ES/ESH-47

OAK RIDGE RESERVATION ANNUAL SITE ENVIRONMENTAL REPORT FOR 1993

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MASTER

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Acronyms and Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos-containing material
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ARAP	Aquatic Resources Alteration Permit
ARAR	applicable or relevant and appropriate requirement
BCK	Bear Creek kilometer
BMAP	Biological Monitoring and Abatement Program
CAA	Clean Air Act
CDI	chronic daily intake
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CET	Center for Environmental Technology
CFC	chlorofluorocarbon
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
CMC	criterion maximum concentration
CNF	Central Neutralization Facility
CRADA	cooperative research and development agreement
CRESO	Clinch River Environmental Studies Organization
CRK	Clinch River kilometer
CRMP	cultural resource management plan
CWA	Clean Water Act
CWG	citizens' working group
CWM	Center for Waste Management
CX	categorical exclusion
CY	calendar year
D&D	decontamination and decommissioning
DAC	derived air concentration
DCF	dose conversion factor
DCG	derived concentration guide
DMR	Discharge Monitoring Report QA Study
DNA	deoxyribonucleic acid
DNAPL	dense nonaqueous phase liquid
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
DWS	drinking water standard
EA	environmental assessment
ECS	Environmental Compliance Section (of OECD, ORNL)
EDE	effective dose equivalent
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EIS	environmental impact statement
ELPAT	Environmental Lead Proficiency Analytical Testing Program
EMD	Environmental Management Division
EML-QAP	Environmental Measurements Laboratory, Quality Assurance Program

EMP	*Environmental Monitoring Plan for the Oak Ridge Reservation*
EMSL-LV	Environmental Monitoring Systems Laboratory, Las Vegas
EPA	U.S. Environmental Protection Agency
EPA-HQ	U.S. Environmental Protection Agency Headquarters
EPCRA	Emergency Planning and Community Right-To-Know Act
EPO	environmental protection officer
EPPIP	environmental protection program implementation plan
ER	environmental restoration
ERP	Environmental Restoration Program
ES&H	environment, safety, and health
ESD	Environmental Sciences Division (ORNL)
ESP	Environmental Surveillance and Protection (section of OECD, ORNL)
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
FTIR	Fourier transform infrared (spectroscopy)
GIS	geographic information system
GWPP	Groundwater Protection Program
GWPS	groundwater protection standard
HCK	Hinds Creek kilometer
HEPA	high-efficiency particulate air (filter)
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments to RCRA (1984)
ICP-MS	inductively coupled plasma mass spectrometry
ICRP	International Commission on Radiological Protection
ICS	incident command system
IRIS	Integrated Risk Information System
IWC	instream waste concentration
LC$_{50}$	lethal concentration to 50% of organisms
LDR	land disposal restriction
LLLW	liquid low-level (radioactive) waste
LLW	low-level (radioactive) waste
LQAP	*Laboratory Quality Assurance Plan*
M&O	management and operating (contractor)
MACT	maximum achievable control technology
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	maximum contaminant level
MEK	Melton Branch kilometer
Mgd	million gallons per day
MHD	Melton Hill Dam
MHR	Melton Hill Reservoir
MIK	Mitchell Branch kilometer
MOA	memorandum of agreement
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants

NHPA	National Historic Preservation Act
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NOD	notice of deficiency
NOEC	no-observed-effect concentration
NOEL	no-observed-effect limit
NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Coast Guard National Response Center
NRWTF	Nonradiological Wastewater Treatment Facility
OECD	Office of Environmental Compliance and Documentation (ORNL)
ONS	U.S. DOE Office of Nuclear Safety
ORAU	Oak Ridge Associated Universities
OREIS	Oak Ridge Environmental Information System
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
ORS	Occurrence Reporting System
OSHA	Occupational Safety and Health Administration
OU	operable unit
PA/SI	preliminary assessment/site investigation
PAM	perimeter air monitoring (station)
PAT	Proficiency Analytical Testing
PCB	polychlorinated biphenyl
PCK	Poplar Creek kilometer
PET	Proficiency Environmental Testing
PIDAS	Perimeter Intrusion Detection Assessment System
PM10	particulate matter less than 10 microns in diameter
POTW	publicly owned treatment works
PWMP	pond waste management project
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
R&D	research and development
RAM	remote air monitoring (station)
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RMPE	Reduction of Mercury in Plant Effluent
ROD	record of decision
RQ	reportable quantity
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SF	slope factor
SHPO	state historic preservation officer
SMCL	secondary maximum contaminant level
SNM	special nuclear material

SOP	standard operating procedure
SPB	southern pine beetle
SPWTF	Steam Plant Wastewater Treatment Facility
SWHISS	Surface Water Hydrological Information Support System
SWM	solid waste management
SWMU	solid waste management unit
SWPPP	Storm Water Pollution Prevention Program
SWSA	solid waste storage area
TCMP	Toxicity Control and Monitoring Program
TDEC	Tennessee Department of Environment and Conservation
TEMA	Tennessee Emergency Management Agency
TOA	Tennessee Oversight Agreement
TRI	toxic release inventory
TRK	Tennessee River kilometer
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSP	total suspended particulates
TWRA	Tennessee Wildlife Resources Agency
UE	uranium enrichment
UE-PCB-FFCA	Uranium Enrichment Polychlorinated Biphenyl Federal Facilities Compliance Agreement
UEFPC	Upper East Fork Poplar Creek
USEC	United States Enrichment Corporation
UST	underground storage tank
VOC	volatile organic compound
WAG	waste area grouping
WCK	White Oak Creek kilometer
WMP	waste management program
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake
WP	Water Pollution Performance Evaluation QA Program
WS	Water Supply Laboratory Performance QC Program

1. Site and Operations Overview

L. W. McMahon, J. B. Murphy, and L. G. Shipe

Abstract

The U.S. Department of Energy (DOE) currently oversees activities on the Oak Ridge Reservation, a government-owned, contractor-operated facility. The three sites that compose the reservation (the Y-12 Plant, Oak Ridge National Laboratory, and the K-25 Site) were established in the early 1940s as part of the Manhattan Project, a secret undertaking that produced the first atomic bombs. The reservation's role has evolved over the years, and it continues to adapt to meet the changing defense and energy 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. Environmental monitoring and surveillance are carried out in and around the reservation in accordance with DOE Order 5400.1, "General Environmental Protection Program," to determine the effects (if any) of past and current operations on the reservation and its surroundings.

BACKGROUND

This document contains a summary of environmental monitoring activities on the Oak Ridge Reservation (ORR) and its surroundings and is required for U.S. Department of Energy (DOE) facilities. The monitoring and documentation criteria are described in DOE Order 5400.1, "General Environmental Protection Program." The results summarized in this report are based on the data collected during calendar year (CY) 1993 and compiled in *Environmental Monitoring on the Oak Ridge Reservation: CY 1993 Results* (Martin Marietta 1994).

To the extent possible, this document follows the *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE-ORO 1992), the authorization and requirement for which are also contained in DOE Order 5400.1. The plan outlines the goals of environmental monitoring for the reservation and its facilities. The plan has been approved by the manager of the DOE Oak Ridge Operations Office (DOE-ORO) and has been reviewed by the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight Division.

Annual environmental monitoring on the ORR consists of two major activities: effluent monitoring and environmental surveillance, as defined in DOE Order 5400.1.

- Effluent monitoring is the collection and analysis of samples or measurements of liquid, gaseous, or airborne effluents for the purpose of characterizing and quantifying contaminants and process stream characteristics, assessing radiation and chemical exposures to members of the public, and demonstrating compliance with applicable standards.
- Environmental surveillance is the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from DOE sites and their environs and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing radiation and chemical exposures to members of the public, and assessing effects, if any, on the local environment.

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 Great Smoky Mountains National Park is 51 km (32 miles) to the southeast (Fig. 1.1).

The ORR lies primarily within the corporate limits of the city of Oak Ridge and encompasses all of the contiguous land owned by DOE in the Oak Ridge area. 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 eastern, southern, and western boundaries (Fig. 1.2).

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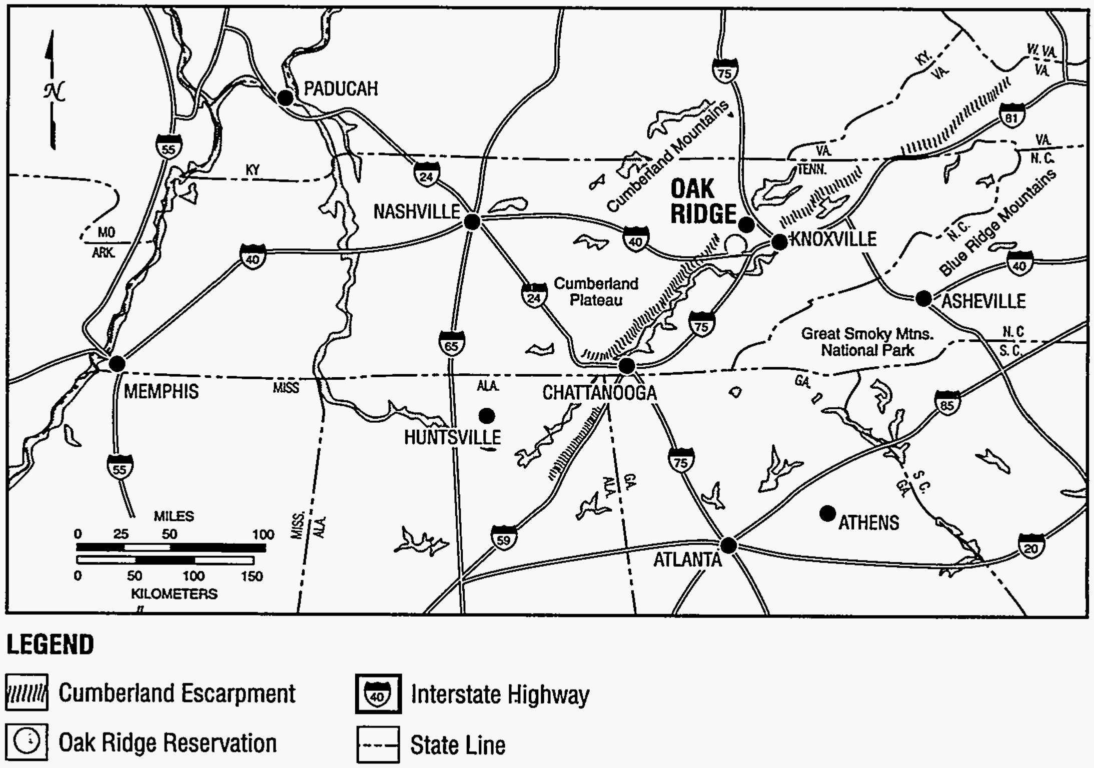

Fig. 1.1. Location of the city of Oak Ridge.

ORNL-DWG 93M-9616R

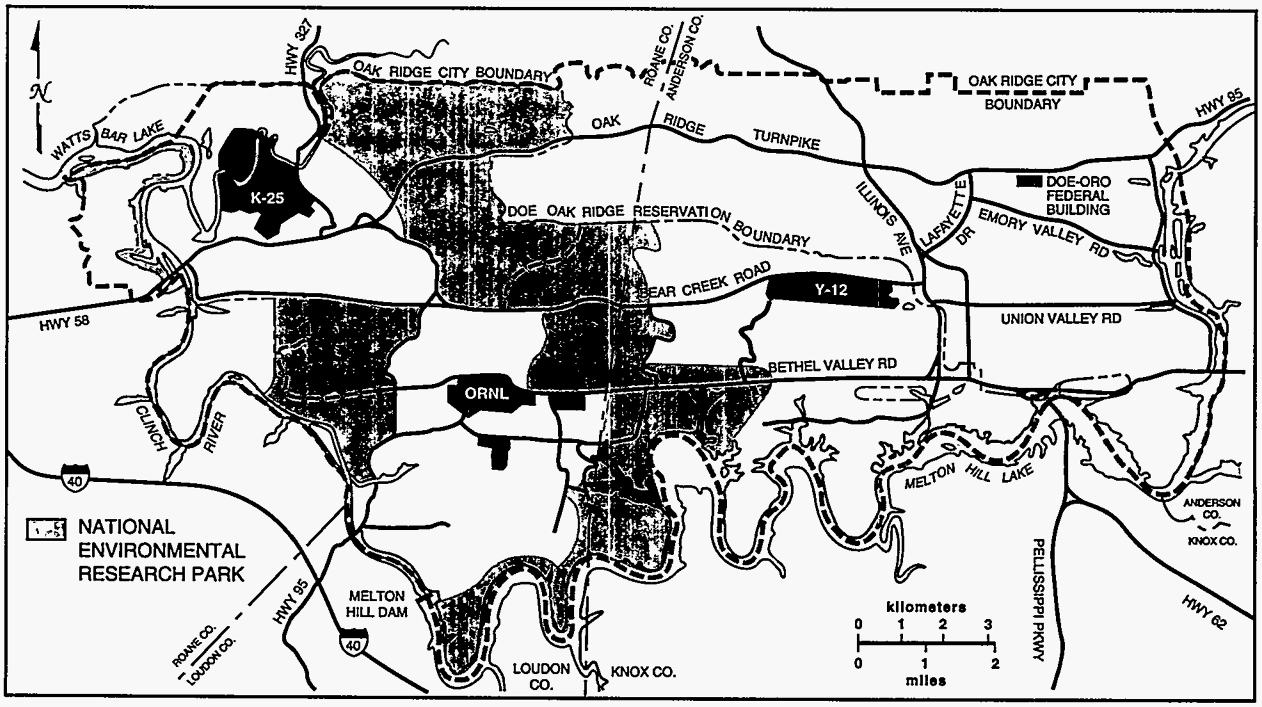

Fig. 1.2. The Oak Ridge Reservation.

The population of the ten-county region is 717,880, with 5% of its labor force employed on the ORR (Fig. 1.3). Other towns nearest the reservation are 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 165,000 (1990 census).

Fewer than 13,000 people live within 8 km (5 miles) of the ORR center. Except for the city of Oak Ridge, the land within 8 km of the ORR is predominantly rural and is used largely for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are popular recreational activities in the area.

ORNL-DWG 94M-8367

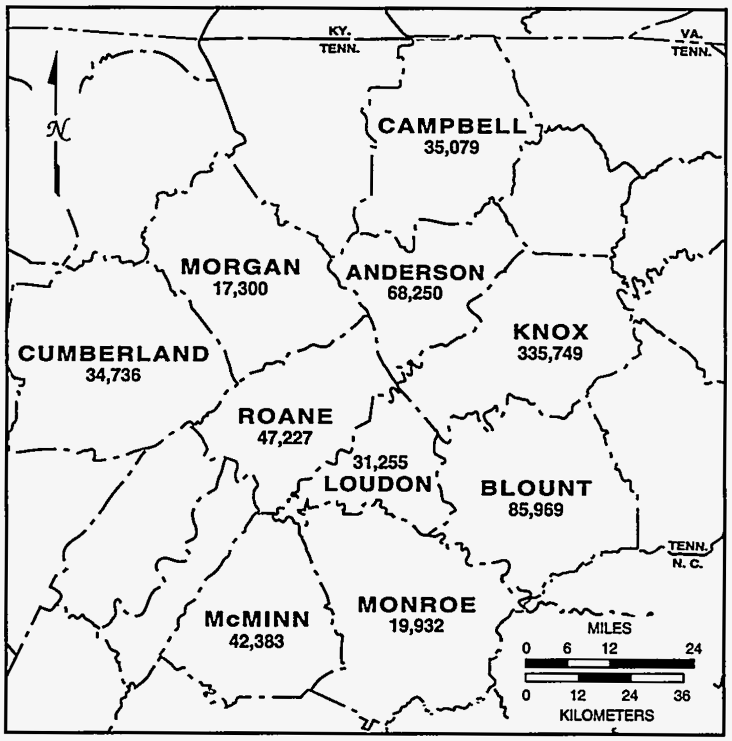

Fig. 1.3. The ten-county region surrounding the Oak Ridge Reservation. (Population figures based on the 1990 U.S. census.)

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.

ORNL-DWG 87M-7054R4

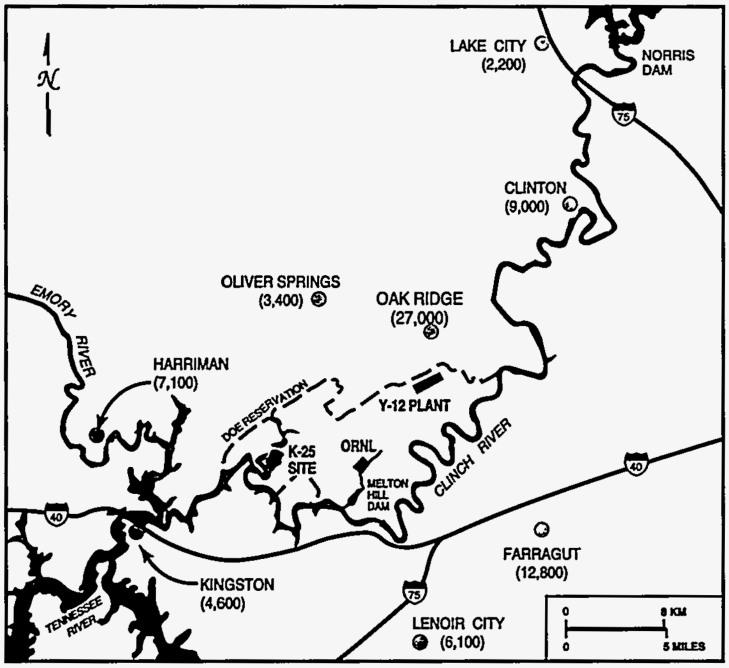

Fig. 1.4. Locations and population of towns nearest to the Oak Ridge Reservation. (Population figures based on the 1990 U.S. census.)

Temperature

The mean annual temperature for the Oak Ridge area is 14.4°C (58°F) (Webster and Bradley 1988). The coldest month is usually January, with temperatures averaging about 3.3°C (38°F) but occasionally dipping as low as –31°C (–24°F).

July is typically the hottest month of the year, with temperatures averaging 25°C (77°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°C (22°F).

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/h (7.4 mph) 75% of the time; tornadoes and winds exceeding 30 km/h (18.5 mph) are rare.

Air stagnation is relatively common in eastern Tennessee (about twice as common as in western Tennessee, for example). An average of about two multi-day air stagnation episodes occur 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.

Precipitation

The 40-year annual average precipitation is 137 cm (53.75 in.), including about 26 cm (10.4 in.) of snowfall. Precipitation in 1993 was 126 cm (49.6 in), about 11 cm (4.3 in.) below the annual average. Precipitation in the region is greatest in the summer months (June through August), largely because of thunderstorm activity. The driest periods generally occur during the fall months, when high-pressure systems are most frequent.

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.

DESCRIPTION OF SITE, FACILITIES, AND OPERATIONS

The reservation contains three major DOE installations: the Oak Ridge Y-12 Plant (Y-12 Plant), the Oak Ridge National Laboratory (ORNL), and the Oak Ridge K-25 Site (K-25 Site). The DOE buildings and structures 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, some ORISE offices and laboratories, the Atmospheric Turbulence and Diffusion Division—National Oceanographic and Atmospheric Administration, the American Museum of Science and Energy, the Martin Marietta Energy Systems, Inc. (Energy Systems), 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.

The reservation is divided geographically into "administrative units," according to which organization manages each unit.

Martin Marietta Energy Systems, Inc.

The ORR is a government-owned, contractor-operated reservation. Energy Systems is the prime contractor managing the Y-12 Plant, ORNL, the K-25 Site, and most other properties on the 14,049-ha (34,700-acre) reservation. The facilities began operating in 1943 as part of the secret World War II Manhattan Project. The primary mission at each facility has changed during the past 50 years. The current missions are described in the following sections.

Oak Ridge Y-12 Plant

Until 1992 the primary mission of the Y-12 Plant was the production and fabrication of nuclear weapon components (Fig. 1.5). 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

ORNL PHOTO 2623-94

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

parts. Fabrication operations included vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Currently the Y-12 Plant is in the midst of refocusing its technical capabilities and expertise to serve DOE and customers who are approved by the DOE. The Y-12 Plant continues to serve as a key manufacturing technology center for the development and demonstration of unique materials, components, and services of importance to DOE and the nation.

To facilitate this effort, the Oak Ridge Centers for Manufacturing Technology have been established at the Y-12 Plant. A total of nine centers are devoted to a specific area of research, manufacturing, and measurement technologies. The facility can accommodate comprehensive development studies and can support the transition of technological areas such as process, environmental management, and manufacturing technology to production (Fig. 1.6).

Y-12 PHOTO 293112

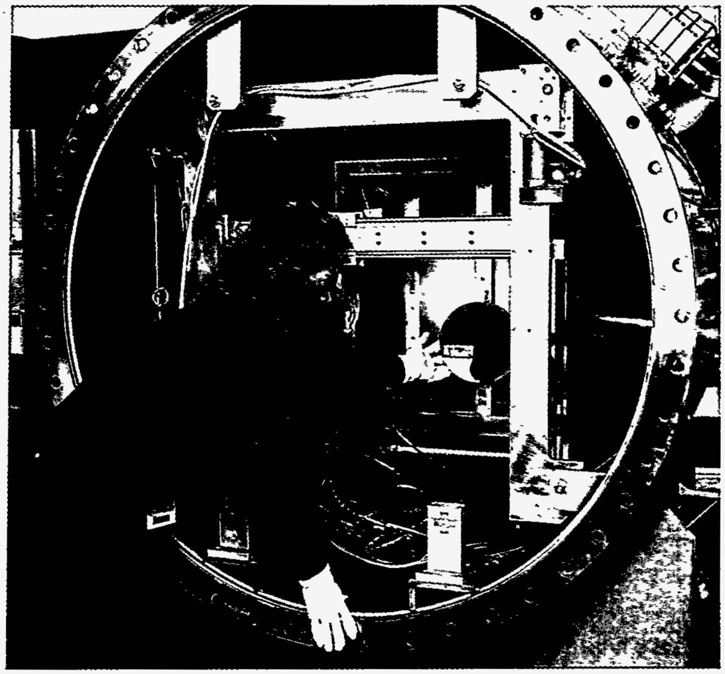

Fig. 1.6. An engineer mounts a gold-coated mirror in an ion-beam milling chamber. The Oak Ridge Centers for Manufacturing Technology are examples of the changing mission of the Oak Ridge Y-12 Plant, from the fabrication of components for nuclear weapons to improving private-sector manufacturing techniques.

Oak Ridge National Laboratory

ORNL, located toward the west end of Melton and Bethel valleys, is a large, multipurpose research laboratory, the primary mission of which is to expand knowledge, both basic and applied, in areas related to energy and the environment (Fig. 1.7). ORNL's facilities include a high-flux nuclear research reactor, chemical pilot plants, research laboratories, radioisotope production laboratories, accelerators, fusion test devices, and support facilities. In addition to the main ORNL complex, the Oak Ridge National Environmental Research Park (Fig. 1.8) is managed by ORNL.

ORNL PHOTO 2622-94

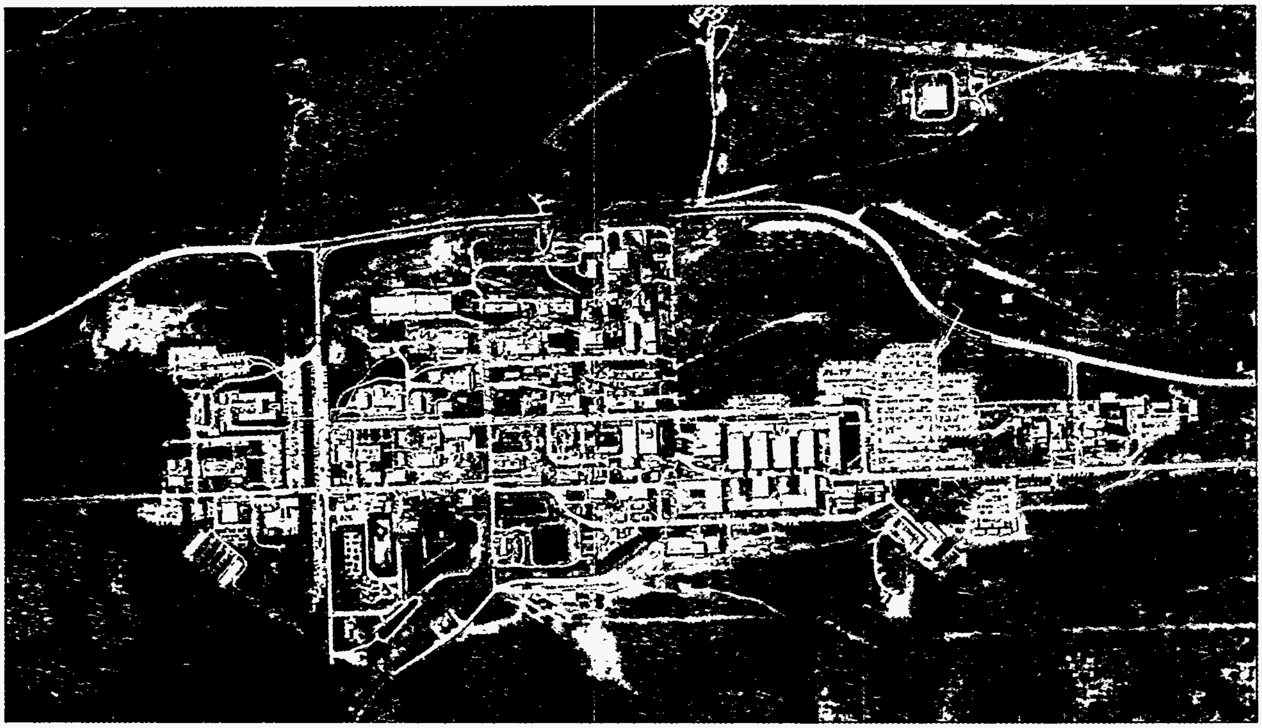

Fig. 1.7. Oak Ridge National Laboratory.

Oak Ridge K-25 Site

The K-25 Site, formerly known as the Oak Ridge Gaseous Diffusion Plant, began operations in 1945 as part of the Manhattan Project (Fig. 1.9). The original mission was to separate the uranium-235 isotope for use in atomic weapons. In December 1987, DOE permanently shut down the gaseous diffusion processes, and the site was placed on the list of facilities slated for decontamination and decommissioning.

The K-25 Site serves as the center of operations for the Energy Systems Environmental Restoration and Waste Management programs. It is also the home of DOE's Center for Environmental Technology and Center for Waste Management (Fig. 1.10); the multifaceted mission of these centers includes activities in technology development, technology transfer, engineering technology, and support for uranium enrichment as well as Martin Marietta central functions, which include business management, engineering, computing, and telecommunications.

Specific missions include management of the Toxic Substances Control Act (TSCA) facility, a unique mixed-waste incinerator; support of risk-based cleanup programs for all contaminated facilities and natural resources; safe and compliant waste management; development and demonstration of innovative environmental technologies; support of the Hazardous Waste Remedial Action Program (HAZWRAP); and provision of cost-effective support and services to K-25 Site users.

Oak Ridge Institute for Science and Education

ORISE is managed for DOE by the Oak Ridge Associated Universities (ORAU), a not-for-profit consortium of 82 colleges and universities (Fig. 1.11). ORISE has stewardship responsibility for 137 ha (340 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 36 ha (90 acres) and lies immediately southeast of the intersection of Bethel Valley Road and Pumphouse Road. It houses one of ORISE's four operating divisions and is being developed for other programmatic uses. ORISE is classified under RCRA as a Conditionally Exempt Small Quantity Generator, and its site accumulation area is located in the Chemical Safety Building on the Scarboro Operations Site.

ORNL PHOTO 10555-91

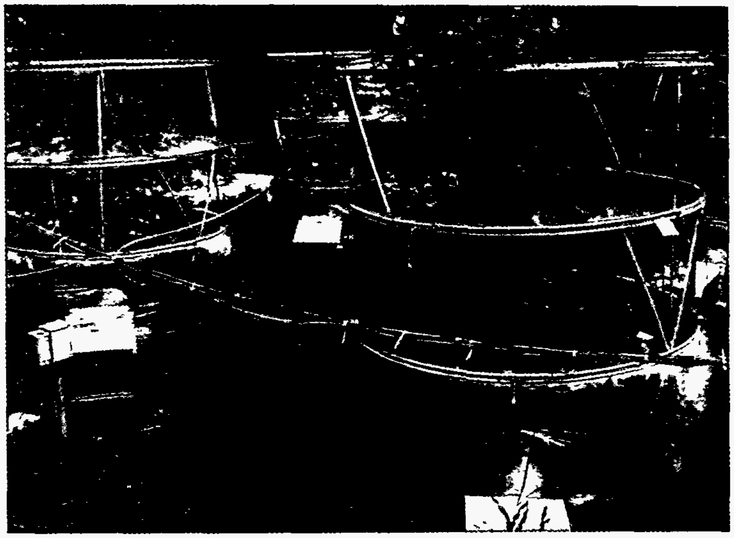

Fig. 1.8. The Global Change Field Research Site, located on the Oak Ridge National Environmental Research Park, is a facility that allows researchers in the ORNL Environmental Sciences Division to investigate how plants will respond to a changing atmosphere. Trees have been grown within open-top chambers and exposed continuously to elevated concentrations of carbon dioxide for up to 4 years in a research project sponsored by DOE's Office of Health and Environmental Research.

ORNL PHOTO 2624-94

Fig. 1.9. The Oak Ridge K-25 Site.

The Freels Bend tract, about 101 ha (250 acres) on the northeastern edge of Freels Bend, abutting Melton Hill Lake, is also within ORISE's area of jurisdiction. Although no programmatic activities are conducted at this site, ORISE does provide maintenance and security, including security for the decommissioned system of cobalt-60 sources at the Variable Dose Rate Irradiation Facility.

KPH 93-2637

Fig. 1.10. In May 1993, the Oak Ridge K-25 Site was dedicated as the home of DOE's Center for Environmental Technology and the Center for Waste Management, demonstrating DOE's commitment to environmental leadership. The centers will foster partnerships between technology users and technology suppliers from government, academic, scientific, and private sectors to deploy innovative, cost-effective technologies to decrease the cost of environmental restoration and waste management.

ORISE PHOTO

Fig. 1.11. An industrial technologist in ORISE's Training and Management Systems Division prepares a job task analysis while observing an analytic chemist at work in the Energy/Environment System Division. ORISE was established by DOE to undertake national and international programs in science and engineering education, training and management systems, energy and environmental systems, and medical sciences. ORISE and its programs are operated by Oak Ridge Associated Universities through a management and operating contract with DOE. (Photo courtesy of ORISE.)

2. Environmental Compliance

E. C. Jones, L. W. McMahon, and L. G. Shipe

Abstract

The policy of the Oak Ridge Reservation and the U.S. Department of Energy (DOE) is to conduct operations safely and to minimize any adverse impact of operations on the environment, ensuring incorporation of all local and national environmental-protection goals in the daily conduct of business. These goals are contained in federal and state statutes, executive orders, and DOE orders. 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.

INTRODUCTION

The ORR comprises the Y-12 Plant, ORNL, the K-25 Site, and two tracts managed by ORISE. The reservation is required to operate in conformance with environmental requirements established by a number of federal and state statutes and regulations, executive orders, DOE orders, and compliance and settlement agreements. Compliance status with regard to these various authorities is summarized in the following sections.

Principal among the regulating agencies are the U.S. Environmental Protection Agency (EPA) (both at headquarters and Region IV) and the Tennessee Department of Environment and Conservation (TDEC). These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations. Ongoing self-assessments of compliance status continue to identify environmental issues. These issues are discussed openly with the regulatory agencies to ensure that compliance with all environmental regulations will be attained.

ORISE is classified under RCRA as a conditionally exempt small quantity generator, and its satellite accumulation area is located in the Chemical Safety Building on the ORISE Scarboro Operations Site. Air emissions through hoods at ORISE facilities are within regulatory limits.

In the following sections, compliance status for the other sites with regard to major environmental statutes and DOE orders is summarized by topic.

COMPLIANCE ACTIVITIES

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 certain nonhazardous waste, underground storage tanks (USTs) used for storage of specific materials, and certain medical waste.

RCRA controls all aspects of the management of hazardous waste, from the point of generation to treatment, storage, and disposal. Hazardous waste generators, including the facilities on the ORR, must follow specific requirements for handling these wastes.

The three ORR sites each generate 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 satellite accumulation areas or 90-day accumulation areas, as appropriate, where they are picked up by waste management personnel. The number of generator accumulation areas at ORNL has increased to 420 and continues to grow as new wastes are identified. The Y-12 Plant has 350 such areas; the K-25 Site maintains 430 accumulation areas.

RCRA requires that owners and operators of hazardous waste management facilities have operating or post-closure care permits for waste management activities. The Y-12 Plant is being operated under interim-status regulations in accordance with a Part A application, the most recent version of which was approved in July 1991. An amended Part A permit application was submitted to TDEC in December 1991 and in August 1993 but has not yet been acted on. RCRA Part B permit applications have been submitted for 20 active storage and treatment units listed on the Part A permit application. These Part B applications are still under review by the state. Ten units operate in accordance with permit-by-rule regulations.

A RCRA Part B post-closure permit for the Y-12 Plant S-3 Pond site was issued in 1991 and subsequently was appealed by DOE. The appeal was resolved in 1993. (See the "RCRA/CERCLA Integration" section for additional detail on this permit.)

ORNL submitted a Part A revision on January 14, 1993, which included 32 units (3 treatment, 28 storage, and 1 disposal), and submitted another Part A revision on October 7, 1993, which included 36 units. During 1993, 25 units operated as interim-status or permitted units, and another 11 units were proposed as either new construction or existing buildings awaiting approval to operate. Two revised Part B permit applications were submitted on April 28, 1993, and October 18, 1993, in response to notices of deficiency (NODs) issued by TDEC for the Chemical Detonation Facility and the Hazardous and Mixed Waste Storage Facilities, respectively. Both permit applications were subsequently approved by TDEC, and draft permits are expected to be issued for review in early 1994. Building 7652 (a hazardous waste storage unit) continues to operate under the 1986 Part B Permit (TN 1890090003 and HWSA-TN001).

Tank 7830A, a hazardous waste storage tank at ORNL, continues to operate under its Part B Permit, which was issued October 15, 1992 (TNHW-027). The other ORNL RCRA units operate under interim status, pending issuance of the Part B permits or completion of closure. ORNL has requested that another unit, Solid Waste Storage Area (SWSA) 5N Burial Ground for retrievably stored, remote-handled transuranic waste (TRU), be removed from RCRA regulation and, instead, be regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Resolution of that request is pending.

The K-25 Site has received four RCRA permits as a result of permit application submissions. Three of the four permits (TNHW-015A, TNHW-056, and TNHW-057) were appealed by DOE and Energy Systems immediately upon issuance in October 1992 because language in the permits required waste from off site to be received only from state-approved facilities; however the appeal was resolved August 5, 1993, through a consent order signed by TDEC, DOE, and Energy Systems. The K-1435 TSCA Incinerator is a hazardous waste treatment unit operating under a RCRA permit (TNHW-15) issued by TDEC on September 28, 1987. A revised RCRA permit based on trial burn results is anticipated to be issued in 1994.

Modifications to K-25 Site RCRA permits for 1993 included an update of contingency-plan information and changes to secondary containment at several waste storage units. A request for a Class 3 Modification to Permit No. TNHW-056 was submitted in November 1993 to allow storage of waste with free liquids and storage of waste other than pond sludge in the K-1065 waste storage units. In December 1993, TDEC approved a request for temporary authorization that was submitted along with the Class 3 Modification to allow storage of Pond Waste Management Project waste with free liquids for 180 days while the modification is being processed. TDEC approval of the Class 3 Modification was received in March 1994.

RCRA Assessments, Closures, and Corrective Measures

The Hazardous and Solid Waste Amendments (HSWA) to RCRA, passed in 1984, require any plant 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 part of Permit No. HSWA-TN 001 for Building 7652 at ORNL. The HSWA permit addresses past, present, and future releases of hazardous constituents to the environment. The HSWA permit requirements have now been integrated into the federal facilities agreement (FFA). (See "RCRA/CERCLA Integration" section for details of the FFA.)

At the K-25 Site a RCRA closure plan for the K-900 Bottle Smasher was approved and issued by TDEC on July 23, 1993, and closure was immediately initiated. Completion of closure is anticipated in early 1994. In November 1993, responses to NODs for closure plans for two units (K-1423 Y-12 Demonstration Project and K-1425 100-Gallon Drain Tank) were submitted to TDEC.

At ORNL, SWSA 6 is currently undergoing RCRA/CERCLA closure. A revised closure plan for SWSA 6 was submitted to TDEC on December 14, 1993. The proposed changes focused on the integration of the RCRA closure with the CERCLA process. In 1993, closure plans were revised for two units (Tank 7075 and New Hydrofracture Surface Facilities) in response to NODs issued by TDEC. The closure plan for Tank 7075 (a hazardous waste storage tank) was deemed complete by TDEC on November 16, 1993. Closure of Tank 7075 will commence after the public notification requirements have been met and formal approval of the plan has been received. The closure activities for Buildings 7824 and 7826 (TRU drum storage units) continued during 1993; closure is expected to be completed in 1994. RCRA-mandated corrective actions were initiated as early as 1986 and continue under the CERCLA process.

At the Y-12 Plant, 21 RCRA units have been certified closed by TDEC since the mid-1980s. Five RCRA Interim Status units have closures in progress. The RCRA closure of the Bear Creek Burial Ground Walk-In Pits was initiated in 1993. Prior to completion of this project, more than 5000 ft^3 of debris removed during the cleanup of the Y-12 Plant Kerr Hollow Quarry was placed in the Walk-In Pits. Disposition of the quarry debris in this manner facilitated final closure of Kerr Hollow Quarry under RCRA.

Additional RCRA treatment, storage, or disposal units requiring closure at the Y-12 Plant include the 9409-5 Tank Storage Unit, the Garage Underground Storage Tanks, and the northern section of the Interim Drum Yard.

Land Disposal Restrictions

HSWA established land disposal restrictions (LDRs), for wastes referred to as "land banned." These restrictions allow storage of hazardous or mixed waste only as necessary to facilitate recovery, treatment, or disposal of untreated waste in land disposal units. The amendments require that all land-banned wastes meet treatment standards based on best available technology prior to land disposal.

The same restrictions apply to the hazardous components of 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 land-banned waste for extended periods. The FFCA contains a compliance schedule that includes the strategies and plans for treatment of the backlog of land-banned waste through the use of existing permitted treatment facilities such as the K-25 Site TSCA Incinerator as well as new facilities.

RCRA/CERCLA Integration

The CERCLA and RCRA corrective action processes are similar. Each process has four steps with similar purposes (Table 2.1).

Table 2.1. 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 implementation of chosen remedy

In January 1992, DOE, EPA, and TDEC negotiated the FFA for environmental restoration activities at the ORR. This agreement is intended to integrate the corrective action processes of RCRA and CERCLA. EPA, DOE, and TDEC have negotiated the agreement 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 at the ORR in accordance with CERCLA. The three parties to the agreement intend to consolidate the DOE CERCLA response obligations with the corrective measures required under the HSWA permit as these units are designated inactive. Response actions under the agreement will achieve comprehensive remediation of releases or threatened releases of hazardous substances, hazardous wastes (including hazardous constituents), pollutants, or contaminants at or from the ORR. For this reason, the agreement supplements corrective actions under the HSWA permit with response actions under CERCLA for releases not currently addressed in the HSWA permit. The parties to the agreement, therefore, intend that activities covered by the agreement will achieve compliance with CERCLA and all other environmental regulations.

In 1992, DOE appealed the applicability of RCRA post-closure permits for closed RCRA units subject to the CERCLA corrective actions. In April 1993, DOE, TDEC, and Energy Systems signed an agreed order regarding the RCRA post-closure permit for the Y-12 Plant S-3 Site (a RCRA-certified closed treatment, storage, and disposal unit subject to corrective actions for groundwater contamination), thereby resolving the appeal and formally agreeing to proceed with CERCLA as the lead regulatory program and with RCRA as an applicable or relevant and appropriate requirement (ARAR). Under this agreement, RCRA will be applied as an ARAR to the extent that post-closure maintenance, care, and monitoring of former RCRA treatment, storage, and disposal units will be conducted in compliance with the terms of RCRA post-closure permits.

In December 1993, ORNL submitted a revised closure plan for WAG 6 to TDEC for review and approval. The revised plan was rewritten based on TDEC guidance to better integrate the CERCLA process into the RCRA Closure Plan. TDEC has not yet responded.

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA, also known as Superfund, was passed in 1980 and was significantly strengthened in 1986 with passage of the Superfund Amendments and Reauthorization Act (SARA)/Title III amendments. CERCLA/SARA requires investigation of abandoned or uncontrolled hazardous waste sites where a release has occurred or may occur, and remediation if the site is determined to pose significant risk to the environment. CERCLA authorizes the EPA to place sites on a National Priority List of the sites most urgently requiring cleanup. (Additional requirements of SARA/Title III reporting are covered in the sections entitled "Emergency Planning and Community Right-to-Know Act" and "Environmental Occurrences").

The ORR was placed on the National Priorities List in December 1989, making the site subject to CERCLA. The CERCLA program assigns liability and provides for compensation, cleanup, and response to hazardous substances released to the environment. Section 120(e)(5) of the act requires a progress report to Congress in implementing CERCLA 120 requirements; a progress report for the ORR was submitted in December 1993.

In accordance with Section 120 of CERCLA, DOE has negotiated an FFA with EPA and TDEC to coordinate ORR cleanup activities. The FFA coordinates responses and remedial actions under CERCLA and the RCRA HSWA permit issued to DOE for the ORR.

The FFA does not replace this RCRA HSWA permit but coordinates remedial activities necessary to protect human health and the environment and reduces duplication of corrective actions or administrative requirements under CERCLA. The FFA also addresses technical standards for new and existing liquid low-level radioactive waste (LLLW) storage tanks.

Under CERCLA, the cleanup of a site may be addressed incrementally by dividing the site into a number of operable units (OUs). Depending on the complexity of the problems associated with the site, a number of OUs may be needed to comprehensively address complete remediation of the site. For example, OUs may address geographical portions of the site, specific site problems, initial phases of an action, or actions that are performed concurrently but are located in different parts of the site.

More than 200 potentially contaminated units have been identified at the Y-12 Plant, resulting from past operations and waste management practices. Many of these sites have been grouped into OUs based on priority and common assessment and remediation requirements. During 1993, field work to support a remedial investigation/feasibility study (RI/FS) was initiated at Bear Creek OU-2 and Upper East Fork Poplar Creek OU-1. Field work was completed at the Abandoned Nitric Acid Pipeline (Upper East Fork Poplar Creek OU-2). Field work was completed at Chestnut Ridge OU-2, and a feasibility study was initiated.

In 1993, the remediation of the 2100-U, 2101-U, and 2104-U concrete settling tanks at the Y-12 Plant was completed. These tanks received flow from the basement sumps located in buildings 9201-4 and 9201-5, where significant quantities of mercury were used in past years. Flows from these sumps were tied into the storm sewer. This project removed an estimated 54,000 lb (24,494 kg) of mercury and mercury-contaminated sediment from the environment.

Other remediation efforts included a piping reroute in another mercury use building (9201-2), which resulted in a 10% reduction in loading of mercury to East Fork Poplar Creek. Additionally, a CERCLA removal action was taken at the Girls' Club in Oak Ridge consisting of covering mercury-contaminated soils.

ORNL's remediation sites are organized into 21 waste area groupings (WAGs) based on drainage area and similar waste characteristics. Currently, seven WAGs and the inactive tanks OU on the ORNL site are being investigated and/or remediated under CERCLA. Of these, five WAGs are being investigated in the CERCLA RI/FS process. These include the following:

- WAG 1—ORNL main plant area;
- WAG 2—White Oak Creek, its tributaries, and White Oak Lake;
- WAG 5—88-acre site including SWSA 5, hydrofracture surface facilities, sludge basin, old hydrofracture waste storage tanks, and TRU waste storage area;
- WAG 10—Subsurface Hydrofracture Facilities, injection wells, observation/monitoring wells, and grout sheets; and
- WAG 6—SWSA 6, the emergency waste basin, and the explosives detonation trench.

In 1993, a CERCLA removal action was planned for removal of strontium-90 from two seeps located along the southern boundary of WAG-5 (along Melton Branch). Implementation of this removal action will occur in 1994. Also in 1993, the scope of the WAG 6 remediation underwent a major change because of public opposition to the selected alternative outlined by the record of decision. In the face of public opposition to the high cost of capping extensive portions of WAG 6 and the relative low risk associated with past and current operations at WAG 6, DOE decided to perform additional environmental monitoring and research and development for another alternative. As a result, in 1994 ORNL will be implementing a multimedia environmental monitoring program to further investigate the flux of contaminants emanating from WAG 6.

Three sites at ORNL are in the CERCLA remedial design/remedial action process:

- WAG 11—the White Wing Scrap Yard (interim remedial action),
- WAG 13—Cesium-137 Contaminated Field and Erosion/Runoff Study Area (interim remedial action), and
- inactive LLLW tanks.

The 209 potentially contaminated units at the K-25 Site were grouped into 14 source OUs and 1 groundwater OU. Of these, the following sites were managed under CERCLA in 1993:

- K-1070 C/D OU—eastern edge of the K-25 Site composed of a 22-acre (8.9 ha) burial ground, three storage areas, and the K-1414 UST site;
- K-1070 SW31 perennial spring—downgradient of the K-1070 C/D burial ground, included in the K-1070 C/D OU;
- K-901 OU—contaminated burial ground, landfarm, holding pond, and two construction waste–disposal areas;
- K-770 OU—contaminated scrap metal yard and contaminated debris, two buildings, and a sewage treatment plant; and
- K-25 Groundwater OU—approximately 1200 acres (486 ha), bound on the south by Tennessee Highway 58, on the east by Blair Road, on the north by Black Oak Ridge, and on the west by the Clinch River.

The K-1407-B holding pond and K-1407-C retention basin are RCRA interim-status units awaiting closure under TDEC regulations. Closure plans for these units were approved granting clean closure, and work is awaiting the decontamination of equipment at the sites before completion (scheduled for mid-1994). At that time, the sites will become exclusively CERCLA units. A record of decision was approved in September 1993, and a remedial design was submitted in October 1993. The actual remediation of both units is scheduled to begin in late 1994, with completion of the action in late 1996.

Sludges contaminated with low-level radioactivity were stored in K-1407-B Holding Pond and K-1407-C Retention Basin and then removed from these ponds in 1988. Portions were fixed in concrete and stored above ground at the K-1417 Drum Storage Yard. The storage yard, also known as the Pond Waste Management Project, is managed under both the CERCLA process and RCRA.

In 1989, during routine inspections of the drums of stabilized K-1407 pond sludge at the K-1417 Storage Facility, it was discovered that many of the drums had begun to corrode. Certain constituents contained in the sludge proved to be incompatible with the container material.

In September 1991, TDEC issued a commissioner's order against Energy Systems and DOE for RCRA violations regarding storage of drums at the K-25 Site. The order assessed a $96,000 penalty against Energy Systems and also sought implementation of the corrective action plan previously submitted to TDEC by DOE and Energy Systems. This action was appealed in October 1991 and was resolved in December 1992 with the issuance of a consent order. The consent order called for implementation of the Pond Waste Management Project action plan as reflected in the September 1991 interim record of decision.

Implementation of the Pond Waste Management Project action plan began October 1991. About 45,600 drums of stabilized sludge were processed and placed in compliant storage, with completion of this phase occurring in October 1992. These drums were stored in existing facilities in buildings K-31 and K-33 and in new storage facilities constructed in the K-1065 area.

Dewatering of approximately 32,000 drums of raw sludge began in September 1992. The processing rate of the dewatering subcontractor was not adequate to meet regulatory milestones, and in early November the subcontractor proposed modifications to the process equipment to improve its performance. On November 14, 1992, a fatal accident occurred during installation of the equipment modifications. The subcontractor activities were suspended pending the results of a DOE investigation. Beginning April 1, 1993, an evaluation of alternatives for restart of the project was performed. The decision was made to repackage the sludge into compatible storage containers, remove it to compliant storage in the K-1065 buildings, and make preparations for contracted, off-site treatment and disposal of the sludge per existing RCRA regulations. It is anticipated that the project will be completed in 1996.

Federal Facilities Compliance Act

The Federal Facilities 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 on mixed waste inventories, treatment capacities, and treatment plans for each site.

The act ensures that opportunities exist for the public to be informed of waste-treatment options, and it encourages active public participation in the decisions affecting federal facilities. The DOE Oak Ridge Operations Office (DOE-ORO) has the lead role in working with the regulatory agencies and the local public in developing site treatment plans. A conceptual site treatment plan for the ORR was provided to the state of Tennessee by DOE-ORO in October 1993. A draft site treatment plan is due in August 1994. This plan will identify the preferred treatment options, location, and schedules and will reflect comments received from key stakeholders and the public. The final site treatment plan for the ORR is to be delivered to the state of Tennessee no later than February 1995. The state must either approve, approve with modification, or disapprove the final site treatment plan by October 1995. Once the plan is approved, the state will enter into a consent order requiring DOE to comply with the plan.

Underground Storage Tanks

USTs on the ORR contain petroleum products and/or CERCLA hazardous substances. All the tanks are regulated under Subtitle I of RCRA, except for tanks containing hazardous wastes that fall under Subtitle C of RCRA.

The Y-12 Plant UST Program includes 47 USTs. This number incorporates regulated petroleum and hazardous substance USTs, and, in the interest of best management practices, tanks that are deferred or exempt from regulation. The following list summarizes the status of the Y-12 Plant USTs:

- Nine active/in-service petroleum USTs.
  - Seven existing tank systems were installed between September 1986 and December 1988. Two of these have been upgraded to meet the current regulatory requirements. The remaining five, emergency generator tanks, will be permanently closed in 1994. Two more tanks were installed in fiscal year (FY) 1993 and meet all current regulatory compliance requirements. The UST registration certificates for these tanks are effective until March 31, 1995.

- Thirty-five closed petroleum USTs (removed or inert-filled).
  - Characterization and excavation are complete at seven tank sites. Documentation for four sites was submitted in FY 1992; the remaining three were submitted during FYs 1993 and 1994. The final documentation was submitted to TDEC, with no further action recommended. Written concurrence from TDEC is pending.
  - Characterizations are complete for five tank sites (12 tanks in total). Corrective action plans have been submitted to the TDEC staff, and to date approval has been received for four of the corrective action plans.
  - Four heating oil tanks have been closed; three prior to December 22, 1988, and one in June 1993. These are exempt from RCRA closure requirements because they are excluded from the statutory definition of regulated USTs.
  - Two emergency power generator tanks were removed in 1974, prior to the promulgation of RCRA Subtitle I regulations.
  - Concurrence from TDEC on final tank closures was received on two tank sites.
  - The closure reports for two waste oil tank sites (Tanks 0084-U and 23-U) are in progress.
  - Three tank sites (six tanks), having an SWMU designation under HSWA, will be investigated under CERCLA.

- Three hazardous-substance USTs.
  - Two concrete burial vaults contain solid uranium oxide. These are deferred from regulation under RCRA. Any UST system containing radioactive material that is regulated under the Atomic Energy Act of 1954 is deferred.
  - A methanol UST was permanently closed in January 1993.

ORNL's UST management program incorporates tanks containing regulated petroleum products and hazardous substances as well as those that are exempt or deferred from RCRA regulations. Program management includes implementation of leak detection, corrosion protection, spill and overflow protection, annual tightness testing, operational controls, record keeping, reporting, and replacement of UST systems that cannot be upgraded by 1998. The program also addresses the immediate removal from service and remediation of required closures, corrective actions, and any upgrading and/or replacement of affected USTs in accordance with the regulatory requirements. Activities in 1993 included initiation of closure of three USTs, initiation or continuation of eight environmental investigations, and completion of final closure of one UST. The status of the tanks managed under the UST Management Program through 1993 is as follows:

- Thirty-four tanks have been excavated or permanently taken out of service. Twenty-three tanks have been approved by TDEC as closed, whereas 11 require additional investigation, corrective actions, and/or review by TDEC before final closure approval.

- Seventeen emergency-generator USTs are active but are deferred from the leak-detection requirements in the Code of Federal Regulations (CFR): 40 CFR 280, Technical Standards and Corrective Action Requirements for Owners and Operators of USTs. These will be taken out of service or upgraded by December 1998.

- Two USTs were upgraded in 1990 to meet the current leak detection requirements and are fully regulated.

- One active UST contains heating oil and is excluded from regulation under 40 CFR 280. A second heating oil UST was taken out of service in 1992, and closure was initiated in 1993.

- Five USTs contain waste oil contaminated with radionuclides and are excluded under 40 CFR 280; these USTs are regulated under RCRA Subtitle C.

- A schedule for upgrading and/or replacing USTs to meet the regulatory requirements by the 1998 deadline has been established by the UST Management Program. Currently ORNL is ahead of the projected schedule for completion.

The K-25 Site UST Management Program includes 22 petroleum and hazardous substance USTs and 16 known or suspected historical UST sites.

- Petroleum and hazardous-substance USTs.
  - Six of these are in operation and consist of two new USTs (unleaded gasoline and diesel) installed in 1991, three emergency-generator USTs and one methanol/unleaded gasoline UST, all of which must be upgraded or removed from service prior to December 22, 1998.
  - One unleaded gasoline UST was placed in temporary closure May 19, 1993.
  - Four additional UST sites were in the investigation/remediation process during 1993. Tanks were removed at three of the sites, and the environmental assessments of the sites indicate no further action. It is anticipated that all three sites will be regulatorily closed in 1994. An environmental reassessment report and addendum to the corrective action plan were submitted to TDEC in 1993 for the fourth UST site (K-1414 9 Diesel UST), which proposed integration of UST and CERCLA regulations for commingled contaminated groundwater plumes. Approval of the K-1414 9 Diesel corrective action plan is also anticipated in 1994.
  - Prior to 1992, 5 UST sites were clean closed according to regulations with no further action required, for a total of 16 regulated USTs at the K-25 Site.
  - The K-1007 unleaded gasoline UST was removed from service and excavated because there had been a release of product prior to the effective date of the UST regulations. Therefore, remediation of this UST site is being addressed by the Environmental Restoration Program, and the site remediation is being tracked as a best management practice in the UST Program.
  - Additionally, 5 USTs, exempt according to RCRA regulations, were tracked as a best management practice within the UST Management Program, for a total of 22 USTs or former USTs.

- Suspected historical USTs.
  - Sixteen known or suspected historical USTs were abandoned prior to the effective date of the UST regulations. The only regulatory requirement for these USTs would be site investigation at the direction of the state if a site were deemed to have the potential to cause harm to public or environment.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. The activities are evaluated for the level of documentation required under NEPA. Ongoing activities or activities having no significant impact on the environment can qualify for a categorical exclusion (CX). Activities with potentially significant environmental impacts may require the preparation of an environmental assessment or an environmental impact statement. Table 2.2 notes the types of NEPA activities conducted at the ORR during 1993.

Table 2.2. NEPA activities during 1993

Types of NEPA documentation	Y-12 Plant	ORNL	K-25 Site
Categorical exclusion (CX) recommendation	11	28	29
CX granted	11	27	16
Approved under general CX documents	332	97	71
Environmental assessment	8	10	2
Special environmental analysis	2	0	0
Environmental impact statement	0	1	0

Energy Systems has developed a procedure that establishes administrative controls and provides requirements for project reviews and compliance with NEPA. The procedure is applicable to all Energy Systems organizations. Provisions apply to (1) the review of each proposed project, activity, or facility for its potential to result in significant impacts to the environment and (2) 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 supporting information. 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 farmland, 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 operation 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.

National Historic Preservation Act

Title 36 CFR 800, "Protection of Historic and Cultural Properties," requires that all undertakings under the direction of federal agencies be reviewed prior to initiation to assess the impacts on cultural and historic resources. DOE-ORO, the Tennessee state historic preservation officer, and the Advisory Council on Historic Preservation have negotiated a programmatic agreement (finalized on May 9, 1994) to outline a DOE-ORO compliance plan for cultural and historic resources. It will require that DOE produce a draft ORR cultural resource management plan within 24 months of implementation of the programmatic agreement. An ad hoc committee of Energy Systems site cultural resource coordinators is currently working on the logistical responsibilities, data needs, and format for the cultural resource management plan. The state historic preservation officer and representatives from the Advisory Council on Historic Preservation toured ORNL, Y-12 Plant, and K-25 Site facilities in 1993.

Compliance with the requirements of the National Historic Preservation Act (NHPA) at ORNL is achieved and maintained in conjunction with NEPA compliance. To identify and evaluate historical and archaeological properties included, or eligible for inclusion, in the National Register of Historic Places, a systematic sitewide intensive survey of ORNL properties was conducted. The results are documented in two reports, *Architectural/Historical Assessment of the Oak Ridge National Laboratory, Oak Ridge Reservation, Anderson and Roane Counties, Tennessee*, ORNL/M-3244 (December 1993), and *An Archaeological Reconnaissance and Evaluation of the Oak Ridge National Laboratory, Oak Ridge Reservation, Anderson and Roane Counties, Tennessee*, ORNL/M-3245 (December 1993), completed in 1993.

The following properties were found to be eligible for inclusion in the National Register of Historic Places: the ORNL Historic District, which is located in the central portion of the ORNL main facilities complex and includes facilities within the 2000 to 5000 areas; Buildings 7001 and 7002 in the East Support Area (7000 area); Building 7503, the Aircraft Reactor Experiment Building (now referred to as the Molten Salt Reactor Experiment Facility); the Tower Shielding Facility (7700 area), which includes Buildings 7700, 7701 through 7704, and 7751; and White Oak Lake and White Oak Dam. Two existing National Register properties were also identified: the Graphite Reactor, a national historic landmark located within the boundaries of the proposed Historic District, and the New Bethel Baptist Church (Building 0903).

In 1993, archaeological/historical reviews, which document the assessment of effects on properties included in or eligible for inclusion in the National Register, were prepared for 16 actions involving either new construction or activities in structures considered eligible for inclusion in the National Register. The reviews were transmitted to the Tennessee state historic preservation officer for approval prior to proceeding with the actions.

In 1993, NHPA compliance training for ORNL staff and management was initiated. Planners and estimators in the Plant and Equipment Division were made aware of NHPA requirements. An NHPA compliance alert to all ORNL division, office, and program managers and to about 200 facility managers was distributed. In addition, the ORNL procedure, *Health, Safety, and Environmental Protection Procedure for Excavation Operations*, ORNL/M-116/R1, was revised to include an addendum that addresses compliance with the Archaeological Resources Protection Act of 1979, as amended, and the Native American Graves Protection and Repatriation Act of 1990. Engineering staff, especially construction engineers, were alerted to these statutory requirements as part of NHPA training.

As part of the cultural resource management plan, a DOE contract will be initiated to inventory all buildings and structures on the K-25 Site for eligibility for the National Register. A field survey will also be performed to confirm archaeological or historic resources in undeveloped areas outside the security fences.

The state historic preservation officer has concurred with determinations of "no historic properties found" for the K-25 Site sewer line upgrade, the K-1423 drum compaction and waste storage and processing facilities, the K-1202 and K-1420-A transfer station and enclosures, and the K-1515 sanitary water waste treatment lagoon. Consultation with the state historic preservation officer and the Advisory Council on Historic Preservation has determined "no adverse effect" to the K-27 Building by the decontamination and decommissioning pilot project. Memoranda of agreement addressing "adverse effect" have been approved by the state historic preservation officer and the Advisory Council on Historic Preservation for the demolition of the K-1028-40/69 guard stations and eight cooling towers. The council is reviewing a memorandum of agreement of adverse effect for the decontamination and decommissioning power plant demolition project (18 buildings). Determinations of "no adverse effect" are currently under review by the state historic preservation officer for the LabPak facility, the property sales facility, the recycle center, and the UF_6 cylinder yard.

During 1993, Y-12 Plant personnel hosted a visit by the state historic preservation officer and representatives from the Advisory Council on Historic Preservation. A presentation was given on the original role of the Y-12 Plant during the Manhattan Project, and a tour of the site was provided, with emphasis on those facilities that were a part of the Manhattan Project. Planning activities for a complete Y-12 Plant cultural resources survey, including archaeological resources and historical resources, began in 1993. The completed Y-12 Plant survey will be combined with the site surveys at ORNL and the K-25 Site and used to prepare the ORR's Cultural Resource Management Plan. Project-specific surveys continue to be conducted in the interim period, in compliance with the NHPA.

Protection of Wetlands

Executive Order 11990 (issued in 1977) was established to mitigate adverse effect 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 NEPA-sensitive resource analysis. Individual surveys and analysis of wetlands for the ORR are conducted by ORNL Environmental Sciences Division personnel on a project-specific basis. DOE-ORO is currently conducting a wetlands survey for the reservation.

The report *Identification and Characterization of Wetlands in the Bear Creek Watershed* (Y/TS-1016) was completed for the Y-12 Plant by Environmental Sciences Division personnel in October 1993. This report, which characterizes and identifies the wetlands in the Bear Creek watershed west of the Y-12 Plant, was submitted to DOE-ORO in December 1993. No other formal requests for wetlands activities were conducted in 1993 pursuant to DOE regulations implementing NEPA 10 CFR 1022. The Y-12 Plant ensures protection of wetlands and nearby tributaries by requiring protective buffer zones and other best management practices whenever nearby activities are proposed that may introduce a potential environmental impact. Projects that plan to alter or eliminate wetlands are first required to obtain the appropriate regulatory permit and meet all conditions of that permit.

In 1993, ORNL staff conducted an analysis of impacts of wetlands regulations on planned and ongoing ORNL construction and remedial investigation activities as required by the DOE implementing regulation at 10 CFR 1022. Regulatory requirements with the potential to impact projects involving wetlands include U.S. Army Corps of Engineers (CWA Section 404) dredge-and-fill permits, federal and state regulations for storm water runoff associated with construction activity, and the Tennessee Aquatic Resources Alteration Permit (ARAP) regulations.

TDEC is developing a regulatory position on wetlands protection that includes mitigation; any impacted wetlands must be replaced in area and function by newly constructed wetlands. ORNL wetland areas are being delineated by using guidelines developed by the U.S. Army Corps of Engineers and working in cooperation with TDEC technical personnel. In 1993, wetlands ecologists provided delineation of wetlands for various planned activities, including weir sediment removal at White Oak Creek and Melton Branch, WAG 6 characterization, site planning and characterization for the proposed Advanced Neutron Source Facility, and the reservationwide southern pine beetle control effort. The southern pine beetle control effort includes delineating and flagging stream-management zones, which establish buffer zones around stream and wetland areas for protection as logging crews remove beetle-infested trees.

Floodplains Management

Executive Order 11988 (issued in 1977) was established to require federal agencies to avoid, to the extent possible, adverse impacts associated with 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 are prepared in accordance with Executive Orders 11988 and 11990 and 10 CFR 1022. Compliance with floodplain and wetlands environmental reviews requires documentation.

At the Y-12 Plant, the NEPA review process is used to evaluate projects for potential impacts to floodplains. A statement of findings was published in the *Federal Register* in May 1993 for the project to construct a new sanitary sewer monitoring station. A NEPA CX was approved in June 1993. A CX is pending approval for a second project, East Fork Poplar Creek Flow Management. A notice of floodplain involvement for this project was published in the *Federal Register* in March 1994.

Evaluation of impact to floodplains at the K-25 Site is ensured through the NEPA review process. The K-25 Site 100-year Floodplain and Surrounding Land Use Map is used during evaluation of proposed actions. Avoidance of proposed actions in the floodplain is recommended if at all possible. Floodplain assessments are currently under review for the Central Neutralization Facility pipeline extension, the K-1515 sanitary plant modification, the bedrock and unconsolidated monitor well installation, and the K-901 OU RI, with approval anticipated in early 1994.

Floodplain maps exist for the ORNL site. In 1993, planned actions (e.g., Interim Action at WAG 5 Seep Area D, Monitoring Station Upgrade Installation at WAG 6, and upgrade of the ORNL Sanitary Sewer System) were reviewed to ensure compliance with Executive Order 11988 and the DOE implementing regulations at 10 CFR 1022.

Endangered Species Act

The Endangered Species Act of 1973 (as amended) provides for the designation and protection of wildlife, fish, and plants that are in danger of becoming extinct. The act also conserves the ecosystems on which such species depend. The act is implemented through project-sensitive resource surveys.

No threatened or endangered animal species (aquatic and terrestrial invertebrates and vertebrates) or critical habitat listed, or proposed to be listed, by the U.S. Fish and Wildlife Service is known to be present on the ORR.

However, the endangered Indiana bat is a possible summer resident along East Fork Poplar Creek and must be included in environmental considerations for proposed construction projects in the area.

Several animal species listed as threatened (Cooper's hawk and the grasshopper sparrow) or endangered (osprey and sharp-shinned hawk) by the state of Tennessee are known to occur on the ORR. The Tennessee dace, a fish species inhabiting Bear Creek and East Fork Poplar Creek, is listed as a "special concern" by the state. Environmental considerations for any proposed project that would disturb habitats where threatened or endangered species occur must include the potentially affected species.

As part of the NEPA process, the ORNL Environmental Sciences Division is consulted to minimize potential effects to threatened and endangered species. Surveys are performed, and mitigating measures are designed as needed. DOE-ORO and Energy Systems are currently communicating on threatened and endangered species with the U.S. Fish and Wildlife Service to discuss plans for performing a reservation-wide survey for threatened and endangered species.

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. A second provision of the SDWA requires individual states to establish programs to prevent contamination of underground sources of drinking water by underground injection of hazardous waste.

Potable water for ORNL and the Y-12 Plant is received from a DOE-owned water-treatment facility located northeast of the Y-12 Plant currently managed by Johnson Controls World 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 compliance requirements.

A recent requirement of the SDWA is the incorporation of the lead and copper rule, which requires compliance monitoring for these parameters. Treatment technique requirements are triggered by exceedences of the lead and copper action levels (0.015 mg/L and 1.3 mg/L, respectively) measured in the 90th percentile. Two consecutive 6-month sampling periods are required to demonstrate compliance.

In June 1993, the Y-12 Plant completed the second of the two consecutive 6-month sampling periods for lead and copper, and compliance requirements have been met. In July 1993, the Y-12 Plant requested from TDEC, and was granted, a reduced monitoring status for lead and copper. The terms of the reduced monitoring status require that 20 samples be taken annually during the months of July, August, or September for the next 3 years. In addition, a request has been filed for exemption from the asbestos-monitoring requirements. Exemption is allowed under TDEC regulations for systems that do not have asbestos-containing pipes.

In October 1993, ORNL completed the first annual sampling period, having completed the two consecutive 6-month sampling periods under the SDWA lead and copper rule. ORNL met the 90th percentile for lead and copper concentration requirements for the two consecutive 6-month sampling periods.

The K-1515 Sanitary Water Plant provides drinking water for the K-25 Site and for an industrial park located on Bear Creek Road south of the site. The facility is also DOE-owned and 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 by testing monthly and quarterly for required constituents and reporting the results 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. The K-25 cross-contamination and backflow prevention program has existed for many years. A quality control check is performed on each backflow prevention device semiannually to ensure that the sewer does not back flow. A project to install a new treatment system to remove chlorine and suspended solids from filter backwash is scheduled for 1994. This improvement is required to comply with National Pollutant Discharge Elimination System (NPDES) discharge requirements.

A cross-contamination control program that has been implemented at the Y-12 Plant, ORNL, and the K-25 Site prevents and eliminates cross-connects of sanitary water with process water and uses backflow prevention devices and an engineering review and permitting process. As part of the program, an inventory of installed backflow prevention devices is maintained, and inspection and maintenance of the devices are conducted in accordance with regulatory requirements.

As of July 1, 1992, TDEC *Regulations for Public Water Systems and Drinking Water Quality*, Chapter 1200-S-1.32(2)(a) ("Plans Review") requires submittal of drawings for state approval and payment of TDEC fees for modifications to water-distribution systems. Changes to DOE-ORO–controlled distribution systems will be evaluated on a case-by-case basis to determine applicability of this requirement.

Clean Water Act

The Clean Water Act (CWA) was originally enacted as the Water Pollution Control Act in 1948 and was later established as the Federal Water Pollution Control Act in 1972. Between 1972 and 1987, it was renamed first the "CWA" (by which it is most commonly known) and then the "Water Quality Act." These names corresponded to amendments or additions made to the law. The objective of the CWA is to restore and maintain 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.

National Pollutant Discharge Elimination System

One of the strategies developed to achieve the goals of the CWA was establishment by EPA of specific pollutant limits 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 NPDES permitting program to regulate compliance with these pollutant limitations. The program was designed to protect surface waters by limiting all releases of effluents into streams, reservoirs, and wetlands.

The Y-12 Plant NPDES permit encompasses about 150 active point-source discharges requiring compliance monitoring that resulted in about 14,000 laboratory analyses in 1993, plus numerous field observations. The number of outfalls continues to decline as they are consolidated or eliminated, or as changes in implementation occur at the site. Although exceedences with the NPDES permit limits and spills to the environment occur, considerable progress was made in 1993 to minimize these incidents and their effect on receiving streams. Monitoring of discharges demonstrates that the Y-12 Plant has achieved an NPDES permit compliance rate of more than 99%, and biological-monitoring programs conducted on nearby surface streams provide evidence of the ecological recovery of the streams. At the Y-12 Plant there were 14 NPDES nonconformances in 1993, compared with 43 in 1992 (Fig. 2.1).

The ORNL NPDES permit, renewed in 1986, lists 161 point-source discharges that require compliance monitoring. Many of these are storm drains, roof drains, parking lot drains, and storage area drains, including storm water runoff from Bethel Valley Road, the public highway that passes through the ORNL site. Occasional spills and precipitation runoff from storm and parking lot drains have resulted in NPDES permit effluent limits being exceeded; however, most of these exceedences are associated with precipitation runoff. Progress continues toward minimizing or eliminating these exceedences (Fig. 2.1). Compliance is determined by approximately 18,000 laboratory analyses and measurements in 1993, plus numerous field observations by various ORNL staff. The NPDES permit limit compliance rate across all discharge points for 1993 was greater than 99%. About 50% or more of ORNL's permit nonconformances are for suspended solids, oil, and grease limit exceedences.

The K-25 Site NPDES permit includes 7 major outfalls and 137 storm drain outfalls. Discharges at previously permitted pond outfalls have been altered to include monitoring of the storm drains that discharge into these ponds. Of the seven major outfalls, the discharges through two outfalls were permanently halted during 1993. One storm drain outfall was added, and three were removed from the permit during 1993. The annual number of K-25 Site NPDES excursions has steadily declined since 1991 (Fig. 2.1). Out of about 25,000 NPDES laboratory analyses completed in 1993, only 10 excursions occurred, indicating a compliance rate of more than 99%.

Status of NPDES Permits

The Y-12 Plant NPDES permit expired on May 23, 1990. The plant continues to operate under the former permit pending issuance of a new permit by TDEC as provided in Tennessee water pollution control regulations. A permit application for renewal was submitted in November 1989 and included some miscellaneous outfalls not specifically listed in the expired permit. An addendum to the November 1989 application was submitted to TDEC in February 1993. The individual storm water permit application was submitted in October 1992. The new NPDES permit is anticipated to be issued in June 1994.

ORNL is currently operating under an NPDES permit, issued by TDEC and EPA Region IV on April 1, 1986, that expired on March 31, 1991. TDEC regulations allow for an expired permit to legally remain in effect until the new permit is issued, provided that a permit renewal application is submitted at least 180 days prior to expiration of this old permit. An application for renewal was submitted to TDEC on September 28, 1990. ORNL anticipates NPDES permit renewal action by TDEC in 1994.

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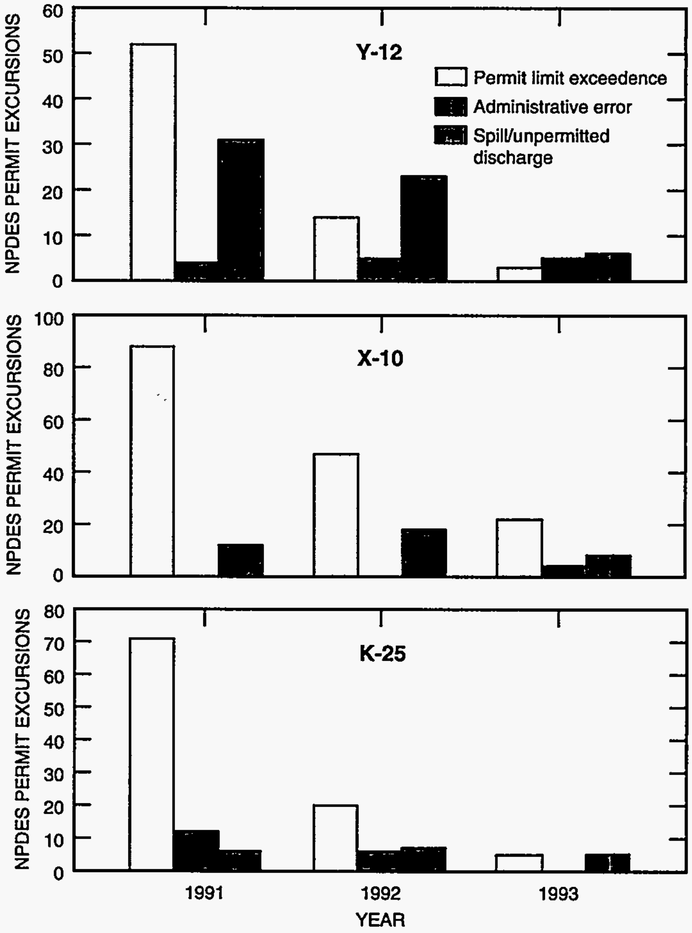

Fig. 2.1. Three-year summary of NPDES nonconformances.

To comply with state and federal regulations, ORNL submitted a separate, individual NPDES storm water application in October 1992. It is anticipated that storm water discharges will continue to be a part of the ORNL NPDES permit. In May 1993, ORNL prepared at TDEC's request an information package to provide TDEC with updated information for use in the permit renewal process. Throughout 1993, periodic discussions took place among TDEC, DOE, and ORNL personnel regarding NPDES permit renewal.

The K-25 Site was issued a new NPDES permit on October 1, 1992. As required by the permit, development of a Storm Water Pollution Prevention Plan was completed by October 1993. This plan identifies areas with the potential to discharge pollutants to the receiving waters and includes a pollutant control strategy to identify actions to minimize discharges of pollutants. Sampling as outlined in the Storm Water Pollution Prevention Plan was initiated during the fourth quarter of 1993.

Sanitary Wastewater

The CWA includes pretreatment regulations for publicly owned treatment works. Sanitary wastewater for the Y-12 Plant is discharged to the city of Oak Ridge under an industrial pretreatment permit. In 1993, a sanitary sewer inflow/infiltration study was conducted at the request of the city of Oak Ridge and DOE. Inflow may result from storm water runoff from rain spouts and manholes, and groundwater may infiltrate through cracks and crevices in the sewer. In addition, clean water systems such as steam condensate and once-through cooling water may contribute to inflow from the Y-12 Plant.

Collection of data for this inflow/infiltration study began in January 1993 and was completed in August 1993. The purpose of the study was to determine the average base flow for the Y-12 Plant and the increase in flow because of storms. Results of the study were useful in identifying clean water sources such as cooling waters and steam condensate connected to the sanitary sewer and in identifying sources of inflow and groundwater infiltration. Dechlorination units have been purchased for use on those chlorine-containing sources when they are rerouted to the storm sewer.

The base flow for the Y-12 Plant was measured at approximately 0.5 million gallons per day, with peak daily flows during intense rainfall approaching 1.0 million gallons per day. Y-12 Plant staff are aggressively pursuing funding for corrective activities to ensure compliance with the city of Oak Ridge sanitary sewer use ordinance and pretreatment permit. Support of the Y-12 Sanitary Sewer Upgrade line item project is included in these activities and is considered vital to bringing the Y-12 Plant sanitary sewer collection system into regulatory compliance. A new monitoring station will be built to allow for more accurate monitoring of the sanitary sewage discharges by the Y-12 Plant. Design of the East End Sanitary Sewer Monitoring Station was completed in 1993, with construction scheduled to begin in early 1994 and be complete by mid-1994.

The city of Oak Ridge performed their annual sanitary sewer compliance inspection on September 9, 1993. During 1993, the Y-12 Plant met all sampling and allowable discharge limits for pollutants listed in the pretreatment permit. Comments by city personnel included a concern of "undesirable materials" entering the sanitary sewer as a result of inflow and infiltration through contaminated soils. The city also commented that the construction of the Y-12 Plant monitoring station is still a high priority. The 1993 permit application questionnaire was briefly discussed. The city plans to issue new permits for industrial customers within the next 2 years. The recently completed questionnaire will be used in conjunction with sludge studies conducted by city-contracted consultants to determine discharge weight limits for each industrial customer.

Sanitary sewer radiological sample results 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, including uranium, that is monitored has exceeded a DCG. Typically the results are three orders of magnitude below DCG limits.

K-25 Site domestic wastewater is treated at the K-1203 Sewage Treatment Plant. The plant does not meet the definition of a publicly owned treatment works. Discharges are regulated under the NPDES permit. The permit requires many of the elements of a pretreatment program in the control and surveillance program for wastewater acceptability at the K-25 Site sewage treatment plant. Specific requirements for sewage sludge management are also included in the K-25 Site NPDES permit.

At ORNL, sanitary wastewaters are collected, treated, and discharged separately from other liquid wastes, according to parameters set forth in the NPDES permit. Sanitary wastewaters include (1) sanitary sewage from Bethel and Melton valleys, (2) area runoff of rainwater, and (3) point sources (e.g., coal yard runoff and once-through cooling water). The sanitary wastewater treatment facility, Building 2521, treats biodegradable wastewaters through a combination of comminutors, chlorination equipment, aeration, and sludge-drying beds. The wastewater is ultimately discharged into White Oak Creek. Leakage of groundwater and laundry wastewaters into the sewage sludge has, at times, caused the sludge to be slightly radioactive. As a result, the sludges were disposed of as solid low-level waste (LLW). Upgrades of the sanitary sewer lines and the laundry facility are planned for FY 1994 to reduce radiological contamination.

Aquatic Resources Protection

The U.S. Army Corps of Engineers and the TDEC both conduct permitting programs for projects and activities with the potential to impact aquatic resources, including navigable waters, surface waters (including tributaries), and wetlands. These are the Corps of Engineers Section 404 Dredge-and-Fill Permits and the TDEC Aquatic Resources Alteration Permits (ARAPs). For ARAP activities, see the "Environmental Permits" section.

Oil Pollution Prevention

Section 311 of the CWA regulates 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 to minimize the potential for oil discharges. This section was then significantly amended by the Oil Pollution Act of 1990 and has the improvement of federal response to oil spills as its primary objective. This act was prompted by major oil spills that occurred on the nation's waterways, such as those that occurred from the Ashland Oil Company to the Ohio River in 1988 and from the *Exxon Valdez* to Prince William Sound in 1989.

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 K-25 Site is subject to the requirements for preparing such a plan because of its oil-storage capacity and location. The plan was prepared and submitted to EPA on February 18, 1993. 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 plan was required for the Y-12 Plant or ORNL although oil spill protection provisions are included in the site Spill Prevention, Control, and Countermeasures plans.

Toxic Substances Control Act

TSCA regulates the manufacture, processing, distribution in commerce, use, and disposal of chemical substances and mixtures that may present an unreasonable risk of injury to human health or the environment. TSCA gives EPA comprehensive authority to identify and control chemical substances manufactured, processed, distributed in commerce, and used within the United States. EPA imposes strict reporting and record keeping of new chemicals and new information for existing chemicals relating to any substantial risk to heath or the environment.

TSCA specifically banned the manufacture, processing, and distribution in commerce of polychlorinated biphenyls (PCBs) but allowed the systematic phaseout of existing PCBs and PCB equipment. EPA codified regulations controlling PCBs in 40 CFR 761. PCBs are not regulated per se by the state of Tennessee; however, PCBs are restricted from land disposal except as a special exception under the Tennessee solid waste regulations. PCBs are also restricted from discharge into waterways under the CWA through the NPDES program administered by the state of Tennessee.

Authorized and Unauthorized Uses

PCBs have been used at the ORR facilities in a variety of systems and applications throughout the 50-year history of the reservation. Many of these uses were common applications that were authorized for continued use under the PCB regulations promulgated in 1979 (uses not authorized in the regulation are banned under the act). These include transformers, capacitors, and various other electrical-distribution equipment, heat-transfer systems, and hydraulic systems. Some of these uses have been phased out and are no longer authorized under the regulations but still exist within the ORR.

Other uses within the ORR included those not contemplated by EPA in 1979 and thus are not included in uses authorized under the regulation. These include ventilation gaskets, metal-working lathes, lubricating systems, and other equipment. Recently, PCBs have been discovered in high-voltage electrical wire and cable insulation, another use not known or authorized by EPA in 1979. These unauthorized uses of PCBs are covered under the equipment-specific agreements with EPA Region IV or the uranium-enrichment PCB federal facilities compliance agreement (UE-PCB-FFCA) and are under negotiation for inclusion in an ORR-PCB-FFCA. (See "Compliance Agreement" section for details.)

Several compliance issues exist at the Y-12 Plant and ORNL because the ORR-PCB-FFCA negotiations have not been completed. DOE has submitted all information required by EPA Region IV in drafting the agreement. DOE-ORO is awaiting a draft agreement from EPA Region IV and continues to provide assistance and information as requested by EPA Region IV. The ORR-PCB-FFCA will provide a vehicle for resolution of PCB compliance issues on the ORR.

Ongoing programs are being pursued to phase out the use of PCBs at ORR by reclassification (a lowering of regulated status for a piece of equipment by draining and by flushing) and by disposal. Other programs to identify equipment and systems containing PCBs and to characterize them by sampling and analysis are aggressively being undertaken. A proposal has been made to EPA to dispose of a PCB-contaminated heat-transfer system at the K-25 Site by flushing. Other similar proposals for various PCB equipment and systems are being suggested for the ORR-PCB-FFCA. As a result of historical and continuing uses of PCBs within the ORR, a large quantity of PCB waste has been and continues to be generated.

Historic PCB Spills

Various locations within the facilities where PCB equipment was used have been identified as sites of historic PCB contamination. These sites resulted from PCB spills occurring throughout the history of the reservation, many of which occurred prior to regulation. K-25 Site historic PCB spill sites are covered under the UE-PCB-FFCA to be cleaned or remediated according to the schedule of the agreement. Spill sites at the Y-12 Plant and ORNL are proposed for inclusion in the ORR-PCB-FFCA.

Progress is being made through ongoing cleanup efforts to remediate these sites. Several historic spill sites and some historically contaminated equipment have been decontaminated at the Y-12 Plant through use of innovative cleanup technologies. ORNL and the Y-12 Plant have undertaken research and development (R&D) projects to develop alternative cleanup technologies. These projects are permitted by EPA Region IV. As with the phasing out of PCB equipment in use, spill-cleanup efforts result in the generation of a large quantity of PCB waste at the ORR. Much of this PCB waste is also radioactive.

Storage and Disposal of PCB/Radioactive Wastes

The PCB regulations require PCB wastes to be disposed of within 1 year of the date the PCBs are removed from service. Because of a lack of available disposal avenues, PCB/radioactive wastes are stored at the K-25 Site, Y-12 Plant, and ORNL for periods exceeding 1 year. The UE-PCB-FFCA allows the K-25 Site to store such wastes generated by the K-25 Site for periods exceeding 1 year. PCB/radioactive wastes older than 1 year generated by other DOE facilities, particularly the Y-12 Plant and ORNL, are also stored at the K-25 Site.

In February 1993, DOE submitted an updated list of PCB compliance issues to EPA Region IV for consideration in developing the ORR-PCB-FFCA. Among these was a request to extend the current UE-PCB-FFCA allowance to store PCB/radioactive wastes for periods exceeding 1 year to all such wastes stored by the three ORR facilities. In addition to the lack of available disposal avenues, concern over the potential for even small amounts of radioactive waste to be shipped off site for disposal prompted DOE to mandate a self-imposed moratorium on the shipment of waste for off-site disposal pending development of procedures to ensure no radioactive material is shipped. The K-25 Site TSCA Incinerator is the only facility in the nation permitted to incinerate RCRA/PCB/radioactive waste.

Various difficulties arise in meeting the storage requirements of the PCB regulations because of the unique characteristics and large volume of PCB wastes generated on the ORR. One of the most significant is the necessity of storing some PCB/radioactive wastes in specific geometrically shaped containers (because of criticality safety concerns) and in areas not meeting PCB regulatory secondary containment requirements. Other storage concerns are the inability to place large items such as ventilation duct systems into containers. Storage concerns of this nature are addressed under the UE-PCB-FFCA and the proposed ORR-PCB-FFCA.

K-25 Site TSCA Incinerator PCB Disposal Approval (Permit)

The K-25 Site TSCA Incinerator is currently operating under an extension of EPA Region IV approval granted on March 20, 1989. This extension is based on submittal of a reapplication for PCB disposal approval filed with EPA Region IV on December 20, 1991, which was within the time frame allowed for reapplication. Minor amendments, updates, and corrections to the reapplication, identified by DOE, have been made in the interim and submitted to EPA. One of the amendments approved for immediate implementation by EPA Region IV was the use of an extraction oxygen monitor instead of the in situ oxygen monitor as originally proposed. This approval was granted on February 25, 1993.

PCB Research and Development Permit

EPA Region IV has issued ORNL two R&D permits to conduct research on alternate disposal methods for PCBs under 500 lb. Research permits are valid for 1 year. Both permits are held by ORNL's Chemical Technology Division.

In December 1992, EPA Region IV issued ORNL an R&D permit for biological dechlorination research with PCBs. ORNL requested in September 1993 that the research permit be extended for 1 year.

EPA Region IV granted the extension in December 1993, and the permit will expire December 29, 1994. On April 21, 1993, EPA issued ORNL an R&D permit to conduct research on the use of a base-catalyzed dechlorination process for removal and treatment of radioactive PCB-contaminated waste. The permit will expire on April 21, 1994. A request for extension and modification of this permit was sent to EPA Region IV in January 1994. EPA Region IV has not yet granted an extension.

In November 1993, ORNL submitted an R&D permit application to EPA Region IV to conduct a field demonstration on the use of base-catalyzed destruction using solvated electrons of PCB-contaminated material. In a conference call on February 3, 1994, EPA Region IV indicated that ORNL would receive a permit to conduct the research, with a limitation of using only 500 lb of PCB-contaminated material. ORNL submitted a permit application to EPA Headquarters (EPA-HQ) in Washington, D.C., requesting that more than 500 lb of PCB-contaminated materials be allowed for use in the demonstration.

In November 1993, EPA Region IV issued the Y-12 Plant an R&D permit for thermal desorption removal/treatment of radioactive PCB-contaminated soil, sediments, and sludge. A request for modification of this permit was submitted to EPA Region IV in March 1994.

Compliance Agreements

The UE-PCB-FFCA was signed February 20, 1992. This agreement between DOE-HQ and EPA-HQ provided a vehicle for resolution of PCB issues at the Portsmouth, Ohio, and Paducah, Kentucky, UE facilities and the former K-25 UE facility at Oak Ridge. In July 1993, the Portsmouth and Paducah facilities became the United States Enrichment Corporation, a wholly owned enterprise of the U.S. government independent of DOE; however, responsibility for PCB regulatory compliance was retained by DOE for these two facilities.

EPA-HQ agreed to continue the UE-PCB-FFCA with DOE for the Portsmouth and Paducah facilities but directed EPA Region IV to enter into an agreement with DOE-ORO that would include the K-25 Site as well as the Y-12 Plant and ORNL. The UE-PCB-FFCA continues in force for the K-25 Site until the new agreement can be completed. The new agreement is tentatively entitled the Oak Ridge Reservation PCB Federal Facilities Compliance Agreement (ORR-PCB-FFCA). DOE-HQ and EPA-HQ meet quarterly to discuss the progress of commitments under the UE-PCB-FFCA. Several proposals to advance efforts under the UE-PCB-FFCA have been proposed and accepted by EPA-HQ. Similar quarterly meetings are being sought with EPA Region IV under the proposed ORR-PCB-FFCA.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacture, storage, and application of registered pesticide products. The regulations for the storage and application of pesticides are found in 40 CFR parts 150 through 189.

The Y-12 Plant, K-25 Site, and ORNL maintain procedures for the storage and application of pesticides. Individuals responsible for the application of FIFRA materials are certified through the University of Tennessee Department of Agriculture. No restricted-use pesticide products are used at the K-25 Site. Safrotin®, used for the control of roaches, is the only restricted-use pesticide used at the Y-12 Plant and ORNL. A small inventory of nonrestricted pesticide products are maintained for use at each facility. It is site policy to store and apply these products in a manner that meets FIFRA requirements for restricted-use products. Storage areas and disposal practices are subject to review and inspection. The Tennessee Department of Agriculture conducted an inspection at ORNL on August 9, 1993. No violations were identified during that inspection.

Emergency Planning and Community Right-To-Know Act

The Emergency Planning and Community Right-To-Know Act (EPCRA) contains four major provisions: (1) planning for chemical emergencies (Sections 301–303), (2) emergency notification of chemical accidents and releases, (Section 304) (see the "Environmental Occurrences" section for additional details), (3) reporting of hazardous chemical inventories (Sections 311 and 312), and (4) toxic chemical release reporting (Section 313).

The emergency-planning section of the law is designed to help communities prepare for and respond to emergencies involving hazardous substances. The emergency notification section of the law requires that a facility immediately notify the community and state of the release of more than a predetermined amount of certain hazardous substances and extremely hazardous substances; this is also known as release reporting. Reporting the hazardous chemical inventory provides local communities and agencies with knowledge of potential hazards posed by stored chemicals. The information also aids on-site emergency-preparedness personnel in responding to an emergency situation. This reporting is done through an annual hazardous chemical inventory, which contains quantities and locations of hazardous chemicals and extremely hazardous substances that have reached the storage threshold as specified within the regulation (Section 312). Also, a list of these chemicals and substances is prepared along with the hazard category (Section 311) and submitted to appropriate local agencies.

In addition, the toxic chemical release report provides information about off-site transfers and releases of toxic chemicals into the air, water, or soil. If the use of the toxic chemical reaches one of the thresholds specified within the act (Section 313) either accidentally or as a result of routine plant operations, then the total amount of the chemical that is released into the environment must be estimated and the amount of the chemical transported as waste to another location must be reported. Reviews are being conducted of toxic chemicals that were used during 1993 for use on the ORR to identify potential toxic chemicals that might be subject to reporting under Section 313. A change in the way the Section 313 reports are prepared became effective with the 1993 report. New DOE guidance requires that toxic chemical usage be aggregated across the three ORR installations to determine whether the reporting threshold is exceeded. Each installation will then submit reports for the chemicals exceeding the threshold.

Reporting of Hazardous Chemical Inventories

During 1993, each site reported hazardous chemical inventories as required by Sections 311 and 312. The Y-12 Plant reported 42 hazardous chemicals and 5 extremely hazardous substances. ORNL reported 22 hazardous chemicals and extremely hazardous substances. The K-25 Site reported 16 hazardous substances, 5 extremely hazardous substances, and 3 hazardous by characteristic categories.

Environmental Occurrences

CERCLA requires notification of the National Response Center if a nonpermitted release of a reportable quantity (RQ) or more of a hazardous substance (including radionuclides) is released to the environment. 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 that they can evaluate whether government response is appropriate.

Other CERCLA provisions allow exemptions from reporting a release of an RQ or more of a hazardous substance if the release is covered by a continuous-release notification or if it is federally permitted. A continuous-release notification provides an exemption from reporting each release of a specific hazardous substance greater than an RQ and allows for an annual report of releases. Releases from the ORR have been evaluated for continuous-release criteria with the conclusion being that there are no continuous releases. Federally permitted releases are releases that comply with a legally enforceable license, permit, regulation, or order.

The Y-12 Plant reported nine releases to the environment to federal and state agencies during 1993. On three separate occasions, the National Response Center was notified of spills involving ethylene glycol (antifreeze) within the Y-12 Plant. Two of the incidents involved government vehicles with broken radiator hoses. The third incident involved two privately owned vehicles involved in a motor vehicle accident. In all three cases, the RQ for ethylene glycol (1 lb) was exceeded.

The Tennessee Emergency Management Agency (TEMA) and the National Response Center were notified of four incidents that involved oil sheens on East Fork Poplar Creek. One of the incidents was caused when a hydraulic line on a bucket truck ruptured. The hydraulic oil ran into a storm sewer drain and subsequently into East Fork Poplar Creek. Another incident occurred following unusually heavy rainfall. An estimated 5 in. of rain fell during a 1-hour period, causing the water level in a basement sump to rise, flushing oil out of an overflow pipe that was at one time connected to an outfall. The outfall had been taken out of service and the end of the pipe was plugged with concrete the previous year. The unusually high water level forced the oil through an opening in the concrete plug. The oil began to seep through the rip-rap on the creek bank and into East Fork Poplar Creek. The sources for the remaining two incidents involving oil sheens were not identified.

Two other incidents within the Y-12 Plant that required notification of TEMA and the National Response Center involved releases of sodium hypochlorite. No adverse impacts from this incident were observed, based on monitoring results and a survey of East Fork Poplar Creek.

ORNL had one release of oil and grease mixed with water in 1993, which was reported to the National Response Center as required under the CWA. ORNL had one reportable release of ethylene glycol, which was also reported to the National Response Center as required by CERCLA. ORNL reported six environmental occurrences to federal and state regulators in 1993.

A vehicle operator for a subcontractor at ORNL attempted to drive a truck with a boom under an asbestos-wrapped steam pipe. The boom brushed against the steam pipe, causing asbestos to be released. There was no personnel exposure and no other property damage as a result of the incident. TEMA was notified. While clearing trees and brush along a power line right-of-way, a bulldozer sheared an air-vent line off a water line, causing a water leak. The leak fed chlorinated water into two tributaries that feed into Melton Branch. The leak was isolated and repaired. DOE-HQ and TEMA were notified.

An underground water line broke, and uncontaminated chlorinated water was released. At the time this leak occurred, the area had experienced an extended period of dry weather, causing the soil surrounding the water line to shrink. This shrinkage placed uneven stress on the line, causing it to crack along its length, resulting in the leak. DOE-HQ and TEMA were notified. When the sump pump in a building basement failed, water entered an elevator pit area containing residual oil and grease. To control the water level, some of this water was pumped to the storm drain system. The sump pump discharge line was rerouted to the Process Wastewater Treatment Plant immediately. The National Response Center, DOE-HQ, and TEMA were notified.

While conducting a radiation walkover survey in an area immediately adjacent to and west of SWSA 6, ORNL health physics technicians discovered 12 localized contaminated spots on the ground. The contamination is believed to be legacy contamination, probably spread by wildlife that resides on the reservation. The areas near a state highway were roped off and "Regulated Area" signs attached. This site has been identified as an additional SWMU and is being managed as such. All of ORNL's SWMUs identified in all of the WAGs are scheduled to be remediated through the Environmental Restoration and Waste Management Division's programs. TEMA was notified. During a daily routine inspection, inspectors discovered that a low-level radioactive solution had leaked out of an inactive LLLW storage tank. The tank was emptied and will remain in inactive status. The National Response Center, DOE-HQ, and TEMA were notified.

The K-25 Site reported seven releases to the environment to state and federal agencies during 1993. An oil sheen was discovered at storm drain 170, located north of Building K-1419. The sheen extended into Mitchell Branch, which is considered waters of the state. It was determined that water containing the oil had been released when a secondary containment dike was drained. On another occasion, an oil sheen was observed at the discharge of storm drain 190. The configuration of the oil-skimming device and other equipment located at this storm drain contributed to this environmental occurrence because they occasionally come in contact with each other during heavy rainfall and allow unwanted materials to flow past the skimmer. One incident was reported when yellow striping was applied to a road prior to a rainstorm, which resulted in an unpermitted discharge of paint into the storm drain system. Approximately 1 gal of diluted paint entered the system.

The RQ for ethylene glycol was exceeded four times at the K-25 Site because of vehicle and equipment failure; each quantity was at or below 40 lb. Although reporting these releases is required, no ethylene glycol was released off site.

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 Program.

General CAA Compliance

CAA compliance is an integral part of the TDEC air permit program in which all three ORR facilities participate. Each site complies with all federal air regulations in addition to the stated air-permit conditions. The CAA program staff routinely participates in both walkdown inspections and internal audits to identify areas for improvement in the operation of air sources.

Major sources are appropriately permitted, and documentation of compliance is developed. A number of minor sources that are exempt from permitting under state of Tennessee rules also are being addressed. All major emission sources are permitted by TDEC and are operating in compliance with those permits. The procedures for permitting, compliance inspection, and documentation of compliance are in place.

Compliance with 1990 CAA Amendments

An increasing number of the new CAA amendment rules have application at all three ORR facilities. Regarding Title VI, Stratospheric Ozone, compliance activities have included response to the final refrigerant-recycling rules that require the purchase and use of certified refrigerant recovery and recycle equipment. In addition, stratospheric ozone protection plans were issued by each facility to outline actions necessary to comply with new limitations on the release of ozone-depleting chemicals and with the 1995 production ban on those chemicals. Compliance requirements for motor vehicle air-conditioner and refrigeration-system maintenance are being met. Studies are proceeding on finding replacements and on performing the necessary modifications to plant refrigeration equipment to accommodate the production ban on ozone-depleting chemicals.

Under Title III, Hazardous Air Pollutants, the major emphasis in 1993 has been on identifying emission sources that will be subject to maximum achievable control technology and on developing emissions inventories for residual risk analyses. Regulatory development of maximum-achievable control-technology standards is also followed closely to enable timely upgrades of emission controls on affected sources.

Under Title V, Air-Permitting Program, each ORR facility is conducting a combined stack-and-vent survey and source-identification program. This information will form the basis for the Title V Permit applications that will be submitted in 1995 and 1996. The comprehensive Title V Permit will replace the individual source permits that were active at each ORR facility.

Radionuclide National Emission Standards for Hazardous Air Pollutants

An FFCA between DOE and EPA for radioactive emission sources on the ORR was signed by all parties in May 1992 and was completed in December 1992. All of the milestones in the FFCA have been met, and the ORR is in full compliance with all requirements of Radionuclide National Emissions Standards for Hazardous Air Pollutants (Rad-NESHAP) as set forth in 40 CFR 61, Subpart H. On March 26, 1993, EPA Region IV certified that DOE-ORO had completed all of the actions required by the ORR Rad-NESHAP FFCA and was considered to be in compliance with the Rad-NESHAP regulations. A Rad-NESHAP inspection performed by EPA in September 1993 resulted in no violations, deficiencies, or findings.

Compliance with the Rad-NESHAP dose limit of 10 mrem per year to the maximally exposed individual of the public was demonstrated by modeling emissions from major and minor point sources during periods of operation. The annual off-site dose to the most-exposed member of the public for the ORR was 1.4 mrem in 1993, which was well below the Rad-NESHAP compliance limit of 10 mrem.

Continuous emissions monitoring is performed at the K-25 TSCA Incinerator, at four ORNL radiological sources, and at 74 exhaust stacks serving uranium-processing areas at the Y-12 Plant. Grab samples and other EPA-approved estimation techniques are used on remaining minor emission points and grouped area sources.

NESHAP for Asbestos

The ORR facilities have numerous buildings and equipment that contain asbestos materials. Compliance programs for asbestos management include identification of asbestos materials, monitoring, abatement, and disposal. Procedures that delineate scope, roles, and responsibilities for maintaining compliance with EPA and Occupational Safety and Health Administration (OSHA) regulatory requirements are maintained at each site. No nonconformances with environmental protection standards were identified in 1993.

Other NESHAPs

The Y-12 Plant is subject to a NESHAP rule for machining beryllium. The Y-12 Plant currently monitors four stacks that serve beryllium-machining and handling areas to demonstrate compliance with the 10 g per day emission limit. Measured stack emission rates at the Y-12 Plant were less than 0.003 g per day. The total emitted for 1993 was less than 1 g.

State-Issued Air Permits

The Oak Ridge Y-12 Plant has 94 active air permits covering 400 air emission points. There are currently about 290 documented exempt minor sources and about 350 exempt minor emission points. Seventy-four operating radiological stacks are equipped with continuous stack samplers to sample uranium emissions. The FFCA approves the use of these samplers and other emissions estimation methods to meet the requirements of 40 CFR 61, Subpart H (National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities), for sampling significant radionuclides emission points.

The number of ORNL air permits listed in the 1992 ORR environmental report (Martin Marietta 1993) was 55. However, in 1993 actions to review permitted emission sources at ORNL identified several inactive and exempt air sources and resulted in cancellation of their permits. As a result of this effort, ORNL has 37 permitted emission sources. Other permitting activities in 1993 included an internal surveillance of all permitted emission sources and the submission of renewal applications for 13 air permits due to expire in 1993.

There were 206 active air emission sources at the K-25 Site at the end of 1993. The total includes 107 sources covered by 58 TDEC air permits and 99 sources that are exempt from permitting requirements. Continuing dialogue with the source operators and with the building managers provides a basis for the withdrawal of permits on sources that are no longer operating. Numerous withdrawals are pending for 1994.

DOE Order Compliance

The following section has been developed to discuss compliance with those environmental requirements not found in specific statutes or where DOE is primarily self-regulating. The following sections provide compliance information for DOE Orders 5400.1, 5400.5, and 5820.2A.

DOE Order 5400.1, General Environmental Protection Program

DOE Order 5400.1 serves to establish 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.

Reports include the radioactive effluent and on-site discharge data report submitted annually to the Waste Information Systems Branch at the Idaho National Engineering Laboratory; the Environmental Restoration and Waste Management 5-year Plan; the Office of Management and Budget Circular A-106 Report; the annual site environmental report; and reports of significant nonroutine releases of hazardous substances consistent with DOE Order 5000.3B, Occurrence Reporting and Processing of Operations Information. An environmental protection program implementation plan (EPPIP) is required to be prepared and updated annually. The EPPIPs for the Y-12 Plant, ORNL, and the K-25 Site were reissued in November 1993. The EPPIP defines specific environmental objectives, including the means and schedules for accomplishment.

An environmental monitoring plan is to be prepared, reviewed annually, and updated every 3 years or as needed. The Environmental Monitoring Plan for the ORR was released by DOE in September 1992 and was reviewed in August 1993. The plan provides a single point of reference for the effluent monitoring and environmental surveillance programs of the Y-12 Plant, ORNL, the K-25 Site, and ORR areas outside specific facility boundaries. The annual review identified the need to update the plan. A revised document was drafted to provide clarification and to reflect current conditions and plans. In December 1993, the draft revised Environmental Monitoring Plan was submitted to the TDEC DOE Oversight Division for review and comment. Comments were returned to DOE in March 1994, and efforts to resolve comments are under way.

Pollution Prevention/Waste Minimization

At the Y-12 Plant, ORNL, and K-25 Site, formalized pollution prevention/waste minimization programs represent an organized, comprehensive, and continuous effort to systematically reduce waste generation. Goals of the programs require the merging of administrative and cultural changes with new technologies and techniques, targeting technical waste minimization in upcoming and ongoing projects, informing and training plant personnel in environmental pollution recognition and prevention, and fostering an environmental ethic in all plant activities.

Formalized pollution prevention councils have been established at the Y-12 Plant and the K-25 Site with representation from the site organizations. The primary functions of the councils are to provide an awareness of the program and identify tasks to implement the program. Elements of the programs include employee pollution prevention awareness through specific training, special awareness campaigns, incentives, and awards programs. The council members act as coordinators within their respective divisions to facilitate the implementation of the program.

An the electronic "swap shop" has been implemented to facilitate the exchange of excess chemicals, furniture, electronic equipment, and general office supplies to employees on the ORR needing the material. Sanitary waste recycling programs were expanded in 1993 to include phone books and laser-printer toner cartridges. Recycling programs are ongoing for lead batteries, scrap metal, and tires. Table 2.3 summarizes recycling activities for paper, cardboard, and aluminum cans from the ORR during the past 3 years.

Table 2.3. Oak Ridge Reservation recycling activities

Material	1991 (tons)	1992 (tons)	1993 (tons)
Aluminum cans	15.7	24.8	28.7
Cardboard	85.5	315.4	428.5
Paper	302.4	552.8	786.6

Groundwater

An exit-pathway well network, as required by DOE Order 5400.1, has been completed at the Y-12 Plant. Historical monitoring data and 1993 monitoring results from the exit-pathway program were scrutinized to evaluate the potential for off-site migration of contaminated groundwater. Sporadic occurrences of the volatile organic compounds carbon tetrachloride and tetrachloroethene, above primary drinking water standards, have been detected in an off-site monitoring well. The monitoring well is located in a generally industrial area, and no drinking water wells have been identified in the area. The detected volatile organic compounds are common industrial solvents previously used at Y-12 Plant in large quantities. Water quality data from the exit-pathway wells at the east end of the Y-12 Plant indicate that these compounds are being transported off the ORR through the Maynardville Limestone at depths of 100 to 300 ft. Property owners in the area have been notified and have been provided with a status report.

