Volume 1

Oak Ridge

RESERVATION

ENVIRONMENTAL REPORT FOR 1997

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OAK RIDGE RESERVATION ENVIRONMENTAL REPORT FOR 1991

VOLUME 1: NARRATIVE, SUMMARY, AND CONCLUSIONS

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EXECUTIVE SUMMARY

SCOPE AND PURPOSE

The *Oak Ridge Reservation Environmental Report for 1991* is the 21st in a series that began in 1971. The report documents the annual results of a comprehensive program to estimate the impact of the U.S. Department of Energy (DOE) Oak Ridge operations upon human health and the environment. The report is organized into ten sections that address various aspects of effluent monitoring, environmental surveillance, dose assessment, waste management, and quality assurance. A compliance summary gives a synopsis of the status of each facility relative to applicable state and federal regulations.

Data are included for the following:

- **Oak Ridge Y-12 Plant,** which fabricates nuclear weapons components and conducts research and development (R&D) activities in support of national defense;
- **Oak Ridge National Laboratory** (ORNL), a center for R&D in the biomedical, environmental, and physical sciences; nuclear and engineering technologies; and advanced energy systems; and the
- **Oak Ridge K-25 Site,** where production operations in uranium enrichment have ceased but active R&D and waste-storage activities continue.

Effluent monitoring and environmental surveillance programs are intended to serve as effective indicators of contaminant releases and ambient contaminant concentrations that have the potential to result in adverse impacts to human health and the environment. These programs also provide data that are used to verify compliance with state and federal permits and regulations. An additional objective of these programs is to provide a standard for measuring the progress in implementing improved environmental management practices and for demonstrating the effectiveness of remedial actions that are designed to correct deficiencies in past practices.

Volume 1 presents narratives, summaries, and conclusions based on environmental monitoring at the three DOE installations and in the surrounding environs during 1991. Volume 1 is intended to be a "stand-alone" report about the Oak Ridge Reservation (ORR) and to provide the reader with an in-depth review of 1991 data. Volume 2 presents the detailed data summaries from which these conclusions have been drawn.

RADIATION DOSE TO THE PUBLIC

Every person in the United States is exposed to naturally occurring and man-made sources of ionizing radiation. As shown in Fig. 1, the average person receives approximately 300 mrem/year from natural sources, which include radon gas, terrestrial and cosmic radiations, and naturally occurring radionuclides that are inhaled and ingested. This person receives an additional 65 mrem/year from man-made sources, which include medical X-rays, nuclear medicine, consumer products, and nuclear technology. The actual exposure of any person to the above sources depends upon that person's location and lifestyle.

Radioactive materials released into air and water from operations on the ORR can add to the radiation exposures received by nearby residents. A hypothetical maximally exposed individual could receive about 2 mrem/year from radionuclides released to the atmosphere and about 0.4 mrem/year from radionuclides discharged to surface waters. A hypothetical person spending 250 h/year fishing on a small section of the Clinch River near an experiment that uses radioactive material could receive about

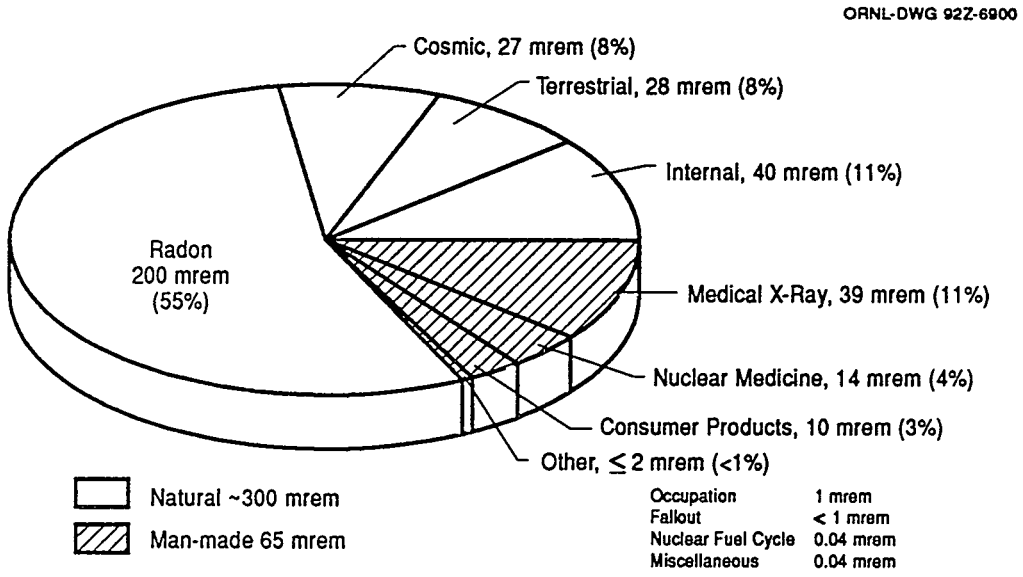

Fig. 1. Typical annual radiation doses from various sources. *Source:* National Council on Radiation Protection and Measurements, 1987, *Ionizing Radiation Exposure of the Population of the United States,* NCRP Report No. 93, Bethesda, Md.

2 mrem; a similar person fishing Poplar Creek, within the K-25 Site, could receive about 15 mrem.

The collective 50-year committed effective dose equivalent to the entire population (approximately 880,000 persons) residing within 80 km (50 miles) of the ORR during 1991 is estimated to be about 29 person-rem from releases of radionuclides from the ORR to the atmosphere. This dose equivalent is about 0.01% of the collective dose equivalent to the entire population from 1 year of exposure to natural radiation (see Fig. 2). A fatal cancer risk from reception of such doses can be calculated using a risk factor of 0.0005 per person-rem of effective dose equivalent, even though there is no conclusive evidence to support the existence of a risk from reception of such a low dose at such a low dose rate (i.e., the actual risk factor could be 0). The calculated fatal cancer risk associated with the 29-person-rem effective dose equivalent is about 0.01. This means that it would take, on average, about 100 years of such exposures for one fatal cancer to have a chance of developing in the entire population. The chance that an individual who receives the average effective dose equivalent (0.03 mrem) might develop a fatal cancer over a lifetime is 1 in 61,000,000.

AIRBORNE DISCHARGES, AMBIENT AIR, AND METEOROLOGICAL MEASUREMENTS

Permitting Status

The Tennessee Department of Environment and Conservation (TDEC) has issued 866 permits for emission sources for the three Oak Ridge installations.

Radioactive Discharges to the Atmosphere

During 1991, 25,000 Ci of radionuclides were released to the atmosphere from Oak Ridge installations. The differences from year to year can be accounted for almost totally by variations in tritium and releases of the inert gases xenon and krypton. The total curie discharge of each radionuclide that was quantified is shown in Sect. 3.

Uranium is the primary radioactive element released from the Y-12 Plant. Uranium emissions have shown a gradual decrease in recent years at the plant. The lowest curie discharge from the Y-12 Plant in the last 5 years was recorded in 1991. This decrease in 1991 reflects a reduction in Y-12 Plant process activities, continued improvements in

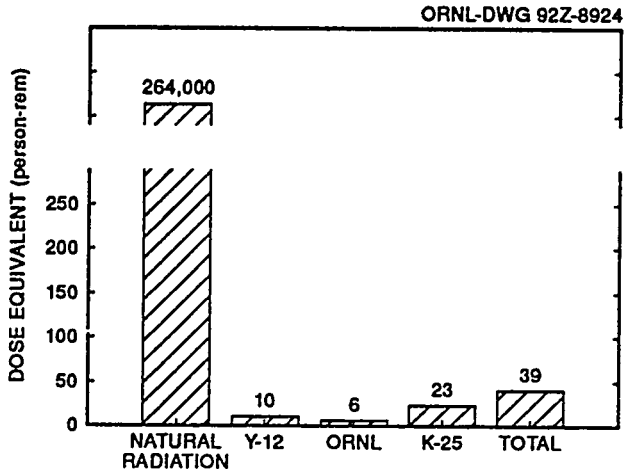

Fig. 2. The collective effective dose equivalent of the entire population within 80 km (50 miles) of the three installations.

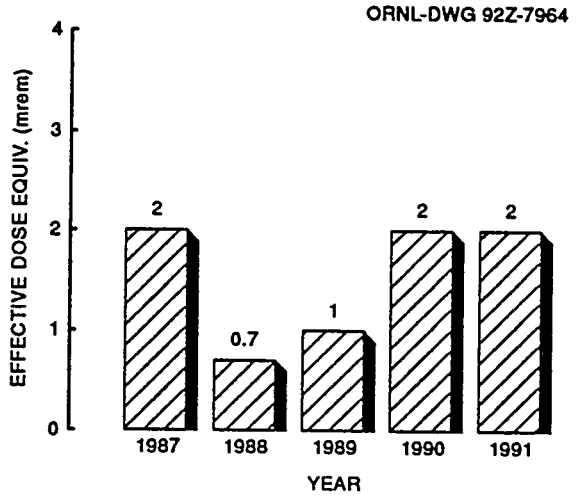

Fig. 3. Estimated maximum effective dose equivalents from airborne emissions from ORR.

administrative controls of the process activities still operating, and recent improvements in contamination control throughout the Y-12 Plant.

Radioactive airborne emissions from ORNL showed a reduction of noble gases to 10% of the previous year. This is because the Laboratory is no longer the source of ^{85}Kr for commercial use. Iodine emissions increased in 1991 concommitant with increased operations at the High Flux Isotope Reactor (HFIR). Tritium, which accounts for 94% of the estimated airborne dose from ORNL shows an elevation over 1990. This increased estimate is due at least partly to improved sampling systems.

Airborne radioactive emissions from the K-25 Site increased due to increased operations of the TSCA incinerator. Although there is an increase in emissions, the largest contributors, uranium and technetium, were well within the acceptable guidelines outlined in the application for the approval to construct the TSCA incinerator. Also, the effective dose equivalents from the K-25 Site and the ORR were well below the NESHAP regulatory limit of 10 mrem.

Discharges, as well as meteorological data, are input into dose models to predict the radiation dose to the maximally exposed individual (Fig. 3) and to the population within 80 km (50 miles) of the DOE Oak Ridge facilities (see Fig. 2).

Radionuclide Concentrations in Air

Atmospheric radionuclide concentrations occurring in the general environment around the ORR, and the general region are monitored continuously or sampled periodically by an air-monitoring network. The reservation perimeter air monitors assess the impact of the entire ORR on air quality. The remote air monitors provide information about reference concentrations of isotopes and gross parameters for the region.

Measurements were taken for concentrations of 15 radioactivity parameters. Data analyses and summaries are presented in Sect. 3.

Analysis of the ORR perimeter air-sampling data shows that operations on the ORR are very slightly increasing local airborne concentrations of radionuclides. These range from less than 0.01% to 0.089% of the derived concentration guides (DCGs) for the network averages. No significant changes in the concentrations of these radionuclides were detected between 1990 and 1991 for the remote stations. Therefore, based on these data, ORR operations are having a slight impact on local air

quality but are not measurably impacting the regional air quality. The local impact is well below the DCG.

WATERBORNE DISCHARGES AND SURFACE WATER MONITORING

Each of the Oak Ridge installations has a National Pollutant Discharge Elimination System (NPDES) permit. More than 400 NPDES stations were sampled, requiring more than 65,000 water analyses. During 1991, the Y-12 Plant was 98.0% in compliance with NPDES standards. ORNL was 98% in compliance, and the K-25 Site was 99.9% in compliance.

Radionuclide Discharges to Surface Streams

The ambient surface water areas monitored by the three installations include the Tennessee and Clinch rivers, White Oak Creek, Bear Creek, East Fork Poplar Creek, and Poplar Creek, all of which could be affected by operations at the DOE installations. Program descriptions and results are presented in Sect. 4.

At the Y-12 Plant, ORNL, and the K-25 Site, radiological effluents were well within limits at all effluent monitoring locations. Radionuclides are discharged to the Clinch River via White Oak Creek for ORNL and Poplar Creek for the Y-12 Plant and K-25 Site. Factors that may be affecting the discharge of radionuclides to the Clinch River are currently under investigation as part of the Environmental Restoration Program. The Gallaher water plant is the closest drinking water source downstream of ORNL. Figure 4 shows the 5-year trend of maximum calculated 50-year committed effective dose equivalent from drinking water at the Gallaher water plant monitoring station.

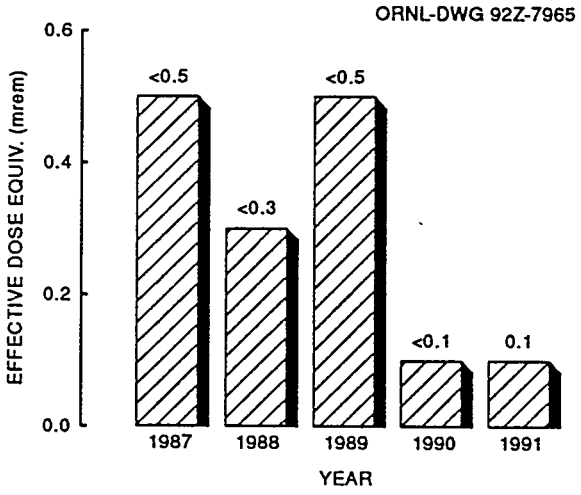

Fig. 4. Maximum calculated 50-year committed effective dose equivalent from drinking water from the Gallaher water plant.

GROUNDWATER MONITORING

Groundwater monitoring has historically been conducted at seven land-based waste disposal sites at the Y-12 Plant per Resource Conservation and Recovery Act (RCRA) interim status requirements. Groundwater monitoring at five of the sites has detected volatile organics, nitrates, heavy metals, and radioactivity at levels that exceed applicable standards. The focus of the assessment monitoring program is to gather data to define the contaminants' migration rates and their concentrations and to better define contaminant plume boundaries. Although it is too early to quantify the rates and extent of migration, data indicate that contamination remains relatively close to its source. For instance at the S-3 Pond near the Y-12 Plant, the highest concentrations are within 150 m (500 ft) of the site; nitrate, the most widespread groundwater contaminant, has been detected in wells as far as 920 m (3000 ft) southwest. Unlike most other groundwater contaminants, nitrate moves relatively unimpeded with groundwater and remains chemically and physically stable during transport. The limits of the nitrate plume may therefore define the maximum extent of migration.

At ORNL, about 250 known potential waste sites are grouped into 20 waste area groupings (WAGs), of which 11 are being monitored along their boundaries for groundwater quality. Because of the large number of remedial action sites at ORNL located close to one another and because of the proven hydrologic interconnections between many of these units, individual monitoring and assessment was shown to be impractical. Therefore, the concept of WAGs was developed to evaluate potential sources of releases to the environment. A WAG is a group of multiple sites that are geographically contiguous and/or occur within hydrologically defined areas. WAGs allow the 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 (SWMU) individually. Some WAGs share common boundaries, but each WAG represents distinct small drainage areas within which similar contaminants may have been introduced. Monitoring data from each WAG will 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.

The K-25 Site Groundwater Protection Program currently includes 204 monitoring wells within 14 operable units and 2 RCRA sites.

The 11 wells at the two K-25 RCRA sites (K-1407-B and C ponds) continued under modified interim status detection monitoring during 1991 as approved by TDEC. Wells at five WAGS underwent annual sampling during 1991. Annual monitoring generally involves sampling for a list of constituents that include field measurements for volatile organics, pH, specific conductivity, gross alpha, gross beta, total uranium, ^{99}Tc, and fluoride.

Evaluations of hydrogeologic and groundwater quality data that were conducted by the K-25 Site during 1989 led to a realization that the approach to groundwater monitoring for remedial actions required modification. Because of the potential for intermingling of groundwaters contaminated by individual sites within the same groundwater drainage basins, it became obvious that the most efficient, cost-effective, and technically defensible approach to groundwater monitoring at the K-25 Site would be to divide the plant into hydrogeologically defined WAGs. Thirteen WAGs, encompassing from 1 to more than 10 individual sites, have been identified.

Information on off-site groundwater monitoring is provided in Sect. 5.5.

BIOLOGICAL MONITORING

Contaminant concentrations in fish samples during 1991 are comparable to, or are generally lower than, concentrations found in previous years. Samples were collected to measure concentrations of mercury, polychlorinated biphenyls (PCBs), ^{60}Co, ^{137}Cs, and total radioactive strontium in bluegill from the Clinch River. No guidelines exist for radionuclide concentrations in fish. However, dose calculations were based on concentrations of radionuclides in fish and assumed consumption rates. These calculations are described in Sect. 2.1 of this report. To put doses from waterborne radionuclides into perspective, a person who eats fish caught at Clinch River kilometer (CRK) 8.0 and drinks water from the Kingston water plant could receive a 50-year committed effective dose equivalent of about 0.2 mrem, less than 0.1% of his or her annual dose from background radiation. Figure 5 shows a 5-year trend of estimated effective dose equivalent for eating fish caught in the Clinch River above Kingston at CRK 8.0.

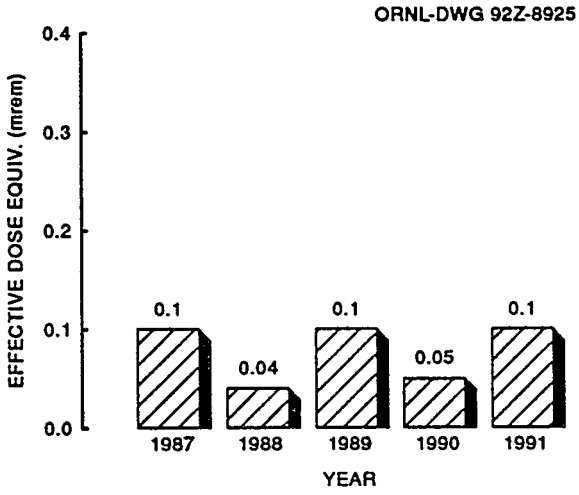

Fig. 5. Maximum calculated 50-year committed effective dose equivalent from eating fish taken from the Clinch River at CRK 8.0.

Milk samples were collected from five locations in the 80-km area around the ORR and were analyzed for ^{131}I and total radioactive strontium. The estimated effective dose equivalent for drinking this milk averages 0.2 mrem.

1991 COMPLIANCE SUMMARY
ENVIRONMENTAL COMPLIANCE ACTIVITY
U.S. DEPARTMENT OF ENERGY

OAK RIDGE RESERVATION

BACKGROUND AND OVERVIEW

The Oak Ridge Reservation (ORR), including the Oak Ridge Y-12 Plant, Oak Ridge National Laboratory (ORNL), Oak Ridge K-25 Site, and the facilities of the Oak Ridge Associated Universities (ORAU), operates in conformance with requirements established by a number of federal and state statutes and regulations, executive orders, U.S. Department of Energy (DOE) orders, and compliance and settlement agreements. Compliance status with regard to major environmental statutes and DOE orders is summarized by site.

DOE Order 5400.1, "General Environmental Protection Program," defines the mandatory environmental standards in effect at DOE operations. These environmental standards fall into three categories: (1) those imposed by federal statutes, regulations, and requirements; (2) those imposed by state and local statutes, regulations, and requirements applicable to DOE; and (3) those imposed by DOE directives. This section summarizes the standards that are significant for environmental compliance with respect to the operations of the ORR.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at the ORR and the component facilities. DOE itself, through directives to field offices and compliance audits, is the initiating organization. Principal among other regulating agencies are the U.S. Environmental Protection Agency (EPA) 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.

EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards as directed by statutes passed by the U.S. Congress. In some instances, EPA has delegated regulatory authority to TDEC when the Tennessee program meets or exceeds EPA's requirements. Where regulatory authority is not delegated, EPA Region IV is responsible for reviewing and evaluating compliance with the EPA regulations as they pertain to the ORR.

Although progress has been made toward achieving full regulatory compliance at the ORR and each of the facilities, much remains to be done. Ongoing self assessments of compliance status and implementation of corrective actions 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.

In 1991, the Oak Ridge Field Office discussed with EPA Region IV the need to negotiate a Federal Facilities Compliance Agreement for the storage of radioactively contaminated polychlorinated biphenyl (mixed PCB) wastes at facilities on the ORR. Activities at the Y-12 Plant, the Oak Ridge National Laboratory, and the K-25 site result in the production of mixed PCB waste for which there is currently no available treatment capacity. Some quantity of mixed waste is from off-site DOE generators, as well. This storage, in so far as it exceeds the yearly storage limit, does not comply with the Toxic Substances Control Act (TSCA) found in 40 CFR 761. Therefore, an FFCA is needed to allow continued generation and

storage of mixed PCB wastes to exceed the one-year storage limit until treatment and disposal options become available and final compliance with TSCA is achieved. On June 1, 1992 a formal request to begin negotiation of the FFCA was sent to EPA Region IV.

CURRENT ISSUES

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The ORR was placed on the National Priorities List in November 1989. In order to satisfy the requirements for an interagency agreement pursuant to Section 120 of CERCLA, the EPA, DOE, and TDEC signed a federal facilities agreement (FFA) that became effective on January 1, 1992. Among other functions, the FFA is intended to coordinate response and remedial actions under CERCLA with those required under the RCRA Hazardous and Solid Waste Amendments (HWSA) permit issued to DOE for the ORR effective on October 25, 1986. The FFA does not replace the RCRA HWSA permit. It supplements those corrective actions under RCRA with appropriate CERCLA actions where RCRA was and is not applicable. Thus, it coordinates remedial activities necessary to protect human health and the environment but prevents needless duplication of corrective actions or administrative requirements.

The FFA also addresses technical standards for new and existing liquid low-level radioactive waste (LLLW) storage tanks, including disposition of leaking LLLW tank systems at ORNL.

NESHAP Compliance

A plan for complying with the NESHAP emissions monitoring requirements was developed for the ORR. This plan was submitted to EPA Region IV in March 1990; however, in February 1991 the plan was rejected. A revised plan was prepared for submission in May 1991. Following EPA review and comment, an approved plan was issued in December 1991. A federal facilities compliance agreement (FFCA) for the ORR has been signed by all parties and is being implemented with a scheduled completion date of December 15, 1992. All of the milestones in the FFCA have thus far been met.

Action Filed by Friends of the Earth, Inc.

On January 17, 1992, Friends of the Earth (FOE), a nonprofit corporation, filed a lawsuit against Admiral Watkins 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, which discharges have their source 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. FOE seeks an injunction to prevent DOE from operating the facilities "in further violation of" the permits, a declaratory judgment, the imposition of civil penalties, and the award of various other costs.

FOE made a request for production of documents, and documents were provided. The complaint was amended to add another environmental group and several individuals as plaintiffs to the lawsuit.

1991 COMPLIANCE SUMMARY ENVIRONMENTAL COMPLIANCE ACTIVITY U.S. DEPARTMENT OF ENERGY

OAK RIDGE Y-12 PLANT

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

COMPLIANCE STATUS

The Y-12 Plant has approximately 185 state air permits; more than 500 air emission sources are permitted by TDEC. Eighty-five radiological stacks are equipped with continuous stack samplers to monitor uranium emissions. A plan for using these samplers to meet the requirements of Chapter 40 of the Code of Federal Regulations (CFR), Part 61, for sampling significant radionuclide emission points was prepared. An Federal Facility Compliance Agreement (FFCA) that established methods and schedules for DOE facilities on the Oak Ridge Reservation (ORR) to become fully compliant with these requirements was negotiated between DOE-Oak Ridge Field Office (DOE-OR) and EPA. This topic is discussed in more detail under Current Issues.

Procedures for permitting, compliance inspection, and documentation of compliance are in place. Initial inspections of all potential air emission sources are complete. Major source areas are appropriately permitted, and documentation of compliance is being developed. A number of minor sources, most of which are exempt from permitting under state of Tennessee rules, are being addressed also. All major air emission sources are permitted by TDEC and are operating in compliance with those permits.

Clean Water Act (CWA)

The Y-12 Plant National Pollutant Discharge Elimination System (NPDES) permit encompasses approximately 225 point discharges that require compliance monitoring, resulting in 10,000 samples per year. Five major wastewater treatment plants have been constructed and brought online since 1983. NPDES excursions and spills have occurred; however, progress continues in minimizing these incidents and their effects on receiving streams. An application for renewal of the Y-12 Plant NPDES permit was provided to TDEC in November 1989, and the NPDES permit expired May 23, 1990. The plant continues to operate under the former permit pending issuance of a new permit by TDEC as provided in Tennessee Regulations 1200-4-1.05(5)(b). A draft NPDES stormwater permit application, based on sampling during storm events, has been prepared and is presently scheduled to be submitted to TDEC by October 1, 1992. The Y-12 Plant is also preparing an addendum to the November 1989 NPDES permit application in order to update this document with recent sampling/analytical data, changes to discharges, and information on stormwater.

Sanitary wastewater is discharged to the plant sanitary sewer system, which is connected to the city of Oak Ridge sewer collection and treatment system. Discharge is monitored in accordance with an industrial user's permit. The monitoring system has been evaluated, and upgrades to the system have been proposed. A new permit was issued by the city of Oak Ridge in May 1991 and is under appeal by DOE pending resolution of language regarding radionuclide limits.

