.5E–1

[a]1 mrem = 0.01 mSv.

[b]All values are based on measured concentrations of radionuclides in water except the second set of values for eating fish, which are based on measured concentrations of radionuclides in fish.

[c]Not applicable; no one has ever been observed swimming or wading at these locations.

When all pathways are considered, the maximum EDE resulting from waterborne radionuclide discharges could have been about 1.5 mrem (0.015 mSv): 1.2 mrem (0.012 mSv) from use of off-site waters plus 0.3 mrem (0.003 mSv) from drinking Kingston water. The collective EDE to the 50-mile population was estimated to be about 2.0 person-rem (0.02 person-Sv). These are small percentages of individual and collective doses attributable to natural background radiation, 0.5% and 0.0008%, respectively.

6.1.2.3 Radionuclides in Other Environmental Media

The CAP-88 computer codes 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 of these media are sampled as part of the surveillance program. The following dose estimates are based on sampling results.

Milk

Milk collected at five locations near the ORR was sampled for strontium, tritium, and ^{131}I. Only strontium was detected in the milk samples. The sampling results were used to calculate potential EDEs to a hypothetical person who drank 310 L of the sampled milk during the year. Such a person could have received EDEs between 0.05 and 0.1 mrem (0.0005 and 0.001 mSv); the average EDE to such persons could have been 0.08 mrem (0.0008 mSv). The average EDE associated with drinking milk in EPA Region 4 is about 0.09 mrem (0.0009 mSv) (EPA 1993a).

Honey

Three bee colonies are located on the ORR. The honey produced in these hives was sampled, and the sampling results were used to calculate potential EDEs to a hypothetical person who consumed 1 kg (2.2 lb) of the sampled honey during the year. That person could have received an EDE between 0.009 and 0.08 mrem (0.00009 and 0.0008 mSv). However, a significant part of the dose is attributable to ^{40}K, which is strictly a naturally occurring radionuclide. Correcting for the contribution of ^{40}K, the EDE to the hypothetical person could be between 0 and 0.06 mrem (0 and 0.0006 mSv).

The average adult likely consumes less than 1 kg of honey per year. The total production of honey in Anderson, Loudon, and Roane counties during 1992 (the latest available data) was approximately 1500 kg (3200 lb). In the extremely unlikely event that all the honey produced in the three counties contained the sampled concentration of radionuclides that gives the highest individual EDE, the resulting collective EDE could have been 0.1 person-rem (0.001 person-Sv).

Crops

Another environmental pathway for ingestion that was evaluated separately is eating vegetables. In 1996, three types of vegetables were sampled: tomatoes, lettuce, and turnips. These vegetable types were chosen as representative of fruit-bearing, leafy, and root vegetables. Tomatoes, lettuce, and turnips were sampled from all nine plots, which are located at the ORR PAMs.

To calculate potential EDEs from eating the sampled vegetables, it was assumed that a person ate 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. Nationwide Food Consumption Survey (NFCS) data were used to estimate consumption rates for home-produced foods (USDA 1994). The U.S. Department of Agriculture conducts the NFCS every 10 years to analyze the food consumption behavior and dietary status of Americans. Based on these assumptions, the average individual's EDE from eating all three vegetable types could have been about 4 mrem (0.04 mSv), about 1.8 mrem (0.018 mSv) from fruit-bearing vegetables, about 0.6 mrem (0.006 mSv) from leafy vegetables, and about 1.7 mrem (0.017 mSv) from root vegetables (Table 6.5). Essentially all (about 99.9%) of these doses are attributed to ^{40}K, which is strictly a naturally occurring radionuclide. If the contribution of ^{40}K is excluded, the annual individual EDE is 0.005 mrem (5E–5 mSv). The reduced EDE is attributed to other radionuclides detected in the vegetables, including ^{238}U, ^{234}U, ^{235}U, ^{60}Co, and ^{137}Cs. Although these radionuclides are measured in emissions from the ORR, uranium isotopes also occur naturally in soil and fertilizers that are spread on gardens, and

Table 6.5. Average EDEs from ingesting vegetables grown at ORR ambient air monitoring stations, 1996

Vegetable	EDE [mrem (mSv)]	
	All reported radionuclides	Excluding ^{40}K
Tomatoes	1.8E+00 (1.8E–02)	7.8E-04 (7.8E–06)
Lettuce	6.0E–01 (6.0E–03)	8.5E-04 (8.5E–06)
Turnips	1.7E+00 (1.7E–02)	3.0E-03 (3.0E–05)
Total	4.1E+00 (4.1E–02)	5.0E-03 (5.0E–05)

^{137}Cs exists in the environment because of weapons testing. Therefore, most of the radioactivity found in the vegetables and the associated radiation annual EDEs may not be attributable to ORR operations. The estimated EDEs for ingesting vegetables grown at the ORR monitoring sites are summarized in Table 6.5.

Hay samples were collected from one background location and from six ORR locations. The six ORR samples were combined into three samples. Statistically significant concentrations were found only for ^{7}Be and ^{40}K, both of which are naturally occurring radionuclides. Essentially all (about 99.99%) of the dose to humans from eating beef and drinking milk from cattle that eat hay was from the naturally occurring ^{40}K. Including the contribution from ^{40}K, the EDE from drinking milk and eating beef was estimated to be about 21 mrem (0.21 mSv); excluding ^{40}K, the EDE attributed to ^{7}Be was estimated to be about 1.7E–03 mrem (1.7E–05 mSv). No statistically significant concentrations of radionuclides emitted from the ORR were found in the hay samples.

White-Tailed Deer

Several deer hunts were held on the ORR during 1996. A total of 464 deer were killed, of which 2 were confiscated because their radionuclide content potentially exceeded the ^{90}Sr in-bone release limit (1.5 times background, which is about 20 pCi/g). The remaining 462 deer had an average field-dressed weight of about 37 kg (81 lb). Assuming 55% of the dressed weight is edible, the average deer would yield about 20 kg (45 lb) of meat. Therefore, based on the average weight, the total harvest of edible meat was about 9,330 kg (20,580 lb).

All deer were surveyed at the TWRA inspection station to estimate the ^{137}Cs content in tissue and total strontium in bone. Based on field measurements, the average ^{137}Cs concentration in the 462 released deer was 0.19 pCi/g (0.007 Bq/g). Laboratory analyses of muscle and liver samples resulted in statistically significant concentrations of only ^{137}Cs and ^{40}K. In 11 of 27 muscle and liver samples collected, the average ^{137}Cs was 0.09 pCi/g (0.003 Bq/g), which is lower than the field average ^{137}Cs concentration. Potassium-40 (^{40}K) was detected in all 27 muscle and liver samples and the average concentration was 2.5 pCi/g (0.09 Bq/g). However, ^{40}K is a naturally occurring radionuclide. The EDE for an individual consuming one average weight deer with the average field concentration of ^{137}Cs (0.19 pCi/g) was estimated to be 0.2 mrem (0.002 mSv). The collective EDE from eating all the harvested deer meat with an average ^{137}Cs concentration of 0.19 pCi/g could have been about 0.09 person-rem (9E–4 person-Sv).

EDEs were estimated for the hunter with the highest potential intake (in terms of concentration and field-dressed weight) who harvested two deer. When actual field-derived ^{137}Cs concentrations (0.74 pCi/g and 0.71 pCi/g) and field-dressed weights (90 lb and 81 lb) are used, and it is assumed that one individual consumed all the deer meat, the highest EDE was calculated to be about 1.5 mrem (0.015 mSv).

Canada Geese

During 1996 whole-body gamma scans were conducted on about 83 geese. The geese were collected from ORNL (18), ETTP (42), and Melton Hill Dam (23). Of the 83 geese screened, ^{60}Co was detected in only one goose, which was confiscated. The average ^{137}Cs concentration was 0.12 pCi/g (4.4E–3Bq/g). The maximum ^{137}Cs concentration was 1.8 pCi/g (7 E–2 Bq/g).

The average weight of the Canada geese scanned during the roundup was about 3 kg (8 lb), half of which is assumed to be edible. A person eating a Canada goose with the average ^{137}Cs concentration could have received an EDE of about 0.01 mrem (1E–04 mSv). A person eating a Canada goose with the maximum ^{137}Cs concentration and the maximum weight of a goose surveyed [4 kg (9 lb)] could receive an EDE of about 0.2 mrem (2E–03 mSv). If it is assumed that one person consumed 8 geese, each with an average ^{137}Cs concentration [0.12 pCi/g (4E–03 Bq/g)], the estimated EDE would be about 0.08 mrem (8E–04 mSv). This is a conservative assumption because most hunters harvest on average one to two geese per hunting season (USFWS 1995).

Approximately 1,077 geese were harvested in the four surrounding counties—Anderson, Knox, Loudon, and Roane. This number is based on a University of Tennessee telephone survey of permit holders taken between September 5 and 15, 1995, and total late season (January 1996, October and December 1996, and January 1997) harvest tag data. Tag data were obtained from one published report (TWRA 1996) and from unpublished data supplied by TWRA staff. September 1996 harvest data were not available; however, the 1995 harvest data indicate the greater number of geese harvested during that hunting period than during later hunting seasons. Of the total number of geese harvested in the four counties, it is estimated that about 460 of these geese could have spent time on the ORR. The annual average collective EDE from consuming 460 geese is estimated to be about 0.005 person-rem (5E–05 person-Sv), assuming all were contaminated at the average ^{137}Cs concentration of 0.12 pCi/g (4E–3 Bq/g).

In 1995, eleven geese were sacrificed and tissue, bone, and thyroid samples were collected and analyzed. In addition, six background geese also were sacrificed, and samples were collected and analyzed. The 1995 average ^{90}Sr concentration in tissue was 6.8 pCi/g (0.25 Bq/g). If one person consumes one goose with average 1996 field and 1995 analytical concentrations of ^{137}Cs and ^{90}Sr, respectively, the annual individual EDE is estimated to be about 2 mrem (0.02 mSv). Taking into account the maximum 1996 field and 1995 analytical concentrations of ^{137}Cs and ^{90}Sr detected in the goose samples, 1.8 pCi/g (0.02 Bq/g) and 11 pCi/g (0.41 Bq/g), respectively, and the maximum goose weight of 4 kg (9 lb), the EDE is estimated to be about 4 mrem (0.04 mSv).

Eastern Wild Turkey

Eight eastern wild turkeys were collected on the ORR in 1996. Whole-body gamma scans were conducted on these turkeys, and ^{137}Cs was detected in only one turkey. The ^{137}Cs concentration in the turkey was 0.09 pCi/g (3.3E–3 Bq/g). Based on this ^{137}Cs concentration and turkey weight of 7.3 lb (3.3 kg), the EDE to a person consuming this turkey is estimated to be about 0.007 mrem (7E–5 mSv). All eight turkeys were released in Roane County.

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 1995 was about 7.5 μR/hour. This equals a dose rate of about 50 mrem/year (0.50 mSv/year). Except for two locations, all measured exposure rates beyond 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 1987, 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 13 μR/hour and ranged between 3.5 and 18 μR/hour. These measured exposure rates were attributed to radiation emanating from a nearby field that contained the remnants of a ^{137}Cs seeding experiment. The experimental plots were remediated during 1994, but new measurements of the exposure rate along the Clinch River have not been performed. Therefore, we assume the exposure rate along the Clinch River caused by the cesium plots was the same as reported last year, about 8 μR/hour (0.006 mrem/hour) above background.

A potential maximally exposed individual is a hypothetical fisherman who was assumed to spend 5 hours/week (250 hours/year) near the point of average exposure. This hypothetical maximally exposed individual could have received an EDE of about 1 mrem (0.01 mSv) during 1995. This dose estimate likely is high, because most of the ^{137}Cs was removed from the experimental fields in 1994.

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. Exposure rate measurements, corrected for background, at the creek bank ranged between 3.9 and 8.3 μR/hour, which is equivalent to an EDE rate from 0.003 to 0.006 mrem/hour (between 0.00003 and 0.00006 mSv/hour). The average exposure rate was about 5.1 μR/hour, which corresponds to an EDE rate of 0.004 mrem/hour (0.00004 mSv/hour). A 4-hour fishing trip could have resulted in reception of an EDE between 0.01 to 0.02 mrem (0.0001 to 0.0002 mSv). If the hypothetical Clinch River fisherman is used, the 250-hour/year exposure time could have resulted in reception of 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 the Y-12 Plant, ORNL, and the ETTP. The doses for ORNL are based on water concentrations associated with nine different sampling locations: Melton Branch (Outfalls X-13 and 2), WOC (Outfall X-14), WOD (Outfall X-15), First Creek, Fifth Creek, Raccoon Creek, Northwest Tributary, and at the 7500 Bridge. 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 Melton Branch (X13): 3E–3 rad/day (3E–5 Gy/day) to fish, 3E–2 rad/day (3E–4 Gy/day) to crustacea, and 7E–3 rad/day (7E–5 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 EFPC at SWHISS house 9422-1 (Station 17), Bear Creek at BCK 4.55 (formerly Outfall 304), and Rogers Quarry discharge point S-19 (formerly Outfall 302). At Bear Creek (BCK 4.55), the maximum dose rates to fish, crustacea, and muskrats were ascertained: 7E–04 rad/day (7E–06 Gy/day), 2E–03 rad/day (2E–05Gy/day), and 1E–01 rad/day (1E–03 Gy/day), respectively. A maximum dose rate of 2 E–03 rad/day (2E–05 Gy/day) was also estimated for crustacea at EFPC. For muskrat, the dominant radionuclide contributor to the internal dose rate was ^{228}Ra, a decay product of ^{232}Th, a naturally occurring radionuclide.

Similar analyses were conducted at the ETTP. The waterways evaluated were Mitchell Branch at K-1700, Poplar Creek at K-1007B, K-716 (downstream of ETTP), K-1710 (upstream of ETTP), and at K-901A, which was located at Clinch River. At Mitchell Branch (K-1700), the maximum dose rates to fish, crustacea, and muskrats from measured uranium and ^{99}Tc concentrations

Table 6.6. 1996 total dose rate for aquatic organisms (rad/day)[a,b]

Measurement location	Fish		Crustacea		Muskrat	
	Av	Max	Av	Max	Av	Max
		ORNL				
Melton Branch (X13)	1E–3	3E–3	1E–2	3E–2	3E–3	7E–3
White Oak Creek (X14)	8E–4	1E–3	6E–3	9E–3	2E–3	3E–3
White Oak Dam (X15)	9E–4	1E–3	7E–3	1E–2	2E–3	3E–3
7500 Road Bridge	4E–4	6E–4	3E–3	5E–3	9E–4	1E–3
First Creek	3E–4	1E–3	3E–3	1E–2	8E–4	3E–3
Fifth Creek	9E–5	5E–4	9E–4	4E–3	2E–4	9E–4
Melton Branch 2	2E–5	6E–5	1E–4	4E–4	4E–5	1E–4
Northwest Tributary	4E–4	7E–4	3E–3	4E–3	7E–4	1E–3
Raccoon Creek	4E–5	1E–4	4E–4	1E–3	1E–4	3E–4
		Y-12 Plant				
East Fork Poplar Creek (Station 17)	1E–4	6 E–4	7E–4	2E–3	2E–4	4E–2
Bear Creek (BCK 4.55)[c]	1E–4	7E–4	8E–4	2E–3	3E–3	1E–1
Rogers Quarry (Outfall S19)[d]	3E–5	3E–4	2E–4	1E–3	3E–5	4E–2
		ETTP				
Mitchell Branch (K-1700)	2E–5	4E–5	1E–4	3E–4	8E–5	1E–4
Poplar Creek (K-1007B)	2E–6	5E–6	1E–5	1E–4	6E–6	1E–5
Poplar Creek (K-1710) upstream of ETTP	2E–6	1E–5	1E–5	2E–4	9E–6	3E–5
Poplar Creek (K-716) downstream of ETTP	3E–6	8E–6	6E–6	1E–4	1E–5	3E–5
Clinch River (K-901-A)	5E–6	1E–5	5E–5	2E–4	2E–5	4E–5

[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. Renamed S19 in current permit.

were 4E–5 rad/day (4E–7 Gy/day), 3E–4 rad/day (3E–6 rad/day), and 1E–4 rad/day (1E–6 Gy/day), respectively. 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).

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 several pathways of exposure is given in Table 6.7. It is unlikely (if not impossible) that any real person could have been irradiated by all

Table 6.7. Summary of estimated radiation dose equivalents to an adult during 1996 at locations on the ORR of maximum exposure

Pathway	Location	Effective dose equivalent (mrem)[a]
Gaseous effluents	Maximally exposed resident to	
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	0.40
	ORNL	0.24
	ETTP	0.056
	ORR	0.45
Liquid effluents		
Drinking water	Kingston Water Plant	0.32
Eating fish	Lower Poplar Creek	1.2
Other activities	Lower Clinch River, CRK 16	0.018
Eating deer		1.5
Eating geese		0.08
Direct radiation	Clinch River shoreline	1.0[b]
	Poplar Creek (ETTP)	1.0

[a]1 mrem = 0.01 mSv.

[b]This likely is an overestimate of the potential dose because the source of direct radiation was remediated during 1994.

of these sources and pathways for a period of one year; however, if the resident who received the highest EDE [0.45 mrem (0.0045 mSv)] from gaseous effluents also drank water from the Kingston plant [0.32 mrem (0.0032 mSv)], ate fish from Poplar Creek [1.2 mrem (0.012 mSv)], and fished the Clinch River near the cesium field or Poplar Creek inside the ETTP [1 mrem (0.01 mSv)], he or she could have received a total EDE of about 3.0 mrem (0.030 mSv), or about 1.0% of the annual dose [300 mrem (3 mSv)] from background radiation. If the above person also was the person who received the highest EDE [1.5 mrem (0.015 mSv)] from eating deer harvested on the ORR, that person could have received a committed EDE of about 4.5 mrem (0.045 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 1996 maximum EDE could have been about 4.5 mrem (0.045 mSv), or about 4.5% 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.

6.1.5 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years from 1992 to 1996 are given in Table 6.8. The variations in values over this five-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 were identified as potential contributors to radiation exposure of the public around the ORR. These facilities include a

Table 6.8. Trends in total effective dose equivalent for selected pathways

Pathway	Effective dose equivalent (mrem)[a]				
	1992	1993	1994	1995	1996
All air	1.3	1.4	1.7	0.5	0.45
Fish consumption	0.4	0.2	1.6	0.9	1.2
Drinking water (Kingston)	0.05	0.07	0.04	0.15	0.32
Direct radiation (Clinch River)	1[b]	1[b]	1[b,c]	1[b,c]	1[b,c]
Direct radiation (Poplar Creek)	11[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.

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.

Airborne emissions from these facilities (based on information supplied by the facilities) should not cause any individual to receive an EDE greater than 3.8 mrem (0.038 mSv). When combined with impacts caused by emissions from the ORR, no individual should receive an EDE in excess of EPA or DOE 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 0.45 mrem (0.0045 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. The estimated collective committed EDE to the about 880,000 persons living within 80 km (50 miles) of the ORR was about 9.9 person-rem (0.099 person-Sv) for 1996 airborne emissions. This represents about 0.004% of the 264,000 person-rem (2,640 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 Pri-

mary 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

Air permits issued by TDEC allow release of permitted quantities of chemicals. No air monitoring data amenable to human exposure analysis were available. (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 (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.

6.2.2.3 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 in estimating the average concentration of a chemical. 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 at current drinking water supply locations (CRKs 23 and 58) both below and above the ORR. The Gallaher Water Station (CRK 23) is located near the water intake for the ETTP and is below the ORNL effluent discharge point. The Knox county water supply intake (CRK 58) is located above the ORR discharge points. In addition, the drinking water pathway was evaluated at the Anderson County Filtration Plant (CRK 84), which is above all DOE inputs, and at CRK 16, which is a location downstream of all DOE inputs.

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
Aluminum	6.0E–03	SMCL
Arsenic	3.0E–04	RfD
Barium	7.0E–02	RfD
Beta-BHC	4.0E–05	TN WQC
2-Butanone	6.0E–01	RfD
Carbon disulfide	1.0E–01	RfD
Chlordane (alpha, gamma)	6.0E–05	RfD
Chloride	7.1E+00	SMCL
Chromium (VI)	5.0E–03	RfD
Copper	4.0E–02	MCL
4,4′-DDE	3.4E–01	SF
4,4′-DDT	5.0E–04	RfD
1,2 Dichloroethene	9.0E–03	RfD
Dieldrin	1.6E+01	SF
Endosulfan I, II	6.0E–03	RfD
Endosulfan sulfate	2.1E–03	TN WQC
Endrin	3.0E–04	RfD
Fluoride	6.0E–02	RfD
Heptachlor	5.0E–04	RfD
Heptachlor epoxide	1.3E–05	RfD
Iron	9.0E–03	SMCL
Lead	4.0E–04	MCL
Manganese	4.7E–02	RfD (water)
Mercury	5.7E–05	MCL
Methoxychlor	5.0E–04	RfD
Nickel (soluble salts)	2.0E–02	RfD
Nitrate	1.6E+00	RfD
PCBs	2.0E+00	SF (mixed)
Selenium	5.0E–03	RfD
Strontium	6.0E–01	RfD
Sulfate	1.4E+01	MCL
Thallium	8.0E–05	RfD
Toluene	2.0E–01	RfD
Trichloroethene	1.4E–04	MCL
Uranium (soluble salts)	3.0E–03	RfD
Vanadium	7.0E–03	RfD
Vinyl chloride	1.9E+00	SF
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 a RfD (mg kg^{-1} day^{-1}), multiply by the consumption rate (2 L/day), and divide by the mass of a reference man, 70 kg.

Table 6.10. 1996 chemical hazard quotients for drinking water[a]

Chemical	Hazard quotient			
	CRK 84[b]	CRK 58[c]	CRK 23[d]	CRK 16[e]
		Metals		
Aluminum	6E–01	2E+00	1E+00	6E+00
Barium	1E–02	1E–02	1E–02	2E–02
Iron	5E–01	2E+00	7E–01	3E+00
Manganese	4E–02	6E–02	3E–02	
Mercury	~5E–02	~6E–02	~7E–02	
Uranium	~1E–03	2E–03	2E–03	2E–03
Vanadium		~1E–02		~1E–02
Zinc	~1E–03	~8E–04	~5E–04	~8E–04
		Anions		
Chloride	2E–02	2E–02	2E–02	2E–02
Fluoride	~8E–02			~7E–02
Nitrate	6E–02	5E–02	5E–02	4E–02
Sulfate	4E–02	4E–02	4E–02	3E–02
		Volatile organics		
2-Butanone	~4E–04	~3E–04	~2E–04	~2E–04
Acetone	~2E–03	~3E–03	~3E–03	~2E–03
Carbon disulfide			~1E–03	~1E–03
Toluene		~6E–04	~6E–04	
Xylene		~7E–05	~6E–05	

[a]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.
[b]Melton Hill Reservoir above all DOE inputs.
[c]Water supply intake for Knox County.
[d]Water supply intake for ETTP.
[e]Clinch River downstream of all DOE inputs.