Additional well installation and groundwater monitoring activities continued through 1993 in support of the Y-12 Plant UST Program and the construction and permitting of new industrial landfills to service the reservation.

Exit-pathway monitoring is conducted at convergence points where groundwater flows from relatively large areas of the K-25 Site and converges before discharging to surface water locations. The exit-pathway monitoring of groundwater quality in both the unconsolidated zone and the bedrock will be supported by surface water monitoring at three convergence points. Existing wells have been incorporated into the exit-pathway network where possible. In addition, four exit-pathway surveillance wells will be installed during 1994 to complete the eight-well perimeter groundwater surveillance network. Baseline sampling of these wells will begin in FY 1994.

Exit-pathway monitoring was initiated at ORNL in 1993. The program monitors groundwater at four general locations that are thought to be likely exit pathways for groundwater affected by activities at ORNL. Existing wells that are part of the ORNL WAG perimeter monitoring network and four surface water locations have been identified as likely discharge locations. Historical monitoring data from the existing wells and 1993 monitoring results from the wells and surface-water locations were scrutinized to evaluate the potential for off-site migration of contaminated groundwater.

A long-term, off-site spring and residential well drinking water quality monitoring program has been conducted since 1989. The objective of the program is to document water quality from groundwater sources near the ORR and to monitor the potential impact of DOE-ORO operations on the quality of these groundwater sources.

Two springs and 17 wells currently are included in the program; these locations were selected on the basis of their proximity to the ORR and a representative distribution of sources from the different geologic formations of the area. They are sampled semiannually, and results are provided in individual reports to the well owners. In past years, no contaminant movement to these off-site locations has been indicated, and the results from sampling in 1993 continue to support this.

Well sampling, well installation, well plugging and abandonment, and the overall operation of the ORR groundwater protection programs were the subject of numerous DOE and internal assessments during 1993. No major findings resulted from these assessments. No Notices of Violation (NOVs) or NODs were issued by the TDEC in 1993. The annual TDEC RCRA Groundwater Compliance Evaluation Inspections were conducted in June and August 1993 at the Y-12 Plant, ORNL, and the K-25 Site. No findings or recommendations were issued as a result of the inspections.

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 off-site radiation doses not exceed 100 mrem per year for all pathways. The primary dose limit is expressed as an "effective dose equivalent," which requires the weighted summation of doses to various organs of the body. Monitoring of effluents released to the environment is required to ensure that radiation doses to the public are maintained in accordance with as low as reasonably achievable (ALARA) policy and consistent with prescribed dose standards. DCG values are provided in Chapter III of this order as reference values for conducting radiological environmental-protection programs. Chapter IV establishes radiological protection requirements and guidelines for the cleanup of residual radioactive material, the management of wastes and residues, and the release of property.

Liquid and airborne radiological effluent annual average concentrations on the ORR did not exceed the applicable DCGs. At specific locations, ORNL storm water and groundwater discharges from areas with legacy contamination exceeded the DCGs. Several such contaminated streams are intercepted by sumps and storm drain catch basins and then routed to on-site treatment facilities. These areas are also targeted for CERCLA remediation, which is ongoing. ORR doses are well below applicable standards for various areas, including airborne emissions and drinking water.

Full compliance with this order will be achieved for the Y-12 Plant through development and approval of an ALARA implementation plan that addresses radiological releases. This plan was issued in January 1994, and approval is pending. The K-25 Site ALARA Program requires that the site establish ALARA goals during the calendar year. In 1993, the K-25 Site established nine ALARA goals. Of the nine goals, eight were fully completed. The ninth goal is scheduled for completion in 1994. Although the K-25 Site is currently in compliance with this order, a pathway analysis will be conducted in 1994 to define further the K-25 Site environmental surveillance requirements. This analysis will include background concentrations and bioaccumulation data to be evaluated for both radiological and nonradiological parameters.

DOE Order 5820.2A, Radioactive Waste Management

DOE Order 5820.2A establishes the policies and requirements for managing ORR radioactive and mixed wastes. Each ORR site has developed a waste management plan to meet these requirements. These plans ensure that (1) the generation of all waste is minimized to the extent reasonably achievable and (2) the transportation, treatment, storage, and disposal of wastes are conducted in a manner that protects the health and safety of on-site personnel, the general public, and the environment. These objectives are met to comply with all applicable laws, federal and state agreements, and DOE orders, including DOE Order 5820.2A. The K-25 Site, ORNL, and the Y-12 Plant waste management plans were reissued in December 1993.

Aggressive action is under way at the Y-12 Plant to fulfill the needs of the D&D requirements of this order. Additional contaminant characterization is needed, and as-built drawings are not available for all buildings. A D&D Program has been established at the Y-12 Plant, and an organizational program structure is in place. The decommissioning of facilities once transitioned into the D&D Program is under the jurisdiction of the Y-12 Plant D&D Program. Based on reviews of historical operating records and on the extent of building contamination levels, current building facilities will be transitioned from Defense Programs into the D&D Program.

Currently, Buildings 9201-4 and 9213 are the only buildings at the Y-12 Plant in the D&D Program. Buildings 9620-2, 9416-2, and 9416-9 are surplus candidate facilities. The Y-12 D&D Program is heavily involved in characterization, removal, and decontamination of process equipment and piping of Building 9201-4. Y-12 Plant D&D is responsible for all surveillance and maintenance activities associated with Building 9201-4. A surveillance and maintenance plan has been developed and approved for these activities. A baseline design report, the framework for the D&D Plan, has been submitted to and approved by DOE. Funding for the project has also been formally planned for and obtained. A life cycle baseline has been developed and is currently being modified in association with prioritization of funding.

ORNL radioactive waste management activities primarily involve TRU waste and LLW. TRU waste continues to be stored at ORNL pending development of a TRU waste-treatment facility. For solid LLW, a site-specific radiological performance assessment for SWSA 6 was submitted to DOE for review in December 1993. Below-grade disposal units (e.g., asbestos silos, low-range silos, and high-range silos) in SWSA 6 were closed in December 1993. As of January 1994, ORNL solid LLW may be disposed of only in the aboveground tumulus Interim Waste Management Facility.

K-25 Site radioactive waste management activities conducted under DOE Order 5820.2A are primarily related to LLW because the site does not store or generate high-level radioactive waste. Although TRU-contaminated material exists on the site, the concentration limits are less than that for TRU waste. LLW management operations concentrate on solid waste management operations, although gaseous LLW streams also exist.

Shipments of contaminated metal continued from the ORR to Scientific Ecology Group, Inc., in Roane County for smelting and supercompaction. About 1.9 million pounds of radioactively contaminated scrap metal were shipped during CY 1993. After smelting and supercompaction, the metal, slag, and compacted material are returned to the ORR. The shielding blocks made by the smelting operation are used by the High Energy Physics Program.

Appraisals and Surveillances of Environmental Programs

Numerous appraisals, surveillances, and audits of the ORR environmental activities occurred during 1993 (see Tables 2.4, 2.5, and 2.6). These tables do not include internal Energy Systems and Martin Marietta Corporation assessments.

Tiger Team Environmental Assessment

Corrective actions for past Tiger Team reviews continue to be implemented. For the Y-12 Plant, an action plan was prepared and was approved in July 1990 for the 1989 Tiger Team assessment. Of the 62 environmental findings identified by the Tiger Team, 47 have been closed, 11 are complete and are awaiting verification of closure, and 4 remain open.

In late 1990, a group of about 80 specialists conducted a Tiger Team assessment of ORNL's Environment, Safety, and Health Program. The environmental subteam reviewed compliance with ORNL procedures, Energy Systems procedures, DOE orders, and federal and state regulations pertaining to environmental protection. Sixty-nine deficiencies were identified. An action plan that addressed corrective measures for each of the Tiger Team findings was prepared, and, after a number of revisions, was approved by then Secretary of Energy Admiral James D. Watkins on October 19, 1991. As of December 31, 1993, 43 of the 69 deficiencies had been resolved. As of December 31, 1993, DOE has approved the closure packages of 37 of the 43 ORNL-closed deficiencies.

Beginning in November 1991, a Tiger Team assessment of the Environmental Management Program at the K-25 Site was performed. During this assessment, 103 environmental findings were identified. Corrective action

Table 2.4. Summary of environmental audits and assessments conducted at the Y-12 Plant, 1993

Date	Reviewer	Subject	Findings
12/31–1/7/93	DOE-ORO	DOE air pollution control program—airborne effluent emission controls	0
1/13–2/4/93	DOE-ORO	Building 9201-1 parking area and weir tank	2
1/19–29/93	DOE-ORO	Best management practices plan implementation	2
1/26–2/6/93	DOE-ORO/Energy Systems Environmental Compliance	Review of NESHAP for radionuclides	0
2/18/93	DOE-ORO	Underground storage tank overfill protection	0
3/10/93	City of Oak Ridge	Sanitary sewer monitoring program	1
5/2/93	DOE-ORO	Herbicide use on East Fork Poplar Creek	0
5/5/93	EPA	NPDES Compliance, Evaluation, and Inspection	3
6/3/93	DOE-ORO	Y-12 Plant drain tie-in procedure	0
6/14/93	DOE-ORO	Groundwater well sampling	0
6/14–19/93	TDEC	Annual RCRA inspection and groundwater compliance evaluation inspection	0
6/18–7/2/93	DOE-ORO	Groundwater well installation	0
6/24–30/93	DOE-ORO	Laboratory and field quality control	0
6/24/93	DOE-ORO	Storm water monitoring program	0
7/7–9/93	TDEC	Air compliance	0
7/19–8/93	DOE-ORO	Environmental appraisal	77
7/27/93	DOE-ORO	NPDES discharge-monitoring report preparation	0
8/5/93	TDEC	Landfill V	4
9/23–24/93	EPA	Rad-NESHAP	0
10/1/93	DOE-ORO	Groundwater well plugging and abandonment	0
12/1/93	DOE-ORO	Radiological monitoring for NPDES permit compliance	2
12/1–3/93	Defense Nuclear Facilities Safety Board	Review of liquid discharges and air emissions at the Y-12 Plant	0
12/1–8/93	DOE-ORO	Groundwater Monitoring Program	0

plans in response to these findings were prepared and approved. Each item is actively tracked in the Energy Systems Action Management System maintained by the K-25 Site quality assurance organization.

Table 2.7 provides a summary of the status of corrective actions from Tiger Team assessments in past years.

Defense Nuclear Facilities Safety Board

In 1993, programmatic assessments of Y-12 Plant Defense Programs operations for complying with selected environmental, safety, and health–related orders in response to the Defense Nuclear Facilities Safety Board were conducted for Enriched Uranium Operations Building 9212 and the 9720-5 warehouse for storage of highly

Table 2.5. Summary of environmental audits and assessments conducted at ORNL, 1993

Date	Reviewer	Subject	Findings
2/11/93	DOE	DOE inspector general audited records management for Water Quality Control Group and RCRA records	0
5/5/93	EPA Region IV	NPDES Compliance Evaluation Inspection	2
5/17–18/93	TDEC/DOE/Energy Systems/ORNL	Hosted two-day permit renewal work session	0
6/6–7/93	TDEC	Inspection of ORNL air emission sources	0
6/14–16/93	TDEC	Inspection of treatment, storage, and disposal and generator areas, training, and record keeping	0
		Reviewed Pollution Prevention Program reporting and planning requirements for state of Tennessee	0
7/2/93	TDEC and DOE-ORO	Surveillance of visible emissions from the ORNL Steam Plant	0
8/9/93	Tennessee Department of Agriculture	Inspection of pesticide storage and use	0
8/9–10/93	TDEC	Visit by RCRA Groundwater group to observe the well-sampling activities at SWSA-6	0
8/12/93	EPA Region IV	Visit by EPA Region IV regarding NPDES issues	0
10/5/93	DOE-ORO	Conduct of Operations—Liquid Waste Solidification Project Readiness Review	0
10/7/93	DOE-ORO	Conduct of Operations—Partial Assessment of 3608 Nonradiological Wastewater Treatment Plant	0
10/8/93, 10/19/93, and 11/8–12/93	DOE Special Issue Review	Pollution prevention implementation across ORNL	0
11/9/93	DOE	Isotopes Shutdown Program involvement with decontamination and decommissioning activities associated with shutdown of Isotopes Program	0

enriched uranium. Included in this assessment was an update and revision of previously conducted site-level assessments. Requirements related to the following DOE orders were assessed: 5400.1, "General Environmental Protection Program"; 5400.5, "Radiation Protection of the Public and the Environment"; 5480.4, "Environmental Protection/Safety/Health Protection Standards"; 5480.5, "Safety of Nuclear Facilities"; 5485.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements"; 5820.2A, "Radioactive Waste Management"; 5400.2A, "Environmental Compliance Issue Coordination"; and 5400.3, "Hazardous and Mixed Waste Program." Ten requests for approval (i.e., corrective actions) were developed for the identified noncompliances. Three requests for approval were written in response to noncompliances identified during the assessment of 5400.1 requirements. These requests involved the ambient air sampling program, development of quality assurance plans, and control of procedures for the NPDES sampling program. The corrective actions included in these requests for approval are being implemented.

Table 2.6. Summary of environmental audits and assessments conducted at the Oak Ridge K-25 Site, 1993

Date	Reviewer	Subject	Findings
5/6/93	EPA Region IV, TDEC, DOE-ORO	NPDES compliance evaluation	0
6/14–17/93	TDEC	RCRA compliance audit	0
7/6–15/93	DOE-HQ	Quality assurance assessment of Oak Ridge facilities	0
7/26/93	TDEC	Air compliance	0
9/23–24/93	EPA-HQ, EPA Region IV, TDEC-Tennessee Oversight Agreement	Rad-NESHAP	0

Table 2.7. Summary of Tiger Team corrective actions

Date of review	Plant	Environmental findings	Status
6/89 2/10–21/92 (follow-up visit)	Y-12	62	47 have been closed; 11 are complete and awaiting verification of closure; 4 remain open
10/22–11/30/90	ORNL	69	47 have been closed; 37 of these have been verified as closed by DOE; 22 remain open
11/12–12/18/91	K-25	102	38 have been closed; 0 of these have been verified as closed by DOE; 64 remain open

ENVIRONMENTAL PERMITS

Table 2.8 contains a summary of environmental permits for the three ORR sites.

NOTICES OF VIOLATIONS AND PENALTIES

No new NOVs or penalties were received by the Y-12 Plant in 1993. ORNL received two NOVs. The K-25 Site received three NOVs and one order and assessment of civil penalty.

ORNL received an NOV from TDEC on May 14, 1993, for failure to submit an environmental assessment report and a corrective action plan for UST 2026 by their respective deadlines of March 17 and April 16, 1993. The two reports were submitted to TDEC on June 9, 1993.

In December 1993, an NOV was sent to ORNL by TDEC for exceeding NPDES limits for the total suspended solids parameter at three outfalls in September 1993: a building foundation and storm water drain, the ORNL sewage treatment plant, and the Coal Yard Runoff Treatment Facility. ORNL has provided to DOE an action plan to address the three outfalls cited in the NOV. The action plan discusses projects at each of the outfalls that are expected to mitigate the potential for future violations. These are the Sanitary Sewer System Upgrade Line Item Project, the Coal Yard Runoff Treatment Facility Upgrade, and the ORNL project to upgrade a number of storm drain outfalls. DOE discussions with TDEC enforcement personnel in Nashville indicate that no fines or additional enforcement actions are to be expected, relative to the subject of this NOV. ORNL responded to the NOV with a letter describing the corrective actions in March 1994.

During July 1993, the K-25 Site received two separate NOVs from TDEC for failure to submit the Environmental Assessment Report/Corrective Action Plan for the K-1414(9) Diesel UST Site and the Environmental Assessment Report for K-1220 UST site by the required submittal dates. Both documents were subsequently submitted to TDEC, which resolved the NOVs.

In September 1993, TDEC performed an inspection of the TSCA Incinerator and the K-1417 Drum Storage Yard at the K-25 Site. TDEC issued an NOV in January 1994 based on observations associated with the K-1417 Drum Storage Yard made during the September 1993 inspection. Action is pending.

On December 23, 1993, an order and assessment of civil penalty of $5000 for the K-1435 Incinerator, Permit No. TNHW-15, was issued by the TDEC. The penalty was issued for an NOV issued on December 2, 1992, for exceeding permitted aqueous waste feed rates on September 18, 1992.

CURRENT ISSUES

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 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 K-25 Site. 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 K-25 Site have exceeded (and are exceeding) the allowable discharge limits established by the NPDES permits. The injunction seeks to force DOE to comply in all respects with DOE's NPDES permits, declaratory judgments, and the award of various other costs.

Friends of the Earth made a request for production of documents, and documents were provided by DOE. The complaint was amended to add another environmental group and several individuals as plaintiffs to the lawsuit. Friends of the Earth took depositions in August 1993 and toured the facility with their expert witness in October 1993.

In October 1992, Friends of the Earth filed a motion for summary judgment with the court. In January 1993, DOE and the U.S. Department of Justice filed a cross-motion for denial of summary judgment. A hearing was held in Federal District Court in Knoxville, Tennessee, in May 1993. At that time, the court ordered the parties to prepare charts or tables summarizing the parties' positions regarding the number and extent of the alleged violations of the NPDES permits and the corrective actions taken, planned, or requested. The parties have complied with this order. Settlement discussions are ongoing.

Action Filed by Boat Dock Owners on Watts Bar Lake

On August 30, 1991, nine marina/boat dock owners on Watts Bar Lake filed a civil lawsuit against Union Carbide Corporation and Martin Marietta Energy Systems, Inc., in the Federal District Court, Knoxville, Tennessee. The suit alleges that plaintiffs have suffered economic losses because of publicity regarding defendants' discharge of various substances into Watts Bar Lake from the DOE Oak Ridge facilities. Plaintiffs also trace their asserted injury to a fishing advisory issued by the state of Tennessee in February 1991. The plaintiffs base their allegations on negligence, strict liability, and nuisance theories and seek compensatory and punitive damages. The plaintiffs rely solely on certain 1990 media reports discussing three draft environmental reports issued by DOE and Energy Systems.

A careful reading of the draft reports reveals that most of the materials described in the reports found their way to Watts Bar decades ago and are buried deep in the sediment, where they are not accessible to humans or the environment. The actual risk to a human or the environment is not the focus of plaintiffs' claims. They do not allege that plaintiffs or their customers suffered any physical injury as a result of materials in Watts Bar Lake, nor do they contend that their properties have been contaminated. The plaintiffs instead claim only that public perception created by the news media reports and fishing advisories may cause a decline in business at their resorts at some point in the future.

Table 2.8 Summary of permits

	Y-12 Plant	ORNL	K-25 Site
Resource Conservation and Recovery Act			
Part B	0	2	4
Part B applications in process	6[a]	3	0
Post-closure	1	1	0
Permit-by-rule units	10	173[b]	92
Solid waste landfills	6[c]	0	0
Annual petroleum UST facility certificate	2	1	1
Clean Water Act			
NPDES	1[d]	1[d]	1
Storm water	1[e]	1[f]	1[e]
Aquatic resource alteration	2	2	2
General storm water construction	3[g]	0	0
Clean Air Act			
Operating air	94	37	54
Construction	38	0	4
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	1	2	0

[a] Six applications have been submitted, representing 20 active units.

[b] Tanks regulated by Permit-by-Rule.

[c] Three landfills are operational, one (Spoil Area 1) is inactive, and one (Landfill VII) is under construction.

[d] In renewal process.

[e] TDEC has incorporated storm water into individual NPDES permit application.

[f] TDEC is expected to incorporate storm water into the NPDES permit applications.

[g] Notice of intent that accesses a general NPDES permit. Notices of intent were filed for construction at landfills V, VI, VII, and the Walk-In Pits.

On January 15, 1993, defendants filed a joint motion for summary judgment on the grounds that the plaintiffs have failed to show that they have sustained a significant interference with their businesses and enjoyment of their property, and thus no private nuisance claim exists. On December 1, 1993, the district court judge denied defendants' motion. This case is scheduled for trial on August 8, 1994.

Moratorium on Off-Site Shipment of Hazardous Waste

A moratorium on off-site shipment (to non-DOE sites) of hazardous waste was placed on DOE facilities, including those on the ORR, in May 1991. The moratorium was put in place to prevent waste containing any radioactive material from being shipped to a facility that is not licensed to handle it. The moratorium essentially requires all RCRA hazardous waste generated on the ORR to be managed as mixed waste (hazardous wastes also contaminated with radioactivity), radioactive PCB wastes, or PCB mixed waste until appropriate procedures are developed and approved to ensure that waste streams are free of radioactivity above background. These procedures have been prepared by each of the sites. The Y-12 Plant received approval from DOE-HQ on January 13, 1994, to use their procedures.

Tennessee Oversight Agreement

The state of Tennessee and DOE have entered into a 5-year monitoring and oversight agreement intended to assure Tennessee citizens that their health, safety, and environment are being protected during facility operations, ongoing cleanup activities, and emergency-response efforts for the ORR and the surrounding areas.

The Tennessee Oversight agreement (TOA) was signed on May 13, 1991, and reflects the obligations and agreements between DOE and the state regarding technical and financial support provided by DOE and the state for its oversight of these activities. The agreement states that DOE will provide financial support to allow Tennessee to carry out its commitments under the TOA and the FFA regarding cleanup activities. The agreement may be extended beyond 5 years or amended as necessary. It may also be modified as appropriate to address community issues that arise.

TDEC is the lead Tennessee state agency for implementation of the agreement. That agency has established a DOE Oversight Division located in the city of Oak Ridge and currently staffed by about 55 employees. TDEC has developed other agreements with various state and local agencies to support oversight activities. The agreements are with a local oversight committee to assist public understanding of issues and activities, the Tennessee Wildlife Resources Agency (TWRA) and the TEMA to conduct emergency management oversight.

Within DOE, the official point of contact designated by the agreement is the director of the Environmental Restoration Division. A DOE-TOA steering committee composed of site and major program representatives has been established to coordinate implementation and promote consistency in implementation across the ORR. Energy Systems and other selected DOE prime contractors have established internal organizations, including the designation of TOA coordinators to facilitate implementation of the TOA.

To date, a variety of activities have been conducted under the agreement. DOE has provided security clearances and has provided training necessary for gaining access to the sites to the state's employees. Environmental data and documents associated with environmental, emergency management, environmental restoration, and D&D programs have been provided to the state for their review. DOE has also been engaged in dialogue with the DOE Oversight Division in further development of the specific DOE and state commitments required by the agreement.

In August 1993, the DOE Oversight Division made available to the public its first annual report of its oversight activities covering the period from May 1991 to May 1993. In the past year, the DOE Oversight Division activities included an audit of the ORR air monitoring system, participation in a DOE audit at the K-25 Site, and commenting on the *ORR Environmental Monitoring Plan.* The DOE Oversight Division routinely visits the three DOE sites to attend formal meetings and briefings, conduct walkthroughs of buildings and grounds, or to conduct observations of site operations to ensure compliance with environmental regulations and DOE orders.

3. Environmental Program Information

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Abstract

Under the Oak Ridge Reservation Environmental Monitoring Program, environmental surveillance and effluent monitoring are conducted to comply with DOE Order 5400.1. In addition, the Environmental Restoration Program and other, miscellaneous programs are being conducted to improve and better understand the ORR environment and its surroundings and to manage and minimize waste. Public education and access to information are important facets of the environmental studies on the reservation.

The *Oak Ridge Reservation Annual Site Environmental Report* provides information about activities at the ORR and their impacts on human health and the environment. It describes the effluent monitoring and environmental surveillance activities conducted at and around the ORR facilities operated for DOE by Energy Systems. The report's primary objective is to summarize environmental monitoring information collected for the previous calendar year and estimate the radiation and chemical dose to the population in the surrounding area. Preparation and publication of the Environmental Report is in accordance with DOE Order 5400.1.

ENVIRONMENTAL MONITORING PROGRAM FOR THE OAK RIDGE RESERVATION

The environmental monitoring program has two components—effluent monitoring and environmental surveillance, both of which are intended to demonstrate that ORR operations comply with DOE and other applicable federal, state, and local standards and requirements. Data from this program are used to evaluate the impacts (if any) of ORR operations on public health or the environment.

The reservation is routinely monitored for radiation, radioactive materials and chemical substances. This information then is used to document compliance with appropriate standards, identify trends, provide information to the public, and contribute to general environmental knowledge.

The environmental monitoring program assists (1) in fulfilling DOE's policy of protecting the public, employees, and the environment from harm that could be caused by its activities and (2) reducing negative environmental impacts to the greatest degree practical.

DOE Order 5400.1 requires that a written environmental monitoring plan be prepared for each site. On September 16, 1992, the *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE/OR-1066) was approved by the manager of DOE-ORO. The plan includes each element of the environmental monitoring program conducted at the ORR. The *Environmental Monitoring Plan* addresses the rationale and design criteria for the monitoring program, location of monitoring stations, frequency of monitoring and measurements, quality assurance requirements, specific program implementation procedures, and direction for preparation and disposition of reports. Implementation of the plan is the responsibility of each respective site.

As described in the plan, environmental surveillance activities include off-site activities such as soil and food-crop sampling, hay and milk sampling, aquatic and terrestrial biological monitoring, stream and sediment monitoring, groundwater monitoring, external gamma radiation sampling, and ambient air monitoring.

ENVIRONMENTAL RESTORATION

Environmental restoration is the process of cleaning up inactive waste sites and facilities to ensure that risks to human health and the environment are either eliminated or reduced to safe levels. This task may be accomplished by removing, stabilizing, or treating hazardous substances.

In December 1989, the ORR was added to the U.S. Environmental Protection Agency's (EPA's) National Priorities List of the nation's hazardous waste sites that most require cleanup. DOE Headquarters established the

Office of Environmental Restoration and Waste Management, making DOE-ORO responsible for cleanup of the reservation.

Two federal laws, the Resource Conservation and Recovery Act of 1976 (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), are the dominant regulatory drivers for environmental restoration activities at the ORR. RCRA sets the standards for managing hazardous waste and requires permits to be obtained for DOE facilities that treat, store, or dispose of hazardous and mixed waste. CERCLA, also known as Superfund, addresses uncontrolled releases of hazardous substances and requires cleanup of inactive waste sites. For complete information on ORR compliance activities, see Sect. 2, "Environmental Compliance."

The following sections highlight some of the environmental restoration activities under way during 1993.

Kerr Hollow Quarry

The 55-ft-deep quarry had been used from 1951 to 1988 as a treatment site for water-reactive and shock-sensitive materials. Waste containers were rolled into the quarry from a chute, then shot by security guards to allow water to enter the containers and react with the waste to render it nonhazardous. More than 19,000 items were removed from the quarry during the cleanup, which began in the summer of 1989 and was completed in December 1993.

The cleanup, the first in DOE's history accomplished entirely by remote control (Fig. 3.1), involved the use of special equipment, including a submarine-like, remotely operated vehicle, a shredder modified for underwater use, and grappling hooks. The 5000 ft^3 (141.58 m^3) of nonhazardous debris generated from the cleanup was packaged and placed adjacent to the Walk-in Pits, a former burial and disposal site also at the Y-12 Plant that underwent a RCRA closure. This action allowed DOE to save several million dollars in disposal costs.

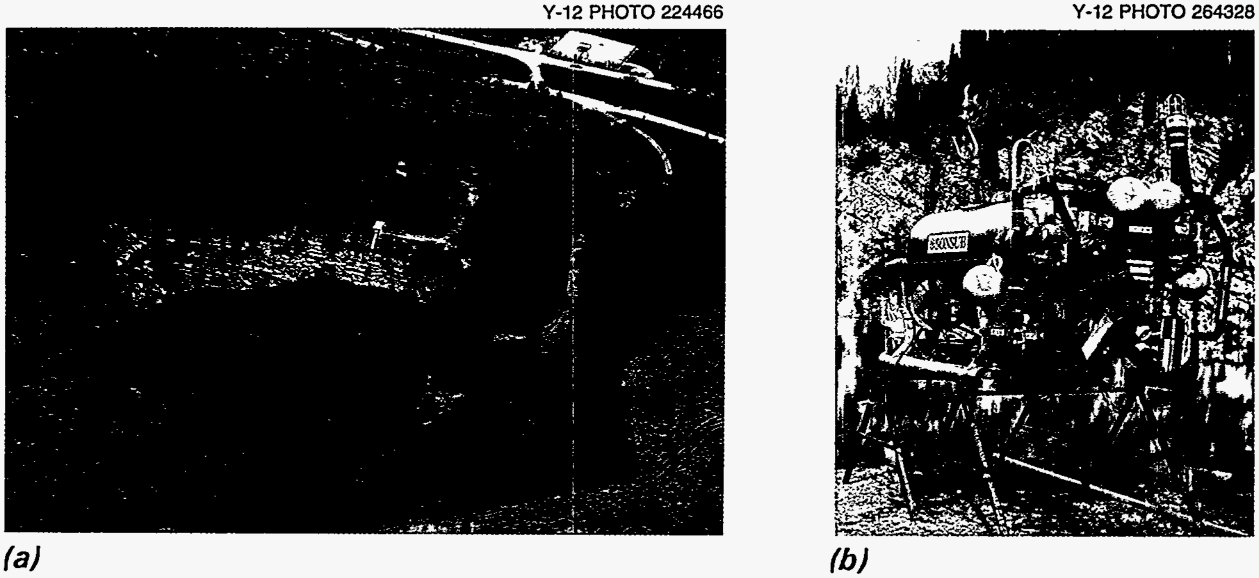

Fig. 3.1. (*a*) More than 19,000 items were removed from Kerr Hollow Quarry, a former treatment site for water-reactive and shock-sensitive materials. (*b*) Because of the underwater nature of the work, special equipment, such as a remotely operated vehicle, was used to complete the cleanup.

Cesium Plots

In the late 1960s, four plots of ground on the ORR alongside the Clinch River were treated with cesium-137 to research the effects of nuclear fallout on the environment. Although the plots do not pose a long-term problem, DOE, EPA, and the Tennessee Department of Environment and Conservation (TDEC) have agreed to an interim remedial action to reduce the level of contamination. Field work began in August 1993, and the project was completed in May 1994. About 1350 yd^3 of soil and brush have been removed from the site and have been transported to Waste Area Grouping 6 at ORNL for storage in underground silos.

Atomic City Auto Parts

Atomic City Auto Parts is an active salvage yard operation in the city of Oak Ridge, once used for salvaging materials and equipment purchased from DOE's Oak Ridge facilities and other sources. In December 1992, DOE agreed to take the lead in cleaning up the facility, which was contaminated by polychlorinated biphenyls (PCBs), radiological contaminants, and heavy metals. The first phase of cleanup, which began in October 1993 and was completed in January 1994, involved removing contaminated materials, including 130 capacitors, miscellaneous electrical equipment, surplus machinery and instruments, salvaged process equipment, and dump trucks. After removal, the materials were surveyed to determine if they could be decontaminated. Materials that could not be decontaminated were packaged in large drums and metal boxes and shipped to the K-25 Site for storage. The second phase of cleanup, due to be completed in August 1995, will include testing for soil contamination.

RCRA Closure of Y-12 Plant Walk-in Pits

The RCRA closure of the Y-12 Plant's Walk-in Pits is an example of the unique challenges faced when performing environmental restoration work on the ORR. This site, one of the last RCRA units in the Y-12 Plant's Bear Creek Burial Grounds to undergo corrective action, was first used in the 1960s for burial and disposal of contaminated materials and shock-sensitive chemicals.

Because of the explosive nature of these wastes, an armor-plated bulldozer was used to remove trees and shrubs and then to spread clay soil over the site (Fig. 3.2). A synthetic liner was then placed over the clay, followed by a concrete-filled blanket to hold the liner in place. This type of cap was chosen because it reduces the chance of surface water mixing with contaminants and migrating to groundwater and receiving streams.

The Walk-in Pits project allowed DOE to cut its costs significantly on another environmental restoration project by several million dollars. More than 20 boxes of nonhazardous debris from the cleanup of Kerr Hollow Quarry, a former waste treatment site also at the Y-12 Plant, were placed under the Walk-in Pits cap.

Because of its location, another former waste disposal area, Bear Creek Burial Ground B, was also capped as part of the Walk-in Pits closure. The entire project was completed in May 1994.

Y-12 PHOTO 30416

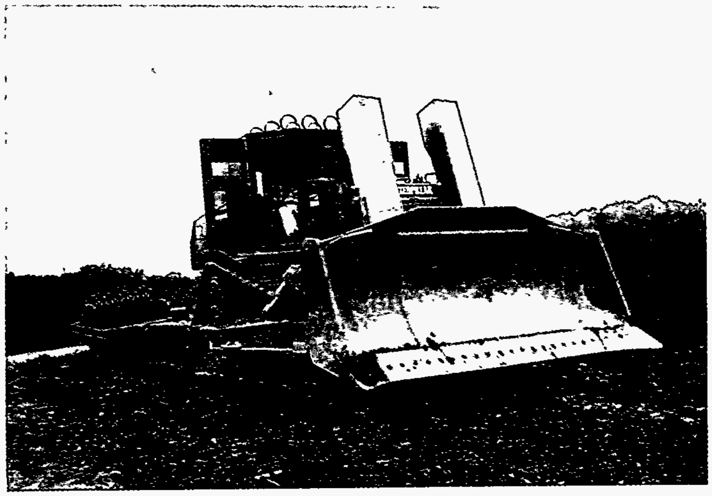

Fig. 3.2. Because of the explosive nature of some of the wastes in the Y-12 Plant Walk-in Pits, an armor-plated bulldozer was used during the RCRA closure of the pits.

East Fork Poplar Creek

In 1983, DOE announced that the floodplain of East Fork Poplar Creek, which begins inside the Y-12 Plant boundary and runs west through the city of Oak Ridge, was contaminated by off-site releases from the Y-12 Plant. Mercury, used primarily in isotope separation processes at the plant, was identified as the primary contaminant; releases occurred both from normal plant operations and from accidental spills. Other heavy metals, radionuclides, and organic compounds also are present in small amounts. Preliminary studies indicate the contamination in the floodplain soils poses no immediate threat to public health. Additional studies to conform with CERCLA requirements were conducted along the creek, its floodplain, and the sewerline beltway. Before remediation can begin, DOE must produce two reports—a remedial investigation and a feasibility study–environmental impact statement, which will form the basis for the DOE-proposed plan that will recommend a preferred remedial alternative. In late summer or early fall 1994, the public will have an opportunity to comment on this plan and the preferred alternative.

Clinch River/Watts Bar Reservoir

Past operations and disposal practices at the ORR have led to low-level contamination in the Clinch River and Watts Bar Reservoir. Peak releases of most contaminants occurred 30 to 40 years ago and included radioactive elements, heavy metals, and organic compounds. Studies have indicated that the levels of contamination pose no imminent risk to human health or the environment. These study results were presented to the public at meetings held in Kingston and Spring City, Tennessee, in early 1993. In January 1994, EPA granted formal approval to split the study area into two operable units, the Lower Watts Bar Reservoir study area and the Clinch River study area. A combined remedial investigation/feasibility study for the Lower Watts Bar Reservoir study area is expected to be completed in November 1994. The proposed plan is scheduled to be submitted to EPA and the state of Tennessee in December 1994. DOE and the regulators hope to issue a record of decision for this study area by May 1995. The Phase 2 investigation of the Clinch River study area began in late summer 1993, the scope of which is the focus of discussions among DOE, EPA, and the state.

SW31 Perennial Spring

The K-25 Site SW31 Perennial Spring is located downgradient of the K-1070 C/D Burial Grounds, which are known to have received a variety of wastes during the 1970s. The primary contaminants of concern in the spring water are volatile organics. During 1993, a capture system was installed to contain the water for shipment to the Y-12 Plant for treatment. Design is proceeding for upgrading existing K-25 Site facilities to be able to treat the water. Completion of the upgrade is scheduled for late 1995.

OTHER ENVIRONMENTAL PROGRAMS

Underground Storage Tank Programs

The UST Programs were established at the Y-12 Plant, ORNL, and the K-25 Site (1) to identify existing UST systems (systems installed prior to December 22, 1988) and establish their regulatory status, (2) to minimize UST liability by regulating certain exempt or deferred USTs in the interest of best management practice, (3) to permanently close out-of-service or unnecessary systems, and (4) to evaluate in-service systems for potential reconfiguration and/or aboveground alternatives.

The permanent closure of a UST system routinely involves the excavation and removal of the tank and associated piping (Fig. 3.3). Tanks can also be inert-filled and closed in place. The chronology of activities associated with a UST removal on the ORR is in accordance with state of Tennessee regulatory guidance. These activities can include overexcavation (including disposal of project-related waste), site characterization, and site restoration. Site restoration may include implementation of an approved corrective action plan.

For USTs where corrective action has been anticipated, alternatives to active remediation have been pursued. In January 1994, the TDEC Division of USTs instituted new guidance that allows a UST owner-operator to evaluate or rank an individual UST site with the potential for replacing anticipated remediation with long-term monitoring. A comparative result can be achieved by pursuing a

Y-12 PHOTO 302567

Fig. 3.3. Tank 2395-U, formerly used to store fuel oil, was removed from the Y-12 Plant in June 1993.

site-specific standard. Y-12 Plant UST Program personnel have discussed these alternatives with TDEC and DOE-ORO staff. TDEC approval of such an alternative has the potential to downgrade remediation to semiannual monitoring.

The Y-12 Plant, ORNL, and K-25 Site UST programs are working to ensure regulatory compliance by the 1998 deadline. Compliance status for each site is summarized in Section 2. (See Appendix E, Table E.1, for the Y-12 Plant UST summary table, which includes a record of submittals of documentation to appropriate regulatory agencies.)

Asbestos Operation and Maintenance Program

The presence of asbestos-containing material in many buildings on the ORR has been well documented. These materials are found throughout the facilities in many forms, including pipe insulation, floor and ceiling tiles, and many other building materials. When allowed to deteriorate or become damaged, these materials could pose both health and compliance concerns.

Removal of asbestos-contaminated material involves one or more of the following types of activities: (1) cleanup, (2) encapsulation, (3) removal, and (4) proper disposal of the asbestos-contaminated material and possible replacement with asbestos-free materials (Fig. 3.4).

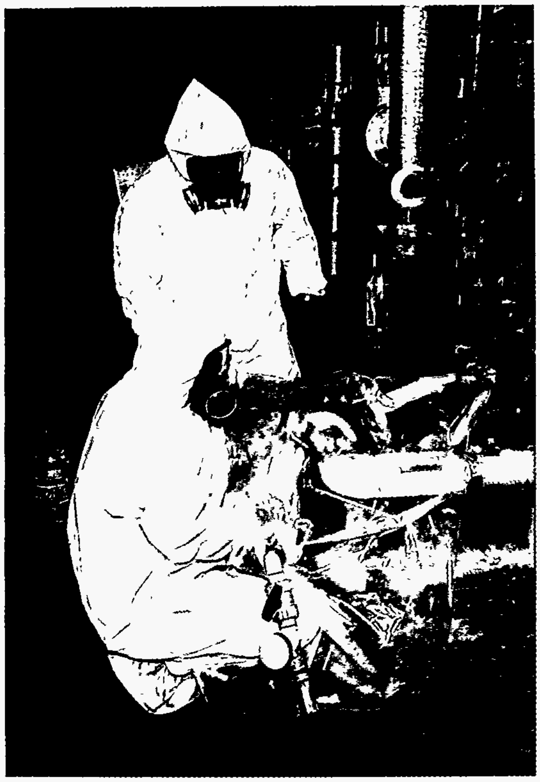

Fig. 3.4. Technicians work on piping covered with asbestos-containing material.

What Is Asbestos?

Asbestos is a generic term for six naturally occurring fibrous minerals found in certain types of rock formations. It has been used in many building products, most notably insulation and fire-resistant materials. The asbestos fibers are usually mixed with a binding material so that they can be shaped and formed for various uses. Asbestos is also a friable material, capable of crumbling into fine particles that have been linked with cancer and diseases of the lung. For that reason, careful handling techniques are employed when asbestos-containing materials are removed or otherwise handled.

Intact and undisturbed asbestos materials do not pose a health risk; however, physical agents, such as moisture, repetitive heating and cooling, and abrasion, can cause the asbestos fibers to be released into the air. Because these fibers are very small and light, they can remain in the air for very long periods. When these fibers are inhaled, they can cause serious health problems, including asbestosis (a fibrous scarring of the lungs), lung cancer, and mesothelioma (a cancer of the lining of the chest or abdominal cavity). These diseases take several years to develop, and symptoms may not appear for 20 years or more after the exposure has occurred.

Because of the health concerns caused by asbestos, EPA promulgated the Asbestos Ban and Phasedown Rule in July 1989. This rule applies to new product manufacture, importation, and processing and essentially bans almost all asbestos-containing material in the United States by 1997. This rule does not require removal of asbestos-containing material currently in place in buildings, and material in good condition is usually left intact and managed in place unless facility renovations disturb it. Recent studies indicate that improper removal of asbestos-containing material may actually increase the risk of exposure by releasing fibers into the air.

Cleanup of asbestos-contaminated material involves a combination of one or more of the following: picking up, shoveling, bagging, wrapping, vacuuming, and wet wiping of any asbestos-contaminated items. Encapsulation involves spraying, painting, or (in some manner) sealing friable asbestos. Removal is the elimination of asbestos-contaminated material. Removal activities include stripping asbestos insulation from pipes, tearing out asbestos wallboard or ceiling tiles, and removing asbestos floor tiles. Cleanup, encapsulation, and removal actions are performed by qualified personnel or a licensed subcontractor. Removal and replacement actions may also involve the removal of asbestos-contaminated material and replacement with asbestos-free material.

The removed asbestos material is bagged and deposited in the Y-12 Plant Centralized Sanitary Landfill II, unless it is also contaminated with radioactivity. If so, the waste undergoes volume reduction and storage, pending further regulatory guidance. The Y-12 Plant Landfill II is the state-approved disposal site for nonradioactive asbestos-contaminated material. Waste minimization and pollution prevention techniques are employed where practicable.

Southern Pine Beetle on the Oak Ridge Reservation

People who travel on the ORR probably have noticed the logging activity that has cleared large stands of pine trees. This activity has created some local interest and speculation about why the trees are being removed. The trees are being killed by the southern pine beetle, and they are being harvested to stop the spread of the beetle (Fig. 3.5).

About half of the 4,453 ha (11,000 acres) of pine forests on the ORR has been infested with the beetle, which is one of the most destructive insect enemies of pines in the southern United States. As of February 1994, more than 324 ha (800 acres) of pine trees had been cleared. The short-term plan is to continue with selective removal of trees. The plan will be reevaluated periodically to ensure that its objectives are being successfully met.

Priority areas to be cut include those that have high visibility (along Highway 95 and Bethel Valley Road, for instance) and areas where dead trees might pose a fire hazard to adjacent facilities. Many trees will be left standing because of overriding environmental concerns. For example, trees will not be cut in habitats that support rare plants and animals, in areas that contain fragile soils, or in environmental monitoring areas.

Eight private logging contractors are working 6 days a week to salvage the timber before its value is lost. Since cutting began, 99% of the salvaged wood has been shipped to a commercial paper-manufacturing company.

The Southern Pine Beetle

The southern pine beetle (*Dendroctonus frontalis* Zimmerman) is a common native of the southeastern United States. It ranges in length from 2.5 to 4 mm (about 1/8 to 3/16 in.). The beetle depends on evergreen trees to complete part of its reproductive cycle.

Female beetles bearing fertilized eggs bore through the bark of the trees and into the cambium layer, which is the living tissue between the bark and the wood. Once there, the beetles bore sinuous, vertical tunnels in the cambium, along which they lay their eggs. After about 28 days, the young beetles have matured, and they bore their way out and fly to other trees to breed.

The beetles damage the tree's phloem (the nutrient-transport tissue) with their tunneling, and if enough beetles attack one tree, it will die. Tree and beetle populations can strike a balance when conditions are right; normally, healthy trees can withstand beetle attacks, and beetles can subsist in weakened trees. When trees experience stress (such as overcrowding, drought, or damage from snow and ice), many weaken and become more susceptible to beetle attack.

This problem for the tree works to the advantage of the beetles because it offers them more opportunity to breed successfully. When many thousands of beetles are present, even the healthy trees are at an increased risk of infection. This problem is compounded when the trees are growing close together because many of the trees are stressed and because it is relatively easy for the beetles to find the trees.

Trees that are dying from beetle infestation look dried out, and their needles turn orange. Small white dabs of pitch in recesses in the bark mark the tunnels where the females have burrowed in. Small round holes in the vicinity of the pitch stains indicate the places where the offspring have burrowed out. When the bark falls away from the wood, scars from the southern pine beetle, often accompanied by those of other boring insects, will be evident in the bark. The wood may also have a bluish stain, which results from infection by fungi that commonly accompany the southern pine beetle and destroy the xylem (water-transport tissue) of the tree.

ORNL PHOTO 2954-94

Fig. 3.5. The southern pine beetle, adults and larvae. (The actual size of the adults is about 1/8–3/16 in.)

The remaining 1%, composed of smaller trees, has been used to make fence posts. The U.S. Treasury receives the revenues from these activities.

The current infestation is the third to hit the reservation since it was formed in the 1940s. At that time, the existing forest, mostly native, second-growth hardwoods,. was harvested for construction. In 1947, a reforestation program was begun, and clear areas as well as areas cleared following commercial logging were planted with various species of pines. The goal was to produce pulpwood while managing the land as an ecological park. A forest-management plan, begun in 1965 and updated every 5 years, continues the strategy of multiple-use woodland management.

Many of the trees now being harvested were planted during the 1970s. Because mostly pine trees were planted, the pines that are now maturing have provided an opportunity for the beetles to flourish. The impacts of the southern pine beetle infestation on the reservation will continue to be seen for the next couple of years as more trees are cut, but environmental researchers and forest managers think that this experience provides them with an opportunity to reevaluate long-term plans for reservation land. The current strategy is to treat each harvested area case by case; some of the harvested areas may be replanted, whereas others may be left to regenerate naturally.

Blue Heron Studies on the K-25 Site

A blue heron rookery lies along Poplar Creek in the K-25 Site. The tall trees, proximity to water and associated aquatic life, and restricted access of humans combine to form an excellent nursery for the young herons (Fig. 3.6). ORNL's Environmental Sciences Division, in conjunction with institutions of higher education, is studying the biology and ecology of these birds. Studies include population counts, collection of vital statistics of the young and adult birds, and chemical analyses of the eggs and young. These data are compared with data from similar rookeries at other locations across the country. One purpose of these studies is to determine what effect, if any, the DOE operations are having on the environment of the reservation. Results of these studies will be included in future reports.

ORNL PHOTO 2867-94

Fig. 3.6. A young blue heron in the K-25 Site rookery.

WASTE MANAGEMENT

The ORR Waste Management Program directs the safe treatment, storage, and disposal of waste generated by past and current operations and from current environmental restoration projects. The purpose of the Waste Management Program is to safely manage radioactive, hazardous, mixed, and sanitary waste from generation to disposal. Radioactive wastes typically managed on the ORR include the following:

High-level waste—contains highly radioactive material resulting from the reprocessing of spent nuclear fuel. Some elements in high-level waste decay slowly and remain radioactive for thousands of years. No high-level waste is generated on the ORR.

Transuranic waste—contains man-made elements heavier than uranium, thus the name trans (beyond) uranium. It is contaminated with alpha-particle–emitting isotopes with decay rates and concentrations exceeding certain specified levels. Transuranic waste decays slowly and requires isolation for thousands of years.

Low-level waste—any radioactive waste not classified as high-level or transuranic waste. It is generated by reactor operations, isotope production, medical procedures, and research and development projects. It typically has small amounts of radioactivity dispersed in large amounts of material. Examples of low-level waste include rags, papers, filters, tools, and protective clothing such as laboratory coats. Low-level waste is generated at the Y-12 Plant, ORNL, and the K-25 Site.

Other types of waste streams generated on the ORR and managed by the ORR Waste Management Program are:

- Industrial wastes—paper, wood, metal, glass, and plastic, coupled with large volumes of construction and demolition debris and small volumes of sanitary wastes from cafeterias. Also included in this category is fly ash from steam plant operations and other special wastes. Regulated by the Tennessee Solid Waste Management Act, this waste is disposed of in permitted landfills at the Y-12 Plant.
- RCRA hazardous wastes—any corrosive, ignitable, reactive, or characteristically toxic material that could negatively affect human health or the environment. Hazardous wastes include chemicals that are characteristically hazardous or listed by RCRA in 40 CFR 261.30 and TN 1200-1-11.02(4). Hazardous waste can exist as a gas, liquid, solid, or sludge. Typical examples on the ORR include sludge generated at wastewater treatment facilities; waste oils; fluorescent light bulbs; and contaminated wipes, gloves, and protective clothing.
- Mixed wastes—RCRA hazardous wastes that are also contaminated with low-levels of uranium or other radioactive material.
- PCB wastes—oils, materials, or electrical equipment that have been contaminated with PCBs, regulated by the Toxic Substances Control Act (TSCA). These waste streams may or may not be radioactively contaminated. Radioactively contaminated waste cannot be disposed of through commercial disposal facilities. Any PCB waste that is radioactively contaminated is placed in storage pending future disposal at the K-1435 Incinerator.
- Asbestos and beryllium oxide wastes—solid wastes that have been contaminated with either asbestos or beryllium oxide, which classifies it as a special waste. It may also be contaminated with low levels of uranium or other radionuclides.
- Scrap metal—derived primarily from demolition activities; the scrap may be either non-uranium contaminated or contaminated with low levels of uranium or other radionuclides.
- Classified wastes—liquid and solid streams containing materials that, for security reasons, are restricted by DOE criteria and managed in accordance with DOE Order 5632.1. These wastes could be contaminated with low levels of radioactivity.
- Treated medical wastes—contaminated bandages, sharps, and culture media. These wastes are placed in biological disposal containers and autoclaved to destroy any biologically active organisms. The treated waste is then disposed of in a landfill at the Y-12 Plant.
- Nonhazardous wastes—all other types of wastes (including liquids) that are nonhazardous or nonradioactive, or both.
- Material access area wastes—combustible and compactible materials (such as paper, wood, and wipes) and noncombustible and noncompactible materials (dirt, concrete, block, and rubble) removed from material access areas. The waste contains low concentrations of enriched uranium and has been monitored to verify that the uranium concentrations are below levels of concern for accountability, recoverability, and security control.

Requirements for meeting waste management regulatory objectives are varied and complex because of the variety of waste streams generated by reservation activities. The goal, however, is to comply with all current regulations while planning actions to comply with anticipated future regulations.

Compliance for waste management operations at the ORR involves meeting EPA and state of Tennessee standards as well as DOE orders. In addition to compliance with these regulations, supplemental policies are enacted for management of radioactive, hazardous, and mixed wastes. These policies include

- reducing the amount of wastes generated;
- characterizing and certifying waste before it is stored, processed, treated, or disposed of;
- pursuing volume reduction and use of on-site storage when safe and cost-effective until a final disposal option is identified; and
- treating hazardous waste.

In 1993, the Oak Ridge Waste Management Program took the first step in resolving a long-standing issue—how to handle large amounts of mixed waste—by preparing the *Mixed Waste Inventory Report*. The inventory is required by the Federal Facility Compliance Act, which requires federal agencies to work with the states and EPA to provide comprehensive data on mixed waste inventories, treatment capacities, and treatment plans for each site. A conceptual site treatment plan for the ORR was provided to the state of Tennessee in October 1993. A draft site treatment plan will be issued in August 1994, followed by the final site treatment plan in February 1995.

The TSCA Incinerator at the Oak Ridge K-25 Site has a key role in the mixed waste compliance strategy (Fig. 3.7). It is the only incinerator of its kind in the United States that can destroy uranium-contaminated PCBs and hazardous organic waste. No commercial incinerators are available to process this material. Using a highly instrumented kiln and secondary combustion chamber as well as a state-of-the-art off-gas treatment system, the TSCA Incinerator sets the standard of performance for meeting waste management challenges. Since its completion in April 1991, it has destroyed more than 9.6 million pounds (more than 4,350,000 kg) of RCRA and toxic waste (about 24,000 drums).

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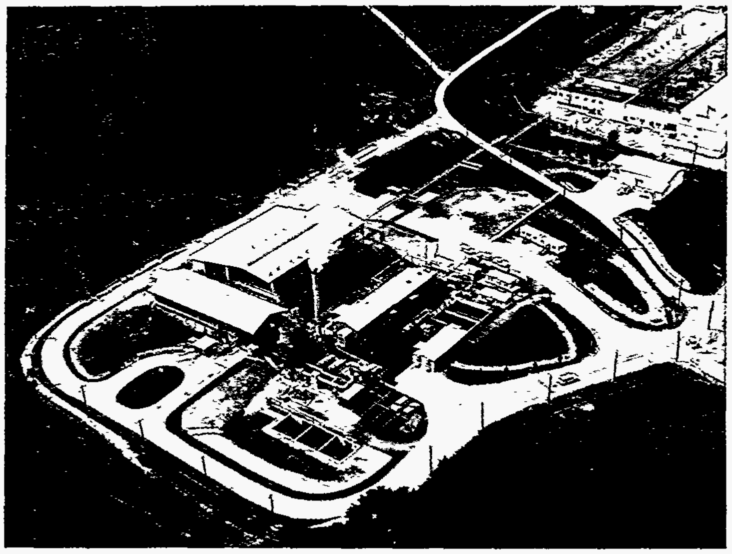

Fig. 3.7. The Toxic Substances Control Act (TSCA) Incinerator began full operations in 1991. More than 24,000 drums of mixed waste had been incinerated as of January 1, 1994.

POLLUTION PREVENTION

In recent years, considerable emphasis has been placed on identifying opportunities to reduce chemical use and resultant pollutants and waste. The shift away from end-of-pipe treatment to preventing waste and pollution at its source has received new impetus by the passage of the Pollution Prevention Act of 1990. This law established a waste-management hierarchy in order of preference:

- source reduction,
- recycling,
- treatment in an environmentally safe manner, and
- as a last resort, disposal in an environmentally safe manner.

The pollution prevention philosophy has become an integral part of the total environmental program. It encompasses a wide variety of activities, including waste minimization, toxics-use reduction, procurement of environmentally friendly materials, and resource and energy conservation. Minimizing the volume and toxicity of wastes and pollutants at their source can be accomplished in a number of ways:

- equipment or technology modification;

- process or procedure modification;
- decreased use and/or substitution of hazardous materials;
- improvements in housekeeping, maintenance, training, and inventory control; and
- reformulation or redesign of products and facilities.

Substantial attention has been focused on the Emergency Planning and Community Right-To-Know Act (EPCRA) Toxic Release Inventory report as a means to document progress in reducing chemical use and releases. Although federal agencies were not subject to EPCRA reporting requirements, DOE-ORO and Energy Systems decided to comply with those requirements, including submittal of the Toxic Release Inventory report.

In January 1991, EPA solicited industry participation in a voluntary program to reduce toxic chemical releases. The program, commonly referred to as the EPA 33/50 program, targeted 17 priority chemicals and set a goal of reducing releases 33% by 1992 and 50% by 1995 (1988 was the baseline year). The reduction goal of 50% has already been met for six of the priority chemicals that are used on the ORR.

A comprehensive pollution prevention program is not solely limited to reducing the use or release of toxic chemicals. Other opportunities for reducing environmental impacts abound, including the establishment of an electronic "swap shop" to facilitate the exchange of excess chemicals, furniture, electronic equipment, and general office supplies to employees needing the material and recycling programs for paper, cardboard, and aluminum cans as well as lead batteries, scrap metals, furniture, and tires. In addition, an energy-conservation program to replace lamps with new fixtures will increase energy efficiency, which will in turn reduce pollutants from power generation. An affirmative procurement program has been established as an integral part of the pollution prevention efforts. This program includes buying products made of recycled material and environmentally sound products that minimize impacts on the environment.

Awareness programs are conducted to help ORR employees understand the concept of pollution prevention. Most suggestions to minimize waste and pollutants and to increase efficiency of processes have come from employees. For example, the K-25 Site hosted a pollution prevention month, of which one activity, War on Paper, collected 31.8 tons of paper for recycling (the equivalent of 541 trees). The Y-12 Plant sponsored "Save Our Plan(e)t," a campaign to encourage reduction, reuse, and recycling at home and at work. For the last 2 years, Energy Systems has sponsored a cleanup of the shoreline along Melton Hill Lake as part of Earth Day celebrations.

CENTERS FOR ENVIRONMENTAL TECHNOLOGY AND WASTE MANAGEMENT

In May 1993, the K-25 Site was dedicated as the home of DOE's Center for Environmental Technology (CET) and the Center for Waste Management (CWM), demonstrating DOE's commitment to environmental leadership. The centers will foster partnerships between technology users and technology suppliers from government, academic, scientific, and private sectors to deploy innovative, cost-effective technologies to decrease the cost of environmental restoration and waste management. The centers will accelerate development, demonstration, and commercialization of improved environmental technologies for DOE, other federal agencies, and the commercial sector.

PUBLIC PARTICIPATION AND STAKEHOLDER INVOLVEMENT

Community awareness and involvement are vital to the success of DOE's environmental restoration and waste management programs. Federal environmental law requires public comment on proposed cleanup plans, and such public input will have a direct bearing on decisions that are made. Citizens can discuss environmental problems with technical experts at public meetings, small discussion groups, open houses, and workshops. People also can receive information through newsletters and fact sheets.

Awareness Programs

The DOE Stakeholders Group was formed in May 1993 to give area citizens—taxpayers, residents of affected areas, employers, employees, contractors, environmental groups, unions, DOE, regulators, and landowners—an opportunity to meet with DOE officials to discuss environmental restoration and waste

DOE has recognized ORR employees for their achievements in the areas of pollution prevention, waste minimization, and resource conservation. The following are awards categories and winners for 1993:

- **Outstanding Local Achievement Award**—Claxton Elementary School Environmental Fair. Hosted by Y-12 Plant employees, it resulted in the establishment of a community recycling center.
- **Commitment/Participation Award**—Y-12 Plant Save Our Plan(e)t Campaign: Y-12 Plant employees developed a campaign to promote resource conservation and pollution minimization and prevention; ORNL Recognition of Outstanding Commitment to Pollution Prevention: Metals and Ceramics Division efforts resulted in more than a 50% reduction in hazardous waste during the past 3 years; and the K-25 Site Pollution Prevention Month: each week during the month of June, activities focusing on pollution prevention were held at the K-25 Site.
- **Zero Generation Award**—Analytical Procedure Modification. Two Y-12 Plant employees were recognized for the development of two new procedures to eliminate waste streams.
- **Integrated Planning and Design Award**—Y-12 Plant Refrigerant Management Program. Chlorofluorocarbon (CFC) emissions decreased 58% from 1992 levels because specifications for equipment and vehicles were revised to use alternative refrigerants.
- **DOE Education and Training Award**—Y-12 Plant Recycle Training Program. Recycling efforts increased by 17 tons thanks to the establishment of an extensive aluminum can, corrugated material, file folder paper, and mixed paper waste-recycling program.
- **Source Reduction Award**—K-25 Site CFCs and Heating, Ventilation, Air Conditioning, and Refrigeration Management Program. The amount of Freon used was reduced from 16,000 to 1600 lb/year.
- **Solid Waste Recycling Award**—ORNL Reuse of Coal Fly Ash. ORNL Steam Plant fly ash was used to manufacture cement, diverting 6 million pounds from the landfill.
- **Radioactive/Hazardous Waste Recycling Award**—K-25 Central Neutralization Facility (CNF) Acid Use Program. The CNF used 1980 gal of acid as a treatment chemical that otherwise would have been considered waste.
- **Partnership Award**—Earth Day/Melton Hill Trash Bash 1993. DOE, Energy Systems, TVA, and Browning Ferris Industries employees collected about 20 tons of garbage along Melton Hill Lake.

management activities. The group meets quarterly, with active participation by 45 members.

Continued efforts to involve the public in the decision-making process included the formation of the East Fork Poplar Creek Citizens' Working Group in May 1993. The East Fork Poplar Creek floodplain, which runs through the city of Oak Ridge, is contaminated with mercury from past operations at the Oak Ridge Y-12 Plant and is under remedial investigation. The citizens' working group was formed to provide the opportunity for two-way communication between the cleanup team and a diverse segment of the community. Monthly information sessions are held to keep working group members informed about the project.

The annual EnvironMENTAL Fair is a community outreach effort sponsored by the Environmental Restoration and Waste Management programs to enhance the educational experience of middle-school students by increasing their awareness of local and global environmental issues and encouraging them to pursue environmental careers (Fig. 3.8). Activities are "hands-on," focusing on ways in which students can help make the world a cleaner, better place to live.

Environmental Update is a newsletter published to bring area residents "up-to-date" on environmental restoration and waste management activities under way or under consideration at the ORR. About 35,000 copies of the newsletter are inserted into area newspapers. Additional copies of the newsletter are kept on file at the DOE Information Resource Center, and 1500 people on the Community Relations mailing list also receive the newsletter.

The DOE Information Resource Center, located at 105 Broadway in Oak Ridge, houses the Administrative Record, a collection of files that contains all the information on which environmental cleanup decisions are based. A variety of other materials are also available, including fact sheets, newsletters, news releases and related news articles.

ENVIRONMENTAL RESEARCH

Oak Ridge National Environmental Research Park

The Oak Ridge National Environmental Research Park, established in 1980, comprises 13,590 acres (5,502 ha) of the ORR. As one of seven DOE research parks, its purpose is to provide protected land areas for research and education in the environmental sciences and to demonstrate that energy technology development can be compatible with a quality environment.

The park is an outdoor laboratory available for basic and applied research projects that include assessment, monitoring, prediction, and demonstration. It protects special habitats, such as those with rare plants or animals, and maintains a data base of wetland and plant information and a plant and animal reference collection for the reservation (Fig. 3.9).

Clinch River Environmental Studies Organization

In 1988, three local school districts (Anderson County, Clinton, and Oak Ridge) joined in a partnership to establish a field laboratory for environmental science education. The Clinch River Environmental Studies Organization (CRESO), sponsored by DOE, manages a 130-acre (52.6-ha) site along the Clinch River in Anderson County. The site, formerly a landfill, was donated by the Anderson County Commission for long-term use as an environmental sanctuary. Teams of students and faculty study plant, animal, and aquatic life at the site. The teams prepare research reports and present their research results at an annual symposium. In addition, researchers have shared their experiences with students visiting from local schools and groups from other states and countries (Fig. 3.10). Hundreds of students and teachers have been involved in CRESO, either as members of research teams or as volunteers.

Fig. 3.8. The EnvironMENTAL Fair is an annual educational event sponsored by the Oak Ridge Environmental Restoration and Waste Management programs. Area middle-school students participate in numerous hands-on activities designed to increase their awareness of environmental issues and encourage them to pursue environmental careers. (Photos courtesy of DOE-ORO.)

ORNL PHOTO 4408-93

Fig. 3.9. Biologists examine the soils and vegetation of a wetland on the reservation. A project is ongoing on the reservation to identify and delineate its wetlands. Wetlands are important for a wide range of ecological and societal values, including wildlife and plant habitat, flood control, and water quality. Wetlands are protected under both federal and state laws.

KPH 93-5910

Fig. 3.10. A group of teachers are shown the receiver and directional antenna used to track king snakes that have been implanted with transmitters. CRESO participants use this information to study the movement of animals in the Anderson County Wildlife Sanctuary.

4. Effluent Monitoring

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R. R. Painter, M. J. Peterson, D. A. Poole, E. M. Schilling,
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Abstract

Effluent monitoring is a major activity on the Oak Ridge Reservation. Effluent monitoring is the collection and analysis of samples or measurements of liquid, gaseous, or airborne 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.

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 IV under the Clean Air Act (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 affected member of the public. In December 1989, the 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 IV certified that DOE-ORO had completed all actions required by the FFCA and is considered to be in compliance with the radionuclide NESHAP regulations. A site inspection by EPA Region IV in September 1993 resulted in no findings of noncompliance.

DOE requirements for airborne emissions are established in DOE orders 5400.1 and 5400.5 and DOE/EH–0173T. The criteria in NESHAP regulations and DOE orders define major effluent sources as emission points with the potential to discharge radionuclides in quantities that could cause an effective dose equivalent of 0.1 mrem/year or greater to a member of the public. Potential emissions are calculated for a source by assuming the loss of pollution control equipment while 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 in an effort to minimize air emissions. In addition, administrative controls play a role in regulating emissions. Each installation has developed an emissions inventory program that includes stack sampling to determine the amounts of pollutants that are not removed by the air pollution control equipment.

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, that is, for any emission point that potentially can contribute greater than 0.1 mrem/year effective dose equivalent to an off-site individual. During 1993, 63 of the Y-12 Plant's 77 stacks were judged to be major sources; three of these sources were not operational in 1993 because of work in progress on process and stack modifications. Twenty-three of the stacks with 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.

During 1993, six monitored uranium stacks at the Y-12 Plant were taken out of service and one was added. Three exhaust systems (stacks 36, 42, and 50) were combined to exhaust through one new stack at Building 9212. Improved emission-control equipment on the new stack has resulted in a measurable decrease in the amount of material released from those processes. Two other stacks in 9201-5, previously serving depleted uranium operations, are now sampled for beryllium. One stack in 9204-4 was taken out of service when uranium processing was discontinued in that area. By the end of 1993, 68 active uranium stacks were being monitored.

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.

Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on 74 process exhaust stacks in 1993. 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 1993, 67 emission points were identified from unmonitored radiological processes and laboratories. In addition, six ventilation areas from buildings housing enriched uranium operations and two ventilation areas from the buildings housing depleted uranium operations were identified from health physics data, where one or more average monthly concentration exceeded 10% of the DAC. For those areas, the annual average concentration is used, with design ventilation rates, to arrive at the annual emission estimate.

Results

An estimated 0.055 Ci (9.0 kg) of uranium was released into the atmosphere in 1993 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 91% of the curie release was emissions of enriched uranium particulate even though only 9% of the total mass of uranium released was enriched material. Figures 4.1 and 4.2 illustrate the decrease in uranium emissions over the past 5 years, in both the curies and total mass. The decrease reflects continued reduction in Y-12 Plant process activities, as well as continued improvements in both physical and administrative controls over the processes and the exhaust filtration systems.

Table 4.1. Y-12 Plant airborne uranium emission estimates, 1993

Source of emissions	Quantity emitted (Ci)[a]	Quantity emitted (kg)
Enriched uranium		
Process exhaust (monitored)	0.029	0.4
Process and laboratory exhaust (unmonitored)	0.004	0.1
Room exhaust (from health physics data)	0.017	0.3
Depleted uranium		
Process exhaust (monitored)	0.002	2.8
Process and laboratory exhaust (unmonitored)	0.002	4.2
Room exhaust (from health physics data)	0.001	1.2
Total	0.055	9.0

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

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. Typically, radioactively contaminated and potentially contaminated airborne emissions are treated, then

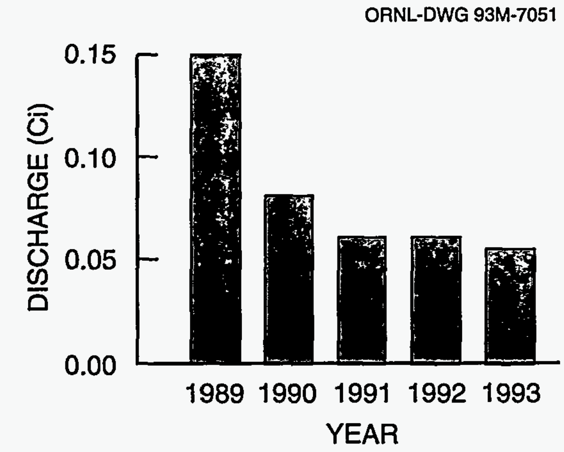

Fig. 4.1. Total curie discharges of uranium from the Y-12 Plant to the atmosphere, 1989–93.

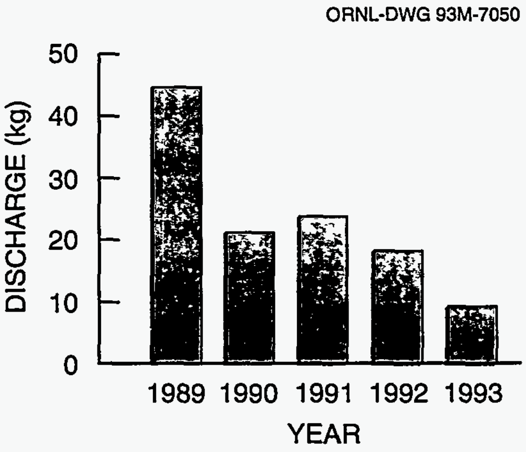

Fig. 4.2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1989–93.

filtered with high-efficiency particulate air (HEPA) and/or charcoal filters before discharge to ensure that any radioactivity released is as low as possible.

Airborne discharges are unique because of the wide variety of research activities performed at ORNL. Radiological gaseous emissions from ORNL typically 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):

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

A stack and vent survey was performed to identify and assign unique numbers to all emission points at ORNL. Each stack and vent was assessed for its potential to discharge regulated air pollutant emissions. Those with no potential for regulated air pollutant emissions, such as steam vents, do not require any further documentation. The first phase of the stack and vent survey focused primarily on radioactive emission sources. The results of the survey identified 17 minor point sources or group sources. Emission estimates were made for each of these point or group sources in 1993.

Annual radioactive airborne emissions for major sources are presented in Table 4.2; data for the minor sources are presented in Table 4.3. 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. Additionally, data from three grouped sources included no numbers that were determined to be different from zero. Historical trends for ^{3}H and ^{131}I are presented in Figs. 4.4 and 4.5, respectively.

Noble gas source terms for Stack 7911 represent a change in the manner in which data are calculated; a new source term was used for isotopic fractions, based on spectral analysis of grab gas samples. The new isotopic fractions were then applied to the gross noble gas totalizer data.

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. The single exception is for noble gases, for which a combination of grab samples and an on-line detector was used.

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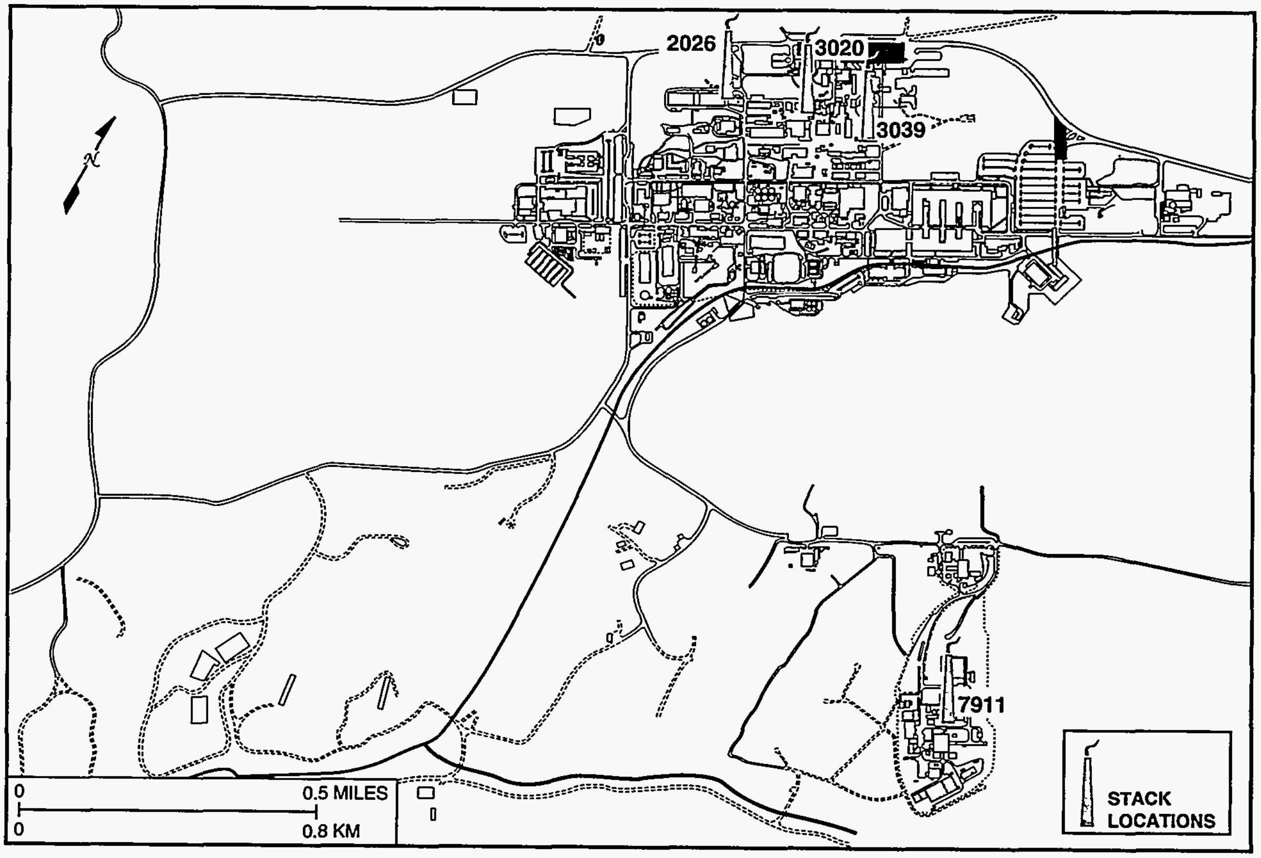

Fig. 4.3. Locations of major stacks (emission points) at ORNL.

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.

All ORNL major source sampling systems use methods that comply with ANSI N 13.1 (1969, R-1982) standards for any emission point with the potential to cause an annual public dose exceeding 0.1 mrem. An upgrade program was initiated to modify each source to meet compliance criteria.

The current sampling systems generally consist of multipoint in-stack sampling probes, sample transport lines, a particulate filter, an activated charcoal canister, a silica-gel tritium trap, flow measurement and totalizing instruments, a sampling pump, and a return line to the stack. The sampling system at Stack 3020 does not have a tritium trap. The sampling system at Stack 7911 includes an on-line noble-gas detector.

Velocity profiles at major sources are performed following the criteria in EPA Method 2. This ensures that the continuous samplers are sampling at acceptable isokinetic conditions and obtain 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, including the sample components. Also, a probe cleaning program was begun to ensure that all radioactive particulate matter emitted from a major source is collected and analyzed. This program requires annual removal and cleaning of sample probes, as well as collection of the rinsate from cleaning the probes at the major stacks.

In addition to major sources, minor sources were also evaluated during 1993 in accordance with the new NESHAP requirement. A variety of methods were used to determine the emissions from the various minor sources. All methods used for minor source emission calculations complied with criteria agreed upon by EPA and/or included in the *NESHAP Compliance Plan for the ORR*. These minor sources will be evaluated on a 1- to 3-year basis, depending on the source type. All emissions, both major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

Table 4.2. Major sources of radiological airborne emissions (in curies)[a] at ORNL, 1993

Isotope	Group			
	2026	3020	3039	7911
^{241}Am	4.05E-06	1.18E-07	1.64E-07	2.71E-07
^{41}Ar				1.80E+03
^{140}Ba	9.20E-05			3.93E-04
^{7}Be			3.77E-04	
^{244}Cm	6.76E-05	1.37E-06	7.67E-08	3.60E-06
^{60}Co	3.18E-07		2.20E-06	
^{134}Cs	2.67E-07		2.30E-07	2.59E-08
^{137}Cs	3.53E-04	3.40E-06	1.43E-04	1.26E-05
^{138}Cs				7.109E+1
^{152}Eu	2.71E-07		1.22E-06	1.61E-07
^{154}Eu	2.35E-06	1.39E-07		
^{155}Eu	4.93E-06	2.51E-07		
Gross alpha		1.55E-06	1.48E-06	
Gross beta		4.52E-06	3.33E-04	2.16E-06
^{3}H			4.28E+01	3.69E+01
^{129}I				2.52E-04
^{130}I				5.50E-05
^{131}I	1.60E-04		1.75E-05	5.30E-02
^{132}I				9.03E-01
^{133}I			1.93E-05	2.02E-01
^{135}I	1.18E-04	1.03E-04	3.44E-04	4.70E-01
^{188}Ir				
^{191}Os	1.80E-06		1.68E-01	2.93E-07
^{212}Pb	4.82E-02	3.38E-02	1.83E-01	9.90E-02
^{238}Pu	2.46E-06	5.22E-08	5.31E-08	1.93E-07
^{239}Pu	6.94E-06	1.82E-07	2.77E-07	5.59E-07
^{188}Re			3.78E-01	
^{228}Th	1.31E-06	2.81E-08	6.39E-08	1.44E-07
^{230}Th	7.00E-09	5.08E-09	2.69E-08	1.75E-08
^{232}Th	3.40E-09	4.86E-09	1.42E-08	9.95E-09
Total Sr	1.65E-05	8.13E-07	6.58E-06	1.98E-05
^{234}U	7.17E-06	2.25E-07	3.50E-07	8.00E-07
^{235}U	3.07E-07	9.54E-09	6.25E-08	7.67E-08
^{238}U	1.73E-07	1.36E-08	3.56E-08	2.02E-08
^{188}W			4.30E-03	
^{135}Xe				5.0E+01
^{138}Xe				7.1E+01

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

Table 4.3. Minor sources of radiological airborne emissions (in curies)[a] at ORNL, 1993

Isotope	Group													
	2000	2523	3018	3074	3544	7025	7512	7567	7569	7600	7830	7852	7860	7877
^{241}Am		2.71E–10	5.70E–11	1.50E–13			3.70E–09	8.78E–10	8.78E–10		3.51E–09	6.50E–12	6.50E–12	
^{137}Ba													4.70E–09	
^{7}Be			9.20E–09	1.40E–11	9.64E–07			8.15E–08	8.15E–08		3.26E–07			
^{241}Cm			1.00E–10											
^{244}Cm				6.20E–12	7.62E–10			1.04E–08	1.04E–08		4.17E–08	6.71E–11	6.70E–11	
^{60}Co				1.20E–13			1.26E–07	6.40E–10	6.40E–10		2.56E–09	2.48E–11	2.50E–11	
^{137}Cs		8.59E–09	6.50E–10	3.00E–11	1.09E–06			3.63E–08	3.63E–08		1.45E–07	4.66E–09	4.70E–09	
^{152}Eu				3.80E–13								2.08E–11	2.10E–11	
^{154}Eu				2.80E–13								1.28E–11	1.30E–11	
^{3}H	6.56E+01					9.35E+01		1.95E–01	1.95E–01		7.80E–01			
^{129}I								1.45E–07	1.45E–07		5.80E–07			
^{131}I		1.74E–07						7.50E–06	7.50E–06		3.00E–05			
^{132}I								8.50E–05	8.50E–05		3.40E–04			
^{133}I								4.25E–05	4.25E–05		1.70E–04			2.06E–09
^{135}I					1.34E–07			1.26E–04	1.26E–04		5.03E–04			5.50E–09
^{40}K				3.10E–12										
^{191}Os								3.20E–07	3.20E–07		1.28E–06			
^{212}Pb					9.13E–08		1.38E–04	1.72E–03	1.72E–03		6.86E–03			1.21E–09
^{238}Pu				3.90E–14				4.08E–10	4.08E–10		1.63E–09	3.23E–12	3.20E–12	
^{239}Pu			3.10E–01	2.60E–14				9.75E–10	9.75E–10		3.90E–09	1.69E–12	1.70E–12	
^{228}Th			1.80E–11	8.80E–14	3.15E–10			3.98E–10	3.98E–10		1.59E–09	1.59E–12	1.60E–12	
^{230}Th		2.11E–10	4.20E–11	7.00E–14	2.19E–10			7.83E–11	7.83E–11		3.13E–10	1.72E–13	1.70E–13	
^{232}Th		2.56E–10	1.20E–10	8.00E–14				7.98E–11	7.98E–11		3.19E–10	7.15E–14	7.10E–14	
Total Sr		8.74E–09		1.50E–11	3.06E–07		1.87E–07	5.53E–09	5.53E–09		2.21E–08	8.83E–10	8.80E–10	
^{234}U	3.25E–09	6.94E–09	1.90E–10	5.20E–13	1.82E–08		6.17E–08	2.46E–09	2.46E–09		9.85E–09	4.74E–12	4.70E–12	
^{235}U		1.51E–09	3.20E–11	3.60E–14	1.23E–10		6.59E–09	3.83E–10	3.83E–10		1.53E–09	1.25E–13	1.30E–13	
^{238}U	1.67E–09	1.18E–09	4.70E–11	2.10E–13	4.76E–09		7.41E–09	3.08E–10	3.08E–10	2.73E–05	1.23E–09	2.56E–13	2.60E–13	

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

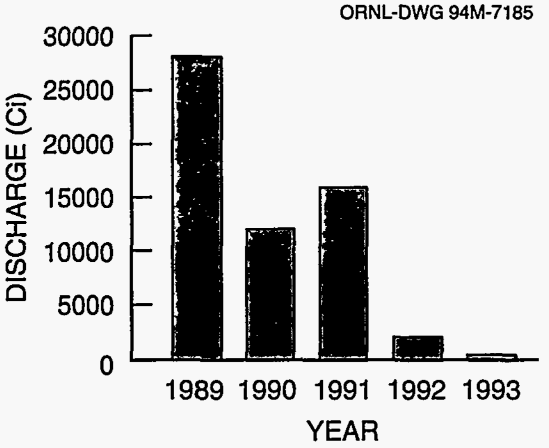

Fig. 4.4. Total discharges of ^{3}H from ORNL to the atmosphere, 1989–93.

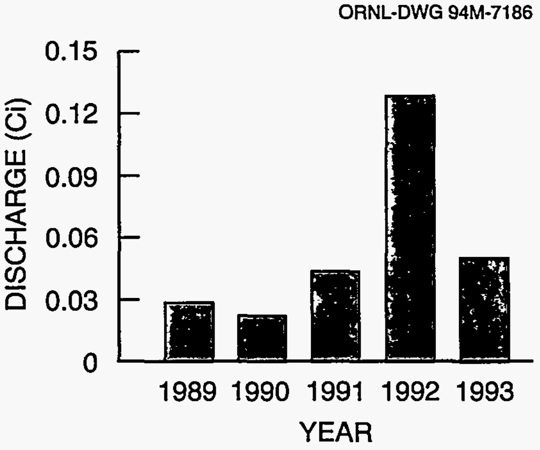

Fig. 4.5. Total discharges of ^{131}I from ORNL to the atmosphere, 1989–93.

Data sources for the various isotopes identified in the 1993 airborne emission source term for major sources are shown in Table 4.4 and are further discussed in the summary. Double entries in the table indicate isotopes that were captured by more than one sampling medium.

Results

The 1993 radioactive airborne emissions data for major sources included 34 isotopes. Table 4.4 provides a listing of the isotopes from each of the four stacks and the respective sampling media on which they were captured.

The charcoal canisters, particulate filters, and silica gel traps were collected weekly and were submitted for analysis. The use of charcoal canisters is a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases.

Particulate filters were held for 8 days prior to a gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as ^{220}Rn and its daughter products. At Stack 3039, a weekly gamma scan was initiated in the latter part of the year 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 is rinsed, and the rinsate is collected and submitted to the laboratory for isotopic analysis identical to that of the particulate filter. The data from the charcoal cartridges, silica gel, probe wash, and the quarterly filter composites are compiled to give the annual emissions for each major source.

Noble gas emissions from Stack 7911 were derived from real-time monitoring data and grab samples.

K-25 Site Radiological Airborne Effluent Monitoring

Locations of airborne radioactive point sources at the K-25 Site are shown in Fig. 4.6. These locations include both individual point sources and grouped point sources such as laboratory hoods. Radioactive emission data were determined from either EPA-approved sampling results or EPA-approved calculation methods.

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 major radionuclide emission source at the K-25 Site and is therefore the only stack that is continuously monitored. In addition to the routine emissions from the TSCA Incinerator in 1993, there were two releases associated with thermal release vent incidents. A thermal release vent incident results in a bypass of the routine emission controls and continuous stack sampling system. On May 5, 1993, a

Table 4.4. Data sources for airborne radioactive emissions from ORNL, 1993

Isotope	Particulate filter	Probe wash	Charcoal cartridge	Silica gel	Real-time monitor	Grab sampler
^{3}H				X		
^{7}Be	X					
^{60}Co	X					
^{82}Br			X			
^{90}Sr	X	X				
^{129}I			X			
^{131}I	X	X	X			
^{132}I			X			
^{133}I			X			
^{134}I			X			
^{135}I			X			
^{134}Cs	X	X				
^{137}Cs	X	X				
^{138}Cs					X	X
^{140}Ba	X	X	X			
^{154}Eu	X	X				
^{155}Eu	X	X				
^{191}Os	X	X	X			
^{194}Os	X	X	X			
^{212}Pb			X			
^{228}Th	X	X				
^{230}Th	X	X				
^{232}Th	X					
^{234}U	X	X				
^{235}U	X	X				
^{238}U	X	X				
^{238}Pu	X	X				
^{239}Pu	X	X				
^{241}Am	X	X				
^{244}Cm	X	X				
^{41}Ar					X	X
^{135}Xe					X	X
^{135m}Xe					X	
^{138}Xe					X	X

power failure occurred, and on May 6, 1993, a false alarm triggered an immediate shutdown. Both incidents were short-term releases of about 10 seconds and caused negligible off-site impacts. The calculated release amounts for both incidents have been added to the routine annual emission totals.

Representative grab-sample techniques (e.g., EPA Method 5 techniques) in combination with operational parameters were used to generate emissions for the K-1015 laundry and the R-114 transfer project in the K-31 and K-33 buildings. The laundry is a minor source that washes and dries contaminated work clothing. Emissions from the K-31 and K-33 buildings are incidental releases associated with a project to transfer R-114 refrigerant from the inactive K-25 Site to the active Paducah, Kentucky, and Portsmouth, Ohio, gaseous diffusion plants.

Material balance calculations were used to generate the emission estimates for the K-1004 A-D laboratories. These laboratories are used to analyze a large number of small-volume samples from across the K-25 Site.

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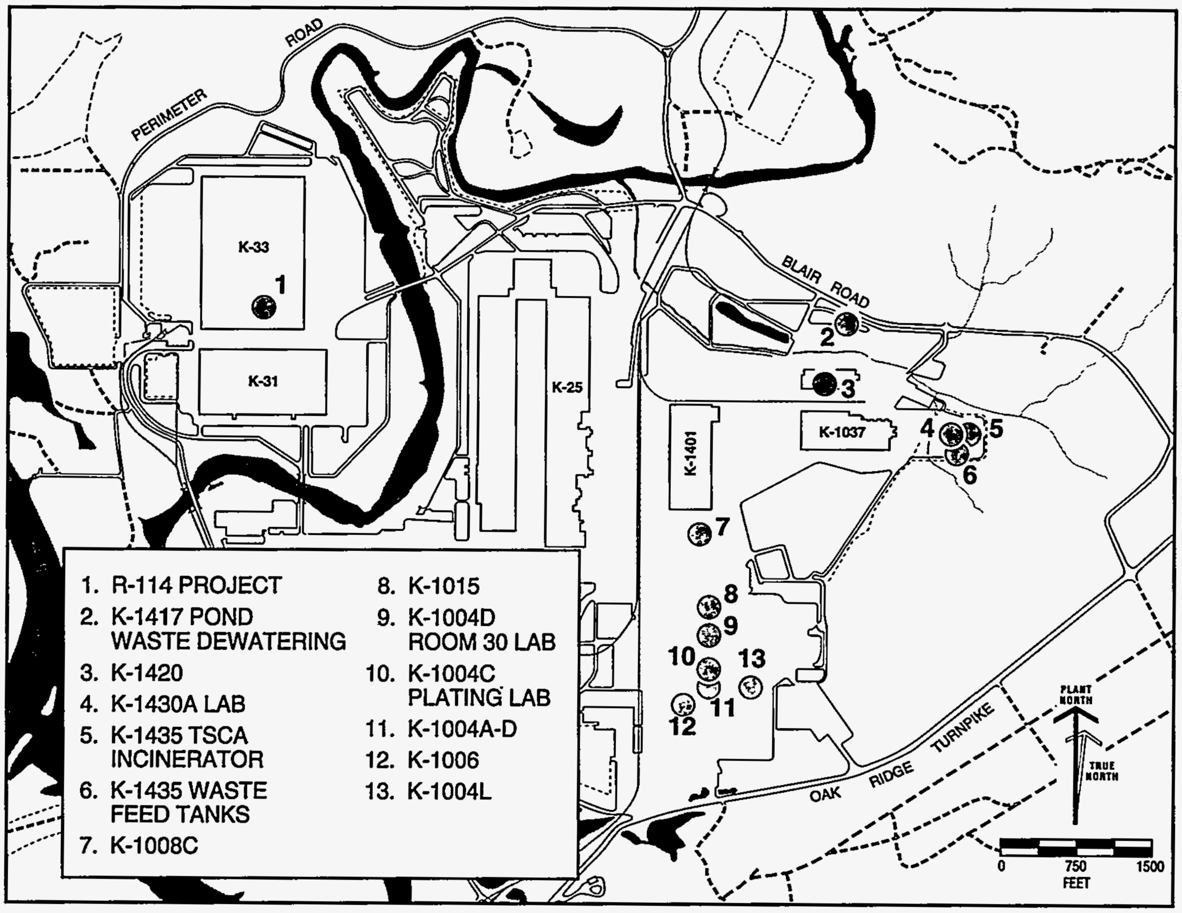

Fig. 4.6. K-25 Site airborne radioactive point sources.

The remaining active sources at the K-25 Site were calculated using 40 CFR 61, Appendix D, emission factors. The Appendix D emission factors are a conservative method of estimating emissions based on the physical form of the radionuclides and the maximum operating temperature of the processes.

Three sources that operated in 1992 were inactive in 1993. The K-1417 Pond Waste Management Project point source dewatering operation was discontinued in the fall of 1992 and has been permanently abandoned. A project was initiated in late 1993 to repackage wet pond waste material into long-term storage containers. This activity is documented as a fugitive and diffuse emission source rather than a point source. During 1994, repackaging of dry pond waste material is slated to begin. The dry material will be handled in a controlled environment with dedicated exhausts and high-efficiency particulate air (HEPA) filters. The dry material repackaging stations and exhausts will be minor point sources. Two additional sources, the K-1420 Disassembly Area and the K-1004-C Plating Laboratory did not operate in 1993. However, both sources are still in the operational ready state.

Results

The K-25 Site's 1993 radionuclide emissions from the TSCA Incinerator and minor emission sources (other than the TSCA Incinerator) are shown in Table 4.5. Additionally, Figs. 4.7 and 4.8 compare the total K-25 Site's 1993 discharges of uranium in curies and kilograms with those of previous years. Uranium is the primary radionuclide of concern at the K-25 Site, and the totals are significantly lower in 1992 and 1993 because of decreased emissions from the TSCA Incinerator. Decreased emissions are the result of lower levels of contamination in the waste feed to the incinerator.

Y-12 Plant Nonradiological Airborne Emissions Monitoring

The release of nonradiological contaminants into the atmosphere at the Y-12 Plant occurs as a result of plant production, maintenance and waste management operations, and steam generation. Most process operations are served by ventilation systems that remove air contaminants from the workplace. TDEC has issued about 90 air permits that cover more than 400 of these emission sources. The allowable level of pollutant emissions from permitted emission sources in 1993 was 27,394 tons/year of regulated pollutants. Actual emissions are lower than the allowable amount; however, the annual emission fees of $76,464 are based on the allowable amount. 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; however, as a best management practice, Y-12 Plant personnel also monitor emissions from four areas that process beryllium.

In anticipation of permitting requirements and implementation of maximum achievable control technology 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 applications are expected to be required sometime in 1995.

Table 4.5. K-25 Site radionuclide air emission totals (curies),[a] 1993

Radionuclide	TSCA Incinerator	Minor sources
^{234}U	3.8E–03	2.1E–04
^{235}U	1.7E–04	9.4E–06
^{238}U	4.0E–03	2.1E–04
^{99}Tc	1.1E–01	1.0E–02
^{237}Np	5.6E–04	5.8E–06
^{137}Cs	5.0E–03	9.5E–08
^{234m}Pa	2.2E–01	1.5E–04
^{238}Pu	2.5E–04	4.2E–06
^{239}Pu	–5.8E–05	7.5E–07
^{228}Th	3.8E–04	3.7E–06
^{230}Th	4.9E–05	9.9E–06
^{232}Th	1.1E–04	2.3E–06
^{234}Th	1.8E–02	1.1E–04
^{109}Cd	7.6E–03	0.0
^{139}Ce	1.5E–07	0.0
^{141}Ce	2.0E–04	0.0
^{57}Co	1.2E–04	0.0
^{60}Co	4.4E–03	0.0
^{40}K	4.0E–02	1.7E–06
^{106}Ru	4.5E–03	–8.6E–07
^{201}Tl	1.1E–06	0.0
^{88}Y	3.6E–05	0.0
Total	4.2E–01	1.1E–02

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

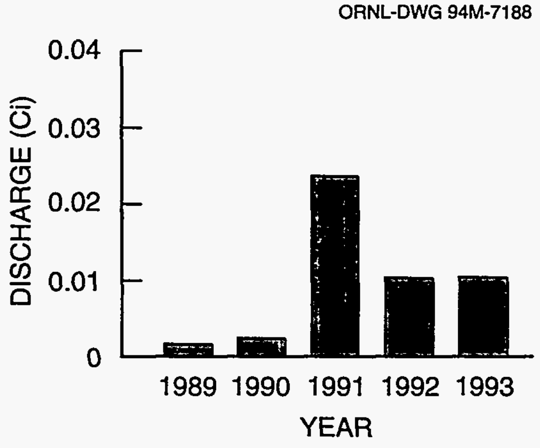

Fig. 4.7. Total curie discharges of uranium from the K-25 Site to the atmosphere, 1989–93.

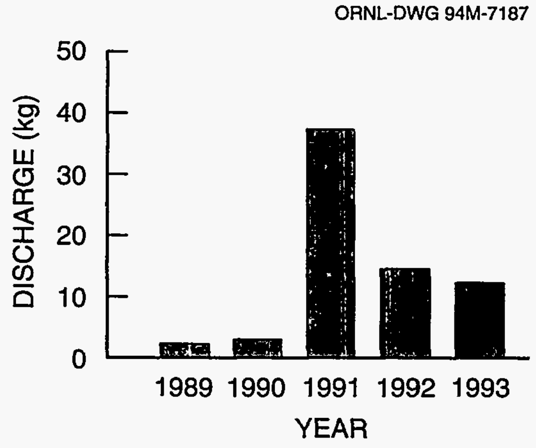

Fig. 4.8. Total kilograms of uranium discharged from the K-25 Site to the atmosphere, 1989–93.

Planning for compliance with anticipated and newly issued requirements under Title VI of the CAA amendments is a major effort. In accordance with the Y-12 Plant CAA implementation plan, a stratospheric ozone protection plan was issued to outline 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 stratospheric ozone protection committee has successfully implemented work practices required to minimize releases of chlorofluorocarbon refrigerants to the atmosphere. Requirements for motor vehicle air conditioner and refrigeration system maintenance compliance are being met. To accommodate the production ban on ozone-depleting chemicals, studies are proceeding on finding replacements for and performing the necessary modifications to plant refrigeration equipment. Activities are scheduled to be completed by October 1995.

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.

Currently, four exhaust stacks that serve beryllium processing areas are sampled continuously by extraction of a portion of the stack gas and filtering out particulate matter. The samples are then analyzed for beryllium, and emission rates are calculated. A significant reduction in beryllium work at the Y-12 Plant has resulted in a decrease in the number of stacks monitored for beryllium from eight to four. During 1993, old samplers were removed from all eight previously operated beryllium stacks, and new samplers were installed on two stacks on buildings 9998 and 9202 where beryllium operations continue. Beryllium operations in Building 9201-5 continue and uranium work has ceased; however, long-term operations are uncertain because of plant downsizing. Thus, two samplers previously used to sample for uranium emissions from 9201-5 were converted to beryllium samplers.

Results

The east and west Y-12 Steam Plant stack opacity monitors were each operational more than 99% of the time in 1993. Both opacity monitoring systems were taken out of service for calibration/recertification (performed annually), for maintenance activities to repair stuck shutters, monitor malfunctions, and self-check. The calibration/recertification was performed by a subcontractor in May. One period of excess opacity emission occurred on March 13, 1993, from the west stack. The excess opacity was limited to one 6-min period and was the result of a differential pressure spike that caused the baghouse bypass to open. Quarterly excess 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 Condition 10 of the air permit. The annual opacity calibration error test reports were submitted to TDEC in June 1993.

Beryllium stack sampling results indicated that less than 1 g of beryllium was released during 1993; most readings on the filters were less than the plant laboratory detectable level. Thus, emission rates of beryllium are well below the NESHAP limit of 10 g/day.

ORNL Nonradiological Airborne Emissions Monitoring

ORNL operates approximately 40 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.

In 1994, ORNL will pay $43,168 in annual emission fees to TDEC. This fee is based on allowable emissions (actual emissions are lower than allowable emissions). In 1994, TDEC inspected all permitted emission sources to ensure compliance; no noncompliances were noted.

ORNL is currently preparing the permit application that will be required under the Title V permit program. It is anticipated that this application will be due to TDEC in the fall of 1995. To facilitate the preparation of this application, an existing survey of all emission points at ORNL is being updated. This survey will locate all emission points and will evaluate their compliance status. Survey results will provide information regarding small sources that are currently exempt from air permit requirements. The survey will also assist compliance efforts that may be required under Title III, Hazardous Air Pollutants.

Actions have been implemented to comply with the prohibition to release 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 implemented actions to phase out the use of Class I ozone-depleting substances. The most significant challenge is the replacement or retrofitting of large chiller systems that require Class I refrigerants.

Results

The opacity monitor at the steam plant operated without incident during 1993. No opacity exceedences above permit limits were noted. Emissions of other materials have been estimated and are provided in Table 4.6.

Table 4.6. ORNL nonradiological airborne emissions, 1993

Chemical	Quantity released		Major release source	Basis of estimate
	lb	kg		
			SARA 313 chemicals[a]	
Nitric acid	43	20	Tank emissions	Engineering calculations
Sulfuric acid	0	0	Tank emissions	Engineering calculations
			Other large-inventory chemicals[b]	
Freon 11	15,600	7,090	Refrigerant	Best engineering judgment
Freon 12	3,073	1,397	Refrigerant	Operating records
Freon 22	3,545	1,611	Refrigerant	Operating records
Freon 113	4,700	2,136	Refrigerant, laboratory uses	Inventory records
			Steam plant emissions (all calculated emissions)[c]	
Particulates	10,863	4,937	Stack emission	Engineering calculations based on emission factors
SO_x	1,251,625	568,863	Stack emission	Engineering calculations based on emission factors
Carbon monoxide	88,075	40,030	Stack emission	Engineering calculations based on emission factors
Volatile organic compounds	2,180	991	Stack emission	Engineering calculations based on emission factors
NO_x	444,099	201,843	Stack emission	Engineering calculations based on emission factors

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

K-25 Site Nonradiological Airborne Emissions Monitoring

The federal CAA provides the basis for protecting air quality and regulating air pollution. 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. Title V of the CAA amendments of 1990 will require the Oak Ridge K-25 Site to submit a new permit application package to TDEC for all sources in operation. Preparation for the new permit application includes an air-emissions inventory of potential and actual emissions from the K-25 Site. To verify the annual air emission fee assessment, which is based on the K-25 Site's potential to emit air pollutants, an inventory of potential emissions from the permitted sources at the K-25 Site was completed in 1992 and updated in 1993. Table 4.7 shows the potential emissions of criteria pollutants from the K-25 Site for the past two years. Efforts are under way to complete the inventory of actual emissions from all permitted sources in operation at the K-25 Site in 1994.

The CAA amendments contain a chapter under Title VI addressing stratospheric ozone protection. This new law requires that EPA promulgate a number of regulations to phase out the production and to limit the release of ozone depleting substances. The substances have been used at the K-25 Site, primarily as refrigerants in gaseous diffusion processes. Because the K-25 Site is no longer involved in uranium enrichment, its stockpile of ozone-depleting substances is being shipped to the operational gaseous diffusion plants in Portsmouth, Ohio, and Paducah, Kentucky, for recycling (see Section 9 for details). Releases of these materials are estimated annually (Table 4.8).

Table 4.7. Potential emissions of criteria pollutants from the K-25 Site, 1992 and 1993

Pollutant	Potential to emit (tons/year)	
	1992	1993
Particulate matter	172	180
Volatile organic compounds	262	166
Sulfur dioxide	429	429
Nitrogen oxides	226	226
Carbon monoxide	157	157
Miscellaneous	291	291
Total	1537	1449

Table 4.8. Estimated K-25 Site emissions of ozone-depleting substances, 1993

Ozone-depleting substance	Estimated emissions (lb/year)
CFC-12	295
HCFC-22	2,175
CFC-113	<50
CFC-114	28,500
Halon-1301	72

On July 1, 1992, a prohibition went into effect on the release of Class I and II compounds from air conditioning and cooling units during service, repair, and disposal. Because it requires the evacuation of refrigeration systems before opening, this prohibition had an impact on the recovery and transfer in 1993 of the CFC-114 from the process cooling units at the K-25 Site to Portsmouth and Paducah.

Additional refrigeration equipment service practices were implemented in 1993 in response to the phase-in of the final refrigerant recycling and emissions reduction rule. The primary areas of applicability included record keeping, a leak repair program for equipment with refrigerant capacity of 50 lb or more, and a safe equipment disposal program.

EPA has promulgated regulations requiring air conditioner maintenance personnel to recover and recycle refrigerants used in vehicles and other refrigeration appliances. It also requires that these personnel be trained and certified in the use of approved refrigerant-recycling equipment. The K-25 Site's service personnel have been trained in the use of the equipment and have entered into the broader EPA-required certification program for refrigerant recycling and emissions reduction.

Results

TDEC has issued 58 air permits for 114 point sources. Most permitted sources were not actively operating in 1993 and are considered to be in standby status. Only 18 of the 114 sources operated during 1993. No concerns or violations were noted during the annual TDEC inspection of air-emission sources, which was conducted in July 1993.

The major source of criteria air pollutants at the K-25 Site are the four boilers in operation at the K-1501 Steam Plant. These boilers use natural gas as their primary fuel source, with No. 2 fuel oil used as backup during curtailment of the natural gas supply. The old coal-fired boilers have been permanently removed from service; the switch to natural gas and No. 2 fuel oil has eliminated the opacity problems associated with the coal-fired boilers. Table 4.9 presents the estimated and allowable emissions from the steam plant for 1993.

The TSCA Incinerator is also a source of air emissions from the K-25 Site. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Estimated emissions from the incinerator are significantly less than the permitted allowable emissions (Table 4.10).

Table 4.9. Estimated air emissions from the K-1501 Steam Plant at the K-25 Site, 1993

Pollutant	Emissions (tons/year)	
	Estimated	Allowable
Particulate matter	1.63	18
Sulfur dioxide	3.97	390
Nitrogen oxides	19.03	205
Organics	1.14	8
Carbon monoxide	20.35	138

Table 4.10. Estimated air emissions from the TSCA Incinerator at the K-25 Site, 1993

Pollutant	Emissions (tons/year)		Percentage of allowable
	Estimated	Allowable	
Lead	0.00025	0.57	0.04
Beryllium	0.000008	0.00037	2.33
Mercury	0.0011	0.088	1.28
Fluorine	0.00086	2.83	0.03
Chlorine	0.054	16.12	0.33
Sulfur	0.53	38.54	1.38
Particulate	0.010	13.14	0.08

LIQUID DISCHARGES

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 derived concentration guide (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 effective dose equivalent of 100 mrem (1 mSv) per year to "reference man," as defined by International Commission on Radiological Protection (ICRP) publication 23. For the water pathway, this assumes the consumption of water to be 730 L/year at the DCG level. DCGs were calculated using methodologies consistent with recommendations found in ICRP publications 26 and 30. DCGs are used as reference concentrations for conducting environmental protection programs at DOE sites, as screening values for considering best available technology for treatment of liquid effluents, and for making dose comparisons. 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 be less than 100% would be required as specified in DOE Order 5400.5.

Y-12 Plant

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 requires the Y-12 Plant to maintain a TDEC-approved radiological monitoring plan and to submit results from the monitoring program on a quarterly schedule as an addendum to the *NPDES Discharge Monitoring Report.* There are no discharge limits set by the NPDES permit for radionuclides; the requirement is only to monitor and report. In 1992, the *Radiological Monitoring Plan for the Y-12 Plant Liquid Effluent Discharge to the Environment* (Y/SUB/92-TK532C/1) was revised and reissued 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) instream locations. The revised monitoring plan was fully implemented in 1993.

Parameters routinely monitored under the plan are

- 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)
- uranium (^{234}U, ^{235}U, ^{236}U, ^{238}U, total uranium, and percentage of ^{235}U)

In addition, the Y-12 Plant is permitted to discharge domestic wastewater to the city of Oak Ridge Sewage Treatment Plant under Industrial and Commercial User Waste Water Discharge Permit Number 1-91. Radiological monitoring of this discharge is also conducted and reported to the city of Oak Ridge. The parameters routinely monitored are

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

As with the NPDES permit, there are no associated discharge limits set by the city of Oak Ridge permit for radionuclides. The current permit requirement is only to monitor and report.