Numerous construction and environmental restoration activities throughout the Y-12 Plant have the potential to impact the local surface streams. Ten five-year aquatic resource alteration permits issued

by TDEC for such projects remained in effect during 1991.

Resource Conservation and Recovery Act (RCRA)

The Y-12 Plant currently operates 32 interim status RCRA units. Other RCRA units that previously had interim status have completed the RCRA closure process. Twenty of currently operated units will be incorporated into Part B permit applications, three operate under permit-by-rule notifications, and eight are undergoing closure. Five additional permits are in draft form, and seven units have permits-by-rule in place. Although waste minimization efforts have reduced the quantities of wastes, improved waste identifications, segregation and tracking have increased the number of waste streams reported to 1400. RCRA violations have occurred, and citations have been received in the past; however, recent improvements in the program have been noted as exemplary by both TDEC and EPA Region IV.

Y-12 Plant RCRA treatment, storage, and disposal facilities were inspected by TDEC in July 1991. No deficiencies or violations were noted by the inspection.

Toxic Substances Control Act (TSCA)

Polychlorinated Biphenyls (PCBs) are used and PCB waste is generated at the Y-12 Plant. The storage, control, and disposal of these are regulated by TSCA. A compliance issue does exist regarding the storage of uranium-contaminated PCB wastes beyond the TSCA 1-year limit (see Current Issues, "Uranium-Contaminated PCB Waste Storage" for details).

Y-12 has numerous facilities that contain asbestos materials. Programs for compliant asbestos management include identification of asbestos materials, monitoring, abatement, and disposal. Procedures that delineate scope, roles, and responsibilities for maintaining compliance with EPA and OSHA regulatory requirements are maintained. No nonconformances with environmental protection standards were identified in 1991.

Underground Storage Tanks (USTS)

The Y-12 Plant Underground Storage Tank Management Program manages 44 petroleum and hazardous-substance USTs and former UST sites, including USTs containing less than 110 gallons. Two USTs were removed in Calendar Year (CY) 1991, bringing the total number of USTs that have been removed or inert-filled to 30. Five additional USTs are designated to be removed. Seven USTs installed since 1986 will be upgraded prior to compliance dates. Two USTs containing solid uranium oxide are deferred from upgrade requirements. Eight former UST sites are being addressed under site investigations and corrective action requirements. Closure documentation has been submitted to TDEC for the 1991 UST removals with a recommendation of "no further action."

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Federal Facilities Agreement (FFA) for the ORR was signed in November of 1991 and effective January 1, 1992. The Y-12 Plant had 113 sites listed as "no further action" sites, 46 for CERCLA Preliminary Assessment/Site Inspections (PA/SIs) sites, and 52 for Remedial Investigations/Feasibility Studies (RID/FSs). This was essentially unchanged from the end of 1990. During 1991, the Y-12 ER developed a Site Management Plan which is the implementing document for compliance with the FFA. In it, 33 FFA sites were consolidated into 12 CERCLA Operable Units (OUs), 72 sites were indicated as requiring PA/SIs, and the remaining sites listed as Proposed No Further Investigation Remediation Units that did not require investigation under CERCLA.

ER progress in 1991 included: (1) the development of RID work plans for the UEFPC OU 1 (Storm Sewer/Mercury Use Areas) and the UEFPC OU 2 (Abandoned Nitric Acid Pipeline), (2) the completion of Phase II RID sampling for the Plating Shop, and (3) and the completion of PAs for 15 sites. Three of the PAs lead to the development of Site Inspection Plans. Also two RODS were granted in 1991: the Chestnut Ridge OU 3 (UNC Disposal Site) and the Mercury Sump Cleanout.

Emergency Planning and Community Right-To-Know Act (EPCRA)

The Y-12 Plant submits three reports annually to comply with the hazardous material reporting requirements of SARA. These provide local

communities and agencies with knowledge of potential hazards posed by stored chemicals and their releases from nearby facilities. The three annual reporting requirements of SARA Title III are:

annual hazardous chemical inventory reporting, including storage totals and locations (Section 312);

facilities to furnish Material Safety Data Sheets (MSDS) or a list of hazardous chemicals identified by hazard category (Section 311); and

facilities to provide an annual inventory of toxic chemical releases into the environment (Section 313).

The Y-12 Plant reports 36 hazardous and extremely hazardous under Sections 312/311 and 8 toxic chemicals under Section 313.

National Environmental Policy Act (NEPA)

Compliance with NEPA, as specified by the DOE NEPA implementing regulations and administered by the Council on Environmental Quality, ensures that consideration is given to environmental values and factors in federal planning and decision making. The Y-12 Plant maintains compliance with NEPA through its plant procedure 70-915, "NEPA Review and Compliance," and administrative procedure 50-66-EM-205, "NEPA Program Administration." In addition, several operating organizations such as Engineering and Maintenance and Utilities have specific operating procedures in which compliance with NEPA is defined. These procedures ensure that all projects initiated through the engineering or maintenance organizations receive a NEPA review and determination by DOE prior to initiation of field activities.

In 1991 the Y-12 Plant submitted more than 120 requests for Categorical Exclusions (CXs) to DOE and 140 CX approvals were received. These approvals included approval of CXs submitted prior to 1991. Included in these submittals and approvals are general CXs. DOE-OR has approved the Y-12 Plant's usage of these general CXs that give blanket approval for a wide range of actions. As a result, numerous activities/projects can be internally approved and documented against a single general CX. Examples of general CXs are routine maintenance and minor building alterations. The Y-12 Plant presently utilizes 17 general CXs.

In 1991 the Y-12 Plant received approved Environmental Assessments (EAs) for the O-Wing Renovation, the Plating Shop Replacement, and the Steam Plant Ash Disposal Facilities projects. In April 1992 the plant was awaiting approval on the Environmental Support Facilities, Sale of Excess Lithium Hydroxide, Replace Deteriorated Infrastructures, and the Life Safety Upgrades projects. These projects have been evaluated in light of the Programmatic Environmental Impact Statement (PEIS) for the reconfiguration of the DOE Nuclear Weapons Complex (Complex 21) and have been determined to be justified separately and independently of the PEIS, thus allowing the actions to proceed. All EAs initiated through the Y-12 Plant are reviewed against the PEIS to ensure that the project would not prejudice a potential alternative of the Complex 21 PEIS.

In conjunction with the NEPA review and documentation process for all new projects, an assessment for compliance with the requirements of numerous sensitive area and cultural resource protection laws is conducted. Examples of these are the Endangered Species Act; the National Historic Preservation Act (NHPA); and Executive Orders 11988, "Floodplain Management," and 11990, "Protection of Wetlands," as administered by the DOE Implementing Regulations on Floodplains and Wetlands and found in 10 CFR, Pt. 1022.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The Y-12 Plant maintains compliance with FIFRA requirements through inspection of controlled pesticide/herbicide storage areas and review of the on-site, restricted-use application program. A new 1992 compliance program manual has been developed and will be implemented once quality review is finished. The manual contains requirements and responsibilities for FIFRA compliance.

Safe Drinking Water Act (SDWA)

Potable water is obtained from the treatment plant located near the Y-12 Plant. The treated water is tested for parameters listed under the state and federal drinking water regulations at various points throughout the plant distribution system. The water was in compliance with all current primary Drinking Water Standards. In 1991 the water plant was managed and operated by Johnson Controls, Inc.

Environmental Audits

Regulatory agencies conducted several audits at the Y-12 Plant during 1991. Reviews conducted by TDEC included RCRA inspections, compliance evaluation inspection (CEI) of the groundwater monitoring program, TSCA inspections, permitting inspections, and solid waste management compliance inspections. No major findings or areas of concern were identified during the inspections.

Release Reporting

Spills and unanticipated releases may trigger release reporting requirements under provisions of one or more of the following statutes: (1) EPCRA (also known as Title III of SARA), (2) CERCLA, (3) RCRA, (4) CWA, (5) CAA, and (6) TSCA. Each spill event is evaluated for reporting requirements and regulatory agencies as well as federal, state, and local emergency response agencies are notified as appropriate. The Y-12 Plant had six CERCLA reportable events in 1991. One event was the discovery of previously released mercury in the storm sewer accounting for a total of less than 15 lb.

Eight oil sheens, resulting from the release of small quantities of oil, were reported to the U.S. Coast Guard National Response Center (NRC) pursuant to requirements of the CWA. There were no reportable releases pursuant to RCRA, CAA, or EPCRA (Title III, SARA).

To determine whether the Y-12 Plant had any reportable releases (i.e., those not federally permitted and exceeding the CERCLA reportable quantities), a compliance assessment of all releases or potential release sources was conducted. It was concluded that no releases of reportable quantities are occurring at the Y-12 Plant; therefore, the plant is in compliance with 40 CFR 302.8. For spills of hazardous substances exceeding RQs, the NRC and the Tennessee Emergency Management Agency (TEMA) are notified immediately. For spills of extremely hazardous substances the local emergency planning committees of areas potentially affected by the release are notified verbally and in writing.

CURRENT ISSUES

A number of specific compliance issues have been identified as a result of recent intensive efforts to attain full compliance. The significant issues are discussed below.

NESHAP Compliance

As required by the FFCA negotiated in December 1991, the Y-12 Plant has implemented a stack and vent survey to identify and characterize all radionuclide emission points. Major emission points, as defined in the regulations, will be continuously sampled to quantify emissions. Periodic emissions estimates will be made as specified in the compliance plan submitted for the FFCA.

NPDES Discharges

A field investigation of outfalls discharging to East Fork Poplar Creek identified several discharges that are not specifically listed on the current NPDES permit. The outfalls have been incorporated into a Miscellaneous Discharge Sampling Plan and applied for on the NPDES permit application filed with TDEC in November 1989. The outfalls are primarily combined cooling waters and stormwater discharge points. The Y-12 Plant has also eliminated a number of abandoned outfalls and discharge points, since filing this application, reducing the number of permitted outfalls to approximately 225. Information on outfall removal will be provided in an addendum to the 1989 application, which is currently being prepared. The permit renewal application addendum will be submitted prior to initiation of permit negotiation, which is anticipated by mid 1993.

NPDES Stormwater Permitting

The Y-12 Plant prepared an individual permit application for stormwater discharges from various drainage areas on the plant site. This application is based on extensive sampling and analytical work and the assimilation of information on disposal areas, outdoor storage facilities, structural controls, and other features affecting the water quality of stormwater runoff. Submittal of the application package to TDEC was delayed upon extension of the regulatory submission deadline from November 1991 to October 1992, thus allowing time for more thorough review, additional sampling, and resolution of rule interpretations. The final application is planned for submittal by the October 1, 1992, deadline.

Discharges of Toxic Pollutants

Activities are underway to reduce discharges of priority pollutants, high temperature, and toxic agents such as chlorine to East Fork Poplar Creek. Projects that address the reduction of chlorine from recirculatory cooling water system blowdown, temperature and chlorine reduction in once-through cooling water discharge, and enhancement of on-site treatment facility capabilities are progressing. Efforts related to reducing nonpoint source pollutants to surface streams and mercury pollution are being planned. The Y-12 Plant also manages an effective Best Management Practices program for the protection of surface stream water quality.

Land Disposal Restricted (LDR) Waste

RCRA mixed, radioactive land ban waste has been stored in some areas at the Y-12 Plant in nonconformance with LDR storage restrictions. These wastes are currently subject to the land ban storage restrictions that permit storage only for accumulation of sufficient quantities to facilitate proper treatment, recycle, or disposal. This waste is being stored at the Y-12 Plant because of the nationwide shortage of treatment and disposal facilities for these types of waste. Storage of waste for this purpose does not comply with the LDR storage restrictions. DOE and EPA are continuing to discuss the issue, and the inventory of such waste is reported to the regulators on an annual basis. DOE-OR is negotiating an FFCA with EPA Region IV that details the steps needed to attain compliance with LDR requirements.

Uranium-Contaminated PCB Waste Storage

Uranium-contaminated PCB wastes are being stored in excess of the one-year limit imposed by TSCA because of the lack of treatment and disposal capabilities. A compliance agreement with EPA is being pursued.

DOE Environmental Assessment (Tiger Team)

In September and October 1989, a team of DOE environmental specialists conducted a comprehensive assessment of environmental practices at the Y-12 Plant. The assessment covered the CWA, the CAA, the RCRA, the TSCA, remedial action programs, radioactive emissions, NEPA, USTS, and environmental monitoring and surveillance. The assessment expressed concern over 24 compliance issues. Other practices relating to Best Management Practices were also examined. Corrective action plans have been developed and are being implemented for these issues. Of the 62 environmental findings, identified by the Tiger Team, 38 remain open and 24 have been completed. Five findings were reopened and 18 were verified closed by DOE.

The Environmental, Safety and Health (ES&H) Progress Assessment team completed a two-week review of the Y-12 Plant on February 21, 1992. The team identified no major concerns and concluded that since the September 1989 Tiger Team Compliance Audit, substantial progress has been made. However, substantial management effort will still be required to achieve ES&H excellence. The assessment identified a total of 13 concerns, 5 improvement items, and 4 strengths.

Waste Minimization Program

Process Waste Assessments (PWAs) are being conducted as part of the ongoing program to identify, screen, and analyze options to reduce the generation of waste. A PWA determines the amount of material for a workplace that is disposed as waste during work operations. It provides a summary of hazardous materials usage and waste production and identifies those processes and operations that need to be improved or replaced to promote waste minimization. The assessment provides a basis for prioritizing the specific modifications to site processes or other waste minimization options developed during the assessment.

Several project teams throughout the site have achieved considerable success in waste reduction and minimization activities. Following are five significant waste minimization/reduction projects:

1. elimination of mixed RCRA/radioactive wipes from shop floor operations by elimination of chlorofluorocarbon solvents;
2. trichloroethane waste stream reduction;
3. elimination of hazardous chemicals and waste in the Y-12 Plant graphics art department;
4. installation of rapid access process for color photographic prints and viewgraphs; and
5. aluminum nitrate waste minimization.

These waste reduction and minimization projects made significant gains in reducing waste during 1991. Though the projects are essentially complete, further reductions in waste generation as a result of these projects are expected to be realized in the 1992 timeframe and beyond through continued improvements.

Groundwater Protection Program

Since initiation of groundwater monitoring activities at Kerr Hollow Quarry (KHQ) and the Chestnut Ridge Sediment Disposal Basin (CRSDB), sporadic, statistically significant analytical results for contaminant indicator parameters have occurred. Analysis of data during 1987 indicated that these occurrences were due to fluctuation and possible grout contamination in the base year samples, not releases from the sites. At the time, representatives of the state of Tennessee were briefed on the results and the interpretations of the data by DOE and Energy Systems. A consensus was reached that the interpretations were valid and that no release of hazardous waste or hazardous waste constituents had occurred. Because of this, it was understood that the sites should remain in detection monitoring and that a groundwater quantity assessment plan would not be prepared. Subsequent years' data have been consistent with the initial interpretations; however, during CY 1991, the Y-12 Plant received two Notices of Violation (NOVs) from TDEC for failure to prepare site-specific groundwater quality assessment plans for KHQ and CRSDB and for failure to properly report the statistically significant analytical results from CY 1990. The Y-12 Plant responded to the NOVs but was subsequently issued a civil penalty of $8,000. The civil penalty is presently under appeal by Energy Systems. To date a groundwater quality false-positive assessment for the sites has been submitted to and approved by TDEC.

SUMMARY OF PERMITS

RCRA, CWA, and CAA Permit Status

Air Permits

Y-12 currently has 98 active operating air permits and 24 active construction air permits, for a total of 122 active air permits. A total of eight air permits (seven operating and one construction) are pending TDEC approval.

RCRA Permits

RCRA permitting activities for CY 1991 included two revisions of the Part A permit application: to include additional waste management units and to increase storage capacities for existing units. Activities also included the submittal of Part B permit applications for 21 RCRA and mixed waste units. As of December 31, 1991, Part B permit applications for three tank storage units had been submitted. Part B permit applications for the other 18 treatment and storage units was completed by May 15, 1992. Permit-by-Rule notifications for three industrial wastewater treatment units were also submitted by May 15, 1992.

NPDES Permits

Y-12 is currently operating under an expired NPDES permit issued by TDEC and the U.S. EPA, Region IV, in May 1985. An application for renewal was submitted to the TDEC in November 1989. Additional permits issued pursuant to the authority of the federal Clean Water Act or the Tennessee Water Quality Control Act for activities that may impact local surface streams include ten aquatic resource alteration permits.

1991 COMPLIANCE SUMMARY ENVIRONMENTAL COMPLIANCE ACTIVITY U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

COMPLIANCE STATUS

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

Authority for enforcement of the CAA is shared between TDEC for nonradioactive emission sources and EPA for radioactive emission sources.

During 1991, ORNL reviewed all existing permitted sources relative to specific exemptions listed in Tennessee Rule 1200-3-9.04. These exemptions exclude those very small air emission sources that contribute insignificant quantities of air pollutants from air permitting requirements. Based upon information from these evaluations, DOE requested several permit cancellations; TDEC notified DOE in January and March of 1992 that 48 sources did not require permits. One new permit for fugitive emissions was received in 1991, and three permit applications remain outstanding. Thus, as of April 1, 1992, ORNL has 59 permitted sources and 3 outstanding applications. An evaluation of ORNL's laboratory research hoods for air permitting requirements has been completed. Based upon guidance provided by TDEC on May 17, 1991, no laboratory hoods currently in operation at ORNL require an air permit.

Regulation of radiological emissions is determined by EPA according to requirements of NESHAP under the authority of the CAA. ORNL is not in full compliance with all requirements of the new NESHAP criteria, which the EPA issued on December 15, 1989. An FFCA that established methods and schedules for all DOE facilities on the ORR to become fully compliant with requirements of 40 CFR 61, Subpart H, was negotiated between DOE-OR and EPA Region IV. Final approval was received in May 1992. This FFCA requires full compliance by December 15, 1992.

TDEC inspected selected ORNL facilities on April 17, 1991, and no violations were noted.

Clean Water Act (CWA)

The ORNL NPDES permit, renewed in 1986, has more than 190 point-source discharges that require compliance monitoring. Many of these are storm drains, roof drains, parking lot drains, and storage area drains. Three major wastewater treatment facilities have been constructed since 1985: the Sewage Treatment Facility, the Coal Yard Runoff Treatment Facility, and the Nonradiological Wastewater Treatment Facility (NRWTF). Occasional spills, excursions, and precipitation runoff from storm and parking lot drains have resulted in NPDES permit effluent limits being exceeded; however, most of these exceedances are associated with precipitation runoff. Progress continues toward minimizing or eliminating these occurrences. The sample compliance rate across all discharge points for the year was 98%. The NRWTF, which went on line April 1, 1990, has continued to operate without a single effluent discharge limit violation.

An application for renewal of the NPDES permit was submitted to TDEC on September 28, 1990, in accordance with the 5-year permitting cycle. The 1986 permit expired on March 31, 1991; TDEC regulations allow for an expired permit to 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.

Numerous construction and environmental restoration activities throughout the ORNL site have the potential to impact the local surface streams. ORNL has applied for and has received ten approvals for several such projects from the U.S. Army Corps of Engineers. TDEC has issued five aquatic resource alteration permits to ORNL.

EPA Region IV conducted a compliance evaluation inspection on June 27, 1991. No notice of deficiencies has been received.

Resource Conservation and Recovery Act (RCRA)

ORNL strives to be fully compliant with RCRA regulations. However, some internal inspections and/or DOE audits have identified some potential noncompliances. Wherever possible, those potential noncompliances have been corrected. Those that cannot be readily corrected are negotiated with regulators, such as compliance with the land disposal restrictions. ORNL generates both RCRA hazardous waste and RCRA hazardous waste mixed with radionuclides (i.e., mixed hazardous waste). The hazardous waste is accumulated by individual generators at several satellite accumulation areas, where it is picked up by waste management personnel and placed in permitted or interim status storage facilities until it is shipped offsite for treatment and/or disposal at a RCRA-permitted facility. ORNL operates several hazardous/mixed waste facilities. ORNL's most recent RCRA Part A revision was submitted on December 23, 1991; another revision incorporating minor changes is planned for spring 1992. Two facilities currently have RCRA Part B permits (Buildings 7652 and 7855). A Part B Permit application was submitted in 1989 for the Chemical Detonation Facility, but TDEC has deferred further action pending guidance from EPA concerning permitting requirements of such units. In accordance with a consent order with TDEC, ORNL is consolidating Part B Permit applications. Five general categories (container storage, transuranic container storage, tank storage, chemical detonation treatment, and transuranic treatment) have been identified. ORNL has already submitted one Part B Permit application for Tank 7830A and is preparing two additional applications for submittal in early 1992 covering container storage facilities. The latter will modify both of the existing Part B permits to include 16 additional storage facilities. Some of those facilities are slated for construction in calendar year (CY) 1992 and beyond. The fifth permit will cover a transuranic (TRU) waste treatment facility; it will be submitted in the late 1990s. Several facilities that currently operate under interim status are scheduled for closure, which is projected to be initiated or completed by November 1992.

ORNL's RCRA treatment, storage, and disposal facilities were inspected by TDEC on March 18 and 19, 1991, and ORNL's satellite and 90-day accumulation areas were inspected July 30, 1991. No deficiencies or violations were noted by either inspection.

Toxic Substances Control Act (TSCA)

ORNL manages all nonradioactively contaminated PCBs in compliance with federal regulations. The facility operates research equipment that contains PCB capacitors. It also operates some miscellaneous equipment and transformers, pumps, electric motors, etc., that contain oil contaminated with PCBs. Both radioactive and nonradioactive PCB wastes are stored onsite in approved storage units. The nonradioactive PCBs are transported off site to EPA-approved facilities for disposal in accordance with regulatory requirements. The drums of radioactively contaminated PCB waste are currently stored onsite awaiting disposal. Continued storage of the radioactively contaminated PCB waste beyond 1 year is not in compliance with TSCA requirements, as further discussed under the current issue "Mixed TSCA Waste Storage."

ORNL has numerous facilities that contain asbestos materials. Programs for compliant asbestos management include identification of asbestos materials, monitoring, abatement, and disposal. Procedures which delineate scope, roles, and responsibilities for maintaining compliance with EPA and OSHA regulatory requirements are maintained. No nonconformances with environmental protection standards were identified in 1991.

Underground Storage Tanks (USTs)

ORNL's UST management program 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 sites with tanks found to be leaking, and it implements any required closures, corrective actions, and any upgrading and/or replacement of affected USTs in accordance with the regulatory requirements. Activities in 1991 include the excavation of two tanks, initiation of five environmental investigations and approval of final closure of five USTs by TDEC. Status of the tanks managed under the UST Program through 1991 is as follows.

- Twenty six tanks have been excavated or permanently taken out of service (20 approved by TDEC as closed while 6 require additional investigation and/or corrective action before final closure approval).
- Twenty four USTs are deferred from 40 CFR 280 regulations. These will be taken out of service or upgraded by December 1993.
- Two USTs were upgraded in 1990 to meet the current leak detection requirements.
- Two USTs contain heating oil and are excluded from regulation under 40 CFR 280.
- Five USTs contain waste oil contaminated with radionuclides and are excluded under 40 CFR 280.

One tank previously listed under the UST Program was determined to be a wastewater treatment tank and thus not subject to UST regulatory requirement; hence the change from 60 to 59 tanks currently listed in the UST.

Emergency Planning and Community Right-To-Know Act (EPCRA)

ORNL submits three reports annually to comply with the hazardous material reporting requirements of SARA. These provide local communities and agencies with knowledge of potential hazards posed by stored chemicals and their releases from ORNL facilities. The three annual reporting requirements of SARA Title III are

- annual hazardous chemical inventory reporting, including storage totals and locations (Sect. 312);
- facilities to furnish Material Safety Data Sheets (MSDS) or a list of hazardous chemicals identified by hazard category (Sect. 311); and
- facilities to provide an annual inventory of toxic chemical releases into the environment (Sect. 313).

ORNL currently reports 16 hazardous and extremely hazardous materials under Sects. 311 and 312 and 3 toxic chemicals under Sect. 313.

National Environmental Policy Act (NEPA)

ORNL is in compliance with NEPA review requirements in accordance with DOE implementing procedures. This compliance is achieved and maintained through the efforts of the Environmental Review and Documentation Section (ERDS) of the Office of Environmental Compliance and Documentation. In 1991, ERDS submitted 49 requests for Categorical Exclusions (CSs) for actions at ORNL, and 48 CX approvals were received. In the same period, 15 draft Environmental Assessments (EAs) were submitted, and no EA approvals were received.