With the exception of aluminum and iron, the HQ values at all water sampling locations were less than one (HQ < 1 is desirable). 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.

6.2.2.4 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 and sunfish collected from Poplar Creek were analyzed for a number of metals, pesticides, and PCBs. Table 6.11 summarizes the HQ and I/CDI ratios derived on average chemical concentrations in fish samples found both upstream and downstream locations from the ORR. Arsenic,

Table 6.11. 1996 chemical hazard quotients (HQs) for metals and estimated dose/chronic daily intake (I/CDIs) for carcinogens in fish[a]

Parameters	Sunfish						Catfish	
	CRK 84[b]	CRK 80[c]	CRK 66[d]	CRK 32[e]	CRK 16[f]	PCK 2.2[g]	CRK 32[e]	CRK 16[f]
HQs for metals								
Arsenic	~4E+00	~4E+00						
Chromium	~3E–02		~1E–02					7E–02
Copper	7E–03	1E–02	6E–03	~6E–03		~9E–03	8E–03	1E–02
Lead								1E+01
Mercury	~2E+00			~2E+00	2E+00	1E+00	2E+00	5E+00
Nickel								1E–01
Selenium		~1E–01	~1E–01	~4E–01				
Silver								
Thallium	8E–02	9E–02	8E–02		~2E–01	~2E–01	5E–01	
Uranium								
Zinc	5E–02	4E–02	4E–02	6E–02	6E–02	6E–02	2E–02	2E–02
HQs for pesticides								
Alpha chlordane				~8E–02	~8E–02	~8E–02	3E+00	2E–01
Gamma chlordane					~3E–01		~1E+00	7E–02
Beta-BHC					~2E–01	~2E–01		
4,4'-DDT					~2E–02			4E–02
Endosulfan I					~1E–03			
Endosulfan II				~2E–03	~2E–03	~1E–03	8E–02	
Endosulfan sulfate							~1E–02	
Endrin				~4E–02	~3E–02	~4E–02	~9E–01	
Endrin ketone						~4E–02		
Heptachlor					~1E–02			
Heptachlor epoxide				~4E–01	~4E–01	~3E–01		
Methoxychlor				~1E–01				
I/CDIs for carcinogens (pesticides and PCBs)								
4,4'-DDE				~1E–01	~1E–01	~8E–02	~5E+00	
Dieldrin				~5E+00	~8E+00			8E+00
Polychlorinated Biphenyls (PCBs)								
Aroclor-1248								
Aroclor-1254					~1E+01	~6E+00		
Aroclor-1260		~8E+00	~9E+00	~3E+00	~1E+01	~6E+00		

[a]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.
[b]Melton Hill Reservoir, above all DOE inputs, Anderson Country Filtration Plant.
[c]Melton Hill Reservoir, Oak Ridge Marina, above ORNL.
[d]Melton Hill Reservoir, above the city of Oak Ridge intake.
[e]Clinch River, downstream of ORNL.
[f]Clinch River, downstream of all DOE inputs.
[g]Poplar Creek, downstream of the ETTP.

lead, and mercury concentrations in fish tissue resulted in HQs greater than one. HQs greater than one for mercury were found in sunfish upstream and downstream of the ORR, catfish downstream of the ORR, and in sunfish found in Poplar Creek (PCK 2.2). An HQ greater than one for arsenic was estimated only for sunfish collected upstream from all DOE and ORNL discharge points; however, an HQ greater than one for lead was calculated for catfish collected from CRK 16, which is downstream from all DOE inputs. Hazard quotients greater than one for chlordane (alpha and gamma) were estimated in catfish samples collected at CRK 32; however, no catfish samples were collected upstream of DOE and ORNL discharge points. In many cases, the hazard quotients, especially for pesticides in sunfish, 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 one indicate a risk greater than 10^{-5}. In sunfish collected upstream and downstream of ORR, I/CDIs greater than one were estimated for Aroclor-1260, a PCB. In sunfish collected downstream of ORR, I/CDIs greater than one were also estimated for 4,4′-DDE, dieldrin, and Aroclor-1254, also a PCB. For catfish, I/CDIs greater than one were estimated for 4,4′-DDE, dieldrin, and Aroclor-1254 and Aroclor-1260 (PCK 2.2). In many cases, the tissue concentrations of PCBs, 4,4′-DDE, and dieldrin were estimated at or below the analytical detection limit. Because of analytical detection limitations, the actual fish tissue concentrations are unknown (an exception is the average dieldrin concentration in the catfish tissue samples collected at CRK 16).

7. Groundwater

W. K. Jago, R. S. Loffman, and C. A. Motley

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 the 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 [15 to 50 m (50 to 175 ft) 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

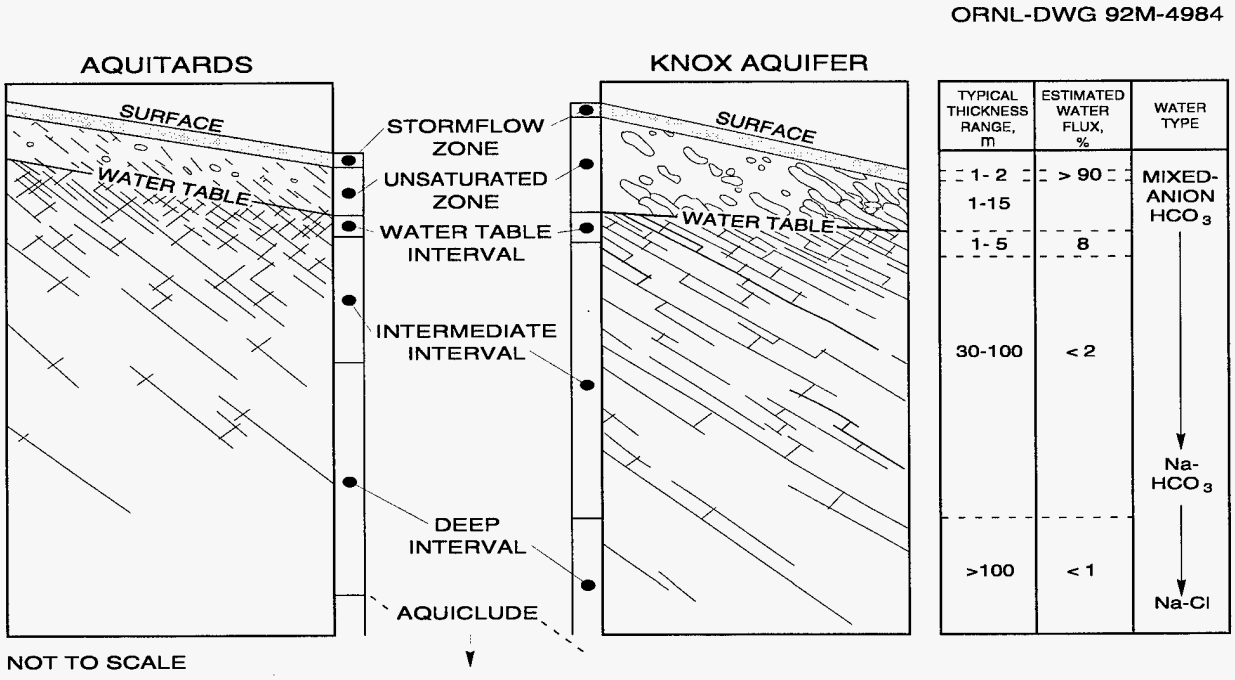

Fig. 7.1. Vertical relationships of flow zones of the ORR: estimated thicknesses, water flux, and water types.

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 1- to 6-m-thick (3- to 20-ft) layer of closely spaced, well-connected fractures near the water table (the water table interval) as shown in Fig. 7.3.

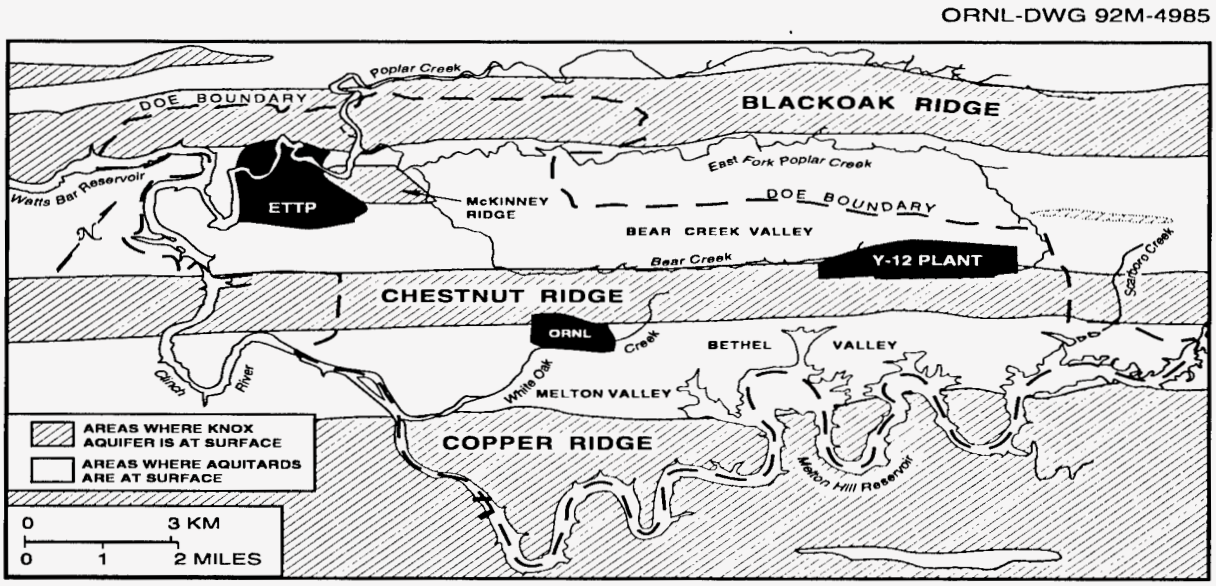

Fig. 7.2. The Knox Aquifer and the aquitards on the Oak Ridge Reservation.

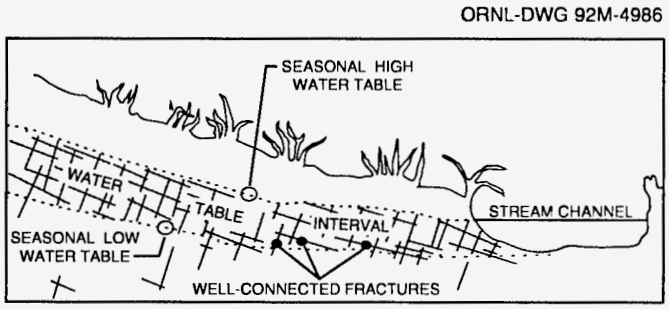

Fig. 7.3. Water table interval.

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 5.3 m (17 ft), 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 125 and 244 m (400 and 800 ft) in Melton and Bethel valleys, respectively (near ORNL), and it is believed to approach 305 m (1000 ft) 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 366 m (1200 ft); 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 15 to 30 m (50 to 100 ft) 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 1.6 km (2 miles) 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 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 VOCs are more dense than water, and there is little dilution.

7.1.5 Groundwater Monitoring Program 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 each ORR facility is coordinated through a site-level groundwater program. The site-level programs provide oversight for surveillance and effluent monitoring and coordination of monitoring required under CERCLA drivers. An integrated water quality program has been established at the DOE level to track and prioritize CERCLA monitoring across all of the ORR facilities. QC procedures for every aspect of data collection and analysis have been established, and data bases are used to organize and report analytical results.

Although the groundwater surveillance monitoring program for the ORR is disposal site- and facility-specific, it contains a number of common components that are interrelated and coordinated to allow both time- and cost-effective project management.

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 1996:

- monitoring to comply with requirements of RCRA interim-status and postclosure regulations,
- monitoring to support CERCLA RI/FS efforts and RODs,
- compliance with TDEC solid waste management (SWM) regulations,
- monitoring to support DOE Order 5400.1 requirements (exit-pathway and surveillance monitoring), and
- monitoring to support best management practices.

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, Oil Landfarm, New Hope Pond, Chestnut Ridge Security Pits, 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 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.

Additional primary regulatory drivers for groundwater monitoring at the Y-12 Plant are the TDEC regulations governing nonhazardous SWDFs and TDEC regulations governing petroleum USTs. 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. Groundwater monitoring to support the petroleum UST program at the Y-12 Plant has progressed past the assessment phase into the corrective action phase, which requires only limited monitoring and is no longer included under the comprehensive 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 concentra-

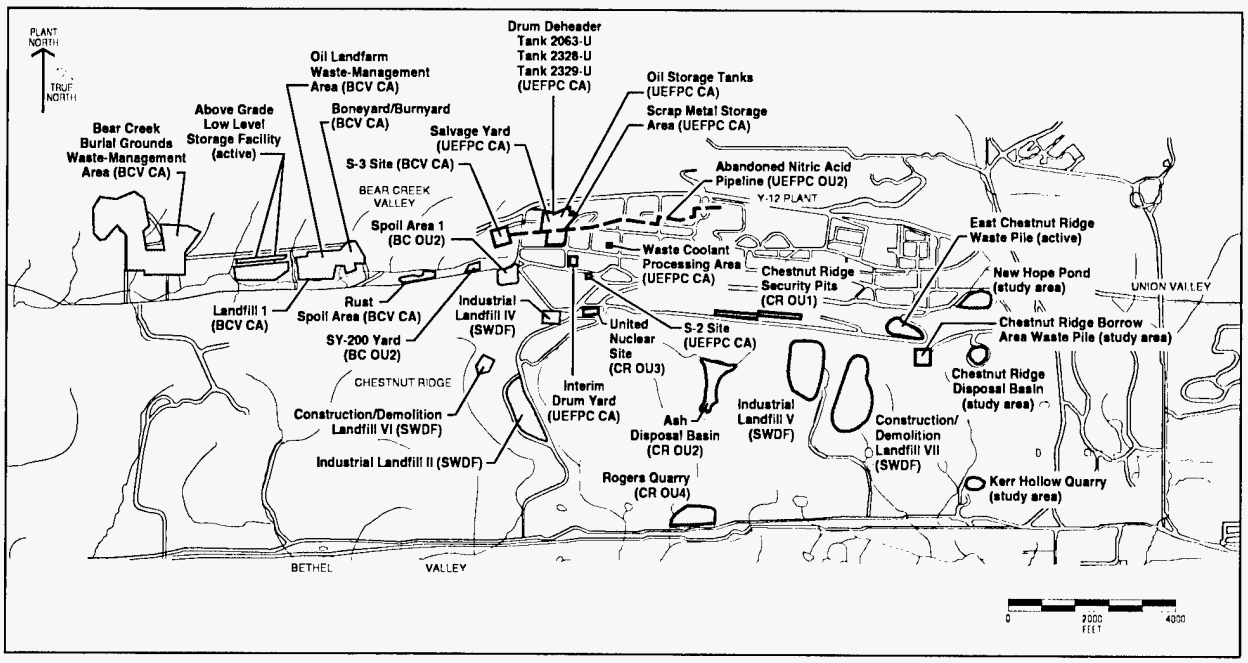

Fig. 7.4. Y-12 Plant inactive regulated units, study areas, and active facilities for which groundwater monitoring was conducted in CY 1996.

tions specifically to augment regulatory and exit-pathway monitoring programs. BMP monitoring is conducted at a number of selected sites or locations either at the request of internal organizations or of TDEC/DOEO, or in lieu of regulatory monitoring required at active facilities.

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 Chestnut Ridge 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.

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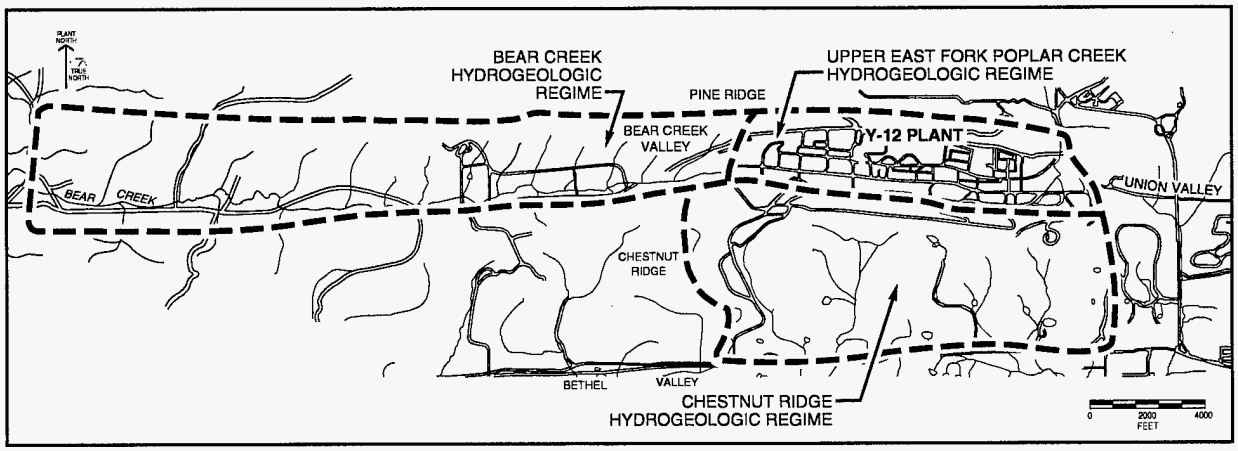

Fig. 7.5. Hydrogeologic regimes at the Y-12 Plant.

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 contami-

nants (other than nitrate and possibly ^{99}Tc) are no longer easily associated with a single source.

7.2.3 1996 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.

One new monitoring well was installed in CY 1996 southwest of the Chestnut Ridge Security Pits for compliance monitoring. Eight piezometers were installed in the vicinity of the S-3 Site and Oil Landfarm waste management area to gather additional data on groundwater table levels. One specially designed, large diameter shallow well was installed near New Hope Pond for conducting aquifer characterization and evaluating the feasibility of groundwater extraction and treatment.

The Y-12 Plant GWPP conducts well plugging and abandonment activities 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 1996, 32 wells were plugged and abandoned. These wells were located along lower EFPC, at the Ash Disposal Basin, and in the extreme western portion of the Bear Creek regime. The wells were plugged and abandoned because they impeded remedial actions, were in poor condition, had a historical lack of security or identity, or had no identifiable future use.

7.2.4 1996 Monitoring Program

Groundwater monitoring in 1996 addressed multiple requirements from regulatory drivers, DOE orders, and BMPs. 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 site.

Figure 7.6 shows the locations of ORR perimeter 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 1997b, 1997c, and 1997d). Details of small-scale monitoring efforts performed outside the scope of the comprehensive monitoring program specifically for CERCLA OUs are published in RI reports.

7.2.5 Y-12 Plant Groundwater Quality

7.2.5.1 Upper East Fork Poplar Creek Hydrogeologic Regime

The 1996 monitoring locations, waste management sites, and petroleum fuel USTs 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 on 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

Table 7.1. Summary of the comprehensive groundwater monitoring program at the Y-12 Plant, 1996[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	8
Maynardville Limestone	EXP/RCRA-CM	21
Oil Landfarm	RCRA-CM/SMP	9
Rust Spoil Area	SMP	1
S-3 Site	RCRA-CM	4
Spoil Area I	SMP	1
Y-12 Burial Grounds	RCRA-CM/SMP	14
Above-Grade Low-Level Storage Facility	BMP	3
East Fork Poplar Creek Hydrogeologic Regime		
Springs/Seeps	EXP/RIFS	2
Maynardville Limestone	EXP/RCRA-CM	10
Scarboro Road north of Y-12	EXP	3
S-3 Site Eastern Plume	RCRA-CM	2
Y-12 Plant –Active Facilities –S-2 Site –Rust Garage –Waste Coolant Area –Salvage Yard –Fire Training Facility –Beta-4 Security Pits –Grid Network	SMP/BMP/RIFS	47
New Hope Pond	RCRA-AM/SMP	13
Union Valley	EXP/RIFS	10
UEFPC Diversion Channel	RIFS	1
Chestnut Ridge Hydrogeologic Regime		
Springs	EXP	1
Surface Water	ROD	1
Ash Disposal Basin	BMP	4
Chestnut Ridge Security Pits	RCRA-AM/CM	11
East Chestnut Ridge Waste Pile	BMP	4
Kerr Hollow Quarry	RCRA-DM	7
Landfill II	SWDF	3
Chestnut Ridge Borrow Area Waste Pile	BMP	6

Table 7.1 (continued)

Hydrogeologic regime/waste disposal site	Requirements[b]	Number of wells/locations
Landfill IV	SWDF	5
Landfill V	SWDF	4
Landfill VI	SWDF	7
Landfill VII	SWDF	6
Rogers Quarry	BMP	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-AM = RCRA Assessment Monitoring at interim status units; RCRA-DM = RCRA Detection Monitoring; RCRA-CM = RCRA post-closure 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.

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 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 1996 groundwater monitoring program in the East Fork regime were (1) to further define contaminant nature and extent, (2) to evaluate potential contaminant exit pathways for both CERCLA RI and RCRA postclosure technical objectives, and (3) to trend contaminant levels over time. Locations of monitoring stations are shown in Fig. 7.7.

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 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,

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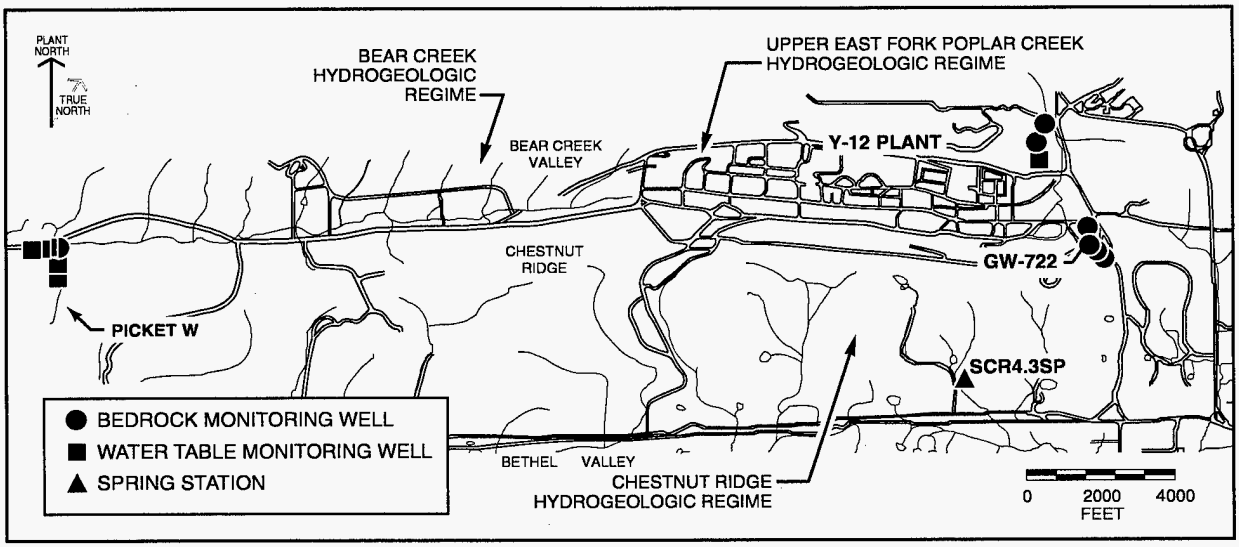

Fig. 7.6. Locations of ORR perimeter surveillance wells and multiport monitoring wells specified in the *Environmental Monitoring Plan (Rev. 1).* Well GW-722 is a multiport monitoring well that is also designated as a perimeter surveillance well.