Results

Radiological monitoring plan sampling locations are noted in Fig. 4.9. Table 4.11 identifies the monitored locations, the frequency of monitoring, and the sum of DCG percentages for radionuclides measured in 1993. All radiological data for all locations were well below the allowable DCGs. The highest summed percentage of DCGs was from the Groundwater Treatment Facility; ^{234}U and ^{238}U were the major contributors of radioactivity there, contributing 1% and 5%, respectively, of the total 7.9% of the sum of the percentages of the DCGs. Isotopes of uranium were the largest contributors of radioactivity at each location with the exception of outfalls 503, 302, and 142. At these locations, ^{241}Am and/or ^{237}Np were the major contributors; however, the measured values for these isotopes were near the detection limit of the method, and the highest value was less than 2% of the DCG.

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 have resulted in effluent data consistently well below DCGs. This can be seen in Fig. 4.10, which shows ^{238}U concentrations since 1989.

Additional radiological monitoring at kilometer 12.4 (mile 7.7) on Upper Bear Creek is conducted in response to Section IV, Part 4, of a 1983 memorandum of understanding agreed to by DOE, EPA, and TDEC.

ORNL-DWG 94M-7071

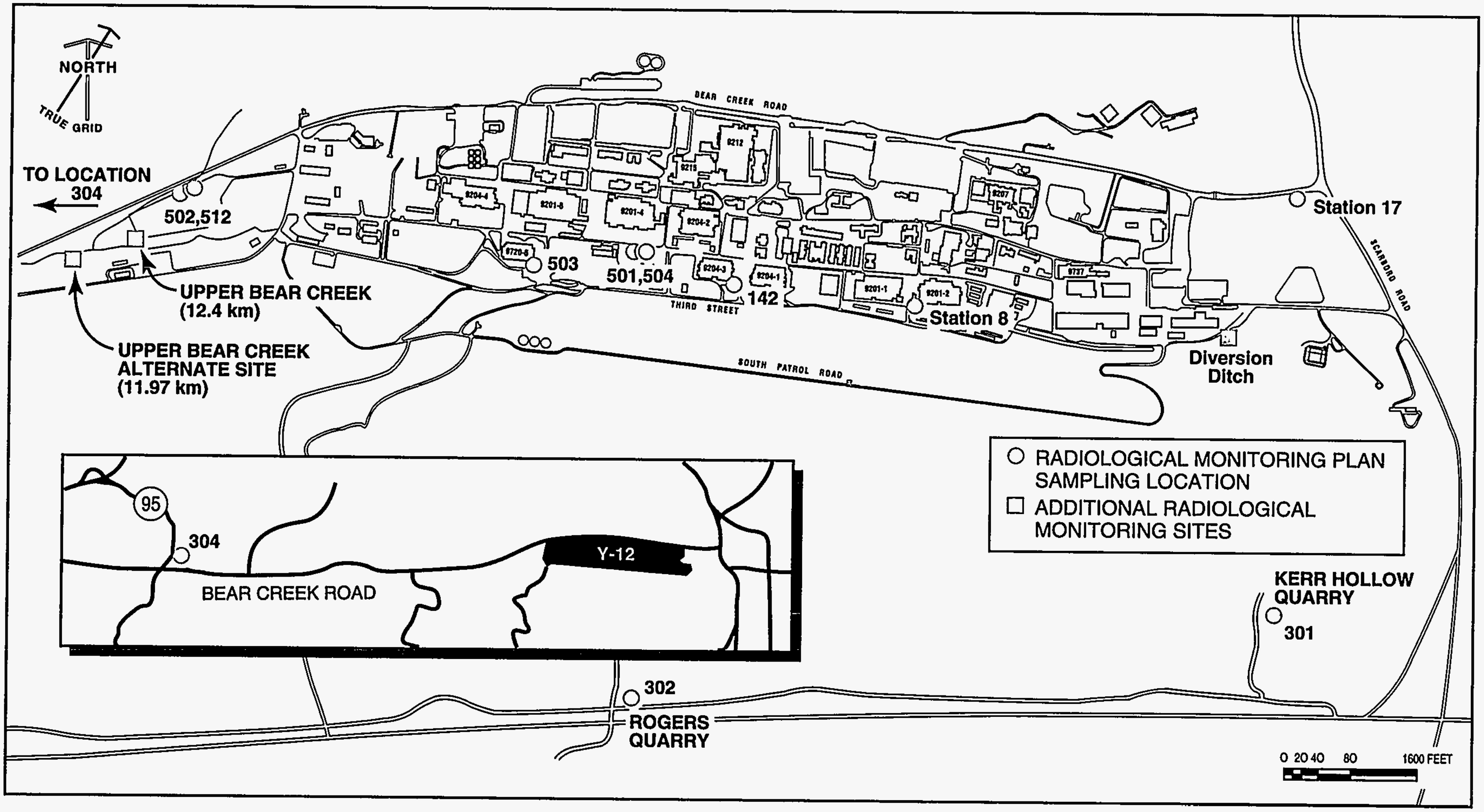

Fig. 4.9. Surface water radiological sampling locations at the Y-12 Plant.

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

Outfall No.	Location	Sample frequency	Sample type	1993 Sum of DCG percentage
	Y-12 Plant wastewater treatment facilities			
501	Central Pollution Control Facility	1/week	Composite during batch operation	4.72
502	West End Treatment Facility	1/week	24-hour composite	2.28
503	Steam Plant Wastewater Treatment Facility	1/week	24-hour composite	1.46
504	Plating Rinsewater Treatment Facility	1/week	24-hour composite	5.27
512	Groundwater Treatment Facility	1/week	24-hour composite	7.90
	Other Y-12 Plant point and area source discharges			
142	Isotope Separation Process	1/month[a]	24-hour composite	3.29
301	Kerr Hollow Quarry	1/month	24-hour composite	1.09
302	Rogers Quarry	1/month	24-hour composite	1.04
	Y-12 Plant instream locations			
304	Bear Creek, Plant Exit (west)	1/week	7-day composite	4.74
Station 17	East Fork Poplar Creek, Plant Exit (east)	1/week	7-day composite	3.29
Station 8	East Fork Poplar Creek, Plant Site	1/week	7-day composite	4.19

[a] Only two samples were collected in 1993; there was no flow for 10 months of the year.

This site, where the creek first approaches Bear Creek Road, was agreed upon as a point in the stream that is characteristic of the effects of the seepage of the S-3 ponds. Because of decreased flow at this site since the closure of the S-3 ponds, a new site at kilometer 11.97 is also being monitored and has been proposed as a replacement site. Analytical data from both these sites have been compared with each other to support the proposed monitoring change. These changes have not been implemented to date. Analytical data are reported monthly to TDEC as an attachment to the discharge monitoring report required by NPDES. These sites were monitored once per week. In addition, a sampling point is maintained in the diversion ditch around Lake Reality, where weekly samples are taken for radiological parameters. For each of these instream locations, all radiological results for 1993 were below 5% of the DCGs.

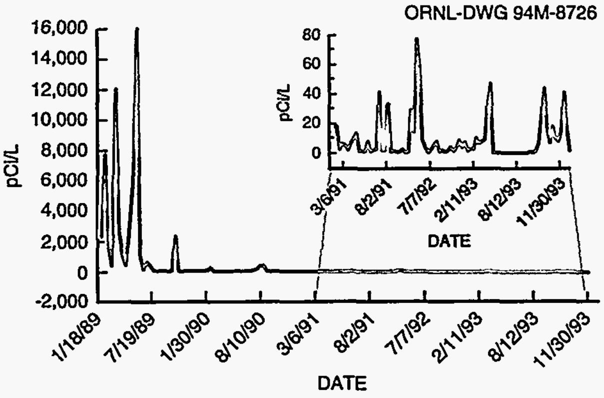

Fig. 4.10. Concentrations of ^{238}U at Y-12 Plant Outfall 501, January 1989 through December 1993. The allowable DCG for ^{238}U is 600 pCi/L.

In 1993, the total of uranium and associated curies released from the Y-12 Plant at the easternmost monitoring station, Station 17 on Upper East Fork Poplar Creek, and the westernmost monitoring station, at Bear Creek kilometer 4.55 (NPDES Outfall 304), was 301 kg, or 0.18 Ci (6.66×10^9 Bq) (Table 4.12). Figure 4.11 illustrates a 5-year trend of these releases.

The City of Oak Ridge Industrial and Commercial User Wastewater Permit allows the Y-12 Plant to discharge wastewater to be treated at the

Table 4.12. Release of uranium from the Y-12 Plant to the off-site environment as a liquid effluent, 1989–93

Year	Quantity released	
	(Ci)[a]	(kg)
	Station 17	
1989	0.20	316
1990	0.135	197
1991	0.162	235
1992	0.087	130
1993	0.081	134
	Outfall 304	
1989	0.138	224
1990	0.131	204
1991	0.082	159
1992	0.060	110
1993	0.094	167

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

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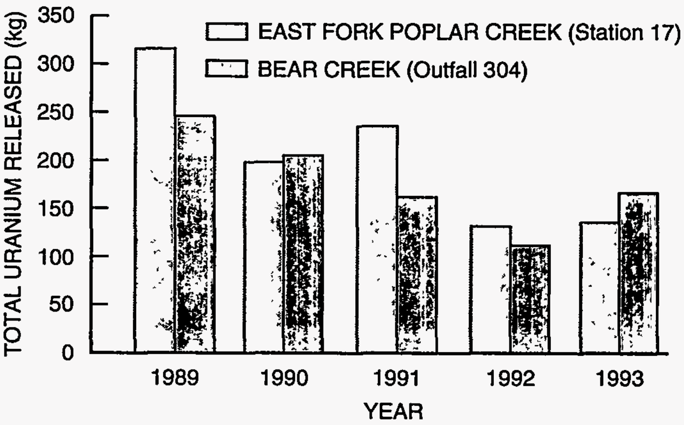

Fig. 4.11. Five-year trend of Y-12 Plant release of uranium to surface water.

Oak Ridge Wastewater Treatment Facility through two main sewage lines into the Oak Ridge sanitary sewer system in accordance with effluent limitations, monitoring requirements, and other conditions set forth in the permit. Samples from the sanitary sewer are collected from two locations to monitor compliance to the permit (Fig. 4.12). The City Monitoring Station, designated SS-4, and the Union Valley Station, designated SS-5, are monitored to measure the contribution from the Y-12 Plant to the sewer system. The Y-12 Plant contribution can be calculated by subtracting the input from the Union Valley Station, which does not have any Y-12 Plant wastes associated with it, from the results of the city station, which is directly downstream of the Y-12 Plant and Union Valley. Two additional in-plant sewer locations (SS-1 and SS-2) are monitored as a best management practice. No single radionuclide in the Y-12 Plant contribution to the sanitary sewer exceeds 1% of the DCG. Summed percentages of DCGs calculated from the Y-12 Plant contribution to the sewer are essentially zero. Results of radiological monitoring are reported to the city of Oak Ridge with the quarterly monitoring report.

During 1993, the DOE Office of Nuclear Safety (ONS) conducted a review of Y-12 Plant operations and discharges to the sanitary sewer. Potential sources of radionuclides discharging to the sanitary sewer had been

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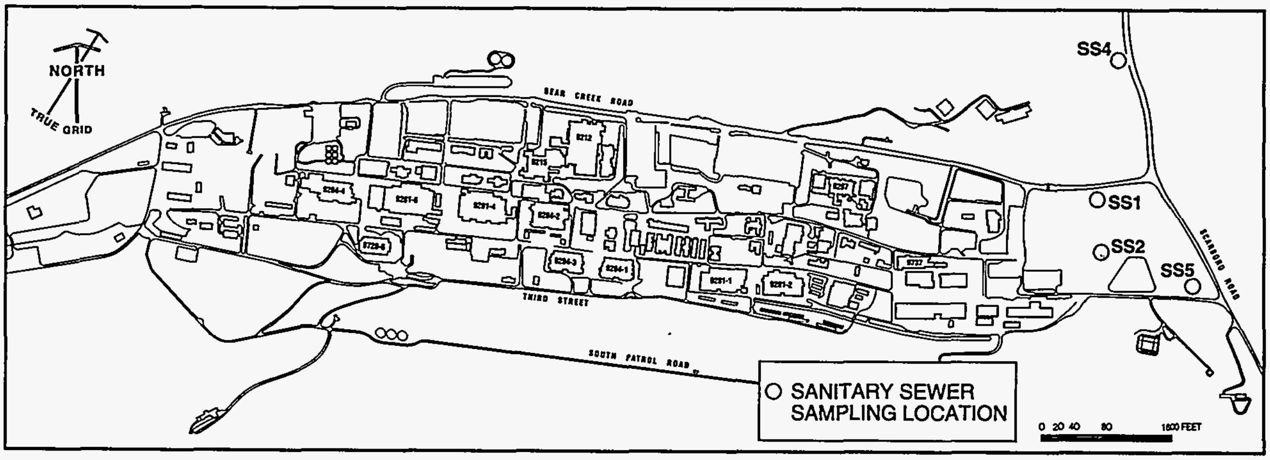

Fig. 4.12. Sanitary sewer sampling locations at the Y-12 Plant.

identified in previous studies at the Y-12 Plant as part of a best management practices initiative to meet the as low as reasonably achievable (ALARA) goals of the Y-12 Plant. Consequently, there were sufficient data to answer the concerns of ONS; ONS "did not find any immediate threats to the safety and health of the public, workers, or the environment." The historical sampling data from the Y-12 Plant sanitary sewer discharges were reviewed with ONS. These data show that levels of radioactivity are orders of magnitude below regulatory levels established in DOE orders and are not considered a safety or health risk. Figure 4.13 shows average uranium levels measured in the Y-12 Plant sewer east and west lines from 1987 through 1993.

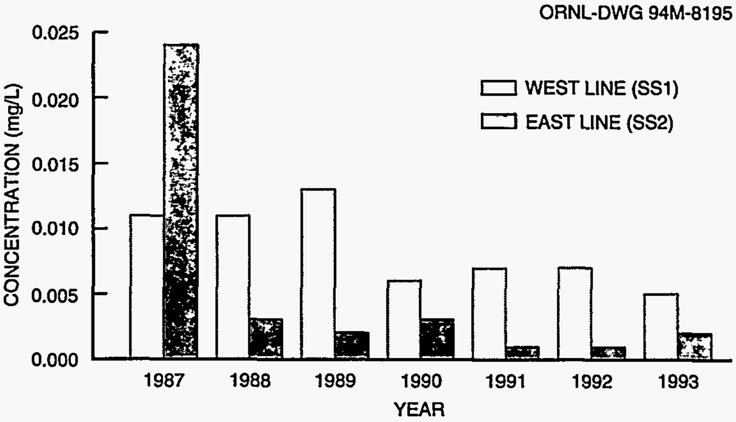

Fig. 4.13. Average total uranium discharge levels from the Y-12 Plant sanitary sewer east and west lines, 1987–93.

ORNL Radiological Summary

Water samples are collected for radiological analyses from Melton Hill Dam and White Oak Creek headwaters, two locations above ORNL discharge points that serve as references for other water sampling locations at the ORNL site. Water samples are also collected from six on-site streams: White Oak Creek, Melton Branch, First Creek, Fifth Creek, Northwest Tributary, and Raccoon Creek. Sampling for radiological analyses is conducted at six ambient stations around ORNL and at five NPDES locations. The six ambient stations are 7500 Road Bridge, First Creek, Fifth Creek, Melton Branch 2, Northwest Tributary, and Raccoon Creek. The five NPDES stations are Sewage Treatment Plant (X01), Nonradiological Wastewater Treatment Facility (X12), Melton Branch 1 (X13), White Oak Creek (X14), and White Oak Dam (X15) (Fig. 4.14).

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 does not imply that effluent points or ambient water sampling stations at ORNL are sources of drinking water. Only three radionuclides had an average concentration greater than 5% of the relevant DCG; the largest was 54% of DCG (Fig. 4.15). For 1993, the sum of DCG percentages at each effluent point and ambient water station was less than 100%.

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. The flow in Melton Branch is usually less than one-third of that in White Oak Creek. In 1993, the monthly ratio of flow in White Oak Creek (measured at White Oak Dam) to flow in the Clinch River (measured at Melton Hill Dam) ranged from 0.0012 to 0.0097, thus providing significant dilution of any radioactivity released into the Clinch River from White Oak Creek.

Amounts of radioactivity released at White Oak Dam are calculated from concentration and flow. As shown in Figs. 4.16 through 4.21, the total discharges or amounts of radioactivity released at White Oak Dam during the past 3 years have shown a general decrease for both gross measurements and specific radionuclides.

Categories of Effluents

Radiological monitoring is conducted at Category I, Category II, and Category III outfalls. Category I outfalls are storm drains; Category II outfalls are roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling-tower blowdown, condensate, and disposal demonstration area; and Category III outfalls are process and/or lab drains. Although there is no NPDES requirement for radiological monitoring at Category III outfalls, concentrations were monitored at five outfalls to support planning for remediation recommendations at Waste Area Grouping 1. Results from sampling those outfalls in 1993 confirmed the presence of strontium. Radiological monitoring at Category III outfalls will be eliminated in 1994.

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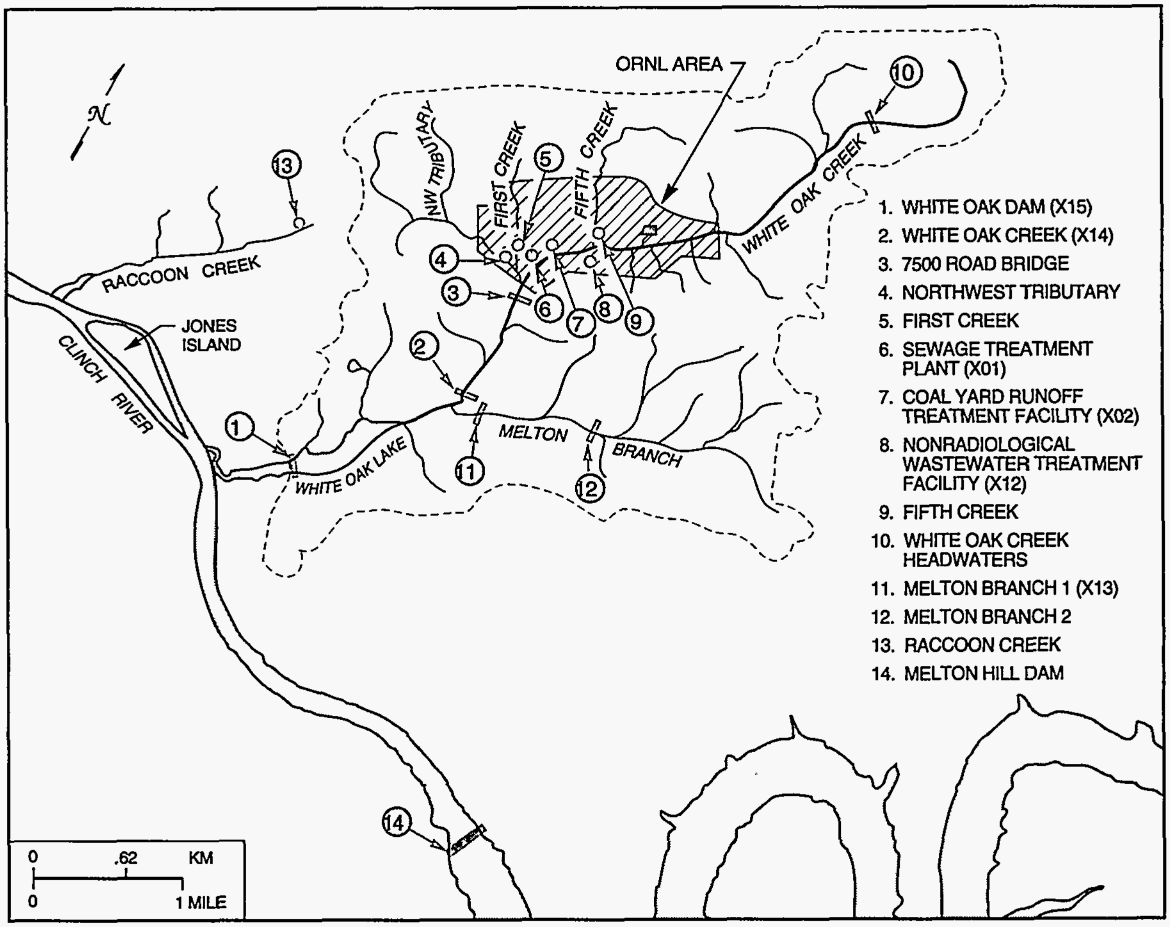

Fig. 4.14. ORNL surface water, NPDES, and reference sampling locations. Bars (▮) indicate sampling locations that have weirs.

K-25 Site Radiological Summary

The K-25 Site conducts radiological monitoring of liquid effluent to determine compliance with applicable dose standards and the ALARA process by maintaining potential exposures to members of the public as low as is reasonably achievable.

Sample Collection and Analytical Procedure

The K-25 Site monitors three major effluent discharge points for radiological parameters: the K-1203 Sewage Treatment Plant discharge (005), the K-1407-J treated effluent from the Central Neutralization Facility (CNF) and the TSCA Incinerator Facility (011), and the K-1515-C filter backwash from the Sanitary Water Treatment Facility (009) (Fig. 4.22). Samples are collected from each of these locations on a weekly basis. The weekly samples are composited into monthly samples and analyzed for radionuclides. Results of these sampling efforts are compared with the DCGs provided in DOE Order 5400.5.

Results

As shown in Table 4.13, the sum of the fractions of the DCGs for each of the effluent points (K-1203, K-1407-J, and K-1515-C) remained below the limit of 1.0. Table 4.14 lists radionuclides released from the K-25 Site to off-site surface waters in 1993.

Uranium releases to surface waters over a 5-year period (1989–93) were investigated to observe their trend (Fig. 4.23). Only those release locations that had data available for the 5-year period were included. Data for the investigation were extracted from the 1989, 1990, 1991, and 1992 annual site environmental report and from the 1993 quarterly performance indicator reports.

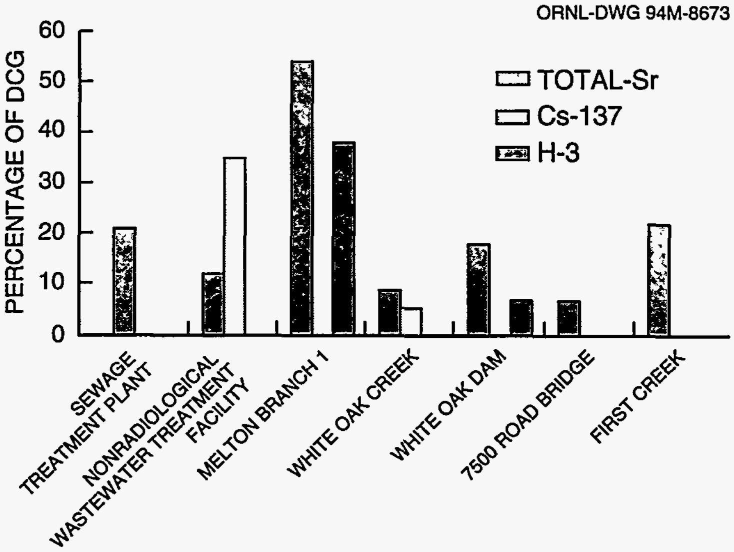

Fig. 4.15. Radionuclides with average concentration *greater than 5% of derived concentration guide in 1993.*

Nonradiological Liquid Discharges

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

The CWA requires that EPA establish limits on the amounts of specific pollutants that may be discharged to surface waters. The standards, called "effluent limitations," are written into NPDES permits issued to all municipal and industrial dischargers. The Y-12 Plant, ORNL, and the K-25 Site 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 Board.

The CWA also created the Federal Pretreatment Program to regulate industrial discharges to sanitary sewer systems, which are also referred to as a "publicly owned treatment works" (POTW). Under the Federal Pretreatment Program, industries are required to monitor and regulate their discharges to the POTW. The state of Tennessee has created the Tennessee Pretreatment Program, which requires municipalities to develop their own pretreatment programs for their local industries. Pretreatment programs issue permits to industries, spelling out the responsibilities of the industries for pretreatment and compliance with the sewer-use ordinance. These responsibilities include the monitoring of 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 K-25 Site have on-site sewage treatment plants. 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.

Y-12 Plant

Surface Water and Liquid Effluents

The current NPDES permit issued May 25, 1985, is a reflection of the 1977 amendments to the Federal Water Pollution Control Act and the Y-12 FFCA signed by EPA and DOE on April 17, 1985. This current NPDES permit combines water quality and industrial best available technology effluent limitations for the metal finishing and steam electric power generation industries with emphasis on biological and toxicological monitoring. Under the conditions of the permit, the Y-12 Plant was required to accomplish the following:

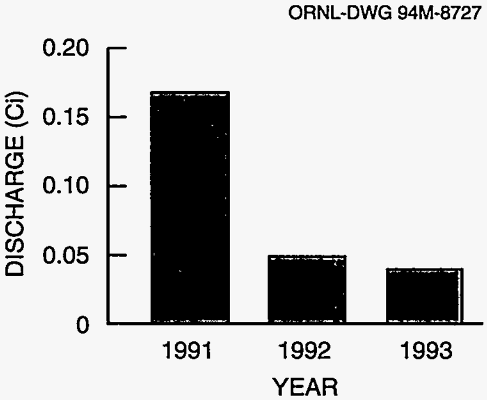

Fig. 4.16. Cobalt-60 discharges at White Oak Dam.

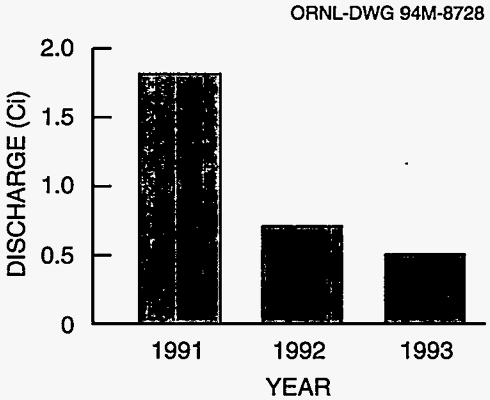

Fig. 4.17. Cesium-137 discharges at White Oak Dam.

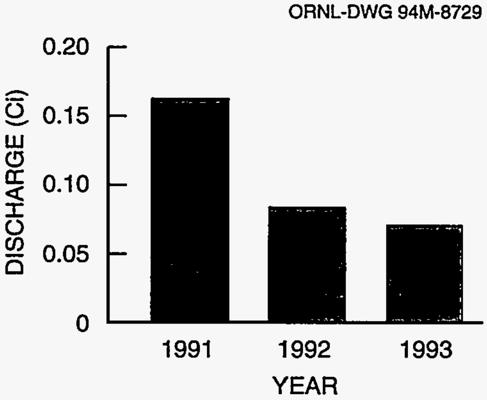

Fig. 4.18. Gross alpha discharges at White Oak Dam.

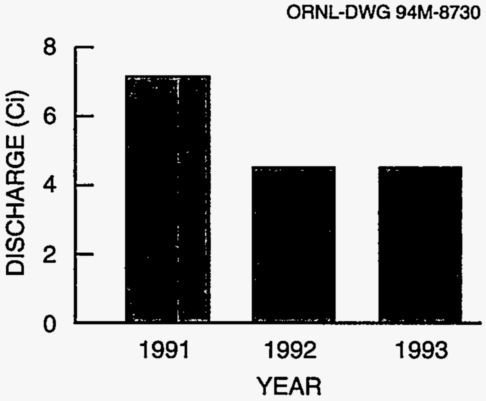

Fig. 4.19. Gross beta discharges at White Oak Dam.

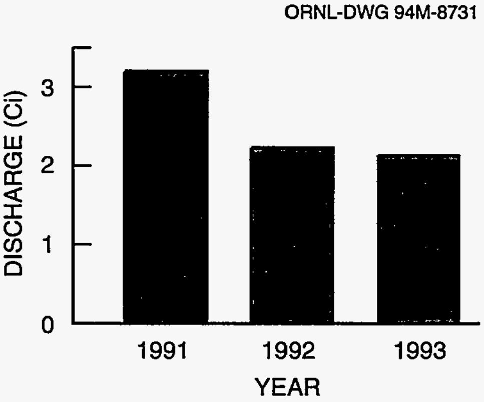

Fig. 4.20. Total radioactive strontium discharges at White Oak Dam.

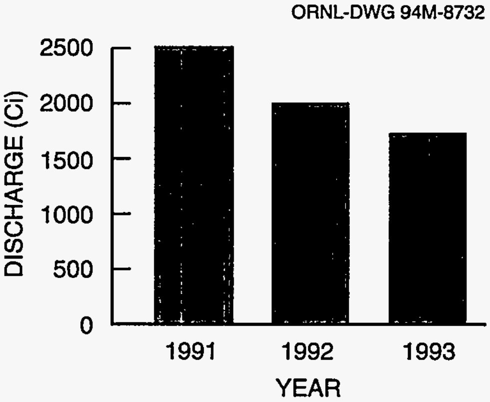

Fig. 4.21. Tritium discharges at White Oak Dam.

- develop and implement a best management practices plan that prevents or minimizes the potential of wastewater from Category I and II outfalls,
- determine the biological toxicity of wastewater streams from several locations and develop a toxicity characteristic monitoring plan as necessary,
- develop a radiological monitoring plan,
- develop a PCB monitoring plan,
- develop a biological monitoring and abatement program (BMAP) for East Fork Poplar Creek, and
- comply with discharge limitations on identified miscellaneous discharge points.

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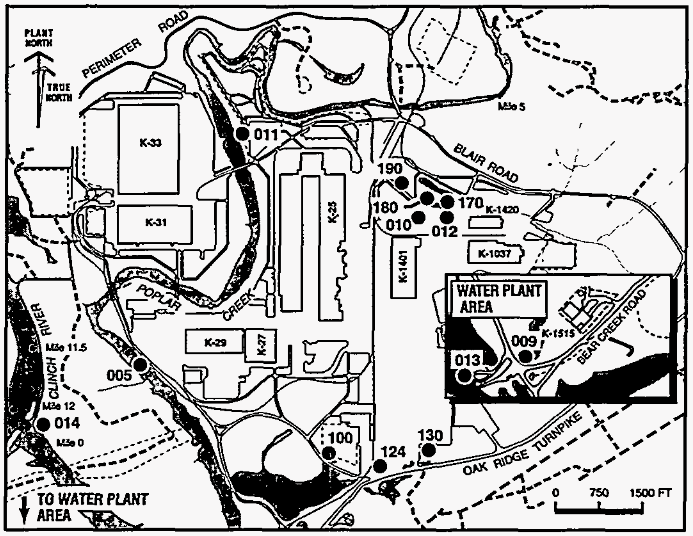

Fig. 4.22. K-25 Site NPDES major outfalls and Category IV storm drain outfalls.

The Y-12 Plant is committed to achieving effluent characteristics that are better than those specified by the best available technology. The effluent limitations for each treatment facility may be adjusted if the treated effluent results in instream toxicity as determined by the toxicity control and monitoring program (TCMP) plan or if East Fork Poplar Creek does not display a healthy ecological system as determined by BMAP.

The Y-12 Plant NPDES permit requires sampling and analysis at 14 serially numbered outfalls, about 195 categorized outfalls, and about 30 miscellaneous discharges. This listing is subject to change as outfalls are eliminated or consolidated. A total of 32 outfalls to East Fork Poplar Creek were eliminated (source flows stopped and outfalls physically removed) in 1993. A total of 14 outfalls had previously been eliminated in 1992. Plans are to remove 15 outfalls in 1994, which will bring the total number of active outfalls to 135. Since the mid-1980s, more than 200 untreated wastewater point sources that previously discharged to the surface water have either been treated or eliminated from direct discharge to the creek.

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 East Fork Poplar Creek before entering the Clinch River. In past years, discharge of coal bottom ash slurry to the McCoy Branch Watershed from the Y-12 Steam Plant occurred only when coal was in use. Bear Creek water quality is affected by area source runoff and groundwater discharges. 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.

Outfalls 302 (Rogers Quarry) and 304, which are considered instream sampling points for McCoy Branch and Bear Creek, respectively, are also compared with state of Tennessee water quality criteria, as a component of surveillance monitoring conducted by the Y-12 Plant. The most restrictive of either the freshwater fish and aquatic life criterion maximum concentration (CMC) or the recreation concentration for organisms only standards (10^{-5} risk factor for carcinogens) was used. See Sect. 5 for these and other results of surveillance monitoring.

The existing Y-12 Plant NPDES permit expired in May 1990. An application for permit renewal was submitted to TDEC/EPA in November 1989, and an addendum to this application was submitted to TDEC in February 1993. The addendum contains an extensive collection of proposed monitoring points and subsequent categories, consisting of 33 Category II outfalls (storm water and cooling water condensate), 12 Category III

Table 4.13. Radionuclide concentrations at K-25 Site surface watter effluent discharge points

Isotope	No. of samples	Concentration (pCi/L)[a]				DCG	Percentage of DCG	Sum of fractions of DCGs
		Max	Min	Median	Average			
K-1203 Sewage Treatment Plant								
^{234}U	12	2.82E+01	4.54E+00	1.55E+01	1.63E+01	5.00E+02	3.27+00	*b*
^{235}U	12	4.80E+01	–1.24E+01	8.60E+00	1.02E+01	6.00E+02	1.70+00[c]	*b*
^{238}U	12	3.54E+00	0.00E+00	1.35E+00	1.74E+00	6.00E+02	2.91E–01	*b*
^{137}Cs	12	7.30E+00	–2.46E+01	3.92E–01	–2.64E+00	3.00E+03	–8.81E–02[b]	*b*
^{99}Tc	12	5.10E+02	–3.24E+02	–5.71E+00	3.66E+01	1.00E+05	3.66E–02	*b*
^{237}Np	12	5.85E+00	–3.49E–01	1.10E+00	1.57E+00	3.00E+01	5.24E+00	*b*
^{238}Pu	12	1.78E+00	–7.30E–01	0.00E+00	4.43E–01	4.00E+01	1.11E+00	*b*
^{239}Pu	12	1.05E+00	–3.56E+00	0.00E+00	–2.14E–01	3.00E+01	–7.13E–01	*b*
^{228}Th	12	2.50E+03	0.00E+00	0.00E+00	2.91E+02	4.00E+02	7.27E+01[c]	*b*
^{234}Th	12	3.35E+02	–1.08E+03	0.00E+00	–1.99E+02	1.00E+04	–1.99E+00[c]	*b*
^{234m}Pa	12	1.21E+04	0.00E+00	0.00E+00	1.87E+03	7.00E+04	2.67E+00	*b*
^{106}Ru	12	1.21E+02	0.00E+00	0.00E+00	1.01E+01	6.00E+03	1.68E–01	*b*
^{143}Ce	12	3.22E+03	0.00E+00	0.00E+00	3.50E+02	3.00E+04	1.17E+00	*b*
^{40}K	12	4.76E+02	0.00E+00	0.00E+00	3.97E+01	7.00E+03	5.67E–01[c]	*b*
Gross alpha	12	2.54E+01	5.39E+00	1.40E+01	1.43E+01	*b*	*b*	*b*
Gross beta	12	1.71E+01	4.67E+00	1.00E+01	1.04E+01	*b*	*b*	*b*
All listed isotopes		*b*	*b*	*b*	*b*	*b*	*b*	8.61E–01[c]
K-1407-J treated effluents from Central Neutralization Facility and TSCA Incinerator								
^{234}U	12	5.24E+01	8.05E+00	2.38E+01	2.63E+01	5.00E+02	5.27E+00	*b*
^{235}U	12	4.85E+01	–1.77E+01	2.22E+01	1.52E+01	6.00E+02	2.54E+00[c]	*b*
^{236}U	12	1.17E+01	0.00E+00	3.94E+00	4.07E+00	5.00E+02	8.14E–01	*b*
^{238}U	12	1.70E+02	5.84E+00	2.78E+01	3.76E+01	6.00E+02	6.27E+00	*b*
^{137}Cs	12	2.88E+01	–4.30E+01	5.41E+00	1.49E+00	3.00E+03	4.96E–02[c]	*b*
^{99}Tc	12	5.05E+02	–2.30E+02	–6.20E+00	3.96E+01	1.00E+05	3.96E–02	*b*
^{237}Np	12	1.33E+01	–5.51E–01	1.29E+00	3.03E+00	3.00E+01	1.01E+01	*b*
^{238}Pu	12	1.45E+00	–2.19E+00	3.41E–01	1.19E–02	4.00E+01	2.98E–02	*b*
^{239}Pu	12	7.49E–01	–2.54E+00	0.00E+00	–2.94E–01	3.00E+01	–9.81E–01	*b*
^{228}Th	12	0.00E+00	–1.01E+00	0.00E+00	–8.42E–02	4.00E+02	–2.10E–02	*b*
^{230}Th	12	2.53E+00	0.00E+00	0.00E+00	2.11E–01	3.00E+02	7.03E–02	*b*
^{232}Th	12	0.00E+00	–5.07E–01	0.00E+00	–4.23E–02	5.00E+01	–8.45E–02	*b*
^{234}Th	12	1.02E+03	–2.52E+02	0.00E+00	2.82E+02	1.00E+04	2.82E+00[c]	*b*
^{234m}Pa	12	3.26E+03	–5.54E+03	0.00E+00	–9.83E+02	7.00E+04	–1.40E+00[c]	*b*
^{106}Ru	12	1.98E+02	0.00E+00	0.00E+00	1.65E+01	6.00E+03	2.75E–01	*b*
Gross alpha	12	1.19E+02	9.81E+00	3.49E+01	4.45E+01	*b*	*b*	*b*
Gross beta	12	1.37E+02	5.45E+00	4.44E+01	5.38E+01	*b*	*b*	*b*
All listed isotopes		*b*	*b*	*b*	*b*	*b*	*b*	2.58E–01[c]

Table 4.13 (continued)

Isotope	No. of samples	Concentration (pCi/L)[a]				DCG	Percentage of DCG	Sum of fractions of DCGs
		Max	Min	Median	Average			
		K-1515-C filter backwash from the Sanitary Water Treatment Facility						
^{234}U	12	8.63E+00	0.00E+00	7.38E–01	1.64E+00	5.00E+02	3.28E–01	*b*
^{235}U	12	5.61E+01	–1.50+01	1.27E+01	1.58E+01	6.00E+02	2.63E+00[c]	*b*
^{238}U	12	2.25E+00	0.00E+00	1.07E+00	8.83E–01	6.00E+02	1.47E–01	*b*
^{137}Cs	12	1.80E+01	–2.11E+01	7.18E+00	5.01E+00	3.00E+03	1.67E–01[c]	*b*
^{99}Tc	12	3.73E+02	–2.68E+02	–5.52E+01	–1.34E+01	1.00E+05	–1.34E–02	*b*
^{237}Np	12	1.17E+00	–1.10E+00	0.00E+00	–3.22E–02	3.00E+01	–1.07E–01	*b*
^{238}Pu	12	2.99E+00	–2.09E+00	1.05E–01	5.61E–02	4.00E+01	1.40E–01	*b*
^{239}Pu	12	7.49E–01	–3.44E+00	0.00E+00	–4.46E–01	3.00E+01	–1.49E+00	*b*
^{228}Th	12	1.62E+03	0.00E+00	0.00E+00	1.35E+02	4.00E+02	3.38E+01	*b*
^{234}Th	12	1.53E+03	–8.63E+02	0.00E+00	1.90E+02	1.00E+04	1.90E+00[c]	*b*
^{234m}Pa	12	8.30E+03	0.00E+00	0.00E+00	1.42E+03	7.00E+04	2.02E+00[c]	*b*
^{106}Ru	12	7.24E+02	0.00E+00	0.00E+00	7.28E+01	6.00E+03	1.21E+00	*b*
^{143}Ce	12	1.22E+03	0.00E+00	0.00E+00	1.02E+02	3.00E+04	3.39E–01	*b*
Gross alpha	12	4.86E+00	–2.10E+00	–7.81E–01	–4.46E–01	*b*	*b*	*b*
Gross beta	12	5.70E+00	–4.21E+00	1.52E+00	1.42E+00	*b*	*b*	*b*
All listed isotopes		*b*	*b*	*b*	*b*	*b*	*b*	4.11E–01[c]

[a] 1 pCi/L = 3.7E–2 Bq/L.

[b] Not applicable.

[c] This calculated value includes sampling results that are at or below the detection limits and/or below background activities.

Table 4.14. Radionuclides released to off-site surface waters from the K-25 Site, 1993

Effluent discharge points are K-1203, K-1407-J, and K-1515-C

Isotope	Amount (Ci)[a]	Isotope	Amount (Ci)[a]
^{137}Cs	1.24E–3	^{236}U	5.76E–4
^{237}Np	1.20E–3	^{238}U	6.05E–3
^{238}Pu	1.62E–4	^{228}Th	2.03E–1
^{239}Pu	–2.14E–4	^{230}Th	2.39E–5
^{234m}Pa	1.14E+0	^{232}Th	–4.79E–6
^{106}Ru	3.76E–2	^{234}Th	3.60E–2
^{99}Tc	3.01E–2	^{40}K	1.89E–2
^{234}U	7.69E–3	^{143}Ce	2.01E–1
^{235}U	1.44E–2		

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

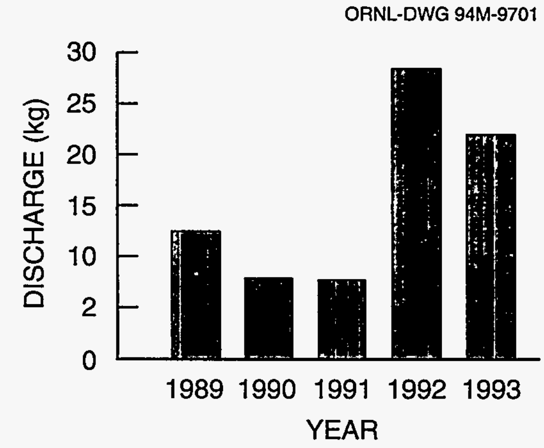

Fig. 4.23. Five-year trend of uranium releases to surface waters from the K-25 Site. Analysis includes discharge locations K-1203 and K-1407-J.

outfalls (process wastewater only), and 6 treatment facilities. Process wastewater is defined as the combination of any of the following types of wastewater:

- once-through noncontact cooling water,
- cooling tower blowdown,
- steam condensate,
- discharges through a previously monitored NPDES permit point,
- periodic discharges regulated under best management practices or other administrative control, or
- discharges regulated by an approved water management plan.

Energy Systems, DOE, and TDEC informational meetings began in October 1992 to start the process of issuing a renewed NPDES permit to the Y-12 Plant. Some of the more significant changes in the revised draft as compared with the 1985 NPDES permit include the following:

- toxicity limitation for the headwaters of East Fork Poplar Creek,
- quarterly toxicity testing at the wastewater treatment facilities,
- a compliance schedule to reduce mercury in East Fork Poplar Creek,
- a compliance schedule for chlorine limitations at all outfalls containing cooling water,
- chlorine limitations of water quality criteria at the headwaters of East Fork Poplar Creek,
- a compliance schedule for correction of elevated ammonia concentrations discharged to East Fork Poplar Creek from a groundwater spring,
- a requirement to manage the flow of East Fork Poplar Creek such that a minimum flow of 7 million gallons per 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, and
- instream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge.

Sanitary Wastewater

Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW under Industrial and Commerical Users Wastewater Permit Number 1-91. Monitoring is conducted under the terms of the permit for a variety of organic and inorganic pollutants.

As required by the city of Oak Ridge, a sanitary sewer application revision/questionnaire was submitted in September 1993. The questionnaire is used by the city's POTW staff to set limits for industrial and commercial discharges. Permits are being reviewed throughout the industrial community to ensure that regulatory limits are met at the POTW discharge point.

Results

Significant improvements continue to be made to water quality at the Y-12 Plant. Since 1991, the discharge from Rogers Quarry (Outfall 302) has improved considerably in meeting NPDES discharge requirements. In 1991, there were 19 NPDES noncompliances at Rogers Quarry because of elevated pH caused by algae growth in the quarry. As ambient temperatures increase in the spring, the algae begin to grow and consume CO_2, which decreases the amount of carbonic acid formed in the quarry and causes a slightly elevated pH. This is a natural phenomenon and occurs in most lakes and ponds in East Tennessee. In 1992, there was one noncompliance at Rogers Quarry; in 1993, there were none. This drastic reduction was accomplished by a subsurface discharge pipe installed at the outlet of the quarry, which allows the discharge of deeper, cooler, CO_2-rich water. This action eliminated pH and temperature noncompliances at the quarry in 1993 (Fig. 4.24). Y-12 Plant discharges to Rogers Quarry ceased in June 1993 and will not resume.

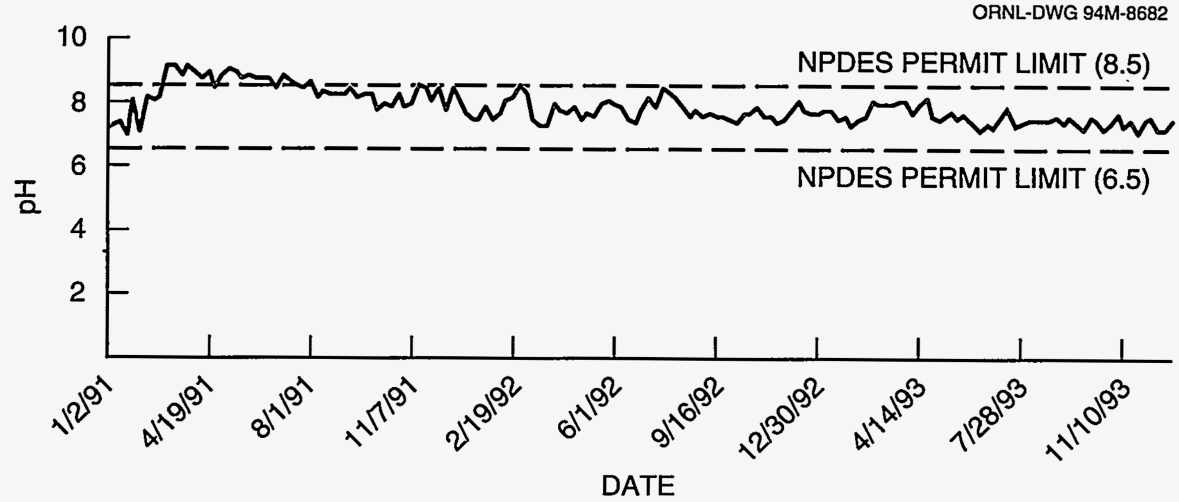

Fig. 4.24. pH measurements at Outfall 302 (Rogers Quarry), 1/1/91 through 12/31/93.

In 1993, the Y-12 Plant reduced NPDES excursions by more than 60% from 1992 (from 43 in 1992 to 14 in 1993). Another significant improvement has been a 57% reduction in the number of NPDES excursions at Y-12 Plant wastewater treatment facilities. This reduction can be attributed primarily to the increase in treatment-facility operator control. In 1993, 36% 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. Only 29% of the NPDES excursions that occurred at the Y-12 Plant were observations made at outfalls located directly on the bank of East Fork Poplar Creek. This represents an 84% reduction in these types of excursions since 1992, even in the midst of increased surveillance along East Fork Poplar Creek. More than 160,000 observations were made along the bank of East Fork Poplar Creek for changes in creek conditions or visible discharges from outfalls (e.g., foam or oil sheen). All Y-12 Plant NPDES permit excursions recorded in 1993 are summarized in Table 4.15. Table 4.16 records the NPDES compliance monitoring requirements and the 1993 compliance record.

The *PCB Monitoring Plan for the Y-12 Plant* specifies sampling locations and frequencies of sampling for PCBs. Quarterly monitoring was conducted at Kerr Hollow Quarry (Outfall 301), Rogers Quarry (Outfall 302), Bear Creek (Outfall 304), and from East Fork Poplar Creek within the Y-12 Plant boundary. All results for the year were less than the analytical detection limit, which is 0.005 mg/L (Table 4.17).

Monitoring of nonradiological parameters at kilometer 12.4 (mile 7.7) on Upper Bear Creek continued in 1993, as it did for radiological parameters, to monitor the influence of seepage from the S-3 ponds site. Because of decreased flow at this site since closure of the S-3 ponds, a new site at kilometer 11.97 is also being monitored and has been proposed as a replacement site. Analytical data from both these sites have been compared, and changes in the monitoring routine have been proposed but have not been implemented to date. Analytical data are reported monthly to TDEC as an attachment to the discharge monitoring report required by NPDES. These sites were monitored once per week for nonradiological parameters. Surface water in the upper reaches of Bear Creek contains elevated trace metals and nitrate concentrations. Nitrate-nitrogen has been used as a key parameter to monitor the influence of the S-3 ponds site on surface water. Figure 4.25 shows average total nitrate data from 1987 to 1993 for the Upper Bear Creek site at kilometer 12.4.

Table 4.18 summarizes the Y-12 Plant calculated sanitary sewer concentrations for 1993 for parameters having a permitted discharge limit. There were no exceedences of permit discharge limits.

Table 4.15. Summary of Y-12 Plant NPDES excursions, 1993

Date	Location	Excursion	Explanation	Corrective action
1/7/93	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Sample analysis exceeded holding time	A provisional result was obtained and reported on the January 1993 discharge monitoring report for total suspended solids.	Evidence of this noncompliance was not discovered until August 1993 while investigations were being conducted into the events leading to missed holding times. The lab has since improved internal computerized warnings to increase the efficiency of processing samples that have holding times.
1/13/93	Outfall 10	Unauthorized discharge	About 10 gal of sewage and potable water were flushed to East Fork Poplar Creek when a manhole overflowed during cleaning of a blocked sewer line. This overflow went into a storm drain.	The water was turned off immediately when the manhole started overflowing. Sandbags will be placed around nearby storm drains prior to future sewer-line flushing.
1/19/93	Outfall 21	Unauthorized discharge	Small amounts of foam were observed discharging from Outfall 21, and about 100 dead fish were discovered in the tributary between Outfall 21 and East Fork Poplar Creek. Samples taken during the incident indicated the presence of disinfectants and surfactants in the water discharged through Outfall 21.	The exact location of the sink responsible for the soapy discharge was not determined. A major effort is under way to reroute sinks and drains illicitly tied to the storm sewer system in buildings 9207 and 9208 to the sanitary sewer. Once the rerouting is completed, incidents of this nature are expected to cease.
2/3/93	Outfall 302 (Rogers Quarry)	Lost sample	Samples were salvaged in the lab before analyses were completed on total suspended solids and sulfate.	The lab has since improved internal computerized warnings to increase the efficiency of processing samples that have holding times.
2/17/93	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Sample concentration (1.1 mg/L iron) exceeded permit limit	The permit limit is 1.0 mg/L for iron.	The facility was evaluated by a wastewater treatment consultant to improve the iron-removal efficiency of the current operation.
3/3/93	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Improper preservation of sample	The composite sample collected at Outfall 503, the Steam Plant Wastewater Treatment Facility, was improperly preserved prior to its being analyzed for metals.	This noncompliance occurred because two bottles containing two different preservatives were stored together, looked the same, and were labeled similarly. Technicians relocated the bottles to prevent confusion, and the lab color-coded the preservative labels to make them more distinctive.
4/16/93	Outfall 109	Visible foam	A trace amount of foam was observed discharging to East Fork Poplar Creek. Investigations were immediately conducted in some of the buildings tied to Outfall 109, and dye tests were performed at the photo lab and at Medical. No source of the origin of the soapy solution was identified.	Projects are under way to modify or reroute sink drains.
5/20/93	Outfall 512 (Groundwater Treatment Facility)	Sample concentration (72 mg/L of oil and grease) exceeded permit limit	A pump located near the final holding tank failed and released oil into the treated effluent at the Groundwater Treatment Facility.	The facility was taken off line until the pump was replaced. Normal operations were resumed once the new pump was installed on June 4.
6/22/93	Outfall 503 (Steam Plant Wastewater Treatment Facility)	Sample analysis exceeded holding time	The holding time for total suspended solids is 7 days. One of the composite samples from 503 was not analyzed until the eighth day, resulting in a noncompliance.	The computerized laboratory tracking system for holding times of composite samples has been modified to be more efficient at monitoring holding times.

Table 4.15 (continued)

Date	Location	Excursion	Explanation	Corrective action
6/29/93	Outfall 503	Sample concentration (1.3 mg/L iron) exceeded permit limit	Investigations indicated that corrosion of the sulfuric acid tank and piping may contribute some iron during the treatment process. It is unknown if this was the source of elevated iron at the treatment facility.	The corroded tank and piping were taken out of service and replaced with a system of polyethylene tanks.
8/25/93	Outfall 302 (Rogers Quarry)	Sample analyses exceeded holding time	The 7-day holding time for the total suspended solids portion of the chemical analysis for Outfall 302 was exceeded. Incorrect analyses were requested at the laboratory. The mistake was realized and a correction was made manually, which resulted in the omission of the request for total suspended solids. Analysis was eventually run for this sample, but the data were reported as provisional because the sample had exceeded the 7-day holding time.	Two unlikely errors in record keeping happened to the same sample, resulting in an omission of the request for analysis of total suspended solids, which happened to carry a 7-day holding time. Sampling personnel have been instructed to double-check sample entry information once it has been entered into the computer. Any changes in lab requests must be verified by the appropriate personnel. Finally, laboratory and sampling personnel have improved communication by meeting weekly.
8/26/93	Outfall 21	Visible oil sheen	An oil sheen was observed entering the oil/water separator on East Fork Poplar Creek. An investigation found that the oil sheen was being emitted from Outfall 21. Lab analyses from samples taken at the outfall indicate that the active ingredient of the substance is the same ingredient in many cleaning agents.	The oil skimmer located upstream of Lake Reality collected a large portion of the visible sheen, and additional booms were set up near the vicinity of Outfall 21. The oil sheen was contained on site, and none of the sheen was observed downstream of the plant. The source of the sheen was not determined.
9/27/93	Outfall 21	Visible oil sheen	A platform lift with a leaking hydraulic line was stationed in a temporary dike in the Biology area near Building 9207. The equipment failure had occurred on the previous Friday (9/26), and the vehicle was moved to the diked area to contain the leaking oil while the equipment was waiting to be repaired. Heavy rain on September 26 flooded the temporary dike around the lift, causing residue from the oil leak to enter a storm drain.	Spill response personnel contained the spill, and booms were placed at the outfall to contain the sheen. The storm line leading to the outfall was cleaned. Garage personnel were dispatched to replace the hydraulic hose, and the equipment was repaired that morning.
12/17/93	Outfall 135	Unauthorized discharge	A tank and dike failure resulted in an estimated 1000 gal of sodium hypochlorite solution being released from the leaking dike to the nearby storm sewer. It is believed that a portion of this solution reached East Fork Poplar Creek through Outfall 135, resulting in an unauthorized discharge.	The storm sewer system south of the leaking dike was plugged once the release was discovered to limit the total volume of sodium hypochlorite solution released to East Fork Poplar Creek. The solution remaining in the dike was pumped into tankers to be transferred to the K-25 Site for treatment and disposal. The north storm basin was plugged as an extra precaution, and the dike was cleaned to remove traces of the spill to prevent subsequent contamination of rainwater collected in the area.

Table 4.16. Y-12 Plant NPDES compliance monitoring requirements and record, 1993

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)		
301 (Kerr Hollow Quarry)	Lithium				5.0	100	20
	pH, standard units			*a*	8.5	100	20
	Total suspended solids			30.0	50.0	100	20
	Temperature, °C				30.5	100	20
	Zirconium				3.0	100	20
302 (Rogers Quarry)	Oil and grease			10.0	15.0	100	52
	pH, standard units			*a*	8.5	100	52
	Settleable solids, mL/L				0.5	100	52
	Total suspended solids			30.0	50.0[b]	98[c]	52
	Temperature, °C				30.5	100	52
304 (Bear Creek)	Oil and grease			10.0	15.0	100	52
	pH, standard units			*a*	8.5	100	52
307 (West Borrow Area)[d]	Temperature, °C					100	2
	pH, standard units					100	2
	Oil and grease					100	2
	Total suspended solids					100	2
308 (East Borrow Area)[c]	Temperature, °C					100	4
	pH, standard units					100	4
	Oil and grease					100	4
	Total suspended solids					100	4
501 [Central Pollution Control Facility (CPCF-I)]	Cadmium, total	0.07	0.19	0.26	0.69	100	52
	Chromium total	0.5	0.75	1.71	2.77	100	52
	Copper, total	0.6	0.9	2.07	3.38	100	52
	Cyanide, total	0.2	0.33	0.65	1.20	100	52
	Lead, total	0.12	0.19	0.43	0.69	100	52
	Nickel, total	0.65	1.1	2.38	3.98	100	52
	Oil and grease	7.1	14.2	26.0	52.0	100	52
	pH, standard units			*a*	9.0	100	52
	Silver, total	0.07	0.12	0.24	0.43	100	52
	Temperature, °C				30.5	100	52
	Total suspended solids	8.5	16.4	31.0	60.0	100	52
	Total toxic organics		0.6		2.13	100	52
	Zinc, total	0.4	0.7	1.48	2.61	100	52
502 [West End Treatment Facility (WETF)]	Cadmium, total	0.07	0.019	0.26	0.69	100	46
	Chromium, total	0.5	0.75	1.71	2.77	100	46
	Copper, total	0.6	0.92	2.07	3.38	100	46
	Cyanide, total	0.2	0.33	0.65	1.20	100	47
	Lead, total	0.12	0.19	0.43	0.69	100	46
	Nickel, total	0.65	1.10	2.38	3.98	100	46
	Oil and grease	7.1	14.2	26.0	52.0	100	47
	pH, standard units			*a*	9.0	100	47
	Silver, total	0.07	0.12	0.24	0.43	100	46
	Temperature, °C				30.5	100	47
	Total suspended solids	8.5	16.4	31.0	60.0	100	46
	Total toxic organics		0.6		2.13	100	13
	Zinc, total	0.4	0.7	1.48	2.61	100	46

Table 4.16 (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)		
503 (Steam Plant Wastewater Treatment Facility)	Chromium, total	0.38	0.38	0.20	0.20	99[c]	156
	Copper, total	1.89	1.89	1.0	1.0	99[c]	156
	Iron, total	1.89	1.89	1.0	1.0	98	156
	Zinc, total	1.89	1.89	1.0	1.0	99[c]	156
	Oil and grease	28.4	37.9	15.0	20.0	100	155
	Total suspended solids	57.0	189.0	30.0	100.0	98[e]	156
	Temperature, °C				30.5	100	155
	pH, standard units			*a*	9.0	100	155
Category I outfalls (precipitation runoff and small amounts of groundwater)	pH, standard units			*a*	8.5	100	27
Category II outfalls (cooling waters, condensate, precipitation runoff, and building, roof, and foundation drains)	pH, standard units			*a*	8.5	100	91
	Temperature,[f] °C					100	91
Category III outfalls (process wastewaters)	pH, standard units			*a*	8.5	100	39
Category IV outfalls (untreated process wastewaters)	pH, standard units			*a*	8.5	100	92
504 (Plating Rinsewater Treatment Facility)	Cadmium, total	0.07	0.019	0.26	0.69	100	3
	Chromium, total	0.50	0.75	1.71	2.77	100	3
	Copper, total	0.60	0.92	2.07	3.38	100	3
	Cyanide, total	0.2	0.33	0.65	1.20	100	3
	Lead, total	0.12	0.19	0.43	0.69	100	3
	Nickel, total	0.65	1.10	2.38	3.98	100	3
	Oil and grease	7.1	14.2	26.0	52.0	100	3
	pH, standard units			*a*	9.0	100	3
	Silver, total	0.07	0.12	0.24	0.43	100	3
	Temperature, °C				30.5	100	3
	Total suspended solids	8.5	16.4	31.0	60.0	100	3
	Total toxic organics		0.6		2.13	100	3
	Zinc, total	0.4	0.7	1.48	2.61	100	3
501/504 (combined discharge from Central Pollution Control Facility and Plating Rinsewater Treatment Facility)	Cadmium, total	0.07	0.019	0.26	0.69	100	0
	Chromium, total	0.50	0.75	1.71	2.77	100	0
	Copper, total	0.60	0.92	2.07	3.38	100	0
	Cyanide, total	0.2	0.33	0.65	1.20	100	0
	Lead, total	0.12	0.19	0.43	0.69	100	0
	Nickel, total	0.65	1.10	2.38	3.98	100	0
	Oil and grease	7.1	14.2	26.0	52.0	100	0
	pH, standard units			*a*	9.0	100	0
	Silver, total	0.07	0.12	0.24	0.43	100	0
	Temperature, °C				30.5	100	0
	Total suspended solids	8.5	16.4	31.0	60.0	100	0
	Total toxic organics		0.6		2.13	100	0
	Zinc, total	0.4	0.7	1.48	2.61	100	0
623 (Steam Plant fly ash sluice water)	pH, standard units			*a*	8.5	100	25

Table 4.16 (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)		
1506 (9204-3 sump pump oil)	Temperature, °C				30.5	100	47
	Oil and grease			10.0	15.0	100	47
	pH, standard units			[a]	8.5	100	47
508 (Experimental Mobile Wastewater Treatment Facility)	Mercury, total			0.002	0.004	[g]	[a]
	pH, standard units			[a]	9.0	[g]	
	Total suspended solids			30.0	45.0	[g]	
510 (Waste Coolant Processing Facility)	Biochemical oxygen demand	1.33	2.65			[g]	
	Oil and grease			15.0	20.0	[g]	
	pH, standard units			[a]	9.0	[g]	
	Temperature, °C				30.5	[g]	
	Total suspended solids			30.0	50.0	[g]	
512 (Groundwater Treatment Facility)	Oil and grease			[a]	15	99	168
	Iron, total			[a]	1.0	100	168
	pH, standard units			[a]	9.0	100	continuous
	PCBs					100	168
Miscellaneous discharges (cooling tower blowdown)	Chromium, total				1.0	100	56
	Copper, total			0.5	1.0	100	56
	Free available chlorine			0.2	0.5	100	56
	pH, standard units			[a]	8.5	100	56
	Temperature, °C			35	38	100	56
	Zinc, total			0.5	1.0	100	56
Miscellaneous discharges (demineralizers)	pH, standard units			[a]	8.5	[g]	
	Total suspended solids			30	50	[g]	

[a] Not applicable.

[b] Limit not applicable during periods of increased surface runoff resulting from precipitation.

[c] One analysis was not performed according to appropriate protocol; i.e., improper presentation, holding-time violation, or lost sample.

[d] Application submitted to add this outfall to the current permit. No limits have been set.

[e] Analytical holding times were exceeded twice (administrative error).

[f] Temperature shall be controlled such that the stream temperature standards delineated in the General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee, as amended, are not violated as a result of this discharge.

[g] No discharge.

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 East Fork Poplar Creek flow (Fig. 4.26). Instream levels of total residual chlorine were typically about 0.01 mg/L as compared with the previous outfall discharge levels of about 1.0 mg/L. Fish populations have significantly increased, and snail and clam survival rates at the headwaters have increased from zero (predechlorination) to more than 90%. Additional dechlorination has been achieved by installation of four tablet dechlorinators at chlorine-discharge sources. About 20 more tablet units are planned for installation in 1994 to bring outfalls into compliance with the new NPDES permit, which will be issued in 1994. Outfall 125, the next-highest nondechlorinated outfall, will begin treatment in 1994, based on design efforts started in 1993.

Table 4.17. Surface water analytical results of polychlorinated biphenyls monitoring plan for the Y-12 Plant, 1993

Site No.	Location	Date sampled	PCB concentration (mg/L)
PCB-1	Outfall 301, Kerr Hollow Quarry	2/3/93	<0.0005
		5/11/93	<0.0005
		9/15/93	<0.0005
		12/8/93	<0.0005
PCB-2	Outfall 302, Rogers Quarry	2/3/93	<0.0005
		5/11/93	<0.0005
		9/15/93	<0.0005
		12/8/93	<0.0005
PCB-3	Outfall 303, New Hope Pond	*a*	
PCB-5	New Hope Pond Inlet	*b*	
PCB-6	Upstream of Outfall 135	2/3/93	<0.0005
		5/11/93	<0.0005
		9/15/93	<0.0005
		12/8/93	<0.0005
PCB-7	Outfall 304, Bear Creek	2/3/93	<0.0005
		5/11/93	<0.0005
		9/15/93	<0.0005
		12/8/93	<0.0005

[a] This outlet was closed in April 1989.

[b] This inlet was closed in November 1988.

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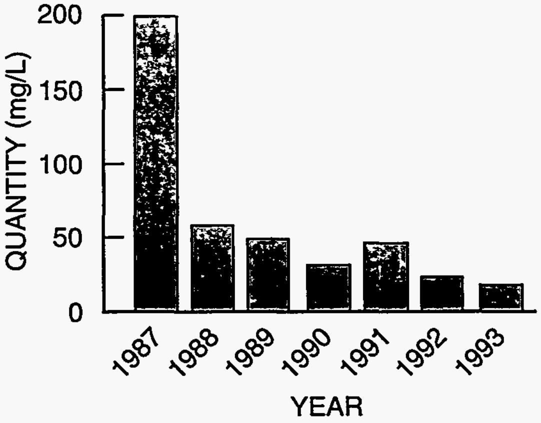

Fig. 4.25. Total nitrate data for Upper Bear Creek site at kilometer 12.4, 1987–93.

Cooling Tower Ozone Treatment

Two cooling towers were converted from chemical to ozone treatment in 1993. This conversion eliminates the use of toxic chemical additions to the cooling towers for control of bacteria. Blowdown from these towers has also been eliminated, thus reducing chlorine discharges to East Fork Poplar Creek. Two additional tower conversions are planned for 1994, which will complete conversion of all towers discharging to East Fork Poplar Creek without dechlorination of discharges.

Flow Management (or Raw Water) Project

Discharges to East Fork Poplar Creek have decreased in volume from about 10 million gal/day in the early 1980s to about 3.5 million gal/day currently. This decrease is primarily because of reductions in plant operations. One result of these reductions is increasing concerns about the Y-12 Plant treatment facilities maintaining discharge contaminant levels that would not affect East Fork Poplar Creek. Accordingly, the proposed new NPDES permit requires addition of Clinch River water to the headwaters of East Fork Poplar Creek by March 1997 so that a flow of 7 million gal/day is maintained at the point where East Fork Poplar Creek leaves the reservation. Design of this project began in 1993.

Ammonia Reduction at Outfall 17

A urea pile was maintained above Outfall 17 for about 10 years; the urea was used for deicing roads and sidewalks. Elevated levels of ammonia nitrate in East Fork Poplar Creek were traced to Outfall 17, and the urea pile was subsequently removed; however, the soil in the area of the pile remains contaminated. A feasibility study started in 1993 will define possible corrective actions. The new NPDES permit will contain compliance requirements for Outfall 17.

Table 4.18. Calculated sanitary sewer compliance summary for Y-12 Plant, 1993

Parameter	No. of samples	Concentration[a]			Reference value[b]	No. of values exceeding reference
		Max	Min	Av		
pH, standard units	45	8.7	6.9	7.5	6–9[c]	0
Cyanide	45	0.020	<0.002[d]	<0.008	0.007	0
Oil and grease	45	75	<2[d]	9	50	0
Phenols	45	0.059	<0.001[d]	<0.016	5.0	0
Biochemical oxygen demand	45	176	<5[d]	<43	300	0
Mercury	45	0.0124	<0.0005	<0.001	0.1	0
Total Kjeldahl nitrogen	45	42.3	<0.2	13.1	90	0
Total suspended solids	45	127.4	<5	25.5	300	0
Arsenic	45	<0.04	<0.04	<0.04	0.1	0
Cadmium	45	<0.004	<0.004	<0.004	0.000024	0
Copper	45	0.022	<0.006[d]	0.10	0.04	0
Iron	45	0.66	<0.06[d]	0.31	1.5	0
Lead	45	<0.05	<0.01	<0.02	0.0016	0
Manganese	45	0.103	<0.002[d]	0.054	1.0	0
Nickel	45	0.008	<0.008[d]	<0.005	0.10	0
Silver	45	<0.019	<0.005	<0.007	0.1	0
Zinc	45	0.212	<0.01[d]	<0.107	2.0	0

[a] All units in mg/L unless otherwise indicated.

[b] Sanitary Sewer Industrial Discharge Permit limits.

[c] Minimum to maximum value.

[d] Calculated value was below the detection limit.

Non-Point Source Studies

Storm water runoff is required to be periodically sampled and analyzed for a large number of contaminants by the NPDES permit and the *Storm Water Pollution Prevention Plan.* The objective of this data collection is to identify possible sources of contaminants that exceed water quality criteria and to provide a basis and direction for corrective actions. 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* was issued in 1993. Additional studies were initiated on the basis of this report. Sampling of parking lot runoff was conducted, and planning began for sampling the scrap yard and selected roof drains. These data will help determine whether these areas are specific sources of contaminants observed in East Fork Poplar Creek. A feasibility study for the scrap yard and storm drains, which defines measures that could be taken to prevent run-on and to provide for sediment collection of runoff, has been completed. These types of investigations will continue as necessary to ensure compliance with the NPDES permit and other regulatory requirements.

Drain Modifications and Reroutes

Extensive plantwide surveys conducted in years previous to 1993 identified incorrectly connected building drains to either the sanitary or storm sewers. 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 buildings. One building was completed in 1993; the others are scheduled for 1994. Changes to the initial plans are expected because of the anticipated downsizing of the plant.

An additional design effort, which began in 1993, identifies primarily floor drains that need to be closed to ensure that accidental or unauthorized discharges are not made to either sanitary or storm sewers. The original scope included 27 buildings but has been reduced to about 18 because many building managers were proactive in closing off drains that were under their control and for which sufficient funding was available. This design will be completed in 1994, and corrective actions will be taken as funding appropriations permit.

In addition, a project was begun to eliminate drains incorrectly discharging to East Fork Poplar Creek from two main buildings in the Biology complex (9207 and 9208). The design work and drain rerouting in 9208 were completed in 1993; work in 9207 will be completed by mid-1994.

Sanitary Sewer Rehabilitation and Improvements

A feasibility study was initiated in 1993 for removal of cooling water from sanitary sewer lines in 11 buildings..This study will be completed in 1994, and corrective actions will be taken as funding appropriations permit. A deteriorated steam condensate line between two buildings needs replacing to eliminate large quantities of water now draining to the sanitary sewer. Design of this project began in 1993 and is scheduled for completion in late 1994.

An initiative began in 1991 to update drawings of the Y-12 Plant storm and sanitary sewer systems. The effort has included an extensive amount of field work in which the location, manhole elevations, and sizes of storm sewer lines throughout the plant were verified by surveying. The field work was completed in 1993 and is being input into a geographic information system (GIS) software package. The end product of the effort will be electronic and hard-copy drawings of the plant storm and sanitary sewer systems. The inclusion of the updated drawings into the GIS software allows easier access to and update of sewer system drawings. Current drawings will aid the plant in spill tracking investigations and will also serve as a means to identify all sources of water contributing flow to individual NPDES-permitted outfalls.

As a requirement of the current sanitary sewer discharge permit, Y-12 Plant personnel completed design of the East End Sanitary Sewer Monitoring Station in October 1993. Construction of the monitoring station and associated rerouting of the Y-12 Plant west sewer line will be instrumental in improving the sampling and flow-measurement capabilities of the Y-12 Plant sanitary sewer discharges. Completion of this construction project is scheduled for middle to late 1994.

At the request of the city of Oak Ridge, the Y-12 Plant initiated special studies to evaluate sanitary sewer flow rates. The *Y-12 Plant Sanitary Sewer Collection System Flow Study* was completed in August and was used to determine the increase in flow in the collection system that could be attributed to rainfall events of varying intensity. This effort helped identify portions of the collection system in need of repair. The study also was used to determine sources of clean water to the sanitary sewer that could be rerouted to the storm sewer system. Clean water sources with an estimated flow in excess of 2×10^5 gal/day have been identified, and steps have been initiated to reroute these sources to the storm sewer. Elimination of these sources from the sanitary sewer could potentially save the Y-12 Plant more than $156,000 a year in sewer-use costs. Additional studies are under way to further characterize flow rates. This information will also be used to identify physical deficiencies and sources of clean water.

A major renovation of the Y-12 Plant Sanitary Sewer has been proposed as a line item project. The Y-12 Plant Sanitary Sewer Upgrade Project is to correct known deficiencies in the entire Y-12 Plant sanitary sewer system, thereby eliminating instances of sewer blockages, backups, and other disruptions of operations experienced because of damaged and blocked sewer piping. Additionally, repairing the deteriorated sewer lines and manholes will facilitate the Y-12 Plant's compliance with current environmental regulations that require surface water and groundwater inflow and infiltration into the sanitary sewer be minimized.

Fish Kill Summary

In the past, the Y-12 Plant has reported chronic fish kills, which have been primarily attributable to elevated levels of chlorine. In the latter part of 1992, two dechlorination units were installed on three of the major outfalls contributing to elevated chlorine levels in East Fork Poplar Creek. For the first 6 months the dechlorination units were operating, routine fish surveys were conducted for the stretch of East Fork Poplar Creek within the Y-12 Plant boundary. During this 6-month observation period, the number of dead fish found in East Fork Poplar Creek decreased dramatically. After establishing the effectiveness of the dechlorination units, the routine fish surveys were discontinued effective June 1, 1993. However, on four separate occasions during 1993, the Y-12 Plant reported to TDEC a fish kill within the plant boundaries attributable to activities within the plant.

On January 19, 1993, a discharge of disinfectant/fungicide through Outfall 21 resulted in 102 dead fish. Outfall 21 discharges into a small tributary feeding into East Fork Poplar Creek. The dead fish were found in the immediate area of the outfall. None of the impacts of this incident were observed below the outfall. The cleaning solution had been poured down a sink that drained into East Fork Poplar Creek. All sinks in the suspect area have now been closed off or rerouted to the sanitary sewer system.

Between April 19 and May 14, 1993, 488 dead fish were reported to TDEC and the Tennessee Wildlife Resources Agency (TWRA) as a result of spawning. The dead fish found were predominantly stonerollers (83%); 63% of those were large adult male stonerollers with breeding tubercules (raised bony spikes along the head and back). The aggressive interactions during the spawning season are physically damaging, reduce feeding, and for older males at the end of the 4- to 5-year life span, may be the final acts before death. This same type of mortality was observed in the spring of 1992 and is expected to be seen again in the spring of each year.

Between September 29 and October 4, 1993, 789 dead fish were retrieved from East Fork Poplar Creek when a feed pump for the System I dechlorination unit failed. The dead fish found were limited to the upper reaches of East Fork Poplar Creek. No adverse impacts from the elevated chlorine were observed below Lake Reality. A new pump was installed, procedures for operating the system were revised, and a new maintenance schedule was written.

Between November 27 and December 3, 1993, 161 dead fish were retrieved from the upper reaches of East Fork Poplar Creek. The exact cause for the fish kill was not identified. No toxic contaminants were identified in the water samples and no changes were observed at the environmental monitoring stations. An effort to control unauthorized discharges to East Fork Poplar Creek continues through Y-12 Plant spill prevention programs.

ORNL Nonradiological Summary

Effluents

The ORNL NPDES permit (TN0002941) became effective on April 1, 1986, and expired in March 1991; the conditions of the expired permit remain in effect until a new permit is negotiated. The permit renewal application was submitted in September 1990, and recent indications from TDEC are that a renewed permit will be issued in 1994. Data collected for the NPDES permit are submitted to the state of Tennessee in monthly discharge monitoring reports.

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

- X01—Sewage Treatment Plant;
- X02—Coal Yard Runoff Treatment Facility;
- X12—Nonradiological Wastewater Treatment Facility;
- X13—Melton Branch;
- X14—White Oak Creek;
- X15—White Oak Dam;
- 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 (process and/or lab drains); and
- COOLS—Cooling Systems (cooling water, cooling tower blowdown, and cleaning wastes originating at space cooling facilities).

Results

Compliance with the NPDES permit for the last 2 years is summarized by major effluent locations in Fig. 4.26. The figure provides a list of the effluent locations and number of noncompliances. The number of noncompliances ranged from 0 to 36 in 1992 and ranged from 0 to 13 in 1993, with the maximum number of noncompliances occurring at the Category II outfalls each year.

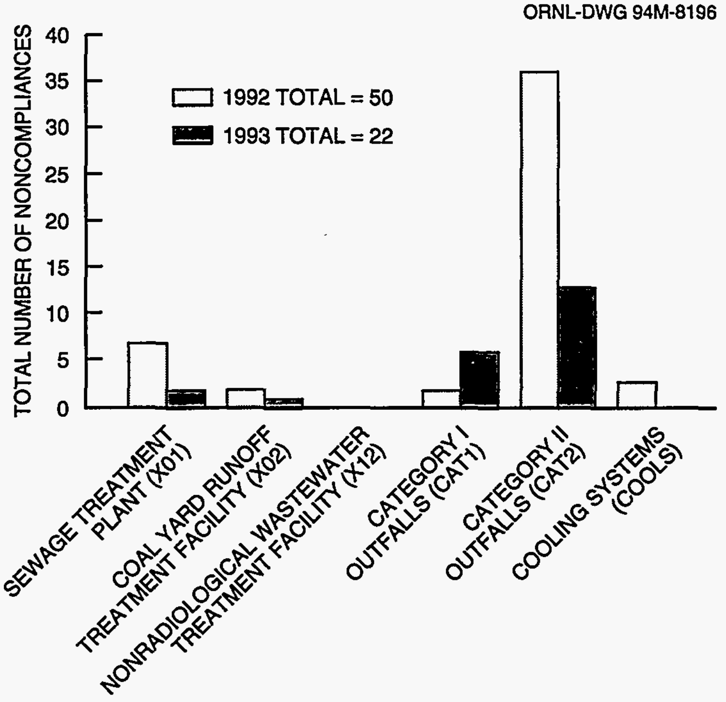

Fig. 4.26. ORNL NPDES noncompliance status comparison and sources of noncompliances, 1992 and 1993.

In 1993, at X01, the two total suspended solids exceedences occurred when a high daily value resulted in a mass load (kilogram per day) daily exceedence. No certain cause was established and no unusual operational conditions were noted. Personnel implemented more stringent influent criteria, and recurrence has not been experienced. At X02, no certain cause was established for the total suspended solids exceedence. The 1.2 in. of rainfall the previous day may have contributed to the suspended solids by mobilizing algae in the discharge basin. At X12, all parameters were 100% in compliance.

At the Category I and II outfalls, the oil and grease and total suspended solids exceedences were attributed to flushing of parking lots or streets by storm water runoff. In one incident, a potable water pipe broke, allowing discharge of potable water through the outfall. 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 wash into these outfalls, carrying oil, grease, and other residue. This situation frequently results in oil and grease and total suspended solids exceedences. Best management practices (including frequent street sweeping) are in place to help avoid these exceedences. In addition, a plan is currently in place to improve sampling points at selected outfalls.

At the cooling systems, all parameters were 100% in compliance.

Mercury in the Aquatic Environment

In the mercury monitoring program at ORNL, samples of surface water and stream sediment in Bethel and Melton valleys are collected semiannually and analyzed for mercury content. This monitoring is conducted to comply with the CWA and Part III of ORNL's NPDES permit. The primary purpose of this effort is to identify, locate, and minimize all mercury contamination in ORNL discharges to the aquatic environment.

In earlier years, before stringent regulations came into 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 separation processes. Most of this activity occurred in or around buildings 4501, 4505, and 3592. These processes are no longer in operation at ORNL. During the time of operation, an unknown number of mercury spills took place. The spills were cleaned up; however, some quantities of mercury escaped and reached the surrounding environment. Sampling locations have been placed in areas surrounding known mercury spills; near outfalls from building areas with a history of mercury concern; and near outfalls from storage areas, spill areas, roads, and parking lot drains. Additional sampling locations have been placed downstream from the outfalls and drains to determine the extent to which any mercury is being transported in surface water and sediment.

Surface water sampling locations are shown in Fig. 4.27. A total of 78 samples are taken from 13 locations. Samples are collected by the manual grab method and placed in 1-L polyethylene bottles with polyethylene caps. In the laboratory, the samples are analyzed for total mercury content by manual cold vapor atomic absorption. Mercury was detected at 8 out of the 13 sampling locations. The highest maximum value reported was 0.31 µg/L at Outfall 207 from White Oak Creek; average concentrations ranged from 0.053 to 0.18 µg/L. The

ORNL-DWG 92M-13528R

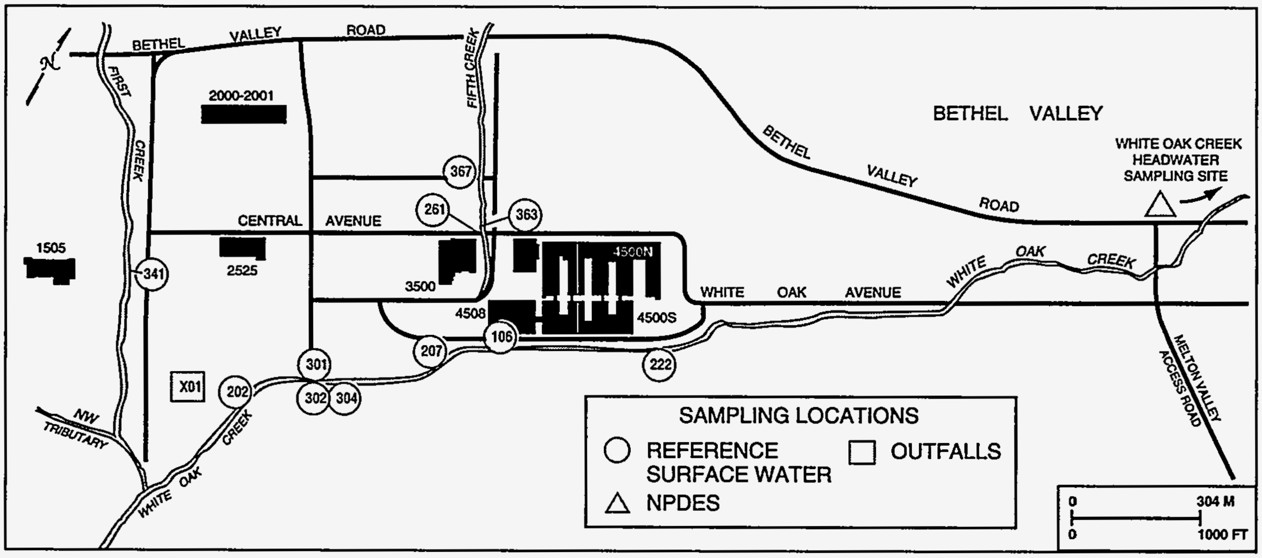

Fig. 4.27. ORNL sampling locations for mercury in water.

Tennessee Water Quality Criteria for Fish and Aquatic Life sets a maximum concentration of 2.4 µg/L for mercury in water. The highest concentration, at Outfall 207, was 13% of the reference value.

Sediment sampling locations are shown in Fig. 4.28. A total of 54 samples are taken from 9 sediment locations. Samples are collected by the manual grab method and placed in glass containers. In the laboratory, the samples are analyzed for total mercury content by manual cold vapor atomic absorption. The highest maximum values reported were 120 µg/g at Outfall 362 and 57 µg/g at Outfall 261, both locations from Fifth Creek. Two sites on White Oak Creek had average concentrations of 1.4 and 2.4 µg/g. Average concentrations at all other sampling locations were much lower, ranging from 0.031 to 0.10 µg/g. In general, results from samples collected in 1993 were similar to those for 1992.

PCBs in the Aquatic Environment

In the polychlorinated biphenyls (PCBs) program at ORNL, samples of stream sediment are collected semiannually and analyzed for PCB aroclor content. This monitoring is conducted to comply with the CWA and Part III of ORNL's NPDES permit. The program to collect water samples for PCB analysis was dropped in 1992, because in previous years concentrations of PCBs in water were below the analytical detection limit at all sampling locations. There are currently no regulatory guidelines for PCB concentrations in stream sediment.

Duplicate samples of sediment were collected at ten locations in streams at and around ORNL (Figs. 4.29 and 4.30). Samples from each location were analyzed by the analytical laboratory for aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Laboratory quantitation limits can vary for individual samples. Only four locations had results above detection limits. The two maximum concentrations, 3900 µg/kg for aroclor-1248 and 1900 µg/kg for aroclor-1254, were reported on White Oak Creek, upstream of the weir at the 7500 Road Bridge. This location represents the area of maximum sediment deposition and collectively represents all potential releases from upstream locations in the ORNL main plant area. Results for aroclor detection are similar to those detected in 1992. Results for most samples collected in 1993 were either below laboratory detection limits or were estimated by the laboratory.

K-25 Site Surface Water Effluents

The K-25 Site was issued a new NPDES permit on October 1, 1992. Currently, this permit covers 7 major outfalls and 137 storm drain outfalls (Fig. 4.22). All process water discharges from the plant pass through an NPDES permitted monitoring point and discharge to the Clinch River, Mitchell Branch, or Poplar Creek. Compliance with the permit for the last four years is summarized by the major effluent locations in Fig. 4.31.

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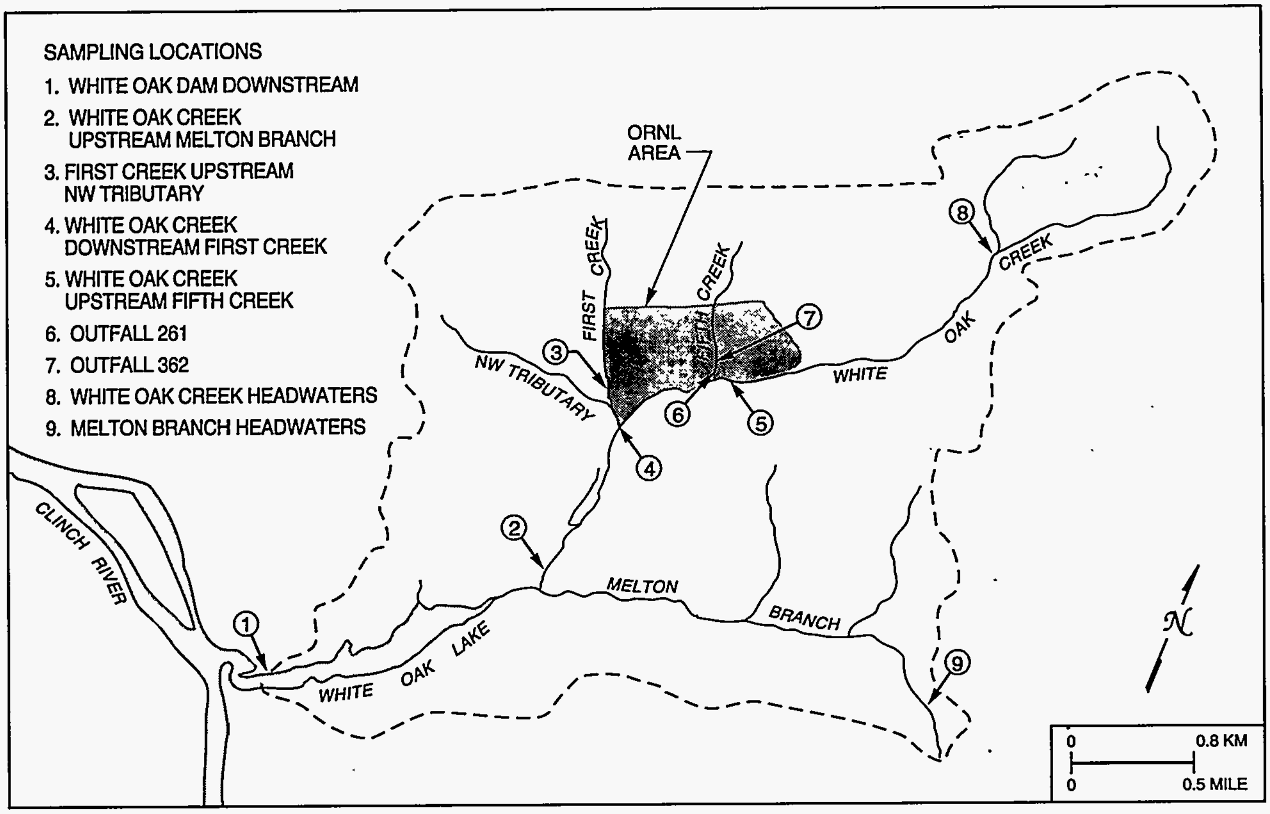

Fig. 4.28. ORNL sampling locations for mercury in sediment.

ORNL-DWG 92M-13529R

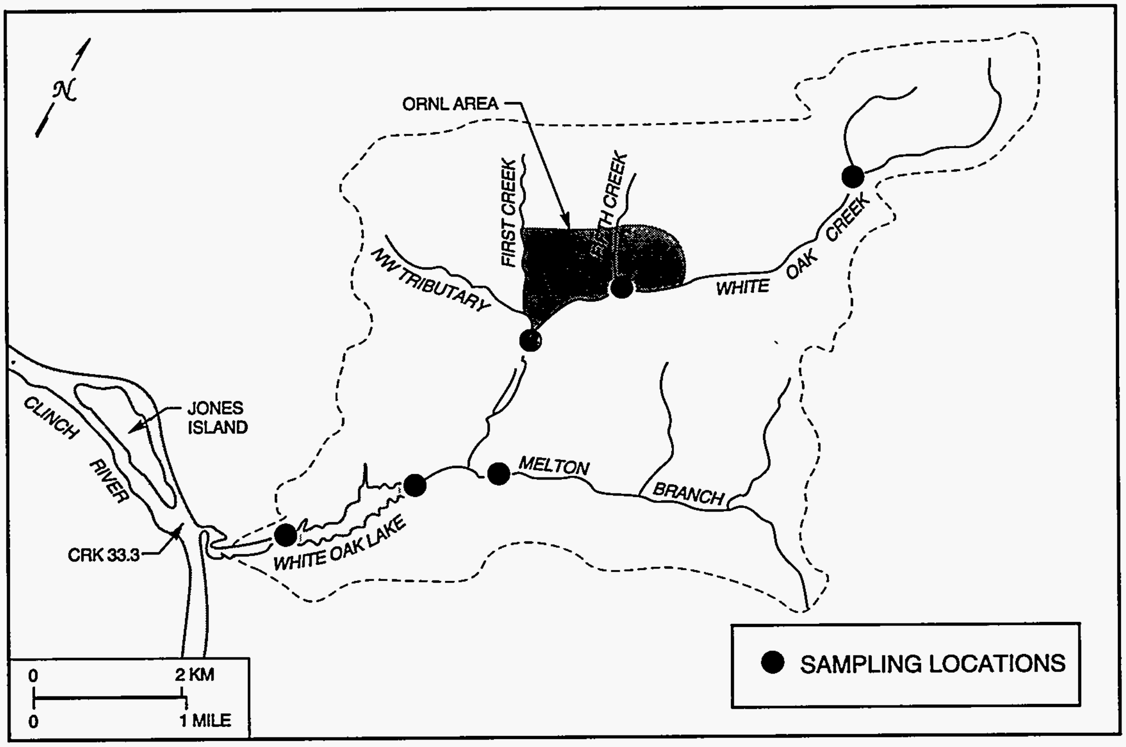

Fig. 4.29. ORNL sampling locations for polychlorinated biphenyls.

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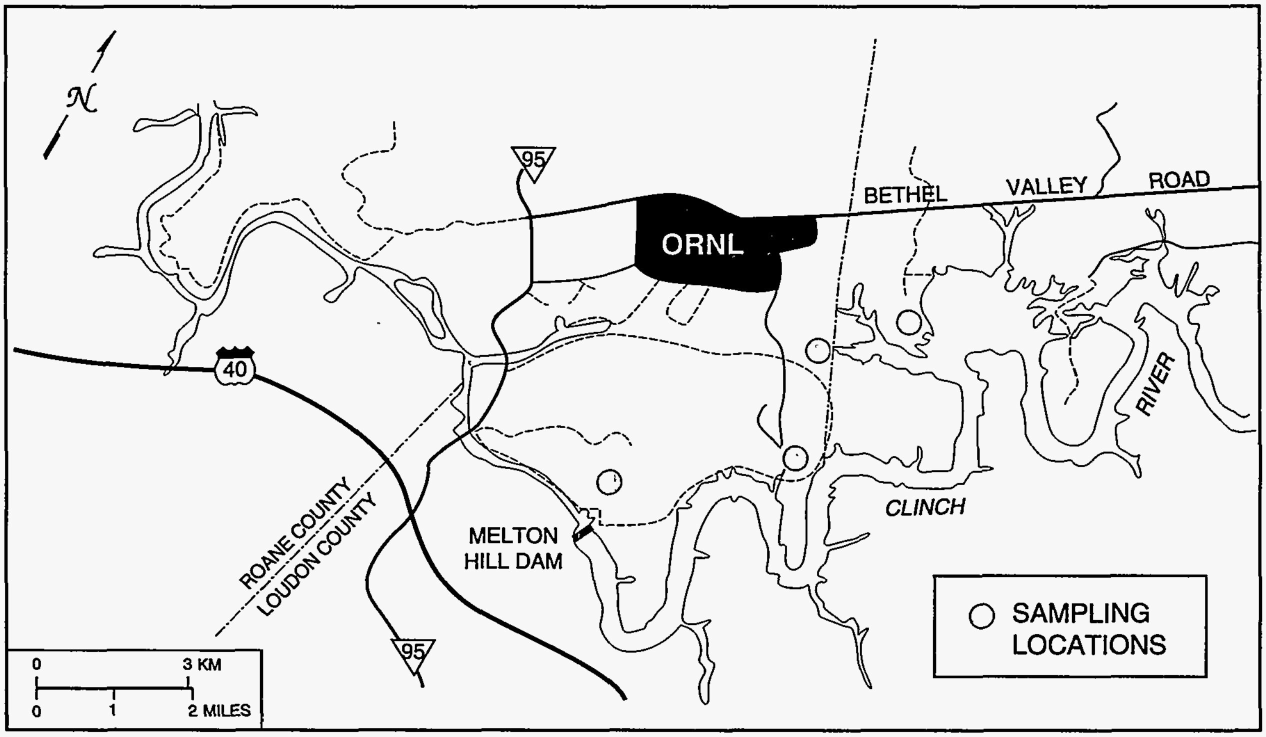

Fig. 4.30. Sampling locations for polychlorinated biphenyls in the greater ORNL area.

Table 4.19 details the permit requirements and compliance records for all of the outfalls that discharged during 1993. The table provides a list of the discharge points, effluent analytes, permit limits, number of noncompliances, and the percentage of compliance. Samples from these outfalls are collected and analyzed as specified in the NPDES permit.

The seven major outfalls at the K-25 Site are 005 (K-1203 Sewage Treatment Plant), 009 (K-1515 Sanitary Water Treatment Facility), 010 (K-1407-E Pond), 011 (K-1407-J CNF discharge to Poplar Creek), 012 (K-1407-F Pond), 013 (K-1513 Sanitary Water Intake Backwash Filter), and 014 (K-1407-J CNF discharge to the Clinch River). In accordance with the compliance schedule in Section E of the NPDES permit, the discharges through outfalls 010 and 012 were permanently ceased on December 30, 1993, which is 10 months earlier than required. Neither of these outfalls had any discharges during 1993. Although no monitoring was required at Outfall 013, routine inspections were conducted to ensure that no unsightly debris or scum discharged through this point as the result of backwash operations from the K-1513 sanitary water intake filter. Outfall 014, which is currently under design, is a permitted outfall for the discharge of effluent from the CNF to the Clinch River. This effluent is currently discharged to Poplar Creek through Outfall 011. Section E of the permit requires that discharges through Outfall 011 be ceased by April 30, 1996.

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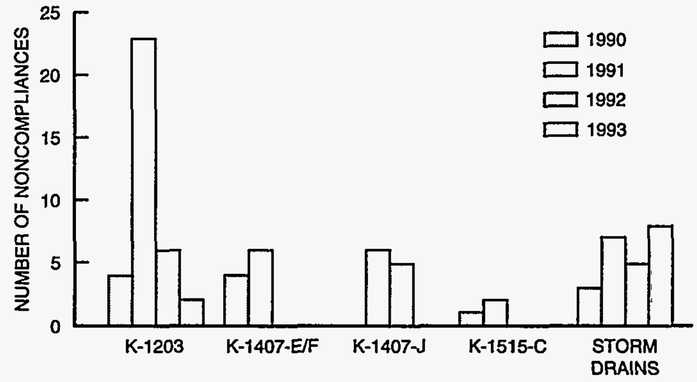

Fig. 4.31. K-25 Site NPDES compliance history by source of noncompliance.

Table 4.19. NPDES compliance at the K-25 Site, 1993

Discharge point	Effluent parameter	Effluent limits				No. of noncompliances	Percentage compliance
		Monthly av[a]	Daily max[a]	Monthly av (kg/d)	Daily max (kg/d)		
005 (K-1203 Sewage Treatment Facility)	Ammonia nitrogen	5	7	12	17		100
	Biochemical oxygen demand	15	20	37	49		100
	Chlorine, total residual	0.14	0.24				100
	Dissolved oxygen		5[b]				100
	Fecal coliform, col/100 ml	200[c]	400				99.6
	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]				83.3
	NOEL,[e] *Pimephales*, %		4.2[b]				100
	pH, standard units		6.0–9.0				100
	Settleable solids, mL/L		0.5				100
	Suspended solids	30	45	74	111		100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
009 (K-1515-C Sanitary Water Plant)	Aluminum	1.0	2.0				
	Chlorine, total residual		1.0				
	Flow, Mgd	*d*	*d*				
	pH, standard units		6.0–9.0				
	Settleable solids, mL/L		0.5				
	Suspended solids	30	40				
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
011 (K-1407-J Central Neutralization Facility)	1,1,1-Trichloroethane	*d*	*d*				100
	Acetone	*d*	*d*				100
	Acetonitrile	*d*	*d*				100
	Benzene	*d*	*d*				100
	Bromoform	*d*	*d*				100
	Cadmium	0.18	0.69				100
	Carbon tetrachloride	0.5	0.5				100
	Chemical oxygen demand	*d*	*d*				100
	Chloride, total	9711	39,479				100
	Chlorine, total residual		0.14				100
	Chlorodibromomethane	*d*	*d*				100
	Chloroform	0.5	0.5				100
	Chromium	1.71	2.77				100
	Copper	1.34	2.15				100
	Dichlorobromomethane	*d*	*d*				100
	Flow, Mgd	*d*	*d*				100
	Ethylbenzene	*d*	*d*				100
	Gross alpha, pci/L	*d*	*d*				100
	Gross beta, pci/L	*d*	*d*				100
	LC_{50}, *Ceriodaphnia*, %		7.05[b]				100
	LC_{50}, *Pimephales*, %		7.05[b]				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
	NOEL[e], *Ceriodaphnia*, %		2.11[b]				100
	NOEL[e], *Pimephales*, %		2.11[b]				100
	Oil and grease		30				100
	PCB	0.00014	0.00014				100
	pH, standard units		6.0–9.0				100
	Silver	0.24	0.43				100
	Suspended solids		40				100

Table 4.19 (continued)

Discharge point	Effluent parameter	Effluent limits				No. of noncompliances	Percentage compliance
		Monthly av[a]	Daily max[a]	Monthly av (kg/d)	Daily max (kg/d)		
	Temperature, °C	*g*	*g*				100
	Tetrachloroethylene		0.7				100
	Toluene	*d*	*d*				100
	Total toxic organics		2.13				100
	Trichloroethylene	0.5	0.5				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*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*	1	*f*
Category III storm drains	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		4.0–9.0			1	99.7
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
Category IV storm drains (to Poplar Creek)	Chlorine, total residual		0.14				99
	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		6.0–9.0			1	99.3
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*			*f*
Category IV storm drains (to Mitchell Branch)	Chlorine, total residual		0.019			1	99.5
	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*	4	*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.
[g] Effluent must not cause the temperature of the receiving stream to exceed 30.5°C.

Results

Outfall 005 is the discharge point for the K-25 Site Sewage Treatment Plant—an extended aeration treatment plant with a rated capacity of 2.3 million L/day (0.6 million gallons per day) and a current use of about 1.4 million L/day (0.36 million gallons per day). Treated effluent from the main plant is discharged into Poplar Creek through this outfall. This facility had two permit noncompliances during 1993. The first one occurred in July and was a result of a decreased reproduction rate of *Ceriodaphnia* spp. during the no-observed-effect limit (NOEL) toxicity test. An investigation revealed no unusual operating conditions or elevated pollutant concentrations that could have caused the reduction in reproduction. The second noncompliance occurred in December and was a fecal coliform permit exceedence. It was directly linked to a heavy rainfall event of >5 in.

in a 26-hour period. The heavy rainfall caused excessive flow through the facility, making it necessary to divert flow to prevent a washout. In an effort to prevent future noncompliances of this nature, a project is currently awaiting the reprogramming of funding by DOE Headquarters (EM-30) to rehabilitate the K-25 Site sewage collection system to minimize infiltration from excessive rainfall.

Outfall 009 is the discharge point for the K-1515 Sanitary Water Plant, which provides sanitary water to the K-25 Site 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. During treatment, residual streams are managed by discharging them to the K-1515-C settling lagoon located adjacent to K-1515 and then to the Clinch River through Outfall 009. In accordance with Section E of the permit, a new lagoon is in the process of being designed and will discharge to the Clinch River by September 30, 1995. This location exhibited 100% compliance with the NPDES permit during 1993.

Outfall 011 is the current discharge point for the CNF, which has provisions for treatment of both nonhazardous and hazardous waste. 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, K-1420 Decontamination Metal Finishing Facility, K-1401 Metal Cleaning Facility, and various small-quantity or infrequent streams from waste disposal requests. After treatment, these waste streams are currently discharged to Poplar Creek. By April 1996, they will discharge to the Clinch River through Outfall 014. The monitoring requirements for Outfall 011 were developed to address the characteristics of steam plant wastewater. This location also exhibited 100% compliance with the NPDES permit during 1993.

The 137 storm drain outfalls are grouped into four categories based on their potential for pollutants to be present in their discharge. Category I storm drains have intermittent flow and drain storm water runoff from areas remotely associated with plant activities and subsurface runoff; Category II storm drains have intermittent flow and drain storm water runoff from building roof drains and paved areas associated with plant activities; Category III storm drains 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 drains have continuous flow and drain cooling water discharges and runoff from industrial areas. Monitoring at storm drain outfalls is conducted semiannually, quarterly, monthly, or weekly for each category, with those storm drains with the highest potential for pollution being sampled most frequently. During 1993, Outfall 05A, which is permitted as the high-water discharge point for Outfall 005, was also recategorized as a Category III storm drain. Because storm water routinely collects in the sump associated with this discharge point, storm water is more frequently discharged through this point than anticipated. Therefore, its sampling frequency was increased to the Category III sampling frequency, which is monthly. Although storm drains 530 and 600 were grouped into Category III, they did not discharge during 1993. Additionally, three Category I storm drains were removed from the permit. Two of the three storm drains (252 and 324) do not exist in the field, and the third storm drain (630) is actually the inlet to storm drain 640. Hence, summary statistics for storm drains 530, 600, 252, and 324 are not included.

The K-25 Site has six Category IV storm drains, all of which require weekly monitoring. Three discharge to Poplar Creek and three discharge to Mitchell Branch. Compliance with the chlorine limitations for these drains became a requirement on October 1, 1993. Chlorine is the primary pollutant in these storm drain discharges because they contain cooling water and sanitary water. Data collected at these storm drains during the first two quarters of 1993 indicated the presence of chlorine in these effluents at levels that would have exceeded their permitted limitations had they been in effect. During 1993, K-25 Site personnel worked to identify and eliminate the sources of chlorine that contributed to these effluents. Figure 4.32 shows how the chlorine levels at two of these storm drains fluctuated prior to elimination of the sources of chlorine and confirms that efforts to eliminate the majority of them were effective. The data for the four remaining Category IV storm drains were also reviewed and found to be similar to those shown in the figure. The only exception is storm drain 170, which had one noncompliance for total residual chlorine during the fourth quarter of 1993. K-25 Site personnel will continue to identify and eliminate sources of chlorine that affect these effluents.

The remaining seven noncompliances occurred at storm drain outfalls. Two resulted from high pH measurements at storm drains 710 and 100. Both of these were attributed to the photosynthetic activity of the algae growing in the storm drains. The by-products of photosynthesis form hydroxide ions, which elevate pH. The other five noncompliances were unpermitted discharges to storm drains or the appearance of visible sheens on receiving waters. These incidents occur for a variety of reasons, such as spills, pipeline breaks, and inappropriate storm drain connections. All NPDES noncompliances were reported under the Occurrence

Reporting System (ORS). Corrective actions to prevent recurrence were documented and tracked under the ORS.

There are 15 cooling towers at the K-25 Site, but only 5 are active. The remaining ten are scheduled for decontamination and decommissioning. Only one of the five active cooling towers discharged blowdown to the storm drainage system (through storm drain 170) during 1993. This discharge was monitored under the requirements of the NPDES permit. Blowdown from cooling towers is no longer being discharged to the storm drainage system.