In conjunction with the NEPA review for all new projects by ERDS, an assessment is conducted for compliance with the requirements of the Endangered Species Act, the National Historic Preservation Act, and Executive Orders 11988, Floodplains Management, and 11990, Protection of Wetlands, is administered through the DOE Implementing Regulations on Floodplains and Wetlands (10 CFR 1022). Potential impact or involvement of the project in these areas is assessed even if there is a determination of no significant environmental impact under NEPA.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

ORNL maintains compliance with FIFRA requirements through inspection of controlled pesticide/herbicide storage areas and review of the on-site, restricted-use application program. A FIFRA compliance manual has been developed that sets forth the requirements for ORNL compliance with FIFRA, documents inspections of FIFRA storage areas, and serves as the basis for development of a general

ORNL procedure that will be included in the revised *Environmental Protection Manual.*

Safe Drinking Water Act (SDWA)

Potable water is obtained from the treatment plant located at the Y-12 Plant. The treated water is tested for parameters listed under the state and federal drinking water regulations. In 1991 the water continue to meet all health standards.

Release Reporting

Spills and unanticipated releases may trigger chemical-release reporting requirements under provisions of one or more of the following statutes: EPCRA (also known as Title III of SARA), CERCLA, RCRA, CWA, CAA, and TSCA. Each spill event is evaluated for reporting requirements, and regulatory agencies are notified as appropriate. ORNL had one CERCLA reportable event in 1991. A release of a small amount of ethylene glycol from machinery involved in construction of a retention dam at the mouth of White Oak Creek was reported to the U.S. Coast Guard National Response Center (NRC) pursuant to requirements of the CWA. There were no reportable releases pursuant to RCRA, TSCA, CAA, or EPCRA (Title III, SARA).

A compliance assessment of all releases or potential release sources was conducted to determine whether ORNL had any reportable releases [i.e., those not federally permitted and exceeding the CERCLA reportable quantity (RQ)] qualifying for reduced reporting under the requirements of 40 CFR 302.8, Continuous Releases. It was concluded that although continuous releases of hazardous substances occur at ORNL, none are subject to the reporting requirements of CERCLA, Sect. 103, or EPCRA, Sect. 304. Potential emissions of hazardous substances from the ORNL Steam Plant that exceed RQs were evaluated. Based upon emission factor calculations, none exceeded the RQ.

CURRENT ISSUES

A number of specific compliance issues have been identified. Some of the most significant issues are discussed below.

Land Disposal Restricted (LDR) Waste Under RCRA

ORNL is storing low-level radioactive waste (LLRW) that contains RCRA hazardous constitutents (and is, therefore, mixed waste) that is subject to land disposal restrictions contained in 40 CFR 268 and Tennessee Rule 1200-1-11.10. According to these regulations, storage is allowed only to accumulate sufficient quantities to facilitate treatment, recycling, or disposal. ORNL's mixed waste is being stored indefinitely because of the lack of treatment or disposal facilities for mixed waste. DOE and EPA are continuing to discuss the issue. DOE expects to negotiate an FFCA with EPA that would detail the steps needed to attain compliance. A draft FFCA that addresses spent solvent and California List mixed-waste streams is under preparation. DOE Headquarters (DOE-HQ) is negotiating with EPA a national capacity variance for the other mixed-waste streams subject to land disposal restrictions.

Mixed TSCA Waste Storage

Radioactively contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by TSCA because of the lack of treatment and disposal capabilities. A compliance agreement with EPA is being pursued by DOE to establish schedules for disposal.

Contaminants Resulting from Storm Runoff

Precipitation runoff has resulted in total suspended solids (TSS) and oil and grease values that exceed NPDES effluent limits at storm drain and parking lot drain outfalls. Studies were initiated in 1991 to identify potential corrective measures along with their feasibility of implementation. Strategies to reduce or eliminate these precipitation-related exceedances include installing treatment plants, source reduction, and administrative actions.

Treatment strategies identified include installation of retention basins and filtration units at individual problem outfalls. An extension of this strategy is to determine the feasibility of combining the flow of several outfalls and rerouting it to a common treatment unit. Source-reduction efforts such as more frequent cleaning of streets and parking lots and increased upgrade and/or maintenance of individual outfalls have been implemented. A

detailed cost-benefit analysis for each option has not been completed. A request for a modification to ORNL's NPDES permit has been submitted to TDEC, based on evidence that the NPDES exceedances of TSS and oil and grease limits experienced over the past 2 years do not appear to have a significant impact on the water quality of the White Oak Creek watershed, given the exemptions from NPDES permitting requirements provided by EPA's regulations governing stormwater runoff from parking lots. The proposal was also included in ORNL's NPDES permit renewal application submitted to TDEC on September 28, 1990.

Ethylene Glycol Spills

Slow releases of ethylene glycol to the environment have occurred by leakage from old piping serving the Central Chilled Water Facility in the main plant complex at ORNL. Occasional ethylene glycol spills also occur. Although ethylene glycol is not directly toxic to aquatic life, it has been designated as a toxic air pollutant under the CAA amendments of 1990. Releases into any environmental media, including surface water, of quantities that exceed the statutory RQ of 1 lb must be reported according to the requirements of CERCLA. ORNL implemented an action plan for replacing ethylene glycol with water coolant. ORNL replenished the system with water, rather than using water-ethylene glycol solutions as in the past. The ethylene glycol wastewater was transported to the Y-12 Plant for use as a carbon source in its wastewater treatment facility (Biodenitrification Facility). The concentration of ethylene glycol has been reduced to 3 ppm or less.

In instances where major ethylene glycol spills occur, containment is provided as soon as is practical to minimize releases to surface waters. Approval has been requested from TDEC to allow treatment of these contained wastes through on-site conventional wastewater treatment facilities for subsequent discharge through NPDES-permitted outfalls.

Releases from Burial Grounds and Waste Disposal Areas

Radionuclides and chemical constitutents released from inactive burial grounds and other waste disposal areas have been found in some groundwater and surface water samples from the Bethel Valley and Melton Valley areas of ORNL. Major known releases include ^{90}Sr, ^{137}Cs, ^{60}Co, and ^{3}H, as well as hazardous, organic, and inorganic constituents. ORNL provides through the Environmental Restoration Program a comprehensive surveillance and maintenance program of those areas where past research, development, and waste management activities have been conducted and have resulted in residual contamination of facilities or releases to the environment. The FFA among DOE, EPA, and TDEC addresses selections of interim and final corrective measures and schedules for implementation.

Tiger Team Assessment

From October 22, 1990, to November 30, 1990, a group of approximately 80 specialists representing DOE-HQ 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. Seventy deficiencies were identified; 43 represented nonconformance with procedural and/or regulatory requirements; and 27 involved best management practices.

An action plan that addressed corrective measures for each of the Tiger Team findings was prepared, and, after a number of revisions, it was approved by DOE Secretary James D. Watkins on October 19, 1991. In the time since the Tiger Team review, ORNL has been actively completing those corrective actions that have adequate funding. In cases where funding is not available, it has been requested. As of May 1992, 19 of the findings have been closed.

SUMMARY OF PERMITS

RCRA, CWA, and CAA Permit Status

Air permitting activities for CY 1991 included a review of the 106 existing permitted sources. It was determined that 48 of these sources no longer required permits. As of April 1, 1992, ORNL has 59 permitted sources, including a new permit for fugitive emissions received in October of 1991. Three applications are awaiting action by the TDEC.

RCRA permitting activity for CY 1991 included the revision of the Part A application to include additional waste management units and the consolidation of the Part B application, which will incorporate the two container storage units currently permitted along with 16 additional container storage units, a storage tank, a chemical detonation treatment unit and a transuranic treatment unit. ORNL submitted to the TDEC Part B applications for the tank storage unit (November 1991), the nine transuranic storage units (March 1992), and the chemical detonation treatment unit (1989). The application for the nine low-level radioactive mixed and hazardous waste storage units has been submitted (May 1992). Preparation of the transuranic waste treatment unit has not been initiated; it will be submitted in the late 1990s.

ORNL is currently operating under an expired NPDES permit issued by TDEC and EPA Region IV on April 1, 1986. An application for renewal was submitted to the TDEC on September 28, 1990. Additional permits issued pursuant to the authority of the CWA or the Tennessee Water Quality Control Act for activities which may impact local surface streams include ten from the U.S. Army Corps of Engineers and five from the TDEC.

1991 COMPLIANCE SUMMARY ENVIRONMENTAL COMPLIANCE ACTIVITY U.S. DEPARTMENT OF ENERGY

OAK RIDGE K-25 SITE

COMPLIANCE STATUS

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

At present, approximately 150 air sources from operations exist at the K-25 Site. Approximately 80 of these sources are permitted by TDEC. The compliance activity issues associated with CAA regulations include asbestos abatement under NESHAP requirements and new regulatory requirements under NESHAP for radionuclide emissions. The asbestos abatement issue has been addressed using an aggressive program for the removal and/or encapsulation of deteriorating asbestos in identified areas and for the formalization of all procedures for asbestos work. Current efforts are focusing on ensuring that all sources are permitted and are operating in accordance with those permits and in compliance with the new NESHAP regulations for radionuclide emissions. At present, inactive TDEC permits are being updated to include new processes.

A review of all site air permits has been performed, and permits for nonoperational sources (47 to date) were deleted from the listing. Fifty permits may require resubmittal within the next 1 to 2 years.

The AVLIS Program has received all necessary air permits and permits to construct from TDEC. NESHAP determinations from EPA Region IV have been made stating that the AVLIS facility is exempt from obtaining an applications to construct.

The K-25 Site, as part of the ORR, is not in full compliance with the new NESHAP regulations that were issued on December 15, 1989. A NESHAP FFCA was signed by DOE and EPA Region IV in April and May of 1992, respectively. This FFCA requires full compliance by December 15, 1992.

A comprehensive stack and vent survey is being conducted in support of both the NESHAP Compliance Plan and the air permitting program. This survey will inventory all air emission sources and should be complete in September 1992.

TDEC performed an audit of the site air program on May 9, 1991. No violations, deficiencies, or findings were identified during the closeout.

Clean Water Act (CWA)

The K-25 Site is operating under an expired NPDES permit that was issued by TDEC and pertains to eight discharge locations. Approximately 22,000 analyses are performed annually as required by the expired NPDES permit. Even though a 99%-plus compliance rate is experienced, occasional excursions occur outside the NPDES permit discharge limits. Each excursion is reported under the Occurrence Reporting System (ORS). An ORS report identifies causes and corrective actions to prevent future occurrences. More than half of the excursions experienced are for aluminum at the Mitchell Branch sampling station; chemical oxygen demand (COD) and low dissolved oxygen at the K-1007-B Pond outfall; and low dissolved oxygen and elevated suspended solids at the K-901-A Holding Pond. These excursions are believed to be the result of natural occurrences during periods of heavy rainfall and thus are not process related. DOE and Energy Systems are working with TDEC to reissue an

NPDES permit that requires monitoring of the pipes discharging into the pond rather than monitoring of the pond outlets. This will enable the site to better identify sources of discharges into the pond.

Corrective actions relating to the NPDES Program include identifying projects to treat and/or remove nonpoint-sources of pollution. These projects include the rehabilitation of sanitary sewer lines to prevent infiltration, the removal and/or treatment of effluents to storm drains to remove residual chlorine, and the remediation of sites that may be contributing to surface water contamination.

A significant infiltration problem with the sewage collection system causes noncompliances at the K-1203 Sewage Treatment Plant during heavy rainfall. A portion of the system has been rehabilitated. To repair the balance of the system, a line-item project has been scheduled for completion by September 30, 1995. There are plans to convert the sewage treatment plant from chlorine disinfection to ultraviolet units for fecal coliform control. This will eliminate NPDES noncompliances for fecal coliform and chlorine.

EPA Region IV performed an audit of the K-25 Site NPDES Program on June 26, 1991. No violations, deficiencies, or findings were identified during the closeout.

Resource Conservation and Recovery Act (RCRA)

The K-25 Site has entered into a consent order with TDEC to update and combine all Part B Permit applications into three applications. These three applications will consist of (1) the K-1435 TSCA Incinerator; (2) the K-1435 and K-1425 TSCA Incinerator storage and treatment units; and (3) all the other units at the K-25 Site combined. The K-1435 Incinerator and ten of the K-25 Site vaults have been permitted. The other units, with the exception of 16 recently added vaults, have operating status by virtue of the June 6, 1991, Consent Order issued by TDEC. The final permit application is scheduled for submittal to TDEC by May 31, 1992.

The K-25 Site has received approval of the RCRA Part A Permit application from TDEC and EPA Region IV for toxic characteristic leachate procedure (TCLP) requirements. The site also has two approved RCRA Part B permits: one for the K-25 vaults and one for the TSCA Incinerator. Revisions of the Part B permits for the TSCA Incinerator storage and treatment units and the K-25 Site vaults (now called the Oak Ridge K-25 Site waste management units) are not yet approved. Closure plans for seven units are being prepared for submittal to TDEC.

The K-1407-B and -C Pond activities and the K-1417 Drum Storage Yard activities are now being handled by the Environmental Restoration Program. All site waste management issues are being handled under the Waste Management Program.

An FFCA has been drafted and negotiations with EPA Region IV are being made to address the long-term storage of hazardous and mixed waste subject to LDR. The FFCA is also addressing dioxin lab sample waste and waste pentachlorophenols.

Effective May 8, 1992, the K-25 Site was out of compliance for generation of mixed "thirds" hazardous wastes. A case-by-case extension was being applied for the LDR waste with EPA Region IV at the publication time of this document.

A RCRA Permit-By-Rule application was submitted to TDEC in October 1991. The application covered previous Permit-By-Rule applications for the K-1407-H Central Neutralization Unit and the K-1407-A Neutralization Unit. Several additional units were included in this revision in order to more accurately reflect the operating authority for these units as waste water treatment units.

TDEC conducted a comprehensive groundwater monitoring evaluation-compliance evaluation inspection of the K-1407-B Pond groundwater monitoring system on March 11–13, 1991. A notice of violation (NOV) was issued on June 14, 1991, to address an incomplete groundwater quality assessment plan outline and not following the proper sampling and analysis plan. The NOV has been completely addressed.

TDEC performed the annual RCRA hazardous waste inspection June 25–27, 1991. No deficiencies were noted in the closeout.

Toxic Substances Control Act (TSCA)

Dielectric fluids containing PCBs are used, and PCB wastes are generated at the K-25 Site. In addition, PCB wastes generated at other DOE-OR sites are stored at the K-25 Site pending disposal at the K-1435 TSCA Incinerator. The management, storage, and disposal of these PCB wastes are regulated by TSCA. Two compliance issues regarding

PCBs exist at the K-25 Site. A FFCA was signed by EPA headquarters on February 20, 1992, to cover the first issue of the storage of uranium-contaminated PCB waste and the second issue of leaking PCB gaskets and electrical equipment located in the shutdown process buildings' ventilation systems. (See Current Issues for details.)

The TSCA Incinerator has completed TDEC testing, and the final air permit has been issued. An application for renewal of the permit to burn PCB waste was submitted and is under review by EPA Region IV.

Underground Storage Tanks (USTs)

There are six active USTs on the K-25 Site. One is scheduled to be closed in 1992. Two former UST sites are presently being addressed under the Environmental Restoration Program—K-1414 Diesel and K-1220-NE. Two new tanks are being installed to provide on-site gasoline and diesel service.

Two suspected releases were identified, one from a methanol UST at K-1414, and one from a diesel UST at K-1402. It has not yet been determined whether a release occurred at the K-1402 tank, and after further review, no methanol release occurred at K-1414. A Permanent Closure Application has been submitted for the K-1402 tank.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The CERCLA Continuous Release Report was prepared, and no continuous releases were identified. Suspected chlorine releases based on material balances are covered by an air permit for fugitive emissions. Use of chlorine is being reduced.

Emergency Planning and Community Right-To-Know Act (EPCRA)

The EPCRA was enacted as a stand-alone portion (Title III) of the Superfund Amendments and Reauthorization Act of 1986 (SARA). Under the provisions of Title III, states developed emergency planning districts and identified local emergency response organizations that could respond in the event of a hazardous release from a local facility. Facilities must notify these districts of materials maintained and of releases occurring from their sites.

The K-25 Site submits three reports annually to comply with the hazardous material reporting requirements of SARA. These reports are provided to the communities and emergency response agencies lists of potential hazards posed by stored chemicals and their releases from the K-25 facilities. The three annual reporting requirements of SARA Title III are:

- annual hazardous chemical inventory reporting including storage locations and totals (Section 312);
- facilities to furnish MSDS or a list of hazardous chemicals identified by hazard category (Section 311); and
- facilities to provide an annual inventory of toxic chemical releases into the environment (Section 313).

The K-25 Site currently reports 25 hazardous and extremely hazardous materials under Sections 312/311 and 3 toxic chemicals under Section 313.

National Environmental Policy Act (NEPA) Program

The NEPA Program at the K-25 Site is progressing toward a more structured approach with a NEPA Management Plan. The plan provides for training of key site personnel, tracking of NEPA documentation preparation and approval, K-25 Site NEPA implementation procedures, and compliance assessment for NEPA commitments. Draft DOE procedures for NEPA compliance were published in the *Federal Register* on November 2, 1990, and final DOE NEPA procedures were published in the *Federal Register* on April 24, 1992. The K-25 Site NEPA procedures for tracking and training will be modified in response to recent Tiger Team findings and in response to DOE-OR Environmental Restoration and Waste Management NEPA implementation procedures that went into effect February 6, 1992.

The K-25 Site Atomic Vapor Laser Isotope Separation Environmental Assessment (EA) was approved by DOE on May 2, 1991. The Pond Waste Management Project Environmental Assessment was approved on September 27, 1991. The EAs for the Decontamination and Decommissioning and Cooling

Tower Removal and K-1414 In Situ Bioremediation projects have been submitted to DOE for review and approval. The EA Determinations for the K-1515 Sanitary Plant Modifications and ORR Storage Facility have been submitted to DOE for review and approval.

In conjunction with the NEPA review process, new projects at the K-25 Site are reviewed for compliance with the following statutes: Endangered Species Act, National Environmental Policy Act, National Historic Preservation Act, Executive Order 11988 Floodplain Management, Executive Order 11990 Protection of Wetlands. If determined necessary, surveys are requested and performed for verification and documentation of compliance.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The K-25 Site maintains compliance with FIFRA requirements through inspection of controlled pesticide/herbicide storage areas and review of the on-site, restricted-use application program. A FIFRA compliance manual has been developed that sets forth the requirements for compliance with FIFRA, documents inspections of FIFRA storage areas, and serves as the basis for developing a general procedure that will be included in the revised *Environmental Protection Manual.*

Safe Drinking Water Act (SDWA)

The K-25 Site operates a sanitary water system to provide potable water. This system consists of a raw water-pumping station on the Clinch River, a filtration and treatment plant, finished water storage tanks, and a distribution system. The facility operator has a Class IV Water Operator Certification from the state.

The Potable Water Facility, which is located south of the site, is in compliance with drinking water quality standards. The water is tested monthly and quarterly for various constituents and the results are reported to TDEC. The plant was inspected by TDEC on October 23, 1991, and received a numerical rating of 96, placing it among the state's approved water systems. Several small maintenance items and painting of the building and storage tanks need to be completed. These items are scheduled for completion in FY 1992. The supply of water is obtained from the Clinch River. The facility will require a new backwash treatment system to remove chlorine and suspended solids to comply with NPDES discharge requirements. This project is scheduled for FY 1994.

Release Reporting

Spills and unanticipated releases may trigger release reporting requirements under provisions of one or more of the following statutes: (1) EPCRA (also known as Title III of SARA), (2) CERCLA, (3) RCRA, (4) CWA, (5) CAA, (6) TSCA. Each spill event is evaluated for reporting requirements and regulatory agencies including federal, state, and local emergency response agencies are notified as appropriate.

To determine whether the K-25 Site had any reportable releases (i.e., those not federally permitted and exceeding the CERCLA reportable quantities), a compliance assessment of all releases or potential releases is conducted annually. No releases were identified at the K-25 Site.

CURRENT ISSUES

A number of specific compliance issues have been identified as a result of recent intensive efforts to attain full compliance. The significant issues are discussed below.

Discharges of Toxic Pollutants to Surface Waters

The K-25 Site has been listed by EPA and TDEC as a point-source discharger of toxic priority pollutants under CWA Sect. 304(l). Chlorine discharged to Mitchell Branch in once-through cooling water has been identified as a primary source of toxicity to the stream. Dechlorination units have been placed at selected storm drains to treat these discharges, and they have eliminated the toxic impact of chlorine on Mitchell Branch. Efforts to identify and eliminate minor toxic contributors are continuing.

Steam Plant Opacity Problems

The opacity problem at the K-25 Site Steam Plant has been resolved by replacing coal-fired boilers with gas-fired boilers. One gas-fired boiler was installed in 1990, and a second is expected to be installed in 1992. Actions have been taken to eliminate completely the use of coal at the K-25 Site.

The coal pile has been removed, and only natural gas and oil are used as fuels. No opacity exceedances have occurred this heating season.

Land Disposal Restricted (LDR) Waste

RCRA mixed, radioactive land ban waste (including some nonradiological classified land ban waste) has been stored in some areas at the K-25 Site for longer than 1 year. These wastes are currently subject to the land ban that permits storage only for accumulation of sufficient quantities to facilitate proper treatment, recycling, or disposal. This waste is being stored because of the nationwide shortage of treatment and disposal facilities for these types of waste. Private-sector technology demonstrations are being conducted that involve uranium extractions from sludge. DOE and EPA are continuing to discuss the issue, and the inventory of such waste is reported to the regulators on an annual basis. DOE-OR has initiated negotiations for an FFCA that would detail the steps needed to attain compliance. Case-by-case efforts that are being pursued with EPA by DOE may offer some relief to this situation.

Mixed TSCA Waste Storage

Uranium-contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by TSCA because of the lack of treatment and disposal capacities. The FFCA for PCB gaskets addresses this compliance issue for uranium enrichment facilities. It also addresses the approximately 10,000 pieces of nonradioactive PCB-containing dielectric equipment associated with the shutdown of diffusion plant operations. The FFCA for uranium enrichment facilities became effective February 20, 1992.

The K-1435 TSCA Incinerator that has been constructed at the K-25 Site will be capable of incinerating waste that is mixed or that contains PCBs. In 1990, a limited amount of waste was incinerated as a part of the startup testing. The incinerator began full operations in early 1991, and it met all regulatory requirements in processing 1.2×10^6 kg of mixed waste. Mixed TSCA waste is being generated in the ash residue at the TSCA Incinerator. Compliance issues regarding the management of the mixed PCB and radioactive waste generated in the ash are being pursued with EPA by DOE.

K-1417 Storage Yard

Sludges contaminated with low-level radioactivity are generated by settling and scrubbing operations and were stored in K-1407-B and K-1407-C ponds in the past. Sludges have been removed from these ponds, and portions have been fixed in concrete at K-1419 and stored above ground at K-1417.

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. Free liquid (water with a pH of 12) on top of the concrete in the drums was found to be causing the corrosion.

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 $96,004 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. Negotiation of an Agreed Order is in progress.

An action plan has been implemented to decant and/or dewater the mixed waste contained in the drums. Implementation of the Pond Waste Management Program (PWMP) action plan, coordinated with state and federal regulators, began in 1991 and will continue through February 1993. A total of 45,000 drums of stabilized material and 32,000 drums of raw sludge must be processed and moved to storage facilities that meet regulations governing mixed wastes.

Of the 77,000 total drums, 10,000 are currently stored in K-25 vaults and 67,000 are located at the K-1417A and B Drum Storage yards. The plan calls for all containers to be transferred to and stored in new and existing facilities, the K-1065 site and K-31 and K-33 buildings, respectively.

A public meeting was held in September 1991 regarding the management of the drums containing the waste. An Interim Record of Decision was signed by DOE and EPA Region IV in September 1991 regarding the pond waste management project.

PCB-Containing Ventilation System Gaskets

Lubricating oil that seeps through PCB-containing ventilation system gaskets in the shutdown process buildings and drips to the floor is considered a PCB spill. TSCA requires immediate cleanup action, documentation, and verification after discovery. New drips from ventilation gaskets are cleaned in general accordance with the EPA spill cleanup policy as contained in TSCA. This includes periodic inspections to identify leaks and initiation of cleanup within 24 hours. Sampling to verify cleanup, however, is performed only on a representative basis rather than for each spill as required by TSCA policy. Drip collection troughs are installed when leaks are discovered. DOE and EPA have signed an FFCA, effective February 20, 1992, to bring the facility into compliance with TSCA regulations for use, storage, and disposal of PCBs. A separate FFCA is being pursued with EPA to cover PCB waste not included in the current FFCA. Issues concerning the handling of mixed (radiologically contaminated) PCB waste is covered in the previous section titled Mixed TSCA Waste Storage.

National Pollutant Discharge Elimination System (NPDES) Permit

The NPDES permit for the K-25 Site expired on September 27, 1989. An application for a new permit was submitted before the expiration of the existing permit, as required by TDEC. Negotiations and development of a new permit are still being carried out by TDEC and the K-25 Site. A draft NPDES permit renewal was received from TDEC on December 26, 1990, and reviewed. K-25 Site comments were submitted in January 1991. The draft permit was placed on public notice on September 13, 1991; however, a public hearing on the permit was canceled. TDEC was planning to issue a second draft. A new permit writer was assigned and the negotiations have resumed.