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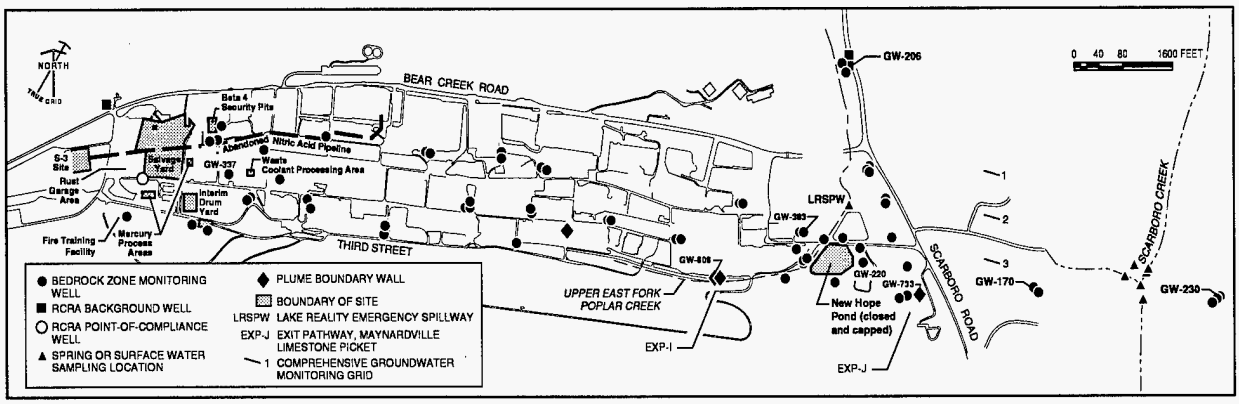

Fig. 7.7. Locations of waste management sites and monitoring wells sampled during 1996 in the Upper East Fork Poplar Creek Hydrogeologic Regime.

several sites located within the Y-12 Salvage Yard, the Waste Coolant Processing Area, petroleum USTs, and process/production buildings in the plant.

Nitrate

Nitrate concentrations exceed the 10 mg/L maximum contamination level in a large part of the western portion of the East Fork regime (Fig. 7.8). (A complete list of DWSs is presented in Appendix D.) 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, the nitrate plume extends about 2500 ft (762.5 m) eastward from the S-3 Site to just downgradient of the S-2 Site. Nitrate has traveled farthest in groundwater in the Maynardville Limestone. Although the nitrate

Table 7.2. Regulatory status and operational history of waste management units and underground storage tanks included in the 1996 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.

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.

Trace Metals

Concentrations of barium, cadmium, chromium, and lead exceeded MCLs during 1996 in samples collected from various monitoring wells at the S-2 Site, the Y-12 Salvage Yard, the Waste Coolant Processing Area, 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) 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 and GW-733) east of New Hope Pond, have

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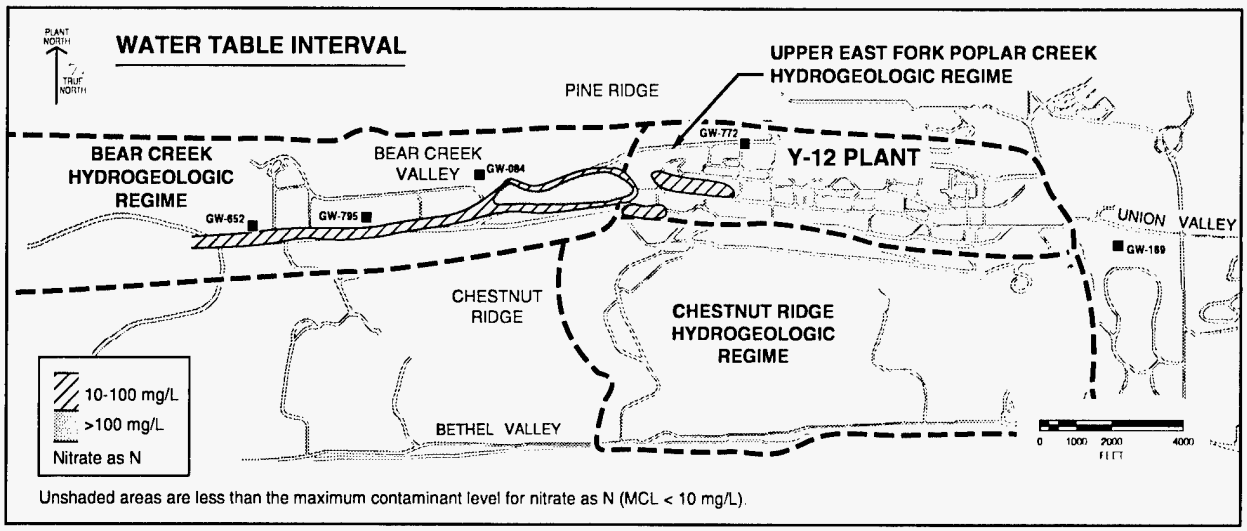

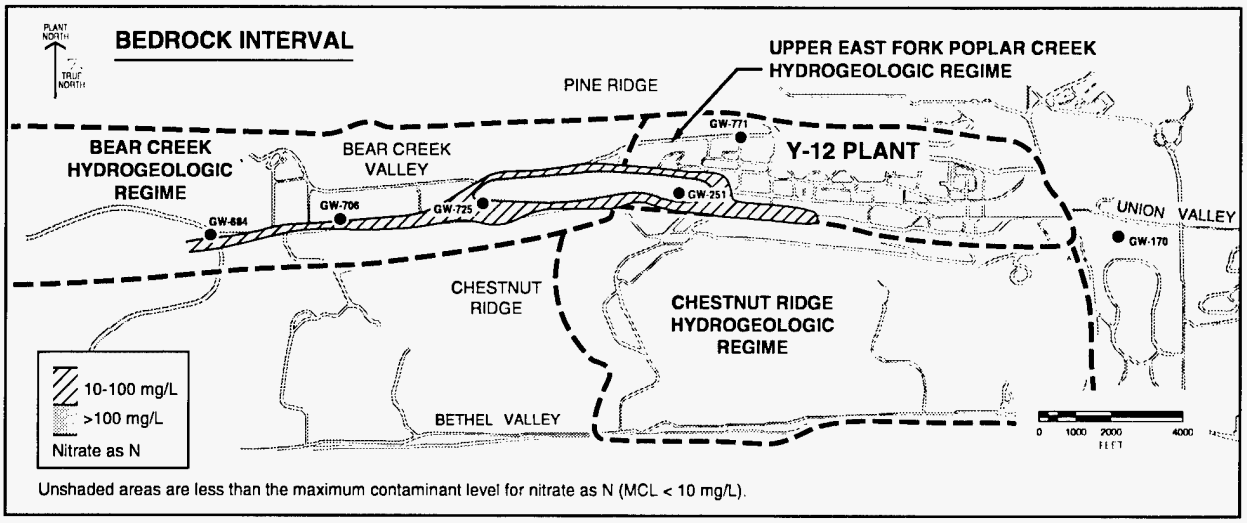

Fig. 7.8. Nitrate (as N) observed in groundwater at the Y-12 Plant.

shown increasing VOC concentrations, indicative of an easterly movement of part of the plume (Fig. 7.10). Data show that VOCs are the most extensive in shallow groundwater; however, data indicate that 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).

The 1996 monitoring results generally confirm findings from the previous five 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 (perchloroethene, trichloroethene, dichloroethene, and vinyl chloride) tend to dominate the VOC plume composition in the western and central portions of the Y-12 Plant. However, perchloroethene and isomers of dichloroethene are almost ubiquitous

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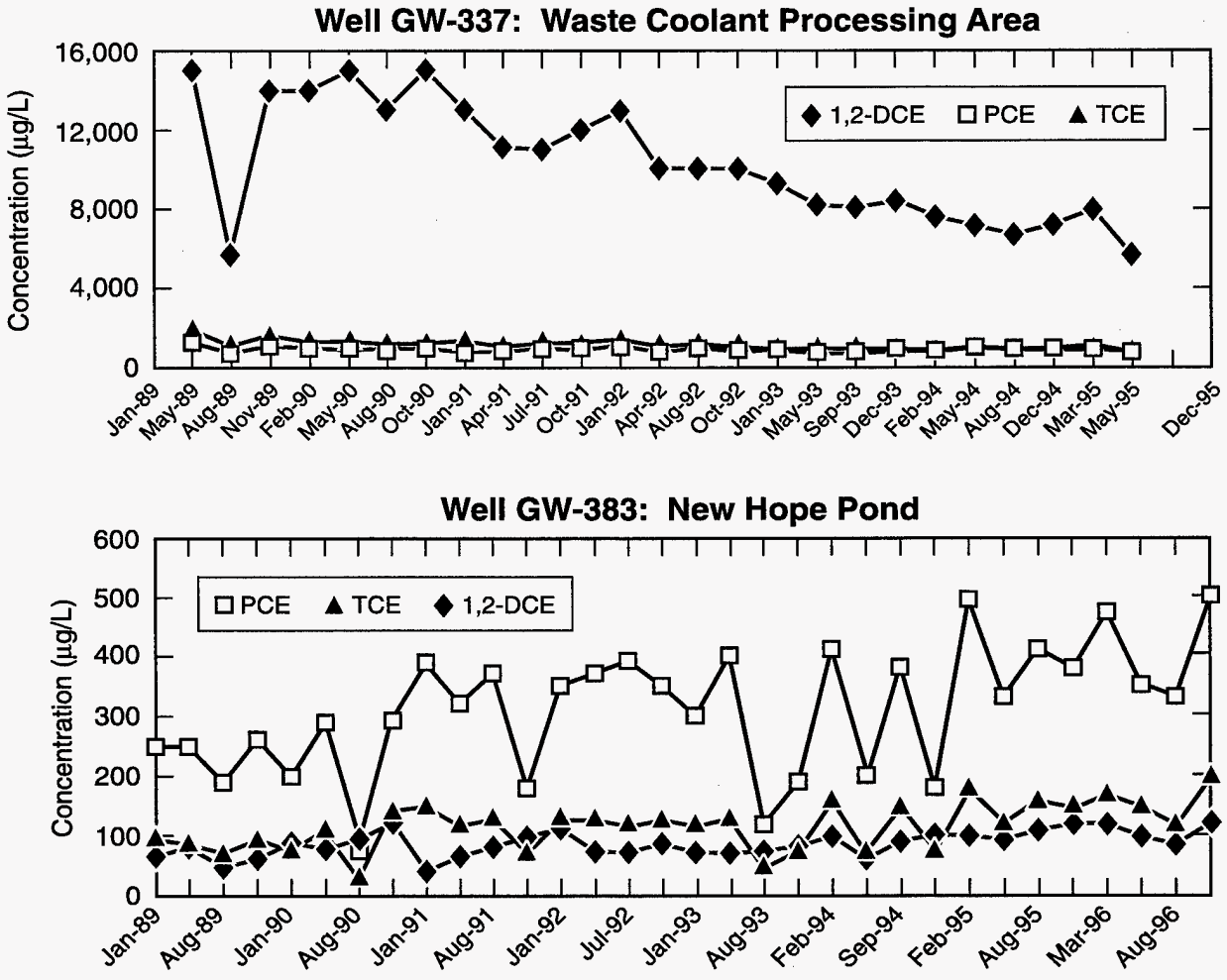

Fig. 7.9. Quarterly VOC concentrations in groundwater in selected wells in East Fork regime. 1,2-DCE: 1,2-dichloroethene; PCE; perchloroethene; TCE: trichloroethene.

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

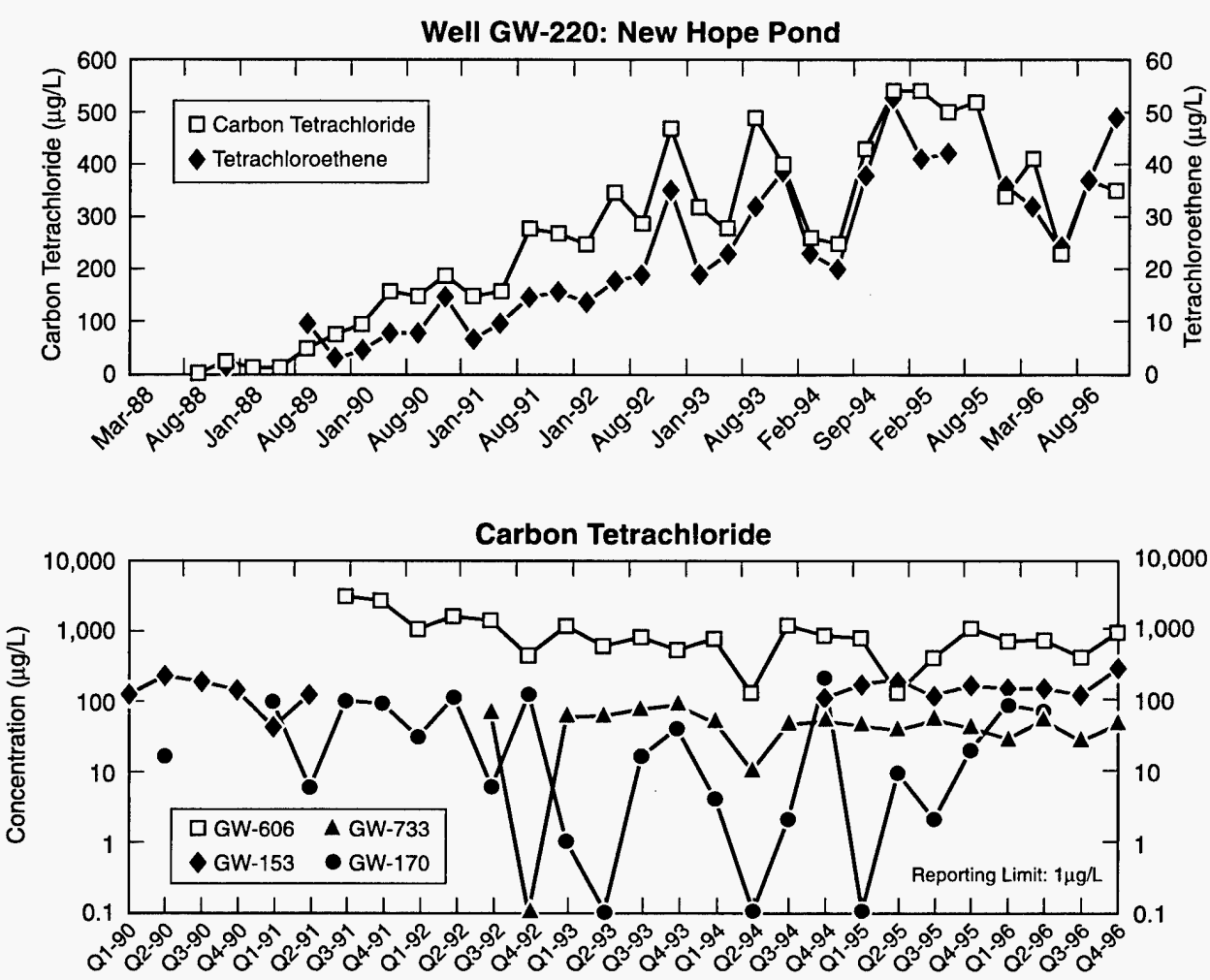

Fig. 7.10. Quarterly VOC concentrations in selected wells near New Hope Pond and exit-pathway wells.

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. Also, consistent with historical patterns, elevated gross beta activity was observed in an area immediately west of New Hope Pond within the Maynardville Limestone. Elevated sporadic gross alpha and beta activity observed in 1994 in off-site exit-pathway wells GW-169 and GW-170, located in Union Valley, was not observed during 1995 or 1996.

Exit-Pathway and Perimeter Monitoring

Exit-pathway groundwater monitoring activities in the East Fork regime in 1996 involved continued collection and trending of data from exit-pathway monitoring stations. In addition, data collected under the scope of the UEFPC remedial investigation (RI) were integrated into evaluations of contaminant exit pathways. The RI effort included sampling of springs, seeps, surface

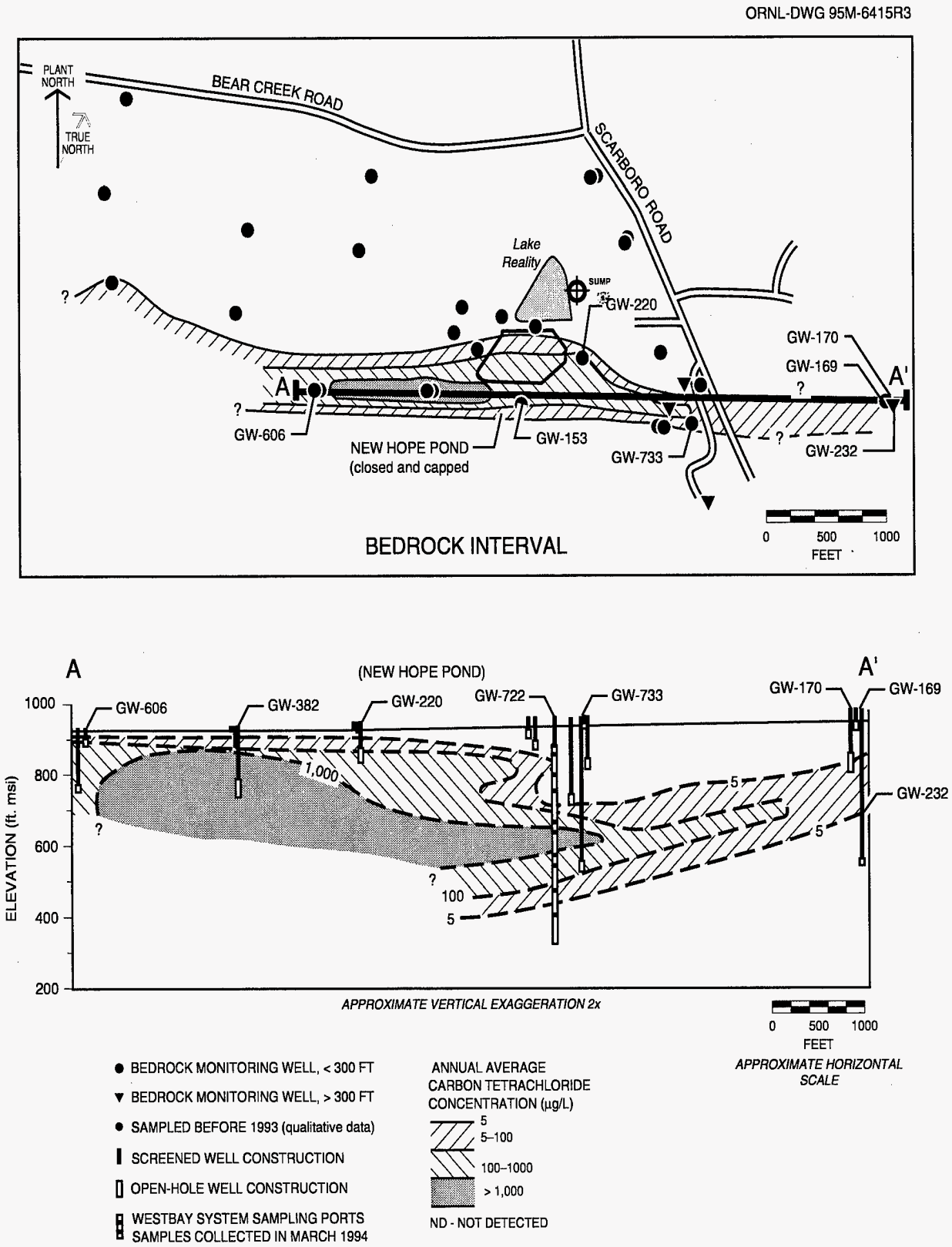

Fig. 7.11. VOC concentrations in Maynardville Limestone at depths between 200 and 500 ft.

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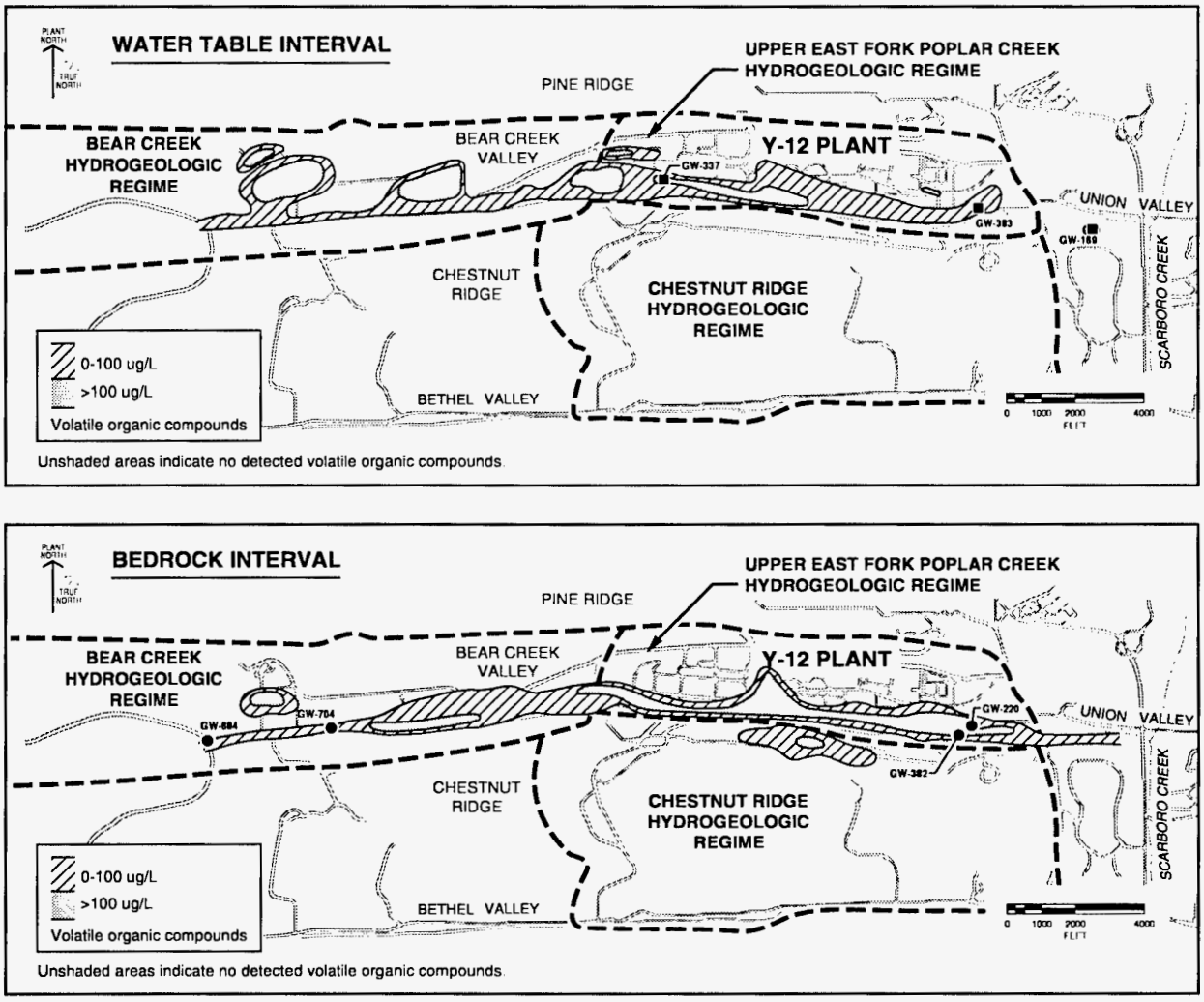

Fig. 7.12. Summed VOCs in groundwater at the Y-12 Plant.