A Storm Water Pollution Prevention Program (SWPPP) is another requirement of the NPDES permit. The K-25 Site SWPPP was initiated in October 1993 and requires that (1) best management practices be developed and implemented, (2) a sampling program be conducted, (3) semiannual inspections be conducted, and (4) sampling and inspection data be used to further develop best management practices to decrease pollutants reaching storm water runoff. Two of the larger projects that were identified as best management practices under the SWPPP are the site wide radiological survey and the storm drain survey. Both were initiated in 1993. However, these are large projects and may take several years to complete. The sampling program has also been initiated. Sampling data have been obtained on several drains. Upon review of the initial sampling data, site-specific sampling and inspection plans will be developed for the storm drains that exhibit characteristics of contaminated runoff. The site-specific plans will be designed to aid K-25 Site personnel in tracking down the sources of contamination entering the identified storm drains. The semiannual inspection requirement will be fulfilled in March 1994. Information from it will be used in conjunction with the monitoring data to determine the sources of pollutants.

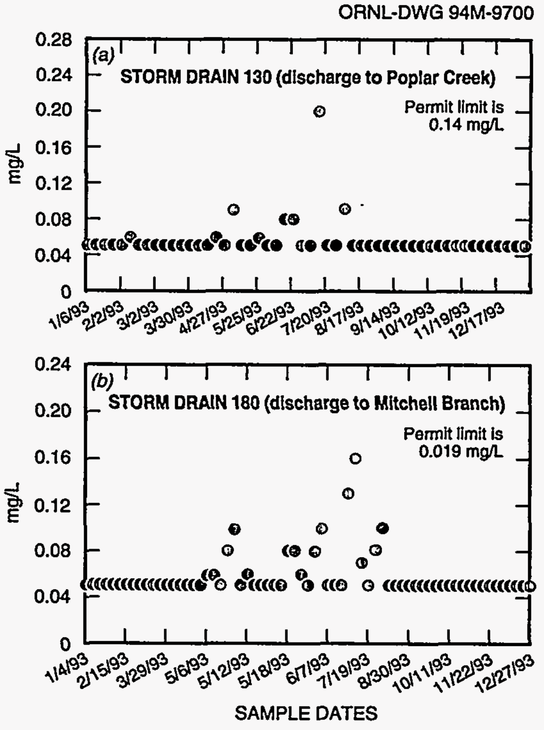

Fig. 4.32. Total residual chlorine results for K-25 Site Category IV storm drains. (*a*) shows storm drain 130, which discharges to Poplar Creek; (*b*) is storm drain 180, which discharges to Mitchell Branch. (Detection limit = 0.05 mg/L. Permit limit became effective 10/1/93.)

Finally, the NPDES permit requires the development and implementation of a TCMP. The permit requires that toxicity testing be performed bimonthly at outfalls 005 and 011 during the first twelve months it is in effect. If any of the toxicity tests are failed at a particular location during this period, the permit requires the location to remain on a bimonthly sampling schedule. However, if a location passes every test during this time, the sampling requirement is reduced to a semiannual frequency for the remainder of the permit. Accordingly, toxicity testing was conducted at outfalls 005 and 011 bimonthly until October 1993. As stated earlier, Outfall 005 failed one toxicity test; it will remain on a bimonthly sampling schedule. Outfall 011 passed every toxicity test; it has been placed on a semiannual testing schedule.

Toxicity Control and Monitoring Program

Y-12 Plant

In accordance with Part III of the NPDES permit issued to the Y-12 Plant, the plant is required to develop and implement a Toxicity Control and Monitoring Program (TCMP). Under the TCMP, various permitted discharges are evaluated for toxicity. Table 4.20 gives results of the toxicity tests from five wastewater treatment facilities (Central Pollution Control Facility, West End Treatment Facility, Steam Plant Wastewater Treatment Facility, Groundwater Treatment Facility, and Building 9204-3 oil/water separator), one cooling tower (Cooling Tower No. 13), one Category IV discharge (the evaporator condensate from the lithium process), and one

Table 4.20. Y-12 Plant Toxicity Control and Monitoring Program (TCMP) summary information, 1993[a]

Outfall	Test date	Species	NOEC (%)	IWC[b] (%)
Lithium evaporator process condensate (Outfall 402)	1/21/93	Fathead minnow	<3	<NOEC
	1/21/93	*Ceriodaphnia*	<3	<NOEC
Steam Plant Wastewater Treatment Facility (Outfall 503)	2/4/93	Fathead minnow	100	13.3
	2/4/93	*Ceriodaphnia*	25	13.3
Oil/Water Separator—9204-3 (Outfall 506)	3/4/93	Fathead minnow	50	0.3
	3/4/93	*Ceriodaphnia*	100	0.3
Central Pollution Control Facility (Outfall 501)	5/13/93	Fathead minnow	100	1.6
	5/13/93	*Ceriodaphnia*	50	1.6
Groundwater Treatment Facility (Outfall 512)	6/10/93	Fathead minnow	<6	2.2
	6/10/93	*Ceriodaphnia*	<6	2.2
Groundwater Treatment Facility (Outfall 512)	6/15/93	Fathead minnow	3	2.2
	6/15/93	*Ceriodaphnia*	1.5	2.2
West End Treatment Facility (Outfall 502)	6/24/93	Fathead minnow	30	0.9
	6/24/93	*Ceriodaphnia*	15	0.9
Proposed Outfall 201	9/9/93	Fathead minnow	100	[c]
	9/9/93	*Ceriodaphnia*	50	[c]
Groundwater Treatment Facility (Outfall 512)	10/14/93	Fathead minnow	3	2.2
	10/14/93	*Ceriodaphnia*	<1	2.2
Cooling Tower No. 13 (Outfall 613)	10/14/93	Fathead minnow	100	2.0
	10/14/93	*Ceriodaphnia*	100	2.0
West End Treatment Facility (Outfall 502)	10/28/93	Fathead minnow	30	0.9
	10/28/93	*Ceriodaphnia*	<10	0.9
Groundwater Treatment Facility (Outfall 512)	11/11/93	Fathead minnow	3	2.2
	11/11/93	*Ceriodaphnia*	3	2.2

[a] These 7-day toxicity tests using fathead minnows and *Ceriodaphnia* were completed in 1993 as part of the TCMP conducted for the Y-12 Plant by Oak Ridge National Laboratory. Summarized are the effluents and their corresponding no-observed-effect concentrations (NOECs) and instream waste concentrations (IWCs). *Note:* Discharge from the treatment facilities is intermittent because of batch operations.

[b] The instream waste concentration (IWC) is based on 3.9 cfs at East Fork Poplar Creek, Station 8 (based on U.S. Geological Study data taken during drought conditions).

[c] This is an instream point; therefore, an IWC is not applicable.

proposed permitted outfall (Outfall 201). For each wastewater, the table shows the date the test was initiated, the no-observed-effect concentration (NOEC) for fathead minnows and *Ceriodaphnia*, and the calculated instream waste concentration (IWC). The formula used to calculate IWC, which is expressed as a percentage, is (flow at facility/flow at Station 8) × 100.

Effluent from the Groundwater Treatment Facility was tested four times in 1993. The effluent's NOECs were 3% and <6% for fathead minnows and ranged from <1% to <6% for *Ceriodaphnia*. The IWC was calculated to be 2.2%.

Effluent from the West End Treatment Facility was tested twice (June and October). The effluent's NOECs were 30% for fathead minnows and <10% and 15% for *Ceriodaphnia*. The calculated instream waste concentration was 0.9%; therefore, it is unlikely that treated effluent from the West End Treatment Facility would adversely affect the aquatic biota in East Fork Poplar Creek.

The treated effluent from the Central Pollution Control Facility had a NOEC of 100% for fathead minnows and 50% for *Ceriodaphnia*. The calculated IWC of Central Pollution Control Facility effluent in East Fork Poplar

Creek was 1.6%. Because the instream waste concentration is less than the NOEC, it is unlikely that treated effluent from that facility would adversely affect the aquatic biota in East Fork Poplar Creek.

Effluent from the Building 9204-3 oil/water separator was not toxic to *Ceriodaphnia* (NOEC = 100%). The NOEC for fathead minnows was 50%, and the calculated IWC was 0.3%. This discharge is now collected for treatment, thus eliminating the need for further toxicity testing for this outfall.

The NOECs for effluent from the Steam Plant Wastewater Treatment Facility were 100% for fathead minnows and 25% for *Ceriodaphnia.* Because the NOECs for both fathead minnows and *Ceriodaphnia* are greater than the calculated IWC of this discharge (13.3%), it is unlikely that the discharge from the Steam Plant Wastewater Treatment Facility would adversely affect the aquatic biota in East Fork Poplar Creek.

The NOECs for the lithium evaporator process condensate for both fathead minnows and *Ceriodaphnia* were greater than the calculated IWC of this discharge; therefore, it is unlikely that this discharge would adversely affect the aquatic biota in East Fork Poplar Creek.

The proposed permitted outfall (Outfall 201) was tested once (September). Water from this site was not toxic to fathead minnows (NOEC = 100%); however, *Ceriodaphnia* reproduction was reduced in full-strength concentration (NOEC = 50%).

Oak Ridge National Laboratory

Under the TCMP, wastewaters from the Sewage Treatment Plant, the Coal Yard Runoff Treatment Facility, and the Nonradiological Wastewater Treatment Facility were evaluated for toxicity. In addition, two ambient instream 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 4.21. 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 instream waste concentration, if appropriate. The NOEC is the concentration that did not 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 4.22.

During 1993, the Coal Yard Runoff Treatment Facility was tested four times; the Sewage Treatment Plant and the Nonradiological Wastewater Treatment Facility were tested twice each. The Coal Yard Runoff Treatment Facility wastewater's NOECs were 100% for fathead minnows and 12% and 25% for *Ceriodaphnia.* The wastewater's instream waste concentration ranged from 0.4% to 3.1% (based on critical low flow of White Oak Creek). Because the IWC was consistently lower than the NOEC, it is unlikely that wastewater from the Coal Yard Runoff Treatment Facility adversely affected the aquatic biota of White Oak Creek during 1993. The Sewage Treatment Plant wastewater's NOEC for *Ceriodaphnia* was 25% in April and October. Per guidelines in the NPDES permit, no fathead minnow tests were conducted for the Sewage Treatment Plant. Because the IWC of the Sewage Treatment Plant was lower than the NOEC for both tests conducted in 1993, it is unlikely that the wastewater from the plant adversely affected the aquatic biota of White Oak Creek. Full-strength wastewater from the Nonradiological Wastewater Treatment Facility was not toxic to *Ceriodaphnia* during the June and October tests; therefore, no IWC was calculated on this facility for 1993. Fathead minnow testing for this facility was discontinued as allowed in the NPDES permit guidelines.

During 1993, the Melton Branch (X13) site was tested nine times and the White Oak Creek (X14) site was tested eight times. Water from X13 reduced fathead minnow survival on two occasions (April and August) and *Ceriodaphnia* reproduction on one occasion (December). Confirmatory tests conducted in May, August, and December showed the water to be nontoxic; thus, the toxicity was transient. Water from X14 was not toxic to *Ceriodaphnia* in 1993; however, fathead minnow survival was lower than the control (NOEC < 100) in the June test. A confirmatory test conducted in June again resulted in reduced fathead minnow survival. A second confirmatory test, also conducted in June, showed the water to be nontoxic; thus, the toxicity appeared to be transient.

To evaluate 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 light for a 20-min period. In August, fathead minnow survival was reduced in the full-strength nontreated and ultraviolet-light-treated water from X13

Table 4.21. Toxicity test results of ORNL wastewaters and ambient waters, 1993

Outfall	Test date	Treatment[a]	NOEC[b] (%) Fathead minnow	NOEC[b] (%) *Ceriodaphnia*	IWC[c] (%)
Coal Yard Runoff Treatment Facility (X02)	May	N	100	*d*	2.4
	May	N	*d*	12	0.5
	Nov.	N	100	25	0.4
	Dec.	N	100	*d*	3.1
Sewage Treatment Plant (X01)	Apr.	N	*d*	25	17.8
	Oct.	N	*d*	25	18.0
Nonradiological Wastewater Treatment Plant (X12)	June	N	*d*	100	*e*
	Oct.	N	*d*	100	*e*
Melton Branch (X13)	Feb.	N	80	100	
		UV	100	*d*	
	Apr.	N	<80	100	
		UV	100	*d*	
	May[f]	N	100	*d*	
		UV	100	*d*	
	June	N	100	100	
		UV	100	*d*	
	Aug.	N	<80	100	
		UV	<100	*d*	
	Aug.[f]	N	100	*d*	
		UV	100	*d*	
	Sept.	N	100	100	
		UV	100	*d*	
	Dec.	N	100	80	
		UV	100	*d*	
	Dec.[f]	N	*d*	100	
White Oak Creek (X14)	Feb.	N	100	100	
		UV	100	*d*	
	Apr.	N	100	100	
		UV	100	*d*	
	June	N	80	100	
		UV	100	*d*	
	June[f]	N	80	*d*	
		UV	100	*d*	
	June[f]	N	100	*d*	
		UV	100	*d*	
	Aug.	N	100	100	
		UV	100	*d*	
	Sept.	N	100	100	
		UV	100	*d*	
	Dec.	N	100	100	
		UV	100	*d*	

[a] N = no sample pretreatment; UV = ultraviolet light pretreatment.

[b] No-observed-effect concentration.

[c] Instream waste concentration (based on critical low flow of White Oak Creek).

[d] Not tested.

[e] Not calculated.

[f] Confirmatory test.

Table 4.22. Average water quality parameters measured during toxicity tests of ORNL wastewaters and ambient waters, 1993

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

Outfall	Test date	pH (standard units)	Conductivity (µS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
Coal Yard Runoff Treatment Facility (X02)	May[a]	7.45	1567	16	880
	May[b]	7.48	1737	20	1128
	Nov.	7.44	2400	27	1600
	Dec.	7.39	4130	29	2000
Sewage Treatment Plant (X01)	Apr.	8.13	425	112	173
	Oct.	7.83	403	100	171
Nonradiological Wastewater Treatment Facility (X12)	June	8.02	782	88	172
	Oct.	7.78	764	89	172
Melton Branch (X13)	Feb.	7.95	527	109	237
	Apr.	8.04	251	113	144
	May	8.24	389	145	203
	June	8.02	747	102	380
	Aug.[c]	7.95	568	103	292
	Aug.[d]	7.78	793	65	407
	Sept.	8.00	390	134	190
	Dec.[e]	7.99	278	92	130
	Dec.[f]	7.96	357	80	169
White Oak Creek (X14)	Feb.	7.98	380	113	169
	Apr.	8.07	291	112	147
	June[g]	8.14	372	118	171
	June[h]	8.07	392	113	175
	June[i]	8.11	343	113	154
	Aug.	8.04	358	113	156
	Sept.	8.07	373	119	164
	Dec.	8.08	361	112	155

[a] Data for test conducted May 6–13, 1993.
[b] Data for test conducted May 19–26, 1993.
[c] Data for test conducted August 12–19, 1993.
[d] Data for test conducted August 27–September 3, 1993.
[e] Data for test conducted December 9–16, 1993.
[f] Data for test conducted December 30–January 6, 1994.
[g] Data for test conducted June 3–10, 1993.
[h] Data for test conducted June 10–17, 1993.
[i] Data for test conducted June 30–July 7, 1993.

(NOEC was <80 and <100, respectively). Although the ultraviolet light treatment did not improve survival, results of the *Ceriodaphnia* test and the fathead minnow growth test provided evidence that the samples were not toxic. Tests of water from sites X13 and X14 showed improved fathead minnow survival or growth in water treated with ultraviolet light.

K-25 Site

In accordance with Part III of the NPDES permit issued to the K-25 Site, the site was required to develop and implement a TCMP. The permit required that toxicity tests be conducted once every 2 months. The program requires reporting data in the form of NOELs and lethal concentrations for 50% of the test organisms (LC$_{50}$s).

The results of the toxicity tests of wastewaters from K-1407-J and K-1203 are given in Table 4.23. This table provides, for each wastewater, the month the test was conducted and the wastewater's NOEL and 96-hour LC_{50} for fathead minnows and *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 4.24.

Table 4.23. Toxicity test results of K-25 Site wastewaters, 1993

Outfall	Test date	Species	NOEL[a] (%)	LC_{50}[b] (%)
K-1407-J (Outfall 011)	January	Fathead minnows	75	>75
		Ceriodaphnia	25	>75
	March[c]	Fathead minnows	25	>75
	April	*Ceriodaphnia*	75	>75
	May	Fathead minnows	75	>75
		Ceriodaphnia	75	>75
	July	Fathead minnows	7.05	>7.05
		Ceriodaphnia	25	>25
	September	Fathead minnows	75	>75
		Ceriodaphnia	25	>75
	November	Fathead minnows	75	>75
		Ceriodaphnia	75	>75
K-1203 (Outfall 005)	January	Fathead minnows	100	>100
		Ceriodaphnia	100	>100
	March[c]	Fathead minnows	100	>100
	April	*Ceriodaphnia*	100	>100
	May	Fathead minnows	100	>100
		Ceriodaphnia	100	>100
	July	Fathead minnows	14.6	>14.6
		Ceriodaphnia	<4.2	>30
	August[d]	*Ceriodaphnia*	30	>100
	September	Fathead minnows	100	>100
		Ceriodaphnia	30	>100
	November	Fathead minnows	100	>100
		Ceriodaphnia	14.6	>100

[a] No-observed-effect limit.

[b] 96-hour lethal concentration for 50% of the test organisms.

[c] Individual *Ceriodaphnia* test (unacceptable control survival); a retest was conducted in April 1993.

[d] Confirmatory test.

Effluent from K-1407-J (Outfall 011) was tested six times with fathead minnows and *Ceriodaphnia*. The effluent's NOELs were 7.05%, 25%, and 75% for fathead minnows and 25% and 75% for *Ceriodaphnia*. The LC_{50}s were >7.05% and >75% for fathead minnows and >25% and >75% for *Ceriodaphnia*. All the toxicity tests conducted for this outfall were within the limits specified by the NPDES permit.

Effluent from K-1203 (Outfall 005) was tested six times with fathead minnows and seven times with *Ceriodaphnia*. The effluent's NOELs were 14.6% and 100% for fathead minnows and <4.2%, 14.6%, 30%, and 100% for *Ceriodaphnia*. The LC_{50}s were >14.6% and 100% for fathead minnows and >30% and >100% for *Ceriodaphnia*. The test conducted in July resulted in a failure based on *Ceriodaphnia* reproduction, and a confirmatory test conducted in August showed the effluent to be nontoxic. With the exception of the July *Ceriodaphnia* test, all tests conducted for this outfall were within the limits specified by the NPDES permit.

Table 4.24. Average water quality parameters measured during toxicity tests of K-25 Site wastewaters, 1993

Outfall	Test date	pH (standard units)	Conductivity (μS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1407-J (Outfall 011)	January	7.80	2831	52	594
	March	7.69	1831	74	363
	April	7.73	1484	41	568
	May	7.76	1899	41	511
	July[a]	7.92	3007	80	438
	July[b]	7.57	4044	41	455
	September	7.65	1808	54	639
	November	7.63	1615	64	680
K-1203 (Outfall 005)	January	7.97	390	101	149
	March	8.09	380	101	172
	April	8.02	390	96	158
	May	7.93	402	85	147
	July[a]	7.71	400	86	155
	July[b]	7.88	414	90	154
	August	7.83	389	81	143
	September	7.90	391	92	147
	November	7.89	435	107	151

[a] Data are for test conducted July 8–15, 1993.

[b] Data are for test conducted July 29–August 5, 1993.

Biological Monitoring and Abatement Program

Monitoring Contaminant Concentrations

The Biological Monitoring and Abatement programs (BMAPs) mandated by NPDES permits at the Y-12 Plant, ORNL, and the K-25 Site each contain tasks concerned with monitoring the accumulation of contaminants in the biota of receiving waters. The primary objectives of the contaminant-accumulation studies are (1) to identify substances that accumulate to undesirable levels in biota as a result of discharges from DOE facilities, (2) to determine the significance of those discharges relative to other sources in determining contaminant concentrations in biota in receiving waters, and (3) to provide a baseline measure of biotic contamination to use in evaluating the effectiveness of any future remedial measures.

The nonradiological contaminants of most concern in biota are mercury and PCBs. Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are associated with discharges at all three facilities. Since 1985, concentrations of these substances in sunfish have been monitored at sites in East Fork Poplar Creek downstream of the Y-12 Plant (Fig. 4.33). In 1992–93, sunfish did not exhibit a decrease in mercury concentration with distance below Lake Reality, a change from the trend observed in previous years. Mean mercury concentrations in sunfish from all sites between Lake Reality at East Fork Poplar Creek kilometer 23.7 (EFK 23.7) and EFK 6.3 were similar; only the site upstream of Lake Reality (EFK 24.8) was substantially different. The twofold to threefold higher concentrations in sunfish above Lake Reality suggests that Y-12 Plant discharges continue to be an important source of mercury in fish in the upper reaches of East Fork Poplar Creek.

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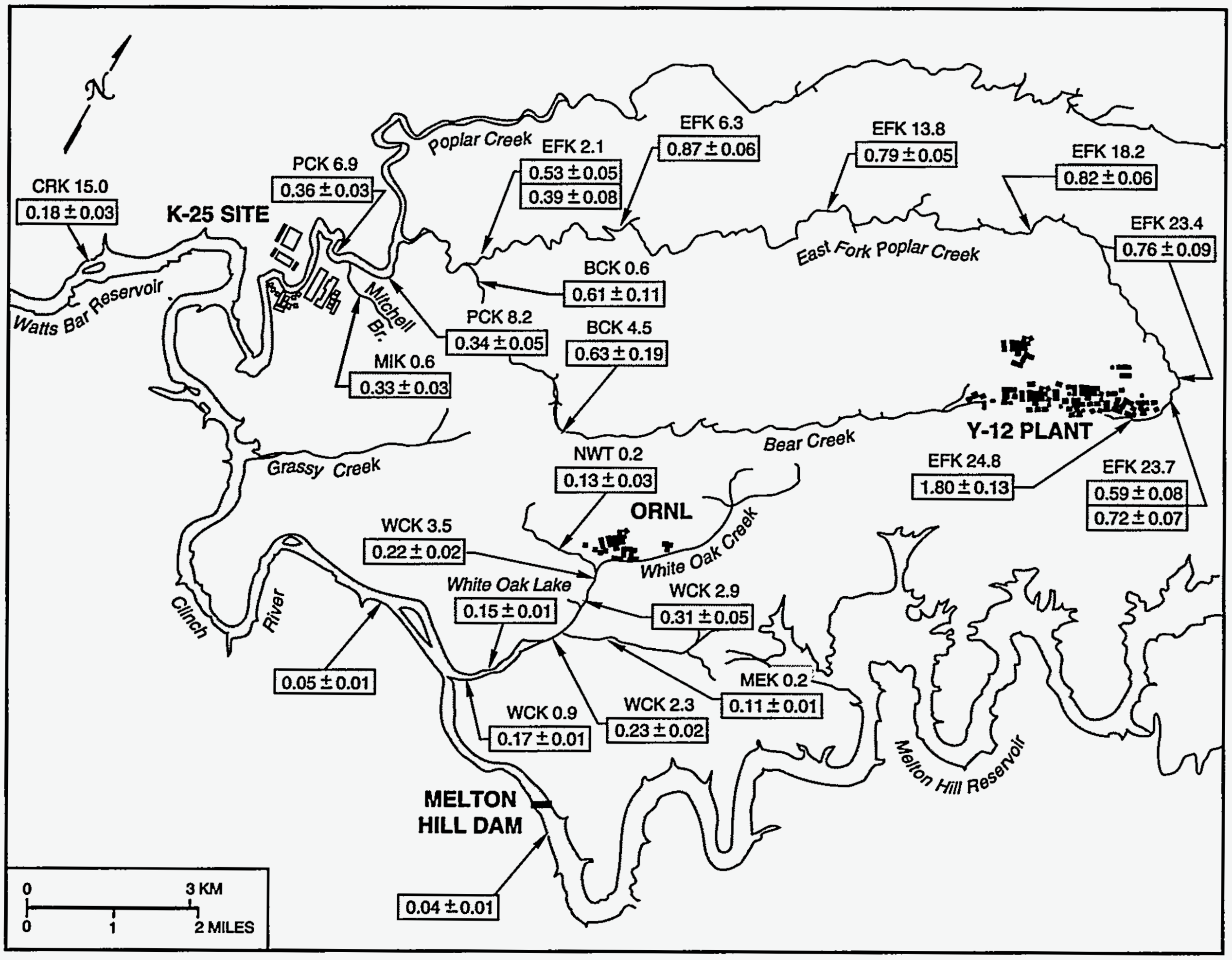

Fig. 4.33. Average concentrations (± standard error) of mercury (in micrograms per gram) in sunfish collected from November 1992–March 1993 at sites on the ORR. Fish are redbreast sunfish (*Lepomis auritus*) at MIK 0.6, EFK sites (bottom values where two appear), and WCK 2.9; rock bass (*Ambloplites repestris*) at BCK sites; and bluegill (*L. macrochirus*) at the remaining sites.

Mean concentrations of mercury at specific sites have not exhibited an increasing or decreasing trend relative to concentrations observed in the mid-1980s except at EFK 23.4, the site nearest the Y-12 Plant (Fig. 4.34). Lower mercury concentrations were observed in redbreast sunfish (*Lepomis auritus*) at EFK 23.4 in 1990–93 than were typical of the 1986–89 period. Mercury concentrations were consistently lower in fish at EFK 23.4 than in fish from the next site downstream. It is not known whether the decrease in mean mercury concentrations at EFK 23.4 is a consequence of reduced mercury discharges via East Fork Poplar Creek, a result of changes in the biological processing of mercury associated with ecological changes (i.e., the construction and colonization of Lake Reality), or a return to "normal" levels of contamination following a period of disturbance related to construction/remediation activities.

A pattern of decreasing concentration with distance downstream is apparent for PCBs in redbreast sunfish in East Fork Poplar Creek (Fig. 4.35). As a result of colonization of Lake Reality and East Fork Poplar Creek upstream of Lake Reality following its construction, it was possible to obtain sunfish from sites upstream of EFK 23.4. Redbreast sunfish from East Fork Poplar Creek above Lake Reality and bluegill from Lake Reality contained PCB concentrations in December 1992 substantially higher than those observed in fish from other East

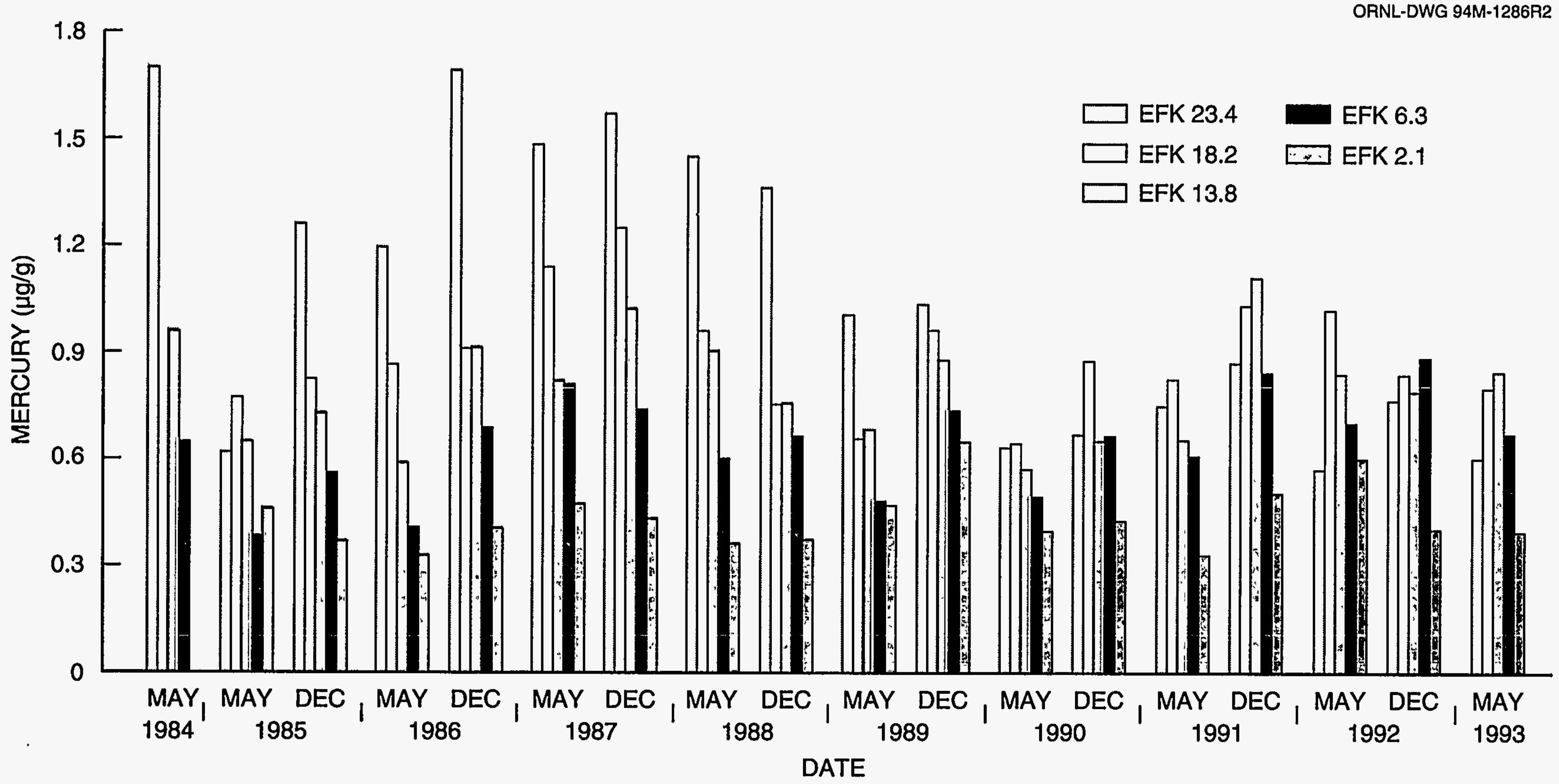

Fig. 4.34. Average concentrations of mercury in redbreast sunfish (*n* = 8) collected at sites in East Fork Poplar Creek, 1984–93. The 1984 data are from the Oak Ridge Task Force study (TVA 1985).

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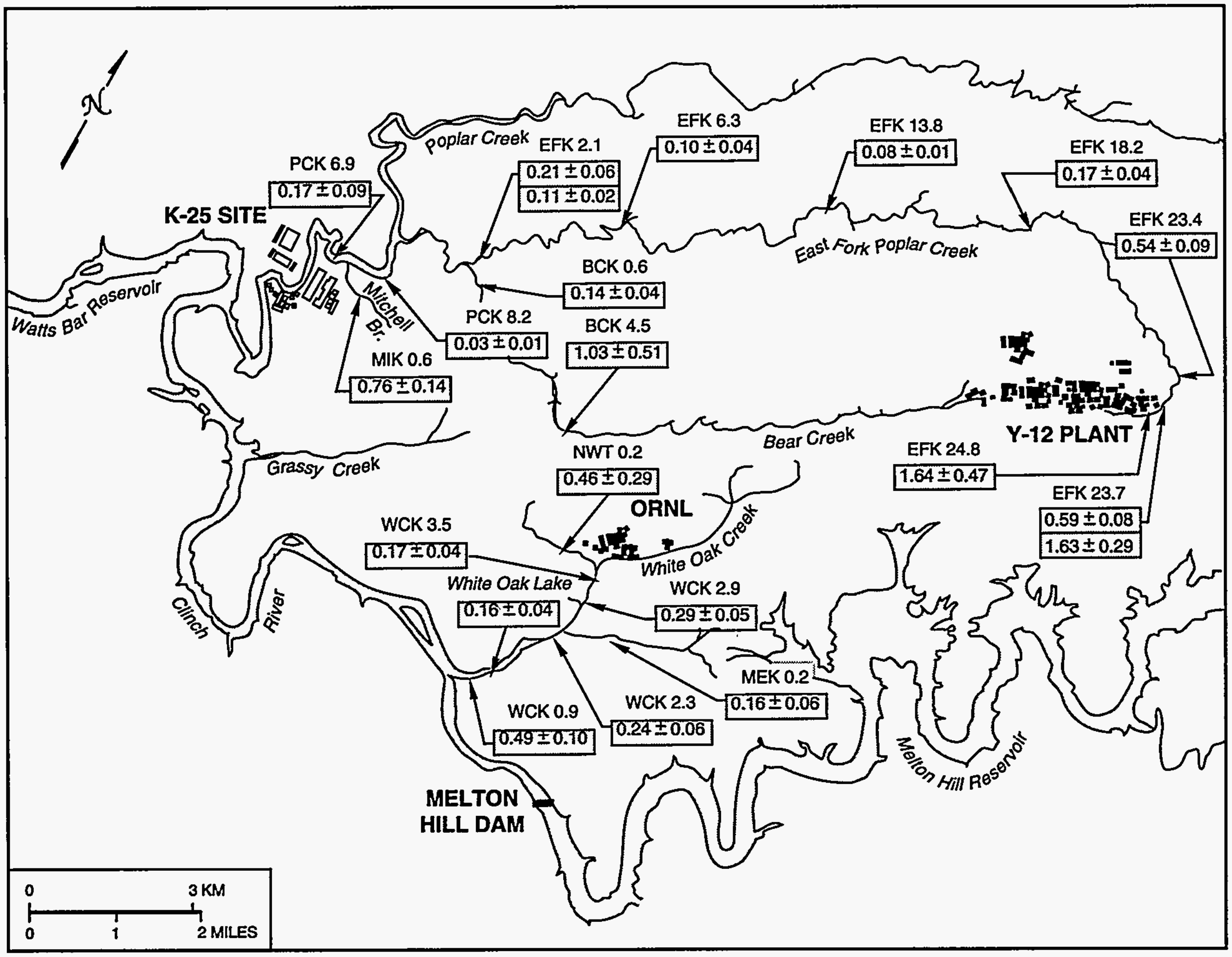

Fig. 4.35. Average concentrations (± standard error) of polychlorinated biphenyls (in micrograms per gram wet weight) in sunfish collected from November 1992 through March 1993 at sites on the ORR. Fish are redbreast sunfish (*Lepomis auritus*) at MIK 0.6, EFK sites (bottom values where two appear), and WCK 2.9; rock bass (*Ambloplites repestris*) at BCK sites; and bluegill (*L. macrochirus*) at the remaining sites.

Fork Poplar Creek sites. The high concentrations in fish at sites in upper East Fork Poplar Creek indicate the importance of the industrialized portion of the Y-12 Plant as a source in relation to contaminated sediment and soil downstream of Lake Reality. PCB concentrations found in East Fork Poplar Creek sunfish in 1992–93 fell within the range observed in previous years (Fig 4.36).

Bluegill (*L. macrochirus*) and other sunfish collected in 1992–93 again showed the presence of multiple sources of mercury and PCB contamination on the ORR. Elevated concentrations of mercury were clearly evident in fish from East Fork Poplar Creek, Poplar Creek, Bear Creek, Mitchell Branch, and White Oak Creek. The highest mean concentrations continued to be in fish from East Fork Poplar Creek and Bear Creek. Overall, mean mercury concentrations in fish in 1992–93 on the ORR were similar to those observed in 1991.

Mean PCB concentrations in sunfish were elevated in White Oak Creek, East Fork Poplar Creek, Bear Creek, lower Poplar Creek, and Mitchell Branch. The highest PCB concentrations were found in sunfish from Mitchell Branch (MIK 0.6), Bear Creek (BCK 4.5), and upper East Fork Poplar Creek (EFK 24.8 and 23.7). Mean PCB concentrations in sunfish from most White Oak Creek sites have decreased significantly over the 1987–93 period. At the other sites on the ORR, mean PCB concentrations in sunfish in 1992–93 remained similar to concentrations observed in previous years.

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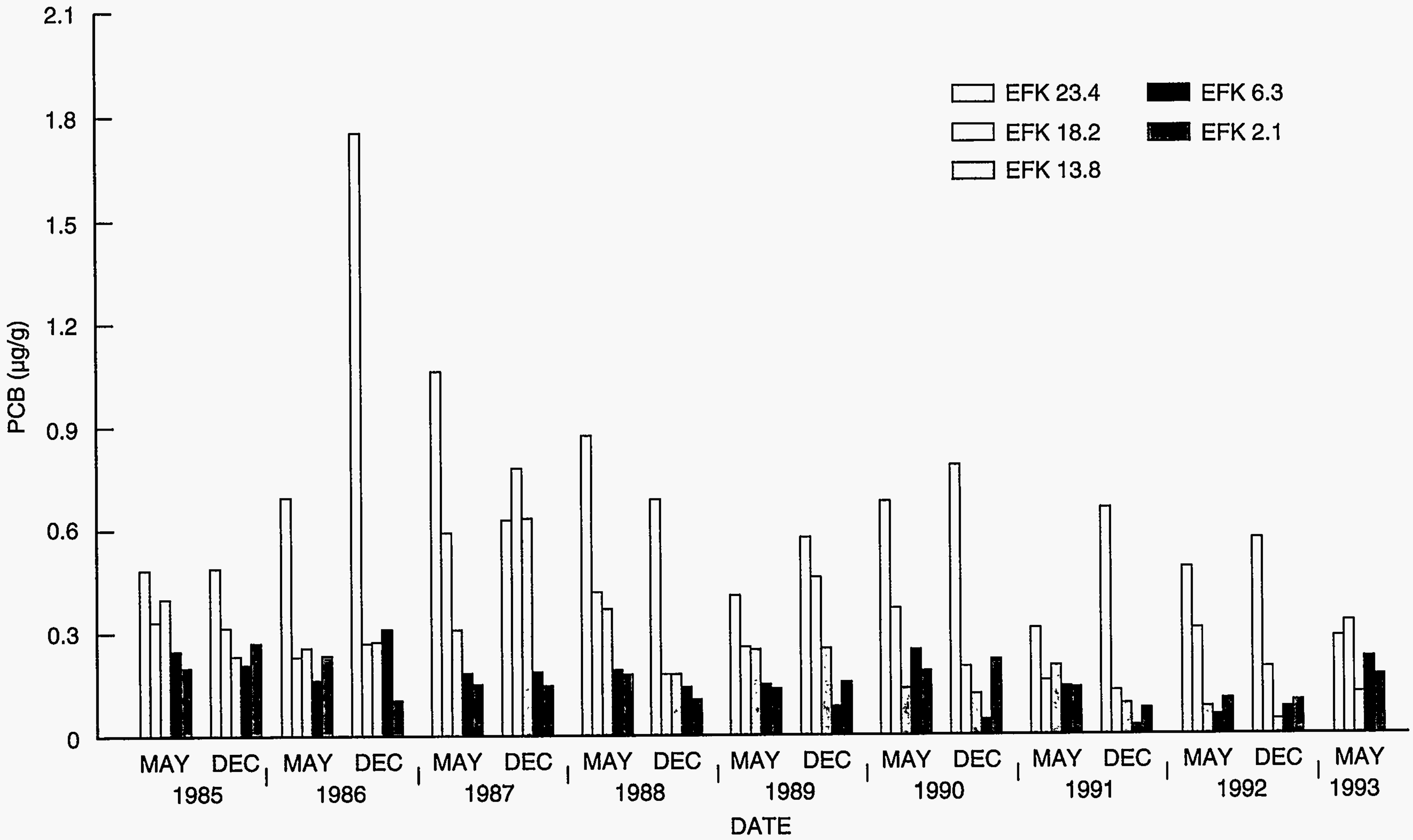


Fig. 4.36. Average concentrations of polychlorinated biphenyls in redbreast sunfish ($n = 8$) collected at sites in East Fork Poplar Creek, 1985–93.

Sunfish serve as good indicators of PCB contamination, particularly in small streams close to specific sources, but they do not accumulate PCBs to the extent that longer-lived, larger, fattier fish such as catfish (*Ictalurus punctatus*) and carp (*Cyprinus carpio*) do. Channel catfish have been found to contain PCBs approaching the U.S. Food and Drug Administration (FDA) limit of 2 µg/g in several reservoirs in East Tennessee, including Watts Bar Reservoir (TVA 1985). As a result of the Oak Ridge Task Force study finding that PCB concentrations exceeded the U.S. Food and Drug Administration (FDA) limit in all channel catfish collected in White Oak Creek Embayment in 1984, annual PCB monitoring of this species was initiated in 1986. Routine collection sites are depicted in Fig. 4.37; sites were selected to provide the ability to distinguish the relative importance of PCB sources in the White Oak Creek and Poplar Creek drainages in contributing to PCB concentrations in Clinch River catfish.

ORNL-DWG 94M-1156

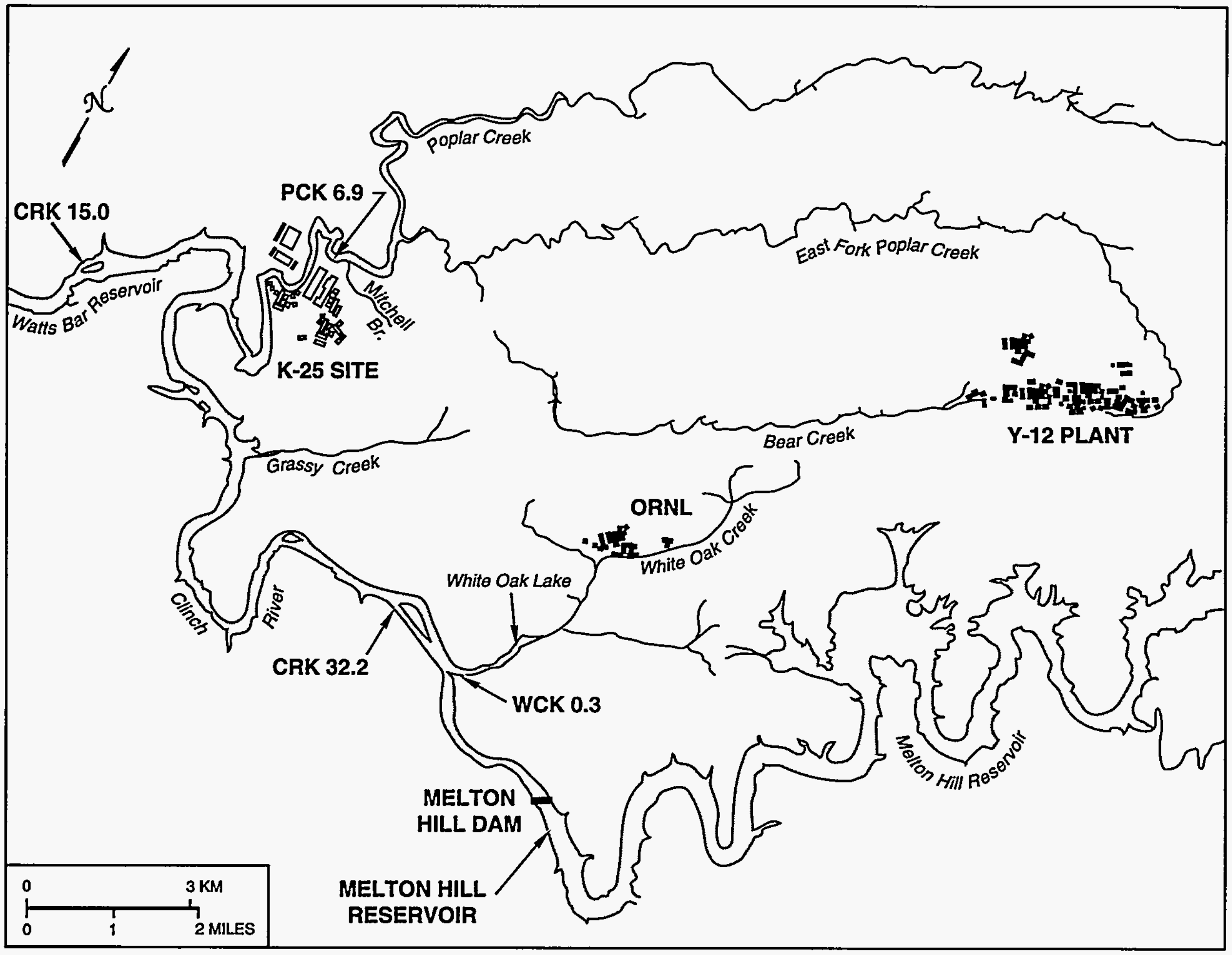


Fig. 4.37. Location of sites on the Oak Ridge Reservation where channel catfish were collected for polychlorinated biphenyls analysis in August and November 1993.

The site-to-site pattern of PCB concentrations in channel catfish in 1993 was similar to the pattern observed previously (Table 4.25). White Oak Creek Embayment continues to yield both the highest mean PCB concentrations (average over all years = 2.6 µg/g) and the largest fraction of catfish exceeding the FDA limit. Mean PCB concentrations have generally remained about 0.9 µg/g at the Clinch River sites and about 0.5 µg/g in Melton Hill Reservoir. With the exception of the mean PCB concentrations in catfish from WCK 0.3, mean PCB concentrations over time at each site yield little indication of a consistent increasing or decreasing trend.

Table 4.25. Changes in average concentrations of PCBs and fraction of fish exceeding U.S. Food and Drug Administration (FDA) limit for channel catfish, 1986–93

Site[a]	1986	1987	1988	1989	1990	1991	1992	1993
			PCBs (μg/g wet weight)					
WCK 0.3	1.30	1.59	0.96	1.54	3.56	3.60	3.29	8.40
CRK 32.2	1.01	1.61	0.58	1.20	0.31	1.38	0.36	0.67
MHR	0.46	0.81	0.52	0.28	0.41	0.29	0.34	0.62
PCK 6.9	*b*	*b*	0.71	1.07	0.92	0.68	0.34	0.92
CRK 15.0	*b*	*b*	0.50	0.79	0.88	1.08	1.27	0.63
			Fraction over FDA limit					
WCK 0.3	3/12	2/8	2/8	4/8	4/8	6/8	5/8	4/4
CRK 32.2	0/8	2/8	1/8	1/8	0/8	1/8	0/8	0/8
MHR	0/6	1/7	0/10	0/8	0/8	0/8	0/8	0/8
PCK 6.9	*b*	*b*	0/8	1/8	1/8	0/8	0/8	0/8
CRK 15.0	*b*	*b*	0/9	1/8	1/8	1/8	2/8	0/8

[a] WCK = White Oak Creek Embayment kilometer, CRK = Clinch River kilometer, MHR = Melton Hill Reservoir, and PCK = Poplar Creek kilometer.

[b] Not sampled.

Channel catfish from WCK 0.3 contained substantially higher PCB concentrations than those in catfish collected from this site in previous years. Only four individuals were obtained from WCK 0.3 in 1993, probably as a result of the construction of a sediment retention structure in 1991 that has prevented catfish movement into or out of the watershed. The higher PCB concentrations may be a result of capturing fish that have been exposed to White Oak Creek PCBs for a longer time than fish collected previously. With construction of the retention structure in 1991, the likelihood of anglers fishing near the mouth of White Oak Creek and catching a catfish that has accumulated high concentrations of PCBs in White Oak Creek Embayment and then moved back to the river has substantially decreased. Continued monitoring of channel catfish will help to evaluate the long-term effect of the sediment retention structure on PCB contamination in Clinch River biota.

Use of Asiatic Clams To Detect Temporal Changes in Organic Contamination Near DOE Oak Ridge Facilities

From 1985 to 1993, organic contaminant concentrations in stream biota were monitored near DOE Oak Ridge facilities. One of the primary objectives of the monitoring effort was to detect spatial and temporal changes in biotic contamination to evaluate the effectiveness of pollution abatement activities. Asiatic clams (*Corbicula fluminea*) were the bioindicator of choice for monitoring most organic contaminants, because clams can accumulate organic pollutants that are rapidly metabolized by fish. Asiatic clams taken from an uncontaminated reference stream were placed annually in cages for 4-week exposures in the receiving streams. Clam monitoring successfully detected a localized source of chlordane contamination, and annual follow-up monitoring tracked a steady decrease in the level of contamination. The use of clams to resolve spatial differences in PCB contamination was found to be limited in the presence of sublethal concentrations of residual chlorine; therefore, the use of resident fish was preferred for monitoring PCBs under those exposure conditions. Annual monitoring of resident sunfish from White Oak Creek, a stream receiving discharges from ORNL, showed a significant decrease in PCB concentration over a 5-year period at all five sites monitored. Overall, the long-term, concurrent monitoring of resident fish and transplanted Asiatic clams was effective in identifying and evaluating changes in organic contaminant bioaccumulation downstream of the DOE facilities.

Effects of Chlorine on Mortality Rates of the Central Stoneroller and Striped Shiner

A chronic fish kill in upper East Fork Poplar Creek at the Y-12 Plant was monitored from 1990 through 1993. Numerous studies, including both laboratory and field experiments, indicated that residual chlorine may contribute to the observed fish mortality. Daily surveys revealed that 60 to 80% of the dead fish were central stonerollers (*Campostoma anomalum*), but biannual quantitative sampling of fish populations since 1990 showed that striped shiners (*Luxilus chrysocephalus*) occurred in densities up to three times greater than the densities of the central stoneroller. To test the hypothesis that central stonerollers may be more sensitive to chlorine than are striped shiners, flow-through toxicity tests were performed with chlorinated tap water at concentrations observed in the stream (0.77, 0.39, and 0.19 mg of total residual chlorine per liter). Dechlorinated tap water was used as a control. The measured end point was "time-to-death," the length of time that elapsed between initial contact with the chlorine and death. Although mean time-to-death was not significantly different between the two species at either of the two highest concentrations tested (mean time-to-death was 160 and 154 min for central stonerollers and striped shiners, respectively, at 0.77 mg/L and was 311 and 319 min for the two species, respectively, at 0.39 mg/L), striped shiners died faster than central stonerollers at 0.19 mg/L (1403 vs 929 min for stonerollers and shiners, respectively). These results suggest that some factor other than chlorine alone (e.g., fish behavior or another toxicant) caused the greater mortality of central stonerollers in the stream. Systems to dechlorinate the stream and several outfalls were installed in November and December 1992, resulting in a significant improvement in the ecological health of the stream.

Reduction of Genotoxic Stress in Sunfish from East Fork Poplar Creek

The structural integrity of deoxyribonucleic acid (DNA) has been proposed as a biological parameter for detecting environmental genotoxicity on the basis that carcinogenic or mutagenic chemicals will cause deleterious modifications to DNA in living organisms. Consequently, the measurement of strand breaks in the DNA of redbreast sunfish was included as a component in the Y-12 Plant BMAP for East Fork Poplar Creek. The integrity of DNA in fish collected just below New Hope Pond in 1987 and 1988 was low (i.e., high number of strand breaks) but increased in 1989 through 1991 when values were similar to those observed in redbreast sunfish from Hinds Creek, a minimally affected, off-site reference stream. This decrease in the number of DNA strand breaks in East Fork Poplar Creek was associated with the closure of New Hope Pond, which was initiated in November 1988. Correlation, however, does not imply causality, and other remedial actions at the Y-12 Plant during this period may have been responsible for the observed reduction in genotoxic stress.

Ecological Recovery of McCoy Branch

Beginning in 1955, a coal ash slurry from the Y-12 Steam Plant was pumped and discharged to an impoundment on McCoy Branch, a small headwater stream on the south slope of Chestnut Ridge. When the pond filled in 1965, the slurry was discharged to Rogers Quarry via McCoy Branch for the next 25 years. As part of the Resource Conservation and Recovery Act Facility Investigation for the filled coal ash pond, a biological monitoring program was implemented in January 1989 to characterize the ecological impacts on McCoy Branch and to monitor the effectiveness of remedial actions. Results obtained from the quantitative sampling of benthic invertebrates showed that a substantial improvement had occurred during 1989, the first year of monitoring (Fig. 4.38). The assessment is based on the number of species (or taxa) comprising three groups of aquatic insects that are relatively intolerant of pollution. No fish were collected from McCoy Branch between the filled coal ash pond and Rogers Quarry, which is currently a barrier to fish movement and prevents recolonization of this reach of stream. A study was initiated in 1993 to evaluate reintroduction of the banded sculpin (*Cottus carolinae*), a common inhabitant of spring-fed, headwater streams on the ORR. The ecological recovery of McCoy Branch was associated with several significant remedial actions that occurred in 1988–90, including (1) conversion from coal to natural gas in several boilers at the Y-12 Steam Plant, (2) cessation of fly ash disposal in Rogers Quarry, and (3) completion of a pipeline that eliminated the use of McCoy Branch to transport the ash slurry to the quarry. These actions resulted in a significant decrease in arsenic to levels after 1989 that are well below the EPA water quality criterion for protection of aquatic life (Fig. 4.39).

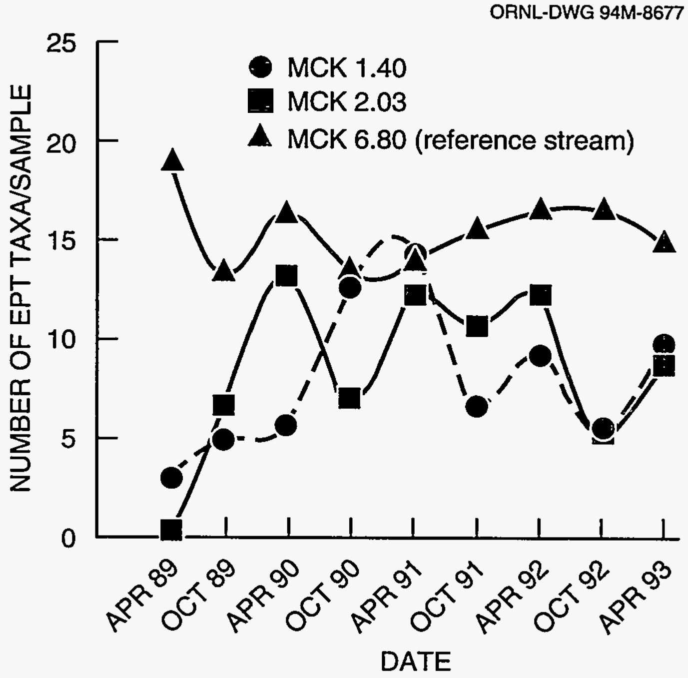
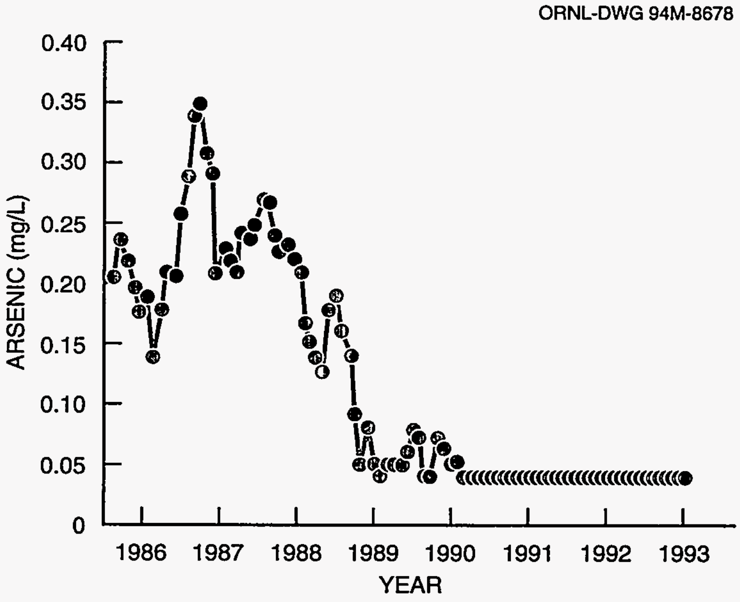


Fig. 4.38. Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa in upper McCoy Branch above and below Rogers Quarry, 1989–93. MCK = McCoy Branch kilometer, which indicates the distance above the confluence with the Clinch River (MCK 2.03 and MCK 1.40 are located above and below Rogers Quarry, respectively). WCK 6.80 is located on White Oak Creek north of Bethel Valley Road and about 6 km west of McCoy Branch.

Fig. 4.39. Average monthly arsenic concentrations in the outfall of Rogers Quarry, January 1986–July 1993. The EPA national ambient water quality criterion for protection of freshwater aquatic life from chronic exposure of arsenic is 0.19 mg/L.



5. Environmental Surveillance

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Abstract

Annual environmental surveillance is a major activity on the Oak Ridge Reservation. 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 during 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.

METEOROLOGICAL MONITORING

Seven meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on the Oak Ridge Reservation (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.

Description

The seven meteorological towers, depicted in Fig. 5.1, consist of one 330-ft tower (MT5) and one 200-ft 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 K-25 Site.

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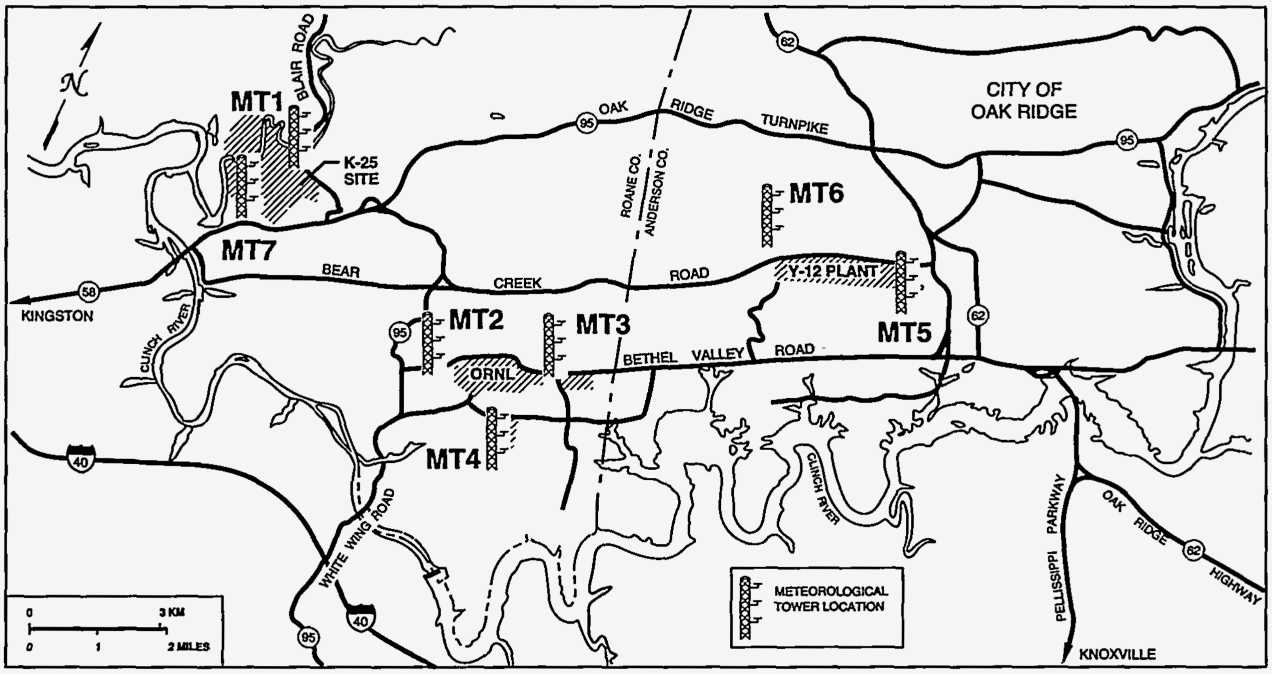

Fig. 5.1. The ORR meteorological monitoring network.

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 at each tower, temperature, wind speed, and wind direction are measured. Humidity and 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 K-25 Site 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 at that site. The towers are polled and the data are filed on disk. Fifteen-minute and hourly values are stored at each site for a running 24-hour period, but only hourly data are routinely stored beyond 24 hours. The meteorological monitoring data from all towers are checked quarterly, and summaries of data are depicted as wind roses such as that shown in Fig. 5.2. 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 (i.e., either hourly values or summary tables of atmospheric conditions). Data quality is checked using predetermined values, and out-of-range parameters are marked invalid (i.e., not input to the dispersion models).

Results

The data presented in Fig. 5.2 are from the top level of the 330-ft tower at the east end of the Y-12 Plant (MT5) and are given as an example of how such data can be used in describing meteorological conditions on the ORR.

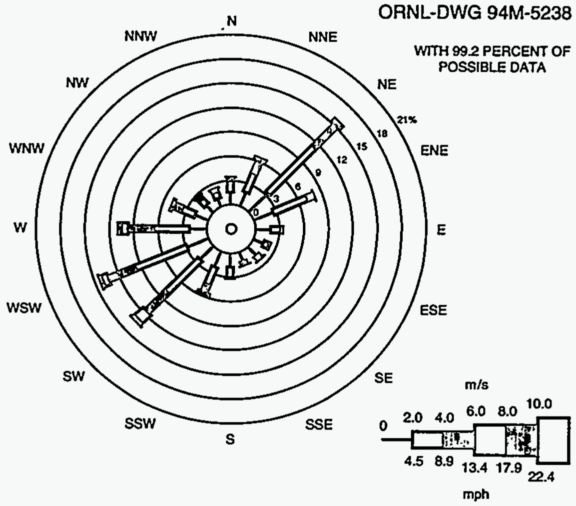

Fig. 5.2. Wind rose produced from data from the eastern meteorological tower (MT5) at the Y-12 Plant.

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 K-25 Site, 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 with 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 capture efficiency (a measure of acceptable data) across all locations and at the 16 tower levels was 95.6% for 1993. The maximum capture efficiency was 99.3%, and the minimum capture efficiency was 85.6%.

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.

Sample Collection and Analytical Procedures

External gamma measurements are recorded weekly at six ambient air stations (Fig. 5.3). In addition, measurements are collected at the American Museum of Science and Energy (Station 41).

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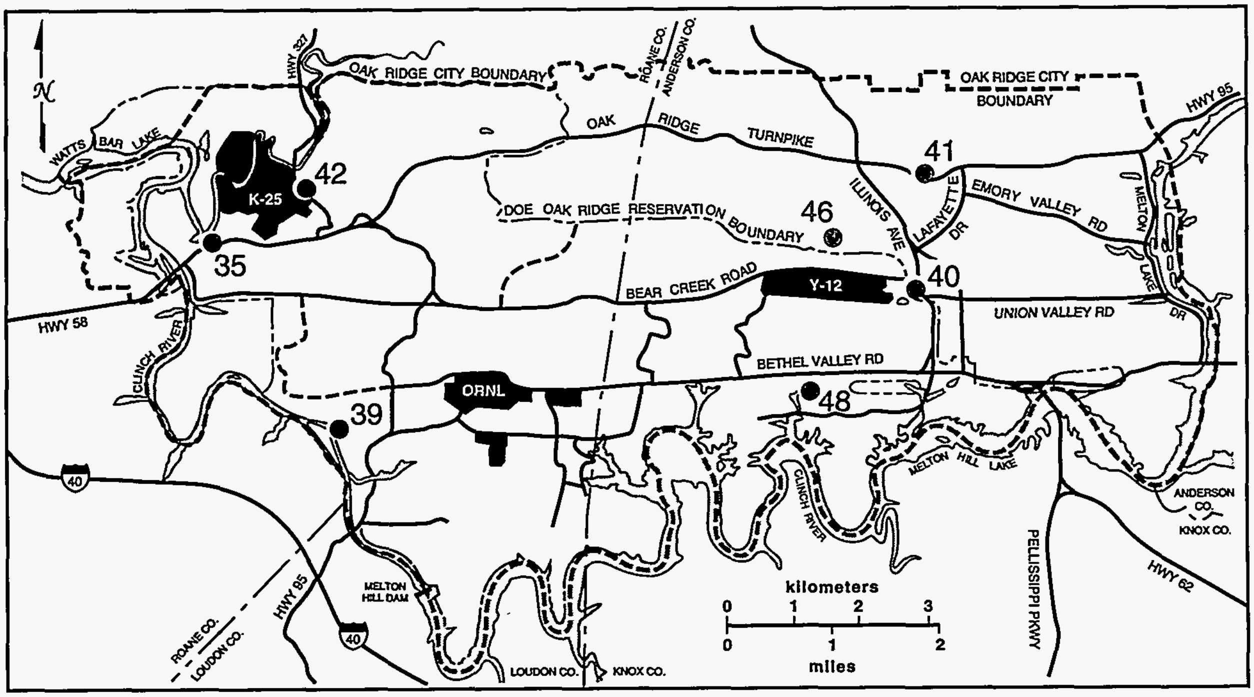

Fig. 5.3. External gamma radiation monitoring locations on the ORR.

Results

Table 5.1 presents the following data for individual stations: number of measurements, maximum value, minimum value, average value, and standard error of the mean. The average value was 7.5 µR/hour. Typical values for cities in the contiguous United States are usually between 5 and 20 µR/hour. The median value for cities in the United States during 1989 (the most recent EPA data published) was 9.3 µR/hour. Any contribution to the external gamma signature by the DOE facilities is not distinguishable at these ORR PAM locations.

AMBIENT AIR MONITORING

In addition to stack monitoring and sampling conducted at the DOE Oak Ridge installations, ambient air monitoring has been developed 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 K-25 Site.

ORR Ambient Air Monitoring

The objectives of the ORR ambient air monitoring program are (1) to maintain surveillance of airborne radionuclides at the reservation perimeter and (2) to collect reference data from remote locations. The ORR PAM

Table 5.1. External gamma radiation measurements at ORR perimeter air monitoring stations, 1993

Station No.	No. of measurements	Exposure rate (μR/hr)			
		Max	Min	Av	Standard error[a]
35	32	11.9	0.4	7.4	0.3
39	44	12.6	7.0	9.9	0.2
40	44	9.4	4.1	7.6	0.1
41	50	11.0	0.5	4.6	0.2
42	48	21.8	1.0	7.4	0.4
46	52	13.5	2.9	8.5	0.2
48	50	11.0	3.4	7.0	0.2
Average	46	13.0	2.8	7.5	0.2

[a] Standard error of the mean.

network associated with objective 1 includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 5.4); the remote air monitoring (RAM) network (objective 2) consists of stations 51 (Norris Dam) and 52 (Fort Loudoun Dam). Sampling is conducted at each ORR station to quantify levels of alpha- and gamma-emitting radionuclides, tritium, beryllium, and total radioactive strontium. All ambient air monitoring stations were converted from low- to high-volume samplers in the second quarter of CY 1993 (Table 5.2).

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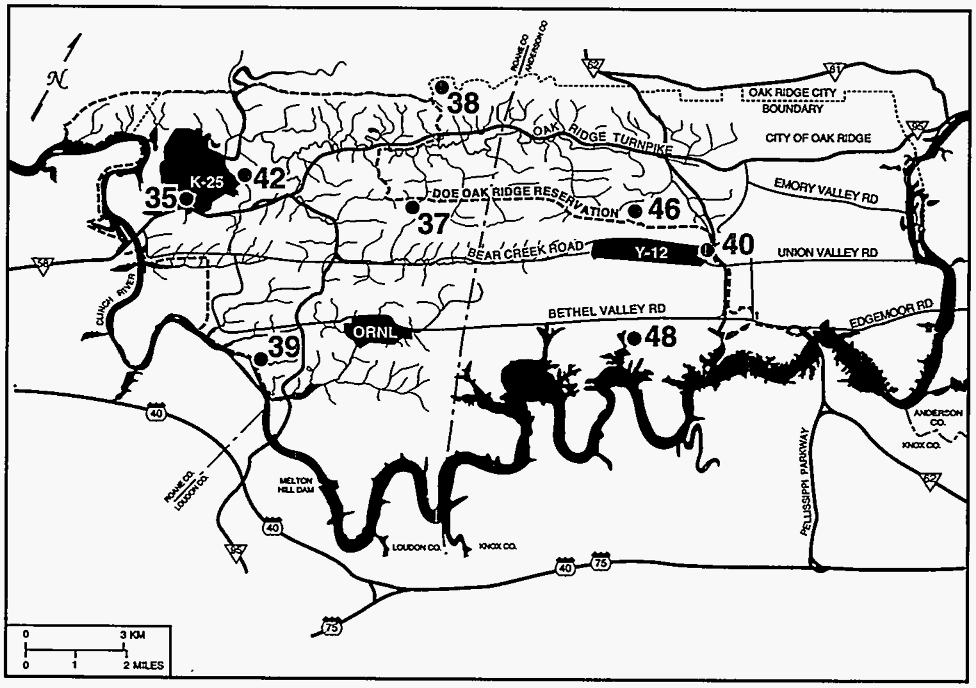

Fig. 5.4. Location of ORR perimeter air monitoring stations. Not shown are the remote air monitoring stations at Norris Dam (26 miles northeast of ORNL, Station 51) and Fort Loudoun Dam (10 miles southeast of ORNL, Station 52). The ORR stations also serve as soil sampling locations.

The ORR PAM stations assess the impact on 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 DCG percentages for the ORR PAM stations' sampling data (Table 5.3) with the RAM stations' sampling data shows that ORR operations do not significantly affect local air quality. Compared with 1992 data, average values have changed for a number of radionuclides: these changes could be because of actual emissions or because of improved sampling instrumentation. There are no significant changes when concentration values are compared with DCG percentages.

Table 5.2. Summary of collection and analysis frequencies for continuous high- and low-volume samples at ORR ambient air monitoring stations

Parameter[a]	Collection frequency	Analysis frequency
U, Pu, Th, Be, Am, Cm	Weekly	Monthly
Total rad Sr	Weekly	Monthly
Gamma scan (filter)	Weekly	Monthly
Tritium	Biweekly	Monthly

[a] All parameters are checked at all locations (35, 37, 38, 39, 40, 42, 46, and remote locations 51 and 52).

Y-12 Plant Ambient Air Monitoring

The following types of ambient air monitoring systems were operated by the Y-12 Plant in 1993:

- twelve low-volume uranium particulate monitoring stations,
- eleven fluoride monitoring stations,
- two total suspended particulate (TSP) and respirable particulate (PM10) monitoring stations, and
- four mercury monitoring stations.

The locations of these monitoring stations are shown in Fig. 5.5. In addition to the permanent monitoring stations, two mobile Fourier transform infrared spectroscopy (FTIR) systems have been obtained for measurement of gaseous hazardous air pollutants. The FTIRs have been used to monitor ambient air near the perimeter of Environmental Restoration projects during construction activities. All ambient air monitoring systems at the Y-12 Plant are operated as a best management practice and are not required for regulatory or DOE order compliance.

Uranium

Samples for routine measurement of uranium particulate are collected by pulling ambient air through a square 14-cm (5.5-in.) filter, which is 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 *Environmental Monitoring Plan for the Oak Ridge Reservation* to obtain total uranium particulate and the percentage of ^{235}U. In this manner, uranium concentrations in ambient air are better correlated to stack-emission data, which is also measured as total uranium. For 1993, the average 7-day concentration of uranium at the 12 monitored locations ranged from a low of 0.00006 μg/m^3 at stations 2, 6, 10, and 12 to a high of 0.00151 μg/m^3 at Station 4 (Table 5.4). At Station 4, the 7-day concentration ranged from <0.00001 to 0.06333 μg/m^3.

Ambient air sampling for uranium around the ORR is required by DOE order, but it is not required around a specific facility such as the Y-12 Plant. The ORR ambient air monitoring network fulfills the DOE order requirement (Fig. 5.4). As part of the ORR network, an ambient air monitoring station was constructed in 1986 within the Scarboro Community of Oak Ridge (Station 46) specifically to measure off-site impacts of Y-12 Plant operations, and it 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 Y-12 Plant, ORNL, and K-25 Site emissions. Thus, the Y-12 Plant perimeter network of ambient uranium samplers is considered redundant and its discontinuation is being considered because of its limited usefulness and high operating cost.

Table 5.3. ORR radionuclide concentrations in air, 1993

Determination	No. detected/ No. sampled	Concentration (10^{-15} μCi/mL)[a]				DCG %
		Average[b]	Max	Min	Standard error	
		PAMs				
^{241}Am	32/72	1.37E–03	1.90E–03	6.77E–04	1.51E–04	0.0069
^{7}Be	72/72	8.18E+01	8.99E+01	7.40E+01	2.03E+00	0.00016
^{244}Cm	9/72	3.05E–03	9.51E–03	1.34E–04	1.40E–03	0.0076
^{60}Co	12/72	8.53E–02	8.53E–02	2.93E–02	7.78E–03	0.00007
^{137}Cs	8/72	3.82E–02	5.51E–02	1.40E–03	8.21E–03	0.00001
^{238}Pu	15/72	1.77E–03	2.84E–03	4.00E–04	3.45E–04	0.0059
^{239}Pu	11/72	9.66E–04	1.32E–03	3.59E–04	1.51E–04	0.0048
^{228}Th	69/72	7.86E–03	1.05E–02	5.17E–03	5.58E–04	0.01964
^{230}Th	68/72	5.41E–03	6.71E–03	4.15E–03	3.34E–04	0.01353
^{232}Th	67/72	6.40E–03	8.10E–03	3.72E–03	5.18E–04	0.0914
Total Sr	35/72	4.79E–02	6.53E–02	3.00E–02	3.69E–03	0.00053
^{3}H	49/99	4.53E+04	7.38E+05	1.56E+03	1.58E+04	0.0453
^{234}U	71/72	5.75E–02	1.09E–01	2.48E–02	1.08E–02	0.064
^{235}U	55/72	9.63E–03	1.48E–02	3.29E–03	1.21E–03	0.0096
^{238}U	67/72	1.93E–02	2.24E–02	1.61E–02	8.53E–04	0.0193
		RAMs				
^{241}Am	6/18	3.09E–03	4.25E–03	1.92E–03	1.17E–03	0.01544
^{7}Be	18/18	9.11E+01	9.78E+01	8.44E+01	6.68E+00	0.00018
^{244}Cm	3/18	2.82E–03	3.56E–03	2.05E–03	7.68E–04	0.0074
^{60}Co	1/18	7.09E–03	7.09E–03	7.09E–03	0.00E+00	0.00001
^{137}Cs	4/18	3.15E–02	4.14E–02	2.18E–02	9.79E–03	0.00001
^{238}Pu	4/18	1.36E–03	1.37E–03	1.32E–03	2.25E–05	0.0045
^{228}Th	16/18	7.99E–03	8.08E–03	7.88E–03	9.96E–05	0.02
^{230}Th	18/18	5.52E–03	5.82E–03	5.22E–03	3.00E–04	0.0138
^{232}Th	17/18	6.74E–03	7.06E–03	6.41E–03	3.23E–04	0.096
Total Sr	8/18	5.85E–02	7.14E–02	4.57E–09	1.28E–02	0.00065
^{3}H	12/26	2.36E+04	8.19E+04	5.73E+03	6.81E+03	0.0236
^{234}U	17/18	3.80E–02	4.33E–02	3.28E–02	5.24E–03	0.0422
^{235}U	11/18	8.08E–03	9.15E–03	7.00E–03	1.07E–03	0.0081
^{238}U	15/18	1.41E–02	1.56E–02	1.40E–02	7.80E–04	0.01481

[a] 1 μCi = 3.7E+4 Bq.

[b] Average concentration is the average of significant values only; this average is divided by the derived concentration guide (DCG) for inhalation of that isotope, multiplied by 100, and presented in the table as the percentage of the DCG, unless the percentage is less than 0.01; in that case, the percentage is reported as less than 0.01.

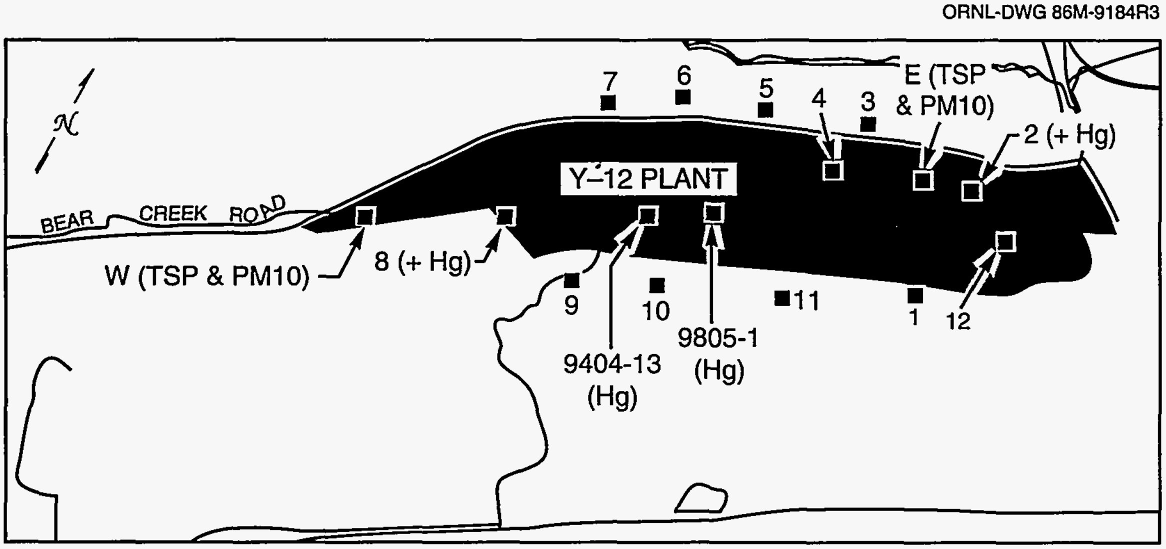

Fig. 5.5. Locations of ambient air monitoring stations at the Y-12 Plant.

Table 5.4. Uranium in ambient air at the Y-12 Plant, 1993

Station No.	No. of samples	7-day concentration ($\mu g/m^3$)[a]		
		Max	Min	Av
1	51	0.00028	<0.00001	0.00008
2	51	0.00019	<0.00001	0.00006
3	43	0.00058	0.00003	0.00008
4	51	0.06333	<0.00001	0.00151
5	51	0.00033	<0.00001	0.00007
6	51	0.00017	<0.00001	0.00006
7	51	0.0002	<0.00001	0.00007
8	51	0.01621	<0.00001	0.00039
9	51	0.00042	<0.00001	0.00008
10	50	0.00015	<0.00001	0.00006
11	51	0.00047	<0.00001	0.00009
12	51	0.00015	<0.00001	0.00006

[a] Because of the low level of uranium on the filters, the ^{235}U measurements were not always attainable. When they were, the results varied such that activity values could not be assigned.

Fluoride

Along with uranium particulate matter, atmospheric fluoride samples are collected at 11 of the 12 sites. Atmospheric fluoride in ambient air is collected on 37-mm-diam (1.5 in.) filters that have been pretreated withpotassium carbonate. The filters are analyzed by the Y-12 Plant Analytical Services Organization using the selective ion electrode method (EPA 340.2).

The 7-day ambient air concentrations of fluorides measured during 1993 at each of the Y-12 Plant perimeter fluoride stations were well below the Tennessee Department of Environment and Conservation (TDEC) standard of 1.6 µg/m³. The maximum 7-day concentration detected during the year was 0.0376 µg/m³ at Station 6 (Table 5.5). The maximum annual average 7-day concentration was 0.0104 µg/m³ at Station 2. Figure 5.6 indicates that the measured ambient air fluoride concentrations at the perimeter of the Y-12 Plant have been well below the state of Tennessee ambient air quality standards for the 7-day average since 1987. Further reductions can be expected in the future because of reductions in plant operations, improved emission controls, and improved administrative and process controls. In addition, ambient air sampling for fluorides around the Y-12 Plant is not required by any federal, state, or DOE criteria. Dispersion modeling using Y-12 Plant meteorological data can be used to predict or estimate exposure in the event of a release, and spot sampling can be conducted to confirm model results. Thus, discontinuation of ambient fluoride sampling is under consideration.

Table 5.5. Fluorides in ambient air at the Y-12 Plant, 1993

Station No.	No. of samples	7-day concentration (µg/m³)[a]				Percentage of standard[b]
		Max	Min	Av	Tenn. std[a]	
1	46	0.0186	0.0072	0.0094	1.6	<2
2	51	0.0236	0.0066	0.0104	1.6	<2
3	47	0.0148	0.0041	0.0081	1.6	<1
4	51	0.0168	0.0058	0.0102	1.6	<2
5	51	0.0127	0.0055	0.0070	1.6	<1
6	51	0.0376	0.0042	0.0089	1.6	<3
7	51	0.0217	0.0047	0.0094	1.6	<2
8	51	0.0144	0.0040	0.0084	1.6	<1
9	51	0.0264	0.0047	0.0083	1.6	<2
10	51	0.0210	0.0042	0.0087	1.6	<2
11	51	0.0219	0.0044	0.0091	1.6	<2

[a] Tennessee standard 7-day average = 1.6 µg/m³.

[b] Percentage of standard calculated using the annual 7-day average fluoride concentration.

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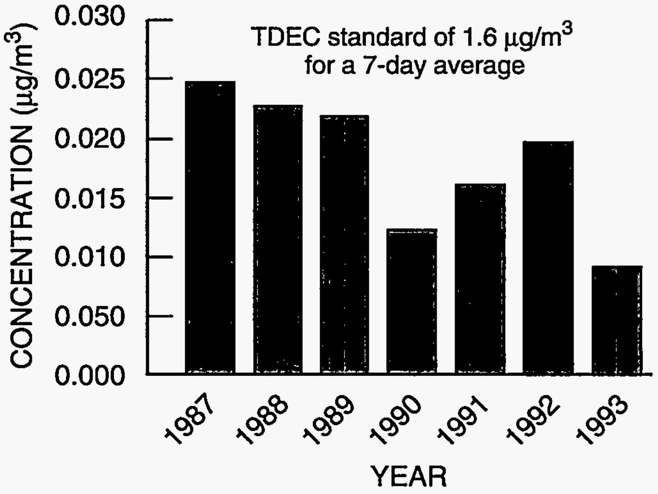

Fig. 5.6. Weekly averages for fluorides in ambient air at the Y-12 Plant, 1987–93.

Particulates

Monitors for TSP and PM10 in ambient air are located at the east and west ends of the Y-12 Plant. Sampling for particulate matter consists of drawing air at a known rate through a preweighed filter for 24 hours every 6 days. A particle concentration can be calculated from the weight differential associated with particle accumulation on the filter during the sample period. The TSP sampling system uses a glass filter; the PM10 sampling system uses a quartz filter. TSP is no longer regulated; however, concentration values are compared with the previous Tennessee 24-hour primary ambient air quality standard of 260 μg/m^3 (Table 5.6). Sample results are used as an internal measure of area ambient air quality. The TSP concentration has not exceeded the primary standard since 1989. During 1993, the maximum 24-hour value at the east TSP station was 128 μg/m^3, or 49.3% of the previous TDEC standard (260 μg/m^3 per 24 hours). The maximum 24-hour value at the west TSP station was 57 μg/m^3, or 22% of the standard.

Table 5.6. Total suspended particulates in ambient air at the Y-12 Plant, 1993

TSP station	No. of samples	Concentration (μg/m^3)				Max % of std[a]
		Max	Min	Av	Tenn. std	
East	53	128.25	3.15	38.14	260	49.33
West	39	57.14	7.79	25.09	260	21.98

[a]TSP is no longer regulated; however, the maximum measurements are still compared with the previous Tennessee 24-hour primary air quality standard of 260 μg/m^3. There were no exceedences at either TSP station.

Three PM10 samplers (samplers designed to collect particles smaller than 10 microns) are located adjacent to the existing TSP samplers, one PM10 at the west site and two PM10s at the east site. The PM10s are operated on the same schedule as the TSPs. The PM10 concentration has not exceeded the primary standard since collection of valid data began in 1992 (Table 5.7). The maximum PM10 concentration during 1993 at the west station was 64.7 μg/m^3, or 43.1% of the TDEC standard of 150 μg/m^3 per 24 hours. The maximum values at the two collocated east stations were 58.9 and 64.9 μg/m^3, or 39.2% and 43.3%, respectively, of the standard.

Ambient air sampling for particulates around the Y-12 Plant is not required by any federal, state, or DOE criteria. Discontinuation of particulate sampling is under consideration.

Table 5.7. PM10 concentrations in ambient air at the Y-12 Plant, 1993

PM10 station	No. of samples	Concentration (μg/m^3)				Max % of std
		Max[a]	Min	Av	Tenn. std	
West	54	64.74	1.39	18.09	150	43.16
East	58	58.91	0.30	17.88	150	39.27
East collocated	60	64.92	0.59	21.30	150	43.28

[a]Maximum measurements are compared with the Tennessee primary air quality standard of 150 μg/m^3 per 24 hours. There were no exceedences at any of the PM10 stations.

Mercury

In 1986, the Y-12 Plant established an on-site monitoring program to measure mercury vapor concentrations in ambient air. The goals of the program were to establish a historical data base of mercury concentrations in ambient air at the Y-12 Plant, identify spatial and temporal trends in mercury vapor concentrations, and demonstrate protection of the environment and human health from releases of mercury from the Y-12 Plant to the atmosphere. Mercury in ambient air at the Y-12 Plant results primarily from mercury vaporization from contaminated soils, the burning of coal at the Y-12 Steam Plant, and fugitive emissions from Building 9201-4, a former lithium isotope separation facility that is contaminated with mercury.

Four ambient air mercury monitoring stations (stations on the east and west ends of the plant and two stations near Building 9201-4) were established in 1986. An additional site at New Hope Pond was monitored while the pond was being closed and capped (1987–89). In February 1988, a control site was established at Rain Gage No. 2 on Chestnut Ridge in the Walker Branch Watershed. After data were collected through October 1989 to establish background concentrations and a seasonal pattern for the control site, the Rain Gage No. 2 site was discontinued.

Because no established or EPA-approved methods for measuring mercury vapor in ambient air existed when the program was initiated, staff of the ORNL Environmental Sciences Division developed a method to meet the needs of the monitoring program for the Y-12 Plant. At each of the sites, airborne mercury is collected onto iodated charcoal by pulling air through a Teflon filter, a flow-limiting orifice, and a glass sampling tube packed with iodated charcoal. The charcoal sampling tubes are normally changed every 7 days. Occasionally, sampling tubes have been changed out over time intervals shorter or longer than 7 days. Average air concentration of mercury vapor for each period is calculated by dividing the total quantity of mercury collected on the charcoal by the total volume of air pulled through the tube. Since January 1992, mercury collected on the charcoal has been analyzed by neutron activation analysis. Prior to 1992, mercury on charcoal was analyzed by cold vapor atomic absorption spectrophotometry after digestion in nitric-perchloric acid. These analytical methods have been demonstrated to yield equivalent, accurate results.

Table 5.8 presents mercury monitoring data for 1993 and data from the reference, or background, location. Figure 5.7 shows the trends in mercury concentrations for the four active ambient air mercury monitoring locations since the inception of the program.

Table 5.8. Annual results of the Y-12 Plant ambient air mercury monitoring program, 1993

Site	No. of samples	Mercury vapor concentration ($\mu g/m^3$)		
		Max	Min	Av[a]
Station No. 2 (east end of Y-12 Plant)	45	0.026	0.003	0.008
Station No. 8 (west end of Y-12 Plant)	45	0.031	0.004	0.012
Bldg. 9404-13 (SW of Bldg. 9201-4)	45	0.250	0.017	0.078
Bldg. 9805-1 (SE of Bldg. 9201-4)	45	0.314	0.010	0.088
Reference site, Rain Gage No. 2	47	0.016	0.002	0.006
(Chestnut Ridge)[b]	47	0.015	<0.001	0.005

[a] National Emission Standards for Hazardous Air Pollutants 30-day average standard = 1 $\mu g/m^3$. American Conference of Governmental Industrial Hygienists 8-hour day, 40-hour work week standard = 50 $\mu g/m^3$.

[b] Data for this site are for February–December 1988 (first line) and January–October 1989 (second line); monitoring was discontinued on October 31, 1989.

With a few exceptions, results of the mercury monitoring program at the Y-12 Plant have shown decreases in annual means for ambient air mercury vapor during 1989 and the early 1990s when compared with data for 1986 through 1988. This decrease is especially apparent for the two monitoring sites that historically have exhibited the highest mercury vapor concentrations: near buildings 9404-13 and 9805-1, located southwest and southeast, respectively, of mercury-contaminated Building 9201-4. The decrease during this period is thought to be related to the reduction in coal burned at the Y-12 Steam Plant beginning in 1989 and to completion prior to 1989 of several major engineering projects that may have caused a temporary increase in mercury air concentrations because of disturbances to contaminated soil and sediment [e.g., New Hope Pond closure, installation of the Perimeter Intrusion Detection Assessment System (PIDAS), Reduction of Mercury in Plant Effluent (RMPE), and Utility Systems Restoration]. All four monitoring sites showed increases in 1993 in average mercury vapor concentration when compared with the record low values reported for 1992. However, with the exception of the Building 9805-1 site, the 1993 averages are not significantly higher (Student's t-test at the 1% level) than those previously recorded for the 1989–91 period, suggesting that mercury vapor

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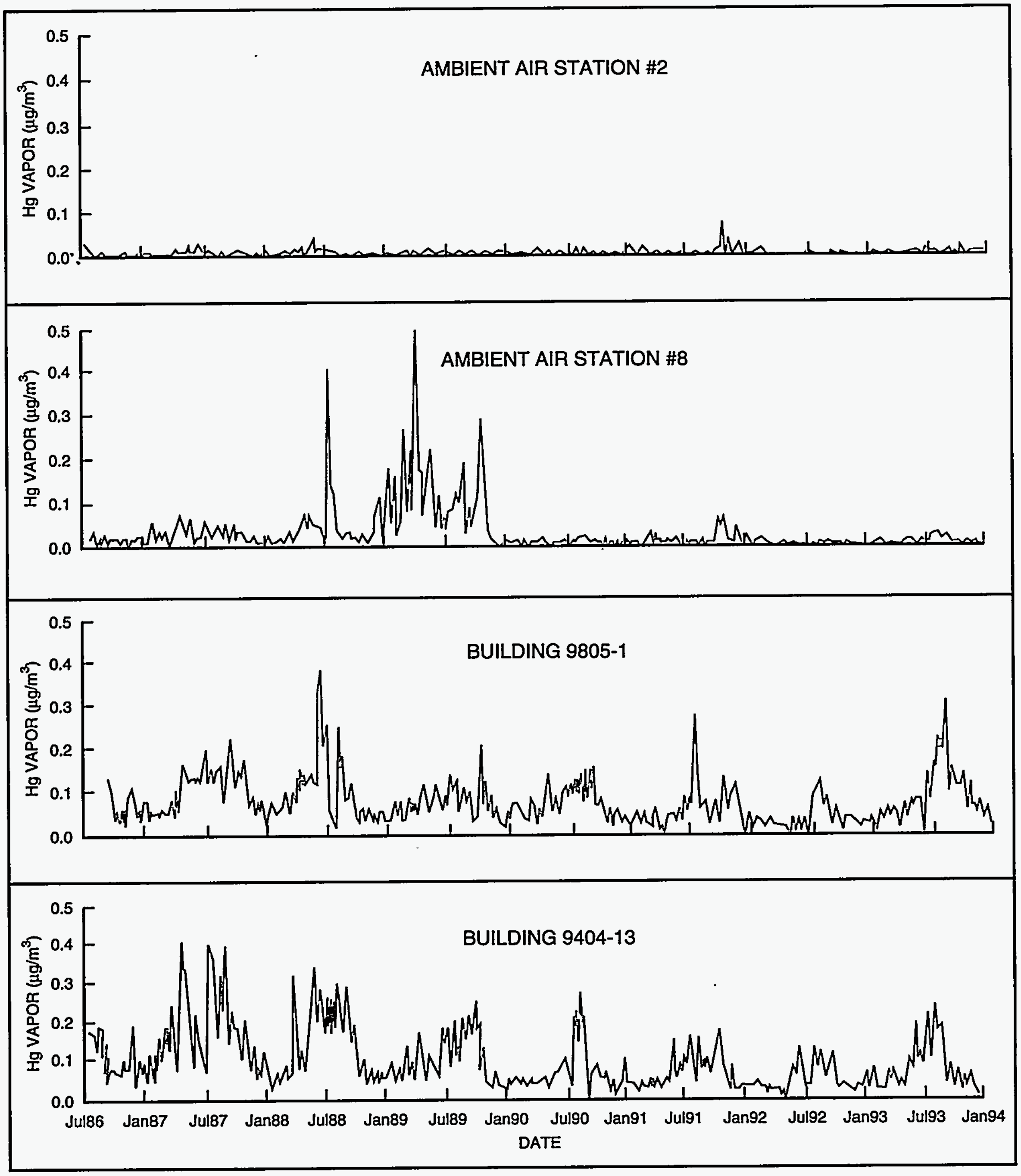

Fig. 5.7. Time trends in mercury vapor concentrations for the four active ambient air mercury monitoring sites at the Y-12 Plant.

concentrations recorded in 1992 were unusually low. Drought conditions during the summer months of 1993 may have contributed to the higher average mercury levels recorded in 1993. The seasonal pattern of higher mercury vapor concentrations during the warmer months of the year continued in 1993 (see Fig. 5.7).

Although ambient air mercury concentrations at the Y-12 Plant in 1993 were elevated above natural background, results indicate that the 1993 concentrations of mercury vapor are well below the National Emission Standards for Hazardous Air Pollutants (NESHAP) guideline of 1 μg/m³ (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). The maximum weekly concentration measured in 1993 (0.314 μg/m^3 at Bldg. 9805-1) is less than 1% of the ACGIH limit for a 40-hour work week.

Monitoring for mercury in the ambient air at the Y-12 Plant will continue in anticipation of future projects that may require data to verify prevention of significant deterioration. In response to a recent DOE appraisal of the program, the addition of background mercury monitoring at remote locations is under consideration.

ORNL Ambient Air Monitoring

The objectives of the ORNL ambient air monitoring program are (1) to sample at stations that are most likely to show impacts of airborne emissions from the operation of ORNL and (2) to provide for emergency-response capability. The specific stations (Fig. 5.8) associated with these objectives are 1, 2, 3, and 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. Station 3 is equipped with a sampler for measuring tritium. ORNL ambient air stations are equipped with low-volume samplers (Table 5.9).

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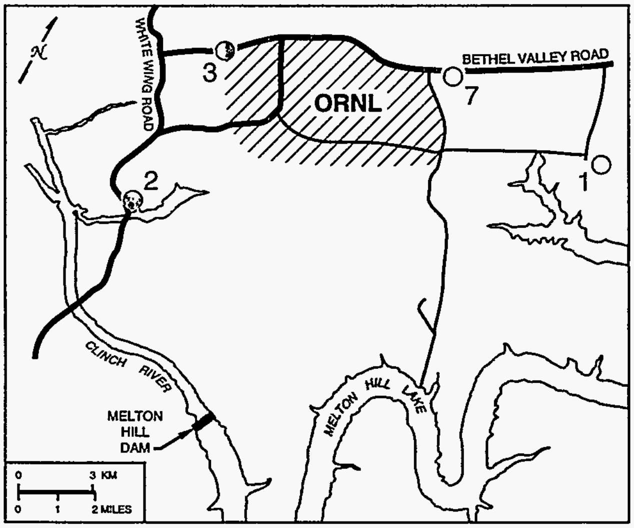

Fig. 5.8. Locations of ambient air monitoring stations at ORNL.

Table 5.9. Summary of collection and analysis frequencies for low-volume samples[a] at ORNL ambient air monitoring stations

Parameter	Collection frequency	Analysis frequency
Stations 1, 2, 3, and 7		
U, Pu, Th, Be, Am, and Cm	Biweekly	Annual
Total rad Sr	Biweekly	Annual
Gamma scan (filter)	Biweekly	Annual
Gamma scan (charcoal)	Biweekly	Biweekly
Station 3 only		
Tritium	Biweekly	Monthly

[a] Type of sampling = continuous.

Results

The ORNL PAM stations are designed to collectively assess the specific impact of ORNL on local air quality and provide for emergency response. A comparison of DCG percentages for ORNL air sampling data from the PAM stations (Table 5.10) with air sampling data from the RAM stations (Table 5.3) shows that ORNL has not had a significant impact on local air quality. Compared with 1992 data, average values have changed for a number of radionuclides. The changes could be because of actual emissions or because of improved sampling instrumentation. There are no significant changes when the concentration values are compared with the DCG percentages.

K-25 Site Ambient Air Monitoring

In 1986, the K-25 Site ambient air monitoring program underwent a major evaluation and modification because of changes in operations and current and proposed monitoring regulations. The result of the 1986 effort changed the program to a five-station network positioned appropriately for environmental monitoring of the K-25 Site (Fig. 5.9). A monitor that collects particles smaller than 10 μm in diameter was added in 1987. Current stations are positioned to best advantage for monitoring in both the prevailing wind directions and the most exposed and nearest residence.

Ambient air monitoring systems that have demonstrated performance characteristics for sampling particulate matter are filtration systems in which suspended particles are collected on filters by drawing a known volume of

Table 5.10. ORNL radionuclide concentrations in air, 1993

Determination	No. detected/ No. sampled	Concentration (10^{-15} µCi/mL)[a]				DCG %
		Average[b]	Max	Min	Standard error	
^{241}Am	2/4	3.57E–03	3.88E–03	3.29E–03	2.82E–04	0.01787
^{7}Be	4/4	2.60E+01	3.53E+01	1.80E+01	3.73E+00	0.00005
^{244}Cm	3/4	4.58E–03	6.15E–03	3.24E–03	8.48E–04	0.001145
^{137}Cs	2/4	9.15E–02	1.04E–01	7.87E–02	1.28E–02	0.00002
^{131}I	2/103	5.26E+00	5.16E+00	5.16E+00	0.00E+00	0.0013
^{133}I	7/103	7.81E+00	9.70E+00	6.09E+00	8.17E–01	0.00039
^{135}I	4/103	6.48E+00	8.78E+00	4.89E+00	1.18E+00	0.00065
^{191}Os	1/103	3.10E–01	3.10E–01	3.10E–01	0.00E+00	0.001
^{212}Pb	12/103	3.68E+01	7.16E+01	1.77E+01	1.20E+01	0.046
^{238}Pu	2/4	4.05E–03	6.97E–03	1.14E–03	2.91E–03	0.0136
^{228}Th	4/4	1.23E–02	1.69E–02	8.24E–03	1.93E–03	0.0309
^{230}Th	4/4	8.85E–03	1.23E–02	5.11E–03	1.47E–03	0.02212
^{232}Th	4/4	1.09E–02	1.46E–02	8.45E–03	1.33E–03	0.1554
Total Sr	2/4	3.68E–02	3.76E–02	3.60E–02	8.01E–04	0.00041
^{3}H	11/13	2.84E+03	1.36E+04	1.12E+02	1.27E+03	0.00284
^{234}U	4/4	7.91E–02	9.53E–02	6.97E–02	5.61E–03	0.088
^{235}U	4/4	2.15E–02	2.82E–02	1.25E–02	3.30E–03	0.0215
^{238}U	4/4	4.61E–02	5.52E–02	3.96E–02	3.81E–03	0.0461

[a] 1 µCi = 3.7E+4 Bq.

[b] Average concentration is the average of significant values only; this average is divided by the derived concentration guide (DCG) for inhalation of that isotope, multiplied by 100, and presented in the table as the percentage of the DCG, unless the percentage is less than 0.01; in that case, the percentage is reported as less than 0.01.

ambient air through the filter. These types of systems are appropriate for all airborne particulate pollutants at the K-25 Site. Two systems were chosen: a high-volume air sampling system for sampling TSP and a similar sampling system to collect PM10. Both systems are appropriate for sampling metals and uranium present in the atmosphere as airborne particulate matter.

The K-25 Site ambient air monitoring network consists of five high-volume samplers and one PM10 sampler. The PM10 sampler is collocated with a high-volume sampler at Station K4. The placement of the PM10 monitor at K4 was based on established siting criteria. The intent is to locate PM10 sampling sites in areas of highest concentrations, whether they be mobile or multiple stationary sources. The PM10 should be located at a site that is among the upper 25% of annual mean TSP concentrations. Station K4 data consistently met these criteria for proper placement of the PM10 monitor.

The sampling schedule for the K-25 Site ambient air monitoring network was established in 1986. For high-volume methods (excluding PM10 samplers), at least one 24-hour sample is obtained every sixth day. For PM10 samplers, a 24-hour sample must be taken from midnight-to-midnight (local time) to ensure national consistency. All ambient air monitors currently in use are operating on the midnight-to-midnight schedule.

The PM10 monitoring schedule was based on Tennessee's state implementation plan grouping defined in terms of the estimated probability of not attaining the PM10 National Ambient Air Quality Standards (NAAQS).

Historical K-25 Site ambient air monitoring data are categorized as having the probability of exceeding the PM10 NAAQS less than 20% of the time; therefore, the K-25 Site is in an area designating a PM10 sampling schedule of 24 hours every sixth day.

In 1988, two additional ambient air monitoring stations were designed, sited, and installed at the K-25 Site to detect polychlorinated biphenyls (PCBs), furans, dioxins, hexachlorobenzene, and uranium in relation to possible operational upsets at the K-1435 TSCA Incinerator (Fig. 5.9). Both the TSCA 1 and TSCA 2 stations are equipped with one standard high-volume sampler for uranium and two modified high-volume systems for sampling of selected semivolatile organics. The stations are positioned to monitor in the direction of the most exposed and nearest residence.

Results

No standards have been exceeded since the installation of the current monitoring network. These data also support the state classification of this area including the K-25 Site as an attainment area for PM10. Standards are attained when the expected number of exceedences per year at each monitoring site averaged over a 3-year period is less than or equal to 1. Because of this classification, PM10 monitoring is not required; however, it has been a K-25 Site best management practice to maximize environmental monitoring capabilities in this area to continue to support area classification criteria designating attainment. Parameters were chosen with regard to existing and proposed regulations and the potential of K-25 Site operations to emit certain pollutants. Changes in emissions may warrant periodic reevaluation of the parameters sampled and the monitoring locations. Table 5.11 lists selected parameters measured during 1993.

In 1993, the ambient air monitors at TSCA1 and TSCA2 were modified to activate only in the event of an operational upset of the incinerator. Originally, TSCA1 and TSCA2 ran continuously, and samples were collected every 48 hours. Samples are now collected and analyzed following abnormal operations only. The sample medium is changed after an abnormal operation or a minimum of every 30 days following a monthly activation test of the system if no abnormal operation was observed. Two operational upsets occurred during the 1993

Table 5.11. Summary of ambient air pollutants measured by the K-25 Site network, 1993

Parameter[a]	Station No.						
	K1	K2	K3	K4	K5	TSCA1	TSCA2
TSP	X	X	X	X	X		
PM10				X			
Arsenic[b]	X	X	X	X	X		
Beryllium[b]	X	X	X	X	X		
Cadmium[b]	X	X	X	X	X		
Chromium (total)	X	X	X	X	X		
Lead	X	X	X	X	X		
Nickel[c]	X	X	X	X	X		
Uranium (total)	X	X	X	X	X	X	X
PCBs						X	X
Furan						X	X
Hexachlorobenzene						X	X
Dioxin						X	X

[a] All parameters are reported as mass per unit volume of air.
[b] Measurement of these pollutants began on October 1, 1993.
[c] Measurement of this pollutant was discontinued on September 30, 1993.

reporting period. These upsets were caused by high-voltage power-supply fluctuations and related problems, not incinerator operation. Analysis of samples taken during these upsets indicated no measurable impact on the environment or the public.

Daily and Annual Pollutant Levels

No NAAQS or Tennessee ambient air quality standards 24-hour or annual primary or secondary standards were exceeded from January 1 through December 31, 1993. The highest single TSP 24-hour level recorded for the year was only 38% of the primary and 66% of the secondary standard; the highest TSP annual average was only 34% of the primary and 42% on the secondary standard. The highest single PM10 24-hour level recorded for the year was only 49% of both the primary and the secondary standards; the PM10 annual average was only 41% of the primary and secondary standards (Fig. 5.10). There are no 24-hour or annual standards for lead; however, the highest recorded quarterly average measurement was only 1.7% of the quarterly limit of 1.5 μg/m^3.

There are no national or state ambient air quality standards for arsenic, beryllium, cadmium, chromium, nickel, or uranium; however, for comparison with exposure limits recommended by the National Institute of Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA), the maximum measured levels of arsenic, beryllium, cadmium, chromium, and nickel were all less than 1% of the applicable limit. The highest single 24-hour level recorded for uranium for the year was 0.00064 μg/m^3, which if extrapolated over a calendar year, would only be 0.4% of the annual limit of 0.15 μg/m^3. The highest annual average for uranium was 0.00025 μg/m^3, which is only 0.17% of the standard for naturally occurring uranium.

Quarterly Pollutant Levels

With the exception of lead, there are no quarterly standards for the measured pollutants. As can be seen in data summary Table 5.12, no standards for lead were exceeded.

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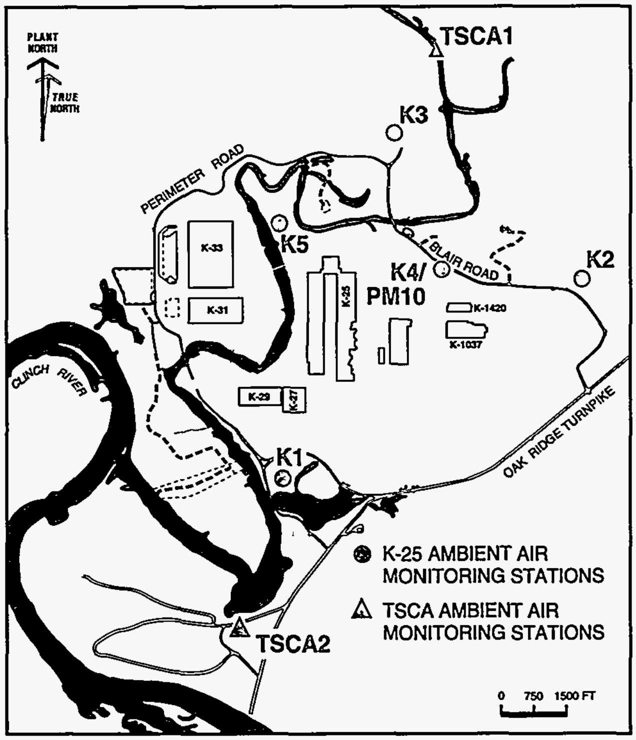

Fig. 5.9. Locations of ambient air monitoring stations at the K-25 Site.