Several NPDES permit exceedances attributed to natural causes are repeatedly occurring. The new NPDES permit will eliminate the need to monitor these parameters.

The Mitchell Branch dechlorinators began operating in June 1991, reducing total residual chlorine output from three storm drain systems.

On January 17, 1992, Friends of the Earth filed a lawsuit under the CWA for DOE Oak Ridge Sites NPDES violations in the U.S. District Court for the Eastern District of Tennessee, Northern Division. Many of the noncompliances listed in the lawsuit will be eliminated with the new permit.

Tiger Team Assessment

A DOE Tiger Team Assessment was conducted at the K-25 Site and DOE-OR between November 12 and December 18, 1991. A team of more than 70 specialists from various DOE offices, contractors, and consultants conducted the assessment. The Tiger Team was divided into three subteams: environment, safety and health, and management.

The K-25 Site was the fifth DOE facility managed by Energy Systems to undergo a Tiger Team assessment. (The others are the Y-12 Plant, ORNL, the Paducah Gaseous Diffusion Plant, and the Portsmouth Gaseous Diffusion Plant.) Many of the findings identified during the Tiger Team assessment are similar to those identified at the other Energy Systems sites and other DOE sites around the country. As described in the *K-25 Site Tiger Team Assessment Report*, a Tiger Team assessment is a snapshot in time. The problems that planned or in-progress improvements are designed to correct are identified as findings to ensure that the assessment documents a complete and accurate status of the condition of the K-25 Site.

In response to previous audits and Tiger Team assessments, Energy Systems has instituted a number of initiatives across all its facilities to improve management and tracking systems, to more clearly define roles and responsibilities, to improve communications, to clarify policies, and to improve policy implementation. In many cases, the Tiger Team acknowledged that progress has been made but that implementation was not complete. The K-25 Site's action plans must be considered in the context of these corporate-wide initiatives; every attempt is being made to ensure that actions executed at various levels in the organization are integrated and consistent.

The Tiger Team concluded that the K-25 Site's Self-Assessment Program had been extremely effective in disclosing site deficiencies. Eighty-five percent of the Tiger Team's findings had been fully or partially addressed by the K-25 Site

Self-Assessment Program. In all, the Tiger Team identified 298 findings in the 3 areas of review, including 103 environmental findings, 165 health and safety findings, 25 management findings, and 5 self-assessment findings.

The Tiger Team assessment identified three noteworthy practices; one was the first ever noteworthy practice for self assessment.

Pollution Prevention

Computer paper is being recycled from the K-25 Site Computer Technology Center. The program for recycling paper is being reviewed for expansion into nonradiological areas. Product substitutions at the paint shop and photography lab have resulted in a decrease of waste generation. No percentage of reduction has been calculated due to the lack of baseline data.

Uranium Heaxafluoride (UF_6) Cylinder Program

The Uranium Hexafluoride (UF_6) Cylinder Program is directed toward improving the safety and reliability of long-term storage for 7,000 cylinders at the K-25 Site. In storage at this site are approximately 5,000 10- and 14-ton cylinders of depleted UF_6, 1,000 cylinders of normal-assay feed UF_6, 400 heel-quantity cylinders (those containing more than 50 pounds of "enriched" material), and 600 miscellaneous empty cylinders.

The K-25 Site UF_6 Cylinder Program is being designed to develop a clear understanding of the current conditions of the cylinders and define any near- and long-term actions for safe storage of the cylinders pending decisions on ultimate disposition of the UF_6 material. Some of the initial actions in the program are a baseline inspection, a corrosion coupon program, and an ultrasonic thickness measurement program. The baseline inspection identified a variety of cylinder defects which will require special attention and also identified four breached cylinders. Immediate corrective actions have been taken to handle the breached cylinders and a schedule of activities has been developed for moving and repairing the cylinders.

The feed cylinders are currently being shipped to the Paducah Gaseous Diffusion Plant. The current DOE direction for the 5,000 depleted cylinders is to store them until at least the year 2020, at which time conversion to oxide will be performed if no other uses have been determined. A plan for cleaning the heel cylinders and empties has not yet been approved (this may be performed at the K-25 Site or at one of the operating gaseous diffusion plants).

Summary of Permits

RCRA,CWA, and CAA Permit Status

RCRA

Eleven RCRA permits were issued by TDEC in 1989. Ten of these permits are for RCRA storage units and one is for the closure of K-1407-B Pond. A RCRA permit for the TSCA Incinerator was issued in 1987.

The K-25 Site has entered into a consent order with TDEC to update and combine all Part B Permit applications into three applications. These three applications will consist of (1) the K-1435 TSCA Incinerator; (2) the K-1435 and K-1425 TSCA Incinerator storage and treatment units; and (3) all the other units at the K-25 Site combined. The K-1435 Incinerator and ten of the K-25 Site vaults have been permitted. The other units, with the exception of 16 recently added vaults, have operating status. The final permit application is scheduled for submittal to TDEC by May 31, 1992.

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CWA

K-25 Site is currently operating under an expired NPDES permit that was issued by TDEC.The NPDES permit for the K-25 Site expired on September 27, 1989. An application for a new permit was submitted before the expiration of the existing permit, as required by TDEC. Negotiations and development of

a new permit are still being carried out by TDEC and the K-25 Site.

CAA

Approximately 150 air sources from operations exist at the K-25 Site. Approximately 80 of these sources are permitted by TDEC. A review of all site air permits has been performed, and permits for nonoperational sources (47 to date) were deleted from the listing. Fifty permits may require resubmittal within the next 1 to 2 years.

The following permits are held at the K-25 Site: Eleven RCRA permits were issued by TDEC in 1989. Ten of these permits are for RCRA storage units and one is for the closure of K-1407-B Pond. A RCRA permit for the TSCA Incinerator was issued in 1987. Approximately 80 air permits issued by TDEC are presently held at the K-25 Site. The K-25 Site is currently operating under an expired NPDES permit that was issued by TDEC.

ACRONYMS AND ABBREVIATIONS

AA	atomic absorption
ACD	Analytical Chemistry Division
ACL	alternate concentration limit
ACN	acetonitrile
ADB	Ash Disposal Basin
ADI	acceptable daily intake
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AESG	Analytical Environmental Support Group
AGM	average geometric mean
ALARA	as low as reasonably achievable
Am	americium
AMAD	activity median aerodynamic diameter
ANAP	Abandoned Nitric Acid Pipeline
ARAR	applicable and appropriate requirements
As	arsenic
ASTM	American Society for Testing and Materials
ATDL	Atmospheric Turbulence and Diffusion Laboratory
ATLC	Atomic Trades and Labor Council
AVLIS	atomic vapor laser isotopic separation
BAT	best available technology
BC	Beaver Creek
BCBG	Bear Creek Burial Grounds
BCHR	Beaver Creek Hydrogeologic Regime
BCK	Bear Creek kilometer
BCV	Bear Creek Valley
BCVWDA	Bear Creek Valley Waste Disposal Area
BF	Brushy Fork
BMAP	Biological Monitoring and Abatement Programs
BMP	best management practices
BOD	biochemical oxygen demand
BRC	below regulatory concern
BTM	breakthrough monitors
CAA	Clean Air Act
CAPCA	Closure and Post Closure Activities
CARL	Comparative Animal Research Laboratory
CAS	Chemical Abstracts Service
CC	Copper Creek
CDI	calculated daily intake
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CH	contact-handled
Ci	curie

CLP	Contract Laboratory Program
Cm	curium
CNF	Central Neutralization Facility
Co	cobalt
COD	chemical oxygen demand
CPCF	Central Pollution Control Facility
CRDL	contract-required detection limit
CRHR	Chestnut Ridge Hydrogeologic Regime
CRK	Clinch River kilometer
CRM	Clinch River mile
CRRI	Clinch River Remedial Investigation
CRSDP	Chestnut Ridge Sediment Disposal Basin
CRSP	Chestnut Ridge Security Pits
Cs	cesium
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
CYRTF	coal yard runoff treatment facility
DAC	derived air concentration
DCF	dose conversion factor
DCG	derived concentration guide
diam	diameter
DMR	discharge monitoring report
DNA	deoxyribonucleic acid
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DWL	drinking water limits
EA	Environmental Assessment
EAP	Environmental Assessment Plan
ECRWP	East Chestnut Ridge Waste Pile
EDE	effective dose equivalent
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EIS	Environmental Impact Statement
EMD	Environmental Management Department
EML	Environmental Measurements Laboratory
EMSL-LV	Environmental Monitoring System Laboratory at Las Vegas
ENE	east–northeast
Energy Systems	Martin Marietta Energy Systems, Inc.
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
ERDS	Environmental Review and Documentation Section
ERP	Environmental Restoration Program
E&SA	Environmental and Safety Activities
ESD	Environmental Sciences Division
ESP	Environmental Surveillance and Protection
ET&I	Equipment Testing and Inspection Division
FAC	free available chlorine
FDA	Food and Drug Administration

FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	feasibility study
FWPCA	Federal Water Pollution Control Act
FY	fiscal year
GQM	groundwater quality monitoring
GUT	garage underground tank
GW	groundwater
GWPP	Groundwater Protection Program
GWPS	Groundwater Protection Standard
GWQAP	groundwater quality assessment plans
GWQAR	groundwater quality assessment reports
H	hydrogen
HAP	hazardous air pollutants
HAZWDDD	Hazardous Waste Development, Demonstration, and Disposal
HAZWRAP	Hazardous Waste Remedial Actions Program
HCK	Hinds Creek kilometer
HEPA	high-efficiency particulate air
HFIR	High Flux Isotope Reactor
Hg	mercury
HRE	Homogenous Reactor Experiment
HSWA	Hazardous and Solid Waste Amendments
HWDU	hazardous waste disposal unit
I	iodine
IAG	interagency agreement
IBI	Index of Biotic Integrity
ICP	inductively coupled plasma
ICRP	International Commission on Radiological Protection
IRIS	Integrated Risk Information System
ISV	in situ vitrification
IWC	instream waste concentration
IWMF	Interim Waste Management Facility
K-25 Site	Oak Ridge K-25 Site
K	Kingston
KHQ	Kerr Hollow Quarry
Kr	krypton
LCR	lowest concentration reported
LDR	land disposal restricted
LLLW	liquid low-level waste
LLW	low-level waste
LLWDDD	low-level waste disposal development and demonstration
LLWDF	Low-Level Waste Disposal Facilities
LSF	Liquid Storage Facility
MAA	material access area
MACT	Maximum Achievable Control Technology
MB	Melton Branch

MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limits
MHD	Melton Hill Dam
MSRE	Molten Salt Reactor Experiment
MT	meteorological tower
NAS	National Academy of Sciences
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
ND	not detected
NDB	Numeric Data Base
NE	northeast
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHP	New Hope Pond
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NNE	north–northeast
NOAA	National Oceanic and Atmospheric Administration
NOEC	no-observed-effect concentration
NOV	Notice of Violation
Np	neptunium
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
NRWTF	Nonradiological Wastewater Treatment Facility
NWT	Northwest Tributary
O&G	oil and grease
OLF	Oil Landfarm Area
OR	Oak Ridge Field Office
ORAU	Oak Ridge Associated Universities
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRER	Oak Ridge Reservation Environmental Report
ORS	Occurrence Reporting System
Pa	protactinium
PA	preliminary assessment
PAM	perimeter air monitoring
Pb	lead
PC	Pond Closure
PCB	polychlorinated biphenyl
PCK	Poplar Creek kilometer
PCP	pentachlorophenol
PET	Proficiency Environmental Testing
PGDP	Paducah Gaseous Diffusion Plant
PIDAS	Perimeter Intrusion Detection and Alarm System
PM10	particulate matter less than 10 microns in diameter
PRTF	Plating Rinsewater Treatment Facility
Pu	plutonium
pvc	polyvinyl chloride

PWA	Process Waste Assessment
PWTF	Process Waste Treatment Facility
PWTP	process waste treatment plant
QA	quality assurance
QC	quality control
Ra	radium
RAM	remote air monitoring
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
R&D	research and development
REDC	Radiochemical Engineering Development Center
RFA	RCRA Facility Assessment
RfD	reference dose
RFI	RCRA facility investigation
RH	remote-handled
RMA	Rocky Mountain Arsenal
RMP	radiological monitoring plan
RMPE	Reduction of Mercury in Plant Effluent
ROD	Record of Decision
RWMD	Reservation Waste Management Division
S-3	S-3 Site
S&A	sampling and analysis
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Se	selenium
SE	standard error of the mean
SERAM	Stack Emission Reduction and Monitoring Project
SF	slope factor
SIE	specific ion electrode
SLF	sanitary landfill
SMCL	secondary maximum contaminant level
SO	sulfur dioxide
SOP	standard operating procedure
SPAD	Steam Plant Ash Disposal
SPCC	Spill Prevention, Control, and Countermeasures
SPWTF	Steam Plant Wastewater Treatment Facility
Sr	strontium
STP	sewage treatment plant
SW	southwest
SWDF	solid waste disposal facility
SWMU	solid waste management unit
SWSA	solid waste storage areas
Tc	technetium
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TCMP	toxicity control and monitoring program
TDC	Tennessee Department of Conservation
TDEC	Tennessee Department of Environment and Conservation (formerly TDC)
TDS	total dissolved solids

Th	thorium
TOC	total organic carbon
TOX	total organic halogens
TRC	total residual chlorine
TRE	Toxicity Reduction Evaluation
TRK	Tennessee River kilometer
TRM	Tennessee River mile
TRU	transuranic
TRV	thermal relief valve
TSCA	Toxic Substances Control Act
TSF	Tower Shielding Facility
TSP	total suspended particulates
TSS	total suspended solids
TSWMA	Tennessee Solid Waste Management Act
TURF	Thorium-Uranium Process Facility
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
U	uranium
UEFPC	Upper East Fork Poplar Creek
UEFPCHR	Upper East Fork Poplar Creek Hydrogeologic Regime
UF	uranium hexafluoride
UNC	United Nuclear Corporation
USGS	United States Geological Survey
UST	underground storage tank
VC7002	Vehicle Cleaning Facility
VOA	volatile organic aromatics
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area grouping
WCK	White Oak Creek kilometer
WCPA	Waste Coolant Processing Area
WCPF	Waste Coolant Processing Facility
WETF	West End Treatment Facility
WIPP	Waste Isolation Pilot Plant
WMA	Waste Management Area
WMCBF	Waste Machine Coolant Biodegradation Facility
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
WOD	White Oak Dam
WOL	White Oak Lake
WOM	White Oak Mountain
WSW	west–southwest
WTF	Waste Treatment Facility
Xe	xenon
Y-12 Plant	Oak Ridge Y-12 Plant

UNITS

µCi	microcurie
µg	microgram
Bq	Becquerel
Btu	British thermal unit
cfm	cubic feet per minute
Ci	curie
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
CY	calendar year
d	day
ft	foot
ft^2	square foot
ft^3	cubic foot
FY	fiscal year
g	gram
gal	gallon
gpd	gallons per day
gpm	gallons per minute
h	hour
ha	hectare
in.	inch
kg	kilogram
km	kilometer
km^2	square kilometer
L	liter
lb	pound
m	meter
M	million
m^2	square meter
m^3	cubic meter
mCi	millicurie
mg	milligram
Mgd	million gallons per day
mil	1/1000 in.
$mile^2$	square mile
min	minute
mL	milliliter
mm	millimeter
mrad	millirad
mrem	millirem
NTU	nephelometric turbidity unit
pCi	picocurie
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
psi	pounds per square inch
R	roentgen
s	second
SU	standard unit
°C	degrees celsius
°F	degrees Fahrenheit
yd^3	cubic yard

CONVERSION TABLE

Multiply	By	To obtain	Multiply	By	To obtain
acre	0.405	ha	ha	2.47	acres
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mile	1.61	km	km	0.621	mile
lb	0.4536	kg	kg	2.205	lb
liq qt-U.S.	0.946	L	L	1.057	liq qt-U.S.
ft^2	0.093	m^2	m^2	10.764	ft^2
$mile^2$	2.59	km^2	km^2	0.386	$mile^2$
ft^3	0.028	m^3	m^3	35.31	ft^3
Bq	27	pCi	pCi	0.037	Bq
nCi	1×10^3	pCi	pCi	1×10^{-3}	nCi
dpm/L	0.45×10^{-9}	µCi/cm^3	µCi/cm^3	2.22×10^9	dpm/L
pCi/L (water)	10^{-9}	µCi/mL (water)	µCi/mL (water)	10^9	pCi/L (water)
pCi/m^3 (air)	10^{-12}	µCi/cm^3 (air)	µCi/cm^3	10^{12}	pCi/m^3 (air)
mCi/km^2	1	nCi/m^2	nCi/m^2	1	mCi/km^2
sievert (Sv)	100	rem	rem	0.01	sievert (Sv)

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1. RESERVATION DESCRIPTION AND SETTING

This report provides information regarding the impacts of the U.S. Department of Energy's (DOE's) Oak Ridge Reservation (ORR) facilities on the public and the environment. It describes the environmental surveillance and effluent monitoring activities conducted at and around facilities operated by Martin Marietta Energy Systems, Inc. (Energy Systems), for DOE. Preparation and publication of this report is in accordance with DOE Order 5400.1. The order specifies the report's content and a publication deadline of June for data from the previous calendar year.

The primary objective of this report is to summarize all information collected for the previous calendar year regarding effluent monitoring, environmental surveillance, and estimates of radiation and chemical dose to the surrounding population. When multiple years of information are available for a program, trends are also evaluated. The first seven sections of Vol. 1 of this report address this objective. The last three sections of Vol. 1 provide information on special environmental studies, solid waste management, and quality assurance programs. Chemicals covered by the Superfund Amendments and Reauthorization Act (SARA) Title III, Section 313, report on gaseous emissions are included in Appendix A. Corrections and amendments to the 1990 report are discussed in Appendix B. Volume 2 is a compilation of the data that are summarized in Vol. 1 and includes some relevant descriptive reference material that does not change from year to year. Volume 2 is not intended to be a stand-alone report.

Although located within the corporate limits of the city of Oak Ridge in eastern Tennessee, the ORR site is predominantly to the west and south of the population center of Oak Ridge. The reservation consists of about 14,300 ha (35,300 acres) of federally owned lands. The city and the reservation are shown on the map of Tennessee in Fig. 1.1.

Oak Ridge lies in a valley between the Cumberland and southern Appalachian mountain ranges and is bordered on one side by the Clinch River. The Cumberland Mountains are about 16 km (10 miles) to the northwest; the Great Smoky Mountains are approximately 113 km (70 miles) to the southeast as shown in Fig. 1.1.

1.1 OPERATIONS ON THE OAK RIDGE RESERVATION

The ORR contains three major operating facilities: 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 locations of these three facilities are shown in Fig. 1.2. The on-site DOE buildings and structures outside the major plant sites consist of the Scarboro Facility, Clark Center Recreational Park, Central Training Facility, and the Transportation Safeguards Division maintenance facility. The off-site DOE buildings and structures consist of the Federal Office Building, Office of Scientific and Technical Information, Oak Ridge Institute of Science and Education (ORISE), Atmospheric Turbulence and Diffusion Division—National Oceanographic and Atmospheric Administration, the American Museum of Science and Energy, Energy Systems administrative support office buildings, and the former museum building. The administrative units (units managed by a major installation or by central Energy Systems) on the ORR are listed in Table 1.1. of Vol. 2.

1.1.1 Y-12 Plant

The Y-12 Plant (Fig. 1.3) is immediately adjacent to the city of Oak Ridge and has five major responsibilities: (1) to fabricate nuclear weapons components, (2) to process source and special nuclear materials, (3) to provide support to the weapons design laboratories, (4) to provide support

ORNL-DWG 87M-7844R2

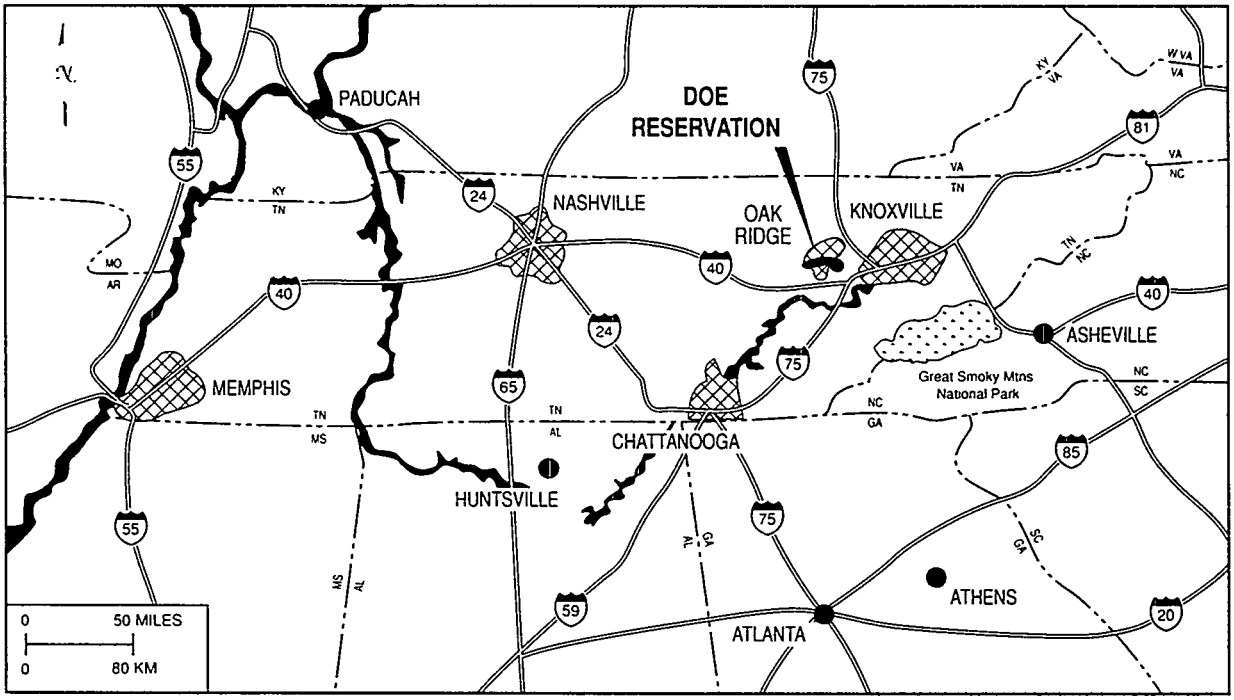

Fig. 1.1. Map showing location of Oak Ridge and the Oak Ridge Reservation in relationship to geographic region.

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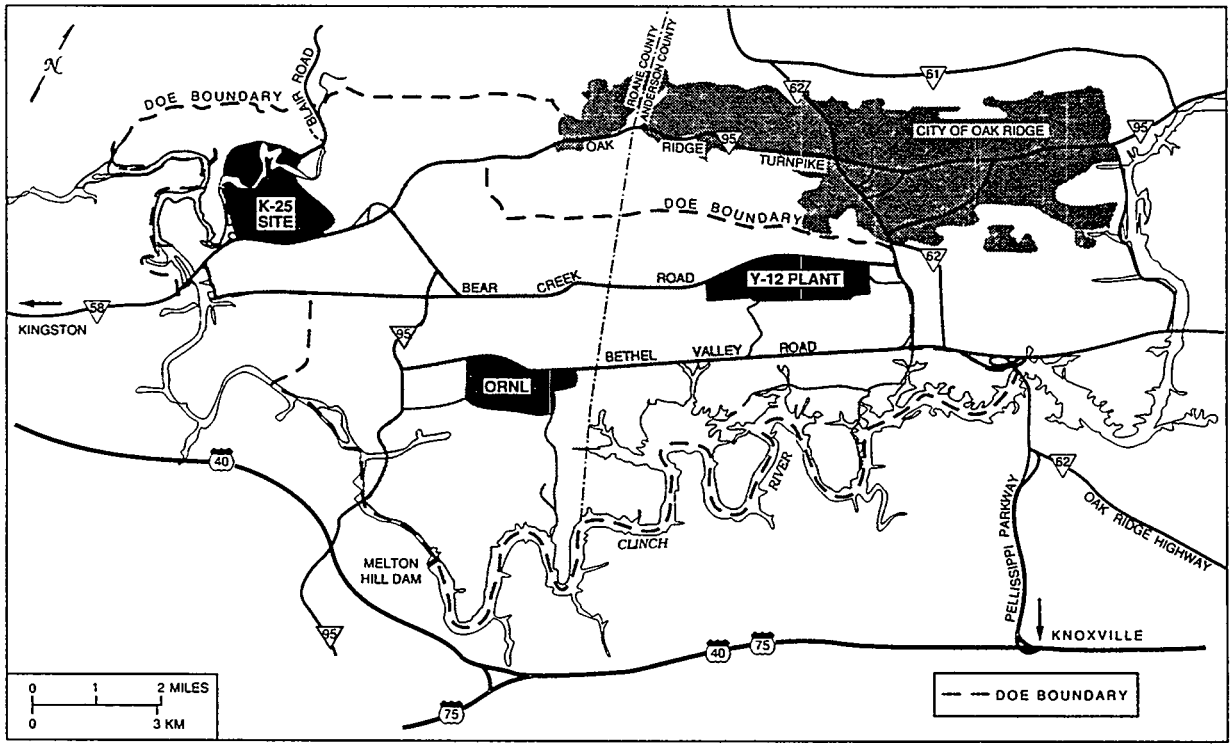

Fig. 1.2. Map showing the Department of Energy's Oak Ridge Reservation and the location of the three major installations.