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 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).

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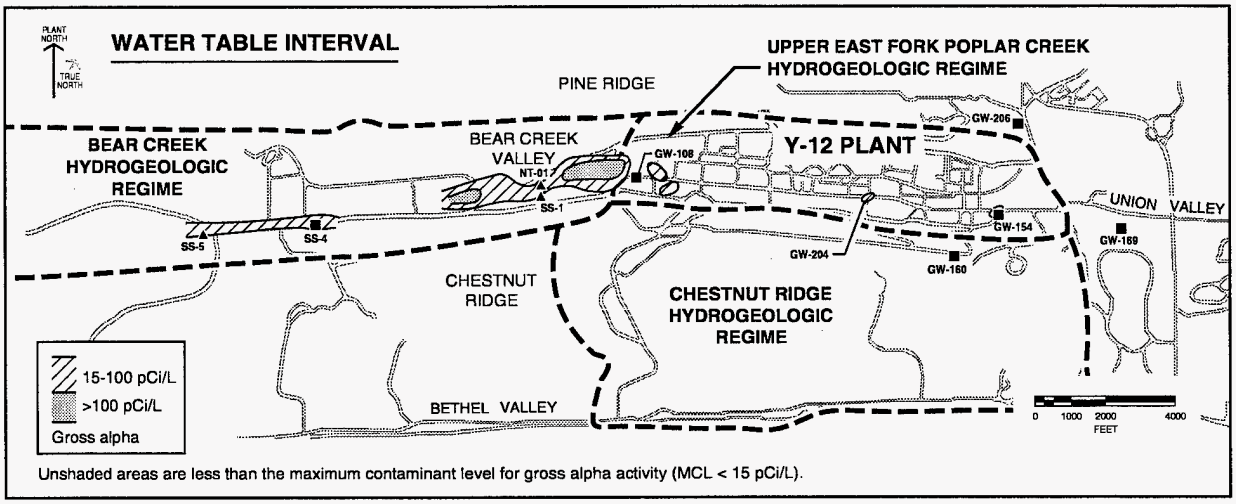

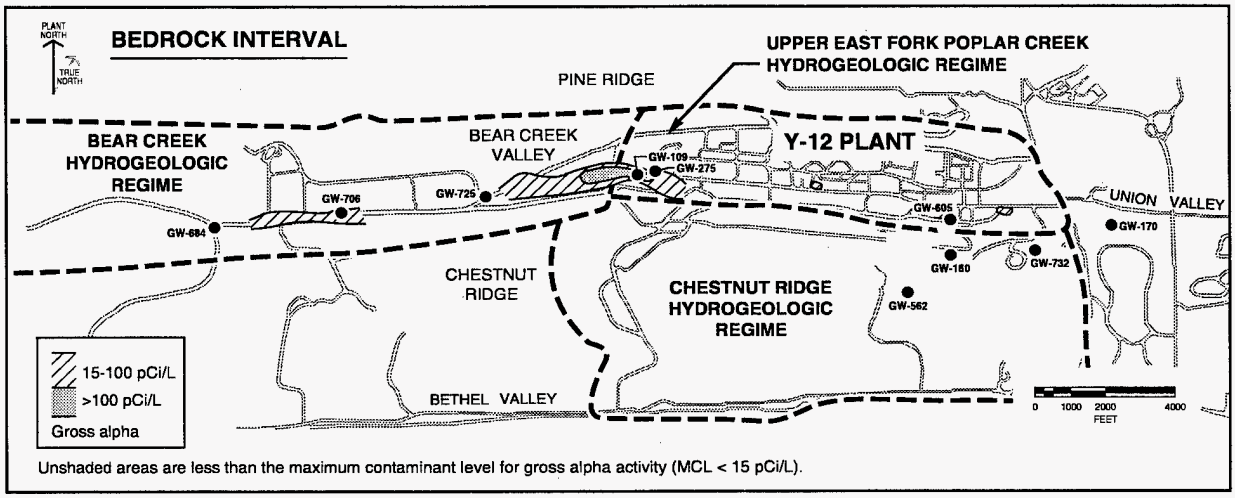

Fig. 7.13. Gross alpha activity in groundwater at the Y-12 Plant.

In addition to the deep pathways within the Maynardville Limestone, two other groundwater exit pathways are also monitored. The first of these is a gravel fill material that was emplaced beneath a concrete diversion channel for UEFPC constructed in the late 1980s. The diversion channel runs from the eastern portion of the Y-12 Plant to the east of New Hope Pond and discharges to Lake Reality. The gravel fill is located within the water table interval and is highly permeable. Part of the monitoring actions for the UEFPC RI have focused on this exit pathway. Monitoring results from a well installed into the fill and seepage points at its terminus showed low but consistent carbon tetrachloride levels. Thus, the diversion channel acts as a preferential pathway for groundwater and contaminant migration.

Groundwater movement and contaminant migration along the diversion channel also appear to be accelerated by the effects of a large dewatering sump located near Lake Reality. Past studies have shown that when this 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. Shallow to intermediate depth wells located in this area (well GW-220) show

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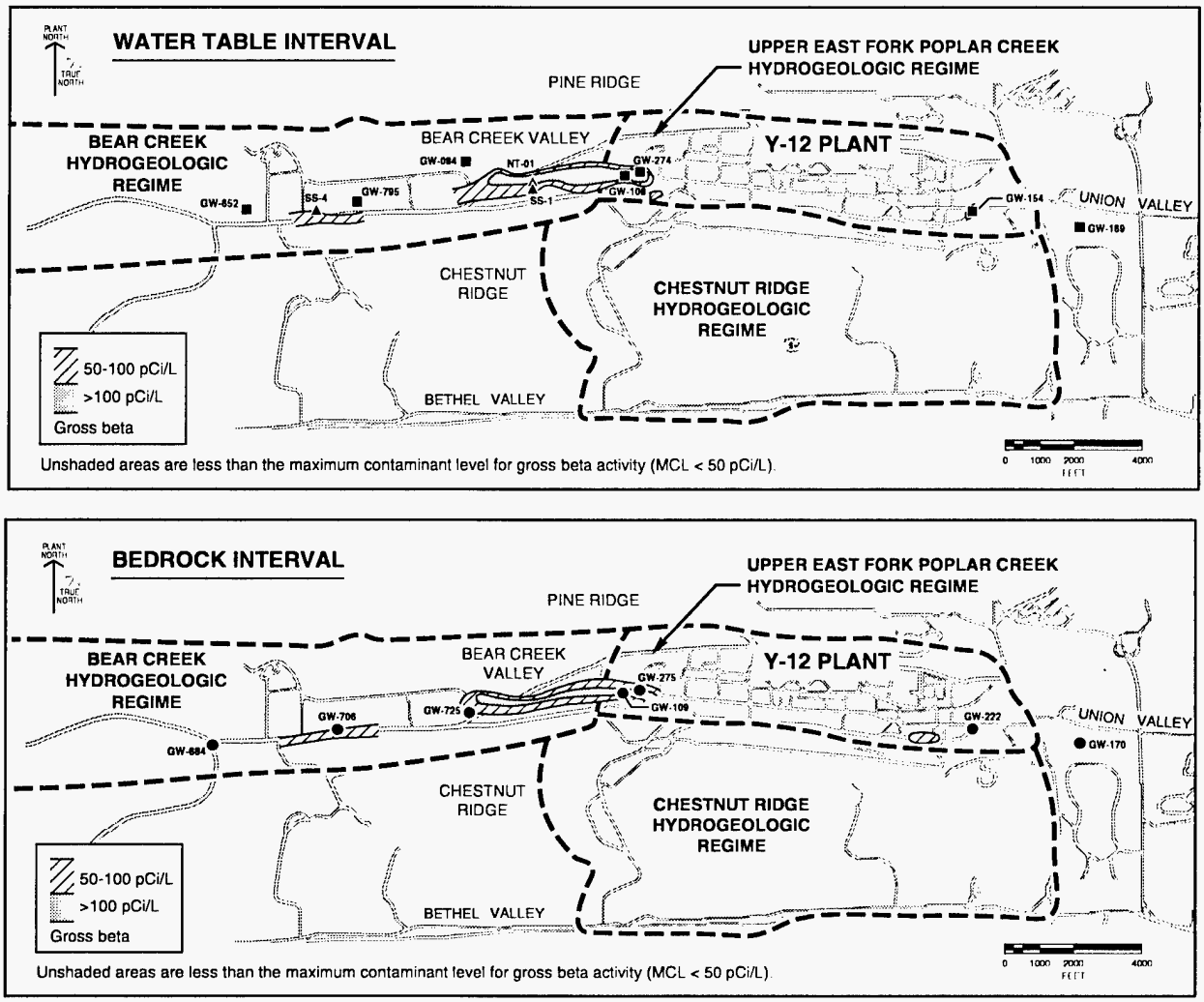

Fig. 7.14. Gross beta activity in groundwater at the Y-12 Plant.

increasing concentrations of VOCs over time (Fig. 7.10).

The second exit pathway that is monitored is the large gap in Pine Ridge through which UEFPC exits the Y-12 Plant. Three wells are located in this water gap that 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 since about 1990 has shown no contaminants moving via this exit pathway.

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 1996, monitoring of numerous locations continued under the lead of the ER Program. 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 1996, 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 draft RI report has been issued to TDEC and EPA for technical review and comment. Upon completion of the regulatory agency review and incorporation of comments, the document will be released for public use. The RI report will contain a detailed description of site history, nature and extent of contamination, and human health and ecological risk assessments.

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 composite monitoring network of 53 wells, 3 springs, and 8 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 1996 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, 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.

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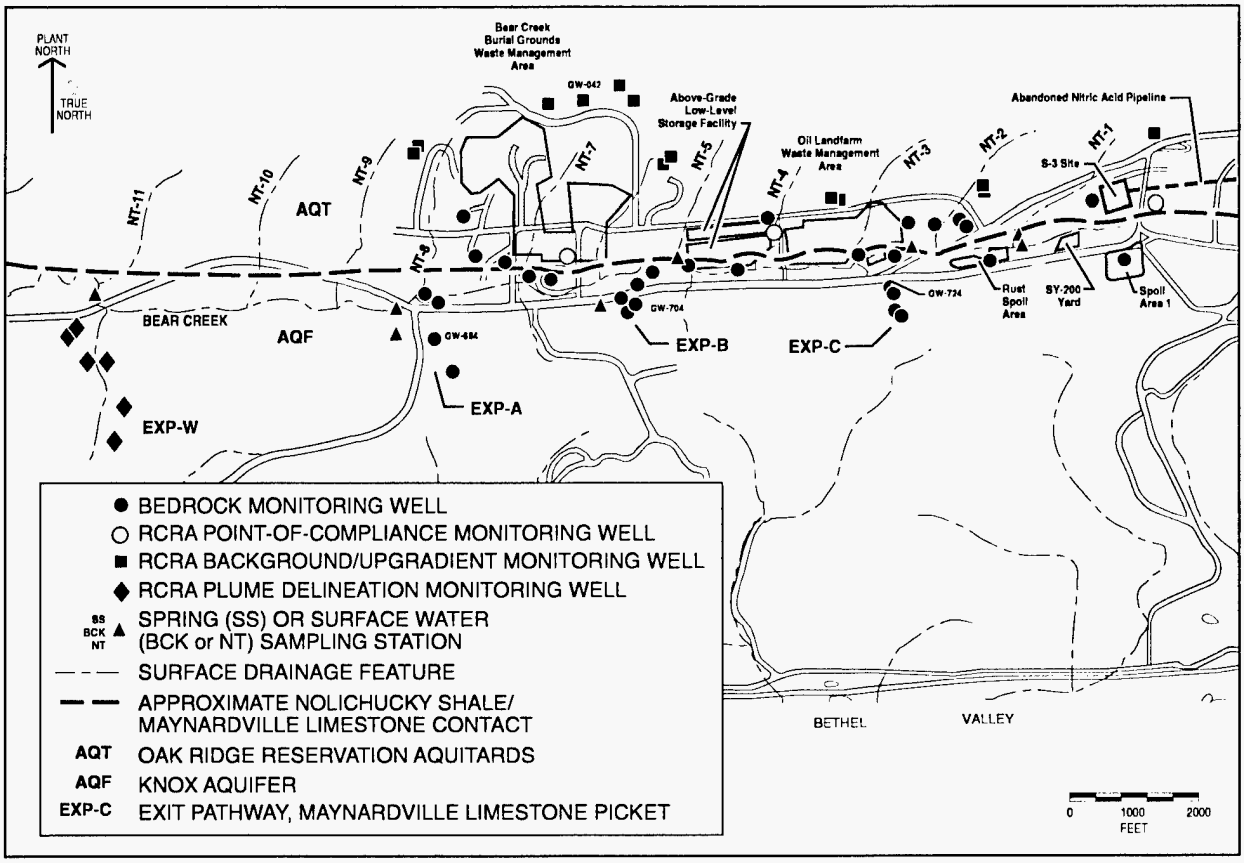

Fig. 7.15. Locations of waste management sites and monitoring wells sampled during 1996 in the Bear Creek Hydrogeologic Regime.

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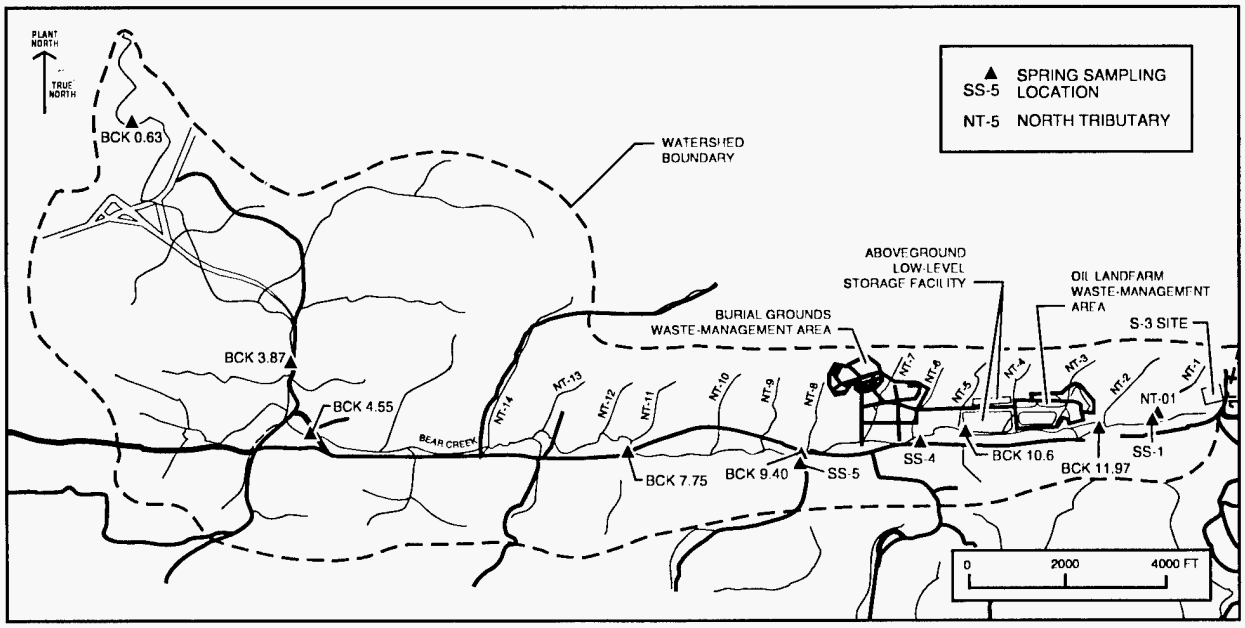

Fig. 7.16. Surface water and spring stations sampled during 1996 in the Bear Creek Hydrogeologic Regime.

Table 7.3. Regulatory status and operational history of waste management units included in the 1996 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.

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 concentrations near source areas within the ORR Aquitards have remained relatively constant since 1986. 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. 7.17), 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 1996 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

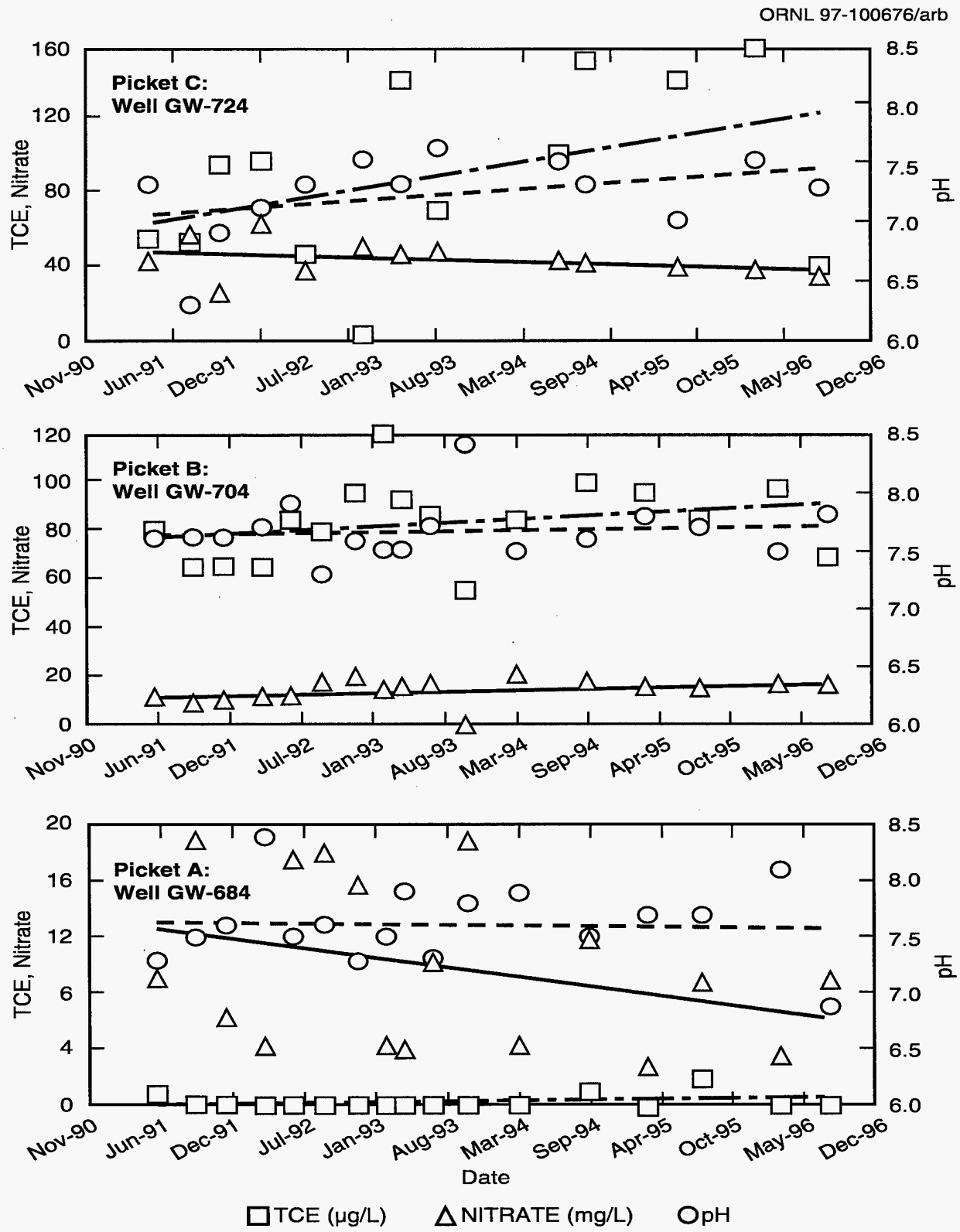

Fig. 7.17. Concentrations of selected contaminants in exit-pathway monitoring wells GW-724, GW-704, and GW-684 in the Bear Creek Hydrogeologic Regime.

ground surface within the ORR aquitards at the S-3 Site. During 1996, the highest nitrate concentrations continued to be seen 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.

The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper part of the aquifer [less than 200 ft (61 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.

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, Bear Creek Burial Grounds, and 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 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.

Significant transport of the 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 (3,660 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 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.

Radionuclides

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 1996 were based primarily on measure-

ments 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, the southern sides of the Bear Creek Burial Grounds, and east of the Oil Landfarm waste management areas. Gross alpha activities near the S-3 site source appear to be increasing, while gross beta activity is decreasing. 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 (3,050 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 1996 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 1996 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.

Surface water and spring samples collected during CY 1996 (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. 7.18).

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 7.19 shows the approximate boundaries of the regime and locations of waste management units and monitoring wells sampled in 1996.