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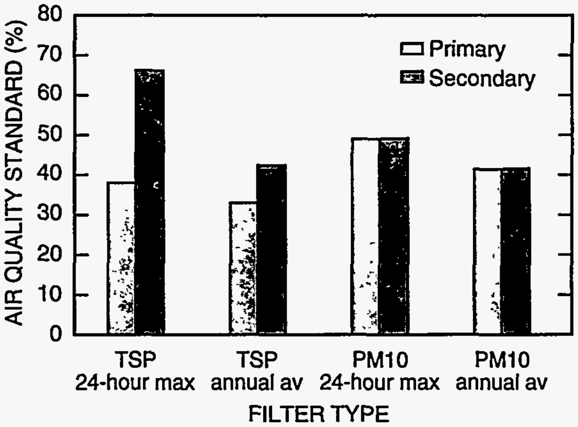

Note: Tennessee Department of Environment and Conservation and National Ambient Air Quality 24-hour standards: TSP = 260 μg/m^3 (primary) and 150 μg/m^3 (secondary); PM10 = 150 μg/m^5 (primary and secondary).

Fig. 5.10. Results of ambient air sampling for TSP and PM10 at the K-25 Site, 1993.

Table 5.12. Results of ambient air sampling for lead at the K-25 Site, 1993

Station No.	No. of samples	Average concentrations[a] (µg/m³)				Individual measurements (µg/m³)		Percentage of standard per qtr.[b]
		Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Min	Max	
K1	59	0.02482	0.01297	0.00502	0.00710	0.00357	0.04023	0.017
K2	56	0.02411	0.01186	0.00441	0.00874	0.00304	0.03641	0.016
K3	55	0.02360	0.00997	0.00397	0.00441	0.00289	0.03019	0.016
K4	59	0.02414	0.01304	0.00567	0.00714	0.00317	0.03652	0.016
K5	56	0.02242	0.01562	0.00421	0.00546	0.00317	0.02997	0.015

[a] Lead concentration averages are the quarterly arithmetic mean of 24-hour results for the first quarter and of monthly composite results for the second, third, and fourth quarters.

[b] Based on the maximum quarterly average compared with the standard for lead equal to 1.5 µg/m³ quarterly arithmetic mean.

Five-Year Trends

Five-year summaries of K-25 Site ambient air monitoring data for each NAAQS parameter and uranium are shown in Figs. 5.11–5.13. Monitoring results are presented for stations K1, K2, K3, K4/PM10, and K5. Five-year emission trends for PM10, TSP, and lead show insignificant variations during this time period, although program changes have affected the minimum analytical detection limits.

The 5-year trend for uranium indicates the level of work at the K-25 Site. For the 1989 to 1990 period, uranium operations at the K-25 Site were minimal, indicated by the low detected ambient air levels. The 1991 results indicate the burning of low levels of radioactive wastes in the TSCA Incinerator, which began in the spring of 1991. Although 1991 ambient air levels for uranium increased, no single recorded level exceeded 14% of the applicable standard for natural uranium.

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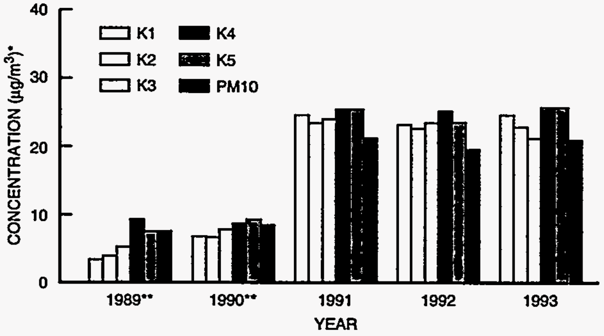

Fig. 5.11. Ambient air monitoring 5-year trend results for particulates at the K-25 Site.

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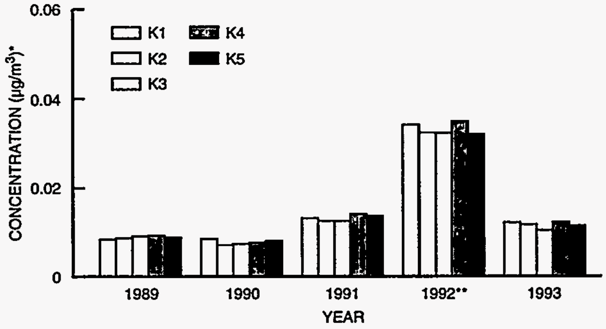

Fig. 5.12. Ambient air monitoring 5-year trend results for lead at the K-25 Site.

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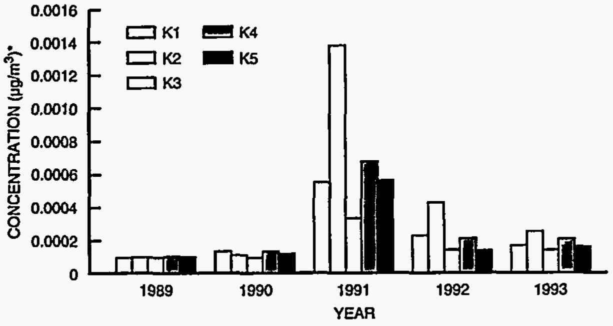

Fig. 5.13. Ambient air monitoring 5-year trend results for uranium at the K-25 Site.

SURFACE WATER MONITORING

ORR Surface Water Monitoring

Under the environmental monitoring plan for the ORR, to assess the impact of past and current DOE operations on the quality of local surface water, samples are collected and analyzed from 22 locations around the ORR (Fig. 5.14). 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. Sampling locations are

- 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)
- Water supply intake for the K-25 Site (CRK 23)
- Clinch River downstream from ORNL (CRK 32)

ORNL-DWG 93M-9752

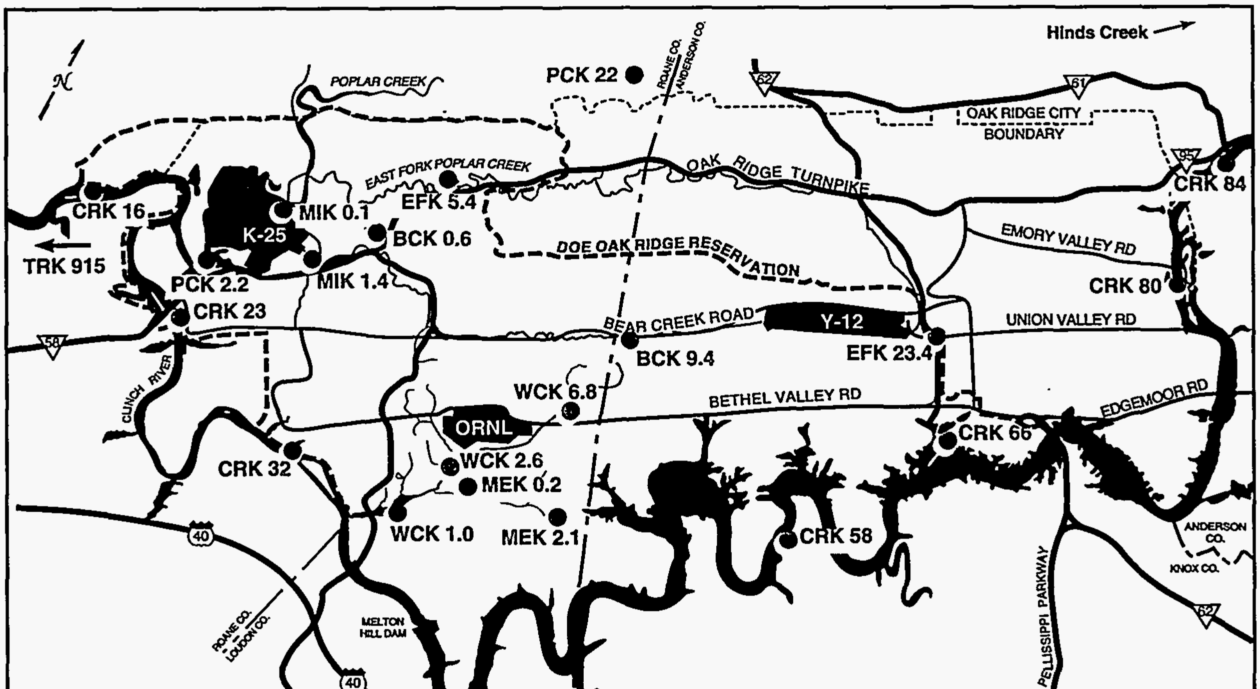

Fig. 5.14. Locations of ORR surface water sampling stations.

- Water supply intake for Knox County (CRK 58)
- Melton Hill Reservoir above city of Oak Ridge water intake (CRK 66)
- Melton Hill Reservoir, Oak Ridge Marina (CRK 80)
- Melton Hill Reservoir above all DOE inputs, Anderson County Filtration Plant (CRK 84)
- East Fork Poplar Creek downstream from floodplain (EFK 5.4)
- East Fork Poplar Creek downstream from Y-12 Plant (EFK 23.4)
- Hinds Creek (reference site for East Fork Poplar Creek) (HC)
- Melton Branch downstream from ORNL (MEK 0.2)
- Melton Branch upstream from ORNL (MEK 2.1)
- Mitchell Branch downstream from K-25 Site (MIK 0.1)
- Mitchell Branch upstream from K-25 Site (MIK 1.4)
- Poplar Creek downstream from K-25 Site (PCK 2.2)
- Poplar Creek upstream from K-25 Site and East Fork Poplar Creek (PCK 22)
- Water supply intake for city of Kingston (TRK 915)
- White Oak Lake at White Oak Dam (WCK 1.0)
- White Oak Creek downstream from ORNL (WCK 2.6)
- White Oak Creek upstream from ORNL (WCK 6.8)

Water quality measurements serve as a guide to the general health of the environment. The sampling and analysis in this program are conducted in addition to requirements mandated in National Pollutant Discharge Elimination System (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 environmental monitoring plan 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.

Tennessee water quality criteria for domestic water supplies and for freshwater fish and aquatic life are used as references for locations where they are applicable. Out of the 79 parameters sought at each of the 22 locations, zinc at Melton Branch downstream from ORNL (MEK 0.2) on the ORR is the only parameter that exceeded 100% of the reference value.

Y-12 Plant Surface Water Monitoring

Routine surface water monitoring that is not required by the NPDES permit is performed at the Y-12 Plant site for a variety of reasons, and various radiological and nonradiological parameters are monitored. Monitoring results are compared with state water quality criteria and with DOE order requirements. Nonradiological data are compared with Tennessee water quality criteria, where a criterion exists for that parameter. The most restrictive of either the freshwater fish and aquatic life criterion maximum concentration or the recreation concentration for organisms only standard (10^{-5} risk factor for carcinogens) was used. Radiological data are compared with DCGs published in DOE Order 5400.5. The DCG for water is the concentration of a given radionuclide that, if ingested at the rate of 730 L/year, would result in an effective dose equivalent of 100 mrem/year to "reference man," as defined by International Commission on Radiation Protection Publication 23. Radiological data are reported as percentage of the DCG for a given radionuclide. In the event that a sum of the DCG percentages for a location ever exceeds 100%, an analysis of the best available technology to reduce the sum of the percentages of the radionuclide concentrations to their respective DCGs to less than 100% would be required as specified in DOE Order 5400.5.

Station 17, located near the junction of Bear Creek and Scarboro roads, is used to monitor East Fork Poplar Creek downstream of Lake Reality but prior to its leaving the easternmost Y-12 Plant boundary (Fig. 5.15). Discharges from Y-12 Plant processes affect water quality and flow in East Fork Poplar Creek before it enters the Clinch River. Daily samples were obtained at Station 17 for radiological and nonradiological parameters; grab samples for mercury and volatile organics were obtained daily at Station 17. With the exception of about

ORNL-DWG 90M-7951R

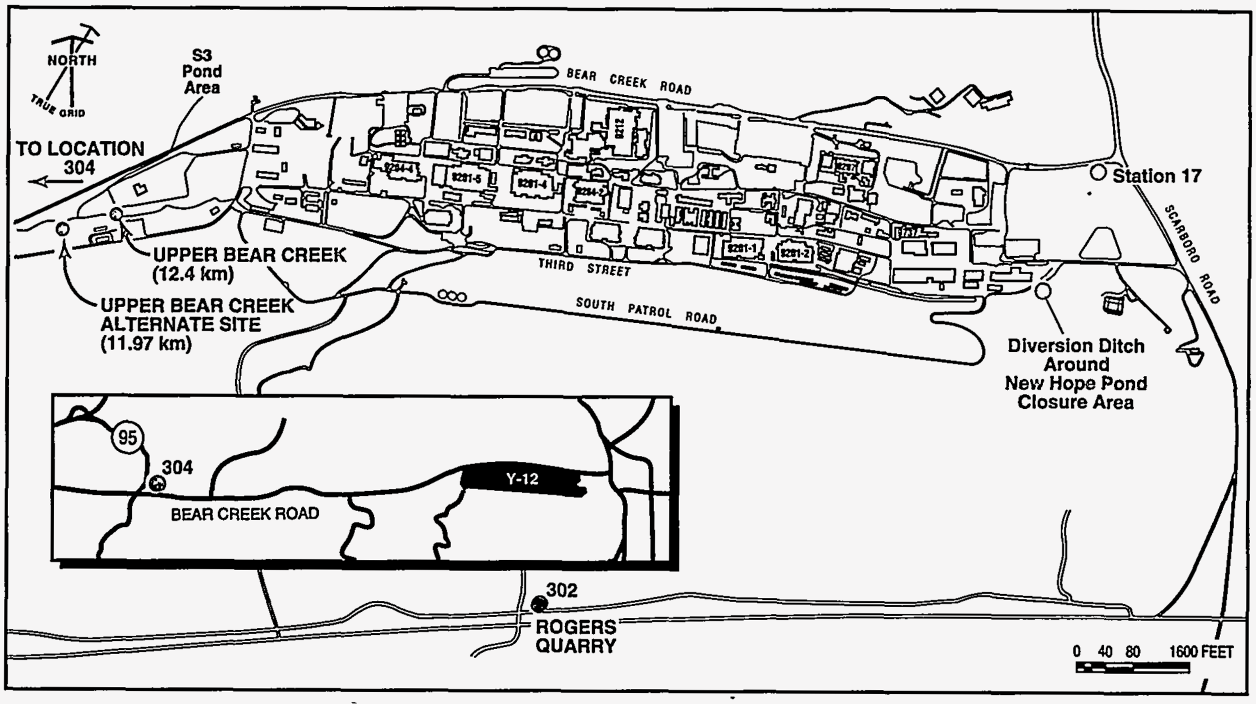

Fig. 5.15. Locations of Y-12 Plant surface water surveillance program sampling stations.

three weeks in February and March when power lines had to be reconstructed (because of damage from a tornado on Feb. 22), 24-hour composite samples were obtained every day of the week, with a 72-hour composite collected on weekends for a variety of chemical parameters.

More than 200 samples were collected in 1993 at Station 17 for analysis of nonradiological parameters, resulting in nearly 15,000 measurements. Comparison with Tennessee water quality criteria, for parameters where there was an exceedence, is shown in Table 5.13. All 203 measurements for silver and mercury were above those criteria, because the analytical-method detection limits for silver (0.006 mg/L) and mercury (0.0002 mg/L) are above the water quality criteria (0.004 and 0.00015 mg/L, respectively). Of the remaining measurements, only a single measurement each for cadmium and chromium exceeded the criteria.

Table 5.13. Surface water sampling measurements exceeding Tennessee water quality criteria at the Y-12 Plant, 1993

Parameter	Location	No. of samples	Concentration (mg/L)			Water quality criteria (mg/L)	No. of measurements exceeding criteria
			Detection limit	Max	Av		
Silver	Station 17	203	0.006	<0.006	<0.006	0.004	203
Mercury	Station 17	203	0.0002	0.0093	<0.0016	0.00015[a]	203
Mercury	Rogers Quarry (Outfall 302)	52	0.0002	0.0006	<0.0002	0.00015	52
Chromium	Station 17	203	0.006	0.028	<0.006	0.016	1
Cadmium	Station 17	94	0.0005	0.0082	<0.0019	0.004	1

[a] The Tennessee water quality standard for recreation is 0.00015 mg/L. The freshwater fish and aquatic life standards are 0.0024 and 0.000012 mg/L for the maximum and continuous concentrations, respectively.

Mercury data are used for long- and short-term trending of mercury concentrations in plant effluents. The legacy of contamination resulting from the use and storage of mercury at the Y-12 Plant has been previously acknowledged and has prompted a series of remedial measures. In the late 1950s, the average annual concentration of mercury in East Fork Poplar Creek peaked at about 2.3 mg/L (2300 µg/L) (Fig. 5.16). Recent annual average concentrations ranged from 0.0014 to 0.0016 mg/L (1.4 to 1.6 µg/L) (Fig. 5.17). Because of mercury abatement activities and decreases in water flow, mercury loading to East Fork Poplar Creek from the Y-12 Plant has decreased significantly. Average daily values were about 60 g/day in the early 1980s, whereas recent values are near 15 g/day. This represents a 75% decrease in mercury releases over the past decade.

All radiological measurements at Station 17 were well below the DCGs. The summed percentage of DCGs for measured radionuclides at Station 17 was 3.29%. The largest single contributor to this total was ^{238}U. The median value for ^{238}U at this location for 1993 was 6.2 pCi/L, which represents 1% of the DCG. In 1993, the total uranium and associated curies released from the Y-12 Plant, as measured at Station 17 on Upper East Fork Poplar Creek, was 134 kg, or 0.081 Ci (3.0×10^9 Bq).

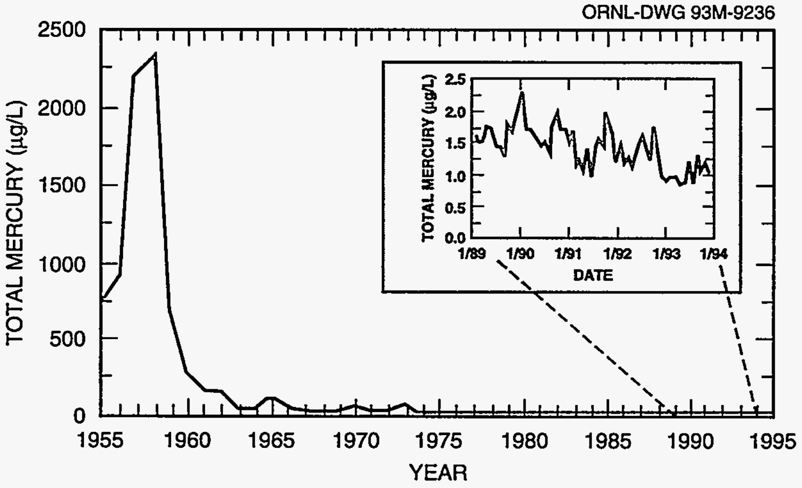

Fig. 5.16. Mercury concentrations in surface water leaving the Y-12 Plant, 1955–93. Values plotted in large graph are annual averages. Values in inset are monthly averages.

NPDES sampling locations 302 (Rogers Quarry) and 304 on Bear Creek (km 4.55) are considered instream sampling points for McCoy Branch and Bear Creek. In past years, coal bottom ash slurry was discharged to the McCoy Branch Watershed from the Y-12 Steam Plant. Bear Creek water quality is affected by area source runoff and groundwater discharges from waste disposal sites. Of measurements collected and comparisons made to state water quality criteria for surface water surveillance, only mercury exceeded the criteria at Outfall 302. Again, this was because the analytical-method detection limit for mercury (0.0002 mg/L) exceeds the water quality criterion (0.00015 mg/L). At Outfall 304, no measurements made as part of the surface water program exceeded water quality criteria.

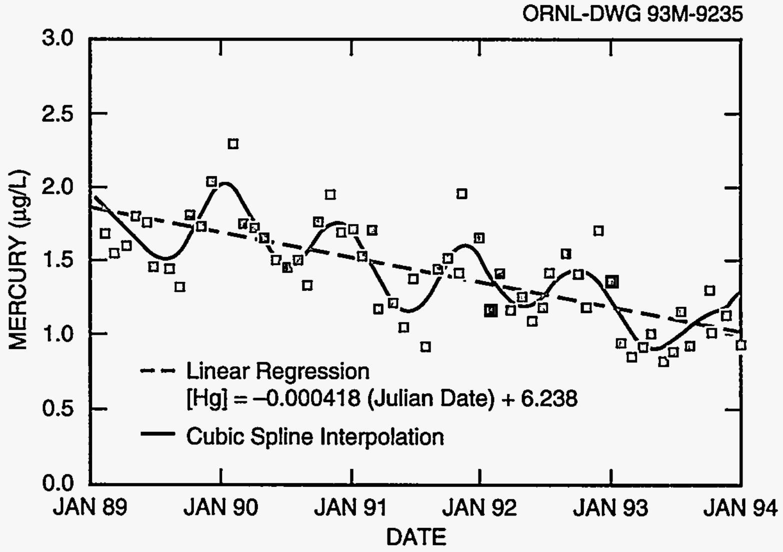

Fig. 5.17. Monthly average ($N = 40$) mercury concentrations in East Fork Poplar Creek at Station 17 near the eastern end of the Y-12 Plant, January 1989–December 1993. Straight and sinusoidal lines fitted to data represent long-term and seasonal trends.

Additional surface water sampling is conducted at Outfall 304 by the Y-12 Plant groundwater protection program to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Section 7).

In addition to surveillance monitoring via conventional surface water sampling, the Y-12 Plant has established a series of monitoring stations on the storm sewer collection system and East Fork Poplar Creek (Fig. 5.18). These stations are officially known as the Surface Water Hydrological Information Support System (SWHISS). The SWHISS network is designed to monitor and record various surface water parameters to aid in spill tracking and water quality determination.

Telemetry delivers real-time monitoring data to the Utilities

ORNL-DWG 94M-8135

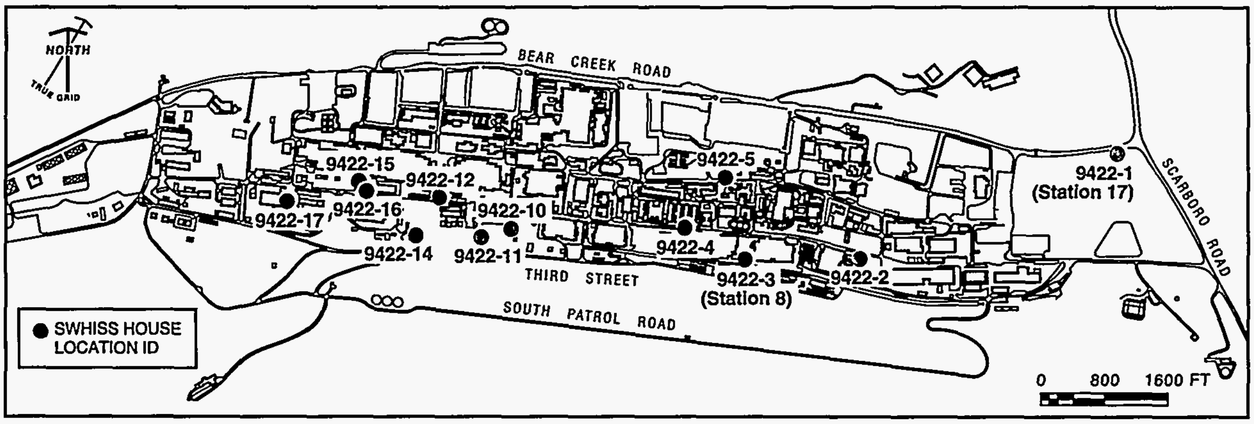

Fig. 5.18. Surface Water Hydrological Information Support System monitoring locations.

Monitoring Station 9 and the SWHISS house central computer in Building 9704-1. Real-time monitoring parameters vary for each site but typically include pH, temperature, conductivity, dissolved oxygen, and flow. Two locations on East Fork Poplar Creek also measure chlorine.

During 1993, the SWHISS network was instrumental in identifying a need for change in operational procedures at the Steam Plant Wastewater Treatment Facility (SPWTF). SWHISS data revealed a need for the installation of an additional pH meter in a process tank because a wide range of pH readings had been observed during discharge from the facility. This addition has improved the quality of treated wastewater discharged.

ORNL Reference Surface Water Monitoring

The net impact of ORNL 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 sampling locations to determine contamination levels before the influence of ORNL activities. One sampling location is Melton Hill Dam above ORNL's main discharge point into the Clinch River. The other sampling location is White Oak Creek headwaters above any ORNL discharge points to White Oak Creek (Fig. 4.15).

Analyses are performed to detect radioactivity and conventional, inorganic, and organic pollutants in the water. Conventional pollutants are indicated by conductivity, temperature, turbidity, pH, total dissolved solids, total suspended solids, and oil and grease. Inorganic parameters are indicated by metal and anion analyses. The presence of organic pollutants is indicated by results from total organic carbon analysis. If the total organic carbon result is greater than 2.5 mg/L, analyses for volatile and semivolatile organic compounds are conducted.

In March 1993, a total organic carbon value of 2.6 mg/L was received for Melton Hill Dam. A recheck of the total organic carbon analysis was performed and resulted in a value of 2.4 mg/L. Values from analyses in the next 4 months ranged from 1.8 to 2.2 mg/L. There were no other high levels of organic compounds detected by the total organic carbon analysis at either location, as indicated by the maximum value of 2.6 mg/L at Melton Hill Dam and by the maximum value of 0.96 mg/L at White Oak Creek headwaters.

In an effort to provide a basis for evaluation of analytical results and for assessment of surface water quality, DWSs (from 40 CFR Parts 141 and 143, as amended, and the Tennessee General Water Quality Criteria for Domestic Water Supply, as amended) have been used. Although DWSs are used, it is unrealistic to assume that members of the public are going to drink water from Melton Hill Dam or White Oak Creek headwaters.

There is reasonably good agreement between parameters measured at White Oak Creek headwaters and those at Melton Hill Dam. At White Oak Creek headwaters, the only average concentrations that exceeded the DWSs are aluminum, iron, and lead. At Melton Hill Dam, the only average concentrations that exceeded the DWSs are aluminum, iron, lead, and manganese. Concentrations of these magnitudes are commonly associated with the hydrogeology of the Clinch River.

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 met the criteria; the percentage of DCG for ^{60}Co at White Oak Creek headwaters was less than one.

K-25 Site Surface Water Monitoring

ORNL-DWG 94M-7061R3

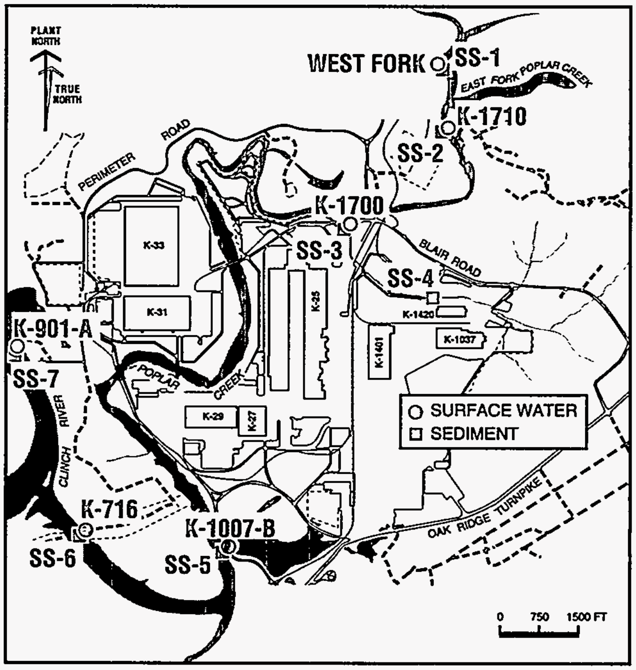

Fig. 5.19. Monitoring locations for surface water and sediment at the K-25 Site.

In addition to the ORR surface water surveillance program, surface water surveillance is conducted at six locations at the K-25 Site (Fig. 5.19) as a best management practice. The West Fork Poplar Creek and K-1710 sampling locations provide information representative of surface water conditions upstream of the K-25 Site. Station K-716 is located downstream of most K-25 Site operations and provides information on the cumulative effects of the operations of the K-25 Site 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 from the six locations 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 for fish and aquatic life, where such standards are published. Many monitored parameters have no published standards.

In most instances, results of the analyses for nonradiological parameters are well below the applicable standards. In the case of silver, the standard is set at a level below the analytical detection limit for the instrument. Silver was not detected at any K-25 Site surveillance location in 1993. Lead and mercury were occasionally detected but always in very low concentrations. In the case of iron and manganese, standards are sometimes exceeded, but the standards are below the level present in ambient waters. Both elements are abundant in the soil of East Tennessee, and water samples collected upstream of K-25 Site operations often show results above the standards. In addition, natural conditions cause periodic exceedences of standards for dissolved oxygen and pH.

Dissolved oxygen measurements regularly fall below the minimum water quality standard during the summer months because of increased temperature (and therefore lower solubility of the gas) and increased biological activity. Similarly, increased photosynthesis during the summer months causes an increase in the pH of area waterways, sometimes exceeding the maximum water quality standard. Water bodies in the vicinity of the K-25 Site 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 1993. For most of the analyses, results are below detection limits for the instrument and method. Moreover, analytical results for samples collected upstream of the K-25 Site are chemically similar in most respects to those collected below the K-25 Site.

The sum of the fractions of the DCGs for all six sampling locations remained below 1.0 for the year, as is required by DOE Order 5400.5 (Fig. 5.20). The highest sum of the fractions, 0.41, was reported for sampling location K-1700, which was well below the conservative limits established by the order. This location receives input from coal pile runoff and once-through cooling water. The 1993 radiological data do not indicate any effects from K-25 Site operations on perimeter surface waters.

ORNL-DWG 94M-9538

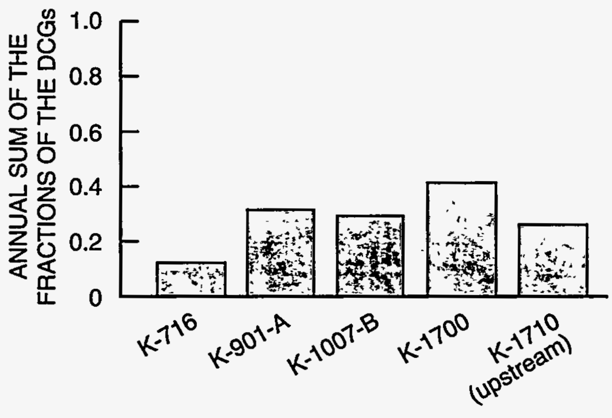

Fig. 5.20. Sum of the fractions of the DCGs for K-25 Site surface water monitoring locations. (Limit for each location is 1.0).

Off-Site Spring and Residential Well Monitoring

In 1989, ORNL implemented a long-term, off-site residential drinking-water-quality monitoring program. The objective of the program as described in the ORR environmental monitoring plan is to document water quality from groundwater sources near the ORR and to monitor the potential impact of DOE-ORO operations on the quality of these groundwater sources.

Currently, 2 springs and 17 wells are included in the program. These locations were selected because of their proximity to the ORR and because they are located on a representative distribution of sources from the different geologic formations of the area. They are sampled semiannually, subject to access availability, and the results are provided in individual reports to the owners.

Parameters monitored include volatile organics, metals, anions, and the radioactive parameters: gross alpha activity, gross beta activity, total radioactive strontium, technetium-99, tritium, and radionuclides observed in a gamma scan. In past years, sampling has not indicated any contaminant movement to these sites, and results from sampling in 1993 continue to support this finding.

A few results (nitrates, fluorides, and manganese) exceeded federal drinking water standards and Tennessee water quality criteria for domestic water supply; however, the concentrations measured were consistent with the historical behavior of the individual wells. In particular, one well, which is located deep in the Conasauga formation, exceeded the standard for fluoride, and another well exceeded the standard for nitrate.

Off-Site Treated Water Monitoring

The ORNL program for assessing ORR impacts to the Clinch and Tennessee rivers uses empirical data from samples taken at the Kingston and Gallaher potable water treatment plants (Fig. 5.21). Treated water samples are collected weekly and are analyzed quarterly for total uranium and specific radionuclides.

Federal and state drinking water standards (DWSs) (40 CFR Parts 141 and 143, as amended, and the Tennessee General Water Quality Criteria for Domestic Water Supply, as amended) were used as reference values. If a DWS for a radionuclide has not been established, 4% of the DCG for that radionuclide was 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. There were no average radionuclide concentrations greater than 14% of reference values at the Kingston Water Treatment Plant and none greater than 4.8% 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 at both Gallaher and Kingston were less than 0.7% of the gross alpha standard. The total uranium measurement is converted to an activity by assuming a natural abundance of uranium isotopes ^{234}U, ^{235}U, and ^{238}U.

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 is used to evaluate long-term accumulation trends.

ORNL-DWG 93M-5468

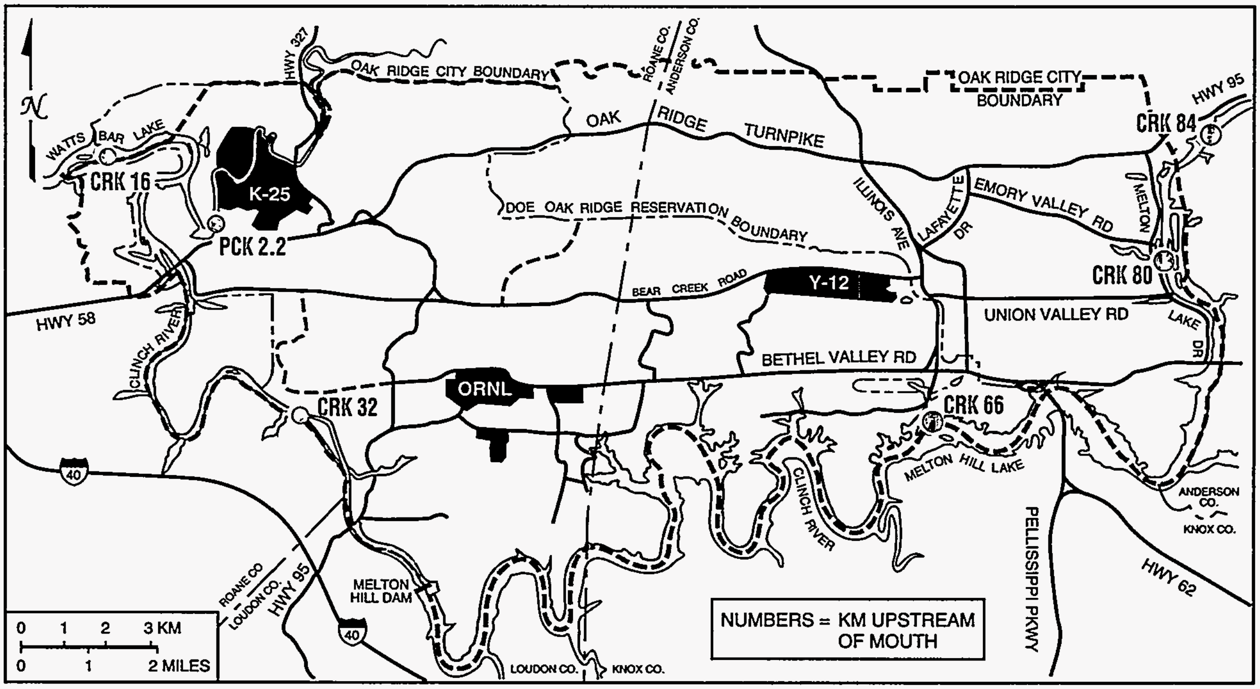

Fig. 5.21. Sampling locations for ORNL off-reservation surface waters.

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 and the remote station at Norris Dam; see Fig. 5.4). 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 environmental monitoring plan for the ORR. Additionally, soil samples are collected at the K-25 Site as a best management practice.

Vertical composite samples were collected at the nine stations once during 1993. Samples were analyzed for gross alpha and beta; gamma emitters; total radiological strontium; and uranium, thorium, beryllium, and plutonium isotopes.

Results

Concentrations for the ORR are summarized in Table 5.14. These values do not differ significantly from previous soil data, but it should be noted that previous soil sampling and analysis programs did not involve homogeneous soils. Based on soil handling criteria established in ORNL/M-116, alpha and beta values are within unrestricted usage ranges.

In addition to the ORR soil sampling program, soil samples are collected at the K-25 Site as a best management practice. Soil samples taken at points coinciding with K-25 Site ambient air monitoring stations are analyzed for radiological activity once per calendar year. The selection of sampling locations in this manner integrates the overall environmental sampling program to allow for comparability of data between the soil and ambient air media in evaluating long-term accumulation trends. Soil sampling locations at the K-25 Site are shown in Fig. 5.22.

The soil samples were analyzed for the following isotopes: ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{237}Np, ^{238}Pu, ^{239}Pu, and ^{99}Tc. Fluorometric methods were used for total uranium, alpha spectrometry for uranium isotopes (excluding ^{235}U) and transuranics, gamma spectrometry for ^{137}Cs and ^{235}U, and gross alpha and beta analyses.

In addition to the requested radioisotopes, ^{234m}Pa, ^{234}Th, ^{106}Ru, and ^{40}K were also detected; however, the results for ^{234m}Pa were close to the minimum detectable activity and ^{234}Th, ^{106}Ru, and ^{40}K were reported as tentatively identified isotopes.

Table 5.14. Results of radiological analysis of ORR soil samples, 1993

Parameter	Station Concentration (pCi/g)[a]								
	35	37	38	39	40	42	46	48	51
^{241}AM		0.01		0.01					
^{60}Co						0.06			
^{137}Cs		0.09							
Gross alpha	1.27	1.06	1.04	1.18	0.81	1.19	0.80	1.16	0.95
Gross beta	3.1	2.35	2.28	2.22	2.39	2.5	2.19	2.42	2.38
^{238}Pu								0.01	
^{228}Th	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.04	0.03
^{230}Th	0.04	0.03	0.03	0.03	0.02	0.37	0.01	0.04	0.03
^{232}Th	0.03	0.03	0.02	0.02	0.02	0.03	0.01	0.04	
Total Rad Sr	0.35	0.45	0.42	0.46	0.65	0.62	0.45	0.62	
^{234}U	0.05	0.05	0.05	0.05	0.05	0.04	0.03	0.06	
^{235}U	0.01	0.01	0.01	0.01	0.004	0.01	0.01	0.01	
^{238}U	0.04	0.03	0.02	0.04	0.04	0.03	0.02	0.03	

[a] 1 pCi = 3.7E–02 Bq.

Data results for 1993 are similar to those reported for 1992. (Because of changes in the sampling program, only 1992 data can be compared with 1993 results.) At location S-1, which is near ORR Station 35, alpha and beta activities reported by the K-25 Site program are slightly higher than those values reported by the ORR program; however, the values are within the associated limits of error and considered to be comparable. For the uranium isotopes, ^{234}U was reported slightly lower by the K-25 Site program than by the ORR program, whereas the K-25 Site program reported slightly higher results than the ORR program for ^{235}U and ^{238}U. Once again, results were within the limit of error for the specific isotopes.

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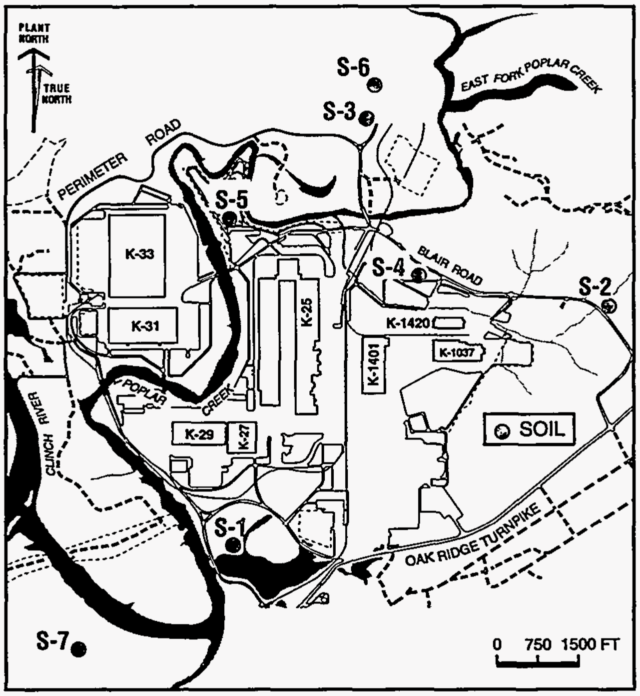

Fig. 5.22. Soil sampling locations at the K-25 Site.

SEDIMENT

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 ORR environmental monitoring plan, sediment samples are collected at 16 sites near surface water and biological monitoring locations in and around the reservation. These environmental monitoring plan sediment sampling locations are shown in Fig. 5.23 and listed descriptively here.

ORNL-DWG 93M-9753R

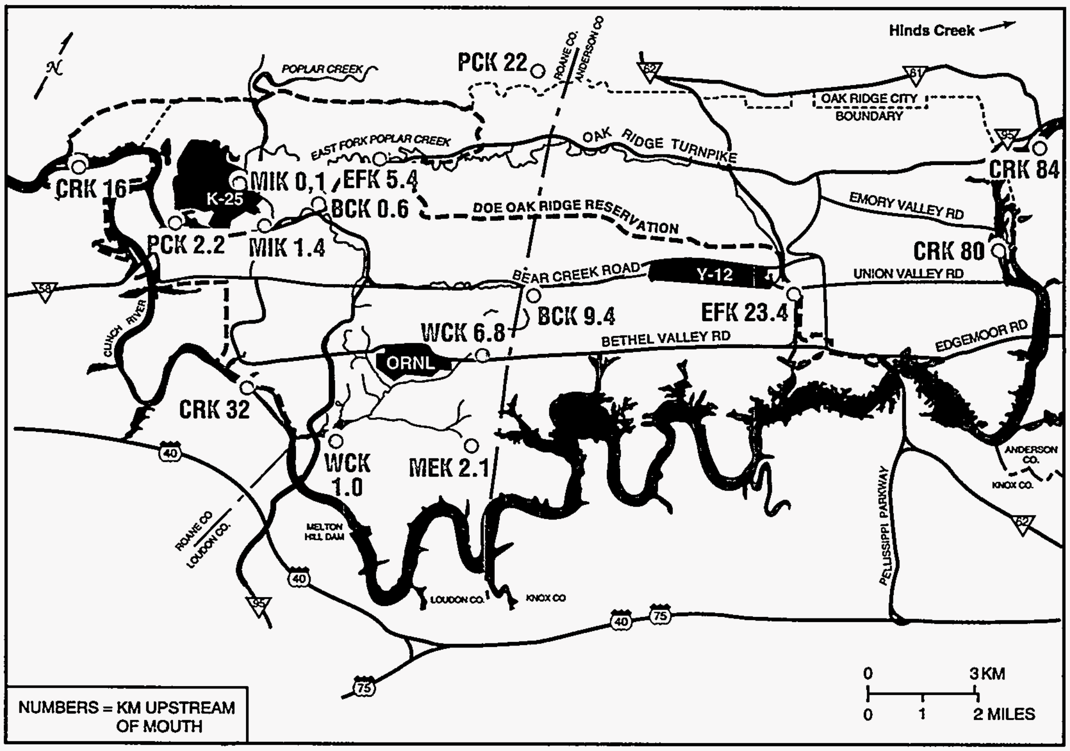

Fig. 5.23. ORR environmental monitoring plan sediment sampling locations.

- 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, Oak Ridge Marina (CRK 80)
- Melton Hill Reservoir above all DOE inputs, Anderson County Filtration Plant (CRK 84)
- East Fork Poplar Creek downstream from floodplain (EFK 5.4)
- East Fork Poplar Creek downstream from Y-12 Plant (EFK 23.4)
- Hinds Creek (reference site for East Fork Poplar Creek) (HC)
- Melton Branch upstream from ORNL (MEK 2.1)
- Mitchell Branch downstream from K-25 Site (MIK 0.1)
- Mitchell Branch upstream from K-25 Site (MIK 1.4)
- Poplar Creek downstream from K-25 Site (PCK 2.2)
- Poplar Creek upstream from K-25 Site and East Fork Poplar Creek (PCK 22)
- White Oak Lake at White Oak Dam (WCK 1.0)
- 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 the sediment, resulting in sensitive, time-integrated measures of contamination. The program was initiated in 1993, and the locations are sampled annually. In the first year of the program, samples were analyzed for total metals, chlorinated pesticides, PCBs, semivolatile organic compounds, and selected radionuclides. Given that this is the first year of the program, there are no historical data that can be used for comparison with the 1993 results. With data from only one sampling, statistical evaluation of the results for each location cannot be performed. In addition, there are no regulatory standards that apply to sediments and against which results can be compared. After 2 years of monitoring, the data will be reviewed and analyses will be dropped or added as appropriate.

K-25 Site Sediment

In addition to the ORR sediment sampling program, sediment samples are taken at some locations near the K-25 Site as a best management practice; they are taken at points coinciding with the K-25 Site surface water sampling locations and are analyzed for radiological activity and other parameters once per calendar year. This activity is part of environmental surveillance monitoring, which assesses the impact of the site's operations on the public and environment as required by DOE Order 5400.1.

Sediment samples are collected at the points that coincide with surface water sampling points, away from the turbulent area of the discharges, when applicable (Fig. 5.19). Samples are collected and analyzed for radiological activity and nonradiological parameters such as total metals, pesticides, PCBs, and semivolatiles. K-25 Site sediment sampling is consistent with the DOE order requirements and is designed to complement the ORR surveillance program.

Results

Analyses for nonradiological parameters indicate that aluminum, iron, and calcium are the dominant metals present. These results are typical for sediment in areas dominated by limestone bedrock. Results for pesticides and semivolatile compounds were all below the analytical detection limit, with the exception of a few compounds that were also detected in the sample blanks. Heavy metals such as lead and mercury are also present. The highest level of lead occurred in a sample from West Fork Poplar Creek, upstream from K-25 Site operations. The highest levels of mercury were in the samples from K-1710 (just below the confluence of East Fork Poplar Creek and Poplar Creek) and K-1700. PCBs above the detection limit occurred in only one sample, an aroclor-1254 from K-1700 (460 µg/kg). This is less than the 1992 results of 5120 µg/kg.

Samples were also analyzed for the following isotopes: ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{237}Np, ^{238}Pu, and ^{239}Pu. Fluorometric methods were used for total uranium, alpha spectrometry for uranium isotopes (excluding ^{235}U) and transuranics, gamma spectrometry for ^{137}Cs and ^{235}U, and gross alpha and beta analyses. In addition to these requested radioisotopes, ^{234m}Pa and ^{234}Th were also reported. However, the reported activities were generally below the minimum detectable activity or below background levels. Ruthenium-106 was reported as a tentatively identified isotope for sediment sampling location 3 (SS-3; Fig. 5.19).

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.

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. 5.24). Areas 1, 2, and 3 are within the predicted air plume for an ORNL source and could also be affected by the K-25 Site. Baled hay was collected from each of the three sites and composited. Areas 2, 4, 5, and 6 are within the predicted air plume for a K-25 Site, an ORNL, and a Y-12 Plant source. Baled hay was collected from each of these sites and composited. Area 6 best represents the combined plumes from all three sites; baled hay was collected from this site.

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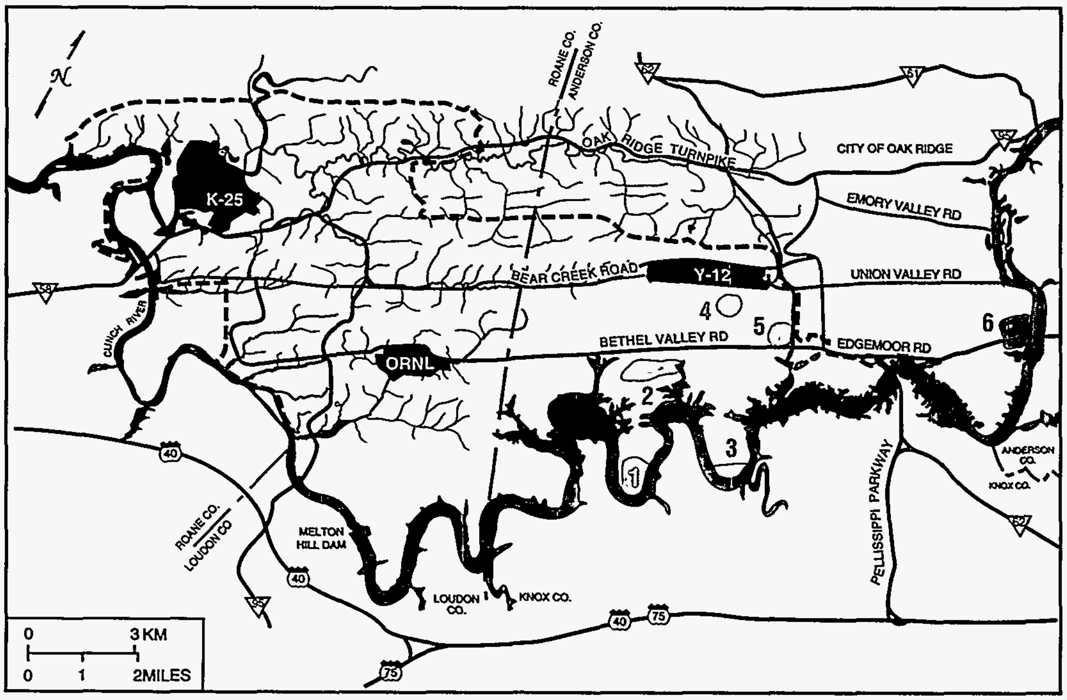

Fig. 5.24. Hay sampling locations on the ORR.

Results

Hay samples were collected during the months of May and June 1993, and samples were analyzed for gross alpha and beta, gamma emitters, and fluorides. Table 5.15 summarizes the results of the sampling effort; note that ^{7}Be and ^{40}K are naturally occurring isotopes found throughout the area. There is no reference sample for hay.

Table 5.15. Concentrations of radionuclides and fluoride in hay from the ORR, 1993

Area	Isotope (Ci/kg)[a]					Fluoride (μg/g)
	^{7}Be	^{60}Co	^{40}K	Gross alpha	Gross beta	
1, 2, and 3	3.1E–09	3.0E–11	1.3E–08	2.8E–10	7.0E–09	1.1
2, 4, and 5	5.5E–09	3.6E–11	1.4E–08	1.0E–09	6.4E–09	1.6
6	1.1E–08	*b*	8.5E–09	3.4E–10	1.3E–08	1.1

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

[b] Not significant.

Vegetables

Tomatoes and turnip greens were grown in nine soil plots established at ambient air stations (Fig. 5.4). Turnips were purchased from private gardens located near stations 39, 40, and 42. (Note: Turnips will be grown in the soil plots in 1994.)

Results

Tomatoes were harvested in July from each station, and turnip greens were harvested in September from each station; turnips were purchased in September. Samples were analyzed for gross alpha and beta, gamma emitters, tritium, and isotopic uranium. Tables 5.16–5.18 summarize the results of the sampling effort.

Table 5.16. Results of radiological analysis of tomatoes grown on the ORR, 1993

Parameter	Station Concentration (pCi/g)[a]								
	35	37	38	39	40	42	46	48	51
^{60}Co								4.9E–03	
Gross alpha	8.7E–01								
Gross beta		1.8E+00	2.0E+00	1.7E+00	1.3E+00	8.7E–01	1.3E+00	1.5E+00	1.1E+00
^{239}Pu		1.6E–04		1.7E–04				1.4E–04	9.0E–05
^{228}Th	1.3E–04	1.5E–04				1.3E–04			
^{230}Th	1.5E–04	1.7E–04		1.3E–04			1.3E–04	1.5E–04	1.9E–04
^{232}Th					1.1E–03				
Total rad Sr				2.3E–02	1.8E–02				
^{234}U	3.0E–04	6.4E–04	1.1E–03	1.1E–03	5.3E–04	4.0E–04	3.4E–04	1.0E–03	9.5E–04
^{235}U		2.7E–04				1.8E–04		2.6E–04	2.8E–04
^{238}U	4.5E–04	4.1E–04	4.3E–04		2.4E–04	2.4E–04		3.6E–04	6.8E–04

[a] 1 pCi = 3.7E–02 Bq.

The analytical results indicate that radionuclide concentrations in tomatoes and turnip greens do not vary significantly when comparing samples obtained from the ORR plots with those collected at the reference station. There is no reference sample for the purchased turnips, but information will be available from the Norris Dam plot in 1994 for comparisons.

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 1993 milk sampling program consisted of monthly grab samples collected from five locations in the vicinity of the ORR (Fig. 5.25). Milk samples are analyzed at ORNL for radioactive iodine (^{131}I) by gamma spectrometry and for total radioactive strontium (^{89}Sr + ^{90}Sr) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for tritium (^{3}H).

Results

Concentrations of total radioactive strontium were detected in milk (Table 5.19). There were no detected concentrations of ^{131}I or ^{3}H. Radioactivity measurements are reported as the net activity, or the difference between the gross activity and instrument background; a value is declared greater than zero and considered to be

Table 5.17. Results of radiological analysis of turnip greens grown on the ORR, 1993

Parameter	Station concentration (pCi/g)[a]								
	35	37	38	39	40	42	46	48	51
^{241}Am		2.8E–03	6.5E–03		1.6E–03		2.8E–03	2.3E–03	2.8E–03
^{7}Be	8.2E–01	1.4E+00	7.0E–01	6.4E–01	6.6E–01	6.4E–01	9.3E–01	8.9E–01	6.1E–01
^{137}Cs					1.2E–02		2.1E–02		
Gross alpha	2.1E–01	2.6E–01	3.1E–01	1.1E–01	6.5E–01	1.1E–01	4.6E–01	2.2E–01	1.6E–01
Gross beta	3.8E+00	4.1E+00	4.7E+00	3.6E+00	3.9E+00	4.1E+00	4.2E+00	3.7E+00	4.5E+00
^{40}K	5.1E+00	5.0E+00	5.0E+00	4.6E+00	4.5E+00	5.4E+00	5.5E+00	5.4E+00	4.2E+00
^{239}Pu							3.7E–03		
^{228}Th	1.0E–02		6.4E–03		8.9E–03	5.1E–03	1.2E–02	8.5E–03	3.8E–03
^{230}Th	1.3E–02	1.1E–02	8.1E–03	3.1E–03	1.0E–02	1.8E–03	1.5E–02	1.3E–02	5.3E–03
^{232}Th	6.3E–04		3.5E–03		7.3E–03	2.4E–03	1.3E–02	4.9E–03	2.7E–03
Total rad Sr	2.1E–01	2.3E–01	1.7E–01		2.1E–01		3.1E–01	2.0E–01	2.2E–01
^{234}U	2.7E–02	1.6E–02	1.4E–02	7.6E–03	2.2E–02	7.6E–03	1.8E–02	1.3E–02	5.6E–03
^{235}U	3.0E–03	3.2E–03	3.7E–03	2.8E–03			1.8E–03	1.5E–03	2.4E–03
^{238}U	1.2E–02	9.2E–03	9.7E–03	2.7E–03	8.8E–03	2.2E–03	1.1E–02	1.0E–02	6.0E–03

[a] 1 pCi = 3.7E–02 Bq.

a detected value if it exceeds 1.645 times its estimated standard error. Average values for radioactive strontium were converted to effective dose equivalents and are presented in Sect. 6 of this report. Results are consistent with data from previous years.

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 ORR environmental monitoring plan by collecting fish from 14 locations annually and analyzing edible fish flesh. Sampling locations are located downstream of DOE activities, at upstream reference locations, and at one off-site reference location. Sampling sites are divided into six larger river locations and eight smaller creek locations. Because of the limited number and size of fish available for sampling on the creek locations, different fish-processing and analytical procedures are used. Only results from sampling at river locations are presented in this report.

Table 5.18. Results of radiological analysis of turnips grown in private gardens on the ORR, 1993

Parameter	Station concentration (pCi/g)[a]		
	39	40	42
^{7}Be	8.7E–02	5.0E–02	
Gross alpha	8.2E–02	7.2E–02	
Gross beta	2.3E+00	2.0E+00	2.1E+00
^{40}K	2.8E+00	2.7E+00	3.5E+00
^{230}Th	3.1E–03	1.4E–02	1.2E–02
^{232}Th	3.1E–03		
^{234}U	1.3E–02	2.1E–02	1.1E–02
^{235}U		1.3E–02	
^{238}U		8.4E–03	5.0E–03

[a] 1 pCi = 3.7E–02 Bq.

The river locations include five sites on the Clinch River and one location on Poplar Creek (Fig. 5.26):

- Melton Hill Reservoir above all DOE inputs, Anderson County Filtration Plant (CRK 84),
- Melton Hill Reservoir, Oak Ridge Marina (CRK 80),
- Melton Hill Reservoir above 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 K-25 Site (PCK 2.2).

Additional monitoring of wildlife on the ORR, both aquatic and terrestrial, is conducted under the Biological Monitoring and Abatement Program (BMAP), a requirement of facility NPDES permits. The eight creek locations for fish collection are included in this effort. Results from this monitoring program are given in a separate report (Martin Marietta 1994*a*).

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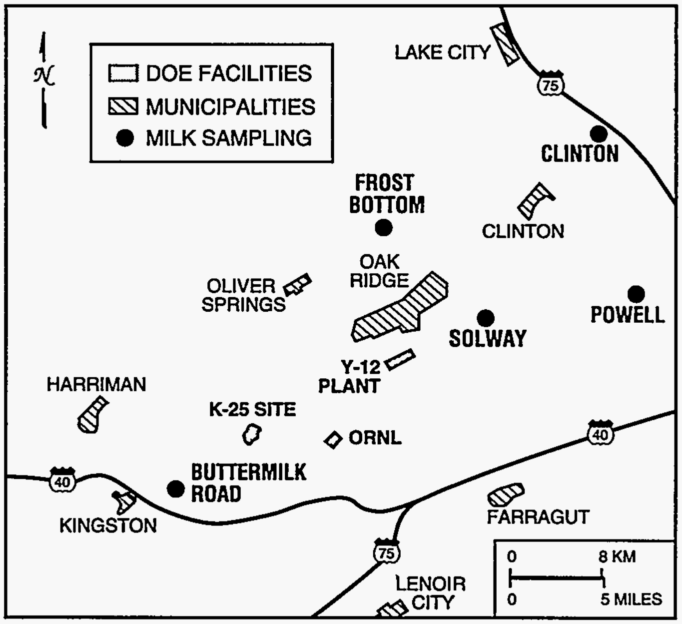

Fig. 5.25. Milk sampling locations in the vicinity of the ORR.

Table 5.19. Concentrations of total radioactive strontium (^{89}Sr + ^{90}Sr) in raw milk, 1993

Station	No. detected/ No. of samples	Detected concentration (pCi/L)[a]			Standard error[b]
		Max	Min	Av	
Buttermilk Road	9/12	2.03	0.68	1.16[c]	0.14
Powell	11/12	2.54	0.70	1.41[c]	0.18
Clinton	11/11	3.78	0.59	1.55[c]	0.28
Frost Bottom	12/12	3.24	1.05	1.79[c]	0.17
Solway	6/6	5.67	2.11	3.64[c]	0.39
Network summary	49/53	5.67	0.59	1.76	0.15

[a] 1 pCi = 3.7E–2 Bq.

[b] Standard error of the mean.

[c] Average is significantly greater than zero at the 95% confidence level. The average value for EPA Region IV is 1.8 pCi/L (U.S. EPA 1993*a*).

Sunfish (*Lepomis machrochirus, L. auritus,* and *Amblophlites 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, six to ten catfish are also 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.

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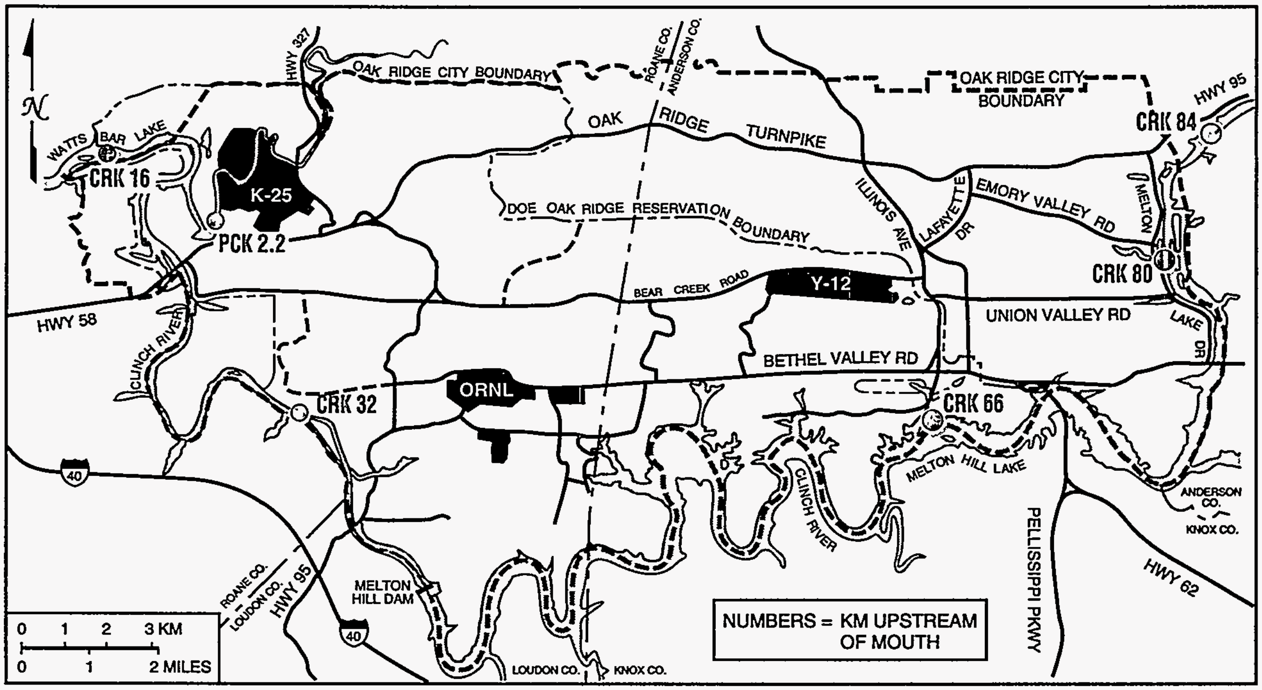

Fig. 5.26. Fish sampling locations along the Clinch River.

Results

For all six locations, most parameters analyzed for in sunfish were undetected. Parameters that were detected in at least one of the six individual samples (metals, pesticides, and PCBs) or in at least one of the three composite samples (radionuclides) are shown in Table 5.20.

Table 5.20. Parameters detected in sunfish from Poplar Creek and Clinch River locations, 1993

	PCK 2.2	CRK 16	CRK 32	CRK 66	CRK 80	CRK 84
			Metals			
Arsenic	X	X				
Chromium	X	X	X	X	X	X
Copper	X	X	X	X	X	X
Lead	X					
Mercury	X	X	X	X	X	X
Selenium	X	X	X	X	X	X
Silver	X					X
Uranium	X	X	X	X	X	X
Zinc	X	X	X	X	X	X
			Pesticides			
4,4′-DDE	X		X			
			PCBs			
Aroclor-1254	X	X	X			
			Radionuclides			
^{137}Cs	X	X	X			X
^{60}Co			X			
Total rad Sr	X	X	X	X	X	X

Most parameters analyzed for in catfish collected at CRK 16 and CRK 32 were undetected. Parameters that were detected in catfish are shown in Table 5.21. Catfish sampling was initiated in 1993, and the locations are sampled annually. Given that this is the first year, there are no historical data that can be used for comparison with the 1993 results.

Table 5.21. Parameters detected in catfish from two Clinch River locations, 1993

	CRK 16	CRK 32
	Metals	
Arsenic	X	
Mercury	X	X
Nickel		X
Thallium	X	
Uranium	X	
Zinc		X
	Pesticides	
4,4′-DDD		X
4,4′-DDE	X	X
Alpha-Chlordane	X	X
	Radionuclides	
^{137}Cs	X	X
Total rad Sr		X

For PCBs, reported values for sunfish and catfish were below the federal Food and Drug Administration (FDA) tolerance of 2 ppm; for mercury, all reported values were below the FDA action level of 1 ppm. Information regarding potential health impacts associated with the sunfish and catfish data is provided in Sect. 6.

White-Tailed Deer

The ninth annual deer hunts managed by DOE and the Tennessee Wildlife Resources Agency were held on the ORR during the final quarter of 1993. ORNL staff, assisted by student members of the Wildlife Society (University of Tennessee Chapter), performed most of the necessary operations at the checking station.

The basic conduct of the managed hunts for 1993 was similar to those of previous years. One archery hunt was held (Oct. 16–17), as were two shotgun-muzzle-loader hunts (Nov. 13–14 and Dec. 11–12). During the archery hunt, 68 deer were taken; 332 were killed during the two gun hunts. From the total harvest of 400 animals, 211 (52.8%) were bucks and 189 (47.2%) were does. The heaviest buck had 10 antler points and weighed 185 lb. The greatest number of points (14) was found on a buck weighing 166 lb. The heaviest doe weighed 120 lb.

Results

Radioactivity concentrations of ^{137}Cs in soft tissue (liver or muscle) continued to be low and acceptable; none of the harvest exceeded 1.0 pCi/g. (The confiscation limit is 5 pCi/g.) Concentrations of ^{90}Sr in bone exceeded 20 pCi/g (the confiscation limit) in 7 deer, which is 1.8% of the 400 harvested.

Resident Canada Geese

One objective of the ORR waterfowl program is to determine concentrations of contaminants 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 for leg-banding and collaring took place on June 29 and 30, 1993. During the roundup, whole-body gamma scans were conducted on 57 geese at the deer-checking station: 10 geese each from ORNL, the K-25 Site, Melton Hill Dam, Oak Ridge Marina, and Clark Center Park; 5 from Solway Park; and 2 from the Y-12 Plant were analyzed. Afterward, the geese were returned to their original areas.

Results

Of the 57 geese counted in 1993, 26 had concentrations of ^{137}Cs that were considered to be statistically greater than zero. Of these, the highest concentration, 0.09 pCi/g, was found in a goose collected at the K-25 Site. The average ^{137}Cs concentration in the 26 geese was estimated to be 0.05 pCi/g.

6. Dose

S. J. Cotter, F. R. O Donnell, and P. A. Scofield

Abstract

The interaction of the radiation emitted by radionuclides with human tissue accounts for most of the doses from radionuclides in the environment. Radionuclides can be taken into the body through ingestion, inhalation, and skin absorption. Humans can also be exposed directly to radiation sources outside the body, which can include radionuclides. Radiation dose can be estimated based on type of radiation, route and length of exposure, and organs exposed. This section presents estimates of the radiation from the small quantities of radionuclides released to air and water as a result of operations at the Oak Ridge Reservation facilities during 1993 and describes the methods used to make these estimates.

RADIATION DOSE

Small quantities of radionuclides were released to the environment from operations at the ORR facilities during 1993. Those releases are quantified and characterized in Sects. 4, 5, and 7. This section presents estimates of the potential radiation from the releases and describes the methods used to make the estimates.

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 tissue and thus do not irradiate the body uniformly.)

A number of the specialized units used to characterize exposures to ionizing radiation are defined in Appendix A. One of these is used repeatedly in this section and is defined as the effective dose equivalent (EDE), 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 (sieverts).

Methods of Evaluation

Airborne Radionuclides

Characterization of the radiological consequences of radionuclides released to the atmosphere from ORR operations during 1993 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 sponsorship of the EPA for use in demonstrating compliance with Rad-NESHAP 40 CFR 61, Subpart H. This package contains the most recent, 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 latest version of the DARTAB computer code to calculate EDEs from radionuclides released to the atmosphere. The dose calculations use the DCFs contained in the ALLRAD88 data file (Beres 1990).

Three types of radionuclide releases were reported in the ORR Rad-NESHAP report for 1993: monitored, sampled, and calculated. Monitored releases are quantified using data from continuous sampling systems. Monitored sources during 1993 included the combined monitored stacks at the Y-12 Plant; stacks associated with buildings 2026, 2523, 3020, 3039, 7830, 7877, and Stack 7911 at ORNL; and the K-25 Site TSCA Incinerator (K-1435) stack.

Sampled releases are calculated using measured radionuclide contents of various media (e.g., grab samples of room air concentrations and sections of filters) and measured flow rates through the sampled media. Sampled sources during 1993 include room exhausts at the Y-12 Plant; stacks associated with buildings 2000, 2523, 3018, 3074, 3544, 7025, and 7512 at ORNL; and discharge points associated with the K-1015 laundry and the K31/K33 R114 transfer project and purging operation at the K-25 Site.

Calculated releases are determined from source inventories (e.g., hot cell, hood, and storage area) using EPA-approved emission factors. Therefore, these calculated releases are conservative and largely hypothetical releases. Their purpose is to determine whether source monitoring or sampling is required. All doses (including those derived from these hypothetical releases) must be reported in the annual site environmental report and in the Rad-NESHAP report; however, it is important to realize that radiation doses associated with calculated releases, which may be hypothetical, are added to the doses associated with monitored and sampled releases.

Monitored and sampled radionuclide releases were modeled for 1 combined release point at the Y-12 Plant, for 13 release points at ORNL, and for 3 release points at the K-25 Site. Table 6.1 lists the source parameter values used in the calculations.

Meteorological data used in the calculations consisted of joint frequency (STAR) distributions of wind direction, wind speed class, and atmospheric stability category. These were derived from data collected during 1993 at the 100-m height on meteorological tower 2 (MT2) for stacks 2000, 2026, 2523, 3018, 3020, 3039, 3074, 3544, and 7025 and at the 30-m height on MT4 for stacks 7512, 7830, 7877, and 7911 at ORNL; at the 60-m height on MT1 for the K-25 Site; and at the 60-m height on MT6 for the Y-12 Plant. Rainfall on the ORR during 1993 was 126 cm (49.6 in.), the average air temperature was 14°C (57°F), and the average mixing layer height was 1000 m.

The dose calculations assume 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 1.4 mrem (0.014 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. About 0.2 mrem (0.002 mSv) of the 1.4 mrem is from calculated emissions. The maximally exposed individual is located about 9300 m (5.8 miles) northeast of the 3039 stack at ORNL, about 13,000 m (8.1 miles) east-northeast of the K-1435 (TSCA Incinerator) stack at the K-25 Site, and about 1080 m (0.7 miles) north-northeast of the Y-12 Plant release point. The calculated collective EDE to the entire population within 80 km (50 miles) of the ORR (about 879,546 persons) was about 26 person-rem (0.26 person-Sv), which is 0.01% of the 264,000 person-rem that this population could have received from natural sources of radiation. About 3 of the 26 person-rem are from calculated emissions.

The EDE received by the hypothetical, maximally exposed individual for the Y-12 Plant was calculated to be 1.3 mrem (0.013 mSv). This individual is located about 1080 m (0.7 miles) NNE of the Y-12 Plant release

Table 6.1. Release 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			
All	Point	20	0	0	Ambient	1080 NNE	1080 NNE
				ORNL			
2026	Point	22.9	1.07	10.1	Ambient	5450 E	9300 NE
3020	Point	61.0	1.52	5.5	Ambient	5450 E	9300 NE
3039	Point	76.2	2.44	2.0	Ambient	5450 E	9300 NE
7025	Point	4.0	0.31	13.6	Ambient	3500 E	7550 NNE
7512	Point	30.5	0.91	8.4	Ambient	4540 ENE	9640 NNE
7911	Point	76.2	1.52	2.4	Ambient	4540 ENE	9640 NNE
7830	Point	4.6	0.22	8.0	Ambient	5810 ENE	10990 NNE
7877	Point	13.9	0.51	8.6	Ambient	5810 ENE	10990 NNE
2000	Point	15.2	0.66	8.9	Ambient	5450 E	9300 NE
3018	Point	61.0	4.11	0.2	Ambient	5450 E	9300 NE
3074	Point	4.0	0.26	10.2	Ambient	5450 E	9300 NE
3544	Point	9.5	0.27	18.0	Ambient	5450 E	9300 NE
2523	Point	7.0	0.3	7.8	57.2	5450 E	9300 NE
				K-25 Site			
K-1435	Point	30.5	1.37	5.6	79.1	5180 SWS	13000 ENE
K-1015	Point	3.7	0	0	Ambient	4340 WSW	14000 ENE
K-31/K-33	Point	25.9	0	0	Ambient		

point. Essentially, all (99%) of this dose is from ingestion and inhalation of uranium, primarily ^{234}U, ^{235}U, and ^{238}U. 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 12 person-rem (0.12 person-Sv), which is 47% of the collective EDE for the ORR.

The EDE received by the hypothetical, maximally exposed individual for ORNL was calculated to be 0.1 mrem (0.001 mSv). This individual is located 5450 m (3.4 miles) east of the 3039 stack and 4540 m (2.8 miles) east-northeast of the 7911 stack. About 8% of this dose is from ingestion and inhalation of tritium; about 55% is from immersion in noble gases. Calculated source terms account for about 25% of the dose. The contribution of ORNL emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 6 person-rem (0.06 person-Sv), which is 21% of the collective EDE for the ORR.

The EDE received by the hypothetical, maximally exposed individual for the K-25 Site was calculated to be 0.1 mrem (0.001 mSv). This individual is located about 5180 m (3.2 miles) west-southwest of the TSCA Incinerator (K-1435) stack. About 57% of this dose is from ingestion and inhalation of uranium, about 8% is from thorium, and about 10% is from neptunium-237. The contribution of K-25 Site emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be about 8 person-rem (0.08 person-Sv), which is 32% of the collective EDE for the reservation.

The reasonableness of the calculated radiation doses can be inferred by examining the radiation doses that could be received from measured air concentrations of radionuclides at the ORR perimeter air monitoring

Table 6.2. Calculated radiation doses to maximally exposed off-site individuals from airborne releases during 1993

Plant	Total effective dose equivalents [mrem (mSv)]	
	Plant max	ORR max
ORNL	0.1 (1E–3)[a]	3E–2 (3E–4)
K-25 Site	0.1 (1E–3)[b]	4E–2 (4E–4)
Y-12 Plant	1.3 (1.3E–2)[c]	1.3 (1.3E–2)
Entire ORR	NA[d]	1.4 (1.4E–2)

[a] The maximally exposed individual is located 5450 m (3.4 miles) E of the 3039 stack and 4540 m (2.8 miles) ENE 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] 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 1993

Plant	Effective dose equivalents	
	Person-rem[a]	Person-Sv
ORNL	6	6E–2
K-25 Site	8	8E–2
Y-12 Plant	12	1.2E–1
ORR	26	2.6E–1

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

stations (PAMs) and the remote air monitoring stations (RAMs) (Fig. 5.4). Individuals assumed to reside at the PAMs have the potential to receive EDEs between 0.3 and 0.7 mrem/year (0.003 and 0.007 mSv/year); these doses include contributions from naturally occurring (background) radionuclides, from 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 0.3 mrem/year (0.003 mSv/year). Between 30 and 70% of the calculated EDEs are attributable to tritium, which was measured at PAMs and RAMs for the first time this year. The source of this tritium is undetermined at this time.

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 0.3 mrem/year (0.003 mSv/year), which is lower than the

1.4 mrem/year (0.014 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 0.7 mrem/year (0.007 mSv/year), which is substantially greater than the 0.1 mrem/year (0.001 mSv/year) based on CAP-88 code modeling. PAM 35 is located near the maximally exposed individual for the K-25 Site. The EDE calculated at PAM 35 was 0.5 mrem/year (0.005 mSv/year), which is higher than the 0.1 mrem/year (0.001 mSv/year) modeled value to the maximally exposed individual.

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 East Fork Poplar Creek, both of which enter Poplar Creek before it enters the Clinch River. Discharges from ORNL enter the Clinch River by way of White Oak Creek and White Oak Lake. Discharges from the K-25 Site 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 K-25 Site (Gallaher) water plant and at the Kingston municipal water plant were used to calculate a maximum individual EDE from drinking water. A person who drank 730 L of K-25 Site water during 1993 could have received an EDE of about 0.2 mrem (0.002 mSv); a person who drank 730 L of Kingston water could have received about 0.07 mrem (0.007 mSv).

A new program was initiated during 1993 that involved sampling 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 (Fig. 5.14). 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.

For locations at which fish were sampled, maximum individual EDEs from eating 21 kg of fish ranged from 0.02 to 0.2 mrem (0.0002 to 0.002 mSv). The maximum value occurred at CRK 32, which is below ORNL inputs and above the confluence of Poplar Creek (Table 6.4).

Measured concentrations of radionuclides in water at the selected locations were input to the LADTAP XL computer code (Hamby 1991) to calculate a potential EDE to maximally exposed individuals who were assumed to swim for 27 hours/year, to boat for 63 hours/year, and to use the shoreline for 67 hours/year at the sampled location. Table 6.4 is a summary of the potential EDEs. Shoreline usage is a significant contributor. Doses attributable to swimming and boating are negligibly small. Except at CRK 84, all potential maximum EDEs, both above and below the ORR, are similar—between 0.1 and 0.2 mrem (0.001 and 0.002 mSv).

At CRK 84, which is above all DOE inputs, the calculated maximum individual EDE is about an order of magnitude below all other calculated values for Clinch River water. The lower dose arises from the fact that only uranium was detected at this location.

When all pathways are considered, the maximally exposed individual to waterborne radionuclide discharges could have received an EDE of about 0.4 mrem (0.004 mSv): 0.2 mrem (0.002 mSv) from use of off-site waters plus 0.2 mrem (0.002 mSv) from drinking K-25 Site water. The collective EDE to the 50-mile population was estimated to be about 2 person-rem (0.02 person-Sv). These are small percentages of individual and collective doses attributable to natural background radiation, 0.1% and 0.0008%, respectively.

Radionuclides in Other Environmental Media

Milk

The CAP-88 computer codes calculate radiation doses from ingestion of meat, milk, and vegetables that contain radionuclides released to the atmosphere. The doses are included in the dose calculations for airborne radionuclides.

One environmental pathway for ingestion, drinking milk, also was evaluated using concentrations of strontium and ^{131}I measured in milk collected from nearby farms. An individual was assumed to drink 310 L of milk containing the highest measured quantity of total strontium (taken to be ^{90}Sr). Such an individual could have received an EDE of about 0.1 mrem (0.001 mSv). No ^{131}I was detected in milk samples during 1993.

Table 6.4. Potential maximum individual EDEs (mrem)[a] from use of off-site waters

Location	Eating fish	Swimming	Boating	Using shoreline	Total
CRK 84: Clinch River above all DOE input	0.03	6E–9	3E–9	2E–4	0.03
CRK 80: Clinch River at Oak Ridge Marina	0.02	6E–4	9E–5	0.2	0.2
CRK 66: Clinch River above Oak Ridge city water intake	0.02	2E–4	6E–5	0.1	0.1
CRK 58: Clinch River at Knox County water intake	*b*	3E–4	2E–4	0.2	0.2
CRK 32: Clinch River below ORNL	0.2	8E–5	2E–7	2E–3	0.2
CRK 23: Clinch River at K-25 Site water intake	*b*	9E–5	4E–5	0.2	0.2
CRK 16: Clinch River below all DOE inputs	0.04	2E–5	7E–6	5E–2	0.1
TRK 915: Tennessee River at Kingston Water Plant intake	*b*	5E–5	8E–6	6E–2	0.06
PCK 22: Poplar Creek above union with East Fork Poplar Creek	*b*	2E–4	7E–5	0.1	0.1
PCK 2.2: Poplar Creek below the K-25 Site	0.06	3E–5	7E–8	1E–3	0.06

[a] To convert mrem to mSv, divide the given values by 100.
[b] Not sampled.

Crops

Another environmental pathway for ingestion that was evaluated separately is eating vegetables. In 1993, tomatoes and turnip greens were sampled from nine plots located at the ORR perimeter air monitoring stations. Turnips were purchased from private gardens in nearby locations. Hay grown on the ORR also was sampled. Three types of vegetables were sampled: tomatoes, turnip greens, and turnips. These vegetable types were chosen as representative of fruit-bearing, leafy, and root vegetables.

To calculate potential EDEs from eating the sampled vegetables, it was assumed that a person ate 13 kg of leafy vegetables, 9.4 kg of homegrown tomatoes, and 55 kg of root vegetables during the year. These ingestion rates also assume that about 70% of the produce consumed was grown locally. Based on these assumptions, the maximum individual's EDE from eating all three vegetable types could have been about 6 mrem (0.06 mSv): about 0.01 mrem (0.0001 mSv) from fruit-bearing vegetables, about 2 mrem (0.02 mSv) from leafy vegetables, and about 4 mrem (0.04 mSv) from root vegetables (Table 6.5). If the contribution of ^{40}K, which is strictly a naturally occurring radionuclide to this dose [about 73% or 4 mrem (0.04 mSv)] is excluded, the maximum individual EDE could have been about 2 mrem (0.02 mSv). This 2 mrem was from the other radionuclides detected in the vegetables. Detected isotopes include thorium (^{228}Th, ^{230}Th, and ^{232}Th), uranium (^{234}U, ^{235}U, and ^{238}U), and total strontium (taken to be ^{90}Sr). Although these radionuclides are measured in emissions from the

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

Vegetable	EDE [mrem (mSv)]	
	All reported radionuclides	Excluding ^{40}K
Tomatoes	1E–2 (1E–4)	1E–2 (1E–4)[a]
Turnip greens	2 (2E–2)	0.7 (7E–3)
Turnips	4 (4E–2)	0.8 (8E–3)
Total	6 (6E–2)	2 (2E–2)

[a] No ^{40}K concentrations were reported in tomatoes.

ORR, many (thorium and uranium isotopes) occur naturally in soil and fertilizers that are spread on gardens. Therefore, most of the radioactivity found in the vegetables and the associated radiation doses are not attributable to ORR operations.

A sample of hay grown on the ORR contained ^{7}Be, ^{60}Co, and ^{40}K. Essentially all of the dose to man, from eating beef and drinking milk from cattle that eat hay, was from the naturally occurring ^{40}K. The EDE from drinking milk and eating beef containing ^{7}Be (also naturally occurring) and ^{60}Co was 7E–2 mrem (7E–4 mSv).

White-Tailed Deer

Several deer hunts were held on the ORR during 1993. A total of 400 deer were killed, of which 7 were confiscated because their radionuclide content exceeded the release limit (20 pCi/g ^{90}Sr in bone). The remaining 393 deer had an average field-dressed weight of about 38 kg (83 lb). Assuming 55% of the dressed weight is edible, the average deer would yield about 21 kg (46 lb) of meat. Therefore, based on the average weight, the total harvest of edible meat was about 8,138 kg (17,940 lb).

All deer were surveyed at the Tennessee Wildlife Resources Agency inspection station to determine the ^{137}Cs content in tissue and total strontium in bone. The average ^{137}Cs concentration in the 393 released deer was 0.27 pCi/g (0.01 Bq/g).

The collective EDE from eating all the harvested deer meat with an average ^{137}Cs concentration of 0.27 pCi/g could have been about 0.1 person-rem (0.001 person-Sv). The EDE for an individual consuming one deer with the average concentration of ^{137}Cs was estimated to be 0.3 mrem (0.003 mSv).

To estimate the EDE to the maximally exposed individual, it was assumed that one person consumed the two deer that could give the highest individual EDE because of their radionuclide content and weight. The two deer that gave the highest dose estimates contained about 2.65 and 2.1 pCi/g (0.098 and 0.078 Bq/g) of ^{137}Cs. In the unlikely event that one person consumed the two deer with the highest ^{137}Cs concentrations, that person could have received an EDE of about 4.6 mrem (0.046 mSv).

Canada Geese

Canada geese are known to use waters on the ORR, even though such use is actively discouraged in contaminated areas. Some data have been collected on radionuclide concentrations in these geese; however, the degree to which the collected data give a representative picture of such concentrations is unknown.

During the annual roundup of Canada geese for leg banding and collaring, whole-body gamma scans were conducted on 57 geese at the deer-checking station. The geese were collected from the Y-12 Plant (2 geese), ORNL (10 geese), the K-25 Site (10 geese), Clark Center Park (10 geese), Solway Park (5 geese), Melton Hill Dam (10 geese), and the Oak Ridge Marina (10 geese) and were surveyed for ^{137}Cs concentrations. Only 26 had concentrations of ^{137}Cs that were considered to be statistically greater than zero. From these 26 results, the average ^{137}Cs concentration was 0.05 pCi/g (1.9 Bq/kg). The maximum concentration, surveyed in a goose collected from the K-25 Site, was 0.09 pCi/g (3.2 Bq/kg).

The total number of goose-hunting days in 1993 was about 70 days. The daily bag limit was two geese. It was estimated that of all the geese harvested from both the Middle Tennessee Unit and Watts Bar, 426 of them could have spent time on the ORR.

The average male giant Canada goose weighs about 5.7 kg (12.5 lb), half of which is assumed to be edible. Thus a person eating the most contaminated goose could have received an EDE of about 0.01 mrem (0.0001 mSv). A person eating the average goose could have received an EDE of about 0.007 mrem (0.00007 mSv). The collective EDE from eating 426 geese harvested in 1993 could have been about 0.003 person-rem (0.00003 person-Sv), assuming all were contaminated at the average level.

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 effective dose equivalent 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 perimeter air monitoring stations around the ORR during 1993 was about 7.5 μR/hour. This equals a dose rate of about 49 mrem/year (0.49 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 K-25 Site.

During 1987, external exposure rate measurements were taken along a 1.7-km (1.1-mile) length of Clinch River bank that is affected by air-scattered radiation emanating from ^{137m}Ba, which derives from ^{137}Cs that was used in experiments on a nearby field. 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 are attributable to radiation emanating from the cesium field and from natural sources. Assuming that the background exposure rate equalled the rate measured at the ORR perimeter air monitoring stations during 1987 (about 5.1 μR/hour), the average exposure rate along the river bank because of ORR operations would have been about 8 μR/hour. This translates to an EDE rate of about 0.006 mrem/hour or 53 mrem/year (0.00006 mSv/hour or 0.53 mSv/year) 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 1993. This dose estimate is high because most of the ^{137}Cs was removed from the experimental fields in 1993.

The radiation field along Poplar Creek emanates from storage areas within the K-25 Site. 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, taken along the creek during 1993 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/h, which corresponds to an EDE rate of 0.004 mrem/hour. A 4-hour fishing trip could have resulted in reception of an EDE between 0.01 to 0.02 mrem (0.0001 to 0.0003 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).

Actual fishing activity on the affected stretch of Poplar Creek needs to be determined to obtain a more realistic assessment of this exposure pathway. It is extremely unlikely that anyone would fish this stretch of Poplar Creek for 250 hours/year.

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., crawdads), 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. Measured (maximum and average) concentrations of radionuclides 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 crawdads and mollusks. Direct radiation doses from sediment are estimated from water concentrations using factors such as a geometry roughness factor, sediment deposition transfer factor, and nuclide-specific ground-surface irradiation dose factors.

Table 6.6 lists average and maximum total dose rates to aquatic organisms from waterways at ORNL. The doses are based on water concentrations associated with nine different sampling locations: Melton Branch (Outfalls X-13 and 2), White Oak Creek (Outfall X-14), White Oak Dam (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 much less than 1 rad/day (0.01 Gy/day).

Table 6.6. 1993 total dose rate for aquatic organisms (rad/day),[a,b] ORNL

Measurement location	Fish average	Fish maximum	Crustacea average	Crustacea maximum	Muskrat average	Muskrat maximum
Melton Branch (X-13)	3.1E–3	5.1E–3	2.7E–2	4.4E–2	7.4E–3	1.2E–2
White Oak Creek (X14)	2.1E–3	4.9E–3	5.6E–3	1.2E–2	1.9E–3	4.3E–3
White Oak Dam (X15)	1.5E–3	3.5E–3	9.3E–3	1.5E–2	2.6E–3	4.5E–3
7500 Road Bridge	1.9E–3	5.0E–3	4.6E–3	9.3E–3	1.6E–3	3.6E–3
First Creek	1.2E–3	3.5E–3	1.1E–2	2.5E–2	2.9E–3	6.8E–3
Fifth Creek	3.1E–4	7.3E–4	1.5E–3	2.4E–3	4.3E–4	7.7E–4
Melton Branch 2	1.7E–5	6.3E–4	1.2E–4	1.4E–3	3.8E–5	3.3E–4
Northwest Tributary	3.6E–4	1.8E–3	1.8E–3	4.9E–3	5.3E–4	1.4E–3
Raccoon Creek	1.6E–4	1.4E–3	1.6E–3	5.4E–3	4.1E–4	1.4E–3

[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 gray/day divide by 100.

The highest dose rates, which were associated with maximum concentrations of radionuclides in water, occurred at Melton Branch (X-13): 0.005 rad/day (0.00005 Gy/day) to fish (a similar dose rate was estimated at the 7500 Bridge), 0.044 rad/day (0.00044 Gy/day) to crustacea, and 0.012 rad/day (0.00012 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).

Table 6.7 lists average and maximum dose rates to aquatic organisms from waterways at the Y-12 Plant and the K-25 Site. At the Y-12 Plant, aquatic organism doses were estimated from radionuclide water concentrations obtained at Bear Creek (Outfall 304), East Fork Poplar Creek (Station 17) and Rogers Quarry (Outfall 302). The maximum estimated dose to aquatic organisms was at East Fork Poplar Creek (Station 17): 0.00043 rad/day (0.0000043 Gy/day) to fish, 0.0023 rad/day (0.000023 Gy/day) to crustacea, and 0.061 rad/day (0.00061 Gy/day) to muskrats.

Similar analyses were conducted at the K-25 Site. The waterways evaluated were Mitchell Branch (K-1700), Poplar Creek (Outfall 005), and in the holding pond that discharges into the Clinch River (K-901-A). The highest estimated absorbed dose to fish was 0.075 rad/day (0.00075 Gy/day) at Poplar Creek (Outfall 005). The highest

Table 6.7. 1993 total dose rate for aquatic organisms (rad/day),[a,b] Y-12 Plant and K-25 Site

Measurement location	Fish average	Fish maximum	Crustacea average	Crustacea maximum	Muskrat average	Muskrat maximum
			Y-12 Plant			
East Fork Poplar Creek (Station 17)	6.9E–5	4.3E–4	3.3 E–4	2.3E–3	4.7E–3	6.1E–2
Bear Creek (Outfall 304)	6.8E–5	3.5E–4	3.3 E–4	1.9E–3	1.1E–3	4.7E–2
Rogers Quarry Outfall 302	3.0E–5	1.1E–4	2.7E–4	1.0E–3	1.5E–5	1.2E–4
			K-25 Site			
Mitchell Branch (K-1700)	3.8E–3	4.3E–2	3.7E–2	4.3E–1	6.8E–4	6.5E–3
Poplar Creek (Outfall 005)	8.7E–3	7.5E–2	8.4E–2	7.3E–1	1.4E–3	1.0E–2
Clinch River (Holding Pond, K-901-A)	2.7E–3	3.2E–2	2.9E–2	3.3E–1	2.3E–3	2.5E–2

[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.

dose rate for crustacea, 0.73 rad/day (0.0073 Gy/day), was also at Outfall 005. The maximum dose rate to muskrats was at the holding pond (K-901-A): 0.025 rad/day (0.00025 Gy/day). With the exception of the maximum dose to crustacea at Poplar Creek (Outfall 005), absorbed doses estimated from maximum radionuclide water concentrations determined on the ORR still resulted in doses far less than the 1 rad/day (0.01 Gy/day) limit prescribed in DOE Order 5400.5.

Current-Year Summary

A summary of the maximum EDEs to individuals by several pathways of exposure is given in Table 6.8. It is unlikely (if not impossible) that any real person could have been irradiated by all of these sources and pathways for a period of 1 year. However, if the resident who received the highest EDE [1.4 mrem (0.014 mSv)] from gaseous effluents, also drank water from the Gallaher plant [0.2 mrem (0.002 mSv)], ate fish from CRK 32 (0.2 mrem), and fished the Clinch River near the cesium field (1 mrem), he or she could have received a total EDE of about 3 mrem (0.03 mSv), or about 1% of the annual dose [300 mrem (3 mSv)] from background radiation. If the individual fished Poplar Creek (1 mrem), the maximum individual dose also could have been about 3 mrem (0.03 mSv), 1% of the natural background dose.

DOE Order 5400.5 limits to no more than 100 mrem (1 mSv) the effective dose equivalent that an individual may receive from all exposure pathways from all radionuclides released from the ORR during 1 year. As described in the preceding paragraph, the 1993 maximum EDE could have been about 3 mrem (0.03 mSv), or about 3% of the limit given in DOE Order 5400.5.

Table 6.8. Summary of estimated radiation dose equivalents to an adult during 1993 at locations of maximum exposure

Pathway	Location	Effective dose equivalent	
		(mrem)	(mSv)
Gaseous effluents	Maximally exposed resident to		
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	1.3	0.013
	ORNL	0.1	0.001
	K-25 Site	0.1	0.001
	ORR	1.4	0.014
Liquid effluents			0.002
Drinking water	Gallaher Water Plant	0.2	0.016
Eating fish	Clinch River, CRK 32	0.2	0.002
Other activities	Clinch River	0.2	
Direct radiation	Clinch River shoreline	1[a]	0.01
	Poplar Creek (K-25 Site)	1	0.11

[a] This is an overestimate of the potential dose because the source of direct radiation was remediated during 1993.

Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years from 1989 to 1993 are given in Table 6.9. The small variations in values over this 5-year period likely are not statistically significant. The dose estimates for direct irradiation along the Clinch River have been corrected for background.

Table 6.9. Trends in committed effective dose equivalent for selected pathways

Pathway	Effective dose equivalent (mrem)[a]				
	1989	1990	1991	1992	1993
All air	1	2	2	1.3	1.4
Fish consumption	0.2	0.3	0.3	0.4	0.2
Drinking water (Kingston)	<0.3	0.04	0.1	0.05	0.07
Direct radiation (Clinch River)	1[b]	1[b]	1[b]	1[b]	1[c]
Direct radiation (Poplar Creek)			11[b]	11[b]	1

[a] To convert mrem to mSv, divide by 100.

[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.

Potential Contributions from Off-Site Sources

Four off-site facilities were identified as potential contributors to radiation exposure of the public around the ORR. Airborne emissions from these facilities (based on information supplied by the facilities), when combined with emissions from the ORR, are not expected to cause any individual to receive an EDE in excess of EPA or DOE limits. No information was obtained about waterborne releases, if any, from these facilities.

A waste processing facility located on Bear Creek Road reported a maximum individual dose of 0.06 mrem (0.0006 mSv) from airborne emissions. A depleted uranium processing facility located on Illinois Avenue reported a maximum emission of 2.5 µCi of depleted uranium. A dose estimate was not reported, but comparison with Y-12 Plant emissions of enriched and depleted uranium indicates that the maximum individual EDE should be no more than 0.00006 mrem (0.0000006 mSv). A decontamination facility located on Flint Road in Oak Ridge reported a maximum individual EDE of about 0.0001 mrem (0.000001 mSv) at their nearest house. A waste processing facility located on Gallaher Road in Kingston reported a maximum individual EDE of about 0.00009 mrem (0.0000009 mSv).

Findings

The maximally exposed off-site individual could have received a 50-year committed EDE of about 1.4 mrem (0.014 mSv) from airborne effluents from the ORR. This dose is within the limit specified in the Clean Air Act 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 26 person-rem (0.26 person-Sv) for 1993 airborne emissions. This represents about 0.01% of the 260,000 person-rem (2,600 person-Sv) that the surrounding population would receive from all sources of natural radiation.

CHEMICAL DOSE

Terminology

The following terms are pertinent to the understanding of chemical exposure. For further explanation of terms and methodology see Appendix B.

- Slope factor (SF). A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of lifetime exposure to a particular level of a potential carcinogen. Units are expressed as mg kg^{-1} day^{-1}.
- Maximum contaminant level (MCL). EPA National Interim Primary and National Primary Drinking Water regulations 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 regulations 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 slope factors and up-to-date health risk and EPA regulatory information for numerous chemicals.

For chemicals for which RfDs are not available, national primary (MCL) and secondary drinking water regulation (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 6.10 lists the RfD and SFs used in this analysis.

To evaluate carcinogenic impacts, SFs are used. 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

Table 6.10. Chemical reference doses and slope factors used in drinking water and fish intake analysis

Chemical	Reference dose or slope factor	Reference[a]
4,4′-DDD	2.4E–1	SF
4,4′-DDE	3.4E–1	SF
Alpha chlordane	1.3	SF
Aluminum	6E–3	SMCL
Arsenic	3E–4	RfD
Barium	7E–4	RfD
Beryllium	5E–3	RfD
Boron	9E–2	RfD
Cadmium	5E–4	RfD
Chloride	7.14	SMCL
Chromium (VI)	5E–3	RfD
Copper	0.04	SMCL
Cyanide	2E–2	RfD
Fluoride	6E–2	RfD
Iron	9E–3	SMCL
Lead	4E–4	MCL
Manganese	5E–3	RfD
Mercury	5.7E–5	MCL
Methylene chloride	7.5E–3	SF
Molybdenum	5E–3	RfD
Nickel	2E–2	RfD
Nitrate	1.6	RfD
PCBs	7.7	SF
Phenols	6E–1	RfD
Selenium	5E–3	RfD
Silver	5E–3	RfD
Strontium	6E–1	RfD
Sulfate	7.14	SMCL
Thallium	8E–3	RfD
Trichloroethane	6E–3	MCL
Uranium	3E–3	RfD
Vanadium	9E–3	RfD
Zinc	3E–1	RfD
Methyl isobutyl ketone	8E–2	RfD

[a] SMCL: secondary maximum contaminant level; RfD: reference dose; MCL: maximum contaminant level; SF: slope factor.

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, the 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.

Methods of Evaluation

Airborne Chemicals

Air permits issued by TDEC allow release of permitted quantities of chemicals. Sampling or monitoring is required only at the ORNL Steam Plant. No air monitoring data amenable to human exposure analysis were available. (See Sect. 4, "Airborne Discharges.")

Waterborne Chemicals

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 is based on the RfD. 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. 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.

Drinking Water

HQs and I/CDI ratios for chemicals found in surface water at statistically significant concentrations are listed in Table 6.11. Many of the sampling data for individual chemicals are reported as "less than" ("<") values, indicating that concentrations are below the limit of detection of the instruments used. These data were used in the analysis only if one or more samples had values above the detection limits. In cases where the estimated intakes are expressed as < values, the ratios are also expressed as < values, and the exposure cannot be fully quantified. For the data that have a tilde (~), the ~ indicates that estimated values and/or detection limits were used in estimating the average concentration of a chemical. These symbols are listed in Table 6.11 to indicate the type of data used to estimate the HQ and/or I/CDI ratio.

To evaluate the drinking water pathway, HQs and I/CDIs were estimated at current drinking water supply locations both above and below the ORR, specifically at Gallaher Water Station (CRK 23), which is the water supply intake for the K-25 Site and is below the ORNL effluent discharge point, above the ORR at the water supply intake for Knox County (CRK 58), and at the Anderson County Filtration Plant (CRK 84). In addition, the drinking water pathway was evaluated at a location downstream of all DOE inputs (CRK 16).

With exceptions of aluminum, iron, and arsenic, the HQ values were less than 1. The elevated iron and arsenic was found at CRK 84, which is above all DOE inputs. Estimation of HQs for arsenic at other water-sampling locations along the Clinch River (both above and below the ORR) resulted in HQs greater than 1. For aluminum, HQs greater than 1 were found at all locations both upstream and downstream of the ORR with the exception of CRK 58. The high concentration of aluminum at all locations may be a reflection of the turbidity and suspended solids in some of the samples. Furthermore, the SMCLs that apply to aluminum are not health-based values.

Fish Consumption

Chemicals in water can be accumulated by aquatic organisms that may be eaten by humans. Bluegill (sunfish) and catfish (at two locations) collected from the Clinch River and Poplar Creek were analyzed for a number of metals, pesticides, and PCBs. Table 6.12 summarizes the HQ and I/CDI ratios for chemical concentrations at several locations. Chemicals with HQs greater than 1 were arsenic, mercury, and lead. Elevated levels of these contaminants were not observed in fish upstream of the ORR; however, HQs greater than one were observed for arsenic and lead in drinking water locations both above and downstream of the ORR. (See Table 6.11.) For carcinogens, I/CDI ratios greater than 1 indicate a risk greater than 10^{-5}. Chemicals that had

I/CDIs greater than one were 4,4′-DDE, alpha chlordane, and PCBs (Aroclor 1254 and 1260). The tissue concentrations of 4,4′-DDE and PCBs (Aroclor 1254 and 1260) were estimated at or below the analytical detection limit. Therefore, because of analytical detection limitations, the actual fish-tissue concentrations are unknown.

Table 6.11. Chemical hazard quotients for drinking water

Chemical	Hazard quotient
Melton Hill Reservoir above all DOE inputs (CRK 84)	
Metals	
Aluminium	1E+0
Arsenic	~5E+0
Barium	3E–2
Chromium	~4E–2
Iron	1E+0
Manganese	5E–1
Uranium	~2E–3
Vanadium	~7E–3
Zinc	~1E–3
Anions	
Chloride	1E–2
Nitrate	4E–2
Sulfate	9E–2
Water supply intake for Knox County (CRK 58)	
Metals	
Aluminium	9E–1
Barium	1E–2
Iron	~5E–1
Manganese	2E–1
Uranium	~4E–3
Zinc	~9E–4
Anions	
Chloride	2E–2
Nitrate	4E–2
Sulfate	1E–1
Water supply intake for the K-25 Site (CRK 23)	
Metals	
Aluminium	1E+0
Barium	~1E–2
Iron	~9E–1
Manganese	3E–1
Uranium	~1E–3
Vanadium	~7E–3
Zinc	~5E–4
Anions	
Chloride	~2E–2
Nitrate	5E–2
Sulfate	9E–2
Clinch River downstream of all DOE inputs (CRK 16)	
Metals	
Aluminum	1E+0
Barium	~1E–2
Iron	~8E–1
Manganese	2E–1
Uranium	~4E–3
Vanadium	~6E–3
Anions	
Chloride	2E–2
Fluoride	~5E–2
Nitrate	6E–2
Sulfate	8E–2

Table 6.12. Chemical hazard quotient and I/CDI for fish intake

Chemical	Hazard quotient	I/CDI
Melton Hill Reservoir—above all DOE input, Anderson County Filtration Plant (CRK 84)		
Sunfish		
Metals		
Chromium	3E–2	
Copper	4E–3	
Mercury	5E–1	
Selenium	1E–1	
Silver	~3E–2	
Uranium	~2E–3	
Zinc	~4E–2	
Melton Hill Reservoir—Oak Ridge Marina (above ORNL) (CRK 80)		
Sunfish		
Metals		
Chromium	3E–2	
Copper	~4E–3	
Mercury	4E–1	
Selenium	~1E–1	
Uranium	~1E–3	
Zinc	3E–2	
Melton Hill Reservoir above city of Oak Ridge water intake (CRK 66)		
Sunfish		
Metals		
Chromium	3E–2	
Copper	4E–3	
Mercury	5E–1	
Selenium	2E–1	
Uranium	~9E–4	
Zinc	3E–2	
Clinch River downstream from ORNL (CRK 32)		
Sunfish		
Metals		
Chromium	4E–2	
Copper	4E–3	
Mercury	2E+0	
Selenium	9E–2	
Uranium	3E–4	
Zinc	4E–2	
Pesticides		
4,4′-DDE		~2E+0
PCB		
Aroclor-1254		4E+2
Catfish		
Metals		
Mercury	2E+0	
Nickel	6E–3	
Zinc	1E–2	

Table 6.12 (continued)

Chemical	Hazard quotient	I/CDI
Pesticides		
4,4′-DDD		~3E–1
4,4′-DDE		~2E+0
Alpha-chlordane		9E+0
PCB		
Aroclor-1254		5E+2
Aroclor-1260		5E+2
Clinch River downstream from all DOE inputs (CRK 16)		
Sunfish		
Metals		
Arsenic	~1E+0	
Chromium	4E–2	
Copper	5E–3	
Mercury	3E+0	
Selenium	~8E–2	
Uranium	~3E–4	
Zinc	3E–2	
PCB		
Aroclor-1254		~3E+2
Catfish		
Metals		
Arsenic	3E+0	
Mercury	7E+0	
Thallium	6E–2	
Uranium	4E–4	
Pesticide		
4,4′-DDE		1E+0
Alpha-chlordane		8E–1
PCBs		
Aroclor-1254		4E+2
Aroclor-1260		5E+2
Poplar Creek downstream from the K-25 Site (PCK 2.2)		
Sunfish		
Metals		
Arsenic	~2E+0	
Chromium	4E–2	
Copper	5E–3	
Lead	~1E+0	
Mercury	2E+0	
Selenium	~9E–2	
Silver	~8E–3	
Uranium	5E–4	
Zinc	3E–2	
Pesticide		
4,4′-DDE		~2E+0
PCB		
Aroclor-1254		~5E+2

7. Groundwater

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Abstract

Most of the population in the Oak Ridge area does not rely on groundwater for potable supplies although suitable water is available. However, local groundwater provides some domestic, municipal, farm, irrigation, and industrial uses 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 U.S. Environmental Protection Agency specifically target the protection of groundwater from contamination by hazardous wastes. The regulations guide groundwater monitoring at the U.S. Department of Energy plants in Oak Ridge. Monitoring programs established on the Oak Ridge Reservation assess groundwater contamination and transport on and off the reservation and are intended to comply with established regulatory requirements.