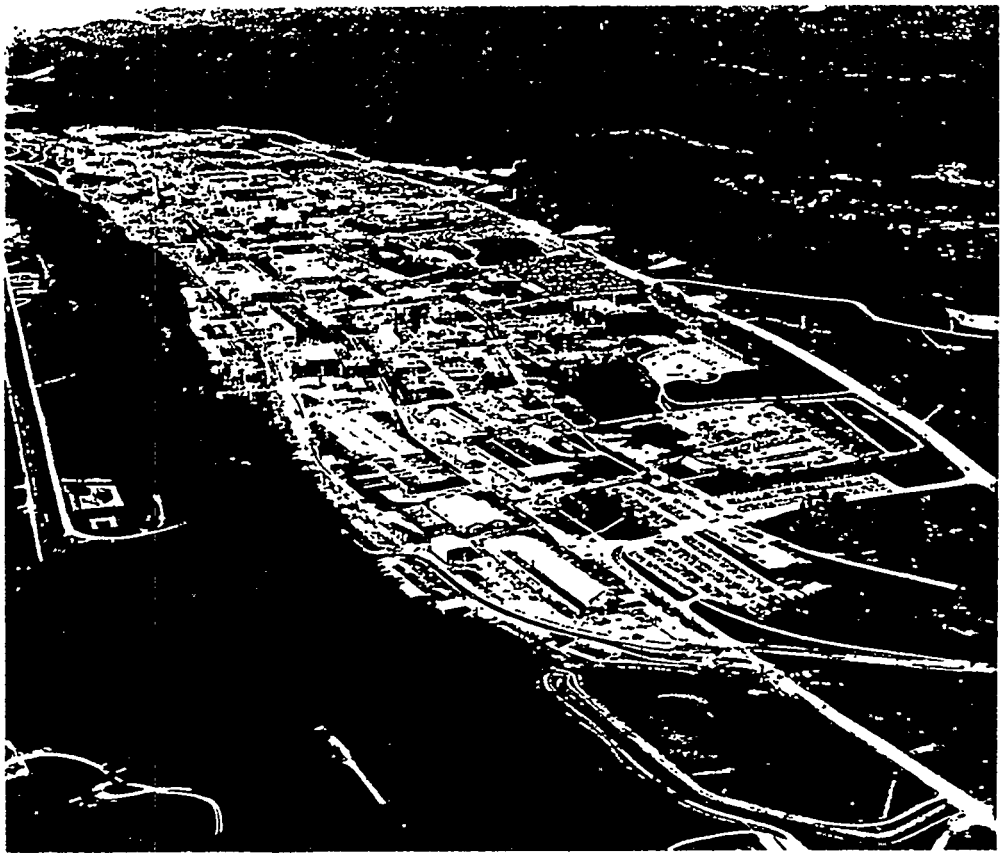

Fig. 1.3. Oak Ridge Y-12 Plant (view looking northwest).

to other Energy Systems installations, and (5) to provide support to other government agencies. Activities associated with these functions include production of lithium compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

The 1990s are expected to be a period of change for the Y-12 Plant. A slowdown in actual weapons production is anticipated, but a significant increase in weapons disassembly should occur, accompanied by significant facility modifications and upgrades as a result of the consolidation of the DOE weapons production complex. In addition, the Y-12 Plant will also play a dominant role in transferring expertise in modern manufacturing practices to private industry.

1.1.2 Oak Ridge National Laboratory

ORNL (Fig. 1.4), located toward the west end of Bethel Valley, is a large, multipurpose research laboratory whose basic mission is to expand knowledge, both basic and applied, in areas related to energy. ORNL's facilities include nuclear reactors, 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 is managed by ORNL, and the ORNL Biology and Fusion Energy divisions and staff from other ORNL divisions are located at the Y-12 Plant. The Applied Technology Division is located at the K-25 Site. All of ORNL's reactors were shut down in 1986 while efforts were under way to improve operating procedures and safety standards for the facilities. The High Flux Isotope

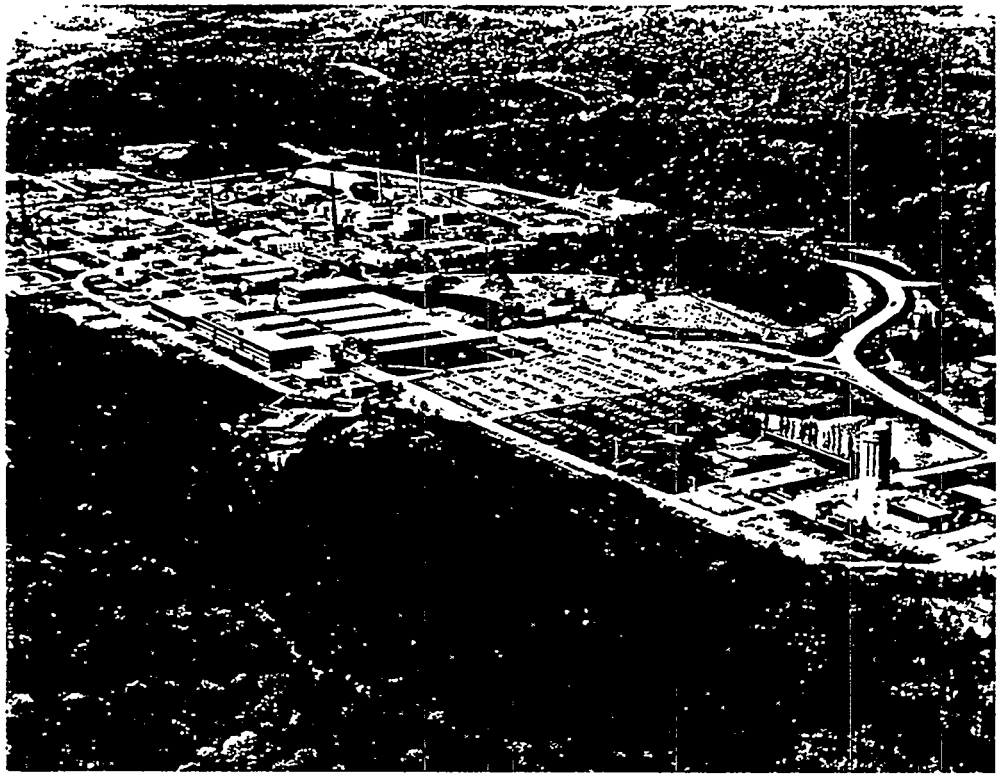

Fig. 1.4. Oak Ridge National Laboratory (view looking west).

Reactor (HFIR) and the Tower Shielding Facility (TSF) resumed operation in 1990.

1.1.3 K-25 Site

Until the summer of 1985, the primary mission of the K-25 Site (Fig. 1.5) was enrichment of uranium hexafluoride (UF_6) in the ^{235}U isotope for use as a fuel in nuclear reactors. The gaseous diffusion process was utilized to produce the enrichment services. In August 1985, the gaseous diffusion process at the K-25 Site was placed in a "ready standby" mode because of declining demands for enriched uranium. The decision to permanently shut down the gaseous diffusion cascade was made in December 1987.

In addition to operating the gaseous diffusion process, K-25 Site personnel were involved in developing and demonstrating more energy-efficient and cost-effective methods for uranium enrichment. Two such methods under development at the K-25 Site were the gas centrifuge process and the atomic vapor laser isotopic separation (AVLIS) system. In 1985 the gas centrifuge process was shut down, and in 1986 the AVLIS work at the K-25 Site was significantly reduced.

Major changes in the role of the K-25 Site began evolving during 1986 and 1987. A significant increase in work for agencies other than DOE is projected in the future. The unique technologies, expertise, and facilities at the K-25 Site constitute a national resource that can effectively be used to solve problems of national importance in areas that complement the ongoing DOE missions. Although enrichment operations at the K-25 Site are shut down, some waste streams are being generated, and wastes now in storage will require disposal in the future.

Waste management activities at the K-25 Site are increasing. Low-level radioactive wastes from other DOE-Oak Ridge Field Office (OR) sites are being placed in K-25 building vaults until a final disposition strategy is identified. Also, polychlorinated biphenyl (PCB) wastes and Resource Conservation and Recovery Act (RCRA) wastes contaminated with uranium began arriving from other DOE-OR sites in 1987 for incineration in

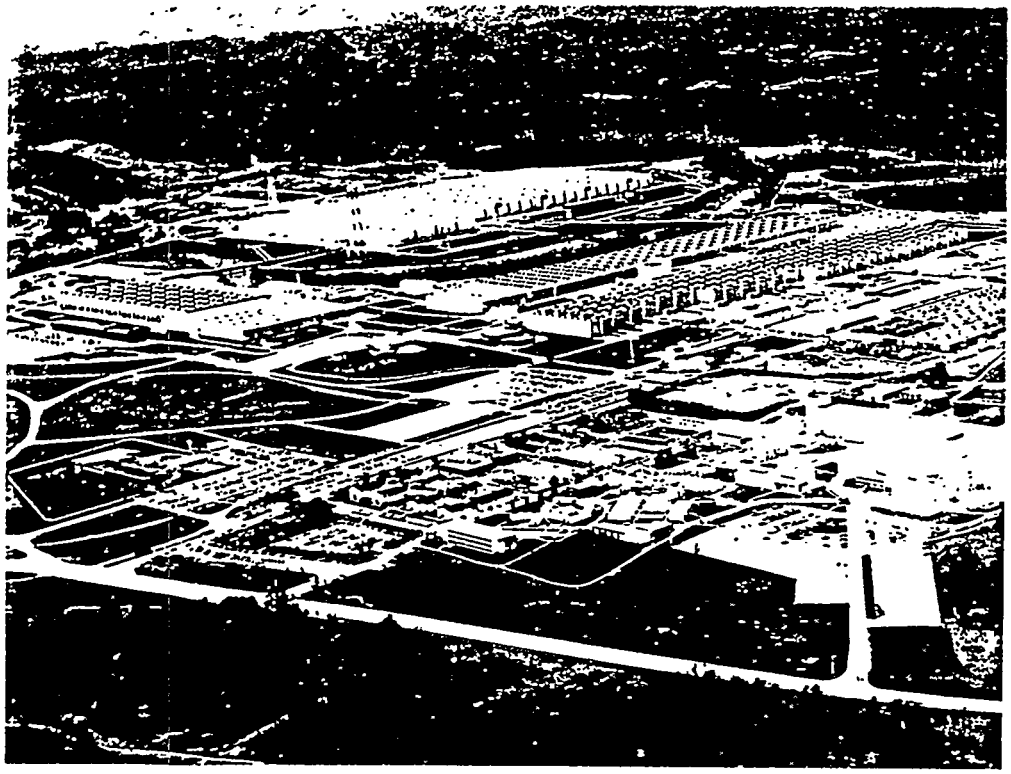

Fig. 1.5. Oak Ridge K-25 Site (view looking northwest).

the K-1435 Toxic Substances Control Act (TSCA) Incinerator.

Other remaining missions at the K-25 Site include advanced enrichment technology research and development, analytical laboratory programs, engineering and computer support, and waste treatment services.

1.1.4 Oak Ridge Institute for Science and Education

ORAU, a not-for-profit consortium of 62 colleges and universities, manages and operates the Oak Ridge Institute for Science and Education (ORISE) for DOE. Among its diverse activities, ORISE has stewardship responsibility for two tracts on the southeastern border of the ORR that from the late 1940s to the mid-1980s were part of an agricultural experiment station owned by the federal government and, until 1981, operated by the University of Tennessee.

The first tract, the South Campus, 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. Air emissions through laboratory hoods are beneath permitting limits. The amount of radioactive material used there is below reportable quantities, and no liquid radioactive wastes were discharged in 1991. ORISE is classified under RCRA as a Conditionally Exempt Small Quantity Generator, and its site accumulation area is located in the old Scarboro School.

The Freels Bend tract consists of about 101 ha (250 acres) on the northeastern edge of Freels Bend abutting Melton Hill Lake. Although no programmatic activities are conducted at this site, ORISE does provide maintenance and security, including security for the decommissioned system of ^{60}Co sources at the Variable Dose Rate Irradiation Facility.

1.1.5 Waste Management at DOE Facilities

Operations associated with the DOE research and production facilities in Oak Ridge produce several types of waste materials. Radioactive wastes

are generated from nuclear research activities, weapons production, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, and uranium processing operations. Nonradioactive (including hazardous) wastes are generated by normal industrial-type support facilities and operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plants, and steam plants.

Nonradioactive, nonhazardous solid wastes are buried in the Tennessee Department of Environment and Conservation (TDEC)–permitted Centralized Sanitary Landfill II, operated by the Y-12 Plant, or in other designated burial areas. Hazardous wastes are shipped to approved disposal sites off the ORR or are stored on-site. Radioactive solid wastes that are managed on-site are placed either in retrievable storage units or in disposal units, depending on the type and quantity of radioactive material present.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques before they are released to the atmosphere.

At all of the sites some of the liquid radioactive wastes are treated and then released according to procedures and the remaining liquid radioactive wastes are contained in tanks for ultimate disposal. After treatment, process water is discharged under National Pollutant Discharge Elimination System (NPDES) permits to White Oak Creek, Poplar Creek, and upper East Fork Poplar Creek, which are small tributaries of the Clinch River.

1.2 REGIONAL DEMOGRAPHY

Except for the city of Oak Ridge (pop. 27,000) the land within 8 km (5 miles) of the ORR is predominantly rural and is used largely for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are favorite recreational activities in the area. The approximate location and population of the towns nearest the ORR are Oliver Springs (pop. 3400), 11 km (6.8 miles) to the northwest; Clinton (pop. 9000), 16 km (10 miles) to the northeast; Lenoir City (pop. 6100), 11 km (6.8 miles) to the southeast; Kingston (pop. 4600), 11 km (6.8 miles) to the southwest; and Harriman (pop. 7100), 13 km (8 miles) to the west. Population levels are based on 1990 U.S. census data (U.S. Department of Commerce 1991). Figure 1.6 shows the locations of these towns. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km (25 miles) to the east and has a population of approximately 165,000. Table 1.2 of Vol. 2 lists cities and population centers within an 80-km (50-mile) radius of the ORR. Directional 80-km-radius population density maps are shown in Figs. 1.7 and 1.8. Figures 1.1 and 1.2 of Vol. 2 show population levels within 80 km of the ORR by sector. The center of these figures is the center of the ORR, and most of the area within an 8-km (5-mile) radius is part of the ORR. Fewer than 13,000 people live within 8 km of the ORR center. The Tennessee Valley Authority (TVA) Melton Hill and Watts Bar reservoirs on the Clinch and Tennessee rivers form the eastern, southern, and western boundaries of the ORR, and the residential sector of Oak Ridge forms the northern boundary.

1.3 CLIMATIC AND ATMOSPHERIC PROCESSES

The nearby Cumberland and Great Smoky mountains have a moderating influence on the climate of the ORR. The mountains frequently divert hot, southeasterly winds that develop along the southern Atlantic coast away from this region. In general, this results in warm, humid summers and cool winters, with no noticeable extremes in precipitation, temperature, or winds. Spring and fall are typically long, and the weather is normally sunny with mild tmeperatures. Severe storms such as tornadoes or high-velocity winds are rare.

1.3.1 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 approximately 3.3°C (38°F) but occasionally dipping as low as –17°C (0°F). Temperature differences between December through February are minor, however. July is typically the hottest month of the year with temperatures averaging 77°F but occasionally peaking at over 37.8°C (100°F). Average daily temperatures fluctuate 12°C (53.6°F) over the course of the year (Davis et al. 1984).

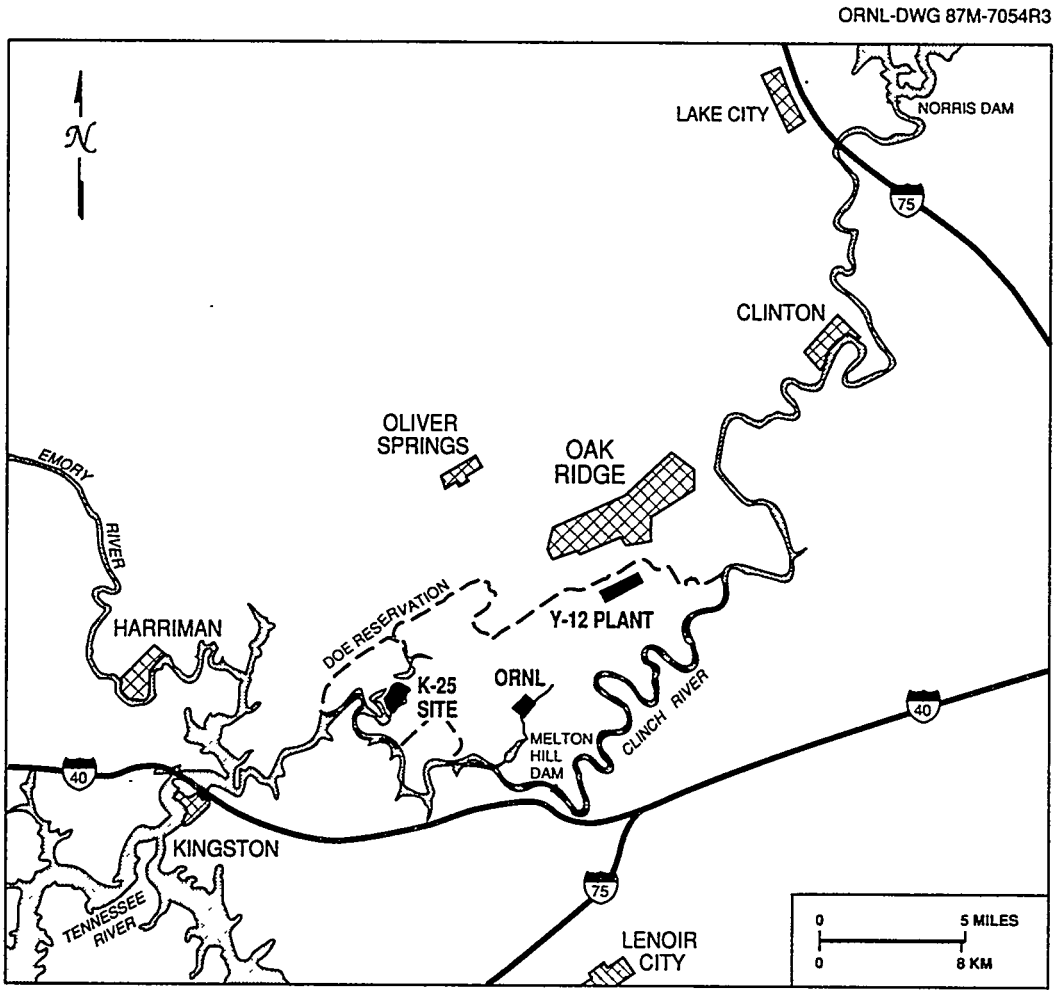

Fig. 1.6. Location map of towns nearest the Oak Ridge Reservation.

1.3.2 Winds

Winds in the Oak Ridge area are controlled in large part by the valley and ridge topography. Prevailing winds are either up-valley (northeasterly) or down-valley (southwesterly); daytime winds typically blow up-valley while nightime winds blow down-valley. Tornadoes and high-velocity winds are rare; wind speeds are less than 11.9 km/h (7.4 mph) 75% of the time, and wind speeds exceeding 30 km/h (18.5 mph) are rare.

1.3.3 Precipitation

Precipitation varies both within and between years, as shown in Fig. 1.9. The 40-year annual average precipitation (water equivalent) is 1.37 m (53.75 in.), including approximately 0.26 m (10.4 in.) of snowfall, with monthly precipitation peaking in January and February. Winter storms are generally of low intensity and long duration. Another peak in rainfall occurs in July when short, heavy rains associated with thunderstorms are common. Typically in October, slow-moving high-pressure cells suppress rain and, while remaining nearly stationary for many days, provide mild, clear, dry weather. Poor air dilution (and thus the primary air pollution episodes) occurs with the greatest frequency and severity during this period. Precipitation in 1991 was 1.53 m (60.16 in.), about 0.15 m (5.8 in.) above the annual average.

1.3.4 Evapotranspiration

Regionally, annual evapotranspiration has been estimated to range from 81 to 89 cm (32 to 35 in.), or 60 to 65% of rainfall (Farnsworth et al. 1982).

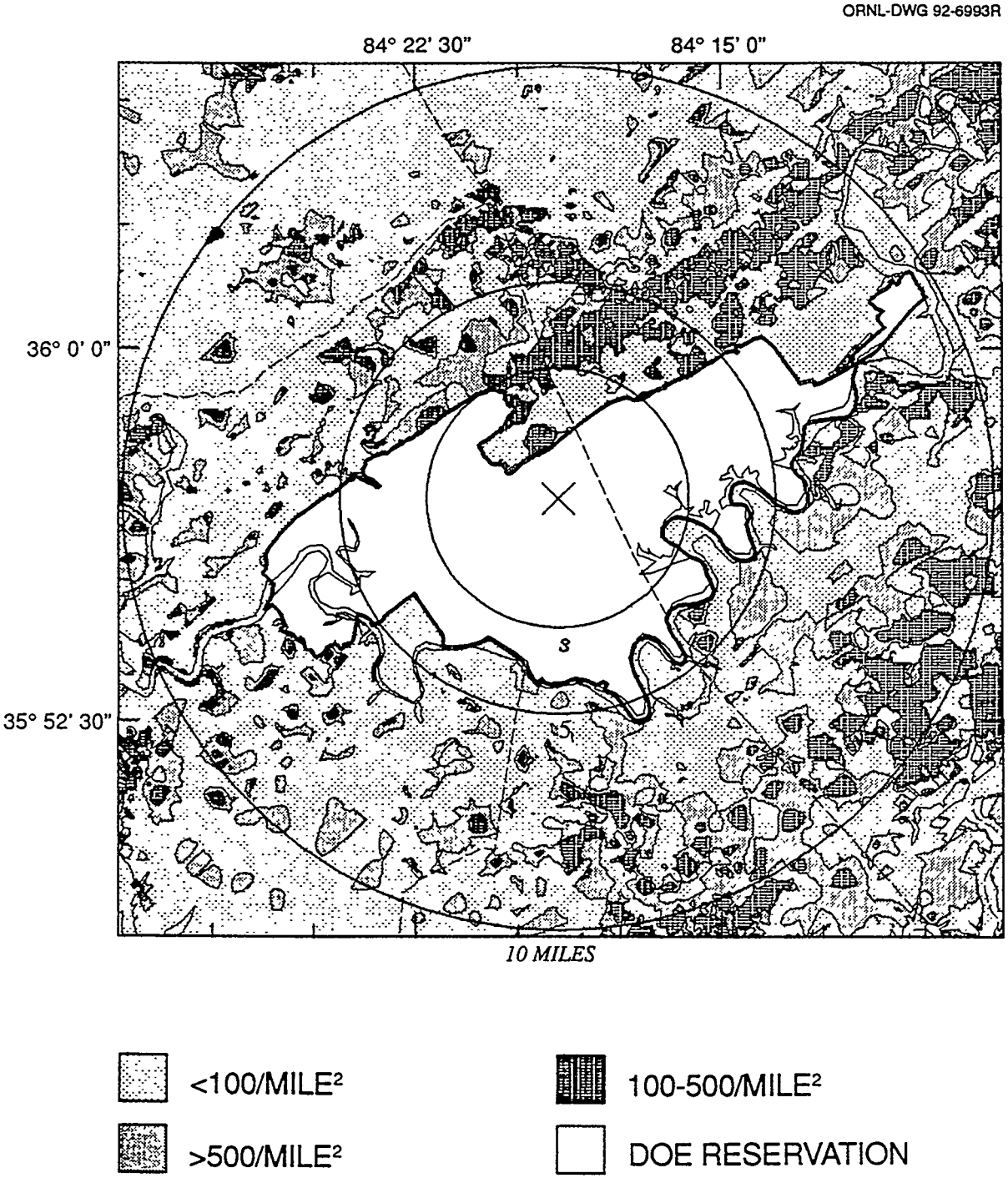

Fig. 1.7. Projected 1991 population densities within 16 km (10 miles) of the center of the Oak Ridge Reservation, based on 1990 census data (U.S. Department of Commerce 1991).