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 SDWFs, and (4) CERCLA OUs. The Chestnut Ridge Security Pits is the only documented source of groundwater contamination in the regime. No integrating CA

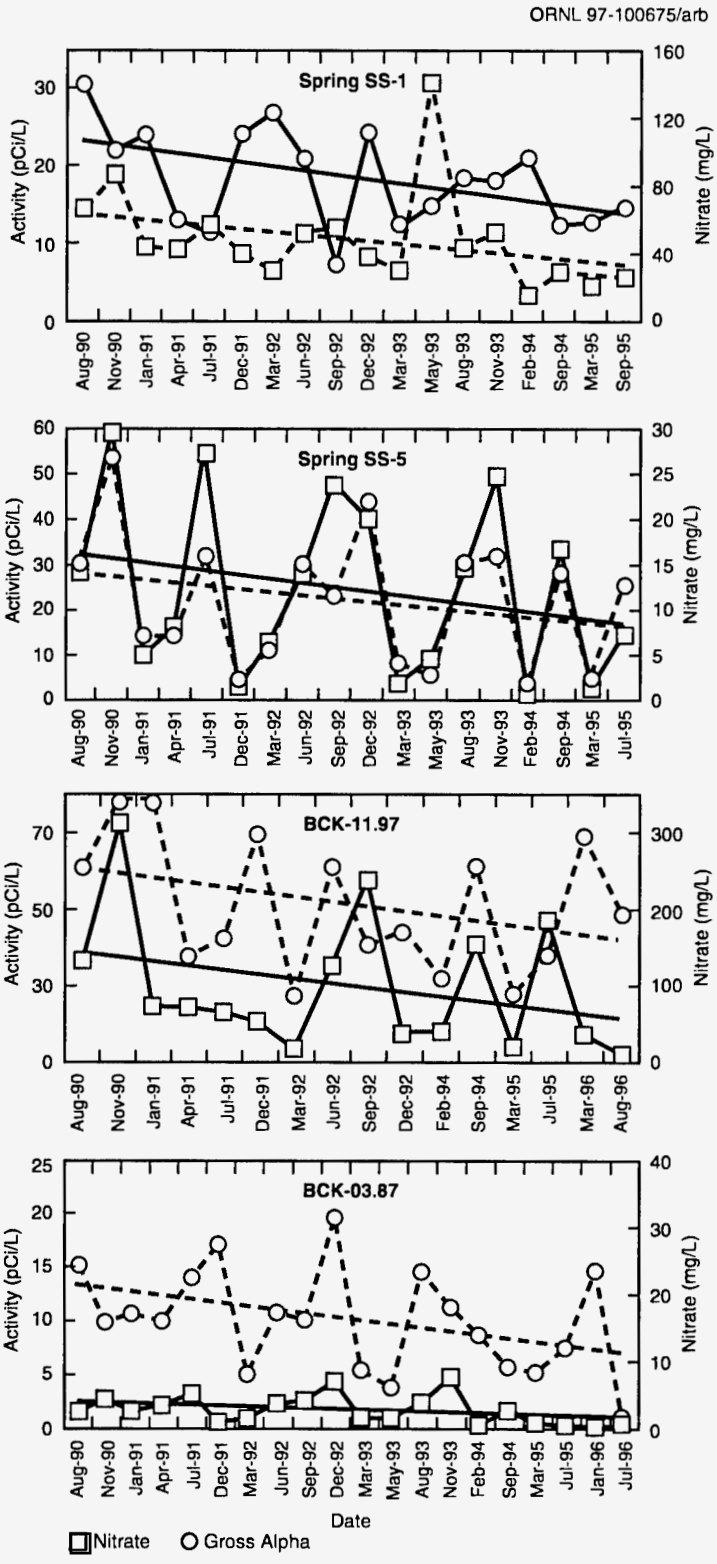

Fig. 7.18. Concentrations of selected groundwater contaminants in springs and surface water in the Bear Creek Hydrogeologic Regime (refer to Fig. 7.16 for station locations).

has been established for the regime because contamination from the Security Pits is distinct and is not mingled with plumes from other sources. Analytes found in groundwater will be addressed as part of the RI/FS for each source. 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.

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 in which findings 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 Chestnut Ridge Sediment Disposal Basin, United Nuclear Site, Industrial Landfill III, and Kerr Hollow Quarry, although no discernable pattern or consistency to the data has been determined.

All units in the Chestnut Ridge regime, with the exception of the Chestnut Ridge Security Pits and the United Nuclear Site, are monitored under either a regulatory detection monitoring program or as a BMP. 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 1996, 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

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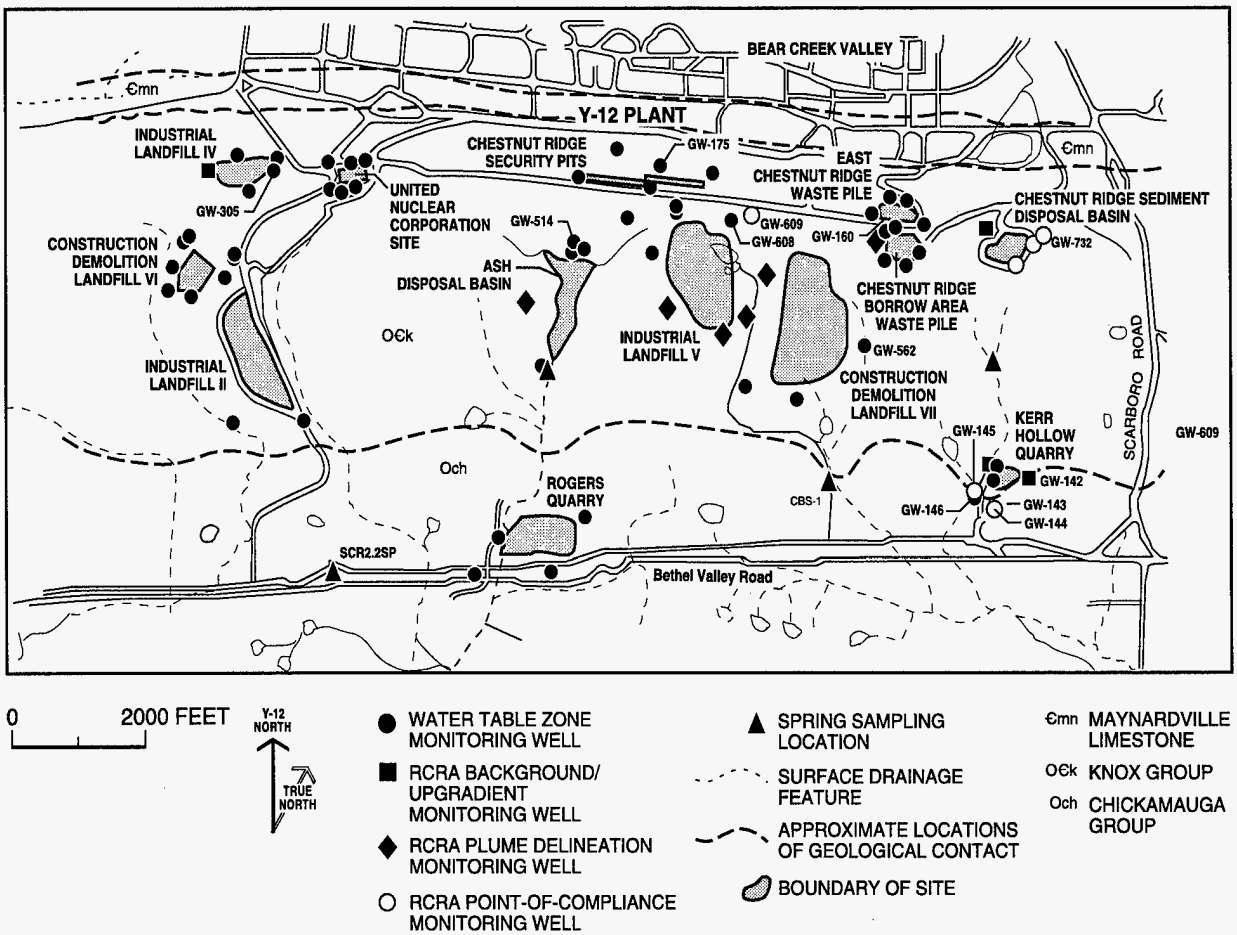

Fig. 7.19. Locations of waste management sites and monitoring wells sampled during 1996 in the Chestnut Ridge Hydrogeologic Regime.

ROD. Plume delineation and contaminants of interest are discussed in the following sections. Two additional issues are also discussed. These two issues include the occurrence of trace levels of VOCs, total strontium, and total uranium at Kerr Hollow Quarry and the occurrence of VOCs in one well located at Industrial Landfill IV.

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 1996 continues to indicate that the lateral extent of the VOC plume at the site is increasing slightly, as evidenced by detectable signature VOCs (1,1,1-trichloro-ethane) in wells GW-608, GW-609, GW-514, GW-796, and GW-175.

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.

Table 7.4. Regulatory status and operational history of waste management units included in the 1996 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.
East Chestnut Ridge Waste Pile	TSD/TSD	Lined, RCRA-interim status hazardous waste storage facility for contaminated soils from the Y-12 Plant.
Ash Disposal Basin	SWMU/CR OU 2	Used until 1967. Site received Y-12 Steam Plant coal ash slurries. Leaching of metals to groundwater are of concern. A CERCLA ROD has been issued.
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.
Rogers Quarry	SWMU/CR OU 4	Used from 1960s until 1993 for disposal of steam-plant coal ash and process debris. Metals contaminants are of primary concern.
Chestnut Ridge Borrow Area Waste Pile	Not regulated/Study Area	Contains soils from off-site locations in Oak Ridge bearing low levels of mercury and other metals.
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 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
Industrial Landfill V	TDEC-permitted Class II industrial SWDF	New facility completed 4/94. Baseline groundwater monitoring began 5/93 and was completed 1/95. Currently under TDEC-SWM detection monitoring.
Construction/Demolition Landfill VI	TDEC-permitted Class IV construction/demolition SWDF	New facility completed 12/93. Baseline groundwater quality monitoring began 5/93 and was completed 12/93. Waste disposal began 4/94. Currently under permit-required detection monitoring per TDEC.
Construction/Demolition Landfill VI	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. Currently under permit-required detection monitoring per TDEC.

[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).

Nitrate

Nitrate concentrations were well below the DWS of 10 mg/L at all monitoring stations.

Trace Metals

Chromium, lead, nickel, arsenic, barium, and cadmium concentrations sporadically exceeded DWSs in a number of wells during 1996. 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; no releases of metals contamination were confirmed. Total strontium and total uranium levels continued to be elevated above background levels at wells GW-142, GW-143, GW-145, and GW-146 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 1996.

Volatile Organic Compounds

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 (Table 7.5). Well GW-305 (Fig. 7.19) located immediately to the east of Industrial Landfill IV has shown low levels of VOCs since the first quarter of 1992 (exclusively 1,1,1-trichloroethane until the fourth quarter of 1996). Concentrations of the VOCs have remained well below applicable DWSs, although an upward trend is evident over time.

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, therefore, not the most feasible explanation. Additional monitoring data are being reviewed

Table 7.5. Annual average summed VOC concentrations in groundwater at the Chestnut Ridge Security Pits

Well number	Summed average VOCs[a] (μg/L)								Percentage decrease
	1989	1990	1991	1992	1993	1994	1995	1996	
GW-173	17.0	13.5	11.8	11.7	NS	NS	NS	NS	31
GW-174	47.8	48.5	43.7	34.0	NS	NS	NS	14	71
GW-175	31.8	38.5	31.0	29.5	17.0	25.3	21.5	13	59
GW-176	285.3	233.5	170.5	139.7	NS	NS	NS	NS	51
GW-177	66.7	18.8	26.3	25.5	33.0	28.3	24.3	22	67
GW-178	43.4	40.0	34.0	29.0	NS	NS	NS	NS	32
GW-179	838.0	455.0	328.3	262.3	NS	NS	NS	NS	69
GW-180	145.8	99.5	74.2	52.3	NS	NS	NS	NS	64
GW-322	696.0	730.3	633.0	538.3	NS	NS	NS	NS	23
GW-607	NS	16.9	ND	ND	ND	NS	NS	NS	100
GW-608	NS	14.8	15.5	(4.5)	(4.0)	(4.3)	(0.8)	(12)	19
GW-609	NS	78.0	67.5	35.5	28.4	54.5	28.5	20	74
GW-610	NS	1.0	0.5	ND	ND	(0.3)	ND	ND	100
GW-611	NS	16.0	9.0	13.5	10.5	12.4	5.5	(5)	69
GW-612	NS	505.8	451.3	358.3	NS	NS	NS	266	47
GW-742	NS	NS	NS	ND	ND	ND	ND	ND	–
GW-743	NS	NS	NS	ND	ND	ND	(2)	ND	–

[a]NS = not sampled, ND = not detected, and ( ) = qualitative result; summed average determined exclusively from estimated concentrations reported below the reporting limit.

and collected in the area to attempt to establish the source of the VOCs. Low levels of VOCs have also been observed at a few additional monitoring locations in 1996. Of particular note, trace levels of carbon tetrachloride continued to be observed in two samples from one Kerr Hollow Quarry monitoring well (Well GW-144).

Radionuclides

Only four samples exceeded the DWS of 15 pCi/L; 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-O 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).

On the ORR, monitoring of one large spring south of Industrial Landfill V and Construction/ Demolition Landfill VII was continued in 1996 at the request of the TDEC/DOE-O and as a BMP. 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 1996. These special projects may be divided into three general categories: technical studies, characterization activities, and technology feasibility studies/demonstrations.

Technical Studies

A plant-wide survey for dewatering sumps located within the Y-12 Plant was completed in 1996. Dewatering sumps are of interest because they may be influencing groundwater and contaminant migration. A number of large sumps were previously known to exist, and two of these were demonstrated to have a significant impact on shallow groundwater flow patterns. The data from the survey indicated that a number of additional sumps are located within the plant and may also have significant impact on contaminant transport patterns. Results of the survey and selection of sumps to be sampled have been provided to ongoing CERCLA RI programs for consideration as part of the scope of these activities.

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 is scheduled to be completed in 1997 and results will be incorporated into characterizations efforts of the UEFPC RI.

Characterization Activities

In addition to the routine effluent and surveillance monitoring, a plant-wide sampling effort was completed in 1996 in conjunction with the UEFPC CERCLA RI to collect detailed characterization data on the nature and extent of radioisotopes in groundwater. Groundwater samples and sediments extracted from groundwater were collected and analyzed for a comprehensive list of isotopes using methods capable of detecting very low activities. These data will be used as part of the CERCLA RI baseline risk assessment and in general groundwater quality evaluations.

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. The capture system will involve installation of a deep well 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. In addition, the 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 func-

tion 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. Design, installation, and testing of the concept are planned for 1997. Groundwater contaminants will be treated using a mobile air-stripper unit. If the feasibility study indicates the design to be successful, groundwater extraction and treatment will be seriously considered as a long-term remedial action.

A multiphase treatability study within the Bear Creek regime continued in 1996. 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 conducted in 1996 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 of the effort to begin in 1997 will involve collection of focused hydrologic data around the S-3 Site and evaluation of the feasibility of installing capture trenches and horizontal wells for shallow groundwater extraction and treatment.

Three additional special studies (termed technology demonstrations) of the applicability of groundwater and soils remedial technologies are currently in various planning stages. These efforts are conducted using DOE funds available to research promising remedial technologies or solutions to unique and complex contamination problems. One of the technology demonstrations involves removal of uranium from soils using electrokinetic methods. Field activities for this demonstration are scheduled to begin in 1997. The remaining two demonstrations will research trench capture and treatment technologies for shallow groundwater contamination.

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.

Recently there has been a shift away from the use of the WAG concept to more of a watershed approach to remediation. To provide continuity with previous reports and comparability of activities and sampling results, the following discussions 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 7.20 shows the location of each of the 20 WAGs.

For discussion purposes, the WAGs are grouped by the valley in which they are located: Bethel Valley WAGs include 1, 3, and 17; Melton Valley WAGs include 2, 4, 5, 6, 7, 8, and 9; and WAG 11 includes the White Wing Scrapyard.

The ORNL exit-pathway program, which is discussed later in this section, is designated to monitor groundwater at four general locations that are thought to be likely exit pathways for groundwater affected by activities at ORNL (Fig. 7.21). The locations are White Wing Scrap Yard, WOC/Melton Valley, West Bethel Valley, and East Bethel Valley.

7.3.1.1 Bethel Valley

WAG 1

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, and the demolition of the Waste Evaporator Facility (Building 3506) via a CERCLA removal action.

WAG 3

WAG 3 is located in Bethel Valley about 1 km (0.6 mile) 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

ORNL-DWG 87M-9552AR2

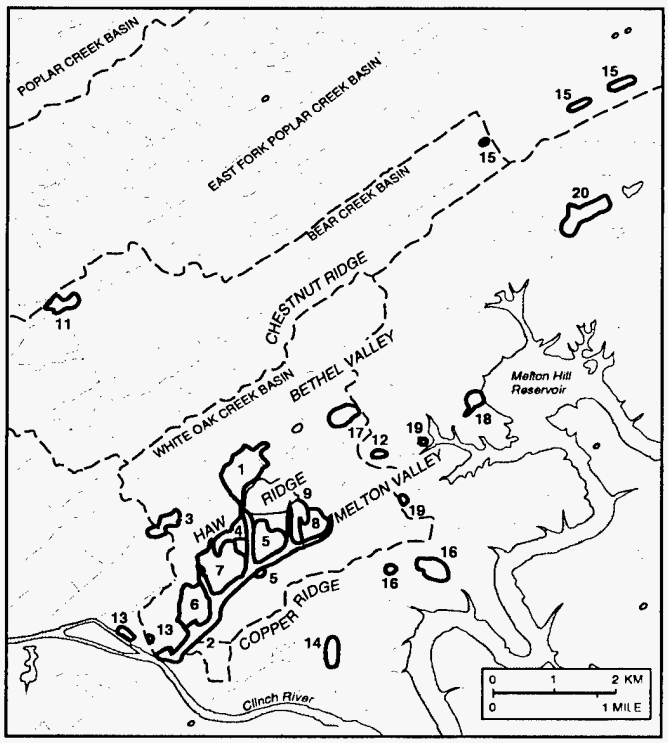

Fig. 7.20. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5.)

ORNL-DWG 93M-10468

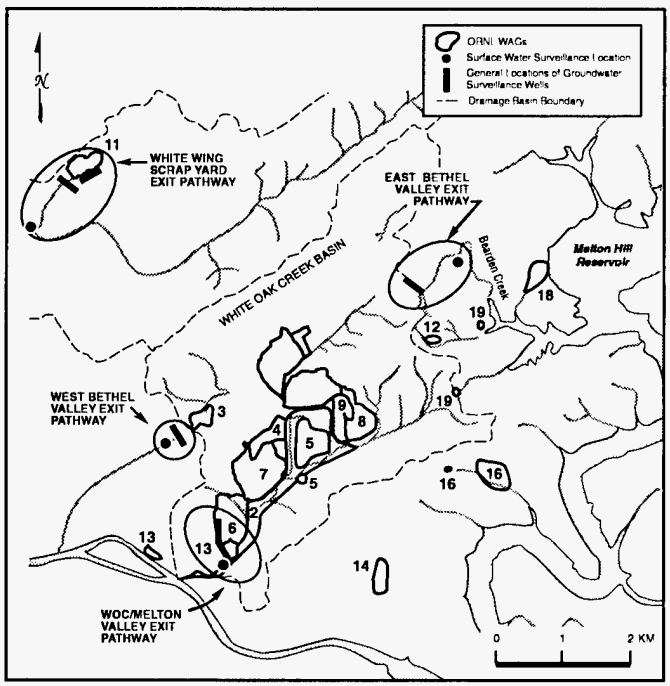

Fig. 7.21. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by Oak Ridge operations.

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 require that only non-RCRA, nonradioactive solid wastes were to be buried in the Contractors' Landfill.

WAG 17

WAG 17 is located about 1.6 km (1 mile) directly east of the ORNL main plant area. 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-burning facilities, garage facilities, welding facilities, and material storage areas that are needed to support ORNL's routine and experimental operations. It is composed of 17 SWMUs. A former septic tank is now used as a sewage collection/pumping station for the area, and seven tanks are used for waste oil collection and storage and for storage of photographic reproduction wastes.

7.3.1.2 Melton Valley

WAG 2

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 4

WAG 4 is located in Melton Valley about 0.8 km (0.5 mile) 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 5

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 wate in SWSA 5 South and SWSA 5 North. The remaining sites are support facilities for ORNL's hydrofracture operations, two LLW 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 were performed in preparation for a removal action. The scope of the removal action is to remove the contents of the tanks. 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 1996.

WAG 6

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 2 km (1.2 miles) 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 7

WAG 7 is located in Melton Valley about 1.6 km (1 mile) 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 is being 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 awaiting redesign and additional site characterization.

WAGs 8 and 9

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.

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 1 km (0.6 miles) 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.

WAG 10

WAG 10 consists of the Old Hydrofracture Facility (OHF) grout sheets, New Hydrofracture Facility, and New Hydrofracture 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.

White Wing Scrap Yard (WAG 11)

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 K-25 Site, 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 the 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 in the same year. Some scrap metal, concrete, and other trash are 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.

7.3.2 1996 Groundwater Quality Well Installation, Development, and Sampling Activities

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 groundwater surveillance program is presented in Table 7.6. The program was reviewed in 1996, and modifications were made effective Oct. 1, 1996, which resulted in some WAGs not being sampled in the calendar year. WAGs, other than WAG 6, are currently monitored to comply with DOE orders 5400.1 and 5400.5, which do not specify sampling schedules. ORNL samples groundwater quality wells at the remaining WAGs in its current program on a rotational basis.

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 1996. As part of the WAG 6 RCRA/CERCLA integrated monitoring approach, RCRA assessment groundwater monitoring continued during 1995 and 1996 under the auspices of the *Environmental Monitoring Plan for WAG 6 at ORNL*, 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 (eight quarterly and 16 semiannually). Routine groundwater monitoring conducted under the plan was initiated in October 1995 and continued into 1996. A subset of 12 RCRA groundwater monitoring wells were sampled on a semiannual basis during 1996 under the routine monitoring scenario. The 9 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 plant perimeter surveillance program, as stipulated in the WAG 6 plan, was initiated in 1993. The program was reviewed in 1996. Modifications were made in the locations sampled and the parameters. A summary of the program is presented in Table 7.7.

7.3.3 ORNL Groundwater Quality

The following section describes the 1996 groundwater monitoring results for the ORNL WAG perimeter monitoring network and the ORNL plant perimeter surveillance (about 130 sampling events). In a few cases, no samples could be collected because the wells were dry.

Eighteen of the 20 wells identified by the ORR EMP represent ORNL's exit pathway and are also part of the WAG perimeter monitoring program (WAG s 2, 3, 6, 11, and 17). As such, 1996 result data from sampling conducted under the WAG perimeter program are used for the monitoring plan program. Several of the wells were not sampled in 1996: two were dry, one is a deep well and does not have a dedicated pump, and the others were not sampled because of changes in the WAG perimeter monitoring program. The four surface water locations (Bear Creek, Raccoon Creek, Bearden Creek, and WOC at WOD) were sampled in September 1996. The results of the plant perimeter monitoring program are discussed as part of the OU discussions.