INTRODUCTION

The groundwater monitoring programs at the ORR 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.

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 differential erosion, a series of valleys and ridges have formed parallel to the thrust faults.

Geologic units designated as the Knox Group and the Maynardville Limestone of the Conasauga Group, both consisting of massive carbonate rocks, 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 occurs at greater depth in the Knox Aquifer and the water flows farther than in the aquitards. The Knox Aquifer is the primary source of base flow in many streams, and most large springs on the ORR discharge from the Knox Aquifer. Yields of some wells penetrating larger solution conduits are reported to exceed 1000 gal/min.

The remaining geologic units (the Rome Formation, the Conasauga Group below the Maynardville Limestone, and the Chickamauga Group) constitute the 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, and the base flows of streams draining areas underlain by the aquitards are poorly sustained because of such flow rates.

Hydrogeological Setting

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 creates sources of useable 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

GLOSSARY

aquiclude—a saturated geologic unit that does not transmit significant quantities of water. Although the transmissive capabilities of the aquiclude on the ORR are poorly known, the term is used in this report to denote the zone below active circulation.

aquifer—a saturated permeable geologic unit that transmits significant quantities of groundwater. The common definition is that an aquifer yields usable quantities of water to wells, but that definition is relaxed in this report (see *aquitard*).

aquitard—less permeable geologic units. In this report the term is used in contrast to *aquifer*, which contains more permeable flow networks.

base flow—the sustained, or "fair weather" flow of a stream.

flux—a state of flow change or fluctuation.

regolith—all less cohesive materials above bedrock, either formed in place or transported.

saprolite—weathered bedrock that has not been transported and that retains some of the original structure.

stormflow zone—the stormflow zone approximately corresponds to the root zone of vegetation and is observed to be thickest in fertile, well-developed, and densely vegetated soils.

thrust fault—a low-angle fault that results in surface compression.

vadose zone—limited above by the land surface and below by the water table.

input is recharge from rainwater infiltrating the soil and whose output is discharge to springs, swamps, rivers, streams, and wells.

Water from the surface moving down into the soil makes its way 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 vadose or unsaturated zone; here 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. Differences in hydraulic head compare the driving force for groundwater movement through the saturated zone. 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 as an underlying unconfined water-table aquifer. An unsaturated, or vadose, zone of variable thickness separates the stormflow zone and water-table aquifer. Near surface-water features, the water-table aquifer is found at shallow depths; along the ridge tops or near other high topographic areas, the water-table aquifer is continuous to depths of several hundred meters. 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 water-table aquifer—the uppermost water table interval, the intermediate interval, the deep interval, and the aquiclude, which is defined by a transition to saline water (Fig. 7.1). 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 flow with depth. The greatest flux is associated with the stormflow zone and the smallest with the deep zone. Water does not flow in the aquiclude.

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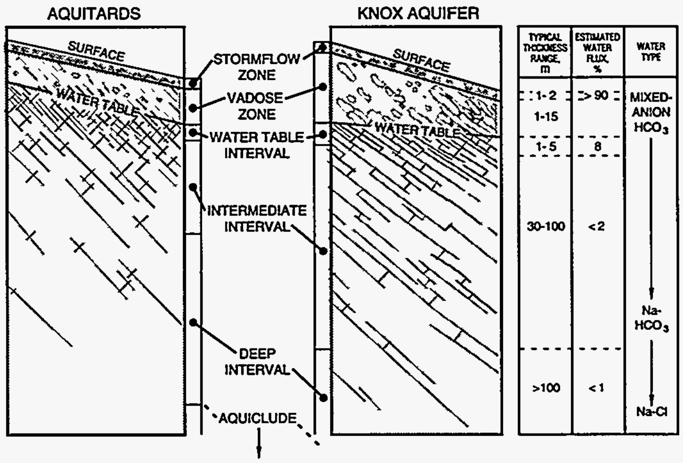

Fig. 7.1. Schematic vertical relationships of flow zones of the ORR, estimated thicknesses, water flux, and water types. (Not to scale.)

Two broad hydrologic units are identified on the ORR: the Knox Aquifer and the 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 aquitards.

Unsaturated Zone Hydrology

The vadose zone exists throughout the ORR except where the water table is near land surface (such as along perennial stream channels). The thickness of the vadose zone is greatest beneath ridges, and thins toward valley floors. Beneath ridges underlain by the Knox Aquifer, the vadose zone commonly is greater than 30 m (100 ft) thick, whereas beneath ridges underlain by an aquitard, the vadose zone is typically less than 15 m (50 ft) thick. The materials above the bedrock consist of clay and silt derived from the weathering of bedrock materials and have significant water storage capability.

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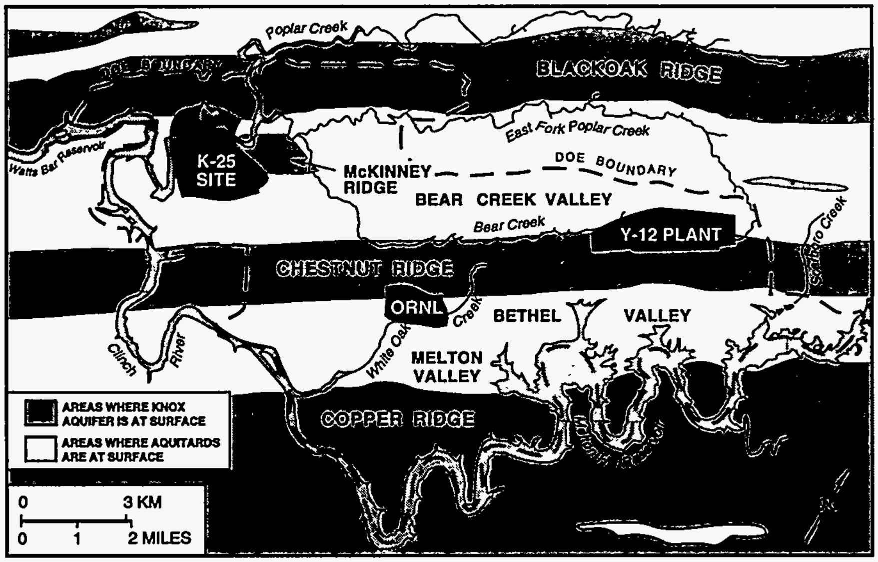

Fig. 7.2. Map showing the Knox Aquifer and the aquitards on the Oak Ridge Reservation.

Most recharge through the vadose zone occurs along fractures and large pores that may become saturated during rain events, even though surrounding small pores remain unsaturated and contain trapped air.

Groundwater occurs in the vadose zone as (1) transient water of limited extent separated from the water table and located above it (particularly in the areas of the Knox Aquifer) and (2) as transient, shallow, subsurface stormflow.

In undisturbed, naturally vegetated areas on the ORR, roughly 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 vadose 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, the 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. However, whereas most buried wastes are below the stormflow zone, 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.

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 layer of closely spaced, well-connected fractures near the water table (the water table interval) as shown on Fig. 7.3.

The range of seasonal fluctuations in depth to the water table and in rates of groundwater flow vary significantly across the reservation. In the areas of 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 per square mile. In the aquitards of Bear Creek Valley, Melton Valley, East Fork Valley, and Bethel Valley, seasonal fluctuations in water levels average 5 ft and typical mean discharge is 26 gal/min per square mile.

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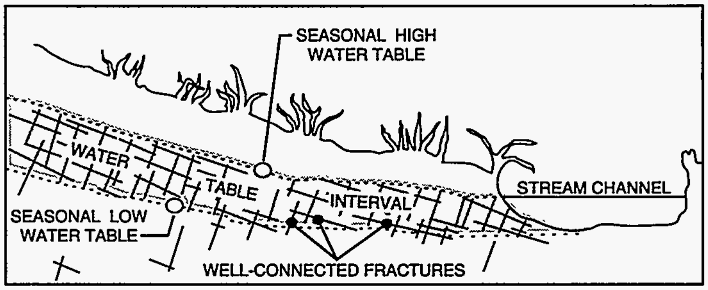

Fig. 7.3. Cross section showing the water table.

As in the stormflow zone, the bulk of water mass in the groundwater zone resides within the "micropores" of blocks of the rock matrix, which are bounded by fractures. Diffusive exchange between water in matrix pores and water in fractures reduces contaminant migration rates relative to water velocities in the fractures. For example, the leading edge of a geochemically nonreactive contaminant mass such as tritium migrates along fractures at a typical rate of 3 ft/day; however, the center of mass of a contaminant plume typically migrates at a rate less than 0.2 ft/day.

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 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.

In the aquitards, chemical characteristics of groundwater change from mixed-cation-HCO_3 water type at shallow depth to a Na-HCO_3 water type at deeper levels (Fig. 7.1). 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 intermediate groundwater interval from the sluggish flow of the deep interval. There is evidence of similar change with depth in the chemical characteristics of water in the Knox Aquifer. 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.

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 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 does suggest 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 Bear Creek Valley (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 K-25 Site.

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 water flux variations; average flux rates 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.

The topographic relief characteristic of the ORR is sufficient to induce the majority of active subsurface flow to remain shallow on the ORR. 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 a few 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. Recent evidence, however, has indicated flow in the intermediate interval occurs off of the ORR, through 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 likely to be less effective in the Knox Aquifer than in the aquitards because of flow along solution features.

Groundwater Monitoring Considerations

Because of the complexity of the hydrogeologic framework on the ORR, groundwater flow and, therefore, contaminant transport are largely unpredictable on a local scale. Consequently, individual plume delineation is not feasible on the ORR. Stormflow and most groundwater discharge to the surface-water drainages on the ORR. For that reason, monitoring surface water quality is the best way to assess the extent to which groundwater on the ORR transports contaminants. Whereas the large number of wells on the ORR provide for characterization of groundwater quality, the combination of the existing monitoring well network and surface water monitoring programs provides sufficient monitoring of groundwater contamination.

Off-Site Spring and Residential Well Monitoring

Groundwater monitoring of residential wells and springs in the vicinity of the ORR is summarized in Section 5.

Regulatory Requirements

Comprehensive Environmental Response, Compensation, and Liability Act

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations include groundwater monitoring as one of several aspects of a broadly scoped remedial investigation/feasibility study (RI/FS), unlike the Resource Conservation and Recovery Act (RCRA) regulations, which detail requirements for specific groundwater monitoring programs. The RI/FS process represents a two-pronged approach to contamination assessments at CERCLA sites. The RI is the data collection mechanism of the FS effort. Accordingly, the RI emphasizes data collection and site characterization.

A number of waste management units formerly listed as interim status units or solid waste management units (SWMUs) regulated under RCRA Section 3004(u), in addition to other non-RCRA tanks and sites, have been identified. In addition, integrator operable units (OUs) have been designated for media (groundwater, surface water, and floodplain sediments) that have received contamination and either provide potential transport or exposure pathways or act as secondary sources.

Like the RCRA facility investigation process for SWMUs, the specific requirements for groundwater monitoring during a CERCLA RI are not explicitly defined in the regulations but are recommended in guidance documents prepared by the EPA. Thus, specific details regarding monitored parameters, monitoring frequency and duration, and the monitoring-well network are developed on a site-by-site basis and are contained in an RI work plan submitted to the appropriate regulatory agency for approval before the investigation is initiated. When sufficient data have been generated to support the FS, groundwater monitoring efforts are reevaluated.

Groundwater monitoring related to source OUs and preliminary assessment/site investigation (PA/SI) efforts is deferred to the integrator OUs. Monitoring in the context of source OUs is conducted only to the extent from which a determination may be made as to whether the OU is contributing to groundwater contamination. Monitoring is addressed on a site-specific basis for those units for which no integrator OU has been identified (the Chestnut Ridge Hydrogeologic Regime of the Y-12 Plant, for example). Monitoring to document effectiveness of remedial measures will be conducted as required under interim or final records of decision.

RCRA Interim Status and Permit Monitoring Programs

RCRA, as amended, recognizes three distinct programs that require groundwater studies: RCRA interim status, RCRA permit monitoring programs, and the RCRA 3004(u) program. Interim status requirements apply to facilities that treat, store, or dispose of hazardous waste if the facilities existed on November 19, 1980, or if the facilities became subject to permitting requirements because of new regulatory requirements. The facilities remain in interim status until a Part B operating or post-closure permit is issued. Two types of groundwater monitoring may be required while a facility is under interim status:

- Detection monitoring [defined in 40 CFR 265.91, 40 CFR 265.92, and TN 1200-1-11-.05(6)] may be required to determine if hazardous waste or hazardous waste constituents have entered the groundwater underlying the facility.
- Assessment monitoring [defined in 40 CFR 265.93(a) and TN 1200-1-11-.05(6)(d)] will then be required to define the rate, extent, and concentration of hazardous waste or hazardous waste constituents that have entered the groundwater from a facility suspected of or known to be leaking.

Interim status facilities must file a Part B operating permit application or post-closure permit application to the regulatory authority. At the time of issuance of the permit, a facility shifts from an interim status monitoring program to the appropriate permit monitoring program required in the facility permit, as illustrated in Fig. 7.4. Where no groundwater contamination has been found, detection monitoring will continue with minor modifications [40 CFR 264.98 and TN 1200-1-11.06(b)(i)]. Sites with groundwater contamination will begin either compliance monitoring or corrective action monitoring, depending on whether an approved corrective action plan is ready to be implemented.

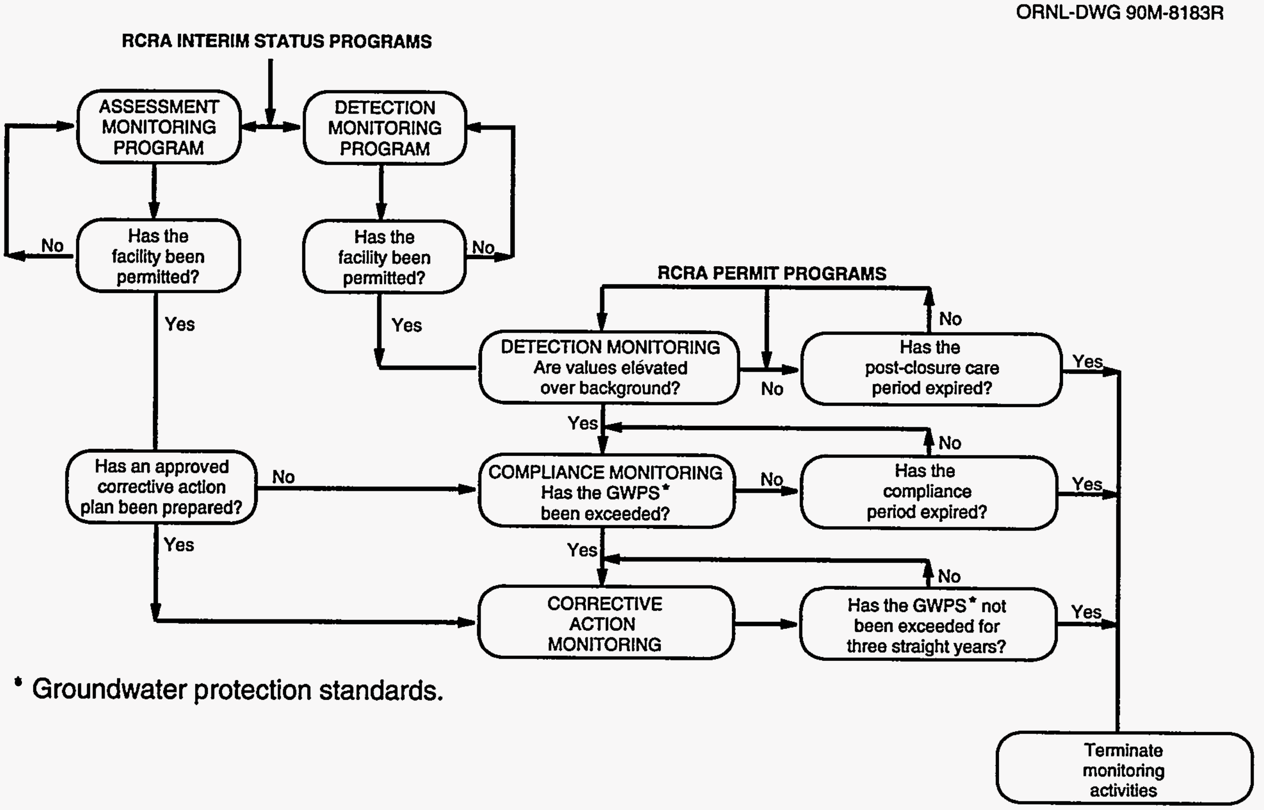

Fig. 7.4. Relationship between RCRA interim status monitoring and permit monitoring programs.

RCRA 3004(u) Monitoring Program

Section 3004(u) was added to RCRA as an amendment in 1984 to require corrective action for all releases of hazardous constituents from any SWMU at any facility seeking a permit. The 3004(u) program requires that sites be characterized to determine whether a threat to human health and/or the environment exists. Should a review of available data indicate a potential for contamination, groundwater monitoring would be necessary to evaluate that medium as an exposure pathway and for design of corrective measures.

The regulatory status and pertinent data regarding the current groundwater monitoring program being conducted at each hazardous waste unit are summarized for the Y-12 Plant, ORNL, and the K-25 Site in later sections of this report.

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 the aforementioned 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. Quality control procedures for every aspect of data collection and analysis have been established, and data bases are used to organize and report analytical results.

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

GROUNDWATER MONITORING AT THE Y-12 PLANT

Background and Regulatory Setting

The comprehensive groundwater monitoring program at the Y-12 Plant includes the following elements:

- monitoring to comply with requirements of RCRA interim status assessment and detection monitoring,
- compliance with RCRA post-closure monitoring requirements,
- monitoring to support CERCLA records of decision,
- compliance with Tennessee Department of Environment and Conservation (TDEC) solid waste management (SWM) regulations,
- monitoring to support DOE Order 5400.1 requirements (exit pathway and grid monitoring programs),
- monitoring to support various elements of the Y-12 Plant Environmental Restoration (ER) Program,
- compliance with regulatory monitoring requirements for petroleum underground storage tanks (USTs), 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 resulting programs and ensures consistent data collection and evaluation.

Additional groundwater monitoring activities are conducted under two broad categories: (1) groundwater investigations that use multiport-instrumented core holes and (2) short-term monitoring activities conducted under specific CERCLA OU RIs. The specific data requirements, technical approaches, or technologies applied by these two areas of investigations result in their being outside the scope of direct implementation by the comprehensive monitoring program. Data generated as a result of these activities, however, is incorporated into evaluations of groundwater flow, contaminant migration, and proposed changes to the comprehensive program.

More than 200 contaminated units have been identified at the Y-12 Plant resulting from past waste management practices. Many of these sites have been grouped into OUs under CERCLA based on priority and common assessment and remediation requirements (Fig. 7.5). Eleven OUs made up of 31 units have been established.

Nine of these OUs are source control OUs that either contain hazardous waste constituents or are direct contributors to contamination of surrounding media, such as groundwater, soils, and surface water. The remaining two OUs are integrator OUs made up of media such as surface water and groundwater that are receptors of contamination from the source OUs and have either become contaminated or act as pathways for contamination. Seven of the source control OUs were still listed as RCRA interim status units in 1993 and, thus, were still subject to monitoring and reporting under RCRA requirements. Details regarding CERCLA OUs are provided in discussions of each hydrogeologic regime.

In April 1993, DOE, TDEC, and Energy Systems signed an Agreed Order for the post-closure permit for the S-3 Site, thereby formally agreeing to proceed with CERCLA as the lead regulatory requirement and RCRA as an applicable or relevant and appropriate requirement (ARAR). Under the Agreed Order, RCRA will be applied as an ARAR to the extent that post-closure maintenance and care of former interim status units will be conducted in compliance with the terms of RCRA post-closure permits. Groundwater monitoring will be integrated with CERCLA programs, and corrective actions will be deferred to CERCLA. Groundwater monitoring data reporting will comply with RCRA post-closure permit conditions as well as CERCLA requirements. Final modifications to the post-closure permit for the S-3 Site are expected to be issued in early 1994. In addition, a schedule for submittal of post-closure permit applications for the remaining six interim status units has been approved by TDEC. It is anticipated that all current RCRA interim status units will be under RCRA post-closure groundwater monitoring and reporting by the end of 1995.

The remaining units have been grouped into Y-12 Study Areas and constitute lower-priority units that will be investigated under CERCLA as preliminary assessments/site investigations (PA/SIs). New OUs or additions to existing OUs will be made if the degree of degree of contamination determined by the PA/SI warrants further study under an RI/FS.

Two additional primary regulatory drivers for groundwater monitoring at the Y-12 Plant are the TDEC SWM regulations for nonhazardous solid waste management facilities and the TDEC regulations governing USTs. Two facilities (Centralized Sanitary Landfill II and Industrial Landfill IV) have been subject to

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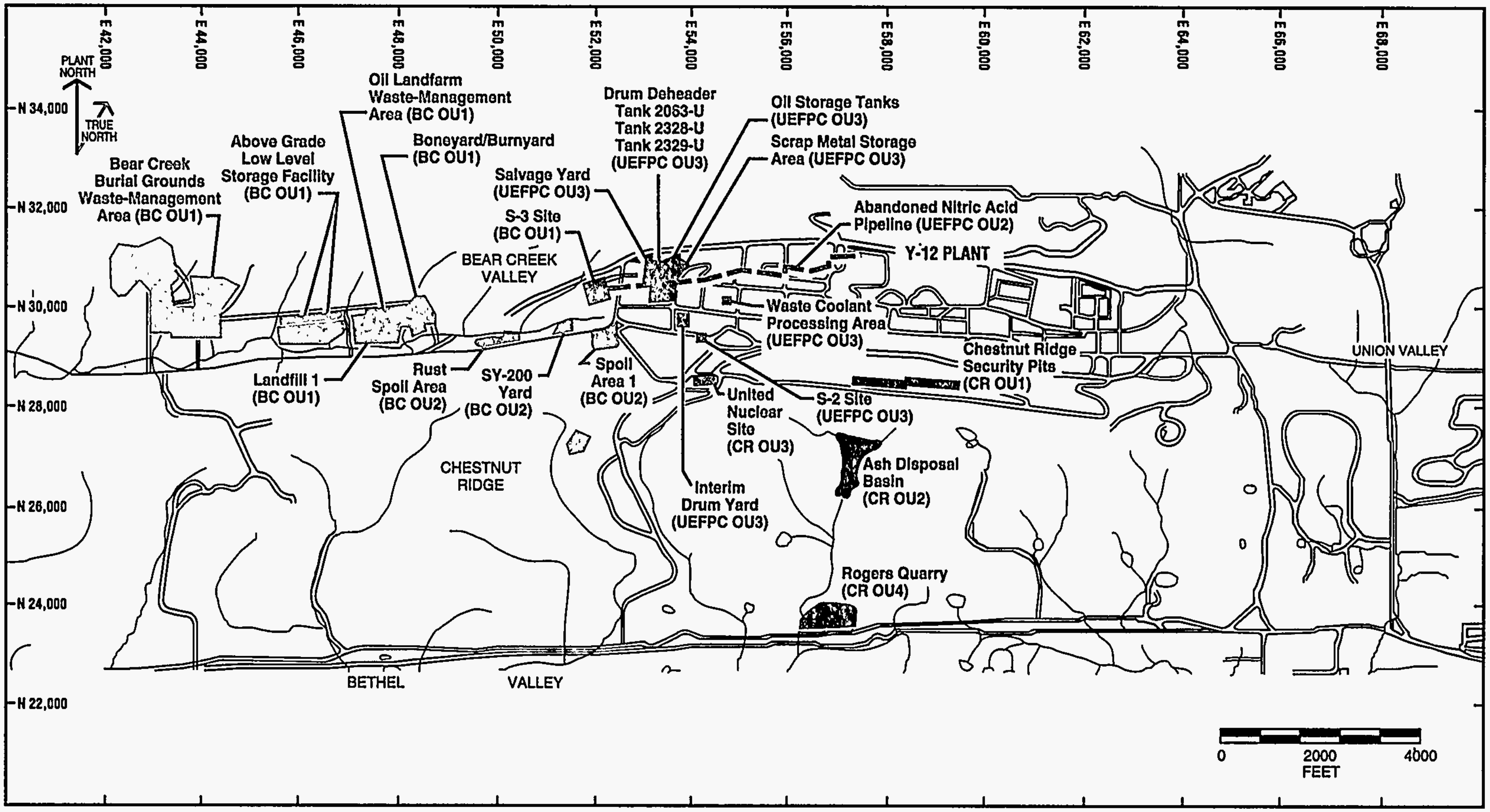

Fig. 7.5. Y-12 Plant source operable units.

groundwater monitoring under the TDEC SWM regulations for several years, and one new facility (Construction/Demolition Landfill VI) was completed in December 1993. Two additional landfill units (Industrial Landfill V and Construction/Demolition Landfill VII) are expected to be completed in early 1994. Baseline groundwater monitoring was initiated for the three new facilities in 1993. Groundwater monitoring to support UST programs decreased in 1993 because several sites have progressed past the assessment phase and into corrective actions, which require only limited monitoring.

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 Hydrogeologic Regime (East Fork regime), and the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge Regime) (Fig. 7.6). 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.

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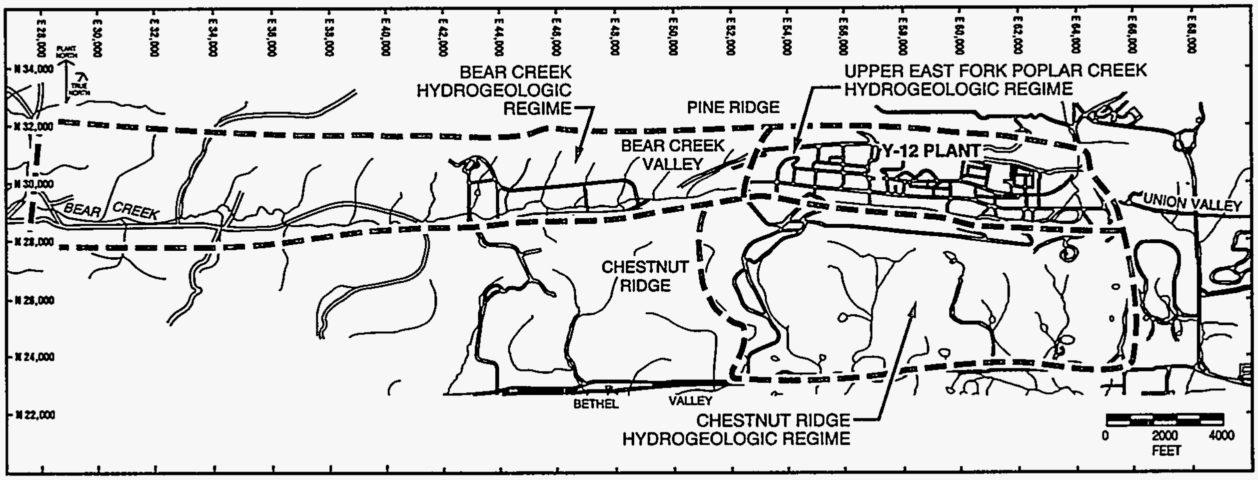

Fig. 7.6. Hydrogeologic regimes at the Y-12 Plant.

The integrator OU for the Bear Creek regime (Bear Creek OU 4) consists of groundwater and surface water within the regime boundaries. The vertical boundary for the first RI phase for Bear Creek OU 4 is the base of active groundwater flow, currently believed to be at a depth approximately 200 to 250 ft. Further investigations of this OU may result in a redefining of the base of active flow. A later RI phase for this OU will target deeper groundwater flow. The integrator OU for the East Fork regime [Upper East Fork Poplar Creek (UEFPC) OU 1] consists of shallow groundwater and surface water within the boundaries of the East Fork regime. Potential surface water contamination associated with the storm sewer system and mercury use areas will be addressed in this integrator OU. No integrator OU has been established for the Chestnut Ridge regime, and groundwater contamination will be addressed as part of each source control OU.

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 (Fig. 7.6). Shallow groundwater flow directions 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 and Chestnut Ridge, located to the north and south, respectively, 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 to surface streams and springs located in Bethel Valley to the south and Bear Creek Valley to the north.

Groundwater in the intermediate and deep intervals moves predominantly through fractures in the ORR aquitards and through fractures and solution conduits in the Maynardville Limestone. Karst development in the

Maynardville Limestone has a significant impact on groundwater flow paths. In general, groundwater flow in the intermediate and deep zones parallels geologic strike of the Maynardville Limestone. Groundwater flow rates in this unit vary widely, but can be quite rapid within solution conduits. The rate of groundwater flow perpendicular to geologic strike from the ORR aquitards to the Maynardville Limestone has not been well established. Several investigations are currently under way or planned to attempt to identify how quickly groundwater beneath waste sites over the ORR aquitards moves to the Maynardville Limestone.

Groundwater flow in the intermediate and deep intervals 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 toward Bear Creek Valley 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.

Historical monitoring efforts have shown that groundwater quality at the Y-12 Plant has been affected by four types of contaminants: nitrate, volatile organic compounds (VOCs), metals, and radionuclides. Of these, nitrate and VOCs are the most widespread, although data obtained since 1988 suggest that the extent of some radionuclides may also be 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. Data obtained as a result of previous monitoring efforts show that contaminant plumes from multiple source units have mixed with one another and that contaminants are no longer easily associated with a single source.

In the Bear Creek regime, horizontal plume boundaries are defined in the bedrock formations that directly underlie the waste disposal units. Exit pathway data obtained to date suggest that contaminants have not migrated much farther than the western edge of the Bear Creek Burial Grounds, although additional data will be obtained during the Bear Creek OU 4 remedial investigation. The vertical extent of contamination in the Bear Creek regime has not been completely defined. However, data obtained to date indicate that nitrate contamination in the immediate vicinity of the S-3 Site has reached depths of 600 ft, and VOCs have been observed in a monitoring well in the Maynardville Limestone, approximately 3500 ft west of the S-3 Site, at depths of approximately 440 ft. Farther west, in the vicinity of the Bear Creek Burial Grounds, groundwater contamination appears to be no deeper than 300 ft, which approximately coincides with the known base of active flow in the Maynardville Limestone. Additional delineation of the vertical extent of contamination will be conducted as part of the Bear Creek OU 4 remedial investigation and exit pathway studies.

In the East Fork regime, plume boundaries in both the horizontal and vertical direction have not been completely defined. New data from part of a recently completed grid-based well network indicate shallow VOC contamination is present in, and limited to, the Maynardville Limestone east of the Y-12 Plant and that contamination crosses both the ORR aquitards and the Knox Aquifer in the interior of the plant. VOC contamination from the Y-12 Plant is now thought to have migrated beyond the ORR boundary through the Maynardville Limestone at depths between 100 and 300 ft, based on data acquired from new exit pathway wells and monitoring of off-site locations. Additional monitoring efforts, to begin in 1994, will help serve to further define the horizontal extent of contamination.

The Chestnut Ridge Security Pits are the only known source of contamination in the Chestnut Ridge regime. Horizontal plume boundaries are generally defined, and data from a deep monitoring well installed in late 1992 indicates no contamination at depths of 400 ft. Considering that the security pits are located above a karst bedrock unit, contaminant flow paths may be very discrete and difficult to detect with conventional monitoring techniques. Because of this, a second dye-tracer study was conducted at the site, beginning in 1992, and full evaluation of the data was recently completed. The results of the study were inconclusive and no statistically significant occurrences of dye at any of the monitoring locations were observed.

1993 Well Installation and Plugging and Abandonment Activities

In 1993, 20 new groundwater monitoring wells were installed. Table 7.1 lists the number of wells installed for each regime. Monitoring wells were installed by the Y-12 Plant Groundwater Protection Program (GWPP) as well as the Y-12 Plant ER Program. The monitoring objectives for the wells are divided into four categories: Category I wells were installed to obtain additional data to delineate the extent of groundwater contamination; Category II wells, to monitor potential exit pathways for groundwater contamination; Category III wells, as new

Table 7.1. Y-12 Plant monitoring wells installed in 1993

Monitoring objective	Bear Creek regime	East Fork regime	Chestnut Ridge regime
Category I	0	0	0
Category II	0	0	0
Category III[a]	1	9	5
Category IV[b]	5	0	0

[a] Includes one replacement well at the Oil Landfarm, nine wells to monitor corrective actions at underground storage tanks, and five wells at Industrial Landfill V and Construction/Demolition Landfill VII.

[b] Includes five wells installed as part of the Bear Creek OU 2 RI.

or replacement wells for compliance monitoring; and Category IV wells, under the direction of the Y-12 Plant ER Program, to obtain specific data required for CERCLA RIs.

The new monitoring wells in 1993 were installed primarily to satisfy various regulatory compliance requirements for SWM facilities or underground petroleum storage tanks. One RCRA assessment well was installed to replace a damaged, existing well at the Oil Landfarm. Five wells were installed in the Bear Creek regime at the Rust Spoil Area, SY-200 Yard, and Spoil Area I as part of CERCLA RI activities at these sites.

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, interfere with planned construction activities, or for which no useful data can be obtained, are selected for plugging and abandonment. In 1993, 89 wells were plugged and abandoned. Approximately one-half of the wells were plugged and abandoned as a result of closure activities at the Bear Creek Walk-in-Pits and construction of Industrial Landfill V and Construction/Demolition Landfill VII. The remainder were plugged and abandoned because of poor condition, historical lack of security or identity, or no identifiable future use.

1993 Monitoring Programs

Groundwater monitoring in 1993 addressed multiple requirements from regulatory drivers, DOE orders, Y-12 Plant ER programs, and best management practices. In addition, monitoring efforts that used multiport monitoring systems continued under both exit pathway and the Y-12 Plant ER Program dense nonaqueous phase liquid (DNAPL) studies. Short-term groundwater sampling was conducted at two CERCLA operable units by the Y-12 Plant ER Program: Bear Creek OU 2 and Chestnut Ridge OU 2. Table 7.2 contains a summary of monitoring activities conducted by the Y-12 Plant GWPP, as well as the programmatic requirements that apply to each site.

Detailed data reporting for monitoring activities conducted by the Y-12 Plant GWPP is contained within the 1993 Annual Groundwater Quality Reports for each hydrogeologic regime (HSW, Inc. 1994a, 1994b, 1994c). Details of multiport monitoring activities through part of 1993 have been formally reported (Dreier et al. 1993), although additional work has been conducted that has not been formally published. Details of monitoring efforts conducted for CERCLA operable units will be published in remedial investigation reports for each respective operable unit.

A majority of monitoring was conducted to comply with RCRA detection, assessment, and compliance monitoring and reporting requirements at the seven RCRA interim status sites at the Y-12 Plant (Table 7.2). The basic objectives of RCRA interim status monitoring remained unchanged from previous efforts as described in the 1991 and 1992 ORR environmental reports. An emphasis on monitoring at the leading edges of contaminant plumes continued, and detection monitoring networks at Kerr Hollow Quarry and the Chestnut Ridge Sediment Disposal Basin remained unchanged. RCRA compliance monitoring for the S-3 Site was initiated in anticipation of final modifications to the post-closure permit to be issued in early 1994. Sampling activities to support the detection monitoring under TDEC SWM regulations continued at the Centralized Sanitary Landfill II and Industrial Landfill IV; and background monitoring under these regulations was initiated at Industrial Landfill V, Construction Demolition Landfill VII, and Construction/Demolition Landfill VI. Minor sampling and analysis work continued at Y-12 Plant UST sites.

Table 7.2. Summary of the comprehensive groundwater monitoring program at the Y-12 Plant, 1993

Hydrogeologic regime/waste disposal site	Requirements[a]	Number of wells	Analytical parameters[b]
	Bear Creek Hydrogeologic Regime		
Background[c]	BMP	16	Standard + CMP
Bear Creek Springs	EXP	5	Standard + (beta for SS-1)
Bear Creek surface water	EXP	5	Standard + (beta for NT-1)
Exit pathway—Traverse A	EXP	3	Standard
Exit pathway—Traverse B	EXP	5	Standard + (beta for GW-694 and GW-706)
Exit pathway—Traverse C	EXP	8	Standard
Exit pathway—Traverse W	EXP	6	Standard
Oil Landfarm	RCRA-AM/SMP	18	Standard + (beta at GW-537 and CMP at GW-40, GW-43, and GW-44 only)
Rust Spoil Area	RCRA-AM	2	Standard
S-3 Site	RCRA-AM/RCRA-CM/SMP	9	Standard + (CMP for GW-115, GW-324, GW-325, GW-613, and GW-614)
Spoil Area I	RCRA-AM/SMP	4	Standard
Y-12 Burial Grounds	RCRA-AM/SMP	31	Standard + (CMP for GW-40, GW-42, GW-79, GW-80, GW-162, GW-342, GW-372, GW-373, and GW-642)
Above Grade Low-Level Storage Facility	BMP	3	Standard + (^{234}U, ^{235}U, ^{238}U for GW-794 and GW-795)
	East Fork Poplar Creek Hydrogeologic Regime		
Background	BMP	7	Standard
Beta-4 Security Pit	GRID	4	Standard
Exit pathway—Traverse J	EXP	2	Standard
Grid C-1	GRID	2	Standard
Grid E-1	GRID	2	Standard
Grid G-1	GRID	2	Standard
Grid G-2	GRID	2	Standard
Grid G-3	GRID	2	Standard
Grid H-2	GRID	2	Standard
Grid H-3	GRID	2	Standard
Grid I-1	GRID	2	Standard
Grid I-2	GRID	2	Standard + TPH
Grid J-1	GRID	2	Standard
Grid J-2	GRID	2	Standard
Grid J-3	GRID	2	Standard
Grid K-1	GRID	3	Standard
Grid K-2	GRID	3	Standard
Grid K-3	GRID	1	Standard
J-Primary	GRID	2	Standard
New Hope Pond	RCRA-AM	11	Standard

Table 7.2 (continued)

Hydrogeologic regime/waste disposal site	Requirements[a]	Number of wells	Analytical parameters[b]
Rust Garage Area	UST	7	Standard + (TPH for GW-633 and GW-634 only)
S-2 Site	GRID	3	Standard
U.S. Geological Survey Sites/exit pathway	EXP	12	Standard
UST Program	UST	13	Standard + (TPH for GW-656, GW-657, GW-658, GW-659, GW-707, and GW-708)
Waste Coolant Facilities/ Salvage Yard/Fire Training Facility	GRID	8	Standard
	Chestnut Ridge Hydrogeologic Regime		
Ash Disposal Basin	BMP	4	Standard + TOX + TOC
Chestnut Ridge Security Pits	RCRA-AM	11	Standard
East Chestnut Ridge Waste Pile	BMP	4	Standard
Kerr Hollow Quarry	RCRA-DM	7	Standard + REP + PHEN
Landfill II	SWDF	3	Standard + AOC + ORP
Landfill III (Chestnut Ridge Borrow Area Waste Pile)	SWDF	7	Standard + AOC + ORP + (U + beta for GW-295 only)
Landfill IV	SWDF	5	Standard + AOC + ORP
Landfill V	SWDF	5	Standard + AOC + ORP + U + OMP + (TPH for GW-799 only)
Landfill VI	SWDF	7	Standard + AOC + ORP
Landfill VII	SWDF	4	Standard + AOC + ORP + OMP + (U + TPH for GW-560, GW-562, and GW-564)
Rogers Quarry	SWDF	4	Standard + BNA
Sediment Disposal Basin	RCRA-DM	8	Standard + REP + BNA
United Nuclear Site	ROD	6	Standard + U + Ra

[a] BMP = best management practices monitoring; EXP = exit-pathway monitoring under DOE Order 5400.1; RCRA-AM = RCRA Assessment Monitoring at interim status units; RCRA-DM = RCRA Detection Monitoring at interim status units; RCRA-CM = RCRA post-closure compliance monitoring; SMP = Y-12 Plant Environmental Restoration Program's Surveillance and Maintenance Program; GRID = grid well monitoring locations under DOE Order 5400.1; UST = petroleum underground storage tank locations; SWDF = monitoring for solid waste disposal facilities under TDEC Rule 1200-1-7-.04; ROD = CERCLA record of decision post-closure monitoring.

[b] Standard = ICP metals scan; Cd, Cr, Pb by AAS; Hg; U (total); VOCs; major anions; gross alpha; gross beta; pH; conductance; TSS; TDS; turbidity; standard field parameters, including dissolved oxygen, water level, pH, temperature, conductance, and redox potential. CMP = RCRA compliance monitoring parameters, including ^{241}Am, ^{129}I, ^{237}Np, ^{238}Pu, total radium, total strontium, ^{99}Tc, ^{3}H, ^{234}U, ^{235}U, and ^{238}U. Beta = beta-emitting isotopes, including total strontium, ^{99}Tc, and ^{3}H. TPH = total petroleum hydrocarbons. REP = four replicate analyses for pH, conductance, TOC, and TOX. PHEN = phenols. TOX = total organic halides. TOC = total organic carbon. ORP = other parameters required by TDEC Rule 1200-1-7-.04, including chemical oxygen demand, cyanide, TOC, and TOX. U = isotopic uranium analysis, including ^{234}U, ^{235}U, and ^{238}U. OMP = other miscellaneous permit-required parameters including ammonia (as N), gamma activity, and trans-1,2-dichloroethene. Ra = total radium. BNA = base/neutral/acid extractable organic compounds (semivolatile organics). AOC = additional VOC list required by TDEC Rule 1200-1-7-.04.

[c] Background monitoring wells are illustrated separately only for comparative purposes. Background wells are associated with individual sites.

Monitoring activities under DOE Order 5400.1 included the exit pathway program, perimeter monitoring, the Upper East Fork Phase I well network, and sampling done for best management practices. Exit pathway program monitoring included sampling and analysis at all exit pathway transects installed in the Maynardville Limestone and Nolichucky Shale (Fig. 7.7). Details regarding installation of these well transects is contained in the 1992 ORR environmental report. Sampling of selected surface water and spring locations was continued in 1993 as part of exit pathway monitoring (Table 7.3). Sampling of selected wells both on and off of the ORR was continued in 1993 to comply with the terms of DOE Order 5400.1. The formal perimeter surveillance well network as specified in the *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE 1992) is shown on Fig. 7.7. Surface water surveillance stations are denoted in Table 7.3. Sampling and analysis of approximately one-half of the UEFPC Phase I well grid was done in 1993. The remainder of the network is anticipated to be added to the monitoring program by mid-1994, pending finalization of funding for the effort and decisions about which existing wells to incorporate into the network.

Sampling and hydraulic data gathering efforts at all six multiport-instrumented core holes used as part of the exit pathway program continued in 1993 (Fig. 7.7). Measurements of hydraulic properties and limited sampling was initiated at all five multiport instrumented core holes installed as part of the DNAPL investigation conducted by the Y-12 Plant ER Program. Background information and summaries of available data analyses from the multiport monitoring systems were presented in the 1992 ORR environmental report. Additional details are presented in Dreier et al. (1993). Details regarding specific monitoring efforts for each hydrogeologic regime are presented in the following subsections.

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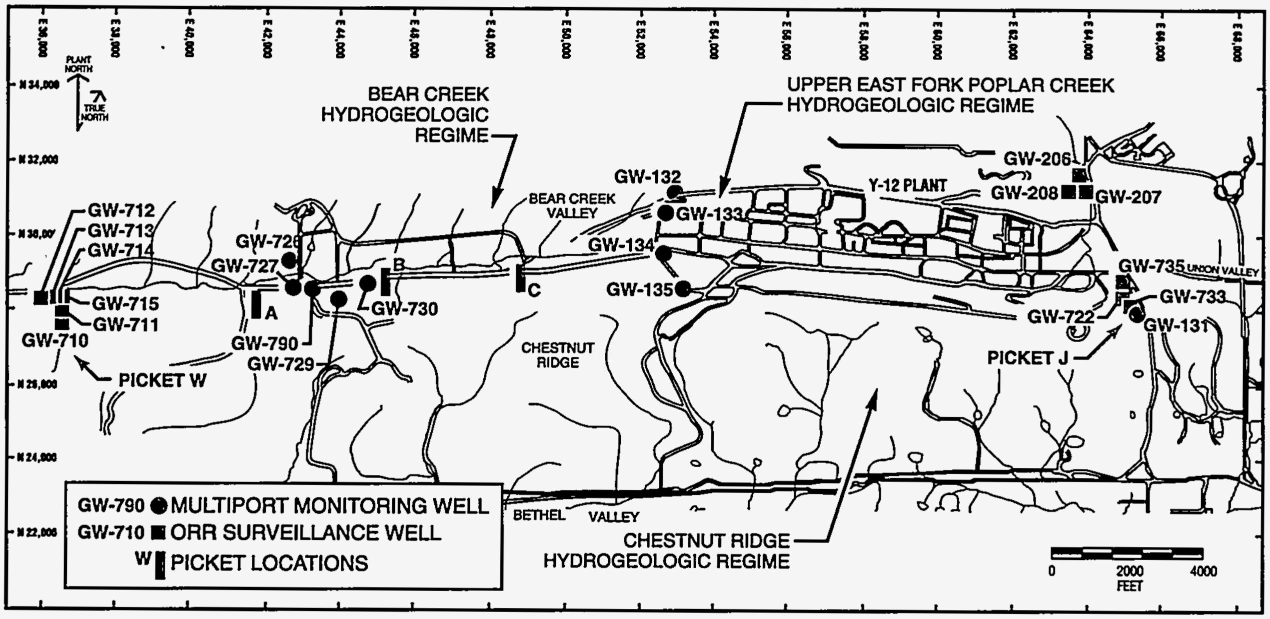

Fig. 7.7. Locations of exit-pathway monitoring pickets, ORR perimeter surveillance wells, and multiport monitoring wells. Well GW-722 is a multiport monitoring well that is also designated as a perimeter surveillance well.

Y-12 Plant Groundwater Quality

Upper East Fork Poplar Creek Hydrogeologic Regime

The East Fork regime encompasses the Y-12 Plant complex, extending west from Scarboro Road. It is separated from the Bear Creek regime by a topographic and hydrologic boundary located near the west end of the plant. The 1993 monitoring locations, waste management sites, and petroleum fuel USTs in the East Fork regime that are addressed in this document are shown in Fig. 7.8. The CERCLA OUs that encompass these sites are shown in Fig. 7.5 and detailed in Table 7.4.

Table 7.3. Description of surface-water and spring monitoring stations included in the Exit-Pathway Monitoring Program

Locations	Description
NT-13 (background)	Tributary that enters Bear Creek at BCK 6.76 and represents drainage from a relatively undisturbed catchment that has not been impacted by waste-disposal activities in Bear Creek Valley.
BCK 0.63	Upstream of the confluence with East Fork Poplar Creek. Represents essentially all surface-water discharge from the Bear Creek watershed.
BCK 4.55	Location of NPDES monitoring site 304. Site represents surface-water discharge from at least one area of the Bear Creek floodplain known to be contaminated with uranium and PCBs. Formal perimeter monitoring location for the ORR.
BCK 9.40	Represents surface-water discharge from area of Bear Creek watershed impacted by waste-disposal activities.
NT-1	North Tributary (NT)-1 to Bear Creek, which probably receives groundwater inputs from S-3 Site contamination.
SS-1	Located on south side of Bear Creek at the confluence with NT-1, near headwaters of Bear Creek
SS-4	Discharges on southside of Bear Creek Road at contact between the Knox Group and the Maynardville Limestone. Location is about 500 ft west of exit-pathway Picket B.
SS-5	Large spring located on south side of Bear Creek Road near contact between the Knox Group and the Maynardville Limestone. Location is coincident with exit-pathway Picket A.
SS-6	Discharges on north side of Bear Creek Road; location is within the Maynardville Limestone about 500 ft west of exit-pathway Picket W.
SS-8	Large spring located at junction of Bear Creek Road and TN 95 near Station BCK 4.55, within the Maynardville Limestone. Westernmost spring monitored under the exit-pathway program.

Upper East Fork Poplar Creek Operable Unit 1

Upper East Fork Poplar Creek (UEFPC) Operating Unit (OU) 1 consists of both surface-water and groundwater components of the hydrogeologic system within the East Fork regime. Numerous sources of contamination to both the surface-water and groundwater flow systems exist within the plant area. Chemical constituents from the S-3 Ponds Waste Management Area dominate groundwater contamination in the western portion of the hydrologic regime. In addition to potential surface-water and groundwater contamination sources identified in UEFPC OUs 1, 2, and 3, most of the potentially contaminated units making up the Y-12 Study Area 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 be addressed in the UEFPC OU 1 RI/FS.

Mercury use areas including buildings and other facilities that have been designated as possible sources of mercury contamination because of known, suspected, or presumed releases will be included in the UEFPC OU 1 RI/FS effort. The area of investigation includes drainages associated with the following buildings and adjoining areas: 9201-2, 9201-5, 9204-4, 9292, 9733-1, 9733-2, and mercury flask storage areas and deflasking facilities. Comprehensive RI/FS activities have not yet been initiated for this OU. However, efforts regarding mercury reduction in effluents and establishment of baseline surface-water quality were conducted in 1993.

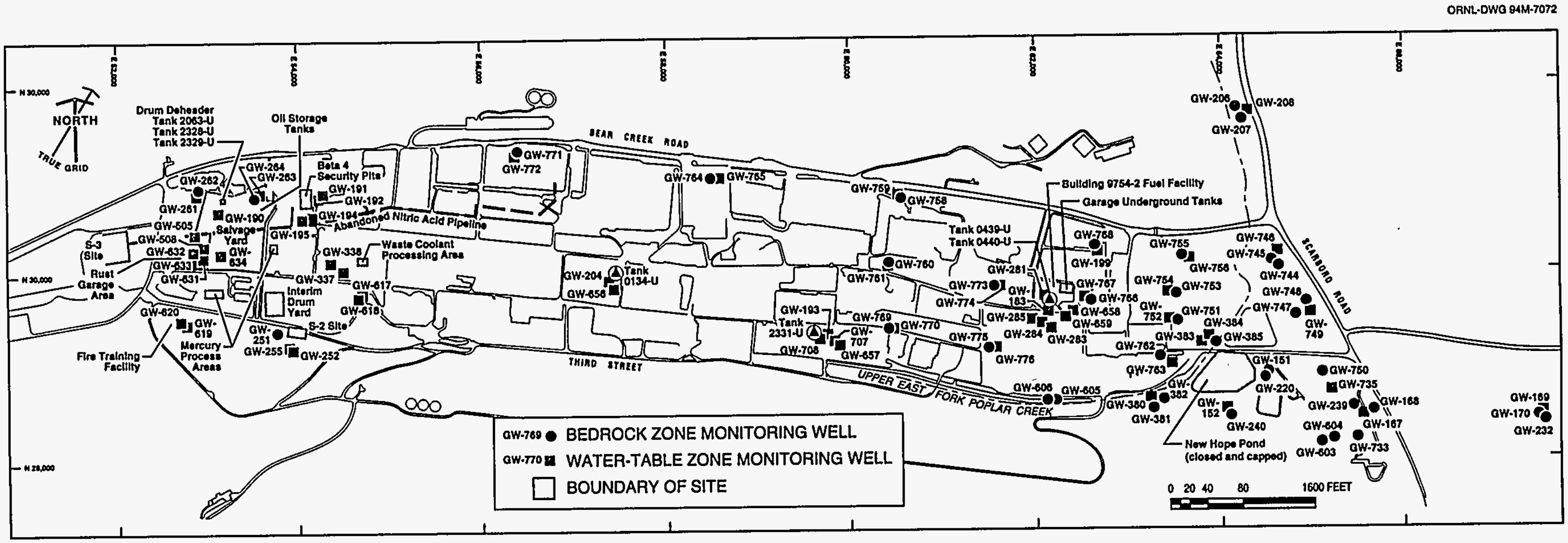

Fig. 7.8. Locations of waste-management sites and monitoring wells sampled during 1993 in the Upper East Fork Poplar Creek Regime.

Table 7.4. Waste management sites, CERCLA operable units, and underground storage tanks included in the 1993 Groundwater Protection Program; East Fork Hydrogeologic Regime

Site name	Regulatory classification	
	Historical[a]	Current[b]
New Hope Pond	TSD Unit	TSD Unit
Mercury Process Spill Areas	SWMU	UEFPC OU 01
Abandoned Nitric Acid Pipeline	SWMU	UEFPC OU 02
Salvage Yard Scrap Metal Storage Area	SWMU	UEFPC OU 03
Salvage Yard Oil/Solvent Drum Storage Area	SWMU	UEFPC OU 03
Salvage Yard Oil Storage	SWMU	UEFPC OU 03
Salvage Yard Drum Deheader	SWMU	UEFPC OU 03
Tank 2063-U	SWMU	UEFPC OU 03
S-2 Site	SWMU	UEFPC OU 03
Waste Coolant Processing Area	SWMU	UEFPC OU 03
Tank 2328-U	SWMU	Y-12 SA
Tank 2329-U	SWMU	Y-12 SA
Interim Drum Yard	SWMU	Y-12 SA
Beta-4 Security Pits	SWMU	Y-12 SA
Tank 2331-U	UST	UST
Tank 0134-U	UST	UST
Building 9754-2 Fuel Facility	UST	UST
Garage Underground Tanks	SMU/UST	Y-12 SA/UST
Rust Garage Area	SWMU/UST	Y-12 SA/UST

[a] Regulatory status before 1992 Federal Facility Agreement: TSD unit—RCRA-regulated land-based treatment, storage, or disposal unit; SWMU—RCRA-regulated solid waste management unit; and UST—Non-RCRA UST.

[b] Modified from *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program.* (U.S. Department of Energy 1992). UEFPC OU 01 = East Fork Poplar Creek Operable Unit 01 (integrator); UEFPC OU 02 = East Fork Poplar Creek Operable Unit 02 (source control); UEFPC OU 03 = East Fork Poplar Creek Operable Unit 03 (source control); and Y-12 SA = Y-12 Plant Study Area.

Upper East Fork Poplar Creek Operable Unit 2

UEFPC Creek OU 2 is the abandoned nitric acid pipeline, which was used between 1951 and 1983 to transport a waste stream made up of nitric acid and depleted uranium from Building 9215 to the S-3 Ponds for disposal. Numerous leaks have been determined, the earliest in 1951 at a weld about 350 ft east of the discharge point.

The primary exposure pathways associated with the nitric acid pipeline are soil contamination resulting from absorptions from leaked solutions, groundwater contamination resulting from waste solutions infiltrating to the groundwater table, and surface-water contamination resulting from groundwater seeps. Nitrate and uranium are the primary contaminants of concern. A small section of the pipeline lies within the Bear Creek regime. Field activities under the RI have been completed. An RI report and FS report are due to EPA in August 1994.

Upper East Fork Poplar Creek Operable Unit 3

UEFPC OU 3 consists of the S-2 Site; the area around Building 81-10; the Coal Pile Trench; the Salvage Yard Oil and Oil/Solvent Storage Areas, Scrap Metal Storage Area, and Drum Deheader; and the Machine Coolant Storage Tanks and Waste Coolant Processing Facility. An RI work plan for this OU is scheduled for completion in February 1994.

Waste Coolant Processing Area

The Waste Coolant Processing Area is used to treat waste coolants collected from various shops within the plant complex. A biodegradation facility and the treatment basin/effluent drain field within the area were closed in accordance with a RCRA closure plan (Stone and McMahon 1988). TDEC certified final closure of the biodegradation facility in 1988.

S-2 Site

The S-2 Site was an unlined earthen reservoir used from 1945 to 1951 for percolation, evaporation, or neutralization of an unknown quantity of liquid wastes. Waste materials reportedly included nitrates of copper, nickel, and chromium; diethyl ether and pentaethers; nitric, hydrochloric, and sulfuric acids; sulfates; dibutyl carbinol and tributyl phosphates; aluminum nitrate; hydrogen fluoride; cadmium; natural and enriched uranium; and cyanide compounds (Kimbrough 1986). The site was closed in 1951, the remaining liquids were neutralized, and the reservoir was filled with soil and seeded with grass (Haase 1987).

Salvage Yard Scrap Metal Storage Area

The Salvage Yard Scrap Metal Storage Area has been used from 1950 to the present for storage of scrap metal, some of which contains low levels of depleted or enriched uranium. Some minor contamination of surficial soils at the site has been reported (Welch et al. 1987).

Oil/Solvent Drum Storage Area

The Salvage Yard Oil/Solvent Drum Storage Area consisted of two storage areas: the east drum storage area and the west drum storage area. Each area was closed as described in respective RCRA closure plans (Welch 1986, Lind and Welch 1989, Welch 1989). Waste oils containing chlorinated organics, uranium and/or beryllium, chlorinated organic solvents, and nonchlorinated flammable solvents were stored in drums on site, and leaking drums and spills have been documented (Welch et al. 1987).

Oil Storage Tanks

Operation of the Salvage Yard Oil Storage tanks began in 1978 when a 6000-gal tank was installed to store oil contaminated with polychlorinated biphenyls (PCBs). A 5000-gal tank was added to the site in 1980. Both tanks were surrounded by an earthen dike and were emptied in 1986 (Welch 1986). Spills and leaks have occurred but were contained within the diked area (Welch et al. 1987).

Drum Deheader

The Salvage Yard Drum Deheader, operated from 1959 to 1989, was used to cut off the tops of and to crush empty drums collected from various locations throughout the Y-12 Plant. Three tanks (2063-U, 2328-U, and 2329-U) at this site had the potential to contaminate groundwater. They all exceeded the maximum allowable leak rate established under the TDEC regulations and were excavated. Soil near the tanks contained elevated concentrations of cadmium, lead, and mercury and detectable levels of volatile organics and PCBs (Stone 1989a).

Building 81-10

Building 81-10 was not monitored during 1993. It is being investigated as part of the RI/FS effort for OU 3.

Coal Pile Trench

The Coal Pile Trench is a 50,000-ft^2 earthen trench located beneath a coal pile west of the Y-12 Steam Plant. The trench was used to dispose of uranium and depleted uranium alloys, molybdenum, thiourea, carbon support forms, and other nonuranium materials. Because of the presence of the coal pile, there is no access to the soil overlying the trench. The primary concern at this time is groundwater contamination from trench leachate, which will be addressed in UEFPC OU 1.

Interim Drum Yard

The Interim Drum Yard is currently a graveled, covered, and diked outdoor storage area previously used to store drums containing various hazardous, mixed, and nonhazardous wastes, including sludge containing chromium, mercury-contaminated wastes, chlorinated and nonchlorinated organics, and plating solutions. Materials contaminated with PCBs are not currently stored at the site but have been in the past. A small portion of the site has been closed in accordance with a TDEC-approved RCRA closure plan (Willoughby et al. 1988). Waste has been removed from the remaining portion, and the yard has been scheduled for closure by the ER organization.

Other Sites

New Hope Pond

New Hope Pond was constructed in 1963 to regulate the quality and flow of water in UEFPC before the water exited the grounds of the Y-12 Plant. Operation of New Hope Pond ceased in 1988, and final closure was certified by TDEC in 1990. Sediment in New Hope Pond contained PCBs, mercury, and uranium but did not exhibit the characteristics of a hazardous waste (Kimbrough and McMahon 1988a, Kimbrough and McMahon 1988b, Saunders 1983). Lake Reality, which replaced New Hope Pond, began operation in 1988. Water from Upper East Fork Poplar Creek enters Lake Reality from an extension of the New Hope Pond inlet diversion ditch and exits through a weir in the west berm.

Beta-4 Security Pits

The Beta-4 Security Pits site was used from 1968 to 1972 for classified disposal of uranium and uranium alloys, scrap metal containing depleted and enriched uranium, organic compounds, acids, and miscellaneous debris (Welch et al. 1987).

Underground Storage Tanks

Petroleum fuel USTs located within the East Fork regime include Tank 2331-U, Tank 0134-U, and the 9754/9754-2 Fuel Facilities. Investigations to assess product releases from these tanks have been performed in accordance with the rules of TDEC (TDEC Division of Underground Storage Tanks). Corrective actions or long-term monitoring are planned for these facilities in accordance with corrective action plans.

Rust Garage Area

The Rust Garage, originally used as a vehicle and equipment maintenance shop, is currently used as a paint shop. Four petroleum fuel USTs were located at the site: 1222-U, 2082-U, 1219-U, and 2068-U. All four tanks at the site were excavated in 1989. Industrial products used on site include lubricating oil, gasoline, diesel fuel, hydraulic fluid, antifreeze, battery acid, and mineral spirits.

A bulk-oil storage platform and an elevated gasoline tank are located south of the garage, and a wash pad is located on the east side of the building. Gasoline and diesel fuel releases associated with operation of the USTs have been reported. Because of their proximity and similar operational history, product releases have been evaluated under a single investigation for the site, which started in 1987. Free product has been recovered from one piezometer at the site (Geraghty and Miller, Inc. 1988a).

Monitoring wells were installed at the site in 1990 as part of a UST site investigation (Eaton and Van Ryn 1991). A corrective action plan was submitted to TDEC in May 1992. Groundwater remediation at Rust Garage is currently planned under the scope of UEFPC OU 1.

Garage Underground Tanks

The Garage Underground Tanks (one diesel and one leaded gasoline) went into service in 1944 at the site of the old Building 9754 Fuel Facility; an unleaded-gasoline tank was added in 1975. They were converted to store liquid waste oil in 1978. These tanks were removed in 1989, and the site is undergoing RCRA closure. The smaller dispenser tanks that were gravity fed by the liquid bulk storage tanks will be closed in conjunction with the corrective actions undertaken at the Building 9754-2 Fuel Facility (Stone 1989b).

Discussion of Monitoring Results

The objectives of the 1993 groundwater monitoring program in the East Fork regime were (1) to further define contaminant plume boundaries and (2) to evaluate potential contaminant exit pathways by using the existing monitoring well network in the Maynardville Limestone. Locations of monitoring wells are shown in Fig. 7.8.

Plume Delineation

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 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. A mound in the water table created by disposal of large volumes of liquid wastes during operation of the S-3 Site (formerly the S-3 ponds) allowed contaminants to move into areas east of the current hydrologic divide.

Sources of VOCs in the East Fork regime include the S-3 Site, several sites located within the Y-12 Salvage Yard, the Waste Coolant Processing Area, petroleum USTs, and process/production buildings in the plant (Fig. 7.8). Concentrations of VOCs in most of the East Fork regime have remained relatively constant since 1988 (Fig. 7.9). Some monitoring locations (e.g., GW-220 and GW-733) on the eastern end of the regime, east of New Hope Pond, have shown increasing VOC concentrations, indicative of an easterly movement of the center of mass of part of the plume (Fig. 7.10).

Nitrate

Nitrate concentrations exceeded the 10 mg/L maximum contamination level during 1993 in a large part of the western portion of the East Fork regime (Fig. 7.11). Groundwater containing nitrate concentrations as high as 5500 mg/L occurred in the unconsolidated zone and at shallow bedrock depths just east of the S-3 Site.

The real 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 eastward from the S-3 Site to just downgradient of the S-2 Site. Nitrate has traveled farthest in groundwater in the Maynardville Limestone.

Trace Metals

Concentrations of barium, cadmium, chromium, and lead exceeded maximum contamination levels during 1993 in samples collected from monitoring wells at the S-2 Site, the Y-12 Salvage Yard, the Waste Coolant Processing Area, the 9754 and 9754-2 Fuel facilities, Rust Garage, two exit-pathway wells, and New Hope Pond. Elevated concentrations of these metals were most commonly reported for groundwater samples collected from wells monitoring the unconsolidated zone. Groundwater at shallow bedrock depths contained elevated metals concentrations near the Y-12 Salvage Yard, the S-2 Site, and at New Hope Pond.

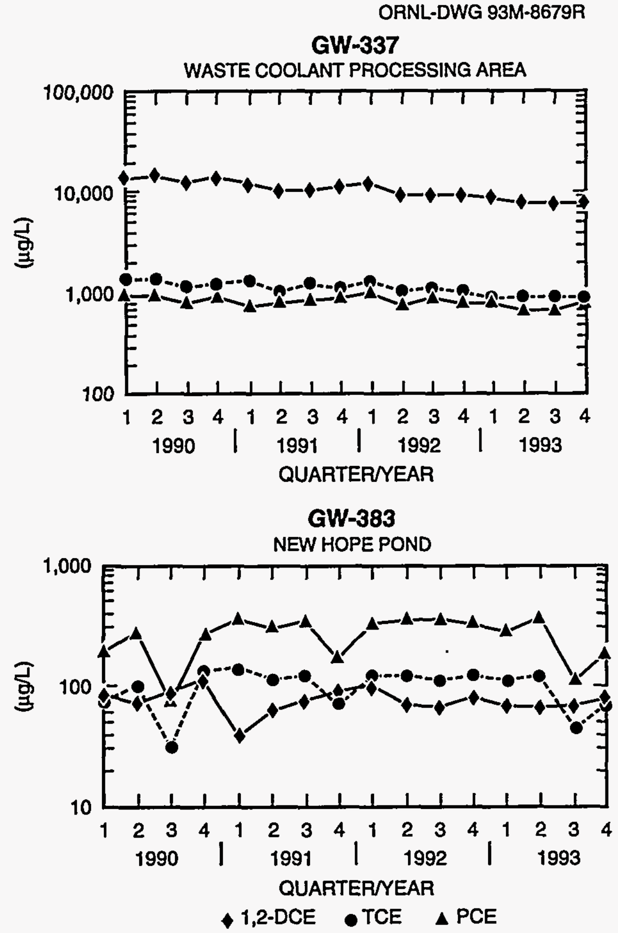

Fig. 7.9. Volatile organic compounds in groundwater in selected wells in the East Fork regime.

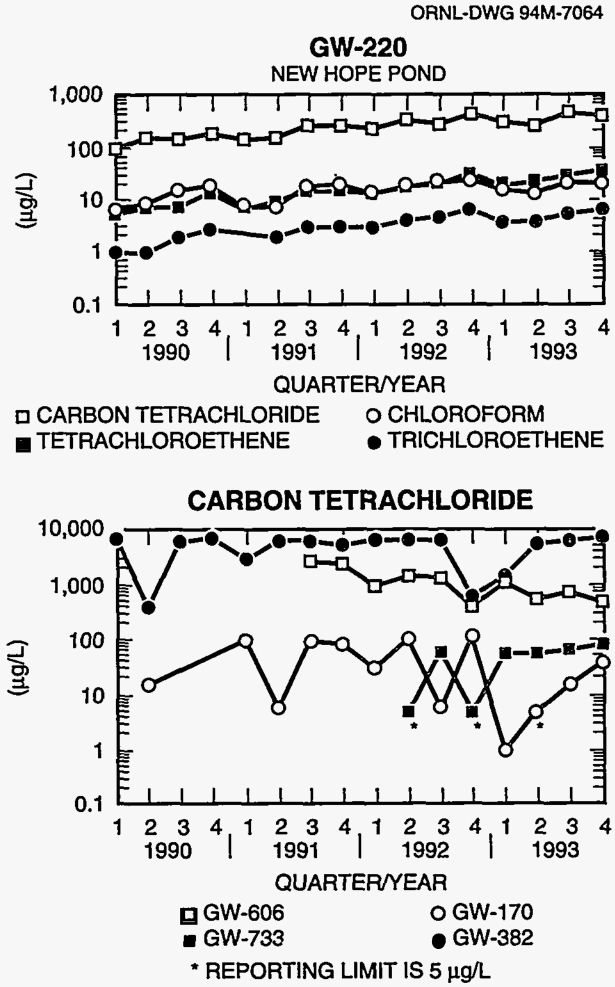

Fig. 7.10. Volatile organic compounds in selected wells near New Hope Pond and exit-pathway wells.

Volatile Organic Compounds

Because of the many source areas, VOCs are the most widespread groundwater contaminants in the East Fork regime (Fig. 7.12). 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 the highest dissolved concentrations of petroleum hydrocarbons (about 60 mg/L) occur in groundwater in the Y-12 Salvage Yard near the Rust Garage Area (Fig. 7.8).

The 1993 monitoring results generally confirm findings from the previous 3 years of a continuous dissolved VOC plume in groundwater in the bedrock zone extending eastward from the S-3 Site over the entire length of the regime. Additionally, the 1993 data confirm previous results identifying the Waste Coolant Processing Facility area as a VOCs source area. “Pockets” of VOCs also are present in groundwater at the Building 9754 and 9754-2 fuel facilities and New Hope Pond (Fig. 7.12).

Results obtained during previous years suggest that New Hope Pond is not a source of VOCs in the wells at the east end of the Y-12 Plant. Data obtained during 1993 support this observation. Groundwater sampled from wells installed upgradient of the site (wells GW-382 and GW-606) contains the same VOCs found in wells downgradient of the site (Well GW-220, Fig. 7.10). The upgradient source of these VOCs has not been pinpointed beyond process and maintenance facilities located in east-central and eastern portions of the Y-12 Plant.

Radionuclides

As in the Bear Creek regime, the primary alpha-particle emitting radionuclides are uranium, isotopes of radium, neptunium, and americium. The primary beta-particle-emitting radionuclide is technetium.

Groundwater with gross alpha activity above 15 pCi/L occurs in scattered points within the East Fork regime (Fig. 7.13). Gross alpha activity exceeding the maximum contamination level is most extensive in groundwater in the unconsolidated zone. Gross alpha activity consistently above 15 pCi/L occurs only in one well (GW-204) at Tank 0134-U and one well west of New Hope Pond (GW-605). Previous data have also suggested an area of elevated gross alpha activity west of New Hope Pond. Sporadic gross alpha activity was observed in several shallow wells scattered across the East Fork regime, notably in exit-pathway wells GW-206 and GW-169. Erratic data distribution, coupled with high turbidity and total suspended solids content in samples from most of the wells, indicate that these values are false positives.

During 1993, in bedrock-monitoring wells, gross alpha activity exceeded 15 pCi/L only at one location, west of New Hope Pond.

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 exceeds 50 pCi/L in groundwater in scattered locations throughout the regime. Gross beta activity consistently above 50 pCi/L occurred only in the western part of the regime, near the Salvage Yard and Rust Garage.

Exit-Pathway and Perimeter Monitoring

Exit-pathway groundwater monitoring activities in the East Fork regime in 1993 involved ongoing monitoring and evaluation of data from new wells installed in mid and late 1992. The CY 1992 ORR environmental report contained a detailed discussion of the new exit-pathway monitoring network. Surface-water quality in UEFPC is regularly monitored in accordance with National Pollutant Discharge Elimination System (NPDES) permits, and the results are summarized in Section 4.

Chemical water quality data from exit-pathway wells monitored in CY 1993 provided the first strong indication that VOCs are being transported off the ORR through the Maynardville Limestone at depths of approximately 100 to 300 ft. Sporadic occurrences of common chlorinated solvents, carbon tetrachloride and tetrachloroethene, above drinking water standards (DWSs) have been confirmed at a depth of 160 ft in an off-site well (Well GW-170, Fig. 7.8) since 1991. This off-site well is located approximately 1500 ft east of the eastern ORR boundary. This off-site well also contained chloroform and trichloroethene, although below the maximum contaminant levels for these two compounds. Two additional wells at the same location as Well GW-170 have been sampled. Well GW-169 (Fig. 7.8) is approximately 40 ft deep. Only trace levels of VOCs have been observed in this well; one sample for trichloroethene was slightly above the MCL in 1991. Carbon tetrachloride and chloroform have not been present above detection levels in the shallow well. Well GW-232 is approximately 400 ft deep. No VOCs have been detected in this well.

In 1993, VOCs were confirmed to exist in Well GW-733 located along the eastern edge of the ORR. Well GW-733 also monitors the Maynardville Limestone and is approximately 160 ft deep. The compositions of the VOCs seen in this well were the same as those observed in Well GW-170. The concentration trend for carbon tetrachloride, the primary contaminant of concern, in both wells GW-170 and GW-733 is illustrated in Fig. 7.10. An areal distribution of VOCs is shown in Fig. 7.12. The data to date indicate that VOC transport is occurring at depth within the Maynardville Limestone and is restricted to that formation. VOCs were not observed in exit-pathway wells drilled to a variety of depths in the ORR aquitards north of Well GW-733. Conversely, VOCs have not been observed at concentrations exceeding MCLs in several wells located south of Well GW-733 in the Knox Aquifer. Source areas for the VOCs are not well defined. Historical data have shown significant VOC contamination within and immediately east of the Y-12 Plant. Multiple sources are likely to include process areas where large quantities of solvents, particularly carbon tetrachloride, were used in the early and mid-1940s. Operations and maintenance facilities, such as the Waste Coolant Processing Area, also represent probable historical source areas.

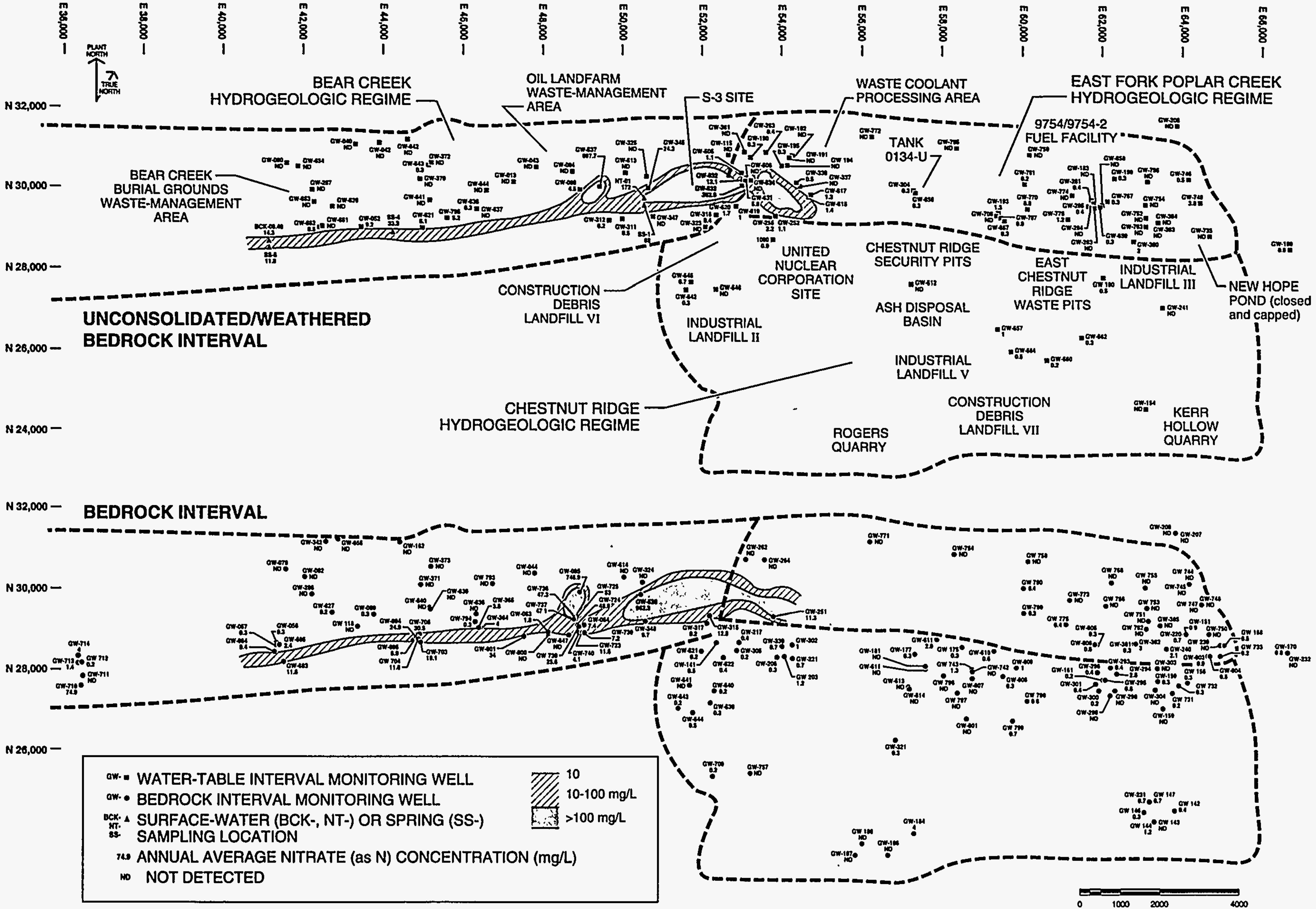

Fig. 7.11. Nitrate (as N) observed in groundwater at the Y-12 Plant.

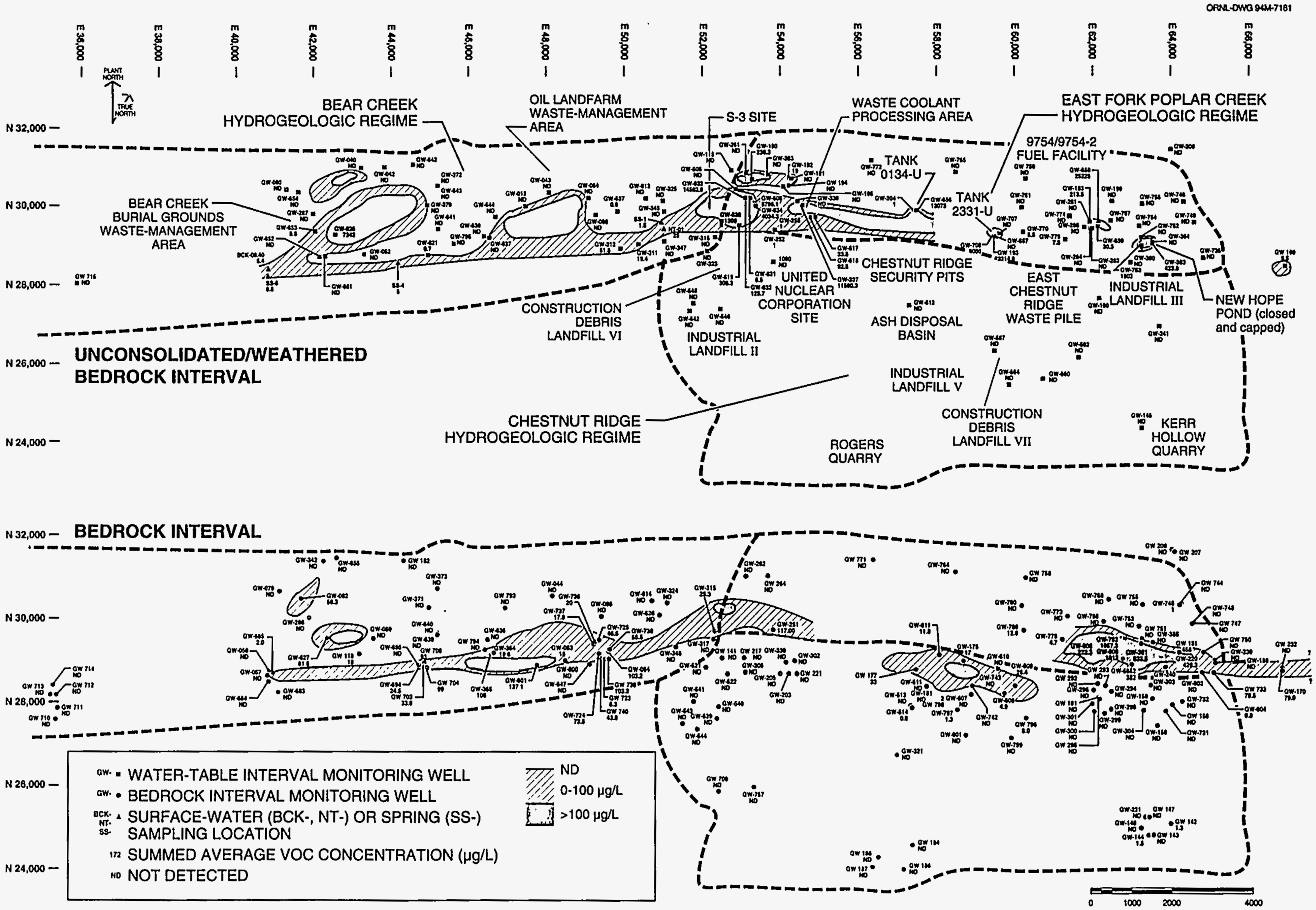

Fig. 7.12. Summed volatile organic compounds in groundwater at the Y-12 Plant.

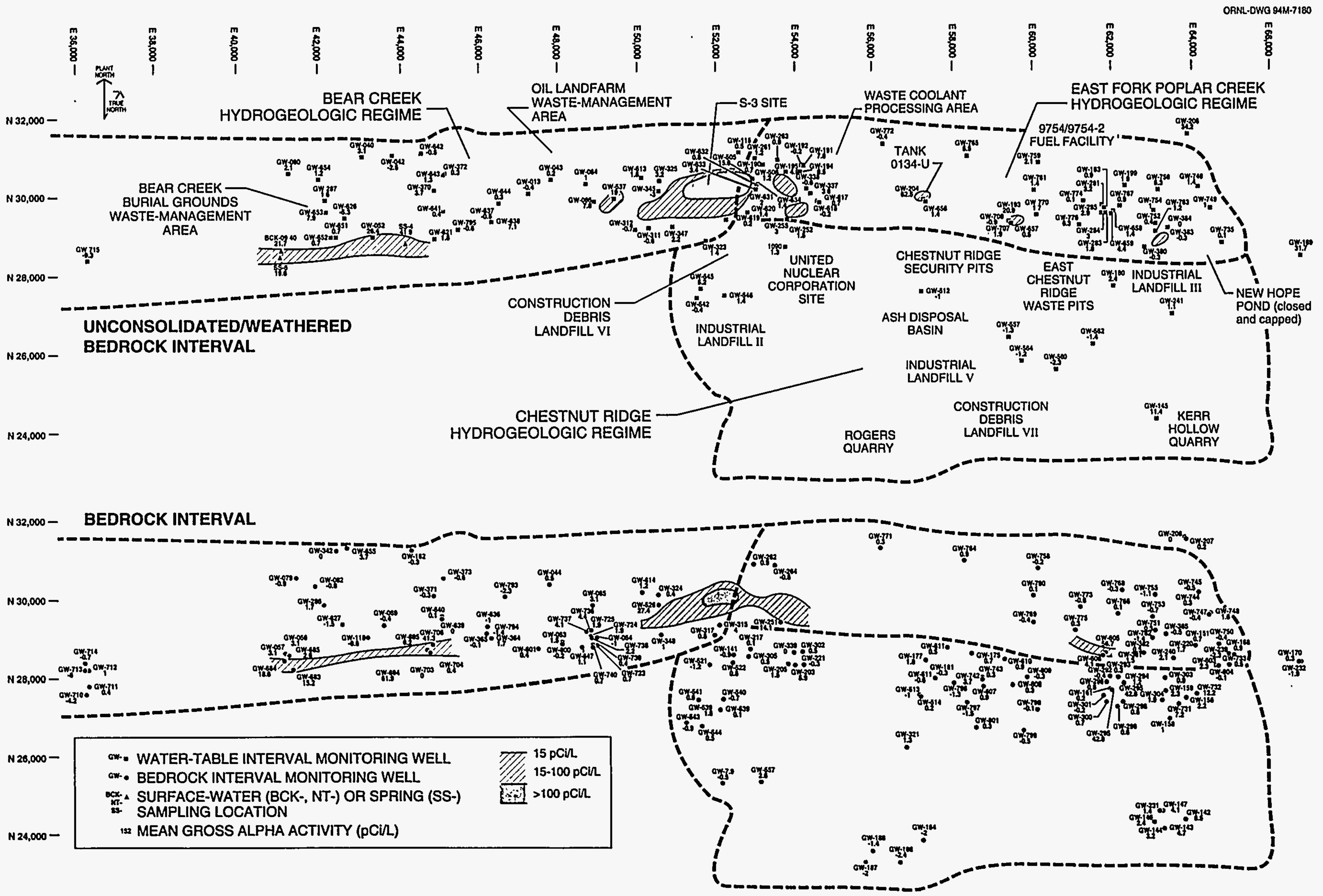

Fig. 7.13. Gross alpha activity in groundwater at the Y-12 Plant.

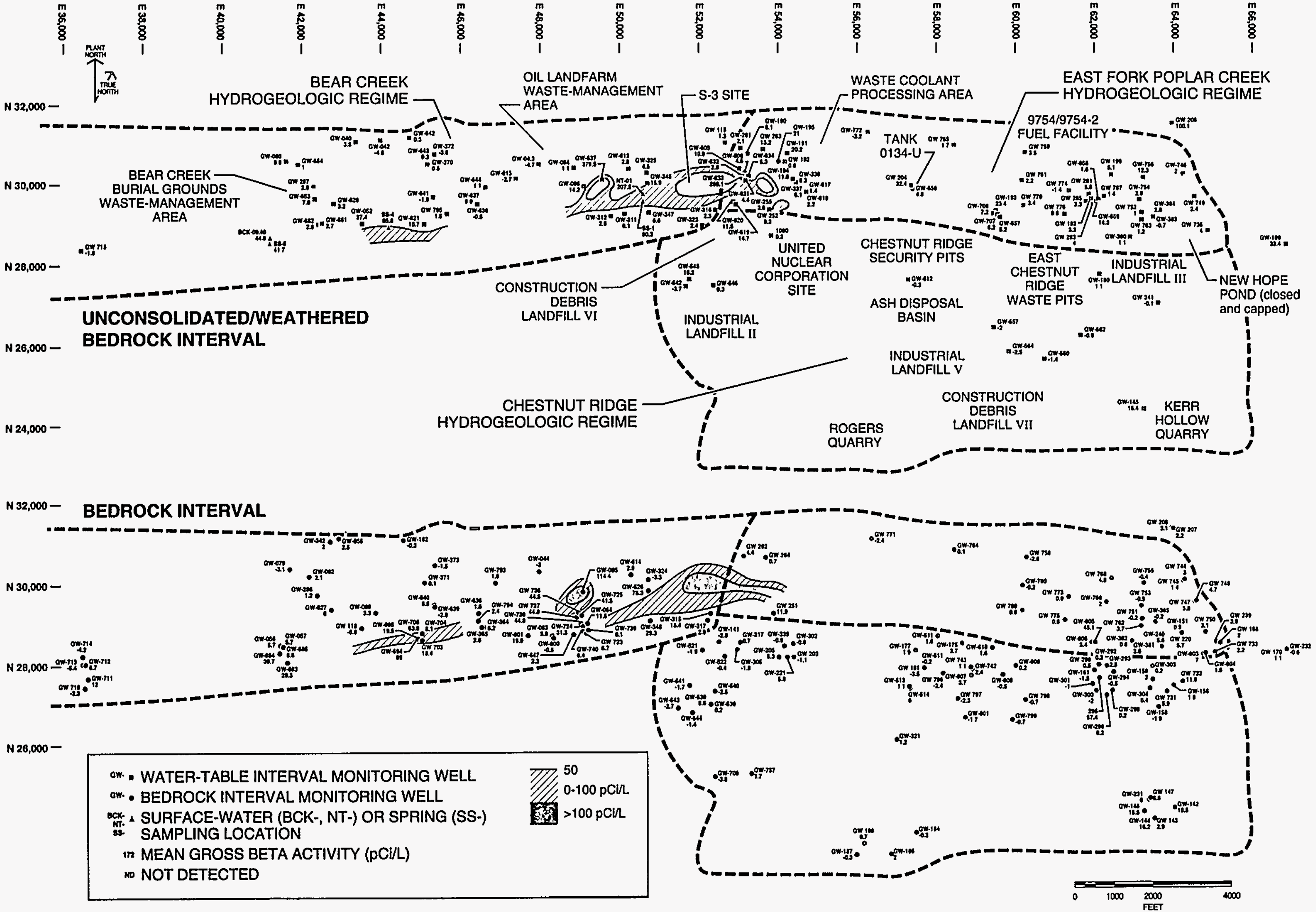

Fig. 7.14. Gross beta activity in groundwater at the Y-12 Plant.

Evaluation of human health risks to date indicates that an exposure route to humans and the environment does not exist because of the depth of the contaminants. However, additional actions are planned to characterize the extent of the VOC contamination and to ensure that no exposure routes exist. Immediate actions include continued monitoring of existing wells both on site and off site. Additional off-site wells are located farther to the east of Well GW-170. These wells, compromised by surface water, will be rehabilitated and sampled. A survey to identify potential discharge springs for groundwater will be conducted and appropriate sampling of these locations conducted. Sampling of surface-water locations and two quarry sites is also planned to ensure that exposure risks are negligible. Based on an evaluation of these short-term actions, the need for any interim remedial measures will be determined. Long-term actions include an expansion of the study area boundaries for UEFPC OU 1 to include the off-site area of concern and implementation of an RI/FS.

In addition to monitoring activities, cross-borehole testing was conducted by means of a cluster of ten wells located along the eastern edge of the ORR. The objective of the cross-borehole tests was to attempt to identify preferred groundwater flow pathways by inducing flow in the aquifer. Flow was induced by pressure injection of a large quantity of deionized water (approximately 2500 gal) into a selected well. The effects of the injection in surrounding wells was monitored by measuring potentiometric surface, specific conductance, and temperature changes. Increases in the potentiometric surface level and temperature, or a decrease in the specific conductance, indicated a hydrologic connection between the injection well and the monitoring point. Two replicate tests were completed. The cross-borehole tests were conducted at least 48 hours after the last rainfall event, and monitoring continued for 48 hours following injection. Initial data from the tests showed positive results for several of the wells, particularly those within the shallow groundwater zone. Some inferences of preferred groundwater flow paths may be made upon complete analysis of the data in 1994.

Bear Creek Hydrogeologic Regime

Located west of the Y-12 Plant in Bear Creek Valley, 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 Bear Creek Valley extending from the west end of the Y-12 Plant to Highway 95. Figure 7.15 shows the Bear Creek regime, locations of wells sampled in 1993, and the locations of its waste management sites. The CERCLA OUs that encompass these sites are shown in Fig. 7.5 and detailed in Table 7.5.

Bear Creek Operable Unit 1

Bear Creek OU 1 includes the following units: S-3 Ponds, Sanitary Landfill I, Boneyard/Burnyard, the Oil Landfarm, and the Bear Creek Burial Grounds (including Oil Retention Ponds 1 and 2). These units were used until the 1980s as the primary area for disposal of various types of hazardous and nonhazardous wastes generated at the Y-12 Plant. A CERCLA RI work plan for this OU is currently in preparation.

S-3 Site

The S-3 Site, constructed in 1951, originally consisted of four unlined surface impoundments. Wastes discharged into the ponds contained nitric and other acids, nitrate wastes, pickling and plating wastes, machine coolants, caustic solutions, depleted uranium in nitric acid solution, technetium in raffinate and condensate. Waste disposal at the site ceased in 1984 (Geraghty and Miller, Inc. 1988b). In 1988, the ponds were closed as a landfill in accordance with a TDEC-approved RCRA closure plan (Energy Systems 1988a). TDEC certified final closure of the site in 1990.

Oil Landfarm

The Oil Landfarm consisted of three areas where waste oils and coolants were applied to nutrient-adjusted soil during the dry months of the year (April to October) to enhance biodegradation. These oils and coolants contained beryllium compounds, depleted uranium, PCBs, and VOCs. About 1 million gallons of waste oil was applied to soils at the site between 1973 and 1982 (Geraghty and Miller, Inc. 1988b). In 1989 the site was covered with a low-permeability engineered cap in accordance with a TDEC-approved RCRA closure plan (Energy Systems 1988b). TDEC certified final closure of the site in 1990.

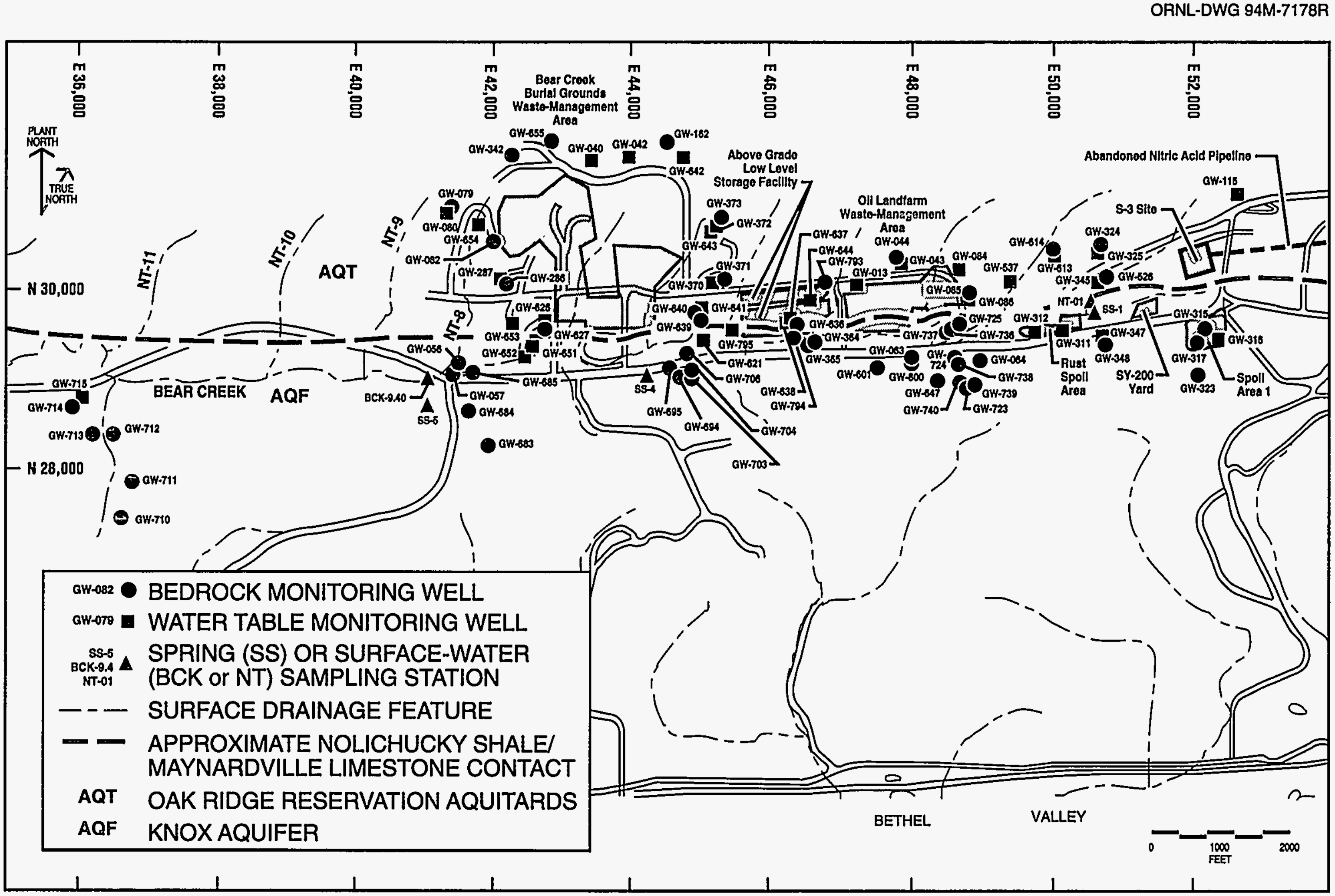

Fig. 7.15. Bear Creek Hydrogeologic Regime, showing the waste-management sites.

Table 7.5. Waste management sites and CERCLA operable units included in the 1993 Groundwater Protection Program; Bear Creek Hydrogeologic Regime

Site name	Regulatory classification	
	Historical[a]	Current[b]
S-3 Site	TSD Unit	BC OU 01
Oil Landfarm Waste Management Area		
Oil Landfarm	TSD Unit	BC OU 01
Burnyard, Boneyard, and Hazardous Chemical Storage Area	SWMU	BC OU 01
Sanitary Landfill I	SWMU	BC OU 01
Bear Creek Burial Grounds Waste Management Area		
Burial Ground A (North and South)	TSD Unit	BC OU 01
Burial Ground C	TSD Unit	BC OU 01
Burial Grounds B, D, E, and J	SWMUs	BC OU 01
Oil Retention Pond No. 1	SWMU	BC OU 01
Oil Retention Pond No. 2	SWMU	BC OU 01
Spoil Area I	SWMU	BC OU 02
SY-200 Yard	SWMU	BC OU 02
Rust Spoil Area	SWMU	BC OU 02
Bear Creek floodplain soils	N/A[c]	BC OU 03
Bear Creek groundwater, surface water, and creek sediments	N/A	BC OU 04
Above Grade Low Level Storage Facility	N/A	N/A

[a] Regulatory status before 1992 federal facility agreement: TSD Unit—RCRA-regulated land-based treatment, storage, or disposal unit and SWMU—RCRA-regulated solid waste management unit.

[b] Modified from *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program* (U.S. Department of Energy 1992): BC OU 01 = Bear Creek Operable Unit 01 (source control OU); BC OU 02 = Bear Creek Operable Unit 02 (source control OU); BC OU 03 = Bear Creek Operable Unit 03 (Source Control OU); and BC OU 04 = Bear Creek Operable Unit 04 (integrator OU).

[c] N/A = Not applicable (not previously regulated as a separate unit or not currently regulated.

Sanitary Landfill I

Sanitary Landfill I was a TDEC-permitted site for disposal of nonhazardous wastes generated at the Y-12 Plant, including paper, cardboard, plastics, rubber, wood, brush, organic refuse, textile products, and asphalt roofing materials. Waste disposal at Sanitary Landfill I was terminated in 1982, and the site was graded, capped, and closed in 1983, in accordance with a TDEC-approved closure plan (Bailey 1983).

Boneyard/Burnyard

The Boneyard/Burnyard consists of about 8 acres used from 1943 to 1970 as a disposal site for waste from the Y-12 Plant. Burning and disposal of debris and sanitary, metallic, chemical, and radioactive wastes are known to have occurred. The site has been abandoned and is predominantly covered with grassy vegetation. The southeastern portion of this site is overlain by the Hazardous Chemical Disposal Area, now considered to be part of the Boneyard/Burnyard. The Hazardous Chemical Disposal Area (about 2 acres) was used for releasing compressed gas from cylinders with leaking or damaged valves and for disposal of reactive or explosive laboratory chemicals. Laboratory chemicals disposed of at the site included acids, bases, organics, water-reactive compounds, and shock-sensitive compounds such as picric acid. The Hazardous Chemical Disposal Area is currently covered with a RCRA-type cap.

Bear Creek Burial Grounds Waste Management Area

The Bear Creek Burial Grounds waste management area includes several waste disposal units designated Burial Grounds A (North and South), B, C, D, E, and J, and two ponds (Oil Retention Ponds Nos. 1 and 2). Each burial ground consisted of multiple trenches used for disposal of liquid and/or solid wastes. Oil Retention ponds No. 1 and 2 were constructed to collect oils seeping from disposal trenches in Burial grounds A South and A North, respectively.

Burial grounds A (North and South) and C primarily received liquid wastes that generally consisted of waste oils and coolants, spent solvents, and mop waters. Solid wastes disposed of at the site included salts, metals (primarily beryllium and uranium) and metal oxides, metal saw-fines, and asbestos. All hazardous waste disposal activities ceased in 1991. Volatile organics in groundwater are the contaminants of primary concern.

Burial grounds A (North and South) and C and the two Oil Retention ponds were closed in 1988 and 1989 in accordance with TDEC-approved RCRA closure plans (Energy Systems 1988c and Energy Systems 1988d). TDEC certified final closure of Burial Ground A (North and South) in 1989. Certification of final closure of Burial Ground C was requested from TDEC in 1990. TDEC certified final closure of Oil Retention ponds Nos. 1 and 2 in 1990.

The nature and extent of soil contamination within each of the listed units in Bear Creek OU 1 and the nature and extent of sediment and surface water contamination within each associated tributary to Bear Creek will be determined during CERCLA investigations.

Bear Creek Operable Unit 2

Bear Creek OU 2 consists of the Rust Spoil Area, Spoil Area 1, and the SY-200 Yard. Field investigations conducted under an EPA-approved CERCLA RI work plan were completed in December 1993.

Rust Spoil Area

The Rust Spoil Area was used between 1975 and 1983 for the disposal of solid wastes generated during various renovation, maintenance, and construction operations at the Y-12 Plant. Nonradioactive construction debris disposed of at the site is estimated at less than 100,000 yd^3, composed of soil fill, masonry, and concrete with reinforcement steel; however, materials containing solvents, asbestos, mercury, and uranium also may have been disposed of at the site (Battelle 1989b). Closure of the site was completed in 1984 in accordance with a TDEC-approved closure plan (MCI 1983). An earlier RCRA facility investigation plan for the site contains a detailed discussion of its operational history (Battelle 1989b). Soil contamination is of primary concern.

Spoil Area I

Spoil Area I has been used since about 1980 for disposal of nonradioactive construction debris. TDEC permitted the site in 1986 for disposal of rubble and other noncombustible, stable solid wastes (TDEC 1986). The site has received about 100,000 yd^3 of debris, including asphalt, brick, concrete, roofing materials, brush, reinforcement steel, rock, and tile. An earlier RCRA facility investigation plan prepared for the site contains a detailed discussion of its operational history (Battelle 1989a). Although plant controls eliminated disposal of hazardous and radioactive wastes, past plant practices indicate that some of the construction material may have been contaminated with trace amounts of asbestos, mercury, beryllium, thorium, and uranium. Soil contamination is of primary concern.

SY-200 Yard

The SY-200 Yard, which operated from the 1950s to 1986, was a gravel-covered area used for temporary storage of equipment, machinery, and miscellaneous items. Records indicate that waste materials were not disposed of or stored at the site. An earlier RCRA facility investigation plan for the site contains a detailed discussion of its operational history (Geraghty and Miller 1989). Soil contamination is of primary concern.

Bear Creek Operable Unit 3

Bear Creek OU 3 consists of the Bear Creek floodplain sediments. Bear Creek's headwaters are just west of the Y-12 Plant, and the creek flows westward through Bear Creek Valley until it exits near State Highway 95. Bear Creek has received contaminated surface-water and groundwater discharges from past waste disposal practices in the Bear Creek Burial Grounds and S-3 waste management areas. Contamination of Bear Creek has been drastically reduced since these waste disposal operations ceased in the mid-1980s and many of the disposal units were closed. Principal contaminants remaining in floodplain soils and sediments are PCBs, uranium, and cadmium. A CERCLA RI work plan for this OU has been submitted to EPA for approval. Approval of the work plan and field activities is pending completion of RI efforts at higher-priority OUs, such as OU 1.

Bear Creek Operable Unit 4

Bear Creek OU 4 addresses contamination within the coupled groundwater/surface-water system and downstream transport of Bear Creek channel deposits. Potential sources of groundwater, surface-water, and sediment contamination are being addressed in Bear Creek OUs 1, 2, and 3.

Groundwater and surface water within the Bear Creek regime will be characterized and remediated as an integrator OU distinct from the contaminated units. This approach is warranted because (1) groundwater contaminant plumes from individual sites are significantly intermingled, making assessment and remediation of individual plumes impractical and (2) the sites share a common hydrologic exit pathway, which is best addressed by a comprehensive approach. Where site-specific groundwater or surface-water data are needed to better identify the source or to support a screening-level risk assessment, groundwater or surface-water assessment activities (e.g., piezometers or well points) may be conducted during the RI/FS process for the source control OUs.

Channel sediments are included in this integrator OU rather than in Bear Creek OU 3 because, once in the stream channel, sediments are directly coupled with the surface-water flow pathway. Floodplain sediments are considered a source term for contaminants entering Bear Creek and not part of this operable unit.

Discussion of Monitoring Results

Groundwater monitoring efforts in the Bear Creek regime during 1993 were the same as those for the East Fork regime: (1) to delineate contaminant plume boundaries and (2) to evaluate potential contaminant exit pathways in the Maynardville Limestone by using the existing monitoring well network.

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. Another nitrate source area lies near the eastern end of the Oil Landfarm waste management area. 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. DNAPLs have been discovered at a depth of 270 ft below the Bear Creek Burial Grounds. The DNAPLs consist primarily of tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, and high concentrations of PCBs.

Contaminant plume boundaries are essentially defined in the bedrock formations that directly underlie many waste disposal areas in the Bear Creek regime, particularly the Nolichucky Shale. The elongated shape of the contaminant plumes in the Bear Creek regime is the result of transport of the contaminants parallel to strike in the Maynardville Limestone (Fig 7.15). A review of historical data suggests that, in general, contaminant concentrations in the Bear Creek regime, within the ORR aquitards, have remained relatively constant since 1986. Certain contaminants at specific sites, however, have shown non-steady-state concentration patterns, as detailed in the CY 1992 ORR Environmental Report. The same trends have been observed in exit-pathway wells located in the Bear Creek regime (Fig. 7.16), with slight increases or decreases observed for selected contaminants.