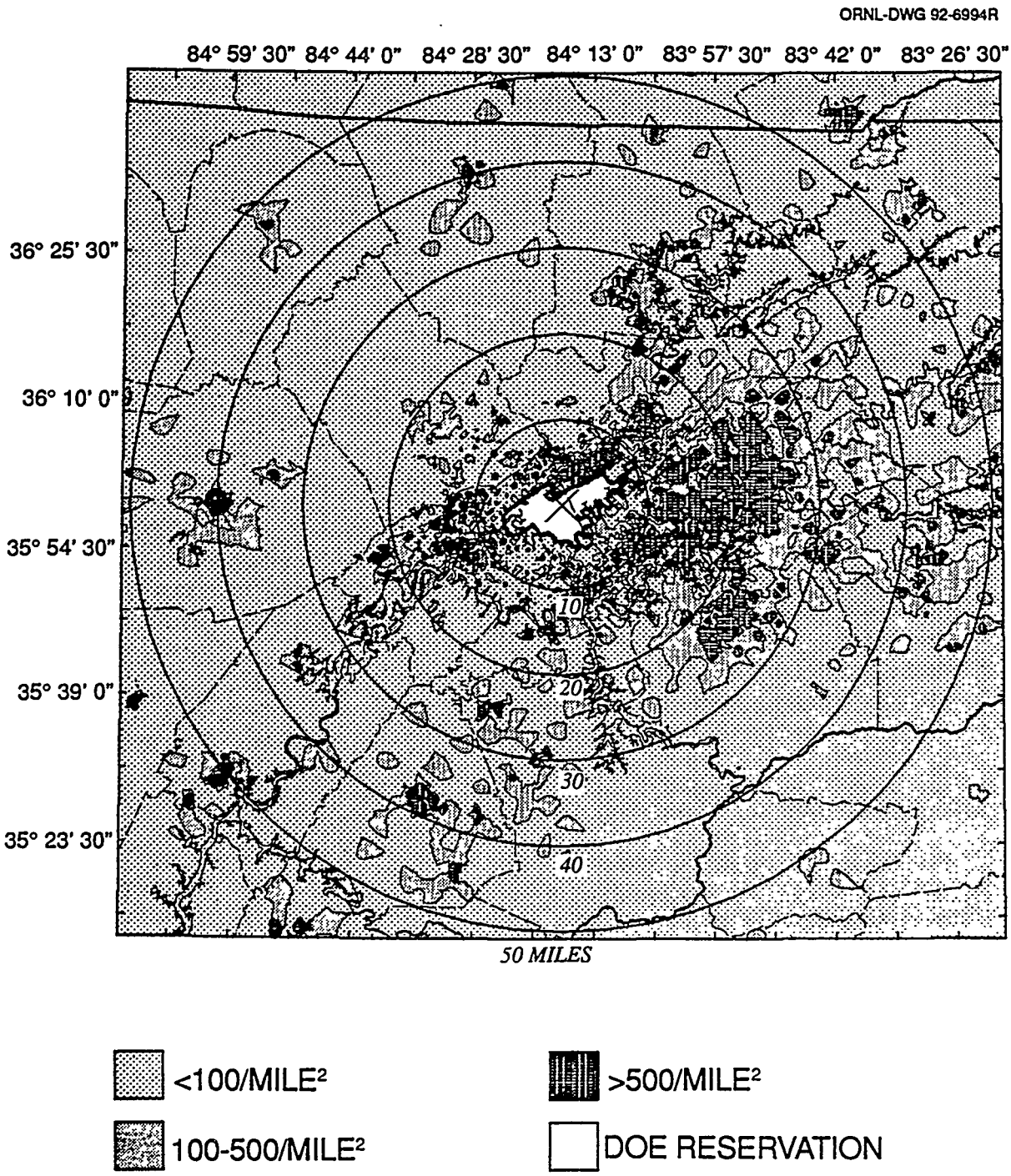

Fig. 1.8. Projected 1991 population densities within 80 km (50 miles) of the Oak Ridge Reservation, based on 1990 census data (U.S. Department of Commerce 1991).

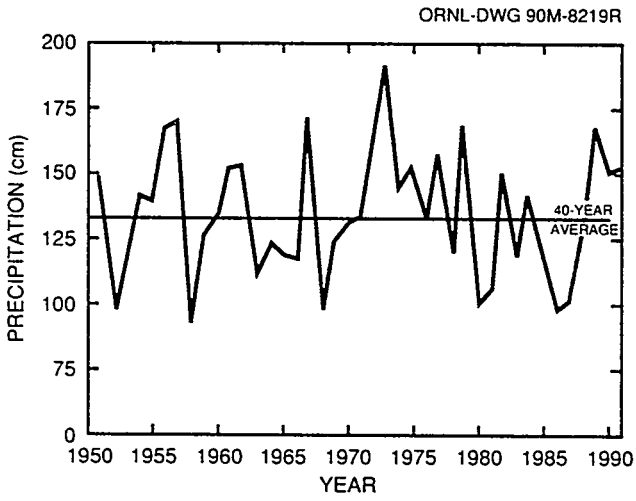

Fig. 1.9. Annual precipitation history of the Oak Ridge area.

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 variable within any given year and is greatest in association with the growing season, which in the vicinity of the ORR averages 220 days from April through September. During this period, evapotranspiration often exceeds the rate of precipitation resulting in soil moisture deficits.

1.4 GEOLOGY

The ORR is located in the Tennessee section of the Valley and Ridge Province, which is part of the southern Appalachian fold and thrust belt [Fig. 1.10 (and Fig. 1.3 of Vol. 2)]. The area is characterized by a succession of northeast-trending thrust faults that structurally stack and replicate the Paleozoic rocks of this area (Fig. 1.11; Fig. 1.12; and Fig. 1.4 of Vol. 2). As a result of thrusting and subsequent differential erosion, a series of valleys and ridges have formed that parallel the thrust faults. In general, the more-resistant siltstone, sandstone, and dolomite units form the region's ridges; the less-resistant shales and shale-rich carbonates underlie its valleys.

1.4.1 Stratigraphy

Throughout the ORR, differential erosion and weathering has resulted in an overall geologic sequence where competent bedrock is overlain by a mantle of regolith (characterized by weathered, unconsolidated materials formed in-place through chemical and physical weathering of the underlying parent bedrock), which is in turn overlain by a veneer of soils or alluvial sediments. In many of the operational areas on the ORR, the natural soil and regolith have been disturbed, removed, reworked, or replaced by fill materials.

The bedrock stratigraphy of the ORR, in ascending order, includes the Lower Cambrian Rome Formation, the Cambrian Conasauga Group, the Cambron-Ordovician Knox Group, and the Middle Ordovician Chickamauga Group. Younger Upper Ordovician to Mississipian rocks are exposed locally in the cores of two synclines north of the White Oak Mountain Thrust Fault (Fig. 1.11). Although minor carbonate beds are found through the Conasauga Group bedrock, the principal carbonate formations on the ORR are the upper Conasauga Group Maynardville Limestone, Chickamauga Group limestones, and the Knox Group. Other formations on the ORR are characterized by silty sandstones, siltstones, and limey siltstones and shales.

1.4.2 Structural Framework

The ORR is located in a foreland fold and thrust belt. As a result, its geology is strongly influenced by structural features at all scales, including regional thrust faults, local thrust, normal and tear faults, local folding of relatively weak bedrock units, and widespread fracture development. The large-scale fault features were formed during the Permian-Pennsylvanian age Alleghenian Orogeny and are not active structures.

Although fracture formation has occurred at various times ranging from the Ordovician period (i.e., from initial deposition and burial) to the present (as a result of unloading associated with erosion and unroofing processes), the Alleghenian Orogeny was probably the strongest influence on fracture development.

Three principal fracture orientations are noted on the ORR based upon bedrock outcrop mapping (Fig. 1.13). One fracture set is parallel to strike of

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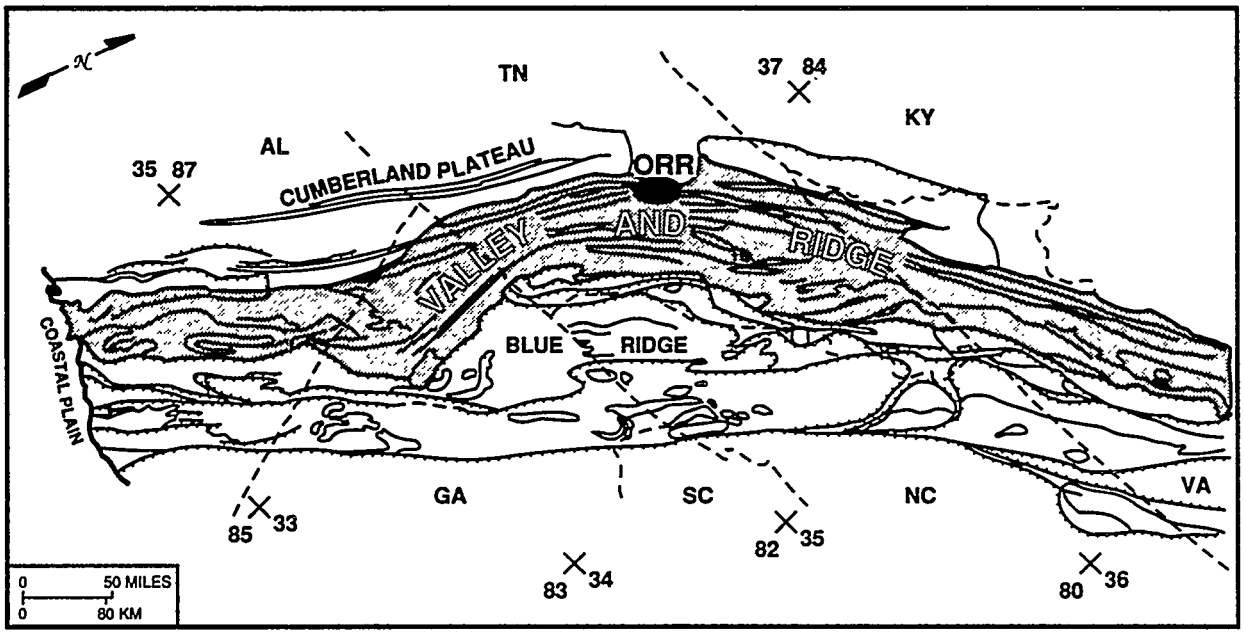

Fig. 1.10. Geology of the southern Appalachians.

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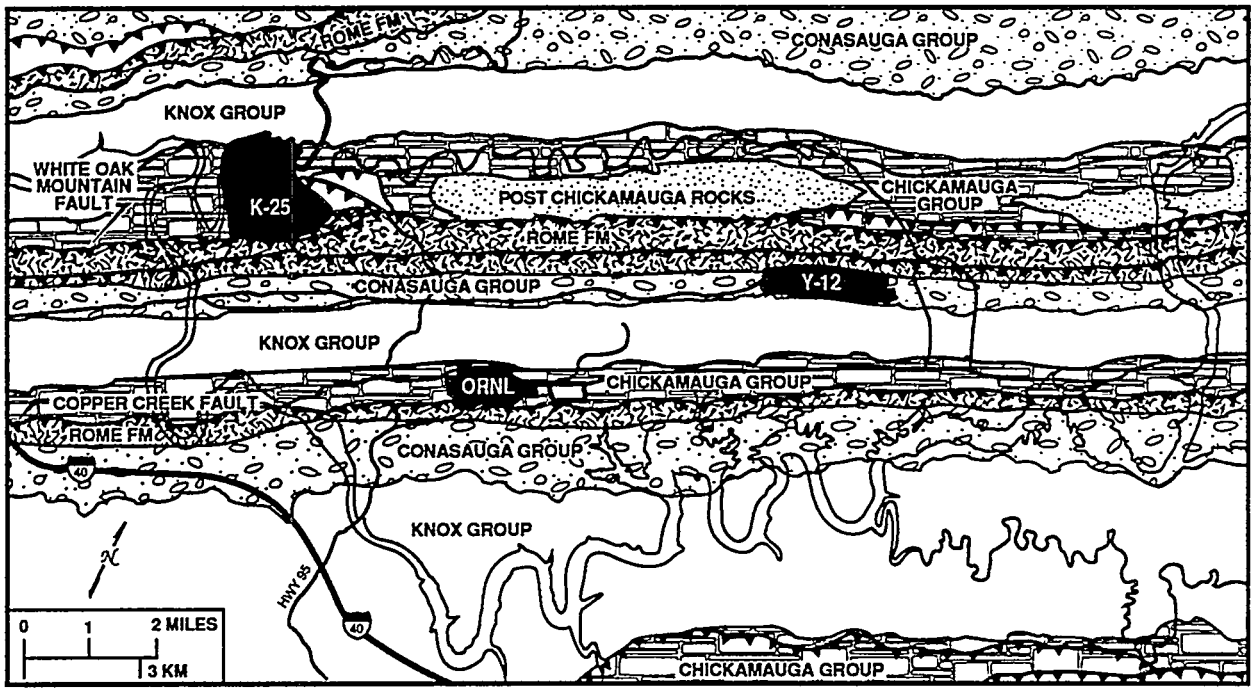

Fig. 1.11. Geologic map of the Oak Ridge Reservation.

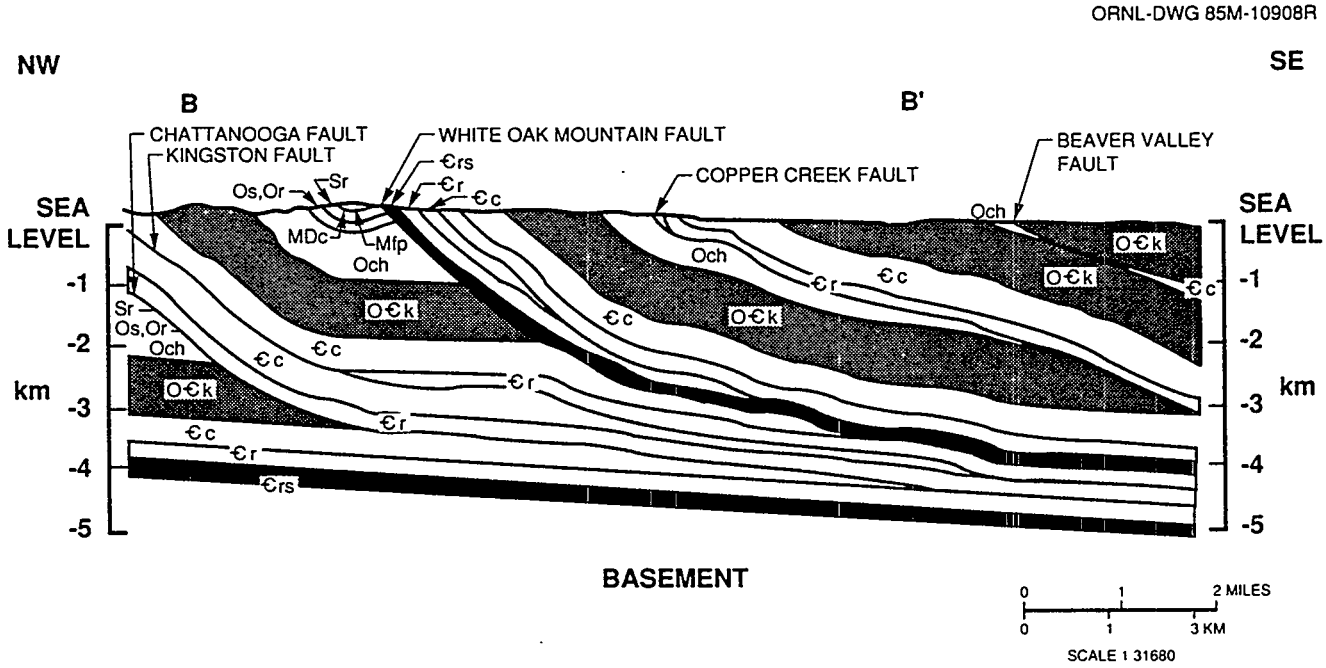

Fig. 1.12. Geologic cross section of the Oak Ridge Reservation.

the bedrock, dipping parallel to bedding. The second fracture set is also parallel to formation strike, but perpendicular to bedding dip. The dip of this set also varies with bedding plane dip and thus is a function of depth, inclined near the surface where bedding planes dip more steeply and vertical at depths where the bedding plane dip flattens. A third fracture set is perpendicular to formation strike. At least these three, but as many as five distinct fracture orientations can be observed in a given borehole location. Furthermore, although weathered, these fractures are either maintained or in some cases enhanced in the regolith.

1.5 GROUNDWATER

Groundwater is a potential source of potable water as well as water for irrigation, industrial, and domestic uses. Groundwater also may provide a pathway for transport of contaminants and is therefore a necessary element in monitoring programs at the ORR. This section provides an overview of groundwater hydrology on the ORR and a discussion of groundwater use. Further details are presented in Sect. 5.

1.5.1 Groundwater Occurrence

Groundwater on the ORR occurs as localized perched water; as transient, shallow, subsurface stormflow in the unsaturated zone; and as an unconfined water table aquifer in the saturated zone. The water table marks the top of the saturated zone, and generally occurs at shallower depths along low-lying areas and surface water features and at greater depths in higher topographic positions. No major confining layers have been identified such that groundwater occurs as a continuum from the water table surface to depths in bedrock. Groundwater flow is controlled by fracture and/or solution cavity distribution and orientation. However, because of topographic relief and a decrease in fracture density with depth, groundwater flow is primarily restricted to shallow depths and discharges to nearby surface water features within the ORR. At greater depths, the

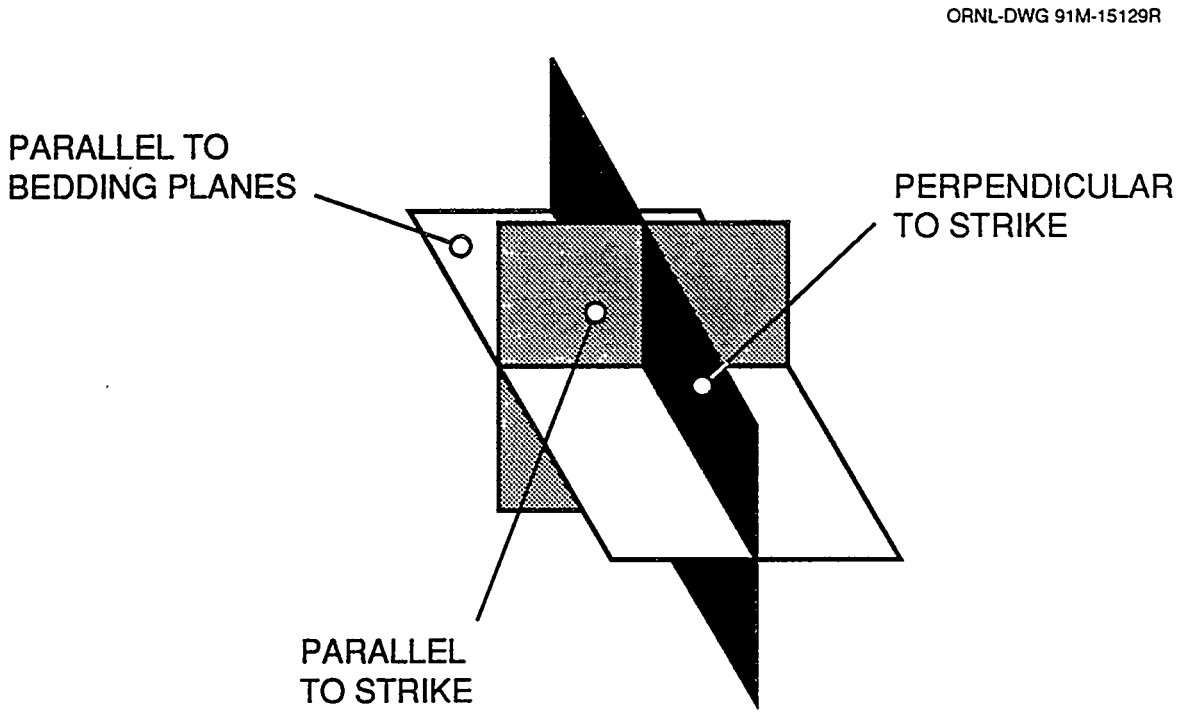

Fig. 1.13. Three sets of fracture orientations.

groundwater on the ORR transitions from fresh water to a highly saline, nonpotable, brine.

1.5.2 Groundwater Use

Groundwater in the Tennessee Valley region provides water to many rural residences, industries, and public water supply systems, and it sustains baseflow in streams and rivers. Most farm use is for livestock watering and washing. More than 50% of the population of Tennessee relies on groundwater for drinking water supplies (Henry et al. 1986). Twenty-one percent of the water used in the state (exclusive of hydroelectric use) is groundwater. Of this amount, about 55% is withdrawn for public and domestic supplies, 42% for self-supplied industrial use, and 1% for irrigation (Bradley and Hollyday 1985 and Henry et al. 1986).

The major portion of the industrial and drinking water supply in the Oak Ridge area is provided from surface water sources. However, single-family wells are common in adjacent rural areas not serviced by public water supply systems. A comparison of census data showing the number of households (175,701) versus the number of households with public utility connections (165,145) in the five counties surrounding the ORR (Anderson, Knox, Loudon, Morgan, and Roane counties) shows that 94% of the population relies on public utility sources for the potable water supply (Rima 1992 and Smith 1986). However, a total of 20,624 drilled, dug, or other residential wells (representing approximately 11% of the total households) are documented within the five-county area, suggesting groundwater is used for other than potable water supplies in the area. Other than those adjacent to the city of Oak Ridge, most of the residential wells in the immediate area are located south of the Clinch River. Groundwater is not used as a source of potable water on the ORR. Well yields are typically low (less than 2 gpm) on the ORR and are generally insufficient to serve as a reliable potable water supply. An exception to this are wells in the principal carbonate aquifer units, in which well yields may exceed 1000 gpm.

1.6 SURFACE WATER

Potable water for most nonrural areas comes from surface water. This section includes discussions of stream classification, surface water hydrology, watershed characteristics, and water use.

1.6.1 Stream Classification

The Clinch River is the major surface water source that receives discharges from the Oak Ridge installations. Four TVA reservoirs influence the flow and/or water levels of the lower Clinch: Norris and Melton Hill on the Clinch River and Watts Bar and Fort Loudon on the Tennessee River.

The area on and around the ORR has no streams classified as wild and scenic rivers. Most of the streams on the ORR are classified for fish and aquatic life, irrigation, and livestock watering and wildlife. Table 1.3 in Vol. 2 gives the state of Tennessee stream use classifications for the Clinch River and its tributaries on or near the ORR. Classifications are based on water quality, designated uses, and resident aquatic biota. For each designated water-use classification, specific water quality criteria are applied. These criteria form the basis for each facility's NPDES permit as mandated by the Clean Water Act.

1.6.2 Surface Water Hydrology

Figure 1.14 shows the locations of surface water bodies in the vicinity of the ORR. The ORR is bounded on the south and west by a 63-km stretch of the Clinch River. Melton Hill Dam is located at Clinch River kilometer (CRK) 37.2 (river mile 23), forming the Melton Hill Reservoir. Several major embayments bound the ORR; the largest is the Bearden Creek embayment, which has an approximate surface area of 48 ha (120 acres). Other embayments include Walker Branch, McCoy Branch, and Scarboro Creek.

Both groundwater and surface water are drained from the ORR by a network of small tributaries of the Clinch River, as shown in Fig. 1.14. At Kingston, Tennessee, the Clinch River flows into the Tennessee River, which is the seventh largest river in the United States. Water levels of the Clinch River in the vicinity of the ORR are regulated by TVA.

Each of the three DOE facilities is located in a different subbasin of the Clinch River. Drainage from the Y-12 Plant enters both Bear Creek and East Fork Poplar Creek; ORNL drains into White Oak Creek and several tributaries; and the K-25 Site drains predominantly into Poplar Creek and Mitchell Branch.

1.6.3 Watershed Characteristics

The Clinch River has its headwaters near Tazewell, Virginia, and empties into the Tennessee River near Kingston, Tennessee, at Tennessee River kilometer (TRK) 914 (river mile 568). The Clinch watershed comprises about 11% of the Tennessee River watershed. Four dams operated by TVA control the flow and levels of the Clinch River. Norris Dam, constructed in 1936, is approximately 50 km (31 miles) upstream from the ORR. Melton Hill Dam, completed in 1963, controls the flow of the river near the ORR. Its primary function is power generation (Boyle et al. 1982). Fort Loudon Dam, on the Tennessee River upstream of the confluence with the Clinch River, controls water flow into Watts Bar Lake, which is formed by Watts Bar Dam. Watts Bar Dam is located on the Tennessee River downstream of the lower end of the Clinch.