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

Table 7.6. Summary of the groundwater surveillance program at ORNL, 1996

WAG	Regulatory status	Wells		Parameters monitored[a] prior to program change	Frequency and last date sampled in 1996	New program	
		Upgradient	Downgradient			Locations	Parameters
				Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	Standard	Rotation Apr–Jun 1996	4 wells	Radionuclides[b] and field measurements[c]
3	DOE Orders 5400.1 and 5400.5	3	12	Standard	Rotation Jun–Jul 1996	*d*	*d*
17	DOE Orders 5400.1 and 5400.5	4	4	Standard	Rotation Apr 1996	All wells	Volatile organics, radionuclides,[b] and field measurements[c]
				Melton Valley			
2	CERCLA and DOE Orders 5400.1 and 5400.5	12	8	Standard	Rotation Mar–Apr 1996	4 wells 16 wells	Full set[e] and field measurements[c] radionuclides[b] and field measurements[c]
4	CERCLA and DOE Orders 5400.1 and 5400.5	4	11	Standard	Rotation Jan–Feb 1996	*d*	*d*
5	CERCLA and DOE Orders 5400.1 and 5400.5	2	20	Standard	Rotation Aug–Sep 1996	*d*	*d*
6	RCRA/CERCLA and DOE Orders 5400.1 and 5400.5	7	17	Volatile organics, radionuclides,[b] and field measurements[c]	Semiannually May, Nov–Dec 1996	12 wells semiannually	Volatile organics, radionuclides,[b] and field measurements[c]

Table 7.6 (continued)

WAG	Regulatory status	Wells		Parameters monitored[a] prior to program change	Frequency and last date sampled in 1996	New program	
		Upgradient	Downgradient			Locations	Parameters
7	CERCLA and DOE Orders 5400.1 and 5400.5	2	14	Standard	Rotation	*d*	*d*
8 and 9	DOE Orders 5400.1 and 5400.5	2	9	Standard	Rotation	All wells	Radionuclides[b] and field measurements[c]
				White Wing Scrap Yard			
11	DOE Orders 5400.1 and 5400.5	6	5	Standard	Rotation	*d*	*d*

[a]Standard: volatile organics, total organic carbon, total organic halides, metals, anions, total phenolics, total suspended solids, alkalinity, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium. Standard field measurements: pH, conductivity, turbidity, oxidation/reduction potential, temperature, and dissolved oxygen.

[b] Gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.

[c]Standard field measurements: pH, conductivity, turbidity, oxidation/reduction potential, temperature, and dissolved oxygen.

[d]Not applicable.

[e]Volatile organics, metals, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.

Table 7.7. Summary of the plant perimeter surveillance program at ORNL, 1996

Exit pathway	WAG	Number of wells	Surface water locations	Sampled under modified program[a,b]
White Oak Creek/ Melton Valley	6 and 2[c]	10	White Oak Creek at White Oak Dam	Yes
West Bethel Valley	3	3	Raccoon Creek	No
East Bethel Valley	17	4	Bearden Creek	No
White Wing Scrapyard	11	3	Bear Creek	No

[a]Parameters monitored under the old program were volatile organics, tritium, total radioactive strontium, gross alpha and beta, ^{60}Co, and ^{137}Cs.

[b]Parameters monitored for under the modified program are volatile organics, ICP metals, tritium, total radioactive strontium, gross alpha and beta, ^{60}Co and ^{137}Cs.

[c]Four wells are part of the ORNL WAG 6 perimeter network, and four wells are part of the ORNL WAG 2 perimeter network. Two wells are deep wells. One well was not sampled pending a decision regarding installation of a dedicated pump (well no. 1236). The second was sampled in a separate sampling event.

of groundwater quality at ORNL WAGs, federal DWSs and Tennessee water quality criteria for domestic water supplies are used as reference values in the following discussions. When no federal or state standard has been established for 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.

7.3.3.1 Bethel Valley

WAG 1

In 1996, as in the past, radionuclides have been detected in a number of WAG 1 wells, with gross beta activity and total radioactive strontium above DWSs at three wells. The highest levels of radioactivity have historically been observed in the same four wells: one in the northwest WAG area and three in the southwest and western WAG area. During 1996, two wells could not be sampled because of construction activities; historically, both wells have had high levels of radioactivity.

The gross beta activity at the wells of concern is attributable mainly to total radioactive strontium and its daughters. Gross alpha activity at WAG 1 ranged from below detection to 780 pCi/L; beta activity ranged from below detection to 19,000 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from below detection to 6,800 pCi/L (the DWS is 8 pCi/L).

VOCs were detected in some of the wells; however, most of these were also detected in the laboratory blanks. One well had vinyl chloride detected above DWSs and has had similar vinyl chloride concentrations in the past. Another well had trichloroethene detected above DWSs, similar to historical trichloroethene concentrations.

Fluoride at one well was detected above the DWS; this is the fourth time fluoride has exceeded the DWS. Nitrate at one well was detected above DWSs; this is the second time nitrate has exceeded the DWS at this well. No well values for metals exceeded DWSs.

WAG 3

Analytical results for 1996 at WAG 3 are similar to those obtained in the previous five years. WAG 3 is located on a north-facing slope, with its upgradient wells to the south. The long

axis of the site runs east to west; consequently, most of the downgradient wells are along the northern border.

Strontium has been detected historically in wells along the entire northern perimeter of the site. Values exceeding the primary DWS for total radioactive strontium and gross beta activity have consistently been observed at four wells in every sampling event. The gross beta signatures are mainly attributable to total radioactive strontium. The data for the wells along the eastern and northeastern boundaries show evidence of radioactive contamination, including ^{3}H and gross alpha activity. The data for the northwest boundary show the presence of ^{3}H.

Gross alpha activity at WAG 3 ranged from not detected to 12 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not detected to 1700 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not detected to 730 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 16,000 pCi/L (the DWS is 20,000 pCi/L).

In a few of the downgradient wells, VOCs were detected. Trichloroethene has consistently been detected above DWSs in every sampling event at one well located in the northeast part of the WAG. During this event, trichloroethene was detected below the DWS. Vinyl chloride was detected at estimated levels just slightly above the DWS. Two wells were dry when sampled; they have been dry during previous sampling events.

WAG 17

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 beta 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 three sampling events. The highest gross alpha activity was 8.6 pCi/L; gross beta was 7.3 pCi/L; total radioactive strontium was 1.7 pCi/L; and ^{3}H was 6200 pCi/L.

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. The pollutants include trichloroethene, 1,2-dichloroethene, vinyl chloride, tetrachloroethene, 1,1-dichloroethene, and benzene.

Exit Pathway

Historically, no wells in the East and West Bethel Valley exit pathways have had VOC or radiological constituents detected above any DWSs. At the East Bethel Valley surface-water location, neither VOCs nor radiological constituents were detected above any DWS. In the West Bethel Valley exit pathway, gross beta activity was detected above DWSs at the Raccoon Creek surface water location at 54 pCi/L. One of the three wells in the West Bethel Valley exit pathway has always been dry when sampled; a second well has also been dry during the last two sampling events.

7.3.3.2 Melton Valley

WAG 2

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. 7.20).

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. Gross beta activity above primary DWSs was detected at one well on the west side of WAG 7 and 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 being detected to 10 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 730 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 350 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 350,000 pCi/L (the DWS is 20,000 pCi/L).

Chromium was detected above DWS at two wells south of WAG 6. Chromium has been found to be above the DWS in the past four sampling events at one of the wells; this is the first time it has exceeded DWS at the other well.

WAG 4

In 1996, as in the past, radionuclides (including gross beta activity, total radioactive strontium, and ^{3}H) have been detected in a number of WAG 4 wells. The highest levels of radioactivity continue to be observed in the same six wells along the eastern boundary. Gross alpha activity at WAG 4 ranged from not being detected to 13 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not being detected to 1200 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not being detected to 620 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not being detected to 7.3×10^{6} pCi/L (the DWS is 20,000 pCi/L).

VOCs continue to be detected in wells on the eastern boundary. Two wells have consistently had VOC concentrations above DWSs. Fluoride has been detected above the DWS at one well five out of the six times it has been sampled.

WAG 5

The results for 1996 sampling are similar to results from previous sampling events. WAG 5 contributes a significant percentage of the ^{3}H and total radioactive strontium that exits the ORNL site at WOD via Melton Branch. Tritium contamination is particularly prevalent in one well on the southern and western boundaries, with values as high as 2.7×10^{8} pCi/L.

Total radioactive strontium appears to be the major beta emitter found in WAG 5 groundwater. It is found mainly in one well on the southern perimeter. Alpha activity above DWSs has historically been consistently observed in one well on the northwestern boundary of the WAG. This well was pumped dry in 1996 (and in 1994).

Gross alpha activity at WAG 5 ranged from not detected to 18 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not detected to 1900 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not detected to 10,000 pCi/L (the DWS is 8 pCi/L).

VOCs were detected in the wells along the southern and western boundaries, including vinyl chloride, 1,2-dichloroethene, benzene, and trichloroethene. Several wells have consistently exceeded DWSs for these contaminants.

No upgradient wells exceeded DWSs for radioactivity or volatile organics.

WAG 6

Results obtained during 1996 were comparable with past results. VOC contamination is apparently isolated in the area around a pair of wells in the northeastern corner of the WAG. During 1996, carbon tetrachloride and trichloroethene were detected above DWSs at one of these wells in every sampling event.

Elevated levels of ^{3}H are found in wells along the eastern perimeter. Gross alpha activity at WAG 6 ranged from not detected to 25 pCi/L (the DWS is 15 pCi/L); and total radioactive strontium ranged from not detected to 41 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 3.4×10^{6} pCi/L (the DWS is 20,000 pCi/L).

WAG 7

WAG 7 was not sampled in 1996. It is not a part of the revised ORNL groundwater surveillance program (see the "WAG 7" subsection in Sect. 7.3.1.2).

WAGs 8 and 9

WAGs 8 and 9 were not sampled in 1996; they will be sampled in 1997 under the revised groundwater surveillance program.

Exit Pathway

In the Melton Valley exit pathway, WOC at WOD had gross beta activity (410 pCi/L), total radioactive strontium (150 pCi/L), and ^{3}H concentrations (110,000 pCi/L) detected above the DWSs. One of the wells also had gross beta activity, total radioactive strontium, and ^{3}H concentrations detected above DWSs; a second well had ^{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. Several of the wells were not sampled because of changes in other programs.

White Wing Scrapyard (WAG 11)

WAG 11 was not sampled in 1996. It is not a part of the revised ORNL groundwater surveillance program. Refer to the previous discussion in this document.

Exit Pathway

In the White Wing Scrapyard exit pathway, the wells were not sampled in 1996 because of program changes. The surface-water location considered in this exit pathway did not have any radionuclide concentrations above DWSs.

7.3.4 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.

7.3.4.1 Wells Plugged During 1996

No wells were plugged and abandoned at ORNL during 1996. A total of 232 wells have been recommended for plugging and abandonment as soon as funds are available.

7.3.4.2 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 ETTP Groundwater Program is a component in the ORR ER strategy that is described in the *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program* (DOE 1995a). 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.

During the fall of 1996, efforts began on incorporating the ETTP Groundwater Protection Program requirements into the Integrated Water Quality Program (IWQP). 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 during 1997. 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. 7.22.

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 (AOCs) in this watershed include the K-1066-J cylinder storage yard; K-1024 dilution pit; K-1064 drum storage and burn area; 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

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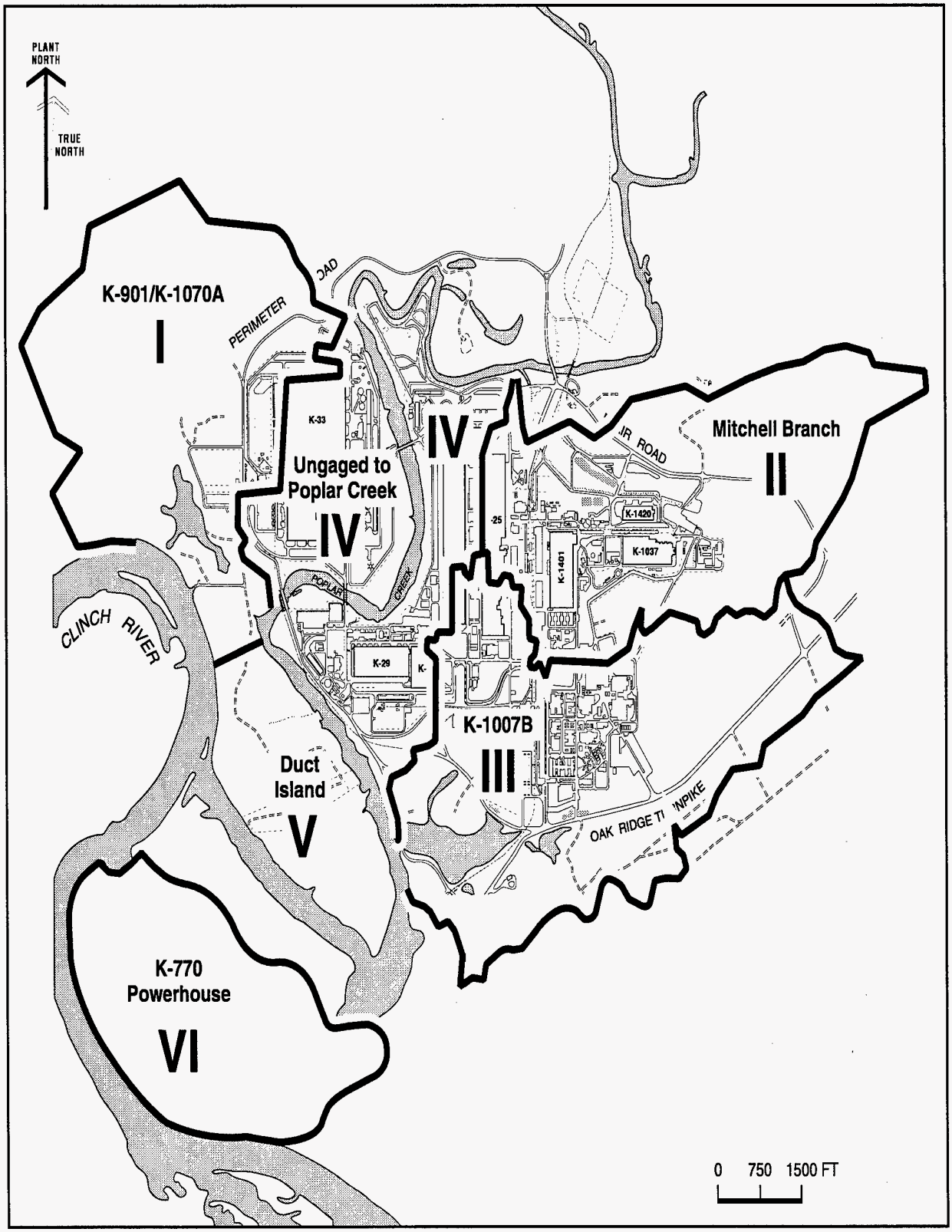

Fig. 7.22. ETTP waste area groupings.

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 holding pond, K-901 north and south disposal areas, 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 contractor's 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 1996 Well Installation and Plugging and Abandonment Activities

At the end of 1996 there were 241 water quality monitoring wells at the ETTP. There were no monitoring wells installed, nor were there any wells plugged or abandoned at the ETTP during 1996. Wells considered obsolete for monitoring or wells whose construction or annular seal integrity are questionable will be candidates for plugging and abandonment at some time in the future.

7.4.4 1996 Groundwater Monitoring Program

Groundwater samples were collected from the K-1407-B and C Ponds monitoring wells during February and August in 1996. Monitoring of these wells, located in the Mitchell Branch Watershed, was conducted to satisfy post-remediation monitoring requirements specified by the TDEC/DOE-O and EPA. Monitoring at two wells (UNW-3 and UNW-9) and one surface water location in Mitchell Branch (SD-195) are required for evaluating remedial action effectiveness at the former ponds (Fig. 7.23). Groundwater samples were collected using micropurge and low-flow sampling procedures. Field measurements of temperature, specific conductance, pH, dissolved oxygen, and oxidation/reduction potential, were collected at each well during sampling. The groundwater samples were analyzed for nitrate, selected metals, and selected radionuclides. No other wells were sampled during 1996 at the ETTP.

7.4.5 1996 Groundwater Monitoring Results

The results from both the wet weather (February) and the dry weather (August) sampling events at the two K-1407-B and C Ponds wells are consistent with results from previous sampling events at these wells. None of the metals analyzed exceeded a primary DWS. As is common in groundwater from the region, manganese and iron concentrations in both wells exceeded the secondary DWSs for these constituents. The secondary DWSs are nonenforceable taste, odor, or appearance guidelines.

Gross alpha activity, with a maximum of 8.76 pCi/L, did not exceed the DWS. Gross beta activity ranged from 0.96 to 19.3 pCi/L (limits of

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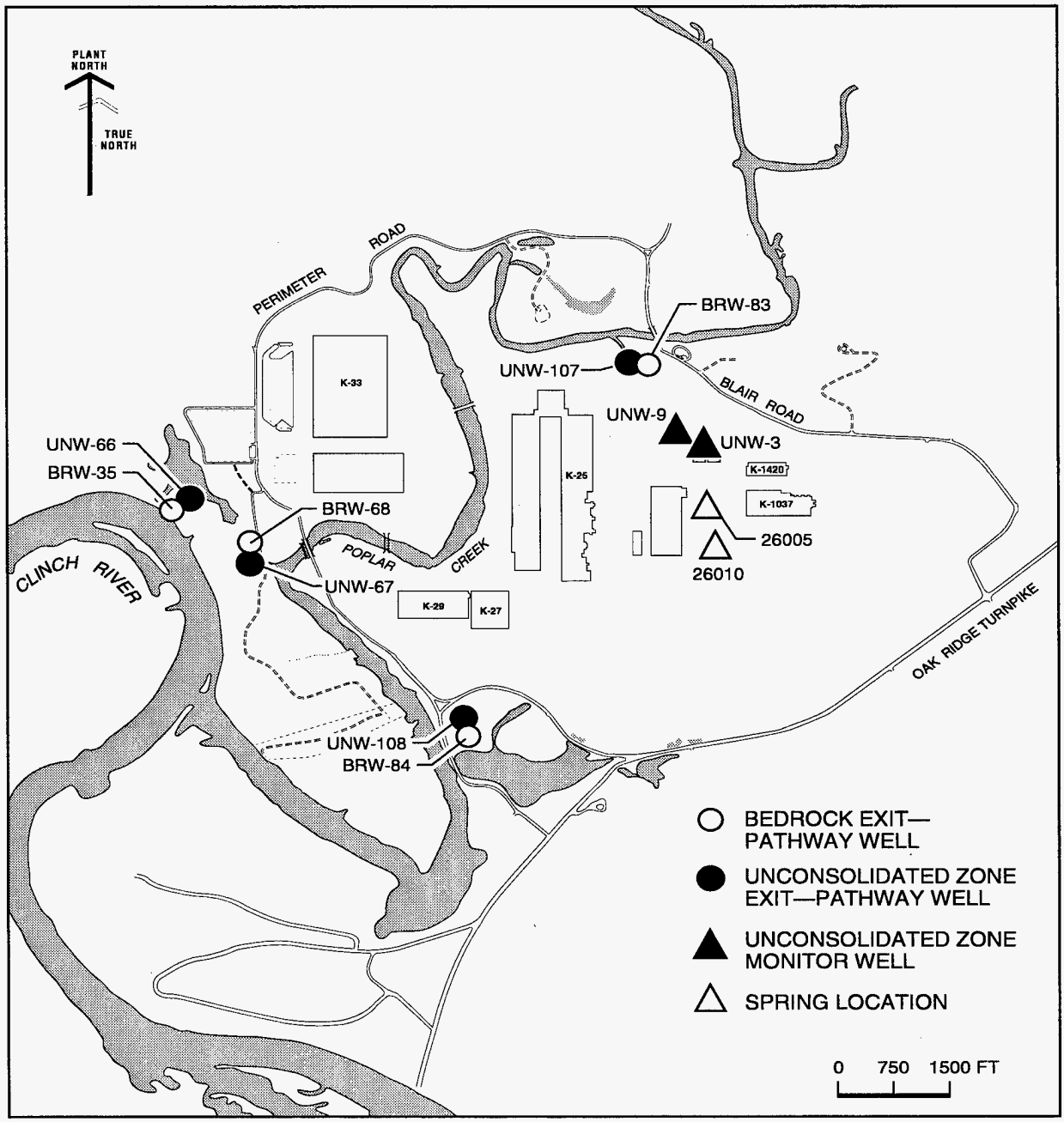

Fig. 7.23. Background and exit-pathway monitoring locations at the ETTP.

error ranged from 3.2 to 9.6 pCi/L), well below the reference value of 50 pCi/L. Also, the radiological results for the individual isotopes analyzed were well below the 4% of their respective DCGs used for determining compliance with the 4 mrem/year drinking water standard for man-made beta.

7.4.5.1 ETTP Springs

Groundwater samples were collected from two springs at the ETTP during 1996. These springs are located north of the K-1070 C/D Classified Burial Ground and are designated as springs 26005 and 26010 (Fig. 7.23).

Previous sampling results for the 26005 spring had shown that the discharge contained contaminants similar to those detected in nearby groundwater monitoring wells. Sampling conducted in 1995 downstream of both springs did not allow a determination of whether only one or both of the springs were contaminated. The discharge from both springs is captured by the storm drain SD-170 network.

Samples were collected from the 26005 and 26010 springs in May 1996 and were analyzed for VOCs, which are the contaminants of concern in groundwater in this area of the ETTP. The laboratory results for these samples confirmed the presence of trichloroethene, tetrachloroethene, 1,2-dichloroethene, and freon 113 in the discharge from both springs. The contaminant concentrations are generally an order of magnitude greater in the 26005 spring located approximately 250 ft north and downgradient of the 26010 spring. Reported concentrations for trichloroethene, the primary contaminant present at both springs, were 490 μg/L at spring 26005 and 40 μg/L at spring 26010.

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 1996 QA/QC results for the three sites have been compiled into a summary that represents the performance of the reservation as a whole. In past years, the results were reported separately for each of the three site analytical laboratories. In 1995, the three laboratories were combined into a single entity, the Analytical Services Organization. The 1996 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.

Preparation of SOPs is a continually evolving process. In 1988, the Environmental Surveillance Procedures QC Program was issued for use by Martin Marietta Energy Systems, Inc., with oversight by DOE-ORO and the EPA.

A process is in place for continuous improvement in the field sampling QA program and for incorporation of new procedures to reflect changing technologies and regulatory protocols. The Environmental Surveillance Procedures QC Committee is tasked with updating the field sampling and QC procedures. Membership in the committee includes representatives from each of the five Lockheed Martin facilities, DOE, ER, Central Waste Management, and the Analytical Services Organization. The committee ensures that requirements from relevant federal and state regulations are incorporated into the procedures and that new procedures are incorporated only after appropriate review and approval. In addition, site-specific procedures are reviewed internally.

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 within Lockheed Martin, 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 QC 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 Control

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 analyte and the current state of work. The

Table 8.1. QA/QC results for the Oak Ridge Reservation, 1996

Program	Total number of analytes	Acceptable	
		Total	Percentage
EPA Contract Laboratory Program (CLP)[a]			83.27
EPA Water Supply Laboratory Performance Quality Control Program (Water Supply)	302	283	93.71
EPA Water Pollution Performance Evaluation Quality Control Program (Water Pollution)[c] and Discharge Monitoring Quality Assurance Study	231	226	97.84
AIHA Proficiency Analytical Testing Program[b]	292	287	98.29
EPA Intercomparison Radionuclide Control Program[b]	157	151	96.18
AIHA Environmental Lead Proficiency Analytical Testing Program	72	71	98.61
DOE Mixed Analyte Performance Evaluation Program	140	133	95.00
DOE Environmental Measurements Laboratory Quality Assessment Program	268	255	95.15
Proficiency Environmental Testing Program	3229	3166	98.05

[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]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.