Nitrate

Unlike most of the other groundwater contaminants, nitrate moves with the groundwater relatively unimpeded. The limits of the nitrate plume probably define the maximum extent of subsurface contamination in the Bear Creek regime.

Data obtained during 1993 indicate that nitrate concentrations exceed the 10 mg/L maximum contamination level in an area that extends west from the S-3 Site for several thousand feet down Bear Creek Valley (Fig. 7.11). During 1993, the highest nitrate concentrations continued to be seen within 1000 ft of the S-3 Site in groundwater in the unconsolidated zone and at shallow depths (less than 100 ft below the ground surface) in the Nolichucky Shale (well GW-526). A secondary nitrate source appears to exist in the vicinity east of the Oil Landfarm.

The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper part of the aquifer (less than 200 ft below the ground surface). Data obtained from exit-pathway monitoring wells installed during 1991 and 1992 suggest that the nitrate plume in groundwater within bedrock in the Maynardville Limestone extends farther down Bear Creek Valley than previously thought.

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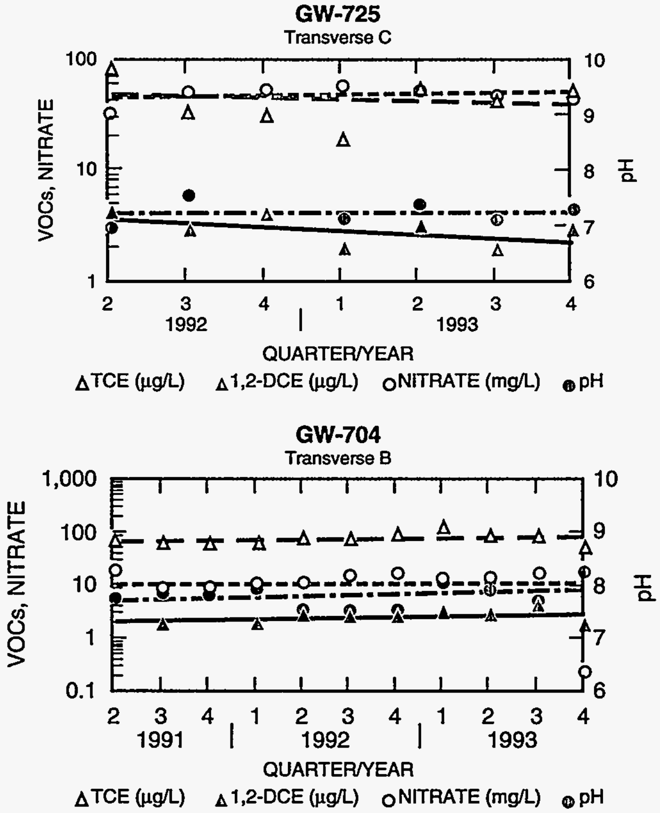

Fig. 7.16. Concentration of selected contaminants in exit-pathway monitoring wells GW-725 and GW-704 in the Bear Creek hydrogeologic regime.

Vertical plume boundaries are not so well defined. Typically, nitrate concentrations exceed the maximum contamination level in groundwater in the upper 300 ft of the Maynardville Limestone. Below this depth nitrate concentrations exceed 10 mg/L in an area immediately down-dip (south) of the S-3 Site. Data obtained since 1986 suggest that the nitrate plume in this area extends more than 500 ft below the ground surface.

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 maximum contamination levels 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 more-neutral pH conditions prevail, only sporadic occurrences of elevated trace metal concentrations are evident.

Based on the 1993 data, the highest concentrations of barium were reported for samples from wells at the S-3 Site. Barium, chromium, and cadmium were detected above maximum contaminant levels in filtered samples from several monitoring wells in the Bear Creek Burial Grounds and Oil Landfarm waste management areas. Monitoring immediately adjacent to the S-3 Site was not done in 1993.

Other trace metal contaminants in the Bear Creek regime are beryllium, boron, cobalt, copper, nickel, strontium, and uranium. Concentrations of these metals most commonly exceed 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 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 that contains detectable levels of VOCs occurs primarily within about 1000 ft 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. Although the plumes generally do not extend more than 1000 ft from the source areas in groundwater in the low-permeability formations that underlie many waste sites, significant transport of the VOCs has occurred in the Maynardville Limestone.

Data obtained from exit-pathway monitoring wells installed during 1991 and 1992 show that in the vicinity of the water table, an apparently continuous dissolved VOC plume extends for about 7000 ft westward from the S-3 Site to just west of the Bear Creek Burial Grounds waste management area. VOCs are also present in the bedrock intervals of both the Maynardville Limestone and the ORR aquitards, but data obtained during 1993 show discontinuous areas of occurrence confined to the vicinity of the Bear Creek Burial Grounds and Oil Landfarm waste management areas.

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 also may be present in groundwater near the S-3 Site.

Evaluations of the extent of these radionuclides in groundwater in the Bear Creek regime during 1993 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from a well exceeded 15 pCi/L (the maximum contamination level for gross alpha activity), then one or more of the alpha-emitting radionuclides were 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 and the western sides of the Bear Creek Burial Grounds and the Oil Landfarm waste management areas. Data obtained from exit-pathway wells installed in 1991 and 1992 show that gross alpha activity in groundwater in the Maynardville Limestone exceeds the maximum contamination level for several thousand feet west of the S-3 Site. Elevated gross alpha activities were observed in five exit-pathway spring and stream monitoring locations.

The extent and distribution of gross beta radioactivity in groundwater in the unconsolidated zone are about the same as those of gross alpha radioactivity (Fig. 7.14). During 1993 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 west of 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, possibly as far as the western portion of the Bear Creek Burial Grounds waste management area. Elevated gross beta activity was observed in three springs and one stream monitoring station that also exhibited elevated gross alpha activity.

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 and groundwater in the Maynardville Limestone are hydraulically connected. The western exit-pathway well transect (Picket W) serves as the perimeter wells for the Bear Creek Regime (Fig. 7.7).

The majority of exit-pathway study activities in 1993 consisted of continued monitoring at four well transects (pickets). The 1992 ORR Environmental Report and Shevenell et al. (1992) contain detailed information about the construction of these pickets and the rationale for their construction. Several other nonmonitoring types of investigations were initiated in 1993 as part of exit-pathway studies. These studies involved evaluation of the geologic characteristics of the Maynardville Limestone, geochemical characterization of groundwater types in Bear Creek Valley, statistical analysis of controlling variables for development of preferred groundwater flow paths, and cross-borehole testing. Results of these investigations will be published in 1994.

Information gathered as a result of exit-pathway studies to date suggests that certain zones within the Maynardville Limestone are more likely to have flow conduits. One of the probable major controlling variables for preferential flow path development is lithology. This particular investigation, therefore, was initiated to better identify where lithologies susceptible to fracturing or cavity development occur.

Characterization of groundwater geochemistry from available data was initiated to examine several items: (1) identification of the depths of active groundwater flow in the Maynardville Limestone, (2) where and to what depths dissolution of bedrock is occurring, and (3) the degree and extent of connection of groundwater flow conduits and fractures.

Statistical analysis of existing drilling and chemical data was initiated in 1993 to help determine which factors have primary influence on development of preferred groundwater flow paths in the Knox Aquifer. Variables, such as elevation, proximity to Bear Creek well location, depth, and stratigraphic zone monitored, are being evaluated. This statistical analysis may provide results that can be incorporated into the two studies noted above.

Cross-borehole testing was conducted at all four exit-pathway transects in the Bear Creek regime to attempt to identify preferred groundwater flow pathways by inducing flow in the aquifer. Cross-borehole tests in this regime were identical to those discussed for the East Fork regime previously. Two replicate tests were completed at pickets A and W; duplicate tests were required to verify results at these two pickets. Single tests were run at pickets B and C. As in the East Fork regime, initial data from the tests showed positive results for several of the wells, particularly those within the shallow groundwater zone. Some inferences of preferred groundwater flow paths may be made upon complete analysis of the data in 1994.

Groundwater quality data obtained during 1993 from the exit-pathway monitoring wells confirmed 1992 data that the horizontal and vertical extent of groundwater contamination in the Maynardville is greater than previously reported. The 1993 data obtained from wells located along the westernmost picket (Picket W) also confirmed that contaminated groundwater generally does not occur much beyond the western side of the Bear Creek Burial Grounds waste management area.

Surface-water samples were collected quarterly from a northern tributary of Bear Creek (the background location), from five springs that discharge groundwater to the creek, and from four points along the main creek channel (Fig. 7.17; Table 7.3). A preliminary review of the 1993 data indicates 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. This assessment is consistent with 1991 and 1992 data.

Nitrate concentrations in Bear Creek exceeded the maximum contamination level during 1993 from south of the S-3 Site to west of the Bear Creek Burial Grounds at BCK 9.40. Nitrate concentrations at BCK 4.55 (NPDES Outfall 304), at the junction of Bear Creek Road and Highway 95, averaged 5.4 mg/L. The average nitrate concentration in surface water samples collected from the farthest downstream point (BCK 0.63), which is located just upstream of the confluence of Bear Creek and East Fork Poplar Creek, was 4.8 mg/L, below the maximum contamination level but above background. (Background is about 0.2 mg/L.) Average nitrate concentrations in spring discharges decreased from an average of 68 mg/L at SS-1 to nondetectable in three out of four quarters at SS-6.

Low concentrations of VOCs (less than 10 μg/L) were detected in surface-water samples and spring discharge samples collected from the upper reaches of Bear Creek (at NT-1 and BCK 9.40). Compounds detected in samples from the creek were trichloroethene, 1,2-dichloroethene, and tetrachloroethene. Spring discharges at

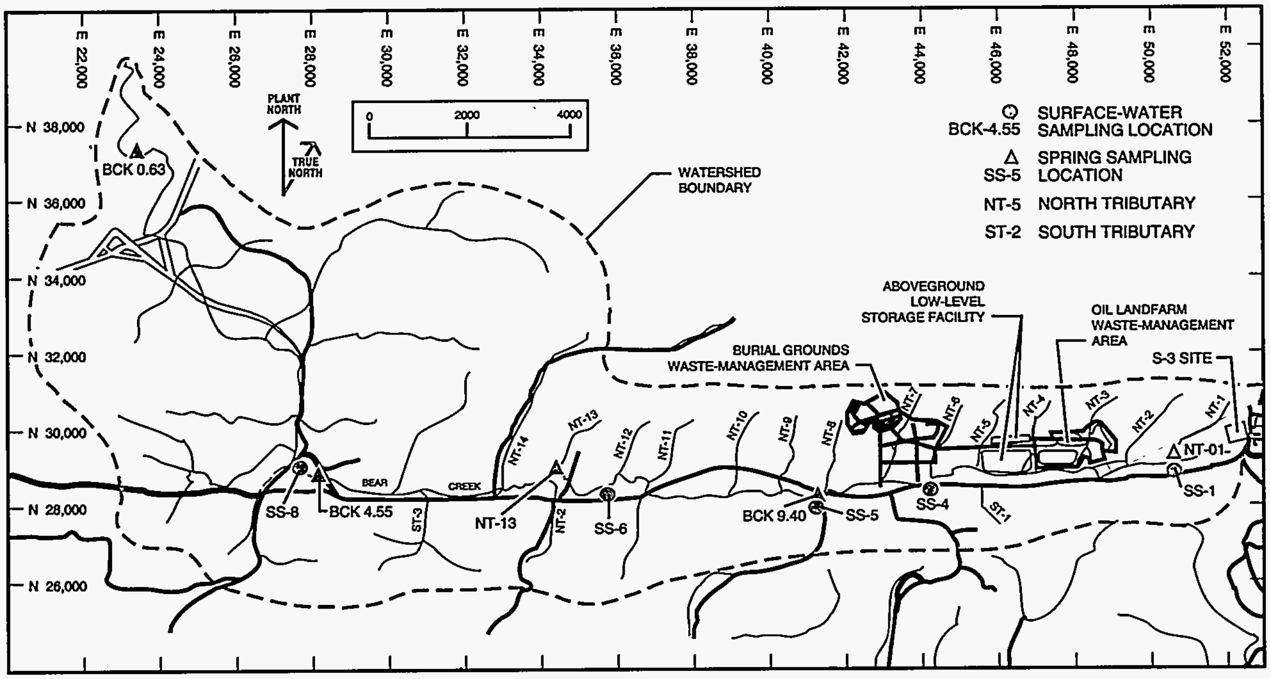
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Fig. 7.17. Bear Creek and its tributaries.

SS-1, SS-4, and SS-5 also contained trace amounts of VOCs. Each of these compounds is a primary component of the VOC plumes in groundwater in the regime.

Based on the 1993 data, uranium is the most common trace metal contaminant in Bear Creek. Concentrations of uranium exceeded background levels throughout reaches of the creek upstream of BCK 9.40. Moreover, uranium concentrations in the creek slightly exceeded background levels at the farthest downstream sampling point (BCK 0.63). Uranium concentrations in spring effluents exceed background levels as far west as the SS-5 location.

Annual average gross alpha activity appeared to be lower in 1993 than in previous years. Gross alpha was above 15 pCi/L only at NT-1 and BCK 9.40 along Bear Creek. Spring discharges west as far as SS-5 had annual average gross alpha above 15 pCi/L. Gross beta activity exceeded 50 pCi/L at BCK 9.40 and NT-01 and was above background levels at all sampling stations downstream. Annual average gross beta exceeded 50 pCi/L at SS-4 and was above background levels at SS-5.

Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge regime is south of the Y-12 Plant and is flanked to the north by Bear Creek Valley and to the south by Bethel Valley Road (Fig. 7.6). The regime encompasses the portion of Chestnut Ridge extending from a gap in the ridge located southeast of the eastern end of the Y-12 Plant to a drainage basin on the ridge located just west of the Centralized Sanitary Landfill II. Figure 7.18 shows the locations of waste management units and monitoring wells sampled in 1993. CERCLA OUs in the regime are shown in Fig. 7.5 and detailed in Table 7.6.

Four categories of sites are located within the Chestnut Ridge regime: (1) RCRA interim status units, (2) RCRA 3004(u) solid waste management units and solid waste disposal units, (3) TDEC-permitted solid waste disposal facilities, and (4) CERCLA OUs. Of the waste disposal sites located in the Chestnut Ridge regime, only the Chestnut Ridge Security Pits have been confirmed as a source of groundwater contamination.

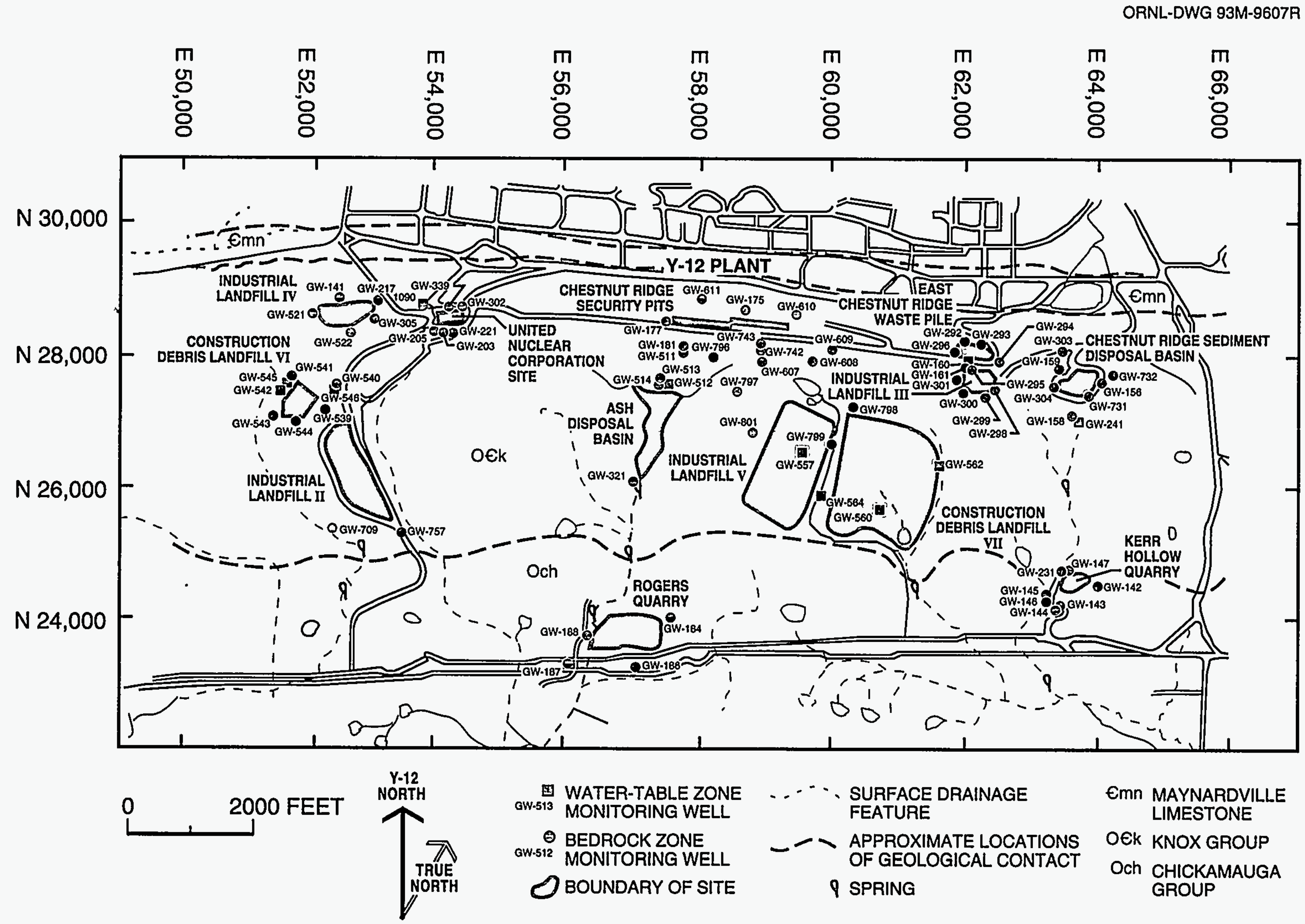

Fig. 7.18. Locations of waste-management sites and monitoring wells sampled during 1993 in Chestnut Ridge Hydrogeologic Regime.

Chestnut Ridge Operable Unit 1

Operable Unit 1 consists of the Chestnut Ridge Security pits, whcih were operated between 1973 and 1988. When in operation, the site was a series of trenches used for disposal of classified hazardous and nonhazardous wastes.

The security pits contain an estimated 3950 tons of waste materials. Detailed waste inventories are classified, but an unclassified inventory listed ten major waste types: acids, fiberglass, beryllium, biological material, debris, heavy metals, inorganics, organics, thorium, and uranium (Energy Systems 1984). Disposal of hazardous waste in the security pits ceased in 1984; disposal of nonhazardous waste ceased in 1988. Closure of the site is described in a TDEC-approved RCRA closure plan and involved construction of a low-permeability cap over the disposal trenches (Energy Systems 1988e). The site was certified closed by TDEC in 1989. Groundwater impacts from the disposal operations are the primary focus of this OU. A CERCLA RI work plan for this OU is in preparation.

Chestnut Ridge Operable Unit 2

Chestnut Ridge OU 2 consists of the Filled Coal Ash Pond (Ash Disposal Basin) and Upper McCoy Branch. The Filled Coal Ash Pond is situated within the McCoy Branch watershed about 0.8 km (0.5 mile) south of the Y-12 steam plant. By 1967, the pond filled, spilling sediments directly into McCoy Branch. From 1967 to 1989, ash was carried within McCoy Branch to Rogers Quarry, about 0.8 km (0.5 mile) downstream of the Coal Ash Pond.

Impacts to surface water, stream sediments, and groundwater from metals, including uranium and major ions, are of concern. Biomonitoring of aquatic organisms in McCoy Branch and Rogers Quarry has shown a biological impact potentially from the ash pond operations. Field sampling activities conducted under an approved RI work plan were completed in summer CY 1993. An RI report is in preparation.

Chestnut Ridge Operable Unit 3

The United Nuclear Corporation (UNC) Site received nitrate-contaminated, low-level radioactive wastes and contaminated equipment packaged in 55-gal drums and in boxes. About 30,000 barrels of waste were placed in the site (Grutzeck 1987). Waste disposal at the site ceased in 1984. Groundwater quality data obtained since 1985 do not suggest groundwater contamination at the site (Early 1989). A CERCLA record of decision was signed in 1991, and the site was capped and closed in 1992 in accordance with the approved CERCLA record of decision and a RCRA closure plan. Prior to cap construction, contaminated soils from the off-site Elza Gate Site cleanup were placed as fill into the UNC disposal site. Post-closure groundwater monitoring is currently ongoing under the Y-12 Plant ER Surveillance and Maintenance Program.

Chestnut Ridge Operable Unit 4

Chestnut Ridge OU 4 consists of Rogers Quarry and Lower McCoy Branch. Rogers Quarry is situated within the McCoy Branch watershed about 1 mile south of the Y-12 Plant. The quarry was the source of construction materials in the 1940s and 1950s. The quarry filled with water and was abandoned with quarrying equipment in place in the early 1960s. Disposal of fly ash and bottom ash from the Y-12 Steam Plant into the quarry began in the 1960s and ceased in 1993. The quarry was also used for disposal of other plant process materials.

Lower McCoy Branch begins at the surface-water discharge point of Rogers Quarry and ends at the McCoy Branch embayment in the Clinch River/Melton Hill Lake.

Impacts to surface water, stream sediments, and groundwater from metals, including uranium and major ions, are of concern. Biomonitoring of aquatic organisms in Rogers Quarry has shown a biological impact potentially from ash disposal operations.

Table 7.6. Waste management sites and CERCLA operable units included in the 1993 Groundwater Protection Program; Chestnut Ridge Hydrogeologic Regime

Site	Regulatory classification	
	Historical[a]	Current[b]
Chestnut Ridge Sediment Disposal Basin	TSD unit	TSD unit
East Chestnut Ridge Waste Pile	TSD unit	TSD unit
Kerr Hollow Quarry	TSD unit	TSD unit
Chestnut Ridge Security Pits	TSD unit	CR OU 01
Ash Disposal Basin	SWMU	CR OU 02
United Nuclear Corporation Site	SWMU	CR OU 03
Rogers Quarry	SWMU	CR OU 04
Industrial Landfill II	SWDF	SWDF
Industrial Landfill III	SWDF	SWDF
Industrial Landfill IV	SWDF	SWDF
Industrial Landfill V	N/A[c]	SWDF
Construction Debris Landfill VI	N/A	SWDF
Construction Debris Landfill VII	N/A	SWDF

[a] Regulatory classification before the 1992 Federal Facility Agreement: TSD Unit—RCRA-regulated land-based treatment, storage, or disposal facility; SWDF—solid waste disposal facility (nonhazardous waste); and SWMU—RCRA regulated solid waste management unit.

[b] Modified from *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program* (U.S. Department of Energy 1992): CR OU 01—Chestnut Ridge Operable Unit 01 (source control and groundwater OU); CR OU 02—Chestnut Ridge Operable Unit 02 (source control and Groundwater OU); CR OU 03—Chestnut Ridge Operable Unit 03 (source control and groundwater OU); and CR OU 04—Chestnut Ridge Operable Unit 04 (source control and groundwater OU).

[c] N/A—Not applicable (new facility).

Other Waste Sites

Chestnut Ridge Sediment Disposal Basin

Beginning in 1973 the Chestnut Ridge Sediment Disposal Basin received soil and sediment that was periodically dredged from New Hope Pond. Soils and sediments removed from New Hope Pond contained PCBs, mercury, and uranium. Results of extraction-procedure toxicity analyses showed that the soils did not exhibit the toxicity characteristics of a hazardous waste. During 1987 and 1988 the disposal basin also received mercury-contaminated soils from several locations at the Y-12 Plant. In 1989 the disposal basin was closed in accordance with a TDEC-approved RCRA closure plan. TDEC certified final closure in 1989. Groundwater monitoring is continuing under RCRA interim status, pending finalization of a RCRA post-closure permit.

Kerr Hollow Quarry

The Kerr Hollow Quarry was a source of stone construction material in the 1940s until it filled with water and was abandoned. From the early 1950s, the quarry was used for disposal of reactive materials from the Y-12 Plant and ORNL. Disposal of these materials at the site ceased in November 1988. The site is currently undergoing closure under RCRA. Groundwater monitoring is continuing under RCRA interim status, pending finalization of a RCRA post-closure permit.

East Chestnut Ridge Waste Pile

The East Chestnut Ridge Waste Pile is a lined RCRA-permitted hazardous waste storage facility constructed in 1987 as a storage site for contaminated soils from the Y-12 Plant. The site is located in the western portion of the Chestnut Ridge regime near the Chestnut Ridge Sediment Disposal Basin.

Industrial Landfill II

Industrial Landfill II, also known as the Y-12 Plant Centralized Sanitary Landfill II, is a TDEC-permitted solid waste disposal facility. It is used as a disposal site for combustible and decomposable solid wastes, including scrap metal, glass, paper products, plastics, wood, organic garbage, textile products, asphalt roofing materials, and special wastes such as asbestos and beryllium oxide. The landfill has been expanded, but the expanded area has not received any wastes. Groundwater monitoring at the site is performed in accordance with a monitoring plan approved by TDEC.

Industrial Landfill III

Industrial Landfill III, also known as the Chestnut Ridge Borrow Area Waste Pile, was constructed as a storage facility for soils removed from the Oak Ridge Civic Center properties and the Oak Ridge Sewer Line Beltway. Soils in both areas contained mercury and other metals (and possibly some VOCs) that originated from the Y-12 Plant. Results of extraction-procedure toxicity analyses indicated that the soils do not exhibit the toxicity characteristics of a hazardous waste. A soil-sampling plan designed to determine if the soils are toxic hazardous wastes based on results of Toxicity Characteristic Leaching Procedure testing was submitted to TDEC for review in 1991 (SAIC 1991). Groundwater quality monitoring has been performed since 1986; contaminant releases to the groundwater system have not been detected.

Industrial Landfill IV

Industrial Landfill IV is a TDEC-permitted solid waste disposal facility that has operated since 1989 for disposal of nonhazardous, nonradioactive industrial wastes, including cardboard, plastics, rubber, scrap metal, wood, paper, and special wastes. Groundwater quality monitoring has been performed at the site since 1987, and contaminant releases to groundwater have not been detected.

Industrial Landfill V

Industrial Landfill V is a Class II TDEC-permitted solid waste disposal facility currently under construction (Fig. 7.18). The facility is expected to be operational in April 1994. Once operational, the facility will receive nonhazardous, nonradioactive industrial wastes, such as those currently placed into Industrial Landfill IV. Baseline groundwater quality monitoring was initiated for this facility in May 1993 in accordance with the facility permit.

Construction/Demolition Landfill VI

This facility was completed and approved to receive waste in December 1993 (Fig. 7.18). Construction/Demolition Landfill VI is a Class IV, TDEC-permitted facility for the disposal of nonhazardous, nonradioactive wastes, such as concrete, wood, and other demolition and construction debris. Baseline groundwater quality monitoring was initiated in May 1993. Groundwater detection monitoring is currently conducted at the facility in accordance with the operating permit.

Construction Demolition Landfill VII

Construction/Demolition Landfill VII is a Class IV, TDEC-permitted solid waste disposal facility currently under construction (Fig. 7.18). The facility is expected to be operational in April 1994. Once operational, the facility will receive nonhazardous, nonradioactive wastes, such as those described for Landfill VI. Baseline groundwater quality monitoring was initiated for this facility in May 1993 in accordance with the facility permit.

Discussion of Monitoring Results

Groundwater quality data obtained in the Chestnut Ridge regime during 1993 support conclusions drawn from previous monitoring results. A more comprehensive suite of analytical tests is applied to most sites in the Chestnut Ridge regime because of various permitting requirements; however, volatile organics and trace metals are the only categories in which findings currently consistently exceed background levels. Gross alpha and beta activities sporadically exceeded screening levels in samples taken from wells at the Chestnut Ridge Sediment Disposal Basin, United Nuclear Site, Industrial Landfill III, and at Kerr Hollow Quarry. No discernable pattern or consistency to the data was noted.

Chestnut Ridge Security Pits

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 1993 do not suggest any significant changes in the overall composition or extent of the VOC plume at the site.

There are two distinct VOCs in groundwater at the security pits. In the western portion of the site, the VOC plume is characterized by high concentrations of 1,1,1-trichloroethane. Tetrachloroethene is a principal component of the VOC plume in the eastern portion of the site. The distinct difference in the composition of the plume is probably related to differences in the types of wastes disposed of in the eastern and western trench areas.

Nitrate

Nitrate concentrations were within background levels in all wells.

Trace Metals

Trace metal concentrations in unfiltered samples sporadically exceeded DWSs in only four wells. Elevated turbidity and suspended solids were also observed in most of these samples, indicating a high probability for false positives.

Volatile Organic Compounds

Efforts to delineate the extent of VOCs in groundwater at 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 7.7).

Radionuclides

Gross alpha activities were above the DWS of 15 pCi/L in five samples from four different wells during 1993. In addition, samples from two wells exhibited elevated gross beta activities above the DWS of 50 pCi/L during two quarters in 1993.

Exit-Pathway and Perimeter Monitoring

Exit-pathway monitoring in the Chestnut Ridge regime has followed a different approach from that for the other two regimes. Contaminant and groundwater flow paths in the karst bedrock underlying the regime are not best identified through conventional monitoring techniques. The comprehensive plan, therefore, presented a rationale for using dye-tracer studies to identify exit pathways. Based on the results of dye-tracer studies, springs and surface streams that represent discharge points for groundwater can be identified for water quality monitoring.

Table 7.7. Annual average summed VOC concentrations in groundwater at the Chestnut Ridge Security Pits, 1989–93

Well No.	Summed average VOCs (μg/L)					Percentage decrease
	1989	1990	1991	1992	1993	
GW-173	17	13.5	11.8	11.7	NS[a]	31
GW-174	47.8	48.5	43.7	34	NS	29
GW-175	31.8	38.5	31	29.5	17	47
GW-176	285.3	233.5	170.5	139.7	NS	51
GW-177	66.7	18.8	26.3	25.5	33.7	49
GW-178	43.4	40	34	29	NS	32
GW-179	838	455	328.3	262.3	NS	69
GW-180	145.8	99.5	74.2	52.3	NS	64
GW-322	696	730.3	633	538.3	NS	23
GW-607	NS	16.9	ND[b]	ND	ND	100
GW-608	NS	14.8	15.5	4.5	5.8	61
GW-609	NS	78	67.5	35.5	30.9	55
GW-610	NS	1	0.5	ND	ND	100
GW-611	NS	16	9	13.5	15	6
GW-612	NS	505.8	451.3	358.3	NS	29

[a] NS = not sampled.
[b] ND = not detected.

A dye-tracer study was initiated and completed in 1992 (SAIC 1993), primarily to confirm results of an initial study conducted in 1990 (Geraghty and Miller, Inc. 1990). The 1992 study used the same dye injection well near the Chestnut Ridge Security Pits and many of the same monitoring points as did the 1990 study. The primary differences included an expanded monitoring network and the use of two fluorescent dyes to verify dye detection.

Results of the second tracer-dye study showed no conclusive occurrences of dyes at the monitoring points and did not corroborate data for detection points in the first study. The 1992 study also showed that the injection well was inappropriate because dye-uptake rates by the formation were inadequate. It is likely that the dye-uptake rates are inadequate because the source well is not screened in a flow conduit interconnected to the rest of the system. A formal comparison report has been completed, which examines results of both studies, to provide recommendations for improvements for future dye-tracer studies in this regime. Future dye-tracer studies are possible within the scope of the Chestnut Ridge OU 1 RI effort.

Monitoring of one large spring located south of Industrial Landfill V and Construction/Demolition Landfill VII is planned for 1994 as a best management practice.

Special Studies

Two research investigations were conducted in 1993 involving groundwater at the Y-12 Plant. These investigations included (1) a continuation of groundwater and contaminant studies in which multiport-instrumented wells were used (Fig. 7.7) and (2) initiation of an evaluation of contaminant transport via colloidal particles in groundwater.

Efforts with regard to multiport-instrumented wells continued for both exit-pathway–related studies and for the Y-12 Plant ERP DNAPL investigation in the Bear Creek regime. Multiport-instrumented wells provide detailed, three-dimensional hydraulic conductivity, potentiometric, and chemical data. These wells, therefore, provide greatly enhanced resolution of the hydraulic and hydrochemical properties of the groundwater flow system. Details regarding installation and background information for these wells was presented in the 1992 ORR Environmental Report.

Monitoring of six multiport wells continued as part of exit-pathway studies in 1993. Ongoing data collection included hydraulic conductivity and potentiometric measurements to evaluate changes over time. In addition, a system was developed to collect samples for volatile constituents and helium analyses. Helium analyses were conducted to examine relative age of groundwater from various depth intervals. In general, groundwater with a long residence time in the subsurface will have a higher helium content. A longer residence time implies slow groundwater movement. Thus, comparisons of helium concentrations allow a determination to be made about the depths of active groundwater flow. In addition, these data and information gathered from analysis of other wells were used to initiate an evaluation of groundwater transport across the geologic boundary between the ORR aquitards and the Maynardville Limestone. Because most of the waste sites in Bear Creek Valley overlie the ORR aquitards, identification of groundwater flow zones across the geologic boundary is critical to understanding how contamination moves to the exit pathway (Maynardville Limestone). A good understanding of these introduction points to the exit-pathway system is critical for appropriate selection and development of future understanding of these introduction points to the exit-pathway system is critical for appropriate selection and development of future remedial measures.

Installation of multiport systems was completed for all five core holes used as part of the DNAPL study. Purging in preparation for sampling was initiated, as was some hydraulic conductivity testing. Geologic data obtained during installation of these particular wells has been evaluated to characterize the density and magnitude of fractures, which are the primary flow pathway for DNAPL in the subsurface. The information obtained to date indicates that fracture density greatly decreases within the lower portions of the Nolichucky Shale in the ORR aquitards. A corresponding change in potentiometric pressure in this geologic interval suggests that a lower boundary may exist for downward DNAPL migration in the subsurface. Additional sampling and analysis activities for these multiport wells are planned for 1994 and include sampling for volatile constituents and helium.

An investigation into contaminant transport via colloidal particles was initiated in 1993. The study focuses on major ions and metals because these constituent types are the most likely to adsorb onto colloids being transported within the active flow system. The study includes about 30 wells located within the ORR aquitards, Maynardville Limestone, and Knox Group within the Bear Creek and Chestnut Ridge regimes. A wide range of geologic units and depths was selected to examine how colloidal transport of contaminants is related to these variables. Very slow pumping rates are used to sample groundwater. Various sizes of filters are used to filter the samples to obtain aliquots for analysis. The various aliquots are analyzed to determine what size range of colloidal particles adsorb and transport contaminants. Approximately half of the subject wells have been sampled to date, and preliminary results are being compiled.

GROUNDWATER MONITORING AT THE OAK RIDGE NATIONAL LABORATORY

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. ORNL has established an ER Program to provide comprehensive management of sites where past and current research, development, and waste-management activities may have resulted in residual contamination of facilities or 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 waste area groupings (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 occur within hydrologically defined areas. WAGs allow establishment of a suitably comprehensive groundwater and surface-water monitoring system in a far shorter time than that required to deal with every facility, site, and solid waste management unit individually. Some WAGs share common 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.

At ORNL, 20 WAGs were identified by the RCRA Facilities Assessment 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 are established around the perimeters of the WAGs determined to have a potential for release of contaminants. Table 7.8 lists the 20 WAGs at ORNL and the number of potential remedial action sites within each WAG. Figure 7.19 shows the location of each of the 20 WAGs.

Table 7.8. Summary of ORNL waste area groupings

WAG	Description	Number of sites[a]
1	Main plant area	117
2	White Oak Creek/White Oak Lake	2
3	SWSA 3	3
4	SWSA 4	3
5	SWSA 5	28
6	SWSA 6	3
7	Low-level waste pits and trenches area	19
8	Melton Valley area	35
9	Homogeneous reactor experiment area	13
10	Hydrofracture injection wells and grout sheets	4[b]
11	White Wing scrapyard	1
12	Closed contractors' landfill	1
13	Environmental research areas	2
14	Tower Shielding Facility	2
15	ORNL facilities at Y-12 Plant	14
16	Health Physics Research Reactor area	5
17	ORNL services area	8
18	Consolidated fuel reprocessing area	10
19	Hazardous waste treatment and storage facility	8
20	Oak Ridge Landfarm	1
	Total	279
	Additional sites outside of WAGs	
c	Surplus contaminated facilities	29

[a] Source: July 18, 1991, letter from Lanny Bates, Director of Environmental Restoration, to Robert Sleeman, DOE-ORO.

[b] Principal sites are located underground, beneath WAG 5.

[c] Not applicable.

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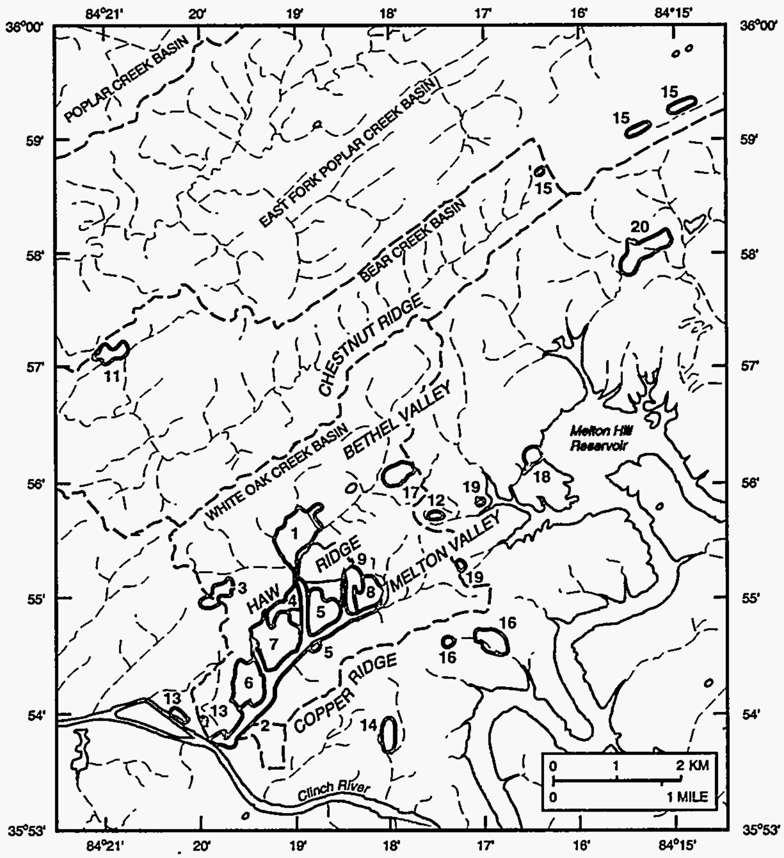

Fig. 7.19. Locations of ORNL waste area groupings (WAGs). (Wag 10 Sites are underground, beneath WAG 5.)

In 1992, some of the WAGs were aggregated into two administrative categories, the Bethel Valley OU and the Melton Valley OU. Each of these operable units is composed of the WAGs in its respective valley. This was done to provide a comprehensive picture of the groundwater in each valley. The Bethel Valley OU includes WAGs 1, 3, and 17, whereas the Melton Valley OU includes WAGs 2, 4, 5, 6, 7, 8, and 9. The ORNL plant perimeter surveillance monitoring is discussed in this section. The ORNL program monitors groundwater at four general locations that are thought to be likely exit pathways for groundwater affected by activities at ORNL (Fig. 7.20).

Bethel Valley Operable Unit

WAG 1

WAG 1, the ORNL main plant area, contains about one-half of the remedial action sites identified to date by the ER Program. WAG 1 lies within the Bethel Valley portion of the White Oak Creek 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.

Most of the WAG 1 sites were used to collect and to store low-level waste (LLW) in tanks, ponds, and waste-treatment facilities, but some also include landfills and spill and leak sites identified during the last 40 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 solid waste management units are related to ORNL's solid and liquid radioactive waste management operations.

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 solid waste management units: solid waste storage area (SWSA) 3, the Closed Scrap Metal Area (1562), and the currently operating 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

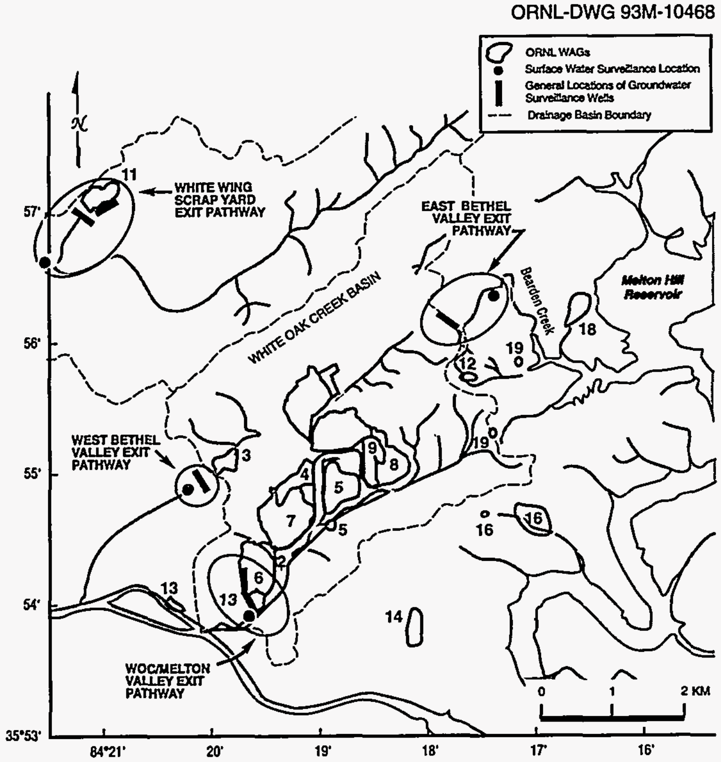

Fig. 7.20. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by ORNL operations.

of disposal elsewhere. Although the information is sketchy, the larger scrap metal equipment (such as tanks and drums) stored on the surface at this site was also probably contaminated. Because only a portion of this material is now buried in the Closed Scrap Metal Area, it is not possible to estimate the amount of contamination that exists in this solid waste management unit.

The Contractors' Landfill was opened in 1975 and is used to dispose of various uncontaminated construction materials. No contaminated waste or asbestos is allowed to be buried at the site. ORNL disposal procedures require that only non-RCRA, nonradioactive solid wastes are 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 eight solid waste management units, a former septic tank now used as a sewage collection/pumping station for the area, and seven tanks used for waste oil collection and storage and for storage of photographic reproduction wastes.

Melton Valley Operable Unit

WAG 2

WAG 2 is composed of White Oak Creek discharge points and includes the associated floodplain and subsurface environment. It represents the major drainage system for ORNL and the surrounding facilities. WAG 2 consists of two solid waste management units: one is the area encompassed by the stream channels of White Oak Creek and Melton Branch, and the other includes White Oak Lake, White Oak Dam, and the embayment.

In addition to natural drainage, White Oak Creek has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the Nonradiological Wastewater Treatment Facility, the sewage treatment plant, 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 hazardous chemicals) 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 is yet to be determined.

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, liquid low-level waste (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 wastes (including radioactive waste) from about 50 agencies. These solid 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 site, 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 control building and asphalt pad have been used for storage through the years.

WAG 5

This WAG contains 28 sites, 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 SWSA 5 and the Transuranic Waste Storage Area. 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 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, a portion of the site, about 10 acres, was set aside for the retrievable storage of transuranic wastes.

The WAG 5 boundary includes the old and new hydrofracture installations. Because Melton Branch flows between the old and new hydrofracture facilities, the new hydrofracture facility has a separate boundary.

WAG 6

WAG 6 consists of three solid waste management units: (1) SWSA 6, (2) the emergency waste basin, and (3) the explosives detonation trench. SWSA 6 is located in Melton Valley, northwest of White Oak Lake 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 wastes that could not be released from ORNL to White Oak Creek. The basin is located northwest of SWSA 6 and has a capacity of 15 million gallons. 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 the first WAG to be investigated at ORNL by the ER Program. The RCRA RI report for WAG 6 has been completed and is documented in a RCRA FI report (Energy Systems 1991).

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.

WAGs 8 and 9

WAG 8 is located in Melton Valley, south of the main plant area, and is composed of 35 solid waste management units that are associated with the reactor facilities in Melton Valley. The solid waste management units consist of active LLLW collection and storage tanks, leak/spill sites, a contractors' soils area, radioactive waste ponds and impoundments, chemical and sewage waste-treatment facilities, a chemical-waste SWSA, and a mixed-waste SWSA. WAG 8 includes the Molten Salt Reactor Experiment facility, the High Flux Isotope Reactor, the Transuranium Processing Plant, and the Thorium-Uranium Recycle Facility.

Radioactive wastes from these facilities are collected in on-site LLLW tanks and 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 northeast of WAG 8. WAG 9 is composed of three solid waste management units: the Homogeneous Reactor Experiment pond, which was used from 1958 to 1961 to hold contaminated condensate and shield water from the reactor; LLLW collection and storage tanks, which were used from 1957 to 1986; and a septic tank that has been used since 1950 for treatment of sewage from Building 7501.

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 injection wells and grout sheets associated with two hydrofracture process experimental locations: the Old Hydrofracture Facility and the New Hydrofracture Facility. The facilities themselves 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. Water tagged with ^{137}Cs, cement, and bentonite were used in formulating the grout.

The Old Hydrofracture Facility 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, served as a pilot plant to demonstrate the feasibility of permanent disposal of liquid radioactive waste in impermeable shale formations by hydrofracture methods. Wastes used in the experiments included concentrated LLLW, ^{90}Sr, ^{137}Cs, ^{244}Cm, transuranics, and other unidentified radionuclides.

The New Hydrofracture Facility is located 900 ft southwest of the Old Hydrofracture Facility on the south side of Melton Branch. The facility was constructed to replace the Old Hydrofracture Facility and to serve as the operational LLLW waste disposal system for ORNL. Wastes used in the injections were concentrated LLLW and sludge removed from the Gunite tanks, ^{90}Sr, ^{137}Cs, ^{244}Cm, transuranics, and other nuclides.

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 solid waste management unit 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 at ORNL.

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.

1993 Groundwater Quality Well Installation, Development, and Sampling Activities

Groundwater quality monitoring wells for the WAGs are designated as 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 in WAG 10. The injection wells previously described are located in WAGs 5, 7, and 8; plugging and abandonment of them was initiated in 1992.

A summary of the groundwater surveillance program is presented in Table 7.9. RCRA assessment data for WAG 6 were submitted to TDEC in March 1993. The report recommended continuing the sampling strategy for 1993 based on results of the analyses. At WAG 6, 8 wells were sampled quarterly for volatile organics and radioactivity parameters; the other 16 wells were sampled semiannually for the same parameters. The remaining WAGs 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 on a rotational basis.

The plant perimeter surveillance program as stipulated in the ORR Environmental Monitoring Plan (EMP), was initiated in 1993. A summary of the program is presented in Table 7.10.

ORNL Groundwater Quality

The following section describes the 1993 groundwater monitoring results for the ORNL WAG perimeter monitoring network and the ORNL plant perimeter surveillance—about 200 sampling events. In a few cases, no samples could be collected because the wells were dry.

Eighteen of the 20 wells identified by the EMP to represent the ORNL plant perimeter are also part of the WAG perimeter monitoring program (WAGs 2, 3, 6, 11, and 17). As such, 1993 result data from sampling conducted under the WAG perimeter program are used for the monitoring plan program. The other two wells (of the 20) were not sampled in 1993 because a decision is pending regarding installation of dedicated pumps in them. The four surface-water locations, Bear Creek, Racoon Creek, Bearden Creek, and White Oak Creek at White Oak Dam, were sampled in October 1993. The results of the plant perimeter monitoring program are discussed as part of the operable unit discussions. Because this was the first time the surface-water locations have been sampled in this program, there are no historical data with which to compare the surface-water results.

Groundwater quality is regulated under RCRA by referencing the SDWA standards. They are applied when a site undergoes RCRA permitting. None of the ORNL WAGs are under RCRA permits at this time; therefore, no permit standards exist with which to compare sampling results. In an effort to provide a basis for evaluation of analytical results and for assessment of groundwater quality at ORNL WAGs, federal DWSs and Tennessee water quality criteria for domestic water supplies have been 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. It should be emphasized that, although drinking water standards are used herein, it is unrealistic to assume that members of the public are going to drink groundwater from ORNL WAGs.

Table 7.9. Summary of the groundwater surveillance program at ORNL, 1993

WAG	Regulatory status	Upgradient/ downgradient wells		Parameters monitored[a]	Frequency and last date sampled
		Bethel Valley Operable Unit			
1	DOE Orders 5400.1 and 5400.5	3	24	Standard	Rotation June 1993
3	DOE Orders 5400.1 and 5400.5	3	12	Standard	Rotation November 1993
17	DOE Orders 5400.1 and 5400.5	4	4	Standard	Rotation July 1993
		Melton Valley Operable Unit			
2	DOE Orders 5400.1 and 5400.5	12	8	Standard	Rotation February 1993
4	DOE Orders 5400.1 and 5400.5	4	11	Standard	Rotation January 1994[b]
5	DOE Orders 5400.1 and 5400.5	2	20	Standard	Rotation April 1993
6	RCRA[c] assessment monitoring and DOE Orders 5400.1 and 5400.5	7	17	Volatile organics, gross alpha, gross beta, ^{3}H, ^{137}Cs, ^{60}Co, total rad Sr + standard field measurements	8 wells quarterly; 16 wells semiannually
7	DOE Orders 5400.1 and 5400.5	2	14	Standard	Rotation August 1993
8 and 9	DOE Orders 5400.1 and 5400.5	2	9	Standard	Rotation October 1993
		White Wing Scrapyard			
11	DOE Orders 5400.1 and 5400.5	6	5	Standard	Rotation January 1993

[a] Standard: volatile and semivolatile 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] Initiated in December 1993 and completed in January 1994. Results will be reported in the 1994 report.

[c] The appropriate regulatory authority at SWSA 6 in WAG 6 is RCRA. The regulatory authority is expected to change to CERCLA, with RCRA as an applicable and appropriate requirement.

Bethel Valley Operable Unit

WAG 1

In 1993, as in the past, radionuclides have been detected in a number of WAG 1 wells, with gross alpha and beta activity and total radioactive strontium above DWSs at a few wells. The highest levels of radioactivity continue to be observed in the same five wells: one in the northwest plant area and four in the southwest and western plant area. (The upgradient wells are located in the northeast corner of the WAG.)

Table 7.10. Summary of the plant perimeter surveillance program at ORNL, 1993[a]

Exit pathway	WAG	Number of wells	Surface water locations
White Oak Creek/Melton Valley	6 & 2[b]	10	White Oak Creek at White Oak Dam
West Bethel Valley	3	3	Raccoon Creek
East Bethel Valley	17	4	Bearden Creek
White Wing Scrapyard	11	3	Bear Creek

[a] All locations are monitored for volatile organics, tritium, total radioactive strontium, gross alpha and beta, ^{60}Co, and ^{137}Cs.

[b] Four wells are part of the ORNL WAG 6 perimeter network, and four wells are part of the ORNL WAG 2 perimeter network. Two other wells were not sampled in 1993, pending a decision regarding installing dedicated pumps in them.

The well in the northwest plant area continues to show gross alpha that is attributable to ^{234}U and ^{238}U. The gross beta activity at the five wells of concern is attributable mainly to the total radioactive strontium and its daughters.

Volatile organic compounds were detected in a few wells; however, most of these were also detected in the laboratory blanks or were at levels within five times the analytical detection limit, and none of the concentrations exceeded any DWSs.

WAG 3

Analytical results for 1993 at WAG 3 are similar to those obtained in the previous 2 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.

Total radioactive strontium is present 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. Apparently, the gross beta signatures are mainly attributable to total radioactive strontium. The data for 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.

In a few of the wells, VOCs were detected, but at levels within five times the analytical detection limit. Trichloroethene has consistently been detected above DWSs in every sampling event at one well located in the northeast part of the WAG. The values have always been less than five times the analytical detection limit for the analysis method used.

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 the eastern and western boundaries show evidence of radioactive contamination, including gross beta activity and ^{3}H. In the past, gross alpha activity has exceeded the DWS at two wells; however, this did not occur in 1993.

The data for the southeastern and southwestern boundaries show evidence of VOC contamination. The contamination has consistently been located primarily in one well. The pollutants include trichloroethene, vinyl chloride, benzene, 1,2-dichloroethene, 1,1-dichloroethene, and tetrachloroethene.

Plant Perimeter

No wells in the East and West Bethel Valley exit pathways have ever had either VOC or radiological constituents detected above any DWSs. At the East Bethel Valley surface-water location, neither volatile organic compounds nor radiological constituents were detected above any DWS. In the West Bethel Valley exit pathway, gross beta activity and total radioactive strontium were detected above DWSs at the Racoon Creek surface water location. One of the three wells in the West Bethel Valley exit pathway has always been dry when sampled; a second well was also dry at the time of the 1993 sampling.

Melton Valley Operable Unit

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. WAG 2 receives contamination from many 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.

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 radioactive contamination, including gross alpha and gross beta activity and ^{3}H. Gross beta activity above primary DWSs was detected at the two wells 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 White Oak Dam are believed to be the result of surface-water underflow at the dam, not groundwater contamination.

Tritium concentrations in the wells at the east end of White Oak Lake were inconsistent with the previous two sampling events. Several of the wells had ^{3}H concentrations two and three times the values previously observed.

Little VOC contamination was detected in the wells. Acetone and carbon disulfide were detected at levels higher than in the past at one of the wells on the west side of WAG 7. However, the concentrations were below ten times the analytical detection limit, a rule of thumb used to determine organic presence applied to common laboratory contaminants.

Chromium was detected above Tennessee general water quality criteria at a well south of WAG 6. This well has had similar results during the past two sampling events. Nitrate was detected for the second time slightly above DWSs at the well on the west side of WAG 7.

WAG 4

Sampling at WAG 4 was initiated in December 1993 and completed in January 1994. A discussion of the results will appear in the 1994 annual site environmental report.

WAG 5

The results for 1993 sampling are similar to results from previous sampling events. WAG 5 contributes a significant percentage of the ^{3}H and total radioactive strontium that exit the ORNL site at White Oak Dam via Melton Branch. Tritium contamination is particularly prevalent 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 (other than ^{3}H) found in WAG 5 groundwater. It is found mainly on the southern perimeter. Alpha activity above DWSs was observed in one well on the northwestern boundary of the WAG and in one well on the southern boundary.

VOCs were detected on the southern and western boundaries, including 1,2-dichloroethene, vinyl chloride, trichloroethene, and benzene. Several wells have consistently exceeded DWSs for these contaminants.

No upgradient wells exceeded DWSs for radionuclides or volatile organics.

WAG 6

Results obtained during 1993 were comparable to past results. VOC contamination is apparently isolated in the area around a pair of wells in the northeast corner of the perimeter. During 1993, 1,2-dichlorethane, carbon tetrachloride, and trichloroethene were detected above DWSs at one of these wells in almost every sampling event. This well is subject to the quarterly RCRA assessment monitoring.

Elevated levels of ^{3}H are found along the eastern perimeter, with the highest levels found in six of the eight RCRA quarterly assessment wells.

WAG 7

Results obtained during 1993 were comparable to past results. Tritium was detected in more than half of the wells but was highest along the western perimeter next to SWSA 6. Compared with previous years, ^{3}H appears to be decreasing at the wells on the western perimeter and increasing on the southern perimeter.

Gross alpha activity was detected at one well in excess of primary DWSs. This activity can be attributed to ^{241}Am, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U. Of these, the ^{238}Pu and ^{234}U exceeded 4% of the recommended DCG.

Gross beta activity was detected at levels in excess of primary DWSs at five wells, and ^{3}H was detected at four of these wells, also above DWSs.

Two wells have consistently had nitrate detected at levels that exceed primary DWSs. Minimal volatile organic contamination has been detected in the WAG 7 wells.

WAGs 8 and 9

The two upgradient wells are located north of the WAGs, two of the downgradient wells are located northwest of the WAGs, two are located south of WAG 8, and the remaining five are in WAG 8 west of WAG 9 and in WAG 9. The analytical results for 1993 are comparable to results from the previous 2 years.

All of the perimeter wells show evidence of radioactive contamination. The data indicate that the gross beta activity is attributable to total radioactive strontium. The two wells on the northwest perimeter exceeded DWSs: one well with respect to ^{3}H contamination and the other with respect to gross beta activity and total radioactive strontium contamination. Total radioactive strontium and gross beta activity levels exceeded the DWSs at the two WAG 9 wells. Although volatile organics were detected at downgradient wells, the values were within five times the analytical detection limit. One well has consistently shown trichloroethene above DWSs. None of the data for the upgradient wells show evidence of volatile organic contamination.

Plant Perimeter

In the Melton Valley exit pathway, White Oak Creek at White Oak Dam had gross beta activity, total radioactive strontium, and ^{137}Cs concentrations detected above the reference values for groundwater. One of the wells also had gross beta activity, total radiation strontium, and ^{3}H concentrations detected above DWSs; a second well had ^{3}H concentrations detected above DWSs. In both wells, this has consistently occurred for the past 3 years. No VOC contamination was detected above DWSs in either the wells or the surface-water location.

White Wing Scrapyard

WAG 11

WAG 11 has gently rolling terrain, and the upgradient wells are located north, east, and south of the WAG. In both sampling events for this WAG, gross alpha activity and gross beta activity were detected at low levels along the entire perimeter of the site, including the upgradient wells. Tritium has been detected in some of the wells, although not during both sampling events. No radiological constituents were detected in 1993 above DWSs.

During both sampling events, trichloroethene was detected above DWSs at two wells. No other volatile organics were detected in those wells, and little VOC contamination was detected at the other wells.

Plant Perimeter

In the White Wing Scrapyard exit pathway, one well, and the duplicate sample taken at the same time, trichloroethene was detected above DWSs, but less than five times the analytical detection limit for the analysis method used to perform the organic analysis. The Bear Creek surface-water location had gross alpha activity detected above DWSs.

Well Plugging and Abandonment at ORNL

The purpose of the ORNL well plugging and abandonment program is to remove unneeded wells and boreholes as a possible source 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.

Wells Plugged During 1993

During 1993, a total of 501 monitoring wells were plugged and abandoned at ORNL. An additional 64 locations where monitoring wells were historically reported were surveyed and examined carefully with special equipment to locate any evidence of the wells. No evidence of wells was found at these 64 locations. Most of the 1993 well plugging and abandonment was accomplished as part of the SWSA 6 activities conducted by the Environmental Restoration Division.

Methods Used

Plugging and abandonment is 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 minimizes 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 "downhole" 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.

Well Evaluation for Plugging and Abandonment

Most of the well plugging and abandonment activity at ORNL in 1993 was done in SWSA 6 in Melton Valley; however, other areas at ORNL have wells that should also be plugged. Several workshops were held to determine which other wells should be candidates for plugging and abandonment. Based on field observations supported by the ER Program and knowledge of field investigators at the workshops, a list of 232 wells has been developed to recommend for plugging and abandonment as soon as funds are available.

GROUNDWATER MONITORING AT THE K-25 SITE

Background

Groundwater effluent monitoring at the K-25 Site is focused primarily on investigating and characterizing sites for remediation under RCRA and CERCLA. As a result of the Federal Facility Agreement (FFA), the principal driver at the K-25 Site is CERCLA. In the past, activities under CERCLA investigations were conducted for individual SWMUs or groupings of SWMUs.

In accordance with the FFA, the potentially contaminated units were grouped into 14 source OUs and 1 groundwater OU (Fig. 7.21). Operable units at the K-25 Site are based on previously defined WAGs. WAG boundaries originally were defined to correspond, as much as possible, with perceived hydrogeological boundaries. An OU is defined as a WAG for which an RI/FS will be performed.

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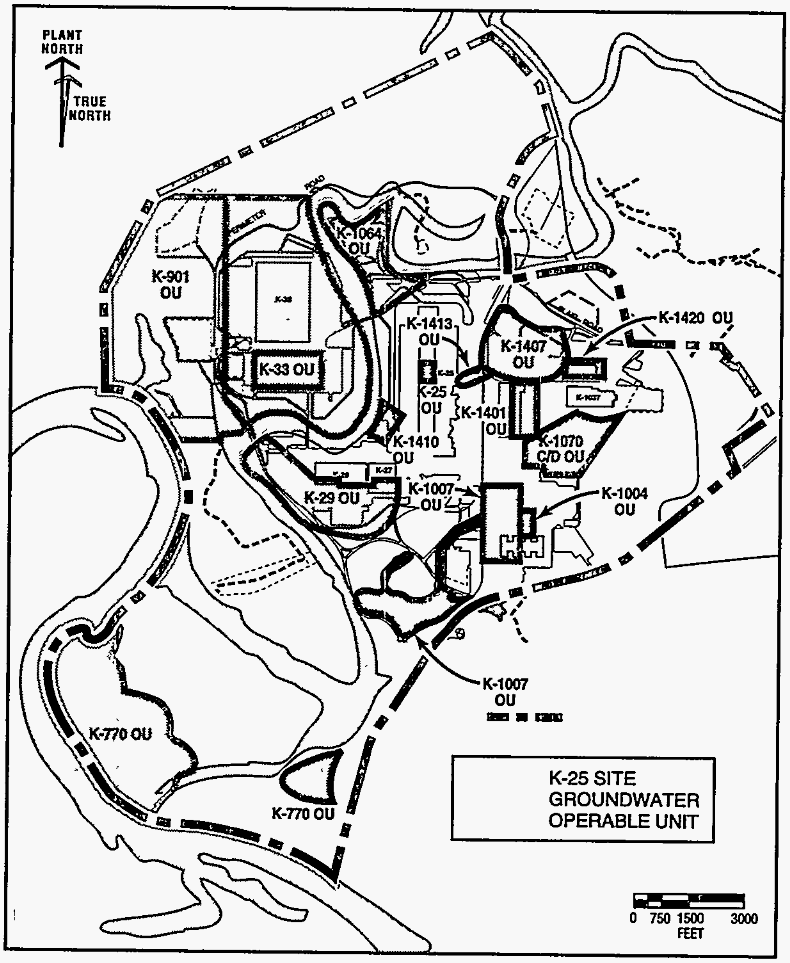

Fig. 7.21. K-25 Site operable unit.

The groundwater OU was designated as encompassing source OUs and areas that may contain unknown waste sites or groundwater contamination plumes. It covers approximately 485.6 ha (approximately 1200 acres) and is bounded on the south by Tennessee Highway 58, on tne east by Blair Road, on the north by Blackoak Ridge, and on the west by the Clinch River (Fig. 7.22). The groundwater OU includes all groundwater underlying the plant area. Because of the karstic nature of the bedrock, subsequent hydrogeologic investigations may change the groundwater OU boundary definition. The strategy for addressing the groundwater OU at the K-25 Site is based on the ORR strategy that emphasizes groundwater monitoring during and after source OU remediation. The impact of source OU remediations will be documented in long-term trends of contaminant concentrations in groundwater. Before a long-term monitoring program can be implemented for the K-25 Site groundwater OU, fundamental studies of the site geology and hydrogeology are necessary. Planned investigations for 1994 will include a sitewide spring and seep survey; a submerged spring survey of Poplar Creek and the Clinch River; geophysical logging of bedrock monitoring wells; slug testing of existing monitoring wells; and continuous water-level monitoring in Poplar Creek, Clinch River, and selected monitoring wells. In addition to these investigations, the groundwater OU will begin sitewide groundwater quality monitoring to support site characterization and development of a water quality baseline for all wells at the K-25 Site. Monitoring for an extended list of baseline parameters over four consecutive quarters has been completed in 191 wells at the K-25 Site. However, many of these wells have not been sampled in recent years, and several new and existing wells have not been sampled since being installed. The sitewide monitoring planned for 1994 will serve to establish baseline water quality for these and all K-25 Site monitoring wells.

A variety of rocks underlie the K-25 Site. Differences in their lithology, mode of deposition, and manner of weathering affect the movement of water through them. Although the initial permeability of the limestone, dolostone, and shale that make up the bulk of the bedrock at the K-25 Site, was low, geologic events subsequent to their formation have developed zones of enhanced secondary permeability through fracturing, weathering, and dissolution that control the flow of groundwater. Solution conduits are present under the K-25 Site, as evidenced by sinkholes and cavities encountered in boreholes. It is likely that many of these cavities are solution conduits. These conduits represent significant drainage pathways for karst groundwater basins and potentially represent contaminant transport pathways as well. A systematic approach to better define the hydrogeology of the K-25 Site is currently being implemented.

Geologic mapping completed in 1993 (Martin Marietta 1994*b*) has increased our understanding of the K-25 Site geology and how it relates to the groundwater flow system. The geologic mapping has led to better definition of the location of contacts between the major rock units and has divided the Knox Group and

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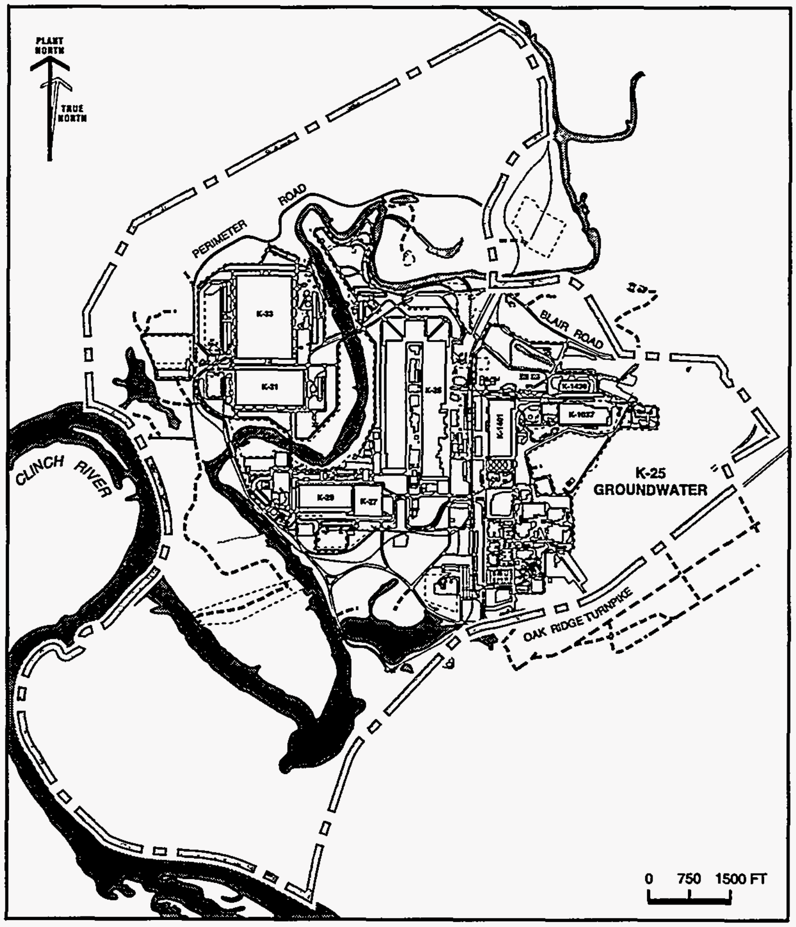

Fig. 7.22. K-25 Site groundwater operable unit.

Chickamauga Supergroup into mappable units. The mapping served to confirm the structural complexity of the geologic units underlying the site. Lemiszki identified an anticline and syncline pair affecting only rocks of the Chickamauga Supergroup. A preliminary analysis of the fracture system in the area indicates the presence of the reservation-wide regional fracture sets, as well as development of an extensive array of shear fractures related to the local folds and faults. Other hydrogeologic characterization activities completed in 1993 include compilation of historical subsurface engineering records and data base development to facilitate searches of the subsurface records, acquisition of historical aerial photographs for development of a digital terrain model and cut and fill map, and instrumentation and collection of continuous water-level data from ten existing monitoring wells.

Current Groundwater Monitoring

Currently, 218 groundwater quality monitoring wells exist at the K-25 Site. During 1993, 12 wells were added to the Groundwater Program. Eight monitoring wells were installed for the purpose of collecting background groundwater quality data for the K-25 Site (Fig. 7.23). Also, four monitoring wells were installed as part of the Environmental Assessment of the K-1220-NE UST site.

Groundwater samples were collected from monitoring wells associated with two source OUs and the exit-pathway monitoring network during 1993. Groundwater samples from selected wells were collected during March, April, May, August, and September 1993. All 218 monitoring wells are scheduled to be sampled during 1994.

Exit-Pathway Monitoring

Exit-pathway groundwater surveillance monitoring is conducted at convergence points where groundwater flows from relatively large areas of the K-25 Site and converges before discharging to surface-water locations. The exit-pathway groundwater surveillance network for the K-25 Site is illustrated in Fig. 7.23. Exit-pathway monitoring of groundwater quality in both the unconsolidated zone and the bedrock will be supported by surface-water monitoring at these three convergence points. Existing wells have been incorporated into the exit-pathway network where possible. In addition, four exit-pathway surveillance wells will be installed during 1994 to complete the eight-well perimeter groundwater surveillance network. Baseline sampling of these wells will begin in FY 1994.

RCRA Monitoring

The K-1407-B and K-1407-C ponds were granted RCRA interim status by TDEC, and detection monitoring was implemented at both sites in January 1986. Detection monitoring was performed in accordance with the interim status RCRA requirements. Interim status groundwater quality assessment monitoring was initiated at each site in November 1987 in response to statistically significant increases in specific conductance and total organic halogens. The statistical increases in these parameters subsequently were determined to be false positives, and a modified detection monitoring program was approved for the K-1407-C Pond in July 1988 and for the K-1407-B Pond in March 1989. Also approved was a change from assessment monitoring to a modified interim status detection monitoring program. The modified detection program was designed to avoid false positive indications from increases in specific conductance, which were demonstrated to be caused by the presence of nonhazardous constituents, and total organic halogens, which were demonstrated to be attributable to a source other than the regulated units. The K-1407-B and K-1407-C ponds are scheduled for clean closure under RCRA in 1994. At that time, the ponds will be subject to CERCLA compliance.

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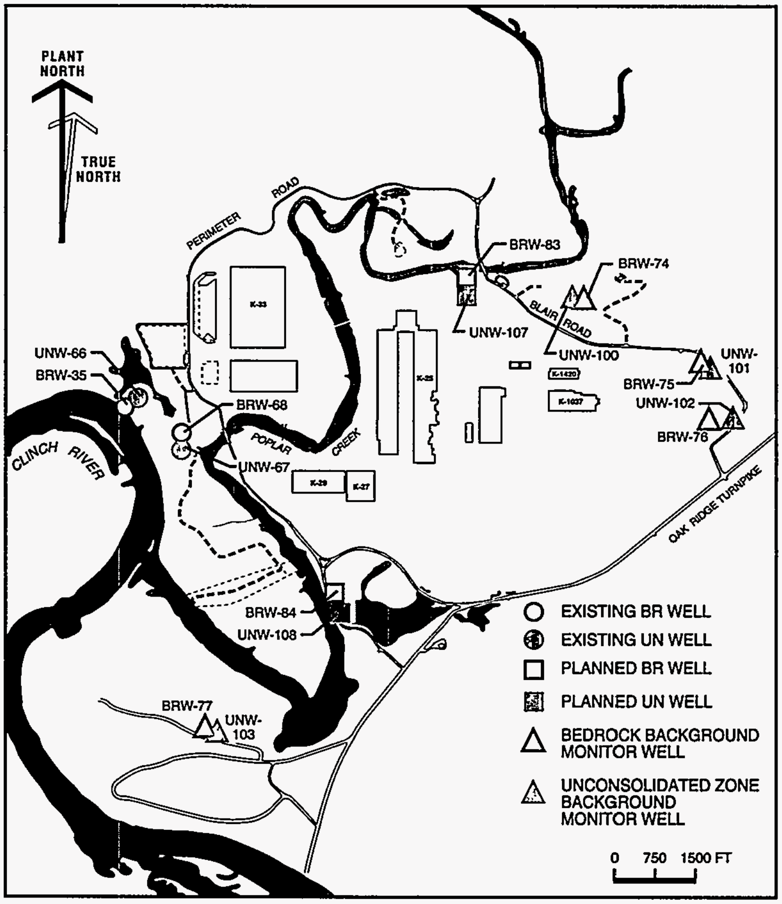

Fig. 7.23. Background and exit-pathway monitoring well locations at the K-25 Site.

K-25 Site Operable Unit

As mentioned in the Background section, 15 CERCLA OUs, including the groundwater integrator OU and 14 source OUs, encompassing surface-water and groundwater media have been established at the K-25 Site. All documentation requirements generated for these OUs are done in accordance with the FFA. The operational history and potential contaminants of concern for each OU are discussed in the following sections.

K-1407 Operable Unit

K-1407-A Neutralization Pit

The K-1407-A Neutralization Pit was used as a reaction pit where sulfuric acid and calcium hydroxide were added to neutralize corrosive wastewater. Potential contaminants are heavy metals. K-1407-A remains in service to neutralize coal pile runoff and to serve as a backup to the new K-1407-H Central Neutralization Facility.

K-1407-B Pond and K-1407-C Pond

The K-1407-B Pond was a 2.3-million-gallon surface impoundment used for settling metal hydroxide precipitates generated during neutralization and precipitation of metal-laden solutions treated in the K-1407-A Neutralization Pit. Liquids in the K-1407-B Pond were drained in October 1988, and removal of the remaining sludge was completed in August 1989. The K-1407-C Pond was a 1.3-million-gallon surface impoundment used for disposal of corrosive and nonhazardous wastes. Liquids in this pond were drained in mid-1987, and sludge removal was completed in November 1988.

K-1407-C Upgradient Area

The upgradient well at K-1407-C Pond (UNW-6) has shown elevated levels of lead, barium, and total chromium during its sampling history. Therefore, the area upgradient of the K-1407-C Pond is being investigated to determine the source of these contaminants.

K-1070-B Classified Burial Ground

The K-1070-B Classified Burial Ground was used from the early 1950s through the mid-1970s for burial of classified equipment, materials, and parts. Potential contaminants include heavy metals and organic solvents.

K-1700 Stream

The K-1700 stream (Mitchell Branch) receives discharge from the K-1407-B Pond and storm drains and surface runoff from most of the solid waste management units located within the K-1407 OU. Sampling has shown the stream sediments to contain elevated levels of heavy metals and uranium.

K-1401 Operable Unit

Acid Line and Degreaser Tanks

The K-1401 acid line is an underground vitreous clay pipeline used to transport corrosive fluids from the K-1401 degreaser tanks to K-1407-A for neutralization. The K-1401 degreaser tanks are stainless steel tanks placed in brick-lined pits within a large concrete structure in the K-1401 building. Equipment is lowered into the tanks for trichloroethane-solvent degreasing. These facilities are still in use.

K-1413 Operable Unit

Neutralization Pit, Sumps, and Process Lines

The K-1413 OU includes the K-1413-C neutralization pit and its line to the K-1401 acid line, two smaller sumps located to the north and east of the K-1413 building, the underground vitreous-clay process lines connecting them to the K-1407-A neutralization pit, the process lines within the K-1413 building, and storm drains in the vicinity. Potential contaminants include heavy metals, organic solvents, and uranium from early uranium fluorination activities at the site.

K-1420 Operable Unit

Oil Storage Area and Process Lines

The K-1420 oil storage area consists of a paved area 50 ft by 275 ft, located north of the K-1420 building. Uranium-contaminated oil was stored at the facility in 5-gal buckets for transfer to 55-gal drums and then transported to the waste-oil decontamination facility inside K-1420. The K-1420 process lines are underground pipelines that connected K-1420 to the K-1407-B Pond for transport of radioactive liquid. Potential contaminants include oil, organic solvents, and uranium. One of the abandoned pipelines was found to contain PCBs, mercury, and uranium.

K-1004 Operable Unit

K-1004-J Vaults and K-1004-L Underground Storage Tank

The K-1004-J and K-1004-L USTs consist of six storage vaults and two USTs (5550-gal and 750-gal). The vaults contain concrete casks for storage of reactor return samples. They were used in the 1950s and 1960s. The potential contaminant is radioactivity.

K-1004-L RCW Lines and K-1004-N Cooling Tower Basin

The K-1004-L recirculating cooling water (RCW) lines circulated cooling water between the K-1004-L building and the K-1004-N cooling tower. The K-1004-N cooling tower basin is a 30- to 40-year-old aboveground tank that is 21 ft long × 21 ft wide × 3 ft deep. Potential contaminants at this OU are chromium, zinc, and other heavy metals; phosphate; and radioactivity.

K-1007 Operable Unit

K-1004 Area Laboratory Drain and Holding Tank

The K-1004 area laboratory drain carries laboratory wastes from several laboratories to the K-1007-B holding pond. The drain was used for disposal of laboratory wastes, including acids, solvents, and other organics, before receipt of an NPDES permit in 1984. Beginning in the 1950s, the K-1007-P1 holding tank received waste from the laboratory drain as well as storm-water runoff.

K-1007 Underground Gasoline Storage Tank

The K-1007 gasoline storage tank was a 250-gal tank located north of the K-1007 building. Gasoline was observed in the soil surrounding the tank when it was excavated and removed in 1986.

K-1064 Operable Unit

K-802-B and K-802-H Cooling Tower Basins

The K-802-B and K-802-H cooling tower basins are in-ground, concrete basins having a capacity of 2.4×10^6 gal and 5.8×10^6 gal, respectively. The basins were used for chromate, zinc, and phosphate treatment of RCW. Additional potential contaminants include other heavy metals and radioactivity.

K-1064-G Burn Area/Peninsula Storage

The K-1064-G burn area/peninsula storage area was used in the 1950s and 1960s for open burning of solvents in an open metal container and in the 1960s and 1970s for drum storage of potential contaminants such as organic solvents, PCBs, and radioactively contaminated waste oils. The drums were removed, and the unit was closed in 1979.

K-1410 Operable Unit

K-1410 Neutralization Pit

The K-1410 Neutralization Pit is a 1.50×10^4-gal (59,803-L) concrete tank used from 1975 to 1979 for neutralization of nickel-plating solutions before discharge to Poplar Creek. Some of the other chemicals known to be present include nickel sulfate, degreaser bath, acid, and corrosive solutions.

K-29 Operable Unit (K-27 and K-29 RCW Lines)

The K-27 and K-29 RCW lines are underground steel pipelines that transported RCW back and forth between the cooling tower basins and the process buildings. They are buried from 3 to 10 ft below grade and range from 16 to 54 in. in diameter. Most were in use from the 1950s to 1985. Potential contaminants include chromium, zinc, and other heavy metals; phosphate; and radioactivity.

K-832-H Cooling Tower Basin

The K-832-H cooling tower basin was used for chromate, zinc, and phosphate treatment of recirculating cooling water. Additional potential contaminants include other heavy metals and radioactivity.

K-732 Switchyard

The K-732 Switchyard has been in operation since 1945. The suspected contaminant is PCB-contaminated oil.

K-1203 Sewage Treatment Plant

The K-1203 sewage treatment plant has been in operation since 1943. The effluent from this plant is monitored at the Environmental Monitoring Station at K-1203-B in accordance with an NPDES permit (No. TN 0002950). Effluent and sludge samples are taken from the chlorine contact tank. Concentrations of several metals detected in sampled sludge have been reported to be above guideline levels.

K-33 Operable Unit

K-892-G, K-892-H, K-892-J, and K-862-E Cooling Tower Basins

These large basins underlie cooling towers and were used for chromate, zinc, and phosphate treatment of recirculating cooling water. Additional potential contaminants include other heavy metals and radioactivity.

K-31 and K-33 RCW Lines

The K-31 and K-33 RCW lines are underground steel pipes that transported treated cooling water between the cooling tower basins and the process buildings. They are buried from 3 to 10 ft below grade and range from 16 to 54 in. in diameter. Most were in use from the 1950s to 1985. Potential contaminants include chromium, zinc, other heavy metals; phosphate; and radioactivity.

K-901 Operable Unit

K-1070-A Contaminated Burial Ground

The K-1070-A contaminated burial ground was used from the late 1940s to 1976 for disposal of unclassified low-level radioactive solid and mixed chemical waste. The burial ground contains distinct burial areas including trenches and pits. The trenches were long, narrow excavated areas where wastes were placed and covered with soil. The typical trench measured 11 ft deep × 3 ft wide × 108 ft long. Waste materials were also placed in small-diameter, deep holes dug with an auger, referred to as pits. These pits were generally 3 ft in diameter and 12 ft deep. Potential contaminants include chemicals, radioactivity, heavy metals, and some organics.

K-1070-A Landfarm

The K-1070-A Landfarm consists of approximately 1.5 acres on which about 5000 ft^3 of fuller's earth was applied from 1979 through 1985. The fuller's earth, a naturally occurring clay, was used to filter lubricating oils from the K-33 process building. Potential contaminants include organics.

K-901-A North Disposal Area

The K-901-A North Disposal Area comprises an area of 6 to 8 acres south of the K-1070-A Landfarm. From the late 1940s to the mid-1970s, it was used for the disposal of common construction materials including road bedding, paint cans, wallboard, lumber, soil, rock, roofing, concrete, asphalt, and steel. Potential contaminants include heavy metals, organics, and radioactivity.

K-901-A Holding Pond

The K-901-A Holding Pond is a surface impoundment of approximately 5 acres located adjacent to the Clinch River. In the late 1950s, softening sludges for the gaseous diffusion process cooling water began to be discharged to the area that was to become the K-901-A Holding Pond. The dam that created the pond was built in 1965 and 1966. The pond contains sludge composed of chromium-hydroxide precipitates, along with lead, nickel, copper, and uranium.

K-901-A South Disposal Area

The K-901-A South Disposal Area is an approximately 0.5-acre area operated from the early 1950s to the mid-1970s. The site received wastes from on-site construction and maintenance activities. Potential contaminants include heavy metals, organics, and uranium.

K-895 Cylinder Destruct Facility

The K-895 Cylinder Destruct Facility, located on the east edge of the K-901-A Holding Pond, was operated from the mid-1960s to the late 1970s to dispose of cylinders containing UF_6 feed, tails, and enriched materials. The facility allowed for a cylinder to be suspended over the pond and punctured by a high-powered rifle shot. After the cylinder was punctured, it was dropped into the pond and subsequently retrieved after the contents were sufficiently hydrolyzed or neutralized. The potential contaminant is uranium.

K-770 Operable Unit

K-770 Scrap Yard

The K-770 Scrap Yard has been used since the 1960s for storage of radioactively contaminated scrap metal. Potential contaminants include radioactivity, PCBs, mercury, and asbestos.

K-1085 Firehouse Burn Area

The K-1085 Firehouse Burn Area was used in the mid-1940s as a firehouse, garage, and fuel station. From the late 1940s to 1960, the area was used for fire training; waste oil was burned in metal pans and excavated pits. Potential contaminants include waste oils, solvents, and heavy metals/uranium that may have contaminated the oils and petroleum products.

K-1070-C/D Operable Unit

K-1070-C/D Classified Burial Ground

The K-1070-C/D Classified Burial Ground was used from 1975 to 1989 for disposal of various wastes in trenches and pits. Potential contaminants include solvents, waste oils, heavy metals, chemicals, pesticides, and radioactivity. An RI is currently under way at this site.

K-1071 Concrete Pad

The K-1071 Concrete Pad is the site of a compactor used until 1983 or 1984 for disposal of classified scrap metal, empty drums and boxes, and fiberglass. Operation records indicate that PCBs and radioactivity are present in the oily residues associated with the materials compacted at the site. This site is being addressed under the RI for the K-1070-C/D Classified Burial Ground.

K-25 Operable Unit

The K-25 OU, located near the center of Building K-25, consists of a dilution pit located outside Building K-1024. Beginning in 1945, the pit received acid/solvent solutions from the building process drain lines that once served the instrument maintenance shops. From 1970 to 1985, the west wing of the building accommodated a centrifuge development laboratory operation. The potential contaminant is uranium.

Other Waste Sites

K-1070-F Old Contractor's Burial Ground

The K-1070-F Old Contractors' Burial Ground was used from 1974 to 1978 and once in 1982 for disposal of construction/demolition debris, such as dirt and rock, scrap metal, roofing material, concrete, asphalt, and asbestos. Potential contaminants are heavy metals, solvents, and uranium.

K-1232 Chemical Recovery Facility

K-1232 is a RCRA facility consisting of eight aboveground steel tanks and four in-ground concrete tanks used for pH adjustment and chemical precipitation of hazardous wastes. Because the unit treats wastes in tanks, it is not subject to RCRA groundwater monitoring requirements. Potential contaminants include nitrates, heavy metals, organics, and uranium.

Groundwater Monitoring Results

K-1407 Operable Unit

The RCRA monitoring wells at the K-1407-B and K-1407-C ponds were the only wells within the K-1407 OU that were sampled during 1993. Groundwater samples were collected during March and again in September from the K-1407-B and C Ponds monitoring wells. At the K-1407-B and C ponds, the primary groundwater contaminants are VOCs and radionuclides. A few metals have sporadically exceeded DWSs, but only aluminum, iron, and manganese have consistently exceeded their respective standards. Generally, aluminum has only exceeded the 0.2-mg/L Secondary Drinking Water Standard in unfiltered groundwater samples. Iron and manganese have exceeded the Secondary Drinking Water Standards of 0.3 and 0.05 mg/L, respectively, at all of the wells during at least one sampling event. However, iron and manganese are present at elevated levels in upgradient wells and at naturally elevated levels in area soils and groundwater. Therefore, the high concentrations of these metals is considered to reflect natural groundwater conditions rather than groundwater contamination.

Cadmium concentrations in unfiltered samples for two wells exceeded the 0.005-mg/L drinking water standard. However, as discussed in Sect. 2.2 (Environmental Compliance), the results of resampling of these wells indicated that cadmium was not detected above the 0.003-mg/L method detection limit. One lead occurrence above the reference value of 0.015 mg/L was reported for an unfiltered sample from one well; however, lead was not detected above the 0.004-mg/L method detection limit when the well was resampled.

Two occurrences of gross alpha activity exceeding the 15-pCi/L reference value and two occurrences of gross beta activity exceeding the reference value of 50 pCi/L were reported for groundwater samples collected during 1993. These results originate from a single well located north of the K-1407-B Pond. Although the alpha activity in groundwater from this well exceeded the reference value during 1993, elevated alpha activity has not been detected consistently over the years at this well. In general, the wells downgradient of the K-1407-B Pond have shown a trend of decreasing levels of beta activity since removal of the sludge from the pond in 1989.

The primary VOCs detected in groundwater in the vicinity of the K-1407-B and C ponds are trichloroethene, 1,2-dichloroethene, 1,1-dichloroethene, vinyl chloride, and tetrachloroethene. Of these compounds, trichloroethene is the most prevalent, exceeding the 5.0-μg/L reference value in 6 of the 11 wells sampled in 1993, with a maximum concentration of 13,000 μg/L reported for 1 well.

K-770 Operable Unit

A total of 16 wells in the K-770 OU were sampled in May and August 1993. The primary contaminant of concern in groundwater at the K-770 OU is radioactivity. Gross alpha activity in unfiltered samples exceeded the 15-pCi/L reference value at three wells, and the filtered results for only one well exceeded the 15-pCi/L reference value, with an activity of 37.6 pCi/L. Gross beta activity above the 50-pCi/L reference value was reported for four wells during 1993. The maximum activity of 336 pCi/L was reported for an unfiltered sample from well. The corresponding filtered result for this well was reported to be 167 pCi/L.

The reported unfiltered metals concentrations that exceeded reference values during 1993 included aluminum, cadmium, chromium, iron, and manganese. As with the groundwater results for the K-1407 OU, the elevated concentrations of aluminum, iron, and manganese can be attributed to the natural presence of these metals at elevated concentrations in local soils and groundwater. The unfiltered result for cadmium exceeded the 0.005-mg/L DWS in groundwater samples collected from five wells. However, the filtered results indicate that only one well, at a concentration of 0.0067 mg/L, exceeded the DWS.

Chromium concentrations reported for filtered samples from three wells exceeded the DWS of 0.1 mg/L and ranged from 0.11 to 1.5 mg/L. None of the filtered sample results from these three wells exceeded the DWSs indicating that the elevated chromium concentrations can be attributed to the presence of suspended material in. the sample contributed by the sampling process. The same holds true for the reported results for lead, which indicated the reference value of 0.015 mg/L was exceeded in unfiltered samples from four wells. However, lead was not detected in the corresponding filtered samples from any of the four wells. No organic compounds were detected in concentrations exceeding a reference value at any of the 16 wells sampled in 1993.

Exit-Pathway Monitoring

Groundwater quality samples collected from exit-pathway monitoring wells during 1993 did not indicate the presence of chemical contaminants above a corresponding reference value. Only pH at two wells, at levels of 9.2 and 9.5, exceeded the reference range of 6.5 to 8.5. The only organic compounds detected were reported at estimated levels below the actual analytical detection method. Fluoride was detected in all samples but never exceeded the Secondary Drinking Water Standard of 2.0 mg/L. Uranium was detected in two samples, but the reported concentrations were an order of magnitude below the corresponding reference level of 0.02 mg/L.

Plugging and Abandonment

No wells were plugged and abandoned at the K-25 Site during 1993. Currently, four wells are scheduled to be plugged and abandoned during 1994. As other wells around the K-25 Site are identified as being unneeded or unsuitable for monitoring, they will be scheduled for plugging and abandonment.

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.

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.

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 Quality Control Program* was issued for use by Energy Systems, with oversight by DOE-ORO and the EPA. This document contained sampling and QC procedures that addressed each of the issues in the preceding list.

Several actions were initiated in 1993 to implement a process for continuous improvement in the field sampling QA program and for incorporation of new procedures to reflect changing technologies and regulatory protocols. An Environmental Surveillance Procedures Quality Control Committee was formed and tasked with updating the field sampling and QC procedures. Membership in the committee includes representatives from each of the five Energy Systems facilities, DOE, Environmental Restoration, 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.

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 Energy Systems, 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.

In June 1993 personnel from the EPA Region IV Environmental Compliance Branch conducted two 3-day workshops at the ORR on environmental field operations. More than 300 DOE and contractor field support personnel attended these training sessions, which focused on the use and application of Region IV SOPs and the QA manual for conducting field operations.

ANALYTICAL QUALITY ASSURANCE

The Energy Systems 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 laboratories have always been involved in the handling and analysis of hazardous materials of high purity, for which strict accountability is required. 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.

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 criteria for QA/QC activities documented at each installation. Additionally, separate QA/QC documents relating to analysis of environmental samples associated with regulatory requirements are consulted.

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.

External Quality Control

In addition to the internal programs, all Energy Systems installations are directed by DOE and expected by EPA regulators to participate in external QC programs. These programs generate data that are readily recognizable as objective packets of results. These packets give participating laboratories and government agencies a periodic view of performance. The sources of these programs are laboratories in the EPA, DOE, and commercial sector. Energy Systems participates in ten such programs (Fig. 8.1).

The Y-12 Plant analyzed 2694 external control samples in 1993. Of all external controls, 97.9% were within specified limits. ORNL reported 2343 external performance evaluation parameters; 97.9% of the results fell within acceptable limits. The K-25 Site reported 885 measurements in the external control program in 1993. Of all controls evaluated, 92% were within specified limits.

The following sections describe the external QC programs in which Energy Systems participates.

Environmental Protection Agency Contract Laboratory Program (CLP)

The Contract Laboratory Program (CLP) is an EPA-administered qualification program for laboratories to do Superfund (CERCLA) program analyses. The program operates from the CLP–Sample Management Office at Alexandria, Virginia, in cooperation with the EPA Environmental Monitoring System Laboratory at Las Vegas (EMSL-LV) and EPA regions. The program qualifies 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.

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.

Water Pollution Performance Evaluation Quality Control Program

This program is used by DOE to evaluate laboratories engaged in analysis of polluted-water samples at existing and former DOE sites. It is administered by EPA in Cincinnati, Ohio (Region V).

American Industrial Hygiene Association (AIHA) Proficiency Analytical Testing Program

The National Institute of Occupational Safety and Health (NIOSH) administers the Proficiency Analytical Testing (PAT) Program as part of their AIHA accreditation process for industrial hygiene air samples.

EPA Discharge Monitoring Report Quality Assurance Study

EPA conducts a national QA program in support of the NPDES permits, and it is mandatory for major permit holders. The EPA supplies the QC samples and furnishes the evaluated results to the permittee, who is required to report the results and any necessary corrective actions to the state of Tennessee. All sites participate.

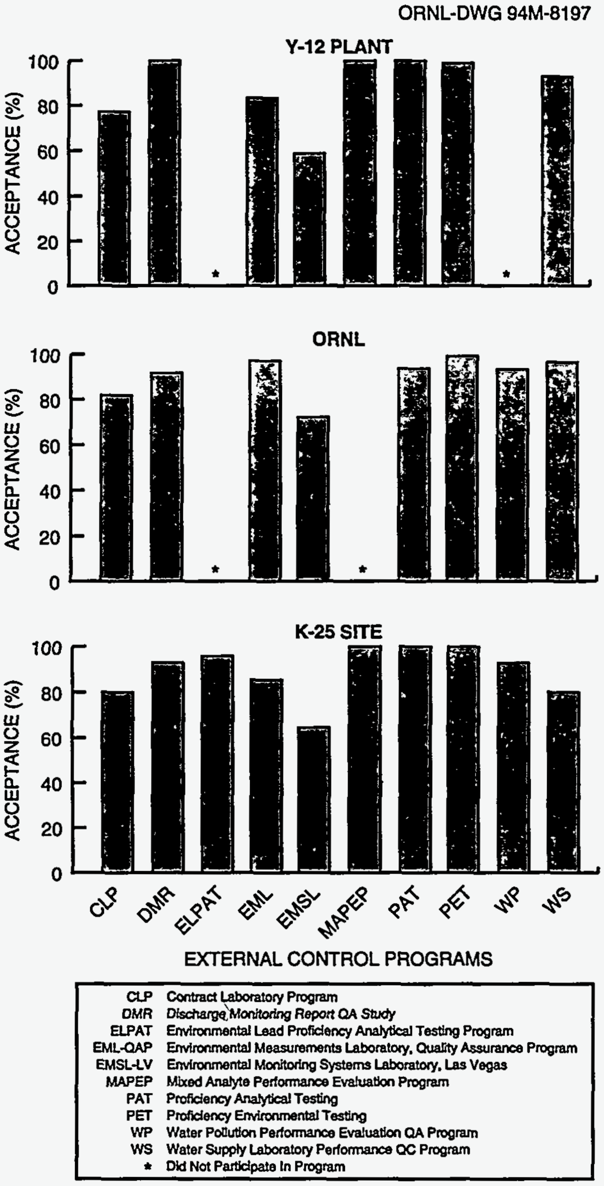

Fig. 8.1. Summary of Analytical Services Organization external performance evaluation programs by site, 1993.

EPA Intercomparison Radionuclide Control Program

The EPA Intercomparison Radionuclide Control Program is administered by EMSL-LV. Samples include water and air filters. The state of Tennessee requires participation for drinking-water certification of radionuclide analysis, and all sites are involved. The EMSL-LV program calculates a normalized standard deviation for each laboratory based on all reported results. By their criteria, any reported value above three standard deviations is considered unacceptable.

Environmental Lead Proficiency Analytical Testing (ELPAT) Program

This program was established in 1992 to evaluate analysis of environmental lead samples in different matrices. The matrices evaluated are paint, soil, and dust wipes. The participating laboratory analyzes each matrix at four levels. In addition, a laboratory may request to become accredited for lead analysis in this program. ELPAT is administered by AIHA.

Mixed Analyte Performance Evaluation Program (MAPEP)

MAPEP is a pilot program set up by the DOE Radiological and Environmental Sciences Laboratory in conjunction with the Laboratory Management Division of the Office of Technology Development. It was set up to evaluate analysis of mixed-waste samples. The program is evaluated by Argonne National Laboratory.

DOE Environmental Measurements Laboratory (EML) Quality Assessment Program

Participation in the radionuclide Quality Assessment Program, administered by the DOE 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.

Proficiency Environmental Testing (PET) Program

The PET program is a service purchased from an outside vendor and is used by all five Energy Systems analytical laboratories and the DOE laboratory at the Fernald, Ohio, facility, to meet the need for a QC 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 lab, and other statistical information. A corporate report is also provided that compares the data from the Energy Systems laboratories with those of other corporate laboratories.

Quality Assessment Program for Subcontracted Laboratories

Requirements for Quality Control of Analytical Data for the Environmental Restoration Program (Martin Marietta Energy Systems, Inc. December 1992) defines the basic requirements that laboratories must satisfy in providing support to ORR environmental restoration projects. Oversight of subcontracted commercial laboratories is performed by Analytical Project Office personnel, who conduct on-site laboratory reviews and monitor the performance of all subcontracted laboratories.

The components of the review process are as follows.

- *Laboratory Quality Assurance Plan* (LQAP)—A review of the LQAP is performed by the Analytical Project Office prior to an initial audit of the laboratory. Each laboratory is required to have an LQAP in place and to correct any deficiencies noted by the Analytical Project Office review.
- Performance evaluation samples—Each laboratory is required to successfully participate in an external performance evaluation program for analytes representative of those anticipated in the environmental samples. Participation is reviewed before samples are submitted to the laboratory and as part of the initial audit and periodic audits.
- Initial audit—After the laboratory has satisfactorily responded to LQAP comments and submitted the required performance evaluation data, an audit is conducted to verify that conditions of *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program* are being implemented.
- Periodic audits—Audits of laboratories participating in the Analytical Project Office pricing agreement are conducted every 6 to 12 months to verify continuing compliance with requirements.

- Monthly progress reports—Reports are submitted to the Analytical Project Office by each laboratory to maintain communication so that changes in certification status, personnel, or facilities may be monitored.
- Project-specific surveillances—Surveillances are conducted as required to monitor specific project data quality.

DATA MANAGEMENT, VERIFICATION, AND VALIDATION

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 requirements, to verify that method quality control requirements are met, and to ensure that project-specific data-quality objectives are met. Data verification may be described as the ongoing routine process of checking to determine whether (1) data have been accurately quantified, 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. Data validation is a systematic process for comparing data with established criteria to ensure that data are adequate for intended use. The level and extent of data validation may vary, based on the project-specific requirements. 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. However, a sampling and analysis project conducted as part of a remedial investigation to support the CERCLA process may generate data that are used to evaluate the risk to human health and the environment. The data may be used to document that no further remediation is necessary or to support a multimillion-dollar construction 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.

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. Electronic data transfer from portable computers in the field and from sophisticated laboratory information management systems used by on-site and commercial analytical laboratories has greatly enhanced the data-review process.

As field and laboratory data are compiled, computer capabilities exist to calculate charge balance; calculate conductivity and compare the data with field and laboratory measurements of conductivity; compare alkalinities and pH, field-duplicate measurements, the 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 the K-25 Site 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 (GIS) with the data bases containing results of environmental monitoring activities.

Integration of compliance-monitoring data for each of the three ORR sites with sampling and analysis results from remedial investigations by the Environmental Restoration Division is a function of the Oak Ridge Environmental Information System (OREIS). OREIS, currently under development, is necessary to fulfill requirements prescribed in both the FFA and Tennessee Oversight Agreement and to support data-management activities for all five facilities managed by Energy Systems. The FFA, a tripartite agreement between DOE, EPA Region IV, 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 Tennessee Oversight Agreement 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 the Environmental Restoration Program, providing consolidated, consistent, and well documented environmental data and data products to support planning, decision making, and reporting activities. When completed, OREIS will provide a direct electronic link of ORR monitoring and remedial investigation results to EPA Region IV and the state of Tennessee DOE Oversight Division.

9. Special Studies

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M. F. Tardiff, L. O. Vaughan, C. H. Wilkinson, and G. G. Worley

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Abstract

Many environmentally related special studies are conducted on the Oak Ridge Reservation each year. The studies included in this section are not associated directly with annual environmental monitoring activities but may be of special interest to some readers. The site most involved with each study submitted its description.

SPECIAL STUDIES AT THE Y-12 PLANT

Integrated Mercury Strategy for the Oak Ridge Reservation

Past waste-disposal and operations activities at the ORR have led to the propagation of mercury in the environment. Much of the environmental media contaminated with mercury was transported off site by East Fork Poplar Creek. Since this problem was identified, a substantial amount of work has been preformed on the ORR and at the Y-12 Plant to measure, remediate, limit, and control mercury contamination. The initial remediation work was performed at the Y-12 Plant between 1985 and 1991 under the Reduction of Mercury in Plant Effluent (RMPE) project.

In 1993, a strategy was developed to integrate further CERCLA actions for mercury remediation on the ORR with anticipated NPDES compliance requirements to limit mercury discharges from the Y-12 Plant and waste management and disposal operations for wastes generated during remedial actions. Another reason for the integrated approach is to minimize duplication of activities and to ensure the dissemination of technical knowledge among the various organizations involved in mercury-related functions. A major component of the integrated mercury strategy is implementation of the Reduction of Mercury in Plant Effluent Phase II Program (RMPE II).

The RMPE II program is structured to serve as a bridge between downstream remediation of Lower East Fork Poplar Creek and upstream remedial actions at the Y-12 Plant. A key goal of this program is to reduce the annual mercury release from Y-12 Plant by about 70% by the end of the 5-year NPDES permit period. Six projects (four building source elimination efforts and two treatment units) have thus far been identified under the RMPE II Program to reduce mercury contamination to upper East Fork Poplar Creek. To eliminate sources of mercury, rerouting of pipes has been proposed for buildings 9201-2, 9201-4, 9201-5, and 9204-4. Installation of an interim mercury treatment unit is proposed for Building 9201-2. This unit will use carbon-column treatment and will serve to prove treatment technology previously demonstrated in laboratory-scale tests. Additionally, a modification to the Central Pollution Control Facility is proposed to provide permanent mercury-treatment capability.

In 1993, an engineering report and preliminary plans were prepared for an interim mercury-treatment unit in Building 9201-2. The unit, which is planned to be operational by July 1994, will treat mercury-contaminated groundwater collected in the basement sumps of Building 9201-2.

Site-Specific Water Quality Criterion for Total Mercury in East Fork Poplar Creek Downstream from the Y-12 Plant

The EPA water quality standard for mercury, which has been adopted by TDEC as a water quality standard, is based on assumptions that are not applicable for East Fork Poplar Creek. The biological availability of mercury in East Fork Poplar Creek is relatively low and is not typical of most systems to which the criterion is meant to be applied. In addition, the EPA standard of 0.012 µg/L (freshwater fish and aquatic life criterion continuous concentration) is based on the assumption that all aqueous-phase mercury is present as methylmercury and that the predominant pathway for bioaccumulation by fish is direct uptake from water. Site-specific data in

East Fork Poplar Creek indicate that these assumptions are incorrect by a wide margin. EPA recognizes the uncertainty associated with the published criterion and encourages using site-specific data that support an alternate limit. In 1993, a study was conducted to establish an alternate water quality limit for mercury in East Fork Poplar Creek.

Site-specific toxicity tests of East Fork Poplar Creek water, and toxicological data supporting the derivation of the EPA water quality criterion for mercury, indicate that adverse effects to aquatic life are unlikely to occur at concentrations of total mercury less than or equal to 0.2 µg/L. Comparison of aqueous-phase mercury concentrations and mercury in fish at the same sites in East Fork Poplar Creek indicate that reduction of aqueous-phase mercury to 0.2 µg/L in the upper reaches of East Fork Poplar Creek would cause mercury levels in fish at those sites to drop to levels safe for human consumption. A site-specific criterion of 0.2 µg/L total mercury in East Fork Poplar Creek at the Y-12 Plant Station 17 monitoring site would be a limit that would continue to force remedial actions, and when met, would ensure that the uses of East Fork Poplar Creek as classified by TDEC are protected with respect to the effects of mercury. DOE has submitted a detailed report of this special study to TDEC.

Environmental Assessment for Interim Storage of Enriched Uranium at the Y-12 Plant

Compliance with NEPA ensures that consideration is given to environmental values and factors in federal planning and decision making. In accordance with NEPA, an environmental assessment for storage of interim enriched uranium at the Y-12 Plant was prepared in 1993. Enriched uranium from dismantled nuclear weapons and other sources has historically been returned to the Y-12 Plant. DOE proposes to continue interim storage of enriched uranium at the Y-12 Plant until decisions on ultimate disposition of enriched uranium and other special nuclear materials are made and implemented. This would require storage of enriched uranium in amounts that would exceed the maximum historical level at the Y-12 Plant. Public meetings were held in early 1994 to determine applicability of a "finding of no significant impact" under NEPA.

Treatment Plant Discharge Project

The Y-12 wastewater treatment facilities have done an excellent job during the past few years in complying with the current National Pollutant Discharge Elimination System (NPDES) Permit (issued in 1985), with very few excursions. Even though these excursions have been minor and infrequent, the goal is to eliminate noncompliances to the greatest extent possible. The Treatment Plant Discharge Project was scoped with the requirement of improving treatment-facility capability to ensure that more stringent effluent standards of the new NPDES permit can be met using the best available technology. An engineering feasibility study was completed in 1993, and a conceptual design report was initiated.