1.6.4 Water Use

Five public water supplies are located downstream within 80 km (50 miles) of the ORR. The K-25 Site water treatment plant is located 4 km (2.5 miles) above the mouth of Poplar Creek and supplies drinking water to approximately 4000 employees. The Kingston water treatment plant serves about 6841 persons, and its intake is located at TRK 914.7 (river mile 568.4), about 0.6 km (0.37 miles) above the confluence of the Clinch and Tennessee rivers and 34.1 km (21.1 miles) below the mouth of Poplar Creek. The Rockwood treatment plant serves about 7387 persons and is located downstream of Kingston on the King Creek embayment near Thief Neck Island. The remaining water plants are on Chicamauga Reservoir. The Dayton plant serves 9605 persons and is located at TRK 810.6 (river mile 503.7). The Soddy-Daisy/Falling Water Utility District plant draws water from the Soddy Creek embayment of

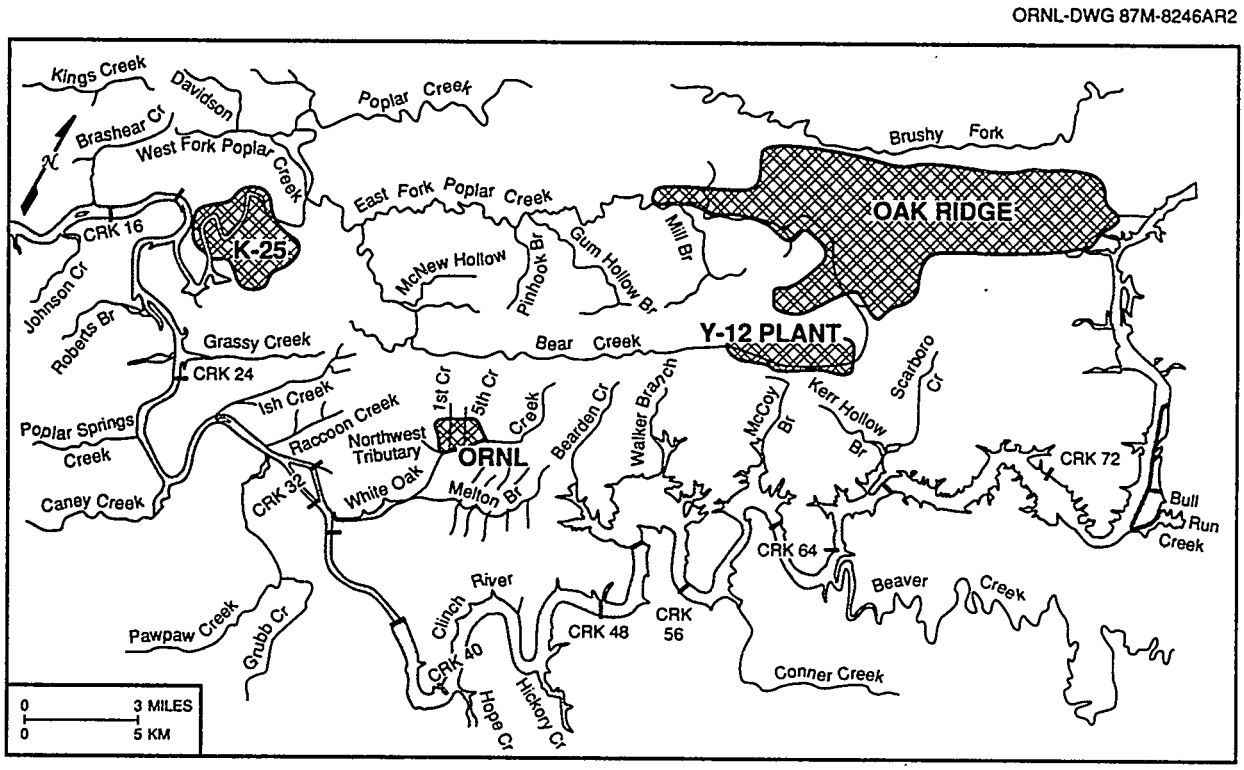

Fig. 1.14. Location map of Oak Ridge Reservation tributaries.

Chicamauga Reservoir, about 8 km (5 miles) from the reservoir proper.

1.7 ENVIRONMENTAL MONITORING

Published environmental summary reports for the DOE ORR have been issued for each year since 1971. The current environmental program is designed primarily to meet various regulatory requirements and DOE directives and to provide a continuity of data on environmental media at unregulated locations. The federal legislative framework that establishes standards and regulates environmental releases consists mainly of the following: Clean Air Act (CAA); The Clean Water Act (CWA); Safe Drinking Water Act (SDWA); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as "Superfund"; RCRA; TSCA; SARA; the Atomic Energy Act (AEA); and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Administrative bodies principally concerned with implementation and enforcement on the federal level are the U.S. Environmental Protection Agency (EPA) and DOE and, on the state level, TDEC.

Environmental monitoring consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the collection and analysis of samples, or measurements, of liquid and gaseous effluents. Environmental surveillance is the collection and analysis of samples, or direct measurements, of air, water, soil, foodstuff, biota, and other media from DOE sites and their environs. Environmental monitoring is performed by each site for the purpose of characterizing and quantifying contaminants, assessing radiation exposures of members of the public, demonstrating compliance with applicable standards and permit requirements, and assessing the effects, if any, on the local environment.

The samples are analyzed for various radioactive, physical, and chemical parameters. In some cases, such as liquid effluent outfalls, the discharge permit may require the analysis of more than 60 different parameters.

Annual summaries are presented in the following sections for each of the media sampled.

The summary tables generally give the number of samples collected and the maximum, minimum, average, and standard error of the mean (SE) values of parameters for which determinations were made. This value is based on multiple samples collected throughout the year. It includes the random uncertainty over time and space associated with sampling, analysis, and the intrinsic variability of media. The random uncertainty is a statement of precision (or imprecision), a measure of the reproducibility or scatter in a set of successive measurements, and an indication of the stability of the average value for a parameter. When differences in the magnitudes of the observations are small, the SE is small, and the precision is said to be high; when the differences are large, the SE is large, and the precision is low. Random uncertainties are assessed and propagated by statistical methods (see Appendix C for calculations). Average values have been compared where possible with applicable guidelines, criteria, or standards as a means of evaluating the impact of effluent releases or environmental concentrations.

In some of the tables, radionuclide concentrations are compared with derived concentration guides (DCGs) as published in DOE Order 5400.5. These concentration guides were established for the drinking water pathway and the inhalation pathway and are guidelines for the protection of the public. DOE Order 5400.5 defines a DCG as the concentration of a radionuclide in air or water from which, under conditions of continuous exposure by one exposure pathway (i.e., drinking water, inhaling air, or submersion) for 1 year, a "reference person" would receive an effective dose equivalent of 100 mrem. A reference person is a hypothetical human who is assumed to inhale 8400 m^3 (296,700 ft^3) of air in a year and to drink 730 L (190 gal) of water in a year. When there are multiple DCGs for a given isotope, the most restrictive value is used. When the percent of the DCG is less than 0.010, the percent is reported as less than 0.01. When total radioactive Sr is measured, it is compared to the DCG for ^{90}Sr, which is the most restrictive value.

The current convention for radioactivity data at the instrument detection limit is to treat it in the same manner as instrument responses above the detection limit. The instrument background is subtracted from the actual instrument signal, and the result is reported. Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and get a negative number. The advantage to this approach is that no bias is introduced in calculating statistical summaries of the data.

Measurements of nonradioactive analytes at or below the instrument detection limit are expressed as less than (<) the detection limit value. In computing summary statistics, the "less than" results are assigned the detection limit value. When a statistic includes one or more "less than" results, the computed value is also expressed as a "less than" quantity.

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2. POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

2.1 RADIATION DOSE

Small quantities of radionuclides were released to the environment from operations at the ORR facilities during 1991. Those releases are quantified and characterized in Sects. 3–7. This section presents estimates of the potential consequences of the releases and describes the methods used to make the estimates.

2.1.1 Terminology

Most consequences to humans associated with radionuclide releases to the environment are caused by interactions between radiations emitted by the radionuclides and human tissue. These interactions involve the transfer of energy from the radiations to tissue, a process that may damage the tissue. The radiations may come from radionuclides located outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (via inhalation, ingestion, and, in a few cases, absorption through the skin). Exposures to radiations from nuclides located outside the body are called external exposures; exposures to radiations 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 specialized units have been defined for characterizing exposures to ionizing radiation. Because the damage associated with such exposures results primarily from the deposition of radiant energy in tissue, the units are defined in terms of the amount of incident radiant energy absorbed by tissue and the biological consequences of the absorbed energy. Some of these units are defined as follows.

Absorbed dose. A physical quantity that defines the amount of incident radiant energy absorbed per unit mass of an irradiated material; its unit of measure is the rad. The absorbed dose depends on the type and energy of the incident radiation and on the atomic number of the absorbing material.

Dose equivalent. A quantity that expresses the biological effectiveness of an absorbed dose in a specified human organ or tissue; its unit of measure is the rem. The dose equivalent is numerically equal to the absorbed dose multiplied by modifying factors that relate the absorbed dose to biological effects. In this report, as in many others, the term "dose equivalent" often is shortened to "dose."

Effective dose equivalent (EDE). A risk-equivalent 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. The weighting factors and specific organs are described in Publications 26 and 30 of the International Commission on Radiological Protection (1977 and 1978).

Committed (effective) dose equivalent. The total (effective) dose equivalent that will be received over a specified time (50 years in this document) because of exposures to, and intakes of, radionuclides during the year of interest.

Collective effective dose equivalent. The sum of effective dose equivalents to all individuals in an exposed population.

Dose conversion factor (DCF). The dose equivalent received from exposure to a unit quantity

of a radionuclide via specific exposure pathway. Two types of DCFs exist. One type gives the committed dose equivalent (rem) resulting from intake (via inhalation and ingestion) of a unit activity (1.0 μCi) of a radionuclide. The second gives the dose equivalent rate (mrem/year) per unit activity (1.0 μCi) of a radionuclide in a unit (cm^3 or cm^2) of an environmental compartment (air or ground surface). Table 2.1, Vol. 2, is a listing of DCFs for inhalation and ingestion of selected radionuclides released from the ORR; Table 2.2, Vol. 2, is a listing of DCFs for immersion in contaminated air and for exposure to a contaminated ground surface (Beres 1990). The radionuclides listed account essentially for all of the radiation doses from the ORR.

2.1.2 Methods of Evaluation

Airborne Radionuclides

Characterization of the radiological consequences of radionuclides released to the atmosphere from ORR operations during 1991 was accomplished by calculating, for each plant and for the entire ORR, EDEs to the maximally exposed off-site individual and to the entire population residing within 80 km (50 miles) of the plants. 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 the National Emission Standards for Hazardous Air Pollutants (NESHAP)–Radionuclides, 10 CFR, Pt. 61. 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 the 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 (Tables 2.1 and 2.2 of Vol. 2).

Radionuclide releases were modeled for seven release points at ORNL, for three release points at the K-25 Site, and for one combined release point at the Y-12 Plant. Table 2.1 lists the source parameter

Table 2.1. 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	1.1	11.4	Ambient	4970 SW	9300 NE
3020	Point	61.0	1.5	9.7	Ambient	4970 SW	9300 NE
3039	Point	76.2	2.4	11.4	Ambient	4970 SW	9300 NE
7025	Point	4.0	0.3	14.0	Ambient	6910 SW	7550 NNE
7512	Point	30.5	0.9	7.3	Ambient	5160 WSW	9640 NNE
7911	Point	76.2	1.5	10.1	Ambient	5160 WSW	9640 NNE
7830	Point	4.6	0.2	7.1	Ambient	3860 WSW	10990 NNE
			K-25 Site				
K-1435	Point	30.5	1.37	5.5	77.2	5180 WSW	13000 ENE
K-1420	Point	18.3	0.25	75.5	Ambient	4820 WSW	13250 ENE
K-1015	Point	3.7	0	0	Ambient	4020 W	14000 ENE

values used in the calculations. The radionuclide release inventory is detailed in Sect. 3 and summarized in Tables 2.3, 2.4, and 2.5 of Vol. 2, which are lists of the nuclides released, the quantity (Ci) released from each release point, and the particle size, expressed as activity median aerodynamic diameter (AMAD), and solubility classes 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 1991 at the 100-m station on meteorological tower 2 (MT2) for stacks 2026, 3020, 3039, and 7025, and at the 30-m station on MT4 for stacks 7512, 7830, and 7911 at ORNL; at the 60-m station on MT1 for the K-25 Site; and at the 60-m station on MT6 for the Y-12 Plant. (See Fig. 2.1.) Rainfall on Oak Ridge during 1991 was 153 cm, the average air temperature was 14°C, and the average mixing layer height was 1000 m.

The dose calculations assumed that each person remained at home (actually outside the house) and 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. Use of this pattern is more conservative than the consumption patterns used in previous annual reports because it assumes more foodstuffs to be obtained from areas of high radionuclide deposition. 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.

Calculated EDEs due to radionuclides emitted to the atmosphere from the ORR are listed in Tables 2.2 (maximum individual) and 2.3 (collective). The EDE received by the hypothetical, maximally exposed individual for the ORR was calculated to be approximately 2 mrem (0.02 mSv), which is below the 10-mrem (0.10-mSv) NESHAP limit and well below the approximately 300 mrem (3 mSv) that the average individual receives from natural sources of radiation. This individual is located approximately 9300 m (5.8 miles) NE of the 3039 stack at ORNL, approximately 13,000 m (8.1 miles) ENE of the K-1435 (TSCA Incinerator) stack at the K-25 Site, and approximately 1080 m (0.7 miles) NNE of the Y-12 Plant release point. The calculated collective

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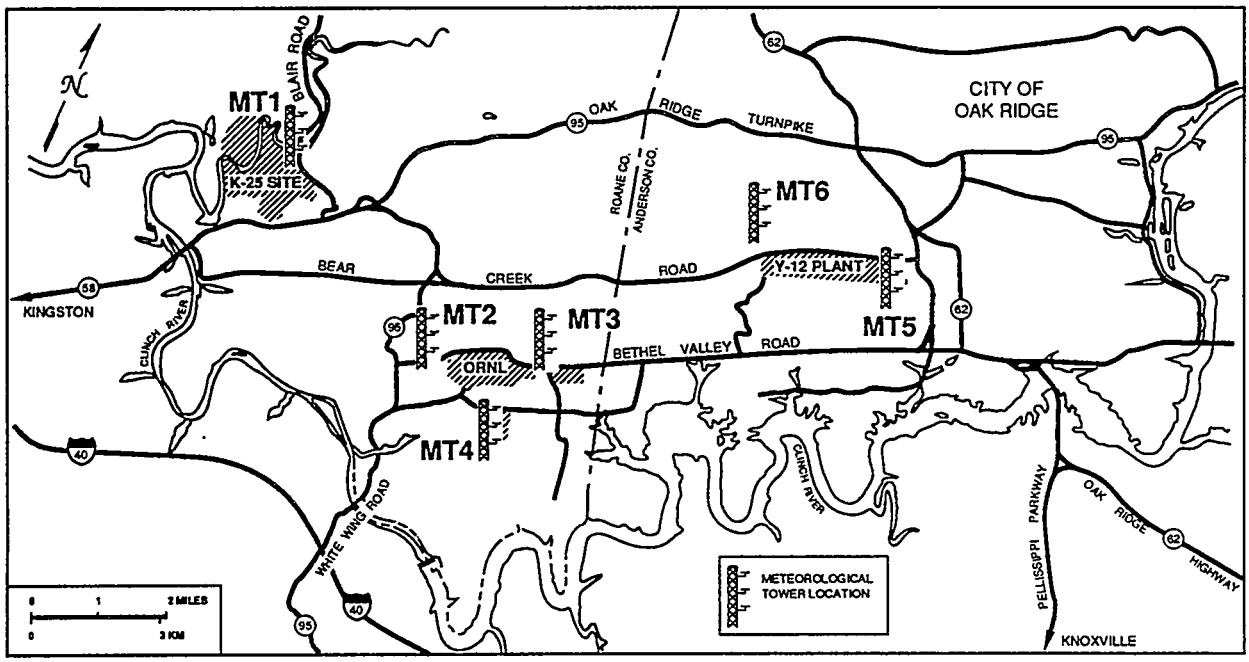

Fig. 2.1. ORR meteorological monitoring network.

Table 2.2. Calculated radiation doses to maximally exposed off-site individuals from airborne releases during 1991

Plant	Total effective dose equivalents (mrem)	
	Plant max	ORR max
ORNL[a]	0.3	0.2
K-25 Site[b]	0.3	0.1
Y-12 Plant[c]	1.4	1.4
Entire ORR[d]	NA	1.7

[a]The maximally exposed individual is located 4970 m (3.1 miles) SW of the 3039 stack and 5160 m (3.2 miles) WSW of the 7911 stack.

[b]The maximally exposed individual is located 5180 m (3.2 miles) WSW of the K-1435 stack.

[c]The maximally exposed individual is located 1080 m (0.7 miles) NNE of the Y-12 Plant release point.

[d]The maximally exposed individual for the entire ORR is the Y-12 Plant maximally exposed individual.

Table 2.3. Calculated collective effective dose equivalents due to airborne releases during 1991

Plant	Effective dose equivalents (person-rem)[a]
ORNL	6
K-25 Site	13
Y-12 Plant	10
ORR	29

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

EDE to the entire population within 80 km (50 miles) of the ORR (approximately 879,546 persons) was approximately 29 person-rem (0.29 person-Sv), which is 0.01% of the 264,000 person-rem that this population could have received from natural sources of radiation.

The EDE received by the hypothetical, maximally exposed individual for the Y-12 Plant was calculated to be 1.4 mrem (0.014 mSv). This individual is located approximately 1080 m (0.7 miles) NNE of the Y-12 Plant release point. Essentially, all of this dose is due to ingestion (2%) and inhalation (98%) 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 approximately 10 person-rem (0.1 person-Sv), which is 25% of the collective EDE for the ORR.

The EDE received by the hypothetical, maximally exposed individual for ORNL was calculated to be 0.3 mrem (0.003 mSv). This individual is located 4970 m (3.1 miles) SW of the 3039 stack and 5160 m (3.2 miles) WSW of the 7911 stack. Approximately 94% of this dose is due to ingestion and inhalation of ^{3}H. The contribution of ORNL emissions to the collective EDE to the population residing within 80 km of the ORR was calculated to be 6 person-rem (0.06 person-Sv), which is 15% 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 0.3 mrem (0.003 mSv). This individual is located approximately 5180 m (3.2 miles) WSW of the K-1435 (TSCA Incinerator) stack. Approximately 75% of this dose is due to ingestion and inhalation of uranium, approximately 17% is due to ^{228}Th, and approximately 7% is due to ^{237}Np. 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 13 person-rem (0.13 person-Sv), which is 45% of the collective EDE for the ORR.

The apparent contradiction between the maximum individual doses (high for the Y-12 Plant and low for the K-25 Site) is due to the locations of the maximally exposed individuals. At the Y-12 Plant, the individual is 1080 m from the stack. At the K-25 Site, the individual is 5180 m from the major stack. If the individual at the K-25 Site was located 1080 m from the stack, that individual's EDE would be about twice that of the EDE for the individual at the Y-12 Plant.

Waterborne Radionuclides

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system via the Clinch River and various feeder streams. Discharges from the Y-12 Plant enter the Clinch River via Bear Creek and East Fork Poplar Creek, both of which enter Poplar Creek prior to entering the Clinch River. Discharges from ORNL enter the Clinch River via White Oak Creek and White Oak Lake. Discharges from the K-25 Site enter the Clinch River via Poplar Creek. These discharges are characterized in Sect. 4. 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. Two methods were used to determine concentrations of radionuclides in water and fish. Method 1 uses measured, annual-average, nuclide concentrations in water samples taken below Melton Hill Dam (Table 4.35, Vol. 2), at the K-25 Site (Gallaher) water plant (Table 4.56, Vol. 2), and before intake to the Kingston municipal water plant (Table 4.57, Vol. 2)) and fish samples from CRKs 8.0, 33.3, and 40 (Table 6.5, Vol. 2). Measured stream flows are used to estimate concentrations at other locations along the Clinch and Tennessee rivers. Method 2 uses measured stream flows and measured nuclide discharges through White Oak Dam (Table 2.6, Vol. 2) to calculate annual-average nuclide concentrations in water. Concentrations in fish are calculated using the LADTAP XL methodology (Hamby 1991), which employs fish to water bioaccumulation factors to calculate radionuclide concentrations in fish from concentrations in water. Tables 2.7 and 2.8 of Vol. 2 are lists of the calculated concentrations in water and fish, respectively, at locations of interest. Results of the maximally exposed individual and collective EDE calculations are summarized in Tables 2.4 and 2.5, respectively. Calculations performed using Method 1 are preferred because they use measured environmental concentrations. The Method 2 calculations confirm the reasonableness of the measured values.

The concentrations of radionuclides in drinking water that produce the highest calculated individual EDE occurred at the Gallaher water plant. A person who drank 730 L of this water during 1991 could have received an EDE of approximately 0.2 mrem (0.002 mSv), using Method 1 calculations, or approximately 0.09 mrem (0.0009 mSv) using Method 2. The total collective EDE to the 37,575 persons who drank water from the plants at Gallaher, Kingston, Rockwood, Dayton, and Soddy-Daisy/Falling Water (Roberts 1992 and McCormick 1992) is estimated to be approximately 0.9 person-rem (0.009 person-Sv), using Method 1 calculations, and approximately 0.7 person-rem (0.007 person-Sv) using Method 2. For the collective dose calculations, it was assumed that each person drank 370 L of water from the plants during the year. The average person drinks 370 L of water per year (NRC 1977). No correction was made to these doses for background because no detectable quantities of radionuclides were found in water sampled near Melton Hill Dam, the location normally used for calculating a hypothetical background dose.

The concentrations of radionuclides in fish that produced the highest calculated individual EDE occurred near the confluence of White Oak Creek and the Clinch River. A person who ate 21 kg of fish from this location during 1991 could have received an EDE of approximately 0.3 mrem (0.003 mSv) using Method 1, or approximately 0.7 mrem (0.007 mSv) using Method 2. The major difference between the two estimates is that Method 2 predicts a ^{137}Cs concentration that is about four times higher than what is measured in fish samples from that location. The total collective EDE from eating 4925 kg of fish from the upper Clinch River, 4925 kg from the lower Clinch River, 29,549 kg from Watts Bar Lake, and 28,228 kg from Chickamauga Lake was calculated to

Table 2.4. Maximum individual EDEs (mrem) for water pathways

Location	Upper CR[a] (Gallaher[b])	Lower CR[a] (Kingston[c])	Watts Bar (Rockwood[d])	Chickamauga (Dayton[e], Soddy-Daisy/ Falling Water[f])
		Method 1		
Drinking water[g]	0.19	0.10	0.014	0.013
Eating fish[h]	0.26	0.094	0.014	0.012
Swimming[i]	0.00056	0.000000	0.000000	0.000000
Boating[j]	0	0.000000	0.000000	0.000000
Shoreline[k]	0	0.000089	0.000013	0.000012
Total	0.45	0.19	0.028	0.025
		Method 2		
Drinking water[g]	0.092	0.091	0.022	0.020
Eating fish[h]	0.74	0.74	0.18	0.17
Swimming[i]	0.00015	0.00015	0.000037	0.000034
Boating[j]	0.000032	0.000032	0.000008	0.000007
Shoreline[k]	0.069	0.069	0.017	0.015
Total	0.91	0.90	0.22	0.20

[a]CR = Clinch River.
[b]DOE drinking water plant serving 4000 persons.
[c]Public water supply serving 6841 persons.
[d]Public water supply serving 7387 persons.
[e]Public water supply serving 9605 persons.
[f]Public water supply serving 9742 persons.
[g]Drinks 730 L/year of water.
[h]Eats 21 kg/year of fish from location.
[i]Swims 120 h/year.
[j]Boats 200 h/year.
[k]Uses shoreline 200 h/year.

be approximately 0.1 person-rem (0.001 person-Sv), using Method 1, and approximately 0.8 person-rem (0.008 person-Sv), using Method 2. Again, differences in estimated doses are because of differences in ^{137}Cs concentrations. For the collective dose calculations, it was assumed that the entire annual catch by sportfishermen was eaten by members of the population within the 50-mile radius. The background EDE, due to eating 21 kg of fish from Melton Hill Lake, was calculated to be approximately 0.01 mrem (0.0001 mSv).

Maximum individual and collective EDEs due to swimming and boating appear to be negligibly small, less than 0.0002 mrem (0.000002 Sv) and 0.00003 person-rem (0.0000003 person-Sv), respectively. EDEs due to shoreline activities also are negligible using Method 1 calculations; however, Method 2 calculations give a maximum individual EDE of 0.07 mrem (0.0007 Sv) and a collective EDE of 0.08 person-rem. The large difference in shoreline exposures is due to the absence of measured concentrations of ^{137}Cs in water samples and the relatively high concentrations predicted using Method 2.