[c]Includes toxicology data from the ORNL Environmental Sciences Division in addition to the Analytical Services Organization.

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.

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 Monitoring Report Quality Assurance Study.

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 utilized 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 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 period.

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 five Lockheed Martin analytical laboratories and the DOE laboratory at the Fernald, Ohio, facility 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 six 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 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 upon 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. Procedures have been written to document the processes. 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.

Electronic data transfers from portable computers in the field and from laboratory information management systems used by on-site and commercial analytical laboratories to environmental data management systems have greatly enhanced the efficiency of the review process. In addition, the ongoing development of data-review software applications continues to provide necessary tools for data review. For example, as groundwater monitoring data are compiled, computer capabilities accomplish the following tasks:

- calculate charge balance;
- calculate conductivity and compare the data with field and laboratory measurements of conductivity;
- compare alkalinities and pH, field-duplicate measurements, results of filtered and unfiltered samples for elemental analyses, and current data with historical data to note results that are statistical outliers from established patterns;
- generate a summary of holding times for volatile organics; and
- screen volatile-organic results from samples against volatile-organic results from laboratory blanks.

Irregularities in the laboratory results that are discovered through this program are flagged and reviewed with the laboratory. If corrections need to be made, the laboratory provides a revised laboratory report. If a data point is found to be an outlier, it remains flagged in the data base as information for the data user.

Continuing improvements are being made to computerized environmental data management systems maintained by the Y-12 Plant, ORNL, and ETTP to improve the functionality of the systems, to allow access by a wide range of data users, and to integrate the mapping capabilities of a geographic information system with the data bases containing results of environmental monitoring activities.

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 all five facilities managed by Lockheed Martin. The FFA, a tripartite agreement between DOE, EPA Region 4, and the state of Tennessee, requires DOE to maintain one consolidated data base for environmental data generated at DOE facilities on the ORR. According to the FFA, the consolidated data

base 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-O.

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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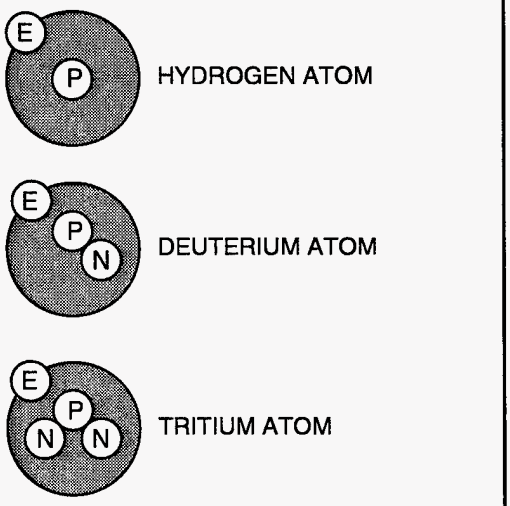

	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1
TRITIUM	1	2

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 (^{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.

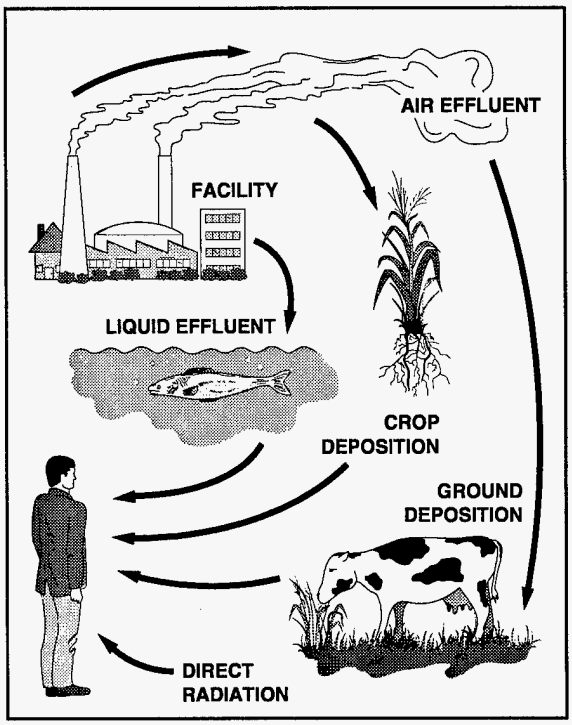

Fig. A.2. Examples of radiation pathways.

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.

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

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.

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 1993b).

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 4.5 mrem (0.045 mSv) from radionuclides released from the ORR during 1996.

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).

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 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.

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 (RfD)

An 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 Environmental Protection Agency (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 [maximum contaminant levels (MCLs)] and secondary drinking water regulation [secondary MCLs (SMCLs)] 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 "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 beyond 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

Once the contaminant oral daily intake via exposure pathways is estimated, the dose can be determined. For chemicals, dose to humans is measured in terms of 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 we calculate a chemical dose, 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 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, we compare the estimated dose attributed from ingesting water or fish from rivers and streams surrounding ORR 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 we assume 10^{-5} 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 (I) is divided by the CDI. A ratio greater than 1 indicates a risk greater 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
			585	Grinding room area exhaust
Y-9201-1-B	01-0020-59	730310P	586	Tool grinding machine shop
			587	Sand blaster exhaust
Y-9201-1-C	01-0020-17	036057P	278	Graphite carbon machine shop
			279	Graphite carbon machine shop
Y-9201-1-E	01-1020-92	035050P	00	Lead machining operations
			6	Welding shop sanding
Y-9201-1W-A	01-0020-99	036129P	00	Machine shop equipment
			272	Grit blasting
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	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-9201-5-J	01-0020-21	730305P	276	Tool grinding machine shop
Y-9201-5E-B	01-0020-21	730305P	273	Electrochemical machine shop
			71	Machining operations L5N
			72	Vacuum inlets L5E machining
			73	Palarite shop-machine
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

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9202-A	01-0020-06	031696P	160	Laboratory beryllium
			161	Laboratory beryllium
Y-9204-2-A	01-0020-46	026107P	301	Storage tank
			302	Storage tank
			303	Storage tank
			304	Storage tank
			305	Storage tank
			306	Storage tank
			307	Storage tank
			308	Storage tank
			309	Storage tank
			310	Storage tank
			311	Storage tank/head tank
			312	Storage tank
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
			343	Storage tank
			344	Lithium chloride crystallizer
			345	Lithium chloride crystallizer
			346	Neutralizer
			347	Process tank
			348	Lithium chloride crystallizer
			349	Processor tanks
			350	Processor tank
Y-9204-2-E	01-1020-55	730325P	351	Oven
			352	Oven
			356	Tungsten screener
			357	Dry box vent
			358	Material handling
			359	Gloveboxes
			360	Outgassing/annealing oven
			361	Material handling
			362	Gloveboxes
			363	Reactor unloading station

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			364	Reactor unloading station
			365	Metal ingot storage glovebox
			366	New metal ingot storage glovebox
Y-9204-2-F	01-0020-51	730309P	368	Classified
			369	Classified
			370	Classified
Y-9204-2-G	01-1020-79	730329P	371	Metal working machine shop
Y-9204-2E-A	01-0020-68	730312P	101	Lathes
			436	Exhaust hoods
			439	Hood exhaust
			444	Electropolishers
			445	Paint spray booth for dye
			370	Classified
Y-9204-3-A	01-0020-89	018208P	106	Furnaces
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
Y-9204-4-B	01-0020-72	730313P	481	Exhaust from machining operations
			482	Exhaust from hood - reclamation
			484	Rolling mill - 1st floor
			485	Exhaust from paint hood
			486	Filtering exhaust from paint booths
			488	Laboratory hoods - 1st floor
			489	Laboratory hoods - reclamation area
			490	Assembly process - 1st floor
			491	Assembly process - 1st floor
Y-9204-4-E	01-0020-33	032932P	258	Plating equipment
			259	Plating equipment
			260	Plating equipment
			261	Plating equipment
Y-9206-A	01-0020-48	012892P	421	Storage tank

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
			16	Dissolving hood
			17	Steam cleaning hoods
			115	Reduction fluid bed
			135	AEC scrubber stack
			136	AEC consolidated stack
			208	Conversion fluid bed
			209	HF purge vent
			210	Chemical makeup area
			211	Hood 29 and 30
			212	Dry vacuum system
Y-9206-C	01-1020-24	730316P	12	Classified
			14	Uranium alloy production
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
			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
			36	East scrubber (C-1 wing)
			40	B-1 sampling lab hood
			42	Chloride removal system (C-1)
			429	Fluorine cylinder rack enclosure
			430	HF dock cylinder/vaporizer
			431	N_2O_4 cylinder purge vent
			432	Muffle furnaces (2) vent room 229
			50	C-1 chip burner enclosure
			500	Primary extraction vent
			501	Secondary extraction vent

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9212-B	01-0020-02	730301P	110	U metal and U metal alloy
			38	U metal drying and briquetting process
			43	Exhaust from chip washing
			48	E-Wing machine shop
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
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	Turco pretreat spray hood
			4	O-wing metal working operations
			6	O-wing metal working operations
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

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			232	Plating equipment
			233	Plating equipment
			234	Plating equipment
			235	Plating equipment
Y-9401-3-A	01-1020-31	034809P	170	Coal-fired boiler
Y-9401-3-B	01-1020-32	034809P	170	Coal-fired boiler
Y-9401-3-C	01-1020-33	034809P	171	Coal-fired boiler
Y-9401-3-D	01-1020-34	034809P	171	Coal-fired boiler
Y-9404-7-A	01-1020-89	034295P	00	Maintenance shop
Y-9404-9-C	01-1020-19	730315P	323	Halar oven
			324	Urethane warming oven
			325	Urethane oven #3
			326	PVC oven #4
			327	PVC oven #5
			328	Steam autoclave
			329	General use oven
			330	Halar spray booth
			331	Blue M oven
			332	Drape forming equipment
			333	Vacuum system
			336	Despatch oven
			337	Rubber preparation equipment
			338	Lab hood
			339	Despatch oven
			340	Vacuum pumps
			341	Plastics fume hood
Y-9616-10-A	01-1020-62	029280P	428	Sulfuric acid storage tank
Y-9616-7-B	01-1020-74	737019P	459	West end treatment storage
			460	West end treatment storage
			461	West end treatment storage
			462	West end treatment storage
			463	West end treatment vent reactor vessel
			464	West end treatment storage
			465	West end treatment vent degasifier unit
			466	West end treatment storage
			467	West end treatment storage
			468	West end treatment storage
			469	West end treatment vent lime silo
			470	West end treatment storage

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			471	WETF laboratory hood
			472	WETF sodium hydroxide tank
			473	WETF clarifier (6-315)
			650	Biological treatment tank
			651	Biological treatment tank
			652	Biological treatment tank
			653	Biological treatment tank
			654	Biological treatment tank
			655	Biological treatment tank
			656	Solids storage tank
			657	Solids storage tank
			658	Solids storage tank
			659	Solids storage tank
			660	Solids storage tank
			661	Solids storage tank
			662	Solids storage tank
			665	WETF-F-380A sludge settling
			666	WETF-F-380B sludge settling
			667	WETF-F-381A sludge concentrator
			668	WETF-F-381B sludge denitrator
			669	WETF-F-384 decant hold tank
			670	WETF-F-382 decant tank/30
			671	WETF-F-385 decant tank/30
			672	WETF-F-390A calcium carbonate
			673	WETF-F-390B calcium carbonate
			674	WETF-F-390C calcium carbonate
			675	WETF-F-400 F-401 slurry tank
Y-9703-16-A	01-1021-03	044659P	00	Surface coating operation
Y-9720-12-A	01-1020-89	034295P	00	Non-special nuclear material
Y-9720-15-A	01-1021-04	044793P	1078	Surface coating operation
Y-9720-25-A	01-1020-89	034295P	00	Drum storage warehouse
Y-9720-28-A	01-1020-89	034295P	00	Drum storage warehouse
Y-9720-31-A	01-1020-89	034295P	00	RCRA and mixed waste storage
Y-9720-32-A	01-0020-42	032547P	201	Classified waste shredder
			435	Classified paper incinerator
Y-9720-32-C	01-1020-99	742886I	435	Classified paper waste incinerator
Y-9720-44-A	01-1020-89	034295P	00	Low-level waste storage pad
Y-9720-58-A	01-1020-89	034295P	00	PCB and RCRA staging and storage
Y-9720-60-A	01-1020-89	034295P	00	DARA solids storage unit

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
Y-9720-9-A	01-1020-89	034295P	00	PCB and RCRA hazardous waste
Y-9738-A	01-0020-14	036776P	576	Sand blaster
			577	Hood with fan
			578	Sand blaster
			579	Hood with fan
Y-9754-3-A	01-0020-07	039250P	00	Fuel service station
Y-9767-4-B	01-0020-38	036293P	00	Chilled water circulating system
Y-9811-1-A	01-1020-95	731997P	400	Waste oil/storage bulk storage
			401	Waste oil/storage bulk storage
			402	Waste oil/storage bulk storage
			403	Waste oil/storage bulk storage
			404	Waste oil/storage bulk storage
			405	Waste oil/storage bulk storage
Y-9811-1-B	01-1020-89	034295P	00	Waste oil/solvent drum storage
Y-9811-6-A	01-1020-82	029415P	377	Dry ash handling system
			378	Dry ash handling system
Y-9811-8-A	01-1020-63	032988P	407	Waste oil/solvent storage
			408	Waste oil/solvent storage
			409	Waste oil/solvent storage
			410	Waste oil/solvent storage
			411	Waste oil/solvent storage
Y-9811-8-B	01-1020-89	034295P	00	Waste oil/solvent drum storage
Y-9815-A	01-0020-11	025895P	780	Vent from dissolvers
			781	Nitric acid storage tank
			782	Nitric acid storage tank
			783	Storage tank/4400 gal
			784	Storage tank/1800 gal
			785	2 storage tanks/2200 gal
Y-9818-A	01-0020-12	025965P	790	Hot well seal tank
			791	10 storage tanks-nitric acid
			792	Bioreactor tanks/ozonation
			793	Basement exhaust
			794	Nitric acid supply line vent
			795	Calcium acetate storage tank
			796	Nitric waste storage tank
			797	Nitric waste storage tank
			798	Nitric acid storage tank
			799	Nitric acid storage tank

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			800	Ozone generator/area exhaust
			801	Nitric acid waste tank
			802	Caustic waste tank
			803	Still condensers
Y-9828-6-A	01-1020-89	034295P	00	Trash monitoring station
Y-9983-74-A	01-1020-89	034295P	00	Old salvage yard
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
			585	Grinding room area exhausts
Y-9201-1-B	01-0020-59	730310P	586	Tool grinding machine shop
			587	Sand blaster exhaust
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-J	01-0020-21	730305P	276	Tool grinding machine shop
Y-9201-5E-B	01-0020-21	730305P	273	Electrochemical machine shop
			71	Machining operations L5N
			72	Vacuum inlets L5E machining
			73	Palarite shop-machine
Y-9201-5N-A	01-1020-18	730314P	67	Machine shop exhaust
Y-9204-2-D	01-1020-57	730327P	342	Salvage vats
			343	Storage tank
			344	Lithium chloride crystallizer
			345	Lithium chloride crystallizer
			346	Neutralizer
			347	Process tank
			348	Lithium chloride crystallizer
			349	Processor tanks
			350	Processor tank

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	Oven
			352	Oven
			356	Tungsten screener
			357	Dry box vent
			358	Material handling
			359	Gloveboxes
			360	Outgassing/annealing oven
			361	Material handling
			362	Gloveboxes
			363	Reactor unloading station
			364	Reactor unloading station
			365	Metal ingot storage glovebox
			366	New metal ingot storage glovebox
Y-9204-2-F	01-0020-51	730309P	368	Classified
			369	Classified
			370	Classified
Y-9204-2-G	01-1020-79	730329P	371	Metal working machine shop
Y-9204-2E-A	01-0020-68	730312P	101	Lathes
			436	Exhaust hoods
			439	Hood exhaust
			444	Electropolishers
			445	Paint spray booth for dye
			370	Classified
Y-9204-4-B	01-0020-72	730313P	481	Exhaust from machining operations
			482	Exhaust from hood - reclamation
			484	Rolling mill - 1st floor
			485	Exhaust from paint hood
			486	Filtering exhaust from paint booths
			488	Laboratory hoods - 1st floor
			489	Laboratory hoods - reclamation area
			490	Assembly process - 1st floor
			491	Assembly process - 1st floor
Y-9206-B	01-0020-03	731689P	13	South stack incinerator
			15	West stack
			16	Dissolving hood
			17	Steam cleaning hoods
			115	Reduction fluid bed
			135	AEC scrubber stack
			136	AEC consolidated stack

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			208	Conversion fluid bed
			209	HF purge vent
			210	Chemical makeup area
			211	Hood 29 and 30
			212	Dry vacuum system
Y-9206-C	01-1020-24	730316P	12	Classified
			14	Uranium alloy production
Y-9212-B	01-0020-02	730301P	110	U metal and U metal alloy
			38	U metal drying and briquetting process
			43	Exhaust from chip washing
			48	E-Wing machine shop
Y-9215-B	01-1020-51	732125P	1	O-wing metal working operations
			2	Turco pretreat spray hood
			4	O-wing metal working operations
			6	O-wing metal working operations
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	323	Halar oven
			324	Urethane warming oven
			325	Urethane oven #3
			326	PVC oven #4

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			327	PVC oven #5
			328	Steam autoclave
			329	General use oven
			330	Halar spray booth
			331	Blue M oven
			332	Drape forming equipment
			333	Vacuum system
			336	Despatch oven
			337	Rubber preparation equipment
			338	Lab hood
			339	Despatch oven
			340	Vacuum pumps
			341	Plastics fume hood
Y-9616-7-B	01-1020-74	737019P	459	West end treatment storage
			460	West end treatment storage
			461	West end treatment storage
			462	West end treatment storage
			463	West end treatment vent reactor vessel
			464	West end treatment storage
			465	West end treatment vent degasifier unit
			466	West end treatment storage
			467	West end treatment storage
			468	West end treatment storage
			469	West end treatment vent lime silo
			470	West end treatment storage
			471	WETF laboratory hood
			472	WETF sodium hydroxide tank
			473	WETF clarifier (6-315)
			650	Biological treatment tank
			651	Biological treatment tank
			652	Biological treatment tank
			653	Biological treatment tank
			654	Biological treatment tank
			655	Biological treatment tank
			656	Solids storage tank
			657	Solids storage tank
			658	Solids storage tank
			659	Solids storage tank

Table C.1 (continued)

Y-12 Plant source number	Source reference number	Permit number	Stack	Stack description
			660	Solids storage tank
			661	Solids storage tank
			662	Solids storage tank
			665	WETF-F-380A sludge settling
			666	WETF-F-380B sludge settling
			667	WETF-F-381A sludge concentrator
			668	WETF-F-381B sludge denitrator
			669	WETF-F-384 decant hold tank
			670	WETF-F-382 decant tank/30
			671	WETF-F-385 decant tank/30
			672	WETF-F-390A calcium carbonate
			673	WETF-F-390B calcium carbonate
			674	WETF-F-390C calcium carbonate
			675	WETF-F-400 F-401 slurry tank
Y-9720-32-C	01-1020-99	742886I	435	Classified paper waste incinerator
Y-9811-1-A	01-1020-95	731997P	400	Waste oil/storage bulk storage
			401	Waste oil/storage bulk storage
			402	Waste oil/storage bulk storage
			403	Waste oil/storage bulk storage
			404	Waste oil/storage bulk storage
			405	Waste oil/storage bulk storage

Table C.2. ORNL air permits

Source number	Emission source reference number	TDEC permit number	Source description
X-2519-1/5	73-0112-03	030284P	Steam plant
X-2525-SV-11	73-0112-49	035026P	Electroplating shop
X-3039	73-0112-93	035494P	Off-gas and hot cell ventilation
X-3500-SV12	73-0112-73	036689P	Electric belt furnace
X-3502-01	73-0112-05	030881P	Spray booths (3)
X-3502-09	73-0112-94	027194P	Hood gluing
X-3502-SVl	73-0112-39	023808P	Oven curing
X-3502-SV2	73-0112-40	023807P	Oven tempering
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-7005-00	73-0112-45	037516P	Lead shop machining operation
X-7005-3/7	73-0112-26	739585P	Five lead melting furnaces
X-7007	73-0112-09	743190P	Paint shop
X-7015-03	73-1106-47	945640P	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-7002-01	73-0112-24	027090F	Boiler, hot water
X-7603-01	73-0112-25	740219F	Steam boiler
X-7667-0	73-0112-0067-6	73-0112-0067-6	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	937114F	Gas/oil boiler	Operating
K1407CNFAIRSTRIPPER	73-0106-90	939748P	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 1996

Date	Stack	Condition	Comments
February 27	East	Opacity monitoring equipment was out of service.	
March 13 and 14	West	Opacity monitoring equipment was out of service.	
May 7	East	Three six-minute periods of excess emissions.	Adjusting the air flow on #3 boiler caused the baghouse bypass to open due to a damaged electronic coil on the baghouse valve.
May 29	East and west	Opacity monitoring equipment was out of service.	Power outage to the boiler master panel.
June 20	West	Opacity monitoring equipment was out of service.	Maintenance was performed due to a damaged monitor filter.
August 8	East	Two six-minute periods of excess emissions.	A power failure caused the baghouse bypass to open.
August 13	West	One six-minute period of excess emissions.	A dirty clinker, caused by a buildup of coal around the burner, continued to burn after the boiler operation ceased.
October 15	East and west	Opacity monitoring equipment was out of service.	An electric power outage due to a transformer fire.
October 21	East	Six six-minute periods of excess emissions.	The cause was the startup of fans on boiler #3 after overhaul.
November 18	East	Opacity monitoring equipment was out of service.	Maintenance was performed due to an integrator board malfunction.
November 24	East	Two six-minute periods of excess emissions.	A reverse air fan malfunction increased the differential pressure causing baghouse 3 bypass dampers to open.

Appendix D: Reference Standards 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	50[f]		
^{3}H	20,000	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	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 as amended.

[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]Regulatory guide for assessing compliance without further analysis.

[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	Fish and aquatic life	Recreation	
					Organisms	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	600		600		17,000	2,700
1,2,4-Trichlorobenzene	70		70			
1,3-Dichlorobenzene					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-Benzofluoranthene					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					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	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	Fish and aquatic life	Recreation	
					Organisms	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		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		0.018[f]		
Iron		0.3				
Lead	0.015[g]		0.005	0.082[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		0.004[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]				0.01		
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	Fish and aquatic life	Recreation	
					Organisms	Water and organisms[d]
Dibromochloropropane	0.2		0.2			
Di(ethylhexyl)adipate	400		400			
Di(ethylhexyl)phthalate	6		6			
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[f]						
cis-1,2-Dichloroethene	70		70			700
trans-1,2-Dichloroethene	100		100			
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[k]				220	2.7
Bromoform	100[k]				3,600	43
Carbon tetrachloride	5		5		44	2.5
Chlorobenzene	100				21,000	680
Chloroform	100[k]				4,700	57
Dibromochloromethane	100[k]				340	4.1
Ethylbenzene	700		700		29,000	3,100
Methylene chloride	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				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.