The project addresses the following areas:

- consolidation of outfalls;
- addition of facilities for effluent retention until a laboratory evaluation can be performed;
- improvement of treatment technology at the Central Pollution Control Facility/Plating Rinsewater Treatment Facility, the West End Treatment Facility, and the Groundwater Treatment Facility, the effluents from which would be fed to a new polishing facility followed by effluent holdups before being discharged into East Fork Poplar Creek; and
- improvement of the Steam Plant Wastewater Treatment Plant, which will continue as a stand-alone facility with additional treatment steps, including aeration to aid in iron removal, an enhanced pH-adjustment system to improve reliability and filtration, and effluent holdup tanks.

SPECIAL STUDIES AT ORNL

ORNL Well Data Base

A data base of information has been developed for wells on the ORNL Site. It contains details of location, physical properties, use, custodianship, and miscellaneous other information. The data were collected from a variety of sources. The initial sources were the well-construction data sets that were collected as part of the

Remedial Action Program (now the Environmental Restoration Program). Additional data were obtained from several other projects.

The data base contains data on more than 2600 wells, including wells that have been plugged and abandoned. A continuing effort is being made to upgrade the data base with information on new wells and additional information on old wells.

Analysis of Compliance Monitoring Data To Assess Priorities for Environmental Restoration

Six years of surface-water compliance and surveillance monitoring data from the ORNL monitoring locations at White Oak Dam, White Oak Creek, Melton Branch, and the 7500 Bridge have been used to determine the largest contributions of contaminants to White Oak Creek and to evaluate remedial action priorities for environmental restoration. Tritium and radioactive strontium dominate the contaminant signature at White Oak Dam relative to potential risk.

The total estimated risk of cancer from drinking water from White Oak Dam at a rate of 2 L per day for 30 years is estimated to be 2×10^{-3}. This risk is equally divided between tritium and radioactive strontium. Most of the tritium and roughly half of the strontium originate in Melton Branch. The balance of these two contaminants comes from White Oak Creek and the main plant area. The major sources of contaminants are WAG 5, WAG 4, the Corehole 8 plume in WAG 1, and the surface impoundments in WAG 1.

This information is being used to influence the remedial action priorities of the Environmental Restoration Program at ORNL. Consequent to this information being made available and a seep and spring survey being conducted by the WAG 2 project, a removal action has been initiated for a strontium seep at WAG 5, and remedial investigations are being conducted for WAG 4, surface impoundments, and the Corehole 8 plume.

1993 Noble Gas Emissions from Stack 7911

The summary data for the 1993 noble gas emissions from Stack 7911, which is the combined effluent from the High Flux Isotope Reactor and Radiochemical Engineering Development Center, represent a change in the manner in which the data are calculated. A new source term for isotopic fractions of the effluent is based on spectral analysis of grab gas samples rather than the previous calculated term based solely on reactor operating parameters. This new term was developed because the previous factors did not account for argon-41, which would be expected as the major noble gas isotope during most of the reactor operation.

A study was conducted in which a number of samples were collected in Marinelli beakers from August 18 to October 28 and analyzed with a germanium detector counting system with minimal holding times. This period included some reactor operation as well as some reactor downtime and a Radiochemical Engineering Development Center campaign (batch operation). This provided good representation of total operating conditions for the year. As expected, argon-41 was the major component and the argon levels diminished when the reactor was down.

Samples included in the calculations were adjusted for temporal distribution. The total activity of each isotope found was compared with the total activity in all the samples to determine its percentage of the total noble gas in the effluent. The new isotope fractions were then applied to the total activity counted by the totalizer driven by the gross noble gas monitor. Total effluent activity was determined, as in the past, from weekly totalizer data for the whole year, using stack flow and monitor calibration factors.

The source term is expected to change again next year. New instruments are being brought on line to provide more full spectrum data that will provide an even more accurate picture of the noble gas levels and mixture.

SPECIAL STUDIES AT THE K-25 SITE

CFC-114 Emissions

K-25 Site emissions of ozone-depleting substances have been dominated in recent years by release of CFC-114 vapor from the shutdown gaseous diffusion plant cooling systems. Leaking had been calculated at an annual rate near 10% of the system contents of more than 2 million lb. This resulted in releases of about 24,000 lb in

1990, 22,000 lb in 1991, and 20,000 lb in 1992 (Fig. 9.1).

In 1993, the liquid CFC-114 was drained from the systems and transferred by rail car for use at the operating gaseous diffusion plants at Portsmouth, Ohio, and Paducah, Kentucky. As required by new regulations, the systems were evacuated to remove as much of the vapor as possible, but residual vapors remained. In preparation for eventual disassembly of the systems, a lengthy process of system purging began in mid-1993. By the end of 1993, the CFC-114 vapor loss through leakage and purging totaled nearly 28,500 lb for the calendar year.

Purging will continue into 1994, and it has been calculated that 15,910 lb of CFC-114 vapor remain to be purged in 1994. With completion of that operation, the CFC-114 emissions will decline to near zero in 1995.

ORNL-DWG 94M-8674

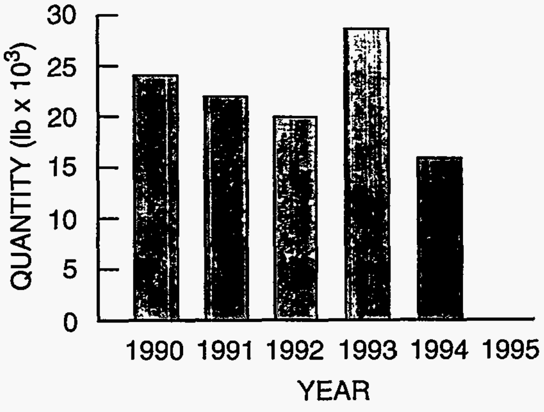

Fig. 9.1. Actual and projected releases of CFC-114 to the atmosphere during disassembly of the K-25 Site gaseous-diffusion systems.

Geologic Mapping of the K-25 Site

A geologic map of the K-25 Site and surrounding area has been prepared as part of the site-wide hydrogeologic characterization efforts under way at the site. Data were collected from December 1992 to April 1993. The map covers approximately 18 miles^2 and ties in geologic contacts at the K-25 Site with an existing geologic map of the ORR. The map fills a critical need for the K-25 Groundwater Program and the K-25 Environmental Restoration Program, which need basic hydrogeologic data to assess the impact of DOE operations on groundwater quality and to plan remedial actions at the K-25 Site.

The K-25 Site is located in the southern Appalachian valley and ridge province of east Tennessee and overlies an area of folded and faulted Cambrian through Ordovician sedimentary rocks in the footwall of the Whiteoak Mountain fault. Environmental Restoration plans for the area require that the geology of the site be well understood because various aspects of the groundwater system are directly influenced by stratigraphic and structural characteristics of the bedrock.

The study involved mapping bedrock geology in and around the plant site (Fig. 9.2). Field mapping focused on (1) checking the accuracy of previously mapped stratigraphic and fault contacts, (2) dividing the bedrock into distinct stratigraphic units based on field criteria, (3) determining the geometry of map-scale folds and faults, and (4) documenting various aspects of the local fracture system.

The results from field mapping can be divided into those related to the stratigraphy of the rock units and those related to their structure. The major stratigraphic information obtained from this mapping effort is the division of the Knox Group and Chickamauga Group carbonate sequence (about 1.5 km thick) into individual formations. Division of the Knox Group followed standard criteria used to map the Knox in other parts of the reservation. Exposures of the Chickamauga Group along the Clinch River and East Fork Poplar Creek, however, have led to a much better understanding of the characteristics distinguishing the formations in the lower part of the group. These subdivisions will eventually be used to define important hydrogeologic units based on correlations with groundwater test results. Although mappable based on characteristics of the weathered residuum, the Rome Formation and the upper part of the Chickamauga Group are poorly exposed; therefore subsurface studies are required to better characterize these units.

Uranium Hexafluoride Storage Cylinder Removal Project

Currently 4841 uranium hexafluoride (UF_6) storage cylinders are located in three K-25 Site cylinder yards. Since K-25 Site operations involving the use of UF_6 have ceased, many cylinders have been shipped to the Paducah Gaseous Diffusion Plant (PGDP). This shipping effort began in 1992 and has continued through the

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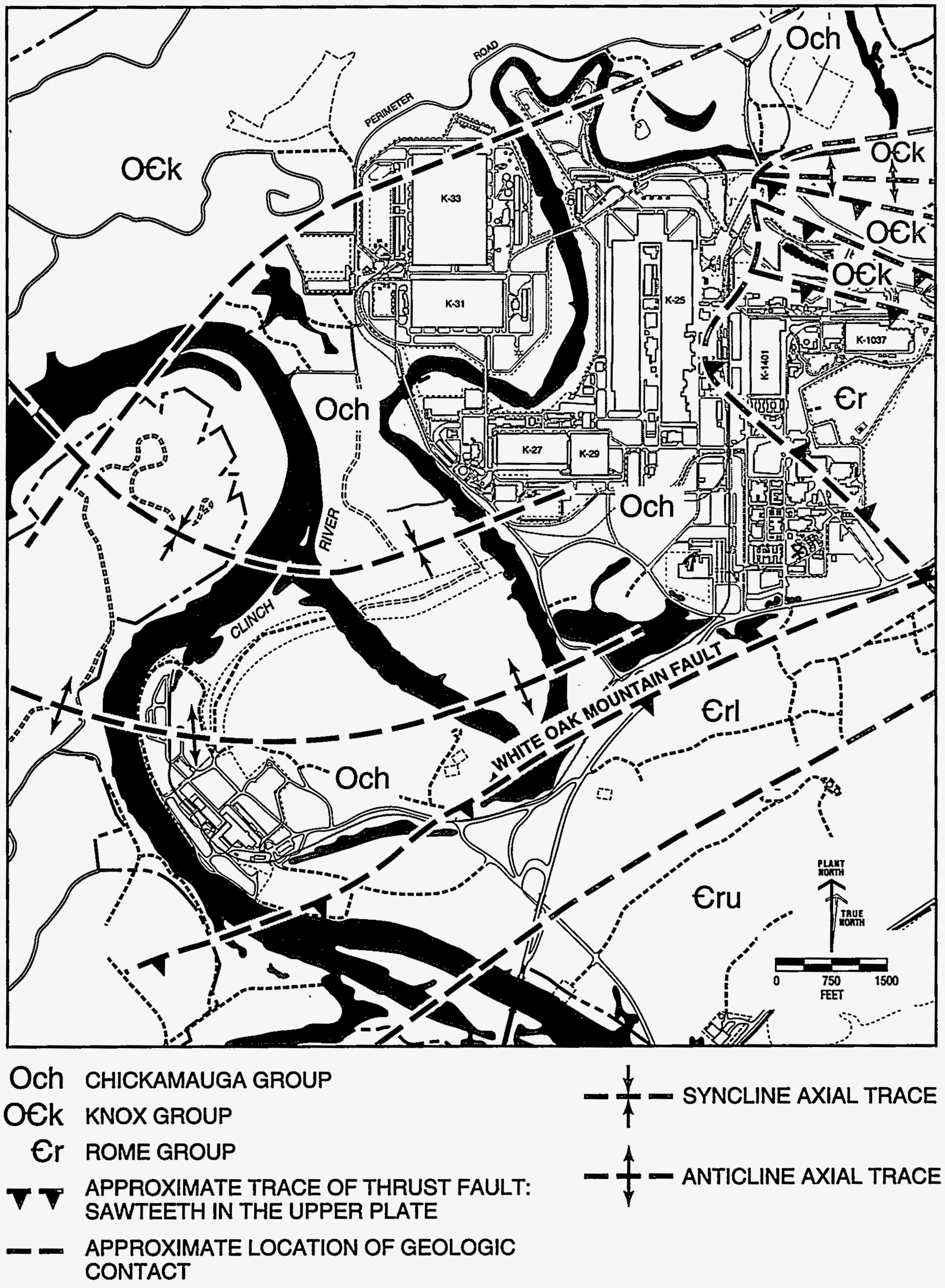

Fig. 9.2. Generalized bedrock geology at the Oak Ridge K-25 Site.

present. In 1993, 606 cylinders were shipped to PGDP (69 by rail and 537 by truck), and 261 cylinders were shipped the previous year. Before shipping, each cylinder is inspected to ensure compliance with U.S. Department of Transportation requirements.

As part of a K-25 Site sitewide outdoor radiation characterization study, a survey of one of these cylinder yards, after removal of a number of the cylinders, provided evidence that the dose rate along the bank of Poplar Creek had been reduced to 8.7% of the previous dose. The cylinder yard, known as the K-1066-E UF_6 Cylinder Storage Yard, is located along the bank of Poplar Creek, east of West Perimeter Road. Through removal of cylinders in this one cylinder yard alone, the potential dose to the public from direct radiation exposure has been significantly reduced.

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).

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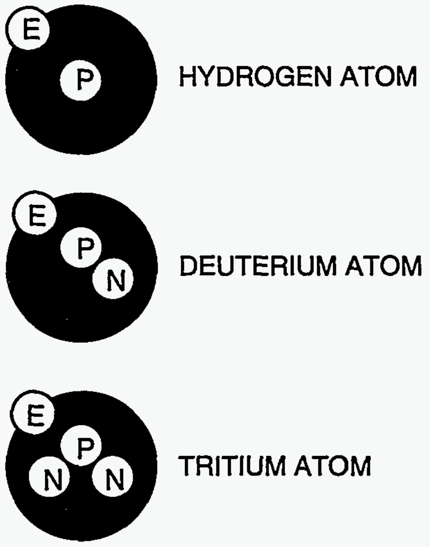

	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1
TRITIUM	1	2

Fig. A.1. The hydrogen atom and its isotopes.

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).

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.

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*	^{234m}Pa	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 days
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 years	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: Kocher, David C. 1981. *Radioactive Decay Tables: A Handbook of Decay Data for Application to Radioactive Dosimetry and Radiological Assessments*, DOE/TIC-11026.

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.

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 Death Valley, California.

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 (Shapiro).

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, important both for internal and external exposure. Gamma emitters deposited in one organ of the body can significantly irradiate other organs.

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, thorium 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 and ingested by the cows would show up in their milk. People drinking the milk would be exposed to this radiation. People also could simply inhale airborne radionuclides. Similarly, radionuclides in water could be injested 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.

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).

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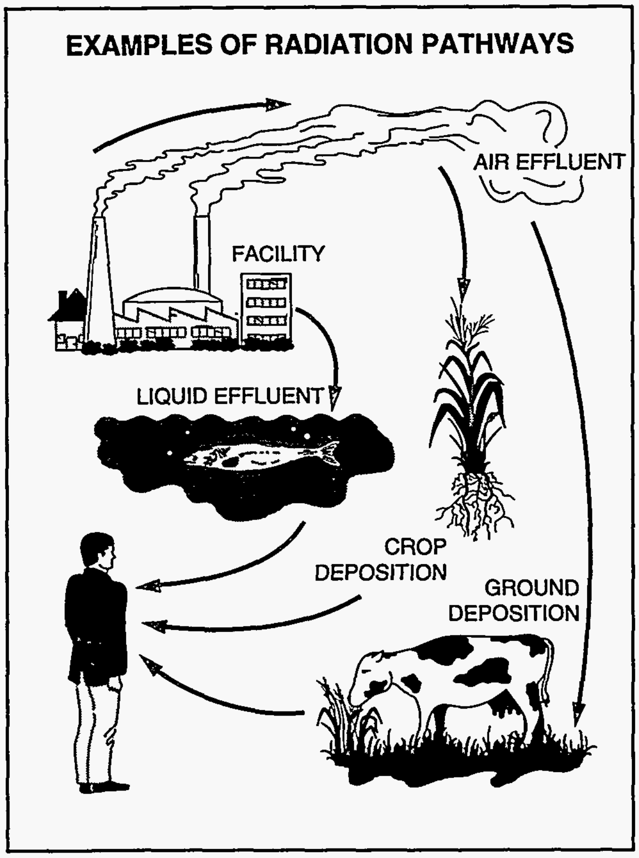

Fig. A.2. Examples of radiation pathways.

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 expressed as fractions of a rem—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 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.

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}
Absorbed dose		
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
Dose equivalent		
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Converting Dose Equivalent

Because a rem represents a fairly large dose of radiation, dose is best expressed as a millirem, or 1/1000 of a rem. The same is true of sieverts. Dose is expressed in millisieverts (mSv). Because 1 mrem equals 0.01 mSv, converting from millirem to millisieverts is simply a matter of moving the decimal point two places to the left. For example, 267 mrem equals 2.67 mSv.

Dose 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; Beres 1990; EPA 1998; EPA 1993).

Comparison of Dose Levels

Table A.2 presents a scale of dose levels, with an example of the type of exposure that may cause such a dose, or the special significance of such a dose. This information is intended to help the reader become familiar with a range of doses that various individuals may receive.

The maximally exposed person living near the ORR area could receive an annual EDE of about 3 mrem (0.03 mSv) from radionuclides released from the ORR during 1993.

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 8.7 μR/h, which results in an equivalent dose of about 53 mrem per year (0.53 mSv per year) (Myrick 1981).

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 USEPA, 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 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 USEPA 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 radiation dose would result in a lifetime excess risk of death from cancer of 0.8%.
25 rem	USEPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency.
75 rem	USEPA 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 will 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 would die within 60 days.

Adapted from *Savannah River Site Environmental Report for 1993, Summary Pamphlet,* WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.

Dose from Internal Radiation

The major contributors to the annual dose equivalent for internal radionuclides are the short-lived decay products of radon (mostly ^{222}Rn), 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 1987a).

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

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 do 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). 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 in a river that receives effluents may take up 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.

Measuring Chemicals

Environmental samples are collected in areas surrounding the ORR and analyzed for chemical constituents that are most likely to be released from ORR. Samples of liquid effluents are also collected. With modern analytical techniques, very small quantities of chemicals can be detected and measured in samples. However, some chemicals are present in such small amounts that they cannot be measured. Typically, chemical concentration is expressed in units of milligrams per liter or micrograms per liter (liquids), both of which are defined as the amount of contaminant (milligrams or micrograms) per liter of water. Concentrations also can be expressed in units of milligrams per kilogram or micrograms per gram, which indicates the amount of contaminant (milligrams or micrograms) per mass (kilogram or gram) of soil or fish tissue. Many of the sampling data for individual chemicals on the ORR are reported as "less than" (<) values, indicating that concentrations are below the limit of detection of the instruments used. These data are used in the analysis only if one or more samples have values above the detection limits.

Exposure Assessment

In this report, it is assumed that people are exposed to the statistically significant concentrations of contaminants. In addition, it is assumed that people living beyond the ORR boundary drink 2 liters (2 L) of water per day (730 L per year) directly from the river and eat 58 g of fish per day (21.2 kg per year) from the river. These assumptions are conservative but are used to ensure that no one is receiving a high dose from ORR effluents. Thus, estimated oral daily intakes or estimated doses to the public can be calculated by multiplying measured concentrations in water by 2 L or multiplying measured concentrations in fish by 58 g.

Toxicity

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 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.

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.

Dose Assessment

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 a lifetime, which is defined as 70 years. Such exposures are called chronic in contrast to short-term exposures, which are called acute.

Definitions

Chronic reference dose (RfD). An estimate of the daily exposure to the human population, including sensitive populations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs are specifically developed to be protective for a for a long-term exposure to a compound.

Hazard quotient (HQ). The ratio of a single substance exposure level over a specified time period to a reference dose (RfD) for that substance derived from a similar exposure period.

Maximum contaminant level (MCL). The chemical concentration limits as defined in EPA National Primary Drinking Water regulations. These regulations are enforceable and apply to all community or public water systems.

Secondary maximum contaminant level (SMCL). EPA National Secondary Drinking Water regulations in public water systems. The EPA SMCLs are unenforceable criteria; however, Tennessee SMCLs, which are the same as the federal SMCLs, are enforceable.

Dose Term for Noncarcinogens

Reference Dose (RfD): 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.

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 U.S. Environmental Protection Agency (EPA) maintains the Integrated Risk Information System (IRIS) data base which contains verified RfDs and slope factors and up-to-date health risk and EPA regulatory information for numerous chemicals.

Dose Term for Carcinogens

Slope factor (SF): A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor 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.

Primary and secondary maximum contaminant level: For chemicals for which RfDs or SFs 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 divided by 70 kg (the reference adult body weight). The result is a dose expressed in milligrams per kilogram per day.

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 (*I*) to the RfD as follows:

$$HQ = \frac{I}{RfD} \ ,$$

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:

$$CDI = \frac{1 \times 10^{-5}}{SF} \ ,$$

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}.

Much of the sampling data for individual chemicals are reported as "less than" (<) values, indicating that concentrations are below the limit of detection of the instruments used. These data were used in the analysis only if one or more samples had values above the detection limits. In cases where the estimated intakes are expressed as < values, the ratios are also expressed as < values and the exposure cannot be fully quantified.

Table B.1. Nomenclature for elements and chemical constituents

Constituent	Symbol	Constituent	Symbol
Aluminum	Al	Nickel	Ni
Ammonia	NH_3	Nitrogen	N
Antimony	Sb	Nitrate	NO_3
Arsenic	As	Nitrite	NO_2
Barium	Ba	Oxygen	O
Beryllium	Be	Ozone	O_3
Cadmium	Cd	Phosphorus	P
Calcium	Ca	Phosphate	P_4
Calcium carbonate	$CaCo_3$	Potassium	K
Carbon	C	Radium	Ra
Chlorine	Cl	Rhenium	Re
Chromium	Cr	Selenium	Se
Cobalt	Co	Silver	Ag
Copper	Cu	Sodium	Na
Fluorine	F	Sulfate	SO_4
Iron	Fe	Sulfur dioxide	SO_2
Lead	Pb	Thallium	Tl
Lithium	Li	Uranium	U
Magnesium	Mg	Vanadium	V
Manganese	Mn	Zinc	Zn
Mercury	Hg		

Appendix C: Air Permits

Table C.1. Air permits at the Y-12 Plant

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Part I. Operating permits at the Y-12 Plant			
Fugitive emission source	01-1020-89	034295P	Fugitive air emission at Y-12 Plant
Y-12-Plant-A(00)	01-0020-08	035025P	Plantwide permit for fluorescent light crusher
Y-9201-1-A(01)	01-0020-15	730303P	Welding booths
Y-9201-1-A(02)	01-0020-15	730303P	Welding shop
Y-9201-1-A(04)	01-0020-15	730303P	Metal fabrication shop
Y-9201-1-A(05)	01-0020-15	730303P	Welding shop
Y-9201-1-A(15)	01-0020-15	730303P	Metal fabrication shop
Y-9201-1-B(16)	01-0020-59	730310P	Tool grinding machines
Y-9201-1-B(18)	01-0020-59	730310P	Sand blaster exhaust
Y-9201-1-C(278)	01-0020-17	730304P	Graphitic carbon machining
Y-9201-1-C(279)	01-0020-17	730304P	Graphitic carbon machining
Y-9201-1-D(09)	01-0020-59	730310P	Fabrication shop
Y-9201-1-D(10)	01-0020-59	730310P	Fabrication shop
Y-9201-1-D(11)	01-0020-59	730310P	Fabrication shop
Y-9201-1-D(13)	01-0020-59	730310P	Metal grinders and milling machines
Y-9201-1-E(00)	01-1020-92	031880P	Lead machining operations
Y-9201-2-B(02)	01-0020-43	012887P	Acid wash station
Y-9201-3-A(01)	01-0020-55	013002F	Diesel generator
Y-9201-4-A(264)	01-1020-96	032956P	Mercury flasking hood
Y-9201-5-B(071)	01-0020-21	730305P	Machining operations L5N hood exhaust
Y-9201-5-B(072)	01-0020-21	730305P	Vacuum inlets L5E machining shop
Y-9201-5-B(03)	01-0020-21	730305P	Rubber-gel potting hood exhaust
Y-9201-5-B(073)	01-0020-21	730305P	Palarite shop, machine exhaust
Y-9201-5-B(267)	01-0020-21	730305P	Tool-grinding machines hood exhaust
Y-9201-5-B(277)	01-0020-21	730305P	Cleaning hood, equipment service
Y-9201-5-B(273)	01-0020-21	730305P	Electrochemical machine, stainless steel
Y-9201-5-D(01)	01-1020-44	025902P	Hood
Y-9201-5-D(02)	01-1020-44	025902P	Film dryer exhaust fume hood
Y-9201-5-E(01)	01-1020-70	025983P	BeO hot press
Y-9201-5-E(02)	01-1020-70	025983P	A53 hot press house vacuum
Y-9201-5-E(08)	01-1020-70	025983P	Room exhaust
Y-9201-5-G(01)	01-0020-44	730308P	Arc melt
Y-9201-5-G(02)	01-0020-44	730308P	DeVilbiss hood
Y-9201-5-G(03)	01-0020-44	730308P	Nitric acid dip tanks
Y-9201-5-G(04)	01-0020-44	730308P	Acid pickling tanks
Y-9201-5-G(05)	01-0020-44	730308P	Abrasive saws
Y-9201-5-G(06)	01-0020-44	730308P	Scrap metal recycle
Y-9201-5-G(07)	01-0020-44	730308P	Vapor degreaser
Y-9201-5-H(01)	01-0020-16	026019P	Mixing process material
Y-9201-5-H(02)	01-0020-16	026019P	Setup and sample area
Y-9201-5-H(03)	01-0020-16	026019P	Vapor blaster
Y-9201-5-H(04)	01-0020-16	026019P	Nickel-plating tank exhaust
Y-9201-5-H(05)	01-0020-16	026019P	Material handling
Y-9201-5-H(06)	01-0020-16	026019P	Material handling

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9201-5-H(07)	01-0020-16	026019P	Glove box and blending station
Y-9201-5-H(08)	01-0020-16	026019P	Inspection house vacuum
Y-9201-5N-A(67)	01-1020-18	730314P	Machine shop exhaust
Y-9201-5N-B(239)	01-0020-30	030484P	Plating tanks and hoods
Y-9201-5N-B(240)	01-0020-30	030484P	Plating tanks and hoods
Y-9201-5N-B(241)	01-0020-30	030484P	Plating tanks and hoods
Y-9201-5N-B(242)	01-0020-30	030484P	Incinerator
Y-9201-5N-B(243)	01-0020-30	030484P	Grit blaster
Y-9201-5N-B(244)	01-0020-30	030484P	Grit blaster and area exhaust
Y-9202-A-(20)	01-0020-06	031696P	Laboratory beryllium
Y-9202-A-(21)	01-0020-06	031696P	Laboratory
Y-9204-2-A(01)	01-0020-46	026107P	Storage tank
Y-9204-2-A(02)	01-0020-46	026107P	Storage tank
Y-9204-2-A(03)	01-002046	026107P	Storage tank
Y-9204-2-A(04)	01-0020-46	026107P	Storage tank
Y-9204-2-A(05)	01-0020-46	026107P	Storage tank
Y-9204-2-A(06)	01-0020-46	026107P	Storage tank
Y-9204-2-A(07)	01-0020-46	026107P	Storage tank
Y-9204-2-A(08)	01-0020-46	026107P	Storage tank
Y-9204-2-A(09)	01-0020-46	026107P	Storage tank
Y-9204-2-A(10)	01-0020-46	026107P	Storage tank
Y-9204-2-A(11)	01-0020-46	026107P	Storage tank
Y-9204-2-A(12)	01-0020-46	026107P	Storage tank
Y-9204-2-A(13)	01-0020-46	026107P	Storage tank
Y-9204-2-B	01-0020-45	012889P	Storage tank
Y-9204-2-B(14)	01-0020-71	025954P	Reduction cell
Y-9204-2-B(15)	01-0020-71	025954P	Reduction cell
Y-9204-2-B(16)	01-0020-71	025954P	Reduction cell
Y-9204-2-B(17)	01-0020-71	025954P	Reduction cell
Y-5204-2-B(18)	01-0020-71	025954P	Caustic scrubber exhaust
Y-9204-2-B(19)	01-0020-71	025954P	Caustic scrubber exhaust
Y-9204-2-B(20)	01-0020-71	025954P	Storage area
Y-9204-2-B(21)	01-0020-71	025954P	Reduction cell
Y-9204-2-B(22)	01-0020-71	025954P	Reduction cell
Y-9204-2-B(23)	01-0020-71	025954P	Caustic scrubber exhaust
Y-9204-2-B(24)	01-0020-71	025954P	Caustic scrubber exhaust
Y-9204-2-B(25)	01-0020-71	025954P	Lithium metal wash station
Y-9204-2-B(26)	01-0020-71	025954P	Cleaning station
Y-9204-2-B(27)	01-0020-71	025954P	Lithium remelt oven
Y-9204-2-B(28)	01-0020-71	025954P	Reduction cell
Y-9204-2-C(29)	01-1020-19	025900P	Classified
Y-9204-2-C(30)	01-1020-19	025900P	Classified
Y-9204-2-C(31)	01-1020-19	025900P	Classified
Y-9204-2-C(32)	01-1020-19	025900P	Classified
Y-9204-2-C(33)	01-1020-19	025900P	Classified

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9204-2-C(34)	01-1020-19	025900P	Classified
Y-9204-2-C(35)	01-1020-19	025900P	Classified
Y-9204-2-C(36)	01-1020-19	025900P	Classified
Y-9204-2-C(37)	01-1020-19	025900P	Classified
Y-9204-2-C(38)	01-1020-19	025900P	Classified
Y-9204-2-C(39)	01-1020-19	025900P	Classified
Y-9204-2-C(40)	01-1020-19	025900P	Classified
Y-9204-2-C(41)	01-1020-19	025900P	Classified
Y-9204-2-C(42)	01-1020-19	025900P	Classified
Y-9204-2-C(43)	01-1020-19	025900P	Classified
Y-9204-2-C(44)	01-1020-19	025900P	Classified
Y-9204-2-C(45)	01-1020-19	025900P	Classified
Y-9204-2-C(46)	01-1020-19	025900P	Classified
Y-9204-2-C(47)	01-1020-19	025900P	Classified
Y-9204-2-C(48)	01-1020-19	025900P	Classified
Y-9204-2-C(49)	01-1020-19	025900P	Classified
Y-9204-2-C(50)	01-1020-19	025900P	Classified
Y-9204-2-C(51)	01-1020-19	025900P	Classified
Y-9204-2-D(52)	01-1020-57	025967P	Storage tanks
Y-9204-2-D(53)	01-1020-57	025967P	Station
Y-9204-2-D(54)	01-1020-57	025967P	Salvage vats
Y-9204-2-D(55)	01-1020-57	025967P	Storage tank
Y-9204-2-D(56)	01-1020-57	025967P	Lithium chloride crystallizer
Y-9204-2-D(57)	01-1020-57	025967P	Lithium chloride crystallizer
Y-9204-2-D(58)	01-1020-57	025967P	Neutralizer
Y-9204-2-D(59)	01-1020-57	025967P	Three lab hoods
Y-9204-2-D(60)	01-1020-57	025967P	Process tank
Y-9204-2-D(61)	01-1020-57	025967P	Lithium chloride crystallizer
Y-9204-2-D(62)	01-1020-57	025967P	Lithium hydroxide neutralizer
Y-9204-2-D(63)	01-1020-57	025967P	HCl head tanks
Y-9204-2-D(64)	01-1020-57	025967P	Process tanks
Y-9204-2-D(65)	01-1020-57	025967P	Process tank
Y-9204-2-D(66)	01-1020-57	025967P	Neutralizer
Y-9204-2-D(67)	01-1020-57	025967P	Neutralizer
Y-9204-2-E(68)	01-1020-55	730328P	Oven
Y-9204-2-E(69)	01-1020-55	730328P	Oven
Y-9204-2-E(70)	01-1020-55	730328P	Tungsten screener
Y-9204-2-E(71)	01-1020-55	730328P	Dry box vent
Y-9204-2-E(72)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(73)	01-1020-55	730328P	Material handling
Y-9204-2-E(74)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(75)	01-1020-55	730328P	Outgassing/annealing ovens
Y-9204-2-E(76)	01-1020-55	730328P	Material handling
Y-9204-2-E(77)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(78)	01-1020-55	730328P	Reactor unloading station

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9204-2-E(79)	01-1020-55	730328P	Reactor unloading station
Y-9204-2-E(80)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(81)	01-1020-55	730328P	Vacuum pump
Y-9204-2-F	01-0020-32	012874P	Storage tank
Y-9204-2-F(082)	01-0020-51	025897P	Classified
Y-9204-2-F(083)	01-0020-51	025897P	Classified
Y-9204-2-F(084)	01-0020-51	025897P	Classified
Y-9204-2-F(085)	01-0020-51	025897P	Classified
Y-9204-2-F(086)	01-0020-51	025897P	Classified
Y-9204-2-F(087)	01-0020-51	025897P	Classified
Y-9204-2-G(088)	S01-1020-79	028350P	Inspection operation
Y-9204-2-G(089)	S01-1020-79	028350P	Metalworking machine shop hood, B-2
Y-9204-2-G(090)	S01-1020-79	028350P	Metalworking machine shop hood, B-2
Y-9204-2-H(492)	S01-1020-42	025952P	Etching vats
Y-9204-2-H(493)	S01-1020-42	025952P	Glue mixing
Y-9204-2E-A(202)	01-1020-91	730938P	Positive Ion Accelerator
Y-9204-2E-A(436)	01-0020-68	730312P	Oven
Y-9204-2E-A(439)	01-0020-68	730312P	Hood exhaust
Y-9204-2E-A(441)	01-0020-68	730312P	Hood
Y-9204-2E-A(442)	01-0020-68	730312P	Hood
Y-9204-2E-A(443)	01-0020-68	730312P	Degreaser
Y-9204-2E-A(444)	01-0020-68	730312P	Electropolishers
Y-9204-2E-A(445)	01-0020-68	730312P	Surface coating
Y-9204-2E-A(448)	01-0020-68	730312P	Glove box
Y-9204-2E-B(12)	01-1020-41	025953P	X-ray testing
Y-9204-2E-B(14)	01-1020-41	025953P	Hoods
Y-9204-2E-B(15)	01-1020-41	025953P	Hoods
Y-9204-2E-C(12)	01-1020-55	730328P	Machine shop hood exhaust, B2E
Y-9204-2E-C(13)	01-1020-55	730328P	Machine shop hood exhaust, specimen shop
Y-9204-3-AJ-106	01-0020-89	018208P	Roof exhaust stack
Y-9204-4-A(02)	01-1020-56	032416P	Wash tank
Y-9204-4-A(03)	01-1020-56	032416P	Quench tanks
Y-9204-4-A(04)	01-1020-56	032416P	1,000-ton press
Y-9204-4-A(05)	01-1020-56	032416P	7,500-ton press
Y-9204-4-A(06)	01-1020-56	032416P	Exhaust from press pit area
Y-9204-4-A(07)	01-1020-56	032416P	Plasma torch cutting machine
Y-9204-4-A(08)	01-1020-56	032416P	Vacuum quench furnace
Y-9204-4-A(09)	01-1020-56	032416P	Ingot cooler
Y-9204-4-A(10)	01-1020-56	032416P	Exhaust from lathe
Y-9204-4-A(11)	01-1020-56	032416P	Grinding facility
Y-9204-4-A(12)	01-1020-56	032416P	Dye penetrant
Y-9204-4-A(13)	01-1020-56	032416P	Salt baths
Y-92044-A(14)	01-1020-56	032416P	Quench tanks
Y-9204-4-A(15)	01-1020-56	032416P	Preheat furnace exhaust
Y-9204-4-A(17)	01-1020-56	032416P	Oven exhaust

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9204-4-A(18)	01-1020-56	032416P	Vacuum furnace quench chamber
Y-9204-4-A(19)	01-1020-56	032416P	7,500-ton press and 1,500-ton press
Y-9204-4-A(88)	01-1020-56	032416P	Grit blast system
Y-9204-4-B(481)	01-0020-72	730313P	Exhaust from machining operation
Y-9204-4-B(482)	01-0020-72	730313P	Exhaust from hood, reclamation area
Y-9204-4-B(484)	01-0020-72	730313P	Rolling mill, first floor assembly
Y-9204-4-B(485)	01-0020-72	730313P	Exhaust from paint hood
Y-9204-4-B(486)	01-0020-72	730313P	Filtering exhaust from paint booths
Y-9204-4-B(488)	01-0020-72	730313P	Laboratory hoods, first floor
Y-9204-4-B(489)	01-0020-72	730313P	Laboratory hoods, reclamation area
Y-9204-4-B(490)	01-0020-72	730313P	Assembly process, first floor
Y-9204-4-B(491)	01-0020-72	730313P	Assembly process, first floor
Y-9204-4-D(1)	01-1020-35	032584P	Product certification cleaning
Y-9204-4-E(258)	01-0020-33	030819P	Plating equipment
Y-9204-4-E(259)	S01-0020-33	025002P	Plating equipment
Y-9204-4-E(260)	S01-0020-33	025002P	Plating equipment
Y-92044-E(261)	S01-0020-33	025002P	Plating equipment
Y-9206-A(01)	01-0020-48	012892P	8,500-gal storage tank, tank farm
Y-9206-A(02)	01-0020-48	012892P	12,800-gal storage tank, tank farm
Y-9206-A(03)	01-0020-48	012892P	10,000-gal storage tank, tank farm
Y-9206-B(013)	01-0020-03	731689P	South stack, incinerator
Y-9206-B(015)	01-0020-03	731689P	West stack
Y-9206-B(016)	01-0020-03	731689P	Dissolving hood
Y-9206-B(017)	01-0020-03	731689P	Steam cleaning hoods
Y-9206-B(115)	01-0020-03	731689P	Reduction fluid bed
Y-9206-B(135)	01-0020-03	731689P	Air emission control scrubber stack
Y-9206-B(136)	01-0020-03	731689P	Air emission control consolidated stack
Y-9206-B(208)	01-0020-03	731689P	Conversion fluid bed
Y-9206-B(209)	01-0020-03	731689P	HF purge vent
Y-9206-B(210)	01-0020-03	731689P	Chemical makeup area
Y-9206-B(211)	01-0020-03	731689P	Hoods 29 and 30
Y-9206-B(212)	01-0020-03	731689P	Dry vacuum system
Y-9206-C(01)	01-1020-24	730316P	Classified
Y-9206-C(02)	01-1020-24	730316P	Classified
Y-9206-E (NEW)	01-1020-24	730316P	Classified
Y-9212-A(019)	01-1020-72	033581P	Filter exhaust, denitrator, fluid bed, etc.
Y-9212-A(021)	01-1020-72	033581P	Centrifuges, liquid pour-up station, etc.
Y-9212-A(022)	01-1020-72	033581P	Reduction salvage, crusher and hopper
Y-9212-A(024)	01-1020-72	033581P	Calciner and dry vacuum system enclosure
Y-9212-A(025)	01-1020-72	033581P	Denitrator area and fluid bed room enclosure
Y-9212-A(027)	01-1020-72	033581P	D-wing, Rm 1010 hoods, Rms 26 and 29
Y-9212-A(028)	01-1020-72	033581P	Reduction, shear, and Rm 1010, enriched uranium conversion facility
Y-9212-A(033)	01-1020-72	033581P	Head house equipment and incinerator
Y-9212-A(036)	01-1020-72	033581P	East scrubber (C-1 wing) exhaust
Y-9212-A(040)	01-1020-72	033581P	B-1 sampling lab hoods

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9212-A(042)	01-1020-72	033581P	Chloride removal system/C-1 wing process exhaust
Y-9212-A(050)	01-1020-72	033581P	C-1 chip burner, enclosures, load hoods
Y-9212-A(111)	01-1020-72	033581P	Reduction fluid beds
Y-9212-A(112)	01-1020-72	033581P	Conversion fluid beds
Y-9212-A(132)	01-1020-72	033581P	Decontamination facility
Y-9212-A(430)	01-1020-72	033581P	HF dock cylinder/vaporizer purge vent
Y-9212-A(431)	01-1020-72	033581P	N_20_4 cylinder purge vent
Y-9212-A(432)	01-1020-72	033581P	Muffle furnaces (2) vent, Rm 29
Y-9212-A(500)	01-1020-72	033581P	Primary extraction vent
Y-9212-A(501)	01-1020-72	033581P	Secondary extraction vent
Y-9212-B(01)	01-0020-02	730301P	U metal drying and briquetting process
Y-9212-B(02)	01-0020-02	730301P	Exhaust from chip washing and drying
Y-9212-B(03)	01-0020-02	730301P	E-wing machine shop
Y-9212-B(04)	01-0020-02	730301P	U metal and U metal alloy casting
Y-9212-C(01)	01-0020-05	025984P	Drum receiving/sampling hood and glove box
Y-9212-C(02)	01-0020-05	025984P	Tube furnace/gas purge vents
Y-9212-C(03)	01-0020-05	025984P	Sampling hoods and safe bottles/Rm 1022
Y-9212-C(04)	01-0020-05	025984P	Dry hoods/Rm 1021
Y-9212-C(05)	01-0020-05	025984P	Dissolver tray hoods/Rm 1021
Y-9212-C(06)	01-0020-05	025984P	Dissolver hood
Y-9212-C(07)	01-0020-05	025984P	Dissolver trays/scrubber
Y-9212-C(08)	01-0020-05	025984P	Shear and saw hood/Rm 1021
Y-9212-C(09)	01-0020-05	025984P	Precipitation process
Y-9212-F(01)	01-1020-49	730321P	Two deburr benches, hood exhaust, A-wing
Y-9212-F(02)	01-1020-49	730321P	Two deburr benches, hood exhaust, A-wing
Y-9212-F(03)	01-1020-49	730321P	Machining, hood exhaust, A-wing
Y-9212-F(04)	01-1020-49	730321P	Machining, hood exhaust, A-wing
Y-9212-F(05)	01-1020-49	730321P	Machining, hood exhaust, A-wing
Y-9212-G(01)	01-1020-47	028435P	Seal-peel pot
Y-9215-A(01)	01-0020-37	731839P	Machine shop hood exhaust, M-wing
Y-9215-B(02)	01-0020-38	012880P	Turco pretreat spray hood
Y-9215-B(1)	01-1020-51	732125P	O-wing metalworking operations
Y-9215-B(2)	01-1020-51	732125P	O-wing metalworking operations
Y-9215-B(4)	01-1020-51	732125P	O-wing metalworking operations
Y-9215-B(6)	01-1020-51	732125P	O-wing metalworking operations
Y-9215-C(02)	01-1020-52	025948P	Hydroform exhaust
Y-9215-C(03)	01-1020-52	730323P	Vapor blaster/metal cleaner
Y-9215-C(10)	01-1020-52	730323P	Nickel plating, metal working exhaust
Y-9215-C(11)	01-1020-52	730323P	Exhaust
Y-9215-C(17)	01-1020-52	730323P	Rolling mill
Y-9215-C(19)	01-1020-52	730323P	Electric annealing oven
Y-9215-D(12)	01-1020-53	025966P	Rolling mill exhaust
Y-9215-D(13)	01-1020-53	025966P	Hood exhaust
Y-9215-D(14)	01-1020-53	025966P	Exhaust from rolling mill
Y-9215-D(IS)	01-1020-53	025966P	Turret lathe and shear exhaust

Table C.1. Air permits at the Y-12 Plant

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9215-E(6)	01-1020-54	025972P	Lab hood
Y-9215-E(7)	01-1020-54	025972P	Lab hoods
Y-9215-E(8)	01-1020-54	025972P	Lab hoods
Y-9401-2-A(205)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(220)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(221)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(222)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(223)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(224)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(225)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(226)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(227)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(228)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(229)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(230)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(231)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(232)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(233)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(234)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(235)	01-0020-88	730286P	Plating equipment
Y-9401-3-A	01-1020-31	029322F	Coal-fired boiler
Y-9401-3-B(170)	01-1020-31	029322F	Coal-fired boiler
Y-9401-3-C	01-1020-31	029322F	Coal-fired boiler
Y-9401-3-D(171)	01-1020-31	029322F	Coal-fired boiler
Y-9401-3-H(01) [9616-10]	01-1020-62	029280P	20,000-gal sulfuric acid storage tank
Y-9401-5-A(01)	01-0020-92	026108P	Uranium chip oxidizer
Y-9404-11-A(1)	01-1020-81	028426P	Purification plant
Y-9404-11-A(2)	01-1020-81	028426P	Purification plant
Y-9404-11-A(3)	01-1020-81	028426P	Purification plant
Y-9404-11-A(4)	01-1020-81	028426P	Purification plant
Y-9404-5-B(02)	01-0020-25	012866P	Spray room exhaust
Y-9404-5-B(03)	01-0020-25	012866P	Spray booth
Y-9404-7-FUG-A(00)	01-1020-89	034295P	PCB drum storage facility
Y-9404-9-C(03)	01-0020-40	012882P	PVC curing ovens
Y-9404-9-D(04)	01-0020-40	012882P	PVC curing ovens
Y-9404-9-E(05)	01-0020-40	012882P	PVC curing ovens
Y-9616-7-A(459)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(460)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(461)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(462)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(463)	01-1020-74	033498P	West end treatment vent, reactor vessel
Y-9616-7-A(464)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(465)	01-1020-74	033498P	West end treatment vent, degasifier unit
Y-9616-7-A(466)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(467)	01-1020-74	033498P	West end treatment storage tank

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9616-7-A(468)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(469)	01-1020-74	033498P	West end treatment vent, lime silo
Y-9616-7-A(470)	01-1020-74	033498P	West end treatment storage tank
Y-9616-7-A(1)	01-1020-80	031254P	Vent from air stripper
Y-9616-7-B(650)	01-1020-74	033498P	Biological treatment tanks
Y-9616-7-B(651)	01-1020-74	033498P	Biological treatment tanks
Y-9616-7-B(653)	01-1020-74	033498P	Biological treatment tanks
Y-9616-7-B(654)	01-1020-74	033498P	Biological treatment tanks
Y-9616-7-B(655)	01-1020-74	033498P	Biological treatment tanks
Y-9616-7-B(655)	01-1020-74	033498P	Biological treatment tanks
Y-9616-7-B(656)	01-1020-74	033498P	Solids storage tanks
Y-9616-7-B(657)	01-1020-74	033498P	Solids storage tanks
Y-9616-7-B(658)	01-1020-74	033498P	Solids storage tanks
Y-9616-7-B(659)	01-1020-74	033498P	Solids storage tanks
Y-9616-7-B(660)	01-1020-74	033498P	Solids storage tanks
Y-9616-7-B(661)	01-1020-74	033498P	Solids storage tanks
Y-9616-7-B(662)	01-1020-74	033498P	Solids storage tanks
Y-9620-2A	01-0020-50	012894P	Storage tank
Y-9623-A(01)	01-1020-25	025970P	Vent from reactor vessel
Y-9623-A(02)	01-1020-25	025970P	Vent from eight tanks
Y-9623-A(03)	01-1020-25	025970P	Lab hood
Y-9623-A(04)	01-1020-25	025970P	Lime silo
Y-9623-A(05)	01-1020-25	025970P	Storage tank
Y-9623-A(06)	01-1020-25	025970P	Storage tank
Y-9720-12-FUG-A(00)	01-1020-89	034295P	Nonspecial nuclear material warehouse
Y-9720-19-A(01)	01-0020-41	012885P	Curing oven
Y-9720-19-C(01)	01-0020-23	012864P	Teflon sintering oven
Y-9720-19-D(03)	01-0020-27	012869P	Plastics spray booth
Y-9720-20-A(01)	01-1020-39	025971P	Small maintenance shop, fabric filter
Y-9720-25-FUG-A(00)	01-1020-89	034295P	Classified waste storage facility
Y-9720-28-FUG-A(00)	01-1020-89	034295P	Drum storage warehouse
Y-9720-31-FUG-A-(00)	01-1020-89	034295P	RCRA and mixed waste storage and staging facility
Y-9720-32-A(201)	01-0020-42	032547P	Classified waste shredder
Y-9720-44-FUG-A(00)	01-1020-89	034295P	Low-level waste storage pad
Y-9720-5-A(130)	01-1020-75	031958P	Hood at 9720-5 east end
Y-9720-58-FUG-A(00)	01-1020-89	034295P	PCB and RCRA staging and storage facility
Y-9720-6-A(1)	01-0020-26	012867P	Paint spray booth
Y-9720-6-A(2)	01-0020-26	012867P	Paint spray booth
Y-9720-6-B(01)	01-0020-75	015154P	Wood working operation
Y-9720-6-B(03)	01-0020-26	012867P	Drying oven
Y-9720-6-E(01)	01-0020-83	016548P	Clean room laboratory
Y-9720-60-FUG-A(00)	01-1020-89	034295P	DARA solids storage unit
Y-9720-9-FUG-A(00)	01-1020-89	034295P	PCB and RCRA hazardous waste drum storage facility
Y-9737-A(01)	01-0020-22	012863P	Oven
Y-9738-A(576)	01-0020-14	025975P	Sandblaster

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9738-A(577)	01-0020-14	025975P	Hood with fan
Y-9738-A(578)	01-0020-14	025975P	Sand blaster
Y-9738-A(579)	01-0020-14	025975P	Hood with fan
Y-9738-A(580)	01-0020-14	025975P	Hood with fan
Y-9739-A(01)	01-1020-78	028105P	Print fold diazo blueprint copier/Rm 160
Y-9739-B(02)	01-1020-78	028105P	Print fold diazo blueprint copier/Rm 174
Y-9767-4-A(01)	01-0020-35	012877P	Chilled water circulating system
Y-9808-A	01-0020-77	015156P	Carpenter shop
Y-9808-A(01)	01-1020-22	026109P	Spray booth
Y-9809-A(01)	01-0020-93	025899P	Oxide storage vaults
Y-9811-1-FUG-B(00)	01-1020-89	034295P	Waste oil/solvent drum storage facility (OD-8)
Y-9811-1-A(1)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(2)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(3)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(4)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(5)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(6)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(7)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-6-A(1)	01-1020-82	029415P	Dry ash handling system
Y-9811-8-A(01)	01-1020-63	032988P	Waste oil/solvent storage facility (OD-9)
Y-9811-8-A(02)	01-1020-63	032988P	Waste oil/solvent storage facility (OD-9)
Y-9811-8-A(03)	01-1020-63	032988P	Waste oil/solvent storage facility (OD-9)
Y-9811-8-A(04)	01-1020-63	032988P	Waste oil/solvent storage facility (OD-9)
Y-9811-8-A(05)	01-1020-63	032988P	Waste oil/solvent storage facility (OD-9)
Y-9811-B(02)	01-1020-45	025903P	Incinerator
Y-9812-A-(287)	01-1020-29	033051P	12,115-gal storage tank
Y-9812-A-(288)	01-1020-29	033051P	12,133-gal storage tank
Y-9812-A-(289)	01-1020-29	033051P	4,876-gal storage tank
Y-9815-A(03)	01-0020-11	025895P	Vent from reactors
Y-9815-A(04)	01-0020-11	025895P	12,000-gal storage tank
Y-9815-A(05)	01-0020-11	025895P	4,500-gal storage tank
Y-9815-A(06)	01-0020-11	025895P	4,400-gal storage tank
Y-9815-A(07)	01-0020-11	025895P	1,800-gal storage tank
Y-9815-A(08)	01-0020-11	025895P	Two 2,200-gal storage tanks
Y-9818-A(01)	01-0020-12	025965P	Hot well seal tank
Y-9818-A(02)	01-0020-12	025965P	11 storage tanks, nitric acid recovery
Y-9818-A(03)	01-0020-12	025965P	Two bioreactor tanks/ozonation tanks
Y-9818-A(04)	01-0020-12	025965P	Basement exhaust
Y-9818-A(05)	01-0020-12	025965P	Nitric acid supply line vent
Y-9818-A(06)	01-0020-12	025965P	Ozone generator/area exhaust
Y-9818-A(07)	01-0020-12	025965P	10,000-gal storage tank
Y-9818-A(08)	01-0020-12	025965P	10,000-gal denitrification feed tank
Y-9818-A(09)	01-0020-12	025965P	4,000-gal nitrate receiving tank
Y-9818-A(10)	01-0020-12	025965P	10,000-gal nitric acid waste tank
Y-9818-A(11)	01-0020-12	025965P	10,000-gal nitric acid waste tank

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9818-A(12)	01-0020-12	025965P	10,000-gal nitric acid waste tank
Y-9828-6-FUG-A(00)	01-1020-89	034295P	Trash monitoring station
Y-9929-F(01)	M01-0020-39	012881P	Open yard coal storage
Y-9983-74-FUG-A(00)	01-1020-89	034295P	Old salvage yard
Y-9998-A(01)	01-0020-13	025957P	Swaging machines
Y-9998-A(02)	01-0020-13	025957P	Swaging machines
Y-9998-A(03)	01-0020-13	025957P	Furnaces
Y-9998-A(04)	01-0020-13	025957P	Nitric acid pickling tanks
Y-9998-A(05)	01-0020-13	025957P	Hood
Y-9998-A(06)	01-0020-13	025957P	Foundry operations
Y-9998-B(1)	01-1020-40	026110P	Machine shop
Y-BCB-FUG-A(00)	01-1020-89	034295P	Bear Creek Burial Grounds
Y-BCBG-NAK	01-00020-00	010002000	Open burn for NaK
Y-CSL-II-FUG-A(00)	01-1020-89	034295P	Y-12 Centralized Sanitary Landfill II
Y-CWSF-FUG-A(00)	01-1020-89	034295P	Containerized Waste Storage Facility
Y-IDY-FUG-A(00)	01-1020-89	034295P	Interim Drum Yard
Y-IWF-FUG-A(00)	01-1020-89	034295P	Industrial Waste Landfill IV
	Part II. Construction permits at the Y-12 Plant		
Y-9201-1-A(01)	01-0020-15	730303P	Welding booths
Y-9201-1-A(02)	01-0020-15	730303P	Welding shop
Y-9201-1-A(04)	01-0020-15	730303P	Metal fabrication shop
Y-9201-1-A(05)	01-0020-15	730303P	Welding shop
Y-9201-1-A(15)	01-0020-15	730303P	Metal fabrication shop
Y-9201-1-B(16)	01-0020-59	730310P	Tool grinding machines
Y-9201-1-B(18)	01-0020-59	730310P	Sandblaster exhaust
Y-9201-1-C(278)	01-0020-17	730304P	Graphitic carbon machining
Y-9201-1-C(279)	01-0020-17	730304P	Graphitic carbon machining
Y-9201-1-D(09)	01-0020-59	730310P	Fabrication shop
Y-9201-1-D(10)	01-0020-59	730310P	Fabrication shop
Y-9201-1-D(11)	01-0020-59	730310P	Fabrication shop
Y-9201-1-D(13)	01-0020-59	730310P	Metal grinders and milling machines
Y-9201-5-B(071)	01-0020-21	730305P	Machining operations L5N hood exhaust
Y-9201-5-B(072)	01-0020-21	730305P	Vacuum inlets L5E machining shop
Y-9201-5-B(03)	01-0020-21	730305P	Rubber-gel potting hood exhaust
Y-9201-5-B(073)	01-0020-21	730305P	Palarite shop, machine exhaust
Y-9201-5-B(267)	01-0020-21	730305P	Tool grinding machines hood exhaust
Y-9201-5-B(277)	01-0020-21	730305P	Cleaning hood, equipment service
Y-9201-5-B(273)	01-0020-21	730305P	Electrochemical machine, stainless steel
Y-9201-5-G(01)	01-0020-44	921689P	Arc melt
Y-9201-5-G(02)	01-0020-44	921689P	DeVilbiss hood
Y-9201-5-G(03)	01-0020-44	921689P	Nitric acid dip tanks
Y-9201-5-G(04)	01-0020-44	921689P	Acid pickling tanks
Y-9201-5-G(05)	01-0020-44	921689P	Abrasive saws
Y-9201-5-G(06)	01-0020-44	921689P	Scrap metal recycle
Y-9201-5-G(07)	01-0020-44	921689P	Vapor degreaser

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9201-SN-A(67)	01-1020-18	730314P	Machine shop exhaust
Y-9202-A(162)	01-1020-94	931742P	Electrolytic deposition of uranium
Y-9203-B(108)	01-1020-93	931697P	Microanalytical lab
Y-9203-B(131)	01-1020-93	931697P	Microanalytical lab
Y-9203-B(137)	01-1020-93	931697P	Microanalytical lab
Y-9204-2-E(68)	01-1020-55	730328P	Oven
Y-9204-2-E(69)	01-1020-55	730328P	Oven
Y-9204-2-E(70)	01-1020-55	730328P	Tungsten screener
Y-9204-2-E(71)	01-1020-55	730328P	Dry box vent
Y-9204-2-E(72)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(73)	01-1020-55	730328P	Material handling
Y-9204-2-E(74)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(75)	01-1020-55	730328P	Outgassing/annealing ovens
Y-9204-2-E(76)	01-1020-55	730328P	Material handling
Y-9204-2-E(77)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(78)	01-1020-55	730328P	Reactor unloading station
Y-9204-2-E(79)	01-1020-55	730328P	Reactor unloading station
Y-9204-2-E(80)	01-1020-55	730328P	Glove boxes
Y-9204-2-E(81)	01-1020-55	730328P	Vacuum pump
Y-9204-2E-A(202)	01-1020-91	730938P	Positive ion accelerator
Y-9204-2E-A(436)	01-0020-68	730312P	Oven
Y-9204-2E-A(439)	01-0020-68	730312P	Hood exhaust
Y-9204-2E-A(441)	01-0020-68	730312P	Hood
Y-9204-2E-A(442)	01-0020-68	730312P	Hood
Y-9204-2E-A(443)	01-0020-68	730312P	Degreaser
Y-9204-2E-A(444)	01-0020-68	730312P	Electropolishers
Y-9204-2E-A(445)	01-0020-68	730312P	Surface coating
Y-9204-2E-A(448)	01-0020-68	730312P	Glove box
Y-9204-2E-C(12)	01-1020-55	730328P	Machine shop hood exhaust, B2E
Y-9204-2E-C(13)	01-1020-55	730328P	Machine shop hood exhaust, specimen shop
Y-9204-4-A(02)	01-1020-56	931629P	Wash tank
Y-9204-4-A(03)	01-1020-56	931629P	Quench tanks
Y-9204-4-A(04)	01-1020-56	931629P	1,000-ton press
Y-9204-4-A(05)	01-1020-56	931629P	7,500-ton press
Y-9204-4-A(06)	01-1020-56	931629P	Exhaust from press pit area
Y-9204-4-A(07)	01-1020-56	931629P	Plasma torch cutting machine
Y-9204-4-A(08)	01-1020-56	931629P	Vacuum quench furnace
Y-9204-4-A(09)	01-1020-56	931629P	Ingot cooler
Y-9204-4-A(10)	01-1020-56	931629P	Exhaust from lathe
Y-9204-4-A(11)	01-1020-56	931629P	Grinding facility
Y-9204-4-A(12)	01-1020-56	931629P	Dye penetrant
Y-9204-4-A(13)	01-1020-56	931629P	Salt baths
Y-9204-4-A(14)	01-1020-56	931629P	Quench tanks
Y-9204-4-A(15)	01-1020-56	931629P	Preheat furnace exhaust
Y-9204-4-A(17)	01-1020-56	931629P	Oven exhaust

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9204-4-A(18)	01-1020-56	931629P	Vacuum furnace quench chamber
Y-9204-4-A(19)	01-1020-56	931629P	7,500-ton press and 1,500-ton press
Y-9204-4-A(88)	01-1020-56	931629P	Grit blast system
Y-9204-4-B(481)	01-0020-72	730313P	Exhaust from machining operation
Y-9204-4-B(482)	01-0020-72	730313P	Exhaust from hood, reclamation area
Y-9204-4-B(484)	01-0020-72	730313P	Rolling mill, first-floor assembly
Y-9204-4-B(485)	01-0020-72	730313P	Exhaust from paint hood
Y-9204-4-B(486)	01-0020-72	730313P	Filtering exhaust from paint booths
Y-9204-4-B(488)	01-0020-72	730313P	Laboratory hoods, first floor
Y-9204-4-B(489)	01-0020-72	730313P	Laboratory hoods, reclamation area
Y-9204-4-B(490)	01-0020-72	730313P	Assembly process, first floor
Y-9204-4-B(491)	01-0020-72	730313P	Assembly process, first floor
Y-9204-4-D(01)	—	730317P	Exhaust hood
Y-9206-B(013)	01-0020-03	731689P	South stack, incinerator
Y-9206-B(015)	01-0020-03	731689P	West stack
Y-9206-B(016)	01-0020-03	731689P	Dissolving hood
Y-9206-B(017)	01-0020-03	731689P	Steam cleaning hoods
Y-9206-B(115)	01-0020-03	731689P	Reduction fluid bed
Y-9206-B(135)	01-0020-03	731689P	Air emission control scrubber stack
Y-9206-B(136)	01-0020-03	731689P	Air emission control consolidated stack
Y-9206-B(208)	01-0020-03	731689P	Conversion fluid bed
Y-9206-B(209)	01-0020-03	731689P	HF purge vent
Y-9206-B(210)	01-0020-03	731689P	Chemical makeup area
Y-9206-B(211)	01-0020-03	731689P	Hoods 29 and 30
Y-9206-B(212)	01-0020-03	731689P	Dry vacuum system
Y-9206-C(01)	01-1020-24	730316P	Classified
Y-9206-C(02)	01-1020-24	730316P	Classified
Y-9206-E (NEW)	01-1020-24	730316P	Classified
Y-9212-B(01)	01-0020-02	730301P	U metal drying and briquetting process
Y-9212-B(02)	01-0020-02	730301P	Exhaust from chip washing and drying
Y-9212-B(03)	01-0020-02	730301P	E-wing machine shop
Y-9212-B(04)	01-0020-02	730301P	U metal and U metal alloy casting
Y-9212-F(01)	01-1020-49	730321P	Two deburr benches, hood exhaust, A-wing
Y-9212-F(02)	01-1020-49	730321P	Two deburr benches, hood exhaust, A-wing
Y-9212-F(03)	01-1020-49	730321P	Machining, hood exhaust, A-wing
Y-9212-F(04)	01-1020-49	730321P	Machining, hood exhaust, A-wing
Y-9212-F(05)	01-1020-49	730321P	Machining, hood exhaust, A-wing
Y-9215-A(01)	01-0020-37	731839P	Machine shop hood exhaust, M-wing
Y-9215-B(1)	01-1020-51	732125P	O-wing metal working operations
Y-9215-B(2)	01-1020-51	732125P	O-wing metal working operations
Y-9215-B(4)	01-1020-51	732125P	O-wing metal working operations
Y-9215-B(6)	01-1020-51	732125P	O-wing metal working operations
Y-9215-C(03)	01-1020-52	730323P	Vapor blaster/metal cleaner
Y-9215-C(10)	01-1020-52	730323P	Nickel plating, metal working exhaust
Y-9215-C(11)	01-1020-52	730323P	Exhaust

Table C.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source description
Y-9215-C(17)	01-1020-52	730323P	Rolling mill
Y-9215-C(19)	01-1020-52	730323P	Electric annealing oven
Y-9401-2-A(205)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(220)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(221)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(222)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(223)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(224)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(225)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(226)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(227)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(228)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(229)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(230)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(231)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(232)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(233)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(234)	01-0020-88	730286P	Plating equipment
Y-9401-2-A(235)	01-0020-88	730286P	Plating equipment
Y-9720-32-A(435)	01-1020-99	9332821	Classified paper incinerator
Y-9811-1-A(1)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(2)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A(3)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A-(4)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A-(5)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A-(6)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)
Y-9811-1-A-(7)	01-1020-95	731997P	Waste oil/storage bulk storage facility (OD-7)

Table C.2. ORNL air permits

ORNL source number	Emission source reference number	Permit number	Source description	Permit type
X-2519-1/5	73-0112-03,33,34	030284P	Five boilers and ash system	Operation
X-2522-TlA	73-0112-10		No. 2 fuel oil storage tank	Application
X-2522-TlA	73-0112-10	024114P	No. 2 fuel oil storage tank	Operation
X-2525-01	73-0112-14	030835P	Degreaser (perchloroethylene)	Operation
X-2525-6	73-0112-95	027257P	Machine shop	Operation
X-2525-SV11	73-0112-49		Electroplating shop	Application
X-2525-SV11	73-0112-49	024151P	Electroplating shop	Operation
X-2525-SV4	73-0112-38	031062P	Six wet and three dry grinders	Operation
X-2525-SV8	73-0112-62		Spray booth and oven	Application
X-2525-SV8	73-0112-62	024949P	Spray booth and oven	Operation
X-2547-01	73-0112-27	028439P	Spray booth	Operation
X-3039			Off-gas and hot cell ventilation	Application
X-3039	73-0112-93	035494P	Off-gas and hot cell ventilation	Operation
X-3500-SV12	73-0112-73	036689P	Electric belt furnace	Operation
X-3502-01	73-0112-05,06,07	030881P	Spray booths #1, #2, and #3	Operation
X-3502-09	73-0112-94	027194P	Hood-gluing	Operation
X-3502-1	73-0112-05,06,07		Manipulator boot shop	Application
X-3502-SV1	73-0112-39	023808P	Oven, curing	Operation
X-3502-SV2	73-0112-40	023807P	Oven, tempering	Operation
X-3502-SV4	73-0112-30	036053P	Cyclone and carpenter shop	Operation
X-3544-SV1	73-0112-70	730468P	Process Waste Treatment Plant	Operation
X-3587-SV1	73-0112-56	029830P	Printed circuit-board facility	Operation
X-3608-01	73-0112-37	730489P	NRWTP air stripper column	Operation
X-4508-SV8	73-0112-61	732645P	Acid etching process	Operation
X-4508-SV9			Sand blaster	Application
X-4508-SV9	73-0112-55	024306P	Sand blaster	Operation
X-6010-00	73-0112-85	025282P	Oak Ridge Electron Linear Accelerator	Operation
X-7002-05	73-0112-08		Paint spray booth	Application
X-7002-05	73-0112-08	030980P	Spray booth	Operation
X-7005-00	73-0112-45	037516P	Lead shop—machining operations	Operation
X-7005-3/7			Five lead-melting furnaces	Application
X-7007-1/2	73-0112-09	030824P	Spray booth and cleaning booth	Operation
X-7007-1/2/3	73-0112-09		Spray booth and cleaning booth	Application
X-7021-00			Sandblaster	Application
X-7021-00	73-0112-58	024307P	Grinding shop	Operation
X-7057-SV1	73-0112-76	030101P	Sand blaster	Operation
X-7069-T1	73-0112-60 NSPS	730836P	Gasoline storage tank	Operation
X-7600-01	73-0112-20	017930P	Nuclear fuel reprocessing	Operation
X-7602-01	73-0112-24	027090P	Boiler, hot water	Operation
X-7603-01			Boiler	Application
X-7603-01	73-0112-25	035134F	Steam boiler	Operation
X-7667-0	73-0112-0067-5	73-0112-0067-5	Chemical detonation facility	Open burning
X-7830-SV1	73-0112-71	731010P	Liquid Waste Solidification Project	Operation

Table C.2 (continued)

ORNL source number	Emission source reference number	Permit number	Source description	Permit type
X-7911-00	73-0112-82	034381P	HFIR, REDC 7920 and 7930	Operation
X-7934-SV2	73-0112-53		Silver-recovery system	Application
X-7934-SV2	73-0112-53	024912P	Silver-recovery system	Operation
X-7935-SV1	73-0112-78	027393P	Equipment cleaning facility	Operation
X-FE	73-0112-97	029660P	Fugitive emission source	Operation
X-FLC	73-0112-99	034960P	Fluorescent lamp disposers	Operation

Table C.3. K-25 Site air permits

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K1004L	73-0106-35	012503P	Main Vent of Development Facility	Operating
K1004TWESTNOVEN	73-0106-96	024301P	Fiber and Polymer Matrix Composites Curing Oven	Operating
K1004TSOUTHOVEN	73-1106-01	024304P	Fiber and Polymer Matrix Composites Curing Oven	Operating
K1004THOOD	73-1106-04	024498P	Hood Evacuates Fumes from Mixing Epoxy Resin and Hardener	Operating
K1004TWIND3	73-1106-28	029901P	Fiber Winding Spools With Epoxy Dip	Operating
K1004TWIND2	73-1106-28	029901P	Fiber Winding Spools With Epoxy Dip	Operating
K1004TWIND4	73-1106-28	029901P	Fiber Winding Spools With Epoxy Dip	Operating
K1004TWIND1	73-1106-28	029901P	Fiber Winding Spools With Epoxy Dip	Operating
K1024FT1	73-0106-18	025655P	Filter Test Facility	Operating
K1037AVLISLCDEV	73-0106-69	029897P	Expansion Lab C Spray Coating W Exhaust Filters	Operating
K1037AVLISOOVEN	73-0106-73	029900P	Electric Oxidation Oven	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Materials Test Unit (MTU)	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Vacuum System Vents	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Materials Handling Development Module (MHDM)	Operating
K1037AVLISEXLAB	73-0106-68	031404P	Electron Beam One (EB-1)	Operating
K1037AVLISLGB	73-0106-77	032345P	Grit Blast Facility with Baghouse	Operating
K1037AVLISQOVEN	73-0106-79	034645P	Quincy Oven	Operating
K1037AVLISGOVEN	73-0106-80	034646P	Grieve Oven TB-500 Electric	Operating
K1037AVLISFURN	73-0106-81	034647P	Huppert Furnace	Operating
K1037MLBH	73-0106-84	035867P	Mechanical Lab—Shaping Graphite and Metal Parts	Operating
K1037AVLISSSB	73-0106-85	035868P	Small Sand Blaster	Operating
K1037AVLISLAB	73-1106-35	932953P	AVLIS Lab - metallothermic reduction unit, chlorinator, and oxide cell	Permit to construct
K1037AVLISPRODCON	73-1106-36	933170P	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
K1098FSB1	73-0106-13	034231P	Sand Blast Facility with Baghouse and Grit Recycle	Operating
K1200SITF	73-0106-61	017338P	System Interface Test Facility seven Vacuum Pumps	Operating
K1200CVTF	73-0106-62	017339P	Centrifuge Verification Test Facility ten Vacuum Pumps	Operating
K1200A123	73-0106-56	019608P	Purge Evacuation, Feed, and Withdrawal 13 Vacuum Pumps	Operating
K1200NBAYOVEN	73-0106-92	024272P	North Bay Oven Cures Fiber and Polymeric Matrix Composites	Operating
K1200FAE1	73-0106-86	029192P	Isotope Separating Process	Operating
K1200CENTERBAY	73-0106-87	732346P	Two Hoods Vent Mixing Epoxy Resins, Coating Fibers, Winding Fibers	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
K1401275029PL	73-0106-38	012506P	Plastic Shop Curing Oven	Operating
K1401121659	73-0106-09	016306P	1,1,1-Trichloroethane Degreaser	Operating
K1401MSMC1	73-0106-32	017337P	Motor Curing Oven	Operating
K1401OOOOVENNE2	73-0106-89	028424P	Electric Oven to Bake out Residual Organics from Metal Parts	Operating
K1401JIGANDFIXT	73-0106-71	029898P	Vacuum Exhaust for Parts Fabrication in the Jig and Fixture Shop	Operating

Table C.3 (continued)

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K1401PLS1,4,6	73-0106-72	029899P	Ovens 1, 4, and 6 Used for Curing Plastic Parts in the Plastic Shop	Operating
K1401CARPENTERSHOP	73-1106-40	032930P	Miscellaneous wood and acrylic plastic working operations with cyclone control	Operating
K1401HCLE	73-0106-28	035840P	Hydrochloric Acid Tank	Operating
K25BULBCRUSHER	73-1106-43	934193P	Flourescent Lamp Disposers with Fabric/Carbon Filters	Operating
K1414RG	73-0106-28	016312P	Gasoline Storage Tank	Operating
K1414UNLGAS	73-1106-39	035063P	20,000 Gal Unleaded Gasoline Underground Storage Tank	Operating
K1414UG	73-0106-28	037113P	Methanol, unleaded gasoline storage tank	Operating
K1200CPL1	73-0106-58	017051P	Vent for aqueous spray chamber, ultrasonic cleaner, solvent	Operating
K1200CPL	73-0106-54	017055P	Aqueous spray, ultrasonic cleaner, solvent degreaser	Operating
K1420PHILLIPSVA	73-0106-70	023798P	Phillips Vapor Degreaser Perchloroethylene	Operating
K1420DISASSEMBL	73-0106-74	032344P	Disassembly Stand for Dismantling Parts	Operating
K1420A1	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	032449I	TSCA Incinerator	Operating
K1435CTANKFARM	73-0106-75	024105P	Tank Farm for Hazardous Liquid Wastes	Operating
K15012720FO	73-0106-28	016312P	K-1501 613,000-gal fuel oil tank	Operating
K15012810FO	73-0106-28	016312P	K-1501 15,228-gal fuel oil tank	Operating
K1501BOILER4	73-0106-04	029902F	Natural Gas Boiler	Operating
K1501BOILER7	73-0106-07	029902F	Gas/Oil Boiler	Operating
K1501SULFACID	73-0106-28	035840P	Sulfuric Acid Storage Tank	Operating
K1501BOILER8	73-0106-12	937114F	Gas/Oil Boiler	Permit to construct
K1501BOILER9	73-0106-12	937114F	Gas/Oil Boiler	Permit to construct
K1600TTFL	73-0106-59	017053P	Development Lab with two Hoods and one Small Oven	Operating
K1652FECS	73-1106-42	733774P	Fire extinquisher charging station	Operating
K-25-B-1	73-0106-19	016309P	Heat Exchange Medium Freon for Plant	Operating
K291	73-0106-63	015097P	Wet Air Evacuation System	Operating
K4029PC	73-0106-42	012660P	Gaseous Diffusion Purge Cascade	Operating
K602WAP	73-0106-93	024297P	Evacuation Wet Air Pumps or Air Jets	Operating
K60212543LO	73-0106-23	016310P	Lube Oil Tank	Operating
K60222540LO	73-0106-23	016310P	Lube Oil Tank	Operating
K60232542LO	73-0106-23	016310P	Lube Oil Tank	Operating
K60242541LO	73-0106-23	016310P	Lube Oil Tank	Operating
K60252545LO	73-0106-23	016310P	Lube Oil Tank	Operating
K60262544LO	73-0106-23	016310P	Lube Oil Tank	Operating
K704316MO	73-0106-24	034218P	Mineral Oil Tank	Operating
K7322140MO	73-0106-24	034218P	Mineral Oil Tank	Operating
K-7322135MO	73-0106-24	034218P	Mineral Oil Tank	Operating

Table C.3 (continued)

K-25 source number	Emission source reference number	Permit number	Source description	Permit type
K7622427MO	73-0106-24	034218P	Mineral Oil Tank	Operating
K7622428MO	73-0106-24	034218P	Mineral Oil Tank	Operating
K7922423MO	73-0106-24	034218P	Mineral Oil Tank	Operating
K7922431MO	73-0106-24	034218P	Mineral Oil Tank	Operating
K892LIMESILO	73-1106-08	025120P	Lime Silo	Operating
K894SULFACID	73-0106-28	035840P	Sulfuric Acid Storage Tank	Operating
K902JET	73-0106-93	024298P	Exhaust Jet	Operating
K902WAP	73-0106-93	024298P	Evacuation Wet Air Pumps	Operating
K90212310LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90212318LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90222321LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90222319LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90222320LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90222311LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90232312LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90232322LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90232323LO	73-0106-23	016310P	Lube Oil Tank	Operating
K9023324470FREON	73-0106-28	035840P	Freon R-114 Storage Tank	Operating
K9023324383	73-0106-28	035840P	Freon Storage Tank	Operating
K9023324469FREON	73-0106-28	035840P	Freon R-114 Storage Tank	Operating
K90242325LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90242324LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90242313LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90252314LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90252378LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90252379LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90262381LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90262380LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90262315LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90272383LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90272316LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90272382LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90282384LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90282317LO	73-0106-23	016310P	Lube Oil Tank	Operating
K90282385LO	73-0106-23	016310	Lube Oil Tank	Operating

Appendix D: Drinking Water Standards

Table D.1. Reference standards for water

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish & aquatic life[c]	Tennessee water quality criteria—recreation[c]	4% of DOE DCG[d]	DOE DCG
Anions (mg/L)							
Chloride		250					
Fluoride	4.0	2.0					
Nitrate	10						
Nitrite	1.0						
Sulfate, as SO_4		250					
Base/neutral/acid extractable organics (µg/L)							
1,2-Dichlorobenzene	600				17,000		
1,3-Dichlorobenzene					2,600		
1,4-Dichlorobenzene	75	5.0	75		2,600		
2,4-Dinitrophenol					1,400		
2,4-Dinitrotoluene					42		
2,4,6-Trichlorophenol					6.5		
2-Methyl-4,6-Dinitrophenol					765		
3,4-Benzofluoranthene					0.3		
Benzo(k)fluoranthene					0.3		
Acenaphthylene					0.3		
Anthracene					0.03		
Benzo(a)anthracene					0.3		
Benzo(a)pyrene					0.3		
bis-(2-chloroethyl)ether					14		
bis-(2-ethylhexyl)phthalate					59		
Di-n-butyl phthalate					12,000		
Diethyl phthalate					120,000		
Dimethyl phthalate					2,900,000		
Fluoranthene					54		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish & aquatic life[c]	Tennessee water quality criteria—recreation[c]	4% of DOE DCG[d]	DOE DCG
Fluorene					0.03		
Hexachlorobenzene					0.007		
Hexachloroethane					89		
Nitrobenzene					1,900		
Pentachlorophenol	1.0			20			
Phenathrene					0.03		
Pyrene					0.03		
Field measurements							
Dissolved oxygen, mg/L				5.0			
Temperature, °C			30.5		30.5		
Turbidity, JTU[e]	1.0						
pH, standard units		(6.5, 8.5)	(6.0, 9.0)	(6.5, 8,5)	(6.0, 9.0)		
Metals (mg/L)							
Aluminum		0.2					
Antimony					4.31		
Arsenic	0.05		0.05	0.36			
Barium	2.0						
Beryllium					0.0013		
Cadmium	0.005		0.01	0.004			
Chromium	0.1		0.05	0.016	670		
Copper	1.3[f]	1.0		0.018			
Cyanide				0.022			
Iron		0.3					
Lead	0.015[f]		0.05	0.082			
Manganese		0.05					
Mercury	0.002		0.002	0.0024	0.00015		
Nickel				1.4	4.6		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish & aquatic life[c]	Tennessee water quality criteria—recreation[c]	4% of DOE DCG[d]	DOE DCG
Selenium	0.05		0.01	0.02			
Silver		0.1	0.05	0.004			
Zinc		5.0		0.117			
			Others				
Asbestos (fibers/L)	7,000,000						
Coliform Bacteria (ml)	0.01						
Color (color units)		15					
Cyanide (mg/L)				0.022			
Odor (T.O.N.)		3					
Total dissolved solids, mg/L		500	500				
			Pesticides/herbicides/PCBs (μg/L)				
2,3,7,8-TCDD (Dioxin)					0.000001		
2,4-D	70						
2,4,5-TP (Silvex)	50						
4,4'-DDT				1.1	0.006		
4,4'-DDE					0.006		
4,4'-DDD					0.008		
Alachlor	2						
Aldicarb sulfoxide	4						
Aldrin				3	0.014		
Atrazine	3						
Carbofuran	40						
Chlordane	2			2.4	0.006		
Dalapon	200						
a-Endosulfan				0.22	2		
b-Endosulfan				0.22	2		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish & aquatic life[c]	Tennessee water quality criteria—recreation[c]	4% of DOE DCG[d]	DOE DCG
Pesticides/herbicides/PCBs (μg/L)							
Endrin				0.18			
Ethylene dibromide	0.05						
Heptachlor	0.4			0.52	0.002		
Heptachlor epoxide	0.2			0.52	0.001		
g-BHC (Lindane)	0.2			2.0	0.63		
Methoxychlor	40						
PCB-1242					0.0005		
PCB-1254					0.0005		
PCB-1221					0.0005		
PCB-1232					0.0005		
PCB-1248					0.0005		
PCB-1260					0.0005		
PCB-1016					0.0005		
PCB, total	0.5				0.001		
Toxaphene	3.0			0.73	0.008		
Radionuclides (pCi/L)[g]							
Am-241						1.2	30
Bi-214						24,000	600,000
Cd-109						400	10,000
Ce-143						1,200	30,000
Co-60						200	5,000
Cr-51						4,000	100,000
Cs-137						120	3,000
Eu-155						4,000	100,000
Gross alpha	15						
Gross beta	50[h]						

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish & aquatic life[c]	Tennessee water quality criteria—recreation[c]	4% of DOE DCG[d]	DOE DCG
H-3	20,000					80,000	2,000,000
I-131						120	3,000
K-40						280	7,000
Np-237						1.2	30
Pa-234m						2,800	70,000
Pu-238						1.6	40
Pu-239/240						1.2	30
Ra-226	5.0					4	100
Ra-228	5.0					4	100
Ru-106						240	6,000
Tc-99						4,000	100,000
Th-228						16	400
Th-230						12	300
Th-232						2	50
Radionuclides (pCi/L)[g]							
Th-234						400	10,000
Thorium, natural						2	50
Total rad Sr	8.0					40	1,000
U-234						20	500
U-235						24	600
U-238						24	600
Uranium, natural						24	600
Uranium, total[i]						20	500
Volatile organics (μg/L)							
1,1,1-Trichloroethane	200		200		170,000		
1,1-Dichloroethene	7.0		7.0		32		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish & aquatic life[c]	Tennessee water quality criteria—recreation[c]	4% of DOE DCG[d]	DOE DCG
1,1,2-Trichloroethane					420		
1,1,2,2-Tetrachloroethane					110		
1,2-Dichloroethane	5.0		5.0		990		
1,2-Dichloroethene	70						
cis-1,2-Dichloroethene	70						
trans-1,2-Dichloroethene	100						
1,2-Dichloropropane	5.0						
cis-1,3-Dichloropropane					1,700		
trans-1,2-Dichloropropane					1,700		
Acrolein					780		
Acrylonitrile					6.7		
Benzene	5.0		5.0		710		
Bromodichloromethane	100[f]						
Bromoform	100[f]				4,700		
Carbon tetrachloride	5.0		5.0		44		
Chlorobenzene	100						
Chloroethane	200						
Chloroform	100[f]				4,700		
Dibromochloromethane	100[f]				4,700		
Ethylbenzene	700				29,000		
Methylene chloride					16,000		
Styrene	100						
Tetrachloroethene	5.0				88		
Toluene	1,000				300,000		

Table D.1 (continued)

Parameter	All parameters					Radionuclides only	
	National primary drinking water[a]	National secondary drinking water[b]	Tennessee water quality criteria—domestic water supply[c]	Tennessee water quality criteria—fish & aquatic life[c]	Tennessee water quality criteria—recreation[c]	4% of DOE DCG[d]	DOE DCG
			Volatile organics (μg/L)				
Total Trihalomethanes	100				100		
Trichloroethene	5.0		5.0		807		
Vinyl chloride	2.0		2.0		5,250		
Xylene, total	10,000						

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[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] DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water. Four percent of the DOE DCG to represent the DOE criterion of 4 mrem effective dose equivalent from ingestion of drinking water.

[e] JTU an NTU are roughly equivalent in the range of 25 to 1000 JTU.

[f] Action level, which is applicable to community water systems and non-transient, non-community water systems.

[g] Only the radiounuclides that were sought at the Oak Ridge Reservation are listed.

[h] Regulatory guide for assessing compliance without further analysis.

[i] Minimum of uranium isotopes.

[j] 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(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
						Petroleum USTs			
9722-6	2312-U	1987	In use	550	Diesel	To be closed by 12/94	NA	NA	NA
9722-5	2313-U	1987	In use	550	Diesel	To be closed by 12/94	NA	NA	NA
9999-7	2316-U	1986	In use	550	Diesel	To be closed by 12/94	NA	NA	NA
9999-5	2320-U	1986	In use	550	Diesel	To be closed by 12/94	NA	NA	NA
9722-4	2333-U	1988	In use	550	Diesel	To be closed by 12/94	NA	NA	NA
9713	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)
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)
9754	2074-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)
9754	2075-U	1944	1979	1,000	Diesel	Removed 10/93	SI	SIR/CAP (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), SRS (2/94), SRS approval (3/94)
9754-1	1222-U	1968	1988	12,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRS (2/94), SRS approval (3/94)
9754-1	2068-U	1968	1980	1,000	Gasoline	Removed 2/90	EA/FPRR	SIR (3/91)	CAP (5/92), SRS (2/94), SRS approval (3/94)

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
9754-1	2082-U	1981	1988	8,000	Gasoline	Removed 12/89	EA	SIR (3/91)	CAP (5/92), SRS (2/94), SRS approval (3/94)
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)
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), SRS (4/94)
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	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	NA	NA
9212	2081-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	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	NA	NA
PRE	2315-U	1960	1988	64	Gasoline	Removed 11/89	ISCR	EAR/CAP (2/91)	OE/CAR (12/92)
9769	2330-U	1949	1988	5,000	No. 2 fuel oil	Inert filled 1988	NI	NA	NA
0962	2336-U	1981	1991	550	Gasoline	Removed 5/91	RIR	NA	NA
Buff. Mtn.	2337-U	1972	1990	250	Gasoline	Removed 3/90	IAR, ISCR SIR, SIR (1/92)	NA	NA
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	TBD	TBD	TBD

Table E.1 (continued)

Location	Tank identification number	Installation date	Out-of-service date	Capacity (gallons)	Contents	Status	Preliminary investigation(s)	Environmental assessment ( ) date to regulatory agency	Corrective action
SYDD	2063-U	1959	1989	130	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	NA	NA
SYDD	2328-U	1959	1989	475	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	NA	NA
SYDD	2329-U	1959	1989	475	Oil/solvent	Removed 7/89	IAR, ISCR/FPRR	NA	NA
						Hazardous Substance USTs			
9767-13	2102-U	1987	1992	7,500	Methanol solid	Removed 1/93	CR	NA	NA
9418-3	2072-U	1943	1960	45,000	Uranium oxide solid	Exempt	CR	NA	NA
Chst. Ridge	2129-U	1984	In use	240,000	Uranium oxide	Exempt	NA	NA	NA

Notes

BMR = baseline monitoring report
CAP = corrective action plan
CAR = corrective action report
CERCLA = conducted under CERCLA
CR = closure report
EA = environmental assessment
EAR = Environmental Assessment Report
FPRR = free product removal report
IAR = initial abatement report
ISCR = initial site characterization report
NA = Not applicable
NI = Not investigated
OE = overexcavation
RCRA = conducted under Resource Conservation and Recovery Act, Subtitle C
RIR = Release Investigation Report
TBD = to be determined
SIR = site investigation report
SRS = site ranking system
SSSR = site-specific standard request
SYDD = Salvage Yard Drum Deheader

Appendix F: Errata

Volume 1

Page	*For*	*Read*
2.5, col. 2, line 10	1.4 mrem (0.014 mSv)	1.3 mrem (0.013 mSv)
2-5, col. 2, line 14	1.4 mrem	1.3 mrem
2-6, col. 1, line 2	45 person-rem (0.45 person-Sv)	21 person-rem (0.21 person-Sv)
2-6, col. 1, line 6	45 person-rem	21 person rem
2-6, col. 2, line 7	0.6 mrem (0.006 mSv)	0.2 mrem (0.002 mSv)
2-6, col. 2, line 10	89%	58%
2-6, col. 2, line 12	7%	27%
2-6, col. 2, line 12	3%	4%
2-6, col. 2, line 16	29 person-rem (0.29 person-Sv)	7 person-rem (0.07 person-Sv)
2-6, col. 2, line 16	67%	34%
2-7, Table 2.2, K-25 Site	0.6	0.2
2-7, Table 2.2, K-25 Site	0.2	0.04
2-7, Table 2.2, ORR	0.2	1.3
2-7, Table 2.3, K-25 Site	29	7
2-7, Table 2.3, ORR	43	21
2-7, col. 2, line 10	1.4 mrem/year	1.3 mrem/year
2-7, col. 2, line 18	smaller than	about the same as
2-8, col. 1, line 1	0.6 mrem/year	0.2 mrem/year
2-10, col. 2, line 34	1.25 lb	12.5 lb
2-12, col. 2, line 6	Outfalls 010 and 057	K-1700 Outfall 001 and K1203 Outfall 005
2-12, col. 2, line 8	Outfall 034	K-901-A Outfall 007
2-12, col. 2, line 10	Outfall 057	K-1203 Outfall 005
2-12, col. 2, line 11	Outfall 010	K-1700 Outfall 001
2-12, col. 2, line 13	Outfall 057	K-1203 Outfall 005
2-12, col. 2, line 14	Outfall 010	K-1700 Outfall 001
2-12, col. 2, line 30	1.4 mrem	1.3 mrem
2-12, Table 2.5, K-25 Site	0.6	0.2
2-12, Table 2.5, ORR	1.4	1.3
2-13, col. 2, line 24	1.4 mrem	1.3 mrem
2-13, col. 2, line 29	43 person -rem	21 person-rem
2-13, col. 2, line 30	0.02%	0.01%
2-13, Table 2.6, All air, 1992	1.4	1.3
10-4, col. 2, line 30	QA/QA	QA/QC

Page 3-17, Table 3.5:

Table 3.5. Total radionuclide emissions during normal operations from the K-25 Site TSCA Incinerator for 1992

Radionuclide	Emissions (CI)
^{237}Np	9.88E–5
^{238}Pu	9.34E–6
^{239}Pu	6.51E–6
^{99}Tc	–6.68E–3
^{228}Th	1.54E–3
^{230}Th	6.05E–5
^{232}Th	2.80E–5
^{234}Th	–5.81E–2
^{137}Cs	–2.02E–4
^{234m}Pa	3.67E–1
^{144}Ce	1.23E–6
^{40}K	1.01E–3
^{106}Ru	4.36E–4
Total uranium	6.01E–3
^{234}U	2.29E–3
^{235}U	9.21E–5
^{238}U	3.63E–3

Page 3-18, Figures 3.11 and 3.12:

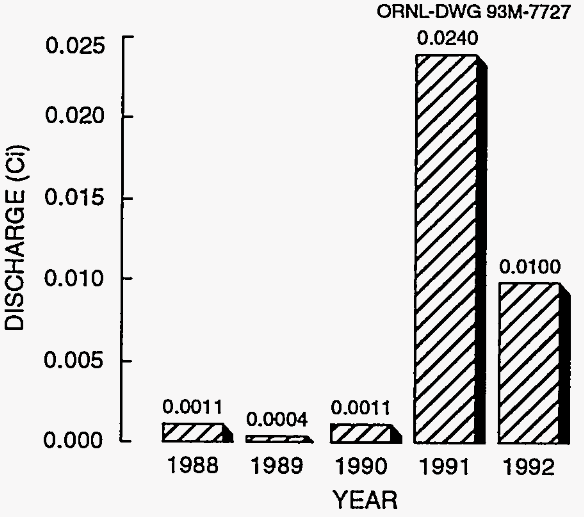

Fig. 3.11. Total curie discharges of uranium from the K-25 Site to the atmosphere, 1988–1992.

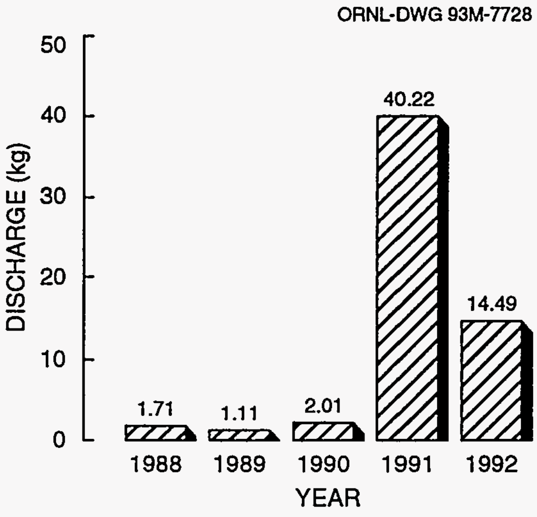

Fig. 3.12. Total kilograms of uranium discharged from the K-25 Site to the atmosphere, 1988–1992.

Volume 2

Page	*For*	*Read*
4-4, Table 4.2, Technetium-99		
Percentage of DCG	0.0004	0.45
4-5, Table 4.3, Parameter	Molydenum	Molybdenum
4-6, Table 4.4, Technetium-99		
Percentage of DCG	0	0.27
4-8, Table 4.7, Technetium-99	(pCi/L)	(pCi/mL)
Percentage of DCG	0.00001	0.010
4-12, Table 4.11, Parameter	Total Kheldahl nitrogen	Total Kjeldahl nitrogen
4-16, Table 4.15, Technetium-99		
Percentage of DCG	–0.000003	–0.003
4-16, Table 4.16, Technetium-99		
Percentage of DCG	–0.00002	–0.02
4-17, Table 4.17, Technetium-99		
Percentage of DCG	0.00000	–0.001
4-21, Table 4.22, Technetium-99		
Percentage of DCG	*a*	0.012
4-28, Table 4.32, Parameter	Sufactants, (MBAS)	Surfactants (MBAS)
4-29, Table 4.33, Technetium-99	(pCi/L)	(pCi/mL)
Percentage of DCG	0.0002	0.17
4-31, Table 4.35, Technetium-99	(pCi/L)	(pCi/mL)
Percentage of DCG	0.0001	0.10
4-33, Table 4.37, Technetium-99		
Percentage of DCG	0.000002	0.002
4-35, Table 4.39, Technetium-99		
Percentage of DCG	0.00003	0.03
4-37, Table 4.41, Technetium-99		
Percentage of DCG	0.0002	0.161
	Throium, total	Thorium, total
4-39, Table 4.44, Technetium-99	0.00003	0.03
10-14, Table 10.12, title	organics	inorganics
10-14, Table 10.12		
3rd quarter laboratory score (%)	29.9	92.9
10-14, Table 10.13, title	inorganics	organics
10-15, Table 10.14		
Insecticides	Endrine	Endrin
Trihalomethanes	Chlorodieromomethane	Chlorodibromomethane
10-34, Table 10.23		
Chromium (2/92)		
Sample 1 performance limits	0.0619–0.868	0.0619–0.0868
10-43, Table 10.26, Nutrients	Orthophosphate	Orthophosphate as P

10-46, Table 10.29, after "Performance Eval-B (Water, pCi/L)," a cut-in heading is missing between "Gross beta" and "^{133}Ba." It should read "Additional EMSL Program water samples."

Glossary

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.

activity — See radioactivity.

AEC — See Atomic Energy Commission.

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.

Appendix IX — List of constituents specified by Appendix IX of the Code of Federal Regulations, Title 40, Part 264. Analyses for Appendix IX constituents are required by the Resource Conservation and Recovery Act under specified conditions.

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).

Automated sampler — A portable, microprocessor-controlled water sampler that utilizes a peristaltic pump for sample collection. The sampler may be used with a flowmeter to obtain a flow-proportional sample or without a flowmeter to obtain a time-proportional sample.

base/neutral and acid extractables (BNA) — A group of organic compounds analyzed as part of Appendix IX and 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.

bias — consistent underestimation or overestimation of the true value.

biomass — The weight of any specific or general kind of organic matter, usually expressed per area or volume.

bioreactor — A container filled with microbial organisms that degrade substances (such as oil) as the substance passes through the container.

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.

blind blank — A sample container of deionized water sent to a laboratory under an alias name as a quality control check.

blind replicate — A second sample taken from the same well at the same time as the primary sample, assigned an alias well name, and sent to a laboratory for analysis (as an unknown to the analyst).

blind sample — A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

calcareous — Resembling, containing, or composed of calcium carbonate.

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.

chemical speciation — The occurrence of chemical elements in different forms or species (e.g., elemental ionic, complexed) depending on environmental conditions.

chlorocarbons — Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethylene, 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.

Ci — See curie.

closure — Control of a hazardous waste management facility under RCRA requirements.

COD — See chemical oxygen demand.

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.

control chart — A statistical tool used to demonstrate whether or not a specific process is within acceptable standards or limits of performance.

control limits — A statistical tool used to define the bounds of virtually all values produced by a system in statistical control.

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.

counter — A general designation applied to radiation detection instruments or survey meters that detect and measure radiation.

counting geometry — A well-defined sample size and shape for which a counting system has been calibrated.

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 (μCi)** — 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.

2,4-D — 2,4-Dichlorophenoxyacetic acid.

D&D — decontamination and decommissioning.

daughter — A nuclide formed by the radioactive decay of a parent nuclide.

DCG — See derived concentration guide.

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 tetrachloroethylene and trichloroethylene.

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.

detector — Material or device (instrument) that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

diatoms — Unicellular or colonial algae of the class Bacillariophyceae, having siliceous cell walls with two overlapping, symmetrical parts. Diatoms represent the predominant periphyton (attached algae) in most water bodies and have been shown to be reliable indicators of water quality.

diatometer — Diatom collection equipment consisting of a series of microscope slides in a holder that is used to determine the amount of algae in a water system.

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.

DNAPL — See dense nonaqueous phase liquid.

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.

DWS — See drinking water standards.

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.

equipment blank — A sample container of deionized water that has been pumped through or has filled a sampling device (e.g., well pump bailer). Laboratory analysis of the blank can identify potential contaminants in water, sample container, or analytical equipment.

equipment rinse — Rinse of equipment with clean water to evaluate equipment decontamination.

eutrophication — Accelerated growth of organisms in a body of water caused by excess nutrients.

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.

fauna — The population of animals at a given area, environment, formation, or time span.

fecal coliform — The coliform group comprises all of the aerobic, non-spore-forming, rod-shaped bacteria. The test determines the presence or absence of coliform organisms.

field blank — A sample container of deionized water generated by filling the sample container at the sample location and that is treated as a groundwater sample.

flora — The population of plants at a given area, environment, formation, or time span.

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.

gas chromatographic volatile organic analyses (GC VOA) — An analytical technique detecting and quantifying volatile organic compounds in a sample by gas chromatography.

gas chromatograph/mass spectrometer volatile organics analyses (GCMS VOA) — An analytical technique for detecting and quantifying volatile organic compounds in a sample by gas chromatography/mass spectroscopy.

gas-flow proportional counter — A device or instrument that measures various alpha- and beta-emitting radionuclides.

Gaussian puff/plume model — A computer-simulated atmospheric dispersion of a release using a Gaussian (normal) statistical distribution to determine concentrations in air.

Geiger-Mueller (GM) counter — A highly sensitive, gas-filled radiation detector that operates at voltages sufficiently high to produce ionization. The counter is used primarily in the detection of gamma radiation and beta emission. It is named for Hans Geiger and W. Mueller, who invented it in 1928.

genotoxicology — The study of the effects of chemicals or radioactive contaminants on the genetics of individual animals or plants.

Geographic information system (GIS) — Computer-based system for storing, manipulating, and analyzing geographical information.

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.

HEPA — High-efficiency particulate air (filter).

herbaceous — Having little or no woody tissue.

heterotrophic — Organisms that obtain energy from the breakdown of existing organic matter; the opposite of autotrophic organisms.

high-purity germanium (HPGe) detector — A device that detects photon radiation by employing diffused junctions generated by application of a high voltage across a semiconductor material.

humic substances — A variety of complex organic molecules found in soils and water following the breakdown of leaves and other types of organic matter.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

hydrogeology — Hydrolic aspects of site geology.

hydrophobic — Not capable of uniting with or absorbing water.

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.

Isco sampler — A portable, microprocessor-controlled water sampler that uses a peristaltic pump for sample collection. The sampler may be used with a flowmeter to obtain a flow-proportional sample or without a flowmeter to obtain a time-proportional sample.

isopach map — A map showing the thickness of geologic units.

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).

K_d (equilibrium distribution coefficient) — The distribution coefficient that is the ratio of the contaminant concentration in sediments to the concentration of the contaminant in the water at equilibrium conditions. This method is used in modeling to determine the extent that a contaminant is adsorbed to sediments or desorbed to the surrounding water.

liquid scintillation counter — The combination of phosphor, photomultiplier tube, and associated circuits for counting light emissions produced in the phosphors.

lysimeters — A container that holds soil. A leachate collection system is located in the bottom of the container.

lower limit of detection (LLD) — The smallest concentration/amount of analyte that can be reliably detected in a sample at a 95% confidence level.

macroinvertebrates — A size-based classification used for a variety of insects and other small invertebrates; as defined by EPA, those organisms that are retained by a No. 30 (590 micron) U.S. Standard Sieve.

macrophyte — A plant that can be observed with the naked eye.

Marinelli beaker — A 1-L beaker molded to fit around a germanium or sodium iodide detector to optimize geometry.

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.

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.

mrem — The dose equivalent that is one-thousandth of a rem.

natural radiation — Radiation arising from cosmic and other naturally occurring radionuclide sources (such as radon) present in the environment.

nonroutine radioactive release — Unplanned or nonscheduled release of radioactivity to the environment.

nonstochastic effects — Biological effects in which the severity in affected individuals varies with the magnitude of the dose above a threshold.

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 grams per liter or nanograms per milliter.

perched groundwater — Unconfined groundwater separated from underlying groundwater by impermeable or nontransmissive material.

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.

planchet — A small, round, lipped, metal dish used to mount samples for radiological analyses.

point of compliance — A vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.

population dose commitment — See collective dose equivalent.

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.

pulse height analysis — A spectroscopy technique in which the voltage (height) of an electronic pulse from a detector is related to the energy of the detected radiation.

purge — To remove water prior to sampling, generally by pumping or bailing.

QA — See quality assurance.

QC — See quality control.

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.

quench — (a) The reduction of the signal from a liquid scintillation cocktail caused by chemical or color interferences; (b) a process by which a gas (usually a halogen) is added to a detector to inhibit avalanche ionizations.

rad — The unit of absorbed dose deposited in a volume of material.

radiation detection instruments — Devices that detect and record the characteristics of ionizing radiation.

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.

reagent — Any substance used in a chemical reaction to detect or measure another substance or to convert one substance into another by means of the reaction that it causes.

reagent blank — A control sample that is used to determine the background of each reagent or solvent used in a given method of analysis. They are composed of all constituents that will contact the sample except the sample itself.

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.

reforestation — The process of planting new trees on land once forested.

refractory — Not easily decomposed or broken down.

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 × 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.

resin — An organic polymer used as an ion-exchange material.

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.

rhizotron — A facility designed to hold soil for plant and root growth. Such facilities are used often in research and study projects.

roentgen — A unit of exposure from X or gamma rays. One roentgen equals 2.58×10^{-4} coulombs per kilogram of air.

rookery — A breeding place or colony of gregarious birds or animals.

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.

source — A point or object from which radiation or contamination emanates.

source check — A radioactive source with a known amount of radioactivity used to check the performance of the radiation detector instrument.

source term — Quantity of radioactivity released in a set period of time that is traceable to the starting point of an effluent stream or migration pathway.

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.

stochastic effects — Biological effects whose probability, rather than the severity, is a function of the magnitude of the radiation dose without threshold (i.e., stochastic effects are random in nature).

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.

Sv — See sievert.

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.

thermoluminescent dosimeter (TLD) — A device used to measure external gamma radiation.

TLD — See thermoluminescent dosimeter.

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 (H-3) — 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.

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.

vadose zone — Soil zone located above the water table.

variation — The divergence in the structural or functional characteristics of an organism from those considered typical of the group to which it belongs.

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, tetrachloroethylene, and trichloroethylene.

watershed — The region draining into a river, river system, or body of water.

weighting factor — A value used to calculate dose equivalents. It is tissue specific and represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue. The weighting factors used in this report are recommended by the ICRP (Publication 26).

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.

worldwide fallout — Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

zooplankton — Small animals that float in the water column (e.g., copepods).

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November 4, 1994

Distribution

OAK RIDGE RESERVATION ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1993

Enclosed for your information is a copy of the *Oak Ridge Reservation Annual Site Environmental Report for 1993*. This report includes the results from on-site and off-site environmental monitoring activities, describes actions to comply with environmental regulations, and discusses the overall environmental impacts of Department of Energy (DOE) activities on the surrounding area. This report is prepared annually for distribution to the public; news media; and local, State, and Federal agencies. The report was prepared for DOE by our contractor, Martin Marietta Energy Systems, Inc. (Energy Systems).

This year's report is somewhat different than previous reports. An attempt was made to streamline the document and provide more summary information. The detailed data has been incorporated into a separate report. Likewise, a summary "pamphlet" is available this year. Its purpose is to convey key environmental monitoring information to those without a technical background. Comments on this report are welcome. All comments will be considered during the writing of the next report. There is a comment sheet and mailing address at the end of the report.

The monitoring data and subsequent data analyses have been collected and performed in accordance with controlled operating procedures. Likewise, both DOE and Energy Systems personnel have reviewed this document for accuracy. To the best of my knowledge, this report accurately summarizes and discusses the results of the 1993 environmental monitoring program.

If you have any questions or desire additional information, please contact James Donnelly at 615-574-6260.

Sincerely,

Joe La Grone
Manager

Enclosure

Oak Ridge Reservation
Annual Site Environmental Report Summary for 1993
(ES/ESH-49)
Comment Sheet

This summary is the first such document published in addition to the annual site environmental report (ASER). The writers and production staff welcome comments, all of which will be considered during the writing of the next report summary. Please fill out this sheet and fax it to 615-574-6965 or mail it to the following address:

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Annual Site Environmental Report for 1993 (ES/ESH-47)
Comment Sheet

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