[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, which is 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 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 *cis*-Dichlorethene and *trans*-Dichloroethene.

[k]Limit for total trihalomethanes (bromodichloromethane + bromoform + chloroform + dibromochloromethane).

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	NA
9714	2335-U	1987	In use	10,000	Diesel	Full compliance	Site check	NA	NA
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)
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 approved (9/95)

Table E.I (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)
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	CERCLA	TBD	TBD
9995	2079-U	1965	1979	55	Gasoline	Inert filled 1979	CERCLA	TBD	TBD
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)
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.I (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	TBD
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	ftee 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	TOU 11/22/96	NA	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	Emergency generator	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	ANF 1996	NA
2011	4	1973	1994	285	Diesel	Excavated	Emergency generator	NFAR 1995	Removed soil
2026	5	1964	1992	285	Diesel	Excavated	Emergency generator	NFAR 1997	Removed soil–site monitored
2088	6	1975	1996	285	Diesel	Excavated	Emergency generator	PCR 1996	Removed soil
2519A	8	1964	1995	500	Gasoline	Closed in place	Emergency generator	SSMR 1997	Site monitored
2519B	9	1975	1992	750	Diesel	Excavated	Emergency generator	SSMR 1997	Removed soil–site 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	Emergency generator	ANF 1996	NA
3019B	13	1952	1992	100	Gasoline	Excavated	Emergency generator	NFAR 1993	Removed soil
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	Unknown	50	Diesel	Closed in place	Emergency generator	ANF 1996	NA
3123	18	1972	1994	285	Diesel	Excavated	Emergency generator	PCR 1994	Removed soil
3125	19	1973	1988	1000	Diesel	Excavated	Emergency generator	NFAR 1995	Removed soil–site monitored

Table E.3 (continued)

ORNL #	TDEC #	Installed	Out of service	Capacity gallons	Contents	Status	Comments	Correspondence (most recent)	Corrective action
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	Emergency generator	SSMR 1997	Site monitored
4500N	24	1975	1995	5000	Diesel	Excavated	Emergency generator	PCR 1995	Removed soil
4500S	25	1960	1989	1000	Diesel	Excavated	Emergency generator	NFAR 1995	Removed soil–site monitored
4500N "B"	54	1995	NA	1000	Diesel	In use	Emergency generator	Annual fee–1997	NA
4501	26	1960	1984	325	Diesel	Closed in place	Emergency generator	ANF 1996	NA
4514	27	1986	1997	1000	Diesel	Closed in place	Emergency generator	APC 1997	NA
6554	28	1977	1990	3000	Ethylene glycol	Excavated	RCRA subtitle I	PCR 1990	NA
7002A	29	1948	1989	300	Waste oil	Excavated	RCRA subtitle I	PCR 1989	Removed soil
7002B	30	1947	1977	8000	Gasoline	Closed in place	RCRA subtitle I	ANF 1996	NA
7009	32	1975	1990	5000	Waste oil	Excavated	RCRA subtitle I	PCR 1990	Removed soil
7063	31	1964	1989	50	Gasoline	Closed in place	Emergency generator	ANF 1996	NA
7069A	33	1956	1989	8500	Diesel	Excavated	RCRA subtitle I	NFAR 1997	Removed soil–site monitored
7069B	34	1956	1989	8300	Gasoline	Excavated	RCRA subtitle I	NFAR 1997	Removed soil–site monitored
7069C	35	1956	1989	4000	Gasoline	Excavated	RCRA subtitle I	NFAR 1997	Removed soil–site monitored

Table E.3 (continued)

ORNL #	TDEC #	Installed	Out of service	Capacity gallons	Contents	Status	Comments	Correspondence (most recent)	Corrective action
7069D	36	1972	1990	10000	Diesel	Excavated	RCRA subtitle I	NFAR 1997	Removed soil–site monitored
7069E	37	1988	NA	6000	Diesel	In use	RCRA subtitle I	Annual fee–1997	Site monitored
7069F	38	1988	NA	15000	Gasoline	In use	RCRA subtitle I	Annual fee–1997	Site monitored
7075	39	1982	1994	4200	Waste oil	Closed in place	RCRA subtitle C	Closure letter 1994	Site monitored
7560	40	Unknown	Unknown	1000	Rad-waste	Closed in place	FFA category d	NA	NA
7562	41	Unknown	Unknown	12000	Rad-waste	Closed in place	FFA category d	NA	NA
7600	42	1960	1996	24000	Heating oil	Closed in place	Unregulated	NA	NA
7602	43	Unknown	Unknown	13000	Wastewater	In use	Unregulated	ANF 1996	NA
7605	44	1962	1989	1000	Heating oil	Excavated	Unregulated	NA	NA
7606	45	1960	1993	1000	Heating oil	Excavated	Unregulated	NA	Soil removed
7615	46	1962	1989	280	Paint solvents	Excavated	RCRA subtitle I	ANF 1996	NA
7618	47	1980	1995	2000	Diesel	Excavated	Emergency generator	PCR 1995	NA
7830	48	1981	Unknown	5000	Waste oil	Closed in place	RCRA subtitle C	ANF 1996	NA
7860A	49	1983	1992	3700	Waste oil	Excavated	RCRA subtitle C	PCR 1992	NA
7860B	50	1982	1993	500	Diesel	Closed in place	RCRA subtitle I	NFAR 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	SSMR 1997	Removed soil–site monitored

Notes: ANF = amended notification form, APC = application for permanent closure, NA = not applicable, NFAR = no further action required, PCR = permanent closure report, SSMR = site status monitoring report.

Appendix F: NPDES Noncompliances

Table F.1. Summary of Y-12 Plant NPDES excursions, 1996

Date	Location	Excursion	Explanation	Corrective action
1/22/96	Tributary 8 Lift Station	Unauthorized discharge to Bear Creek	The Tributary 8 lift station collects flow and groundwater seepage from closed waste disposal areas in Bear Creek Burial Grounds C-West/Walk-In Pits. A pump at the Liquid Storage Facility (LSF) oil/water separator failed and allowed an overflow condition.	Valves from the 3 underground seep lines were immediately closed, shutting off flow to the lift station. Investigation revealed that a pump at the LSF oil waste separator had failed. The water level point in this unit is interlocked with the Tributary 8 lift station, thus a signal had been relayed to cut off the lift station pumps. The failed LSF separator pump was replaced, and the system returned to normal.
1/27/96	Tributary 8 Lift Station	Unauthorized discharge to Bear Creek	High incoming seep water flow due to heavy rainfall and snow melt exceeded the pumping capacity of the Tributary 8 lift station. Approximately 500 gallons were discharged to the Tributary 8 downstream of the original point of seep collection.	An examination of the Tributary 8 lift station pumps determined that they were operating below expected design capacity. The pumps were replaced or repaired, and the lift station is currently operating near design capacity.
2/25/96	Outfall 200	Oil sheen	During routine annual maintenance, a gear box in Cooling Tower 9409-34 was overfilled with gear oil. Less than one quart of excess oil spilled onto exposed surface of the water in the cooling tower basin. Later, the float on the cooling tower line stuck in the open position causing the tower basin to overflow. This water with an oil sheen flowed over the ground a short distance to a storm drain and through Outfall 200. The amount of oil estimated to have reached EFPC was less than a cup.	Cooling Tower 9409-34 was shut off. The oil sheen remaining on the water in the basin was removed, the oil cleaned off the surfaces, and the make-up feed was valved off. The oil skimmer on EFPC near Lake Reality caught all of the sheen and none was released off-site. The oil sheen was removed from the oil/water separator surface.
2/28/96	Outfall 200	Oil sheen	Local rains occurring after the initial oil sheen transpired (2/25/96) resulted in the flushing of a miniscule amount of oil through Outfall 200.	The oil skimmer on EFPC caught all the oil sheen and none was released off-site.

Table F.1 (continued)

Date	Location	Excursion	Explanation	Corrective action
3/5/96	Outfall 512	Permit limit exceedence (iron – 1.6 mg/L)	The permit limit at Groundwater Treatment Facility (Outfall 512) is 1.0 mg/L. Investigation revealed the source to be leachate and groundwater collected from the Tributary 8 seeps. Groundwater chemistry in this area remains variable.	Discharge was discontinued. Iron removal using hydrogen peroxide as an oxidizer was added back to the treatment process, and the filter replacement frequency was increased to facilitate iron removal.
3/29/96	Outfall 201	Permit limit exceedence (pH – 9.3): unauthorized discharge.	The cause of the elevated pH is believed to be an accidental release of resin regeneration wastewater from the demineralizer facility in Building 9409-18. The resin beds are rinsed with caustic and acid with the resulting wastewater drained to the sump of a pumping station for transmission to the Steam Plant Waste Water Treatment Facility. On this day, the pumping system failed to operate correctly. An unknown quantity of wastewater in the sump seeped through opens in the sump wall, into the stormdrain system and into EFPC.	An inoperable pump was replaced with a new pump. The sump was repaired, and a coating system has been installed in the sump to seal leaks. The sump leak was tested and passed. A surveillance schedule has also been established to frequently review sump conditions.
7/24/96	Outfall 201	Permit limit exceedence (pH – 8.8): unauthorized discharge	The cause of the elevated pH is believed to have resulted from the demineralizer facility in Building 9409-18. At the time of this incident, the facility was regenerating the south ion bed and discharging to the west sump. A leak is believed to have been the cause of this event.	Operations utilizing the west sump at 9404-18 were suspended. A leak check/inspection was performed on the sump and connected piping. The piping was found to be leaking. The joint was sealed and the piping left uncovered for a period of time, allowing the material to cure and further observation of any additional leakage. The work joint and adjacent piping have been covered, and no additional problems have been observed.

Table F.1 (continued)

Date	Location	Excursion	Explanation	Corrective action
8/1/96	Outfall 058	Oil sheen	The sheen was observed coming from Outfall 058 on the south bank of the creek behind Building 9201-2. The initial sheen measured approximately eight inches by sixteen inches and had a visible tail along the creek bank of three to four feet. The total amount of oil discharged is estimated at less than eight ounces.	Temporary booms and oil absorbent pads were placed at the outfall to contain and collect the sheen. The pads were removed the following day and the temporary boom on August 3 since no additional sheen had been captured. All of the sheen was collected at the outfall or the permanent oil water separator.
8/15/96	Outfall 512	Permit limit exceedence (iron – 2.0 mg/L)	This occurrence occurred at the location at which wastewater from the Groundwater Treatment Facility is monitored prior to discharge to EFPC. A potential source for this occurrence is the scaling of oxidized iron from the interior of the discharge piping.	The section of carbon steel piping located between the final treatment unit and the NPDES monitoring point will be replaced.
11/30/96	Tributary 8 lift station	Unauthorized discharge to Bear Creek	The Tributary 8 lift station collects flow and groundwater seepage from closed waste disposal areas in Bear Creek Burial Grounds C-West/Walk-In Pits. An overflow condition was created when the lift station holding tank level sensor became uncoupled, preventing automatic operation of the pumps.	Upon discovery of the upset condition, the lift station pumps were manually started immediately. Electricians made temporary electrical repairs, and the lift station pumps were returned to normal operation. Permanent repairs were completed 12/2/96.

Table F.2. Summary of ORNL NPDES excursions, 1996

Date	Location	Excursion	Explanation	Corrective action
4/1/96	Outfall 231	Oil sheen	On 4/1/96, an oil sheen was noted at stormwater Outfall 231 on White Oak Creek during rainfall. The sheen was attributed to stormwater runoff conveyance of automotive lubricant (transmission fluid) that had been leaked from a vehicle that had broken down in a parking area. The vehicle had been towed away for maintenance at the time the oil sheen was discovered.	ORNL spill response personnel were contacted and quickly placed oil containment booms on the bank of White Oak Creek below Outfall 231. The booms were effective in skimming fluid from the Outfall 231 stormwater effluent at the entry point to WOC. Spill response personnel also contained and cleaned up the fluid remaining on the surface of the parking area, using absorbent pads.
5/14/96	X02 (Coal Yard Runoff Treatment)	Iron	On 5/14/96, the ORNL Coal Yard Runoff Treatment Facility (CYRTF) experienced an excursion of the iron limit of 1.0 mg/L, daily maximum; the concentration measured on that day was 1.5 mg/L. CYRTF basin sediment removal activity, which consisted of stabilizing the sediment with cement dust and removing the sediment with a mechanical loader may have contributed to the excursion.	No certain cause for the iron excursion has been determined. Therefore, no corrective actions have been developed. Additional sampling in May 1996 has indicated no additional NPDES limit excursions. In addition, the CYRTF is currently undergoing an upgrade project, including effluent sand filtration, which is expected to enhance the NPDES permit compliance capabilities of that facility.
7/31/96	X01 (Sewage Treatment Plant)	Fecal coliform	The measured sewage plant fecal coliform concentration was > 5,000 colonies per 100 ml, compared to an NPDES permit daily-maximum limit of 5,000 colonies per 100 ml. Other pertinent STP effluent parameters, including total suspended solids and chlorine, were within normal ranges and were in compliance with permit limits on and around 7/31/96. ORNL was experiencing rainfall at the time of the excursion; approximately 2.7 inches of rain fell on 7/31.	No certain cause for the fecal coliform excursion has been determined. Therefore, no corrective actions have been developed. Additional sampling in 1996 has indicated no additional NPDES limit excursions. STP personnel indicated that the operating conditions on 7/31 were not such that any problems would have been expected. ORNL is planning to replace the existing STP chlorine disinfection system with an ozone system in 1997, which should enhance the capability to disinfect the STP effluent. In addition, the STP collection system is currently undergoing an upgrade project which will decrease the potential for stormwater inflow and infiltration into the system, which is expected to enhance the NPDES permit compliance capabilities of the STP.

Table F.2 (continued)

Date	Location	Excursion	Explanation	Corrective action
8/13/96	X02 (Coal Yard Runoff Treatment)	Iron	No clear cause has been determined for the iron limit excursion that occurred at CYRTF on 8/13/96. ORNL had received rainfall for several days up to and including August 13. CYRTF personnel indicated that operating conditions were normal on and around August 12. Following clarification and filtration, the CYRTF effluent is released to WOC as pond overflow that is discharged through a flume, and algae is typically abundant on the surface of the pond in late summer and early fall. As no unusual circumstances were identified on the date of the excursion, it is believed that algal accumulation of iron may have contributed to the excursion. Experiments have been conducted in the past with iron-bearing CYRTF effluent samples in which algae was filtered out and the iron concentration became negligible.	In 1994, following an iron-limit excursion at CYRTF, the discharge flume was equipped so as to discourage algae from leaving the CYRTF pond with released effluent. ORNL is currently evaluating additional alternatives to further discourage algal conveyance in CYRTF effluent.
12/5/96	Outfall 341	Oil sheen	On 12/5/96, an oil sheen was noted at Outfall 341 on First Creek (FC) during rainfall. Outfall 341 receives stormwater runoff from the west-central portion of the ORNL main plant area. The volume of the substance in the creek was estimated at a few gallons.	ORNL spill response personnel were contacted and quickly placed on containment booms at two locations on First Creek downstream from Outfall 341. Oil absorbent pads were used to clean up oil residue, and pads were placed at the outfall and along both sides of the creekbank to accumulate any remaining residue. Most of the floating material was removed by the booms and pads. A survey of the creek downstream from Outfall 341 revealed no impacted fish or other aquatic species. The release was traced to Building 2010 where waste cooking oil is containerized. Area personnel were counseled in spill prevention and cleanup practices.
4/17/96	Outfall 231	Potable water release	A potable water underground pipe broke, releasing chlorinated drinking water into White Oak Creek.	The broken pipe was secured within 45 minutes, stopping the release. The pipe was repaired the following day. Stream surveys indicated approximately 30 dead minnows, which may have died due to the chlorine in the released water.

Table F.2 (continued)

Date	Location	Excursion	Explanation	Corrective action
Calendar Year 1996	Category I & II Outfalls (stormwater runoff)	Total suspended solids	12 TSS limit excursions were measured at 11 outfalls during storm sampling events.	Seven of the exceedances were corrected with minor improvements in erosion controls. One exceedance will be corrected by physically removing the outfall. Four of the exceedances will be corrected when the outfall pipe is reconfigured so as to improve the representativeness of future samples.

Table F.3. Summary of ETTP NPDES excursions, 1996

Date	Location	Excursion	Explanation	Corrective action
1/22/96	Outfall 014 (Central Neutralization Facility)	Total petroleum hydrocarbon	On January 22, 1996, Outfall 014 experienced a Total Petroleum Hydrocarbon (TPH) exceedence.	CNF waste evaluation criteria document revised to include TPH for suspect influent waste streams. Organics treatment added to CNF treatment train.
2/09/96 2/16/96	Outfall 170	Unpermitted discharge	Sewer line and lift station damaged by freeze/thaw cycle, overflowed and discharged sanitary sewage to Outfall 170.	Short term: Storm water catch basins blocked, and wastes removed. Long term: Redesign of area sewer line to provide additional freeze protection. Modification of sanitary sewer cold weather inspection procedures.
2/21/96	Outfall 120	Unpermitted discharge	Bypass pump failure resulted in spill of sanitary sewage to Outfall 120 during sewer system repair project.	Storm water catch basins blocked, and wastes removed. 24-hour surveillance and monitoring of pump operations was added for duration of project.
8/25/96	Outfall 014	Unpermitted discharge	Inappropriate valving configuration resulted in a bypass of CNF organics treatment unit.	Short term: Administrative tag placed on valve switch. Long term: Automatic valving interlock system was installed to prevent bypass.

Appendix G: Errata

Appendix G: Errata

The following corrections pertain to LMES 1996. *Oak Ridge Reservation Annual Site Environmental Report for 1995,* ES/ESH-69, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Page	For	Read
5-23, line 10	selenium, cadmium, and zinc were above those	selenium, and cadmium were above those
5-23, lines 14 and 15	some measures for copper and mercury exceeded the criteria.	some measures for copper, zinc, and mercury exceeded the criteria.
5-24, lines 6 and 7	selenium, silver, arsenic, cadmium, and zinc exceeded the criteria	selenium, silver, arsenic, and cadmium exceeded the criteria
5-24, lines 11 and 12	silver, arsenic, cadmium, mercury, selenium, and zinc exceeded water quality criteria	silver, arsenic, cadmium, mercury, and selenium exceeded water quality criteria

Replace Table 5.14 of 1995 ASER with the following.

Table 5.14. Surface water sampling measurements exceeding Tennessee water quality criteria at the Y-12 Plant, 1995

Parameter	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number of measurements exceeding criteria
			Detection limit	Max	Av		
Silver	Station 17	246	0.006	<0.02	<0.006	0.004	246
Arsenic	Station 17	246	0.04	<0.04	<0.04	0.0014	246
Cadmium	Station 17	246	0.004	<0.004	<0.004	0.0039	246
Copper	Station 17	246	0.006	0.031	<0.008	0.018	11
Mercury	Station 17	493	0.0002	0.0100	0.0010	0.00015	492
Selenium	Station 17	246	0.1	<0.1	<0.1	0.02	246
Zinc	Station 17	246	0.01	0.33	0.07	0.117	26
Silver	Station 304	6	0.006	<0.006	<0.006	0.04	6
Arsenic	Station 304	6	0.04	<0.04	<0.04	0.0014	6
Cadmium	Station 304	6	0.004	<0.004	<0.004	0.0039	6
Mercury	Station 304	6	0.0002	<0.0002	<0.0002	0.00015	6
Selenium	Station 304	6	0.1	<0.1	<0.1	0.02	6
Silver	Outfall 302 (S19)	6	0.006	<0.006	<0.006	0.004	6
Arsenic	Outfall 302 (S19)	32	0.04	<0.04	<0.04	0.0014	32
Cadmium	Outfall 302 (S19)	32	0.004	<0.004	<0.004	0.0039	32
Selenium	Outfall 302 (S19)	32	0.1	<0.1	<0.1	0.02	32

The following figure replaces Fig. 5.16, p. 5-27.

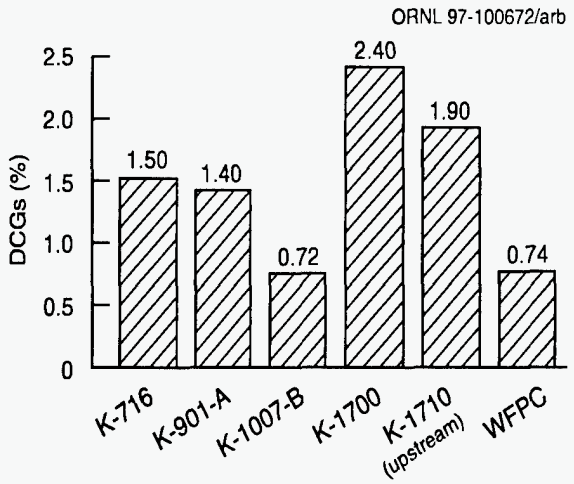

Fig. 5.16. Percentage of DCGs for ETTP surface water monitoring locations.

On page 6-9, the first full paragraph should read as follows:

Of the geese harvested in the four surrounding counties (Anderson, Knox, Loudon, and Roane), it is estimated that about 424 of the geese could have spent time on the ORR. The collective EDE from eating 424 geese harvested in 1995 could have been about 0.003 person-rem (3E–5 person-Sv), assuming that all were contaminated at the average ^{137}Cs concentration.

The following corrections pertain to *Environmental Monitoring and Surveillance of the Oak Ridge Reservation*, ES/ESH-71, Oak Ridge National Laboratory, October 1996.

Page	For	Read
4-25, Table 4.3		
Alkalinity-CO_3 (mg/L)		
No. detected	14	15
Av	35.42857	37.8666667
4-26, Table 4.3		
Conductivity (μmhos/cm)		
Min	4.4	33
Av	332.755	335.9875
4-30, Table 4.4		
Conductivity, field measurement (μmhos/cm)		
Max	6900	7930
Av	717.5253	867.92
4-35, Table 4.5		
Conductivity, field measurement (μmhos/cm)		
Min	6.5	173
Av	1323.543	1461.70
4-183, Table 4.50		
Alkalinity-CO_3 (mg/L)		
No. detected	3	4
4-184, Table 4.50		
^{239}Pu (pCi/L)		
No. samples	24	25
No. detected	24	25
Av	0.004358	0.0043583
4-192, Table 4.52		
Static water level (ft-TOC)		
No. samples	2	4
No. detected	2	4
Min	–4.75	–8.43
Av	–4.185	–5.375
4-192, Table 4.52		
Conductivity, field measurement (μmhos/cm)		
Max	51.3	51300
Min	27.9	17900
Av	39.525	39525
4-199, Table 4.54		
Bear Creek Exit Pathway		
Well	BCK-00.63	BCK-03.87

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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