When all pathways are considered, the maximally exposed individual to waterborne radionuclide discharges could receive an EDE of approximately 0.5 mrem (0.005 mSv), using Method 1, or approximately 0.9 mrem (0.009 mSv), using Method 2. The collective EDE to the 50-mile population was calculated to be approximately 1 person-rem (0.01 person-Sv), using Method 1, or

Table 2.5. Collective EDEs (person-rem) for water pathways

Location	Upper CR[a] (Gallaher[b])	Lower CR[a] (Kingston[c])	Watts Bar (Rockwood[d])	Chickamauga (Dayton[e], Soddy-Daisy/ Falling Water[f])
		Method 1		
Drinking water	0.38	0.35	0.054	0.13
Eating fish	0.062	0.022	0.020	0.017
Swimming	0.00015	0.000000	0.000000	0.000000
Boating	0	0.000000	0.000000	0.000000
Shoreline	0	0.000024	0.000020	0.000018
Total	0.44	0.37	0.073	0.084
		Method 2		
Drinking water	0.19	0.18	0.084	0.20
Eating fish	0.18	0.17	0.26	0.22
Swimming	0.000041	0.000040	0.000060	0.000052
Boating	0.000005	0.000005	0.000008	0.000007
Shoreline	0.019	0.018	0.027	0.015
Total	0.38	0.38	0.36	0.45

[a]CR = Clinch River.
[b]DOE drinking water plant serving 4000 persons.
[c]Public water supply serving 6841 persons.
[d]Public water supply serving 7387 persons.
[e]Public water supply serving 9605 persons.
[f]Public water supply serving 9742 persons.

approximately 2 person-rem (0.02 person-Sv), using Method 2. These are very small percentages of individual and collective dose attributable to natural background radiation, 0.02–0.03% and 0.0004–0.0008%, respectively.

Radionuclides in Other Environmental Media

Milk

The CAP-88 computer codes calculate radiation doses due to ingestion of meat, milk, and vegetables that contain radionuclides released to the atmosphere. Using the conservative food consumption pattern described in Sect. 2.1.2, about 30% of the maximum individual dose for the ORR is due to ingestion of foodstuffs.

One environmental pathway for ingestion, drinking milk, is evaluated separately using radionuclide concentrations measured in milk collected from nearby farms. An individual is assumed to drink 310 L of milk containing measured quantities of total strontium (taken to be ^{90}Sr) and ^{131}I (see Sect. 6.1 and Tables 6.1 and 6.2 in Vol. 2). Such an individual could receive an EDE of about 0.2 mrem (0.002 mSv).

Deer

As described in Sect. 6.3, several deer hunts were held on the ORR during 1991. A total of 476 deer were killed, of which 7 were confiscated because their radionuclide content exceeded the release standard. The remaining 469 deer had an average field-dressed weight of 37 kg (82 lb). Assuming 55% of the dressed weight is edible, the average deer would yield 20 kg (45 lb) of meat. The summed total harvest of edible meat was about 10,900 kg (24,000 lb).

All deer were sampled to determine their ^{137}Cs content and randomly selected deer were sampled for ^{60}Co and total strontium in tissue. The average ^{137}C concentration in the 469 released deer was 0.11 pCi/g. Based on the random sampling results, the average ^{60}Co concentration was 0.004 pCi/g, and

the average total strontium concentration (assumed to be ^{90}Sr) was 0.092 pCi/g.

The collective EDE from eating all the harvested deer meat could be about 0.07 person-rem (0.0007 person-Sv). The EDE for an individual consuming one deer with average concentrations of ^{137}Cs, ^{60}Co, and total strontium (^{90}Sr) was estimated to be 0.14 mrem. To estimate the EDE to the maximumly exposed individual, it was assumed that this person consumed two deer that due to their radionuclide content and weight could give the highest individual EDE. The two deer that gave the highest dose estimates contained 0.7 and 0.64 pCi/g of ^{137}Cs and were assumed to contain the highest measured concentrations of ^{60}Co and ^{90}Sr in the random samples, namely 0.12 pCi/g of ^{60}Co and 0.25 pCi/g of ^{90}Sr. In this unlikely event that one person consumed both of the highest-dose deer, that person could receive an EDE of about 1 mrem (0.01 mSv). No information is available concerning background concentrations of radionuclides in the deer. At least some of the ^{137}Cs is due to deposition from past weapons tests.

Waterfowl

Waterfowl are known to use waters on the ORR, even though such use is actively discouraged in contaminated areas (see Sect. 6.9). Two species of waterfowl that are resident on or near the ORR are giant Canada geese and wood ducks. Some data have been collected on radionuclide concentrations in these fowl; however, the degree to which the collected data give a representative picture of such concentrations is unknown.

Fourteen geese were sampled for ^{137}Cs, and 12 of the 14 were sampled for ^{60}Co. Average tissue concentrations were 0.24 pCi/g of ^{137}Cs and 0.002 pCi/g of ^{60}Co. Maximum tissue concentrations, in a goose collected near White Oak Lake, were 3.3 pCi/g of ^{137}Cs and 0.02 pCi/g of ^{60}Co. 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 receive an EDE of about 0.5 mrem (0.005 mSv). A person eating the average goose could receive an EDE of about 0.04 mrem (0.0004 mSv). The collective EDE from eating 412 geese harvested in the middle Tennessee unit, which includes the ORR, during the 1991–1992 hunting season, assuming all were contaminated at the average level, could have been approximately 0.01 person-rem (0.0001 person-Sv). The goose hunting season lasted about 56 days. The daily bag limit is two geese.

Three wood ducks were captured on the Clinch River and analyzed for ^{137}Cs in muscle. The average concentration was 1.5 pCi/g. The maximum concentration was 2.6 pCi/g. An average male wood duck weighs about 0.91 kg (2 lb), half of which is assumed to be edible. Thus a person eating the most contaminated duck could receive an EDE of about 0.06 mrem (0.0006 mSv). A person eating the average duck could receive an EDE of about 0.04 mrem (0.0004 mSv). A collective EDE from eating wood ducks harvested near ORR cannot be estimated because harvest data are unavailable. The wood duck hunting season lasts approximately 30 days. The daily bag limit is two ducks.

Direct Radiation

External exposure rates from background sources in the state of Tennessee average about 6.4 μR/h and range between 2.9 and 11 μR/h. These exposure rates translate into annual dose equivalent rates that average 49 mrem/year and range between 22 and 84 mrem/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 1991 was about 6.7 μR/h (Table 3.14). This equals a dose rate of about 51 mrem/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/h and ranged between 3.3 and 32 μR/h. These measured exposure rates are attributable to radiations 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/h), the average exposure rate along the river bank due to ORR operations would have been about 8 μR/h. This translates to a dose rate of about 0.007 mrem/h or 61 mrem/year above background.

The potential maximum individual exposure to this radiation field has been evaluated by assuming that a fisherman spends 5 h/week (250 h/year) near the point of maximum exposure. Based on the fact that the average fishing trip in East Tennessee lasts approximately 4 h and the observation that fishermen move up and down the river regularly, we now assume that the individual is exposed to the average exposure rate with background subtracted, 8 μR/h. Thus the maximally exposed individual during 1987 could have received an EDE of about 1.7 mrem (0.017 mSv). Correcting for radioactive decay of the cesium, the hypothetical, maximally exposed individual could have received an EDE of about 1.6 mrem (0.016 mSv) during 1991. These doses round to 2 mrem (0.02 mSv).

The radiation field along Poplar Creek is due to a storage area 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 taken along the creek during 1991 ranged between 50 and 100 μR/h, which is equivalent to a dose rate between 0.044 and 0.088 mrem/h. A 4-h fishing trip could result in reception of an EDE between 0.2 to 0.4 mrem (0.002 to 0.004 mSv). If the hypothetical Clinch River fisherman is used, the 250-h/year exposure time could result in reception of an EDE of about 15 mrem (0.15 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.

2.1.3 Doses to Aquatic Biota

DOE Order 5400.5, Chapter II, sets an interim absorbed dose rate limit of 1 rad/day to native aquatic organisms. To demonstrate compliance with this limit, absorbed dose rates to fish, invertebrates (mollusks), and crustacea (crawdads) were calculated using the computer code CRITR2 (Baker and Soldat, in preparation, and National Research Council of Canada 1983). Measured (maximum) concentrations of radionuclides in surface waters on and around the ORR (see Table 4.2) 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 an element-specific sediment deposition transfer factor, and nuclide-specific ground-surface irradiation dose factors. Table 2.6 is a summary of total dose rates to these aquatic organisms from these pathways. The results of these calculations indicate that the absorbed dose rates to aquatic biota should not exceed 1 rad/day. The highest calculated dose rates occur at the Northwest Tributary—0.02 rad/day to fish, 0.007 rad/day to crawdads, and 0.007 rad/day to mollusks.

On May 28, 1991, frogs that had been run over by vehicles were discovered on the road north of Basin 3524. The carcasses were surveyed with a count rate meter and one was found to be contaminated. Based on the level of contamination observed, an Incident Report was issued on May 29, 1991.

Because of this incident, frogs from around Basin 3524 were collected and their radionuclide content was determined (see Table 2.9 of Vol. 2). Two types of frogs were collected: the southern leopard frog (*Rana utricularia*) and the bullfrog (*Rana catesbeiana*). (The leopard frog is much more abundant than the bullfrog in the basin.) To determine if the 1 rad/day limit to these frogs could be exceeded, dose rates due to the internally deposited radionuclides were calculated. The average absorbed dose rate was estimated to be 0.0024 rad/day.

Additional calculations were performed to estimate dose rates from submersion in water and irradiation from sediments. Measured radionuclide concentrations in the water and sediments were used. Assuming that an adult frog spends approximately 30% of its time on the sediment and 70% of its time immersed in water, it could experience an external dose rate of 0.4 rad/day. (This is a conservative assumption for the leopard frog since it may leave the basin when vegetation can provide protection.) Thus,

Table 2.6. Total dose rate for aquatic organisms (rad/day)[a]

Location	Fish (maximum)	Crawdad (maximum)	Mollusk (maximum)
Melton Branch Weir X-13	8.8E-4	3.4E-3	3.4E-3
White Oak Creek Weir X-14	2.5E-3	2.1E-3	2.2E-3
White Oak Dam Weir X-15	5.0E-3	3.6E-3	3.6E-3
First Creek	1.6E-4	3.2E-3	3.2E-3
Fifth Creek	1.5E-4	1.0E-3	1.0E-3
7500 Bridge	1.0E-2	3.0E-3	3.0E-3
Melton Branch 2	7.8E-4	5.4E-4	5.5E-4
Northwest Tributary	2.1E-2	7.2E-3	7.3E-3
Raccoon Creek	1.9E-5	3.8E-4	3.8E-4

[a]Total dose rate includes the contribution of internally deposited radionuclides, sediment exposure (derived from water concentrations), and water immersion.

the total dose rate from internally deposited radionuclides and external sources was estimated to be 0.4 rad/day.

For completeness, potential dose rates to frog eggs and tadpoles also were calculated. Since frog eggs are deposited onto vegetation within the water body, it was assumed that their exposure mode was submersion in water. The resulting dose rate to the frog eggs was calculated to be 0.002 rad/day. The gestation period for leopard frogs eggs is about 9 days. Dose rates to tadpoles are higher because they are in contact with the sediments in addition to being submersed in water. The absorbed dose rate to a tadpole from both external exposure pathways was calculated to be between 1 and 2 rad/day. It is important to note that the leopard frog is a tadpole for approximately 3 months.

Basin 3524 is not a natural water body; it is a surge basin that is slated for remediation. Once the basin is remediated, this frog habitat will cease to exist.

2.1.4 Current-Year Summary

A summary of the maximum EDEs to individuals via several pathways of exposure is given in Table 2.7. It is unlikely (if not impossible) that any real person can be irradiated by all of these sources and pathways for a period of one year. However, if the resident who receives the highest EDE (2 mrem) from gaseous effluents, also ate fish from the upper Clinch River (0.3 mrem), and fished the Clinch River near the cesium field (2 mrem), he or she could receive a total EDE of about 4 mrem (0.04 mSv), or about 1% of the annual dose (300 mrem) from background radiation. If the individual fished Poplar Creek (15 mrem), the maximum individual dose could be about 17 mrem (0.17 mSv), 6% 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 one year. As described above, the 1991

Table 2.7. Summary of estimated radiation dose equivalents to an adult during 1991 at locations of maximum exposure

Pathway	Location	Effective (mrem)
Gaseous effluents	Nearest resident to	
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	1.4
	ORNL	0.3
	K-25 Site	0.3
	ORR	1.7
Liquid effluents		
Drinking water	Kingston	0.1
Eating fish	Upper Clinch River	0.3
Other activities	Upper Clinch River	negligible
Direct radiation	Clinch River shoreline	2
	Poplar Creek (K-25 Site)	15

Table 2.8. Five-year trends in committed effective dose equivalent for selected pathways

Pathway	Effective dose equivalent (mrem)				
	1987	1988	1989	1990	1991
All air	2	0.7	1	2	2
Fish consumption	0.3	0.2	0.2	0.3	0.3
Drinking water (Kingston)	<0.5	0.1	<0.3	0.04	0.1
Direct radiation (Clinch River)	2[a]	2[a]	2[a]	2[a]	2
Direct radiation (Poplar Creek)					15

[a]These values have been corrected by removing the contribution of natural background radiation.

maximum EDE could have been 4 or 17 mrem (0.04 or 0.17 mSv), or less than 17% of the DOE Order 5400.5 limit.

2.1.5 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years 1987–1991 are given in Table 2.8. The small variations in values over this 5-year period likely are not statistically significant. The slight increases in effective doses from consumption of water during 1987 and 1989 are not real because the calculations include "less than" values of radionuclide concentrations. For 1990 and 1991, radionuclides previously reported as being present at "less than" concentrations, were not included in the dose estimates. The 1991 increase is due to increased ^{90}Sr and uranium in the samples. The dose estimates for direct irradiation along the Clinch River have been corrected for background.

2.1.6 Potential Contributions from Off-Site Sources

Three 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 0.03 mrem due to airborne emissions. A depleted uranium processing facility located on Illinois

Avenue reported a maximum emission of 0.059 kg (0.13 lb) of depleted uranium. A dose estimate was not reported, but comparison with Y-12 Plant emissions of enriched and depleted uranium (0.59 kg) indicates that the dose should be about 50 times lower than the 1 mrem maximum attributable to the Y-12 Plant. A decontamination facility located on Flint Road in Oak Ridge reported a maximum individual EDE of about 0.005 mrem.

2.1.7 Findings and Conclusions

The maximally exposed off-site individual could receive a 50-year committed EDE of approximately 2 mrem due to 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 approximately 8.8×10^5 persons living within 80 km (50 miles) of the ORR is approximately 40 person-rem for 1991 airborne emissions. This represents about 0.01% of the 2.6×10^5 person-rem that the surrounding population would receive from all sources of natural radiation.

2.2 CHEMICAL DOSE

Varying amounts of chemicals were released to the environment from operations at ORR facilities during 1991. These releases are characterized and quantified in Sect. 4. This section estimates potential human exposure to these chemicals, and the exposures are compared to acceptable levels of exposure as defined by federal standards and regulations.

Chemicals enter the body by several pathways, including inhalation of air and dust, ingestion of food and water, and absorption through the skin. Analysis of potential exposure through inhalation is not possible because of a lack of environmental monitoring data. Engineering calculations indicate that no sources on the ORR require monitoring to demonstrate compliance with NESHAP regulations. Potential exposure through dermal contact is considered to be unlikely for members of the general public because the sites are restricted areas.

The environmental monitoring data on surface water and fish allow an analysis of the ingestion pathway via drinking water and consumption of fish.

2.2.1 Terminology

The following terms are pertinent to the understanding of exposure.

Acceptable Daily Intake (ADI). Intake of a chemical, measured in mg/day, that is not anticipated to result in an adverse health effect over a lifetime of exposure. ADIs are calculated from several different federal standards and regulations.

Calculated Daily Intake (CDI). Intake of a chemical, expressed in mg/day. Adults are assumed to drink 2 L of water per day.

Slope Factor (SF). An estimate based on a lifetime probability that a chemical will cause cancer at a dose of 1 mg/kg/day.

Maximum Contaminant Level (MCL). EPA National Interim Primary and National Primary Drinking Water regulations that apply to all community or public water systems. Secondary MCLs are unenforcable criteria that apply to taste and odor.

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. SMCLs are unenforcable criteria that apply to taste and odor.

2.2.2 Methods of Evaluation

Airborne Chemicals

The release of chemicals into the air at ORR facilities is discussed in Sect. 3. 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.

Waterborne Chemicals

EPA has set daily intake standards for chemicals in the form of oral RfDs and SFs. These values are available from EPA's Integrated Risk Information System (1991). For noncarcinogenic chemicals, daily exposure to the RfD, in mg/kg/day, should result in no adverse effect over a lifetime. ADIs in mg/day

were calculated from RfDs by multiplying by 70 kg, the average human body weight.

For carcinogens, ADIs were calculated from SFs using the formula:

$$ADI = \frac{1 \times 10^{-5} \times BW}{SF},$$

where

BW = 70 kg and

SF = a slope factor of risk per unit dose (risk per mg/kg/day).

A 1 in 100,000 (10^{-5}) lifetime risk of developing cancer was used in calculating the ADI.

For chemicals for which RfDs and SFs were not available, national primary and secondary drinking water regulations were used to calculate ADIs. The regulation concentrations, expressed in mg/L, were converted to ADI values by multiplying by two L (the average daily adult water intake).

Acceptable daily intakes for chemicals found in surface water at concentrations above detection limits are listed in Table 2.9. For RfDs and SFs, it is assumed that water ingestion is the only pathway of exposure.

Calculated daily intakes based on concentrations of chemicals found above detection limits at reference sites and at the three ORR sites are listed in Tables 2.10–2.13. Average values of the sampling

Table 2.9. Acceptable daily intakes for chemicals found above detection limits at ORR facilities

Chemical	ADI (mg/day)	Reference
Aluminum	0.1	SMCL[a]
Ammonia	68	RfD
Arsenic	0.07	RfD
Barium	4.9	RfD
Beryllium	0.35	RfD
Boron	6.3	RfD
Cadmium	0.035	RfD
Chloride	500	SMCL
Chloroform	0.1148	SF
Chromium VI	0.35	RfD
Copper	2.6	MCL[b]
Cyanide	1.4	RfD
Fluoride	4.2	RfD
Iron	0.6	SMCL
Lead	0.03	MCL
Manganese	7.0	RfD
Mercury	0.021	RfD
Molybdenum	0.28	RfD
Nickel	1.4	RfD
Nitrate	112	RfD
PCBs	0.00009	SF
Selenium	0.35	RfD
Silver	0.35	RfD
Strontium	62	RfD
Sulfate	800	MCL
Thallium	0.0049	RfD
Trichloroethylene	0.06	SF
Uranium (natural)	0.21	RfD
Vanadium	0.49	RfD
Zinc	14	RfD

[a]SMCLs apply to all public water systems.

[b]MCLs apply to all public water systems (copper and sulfate) or to community water systems (lead).

data (in mg/L) were multiplied by two to estimate daily intake levels based on consumption of 2 L of water per person. Much of the sampling data for individual chemicals were reported as "less than" (<) values, indicating that concentrations were 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 limit. Since average sample concentrations were reported as < values, the CDIs are also reported as < values. The CDIs were compared with the ADIs to establish whether the ingestion of 2 L of water would result in an exposure above the ADI. CDI/ADI ratios less than one indicate an acceptable level of risk, while CDI/ADI ratios greater than one indicate an unacceptable risk, or the need for further study. Where CDIs are expressed as < values, CDI/ADI ratios are also expressed as < values, and the exposure cannot be fully quantified.

Sampling data for only inorganic chemicals were available for the two reference sites, Melton Hill Dam and White Oak Creek headwaters (Table 2.10). These sampling locations represent background concentrations before the influence of the ORNL site and are useful for identifying the nonsite-related levels of chemicals. With the exceptions of aluminum and iron, CDI/ADI ratios were less than one. The high concentrations of aluminum and iron in both the reference and monitoring samples may be a reflection of the turbidity and high suspended solids in some of the samples. Furthermore, the SMCLs that apply to aluminum and iron are not health values but are purely aesthetic, unenforcable criteria.

Table 2.10. Chemical dose/acceptable daily intake comparisons for surface waters at ORR reference locations—annual 1991 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
	Melton Hill Dam		
Aluminum	<1.3	0.1	<13
Barium	<0.64	4.9	<0.13
Beryllium	<0.001	0.35	<0.003
Chromium	<0.01	0.35	<0.036
Copper	<0.0166	2.6	<0.006
Fluoride	<0.94	4.2	<0.224
Iron	1.58	0.6	2.63
Manganese	<0.26	7.0	<0.037
Nickel	<0.012	1.4	<0.008
Nitrate	<3.4	112	<0.030
Strontium	0.17	62	0.003
Sulfate	38	800	0.048
Vanadium	<0.005	0.49	<0.010
Zinc	<0.0116	14	<0.001
	White Oak Creek Headwaters		
Aluminum	1.0	0.1	10
Barium	<0.128	4.9	<0.026
Beryllium	<0.001	0.35	<0.003
Chromium	<0.0136	0.35	<0.039
Fluoride	<0.86	4.2	<0.205
Iron	<1.18	0.6	<1.97
Manganese	<0.186	7.0	<0.027
Nickel	<0.0088	1.4	<0.006
Nitrate	<3	112	<0.027
Strontium	0.058	62	0.0009
Sulfate	<5.8	800	<0.007
Vanadium	<0.004	0.49	<0.008
Zinc	<0.015	14	<0.001

[a]Values based on 1991 annual average sampling concentrations.

Table 2.11. Chemical dose/acceptable daily intake comparisons for surface waters at Y-12 Plant locations—annual 1991 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
	Upper Bear Creek (km 12.4)		
Aluminum	<1.38	0.1	<13.8
Arsenic	<0.010	0.07	<0.143
Barium	0.218	4.9	0.044
Beryllium	<0.001	0.35	<0.003
Boron	0.184	6.3	0.029
Cadmium	<0.003	0.035	<0.086
Chromium	<0.004	0.35	<0.011
Copper	<0.018	2.6	<0.007
Cyanide	<0.004	1.4	<0.003
Iron	<2.16	0.6	<3.6
Lead	<0.006	0.03	<0.2
Manganese	0.116	7.0	0.017
Molybdenum	<0.014	0.28	<0.05
Nickel	<0.02	1.4	<0.014
Nitrate	91.2	112	0.407
Silver	<0.014	0.35	<0.04
Strontium	0.880	62	0.014
Thallium	<0.002	0.0049	<0.408
Uranium	1.28	0.21	6.10
Vanadium	<0.012	0.49	<0.024
Zinc	<0.036	14	<0.003
	Upper Bear Creek (km 11.97)		
Aluminum	<0.44	0.1	<4.4
Barium	0.98	4.9	0.2
Beryllium	<0.0008	0.35	<0.002
Boron	0.188	6.3	0.030
Cadmium	0.017	0.035	0.474
Chromium	0.004	0.35	0.011
Copper	0.014	2.6	<0.005
Cyanide	<0.004	1.4	0.003
Iron	<0.26	0.6	<0.433
Lead	<0.002	0.03	<0.067
Manganese	2.906	7.0	0.415
Mercury	<0.0008	0.021	<0.038
Molybdenum	<0.012	0.28	<0.043
Nickel	0.076	1.4	0.054
Nitrate	318	112	2.839
Silver	<0.012	0.35	0.034
Strontium	1.4	62	0.022
Thallium	<0.002	0.0049	<0.408
Uranium	0.448	0.21	2.13
Vanadium	<0.008	0.49	<0.016
Zinc	0.022	14	0.002

Table 2.11 (continued)

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
	East Fork Poplar Creek: Station 17		
Cadmium	<0.0012	0.035	<0.034
Chloride	38	500	0.076
Chromium	0.012	0.35	0.034
Copper	<0.014	2.6	<0.005
Fluoride	2.0	4.2	0.476
Lead	<0.004	0.03	<0.133
Mercury	0.0028	0.021	0.133
Molybdenum	<0.014	0.28	<0.05
Nickel	<0.074	1.4	<0.053
Nitrate	11.22	112	0.100
Selenium	<0.004	0.35	<0.011
Sulfate	136	800	0.17
Uranium	0.062	0.21	0.295
Zinc	0.088	14	0.006

[a]Values based on 1991 annual average sampling concentrations.

Twenty-one inorganic chemicals for which ADI values are available were present at concentrations above the limits of detection at the three Y-12 Plant surface water sampling stations (Table 2.11). Aluminum, iron, uranium, and nitrate had CDI/ADI ratios greater than one in upper Bear Creek. For uranium and nitrate, ratios were less than one at the next downstream sampling location, K-1710 on Poplar Creek.

Fourteen inorganic chemicals and two organic chemicals at the three ORNL sampling locations were present at concentrations above the limits of detection (Table 2.12). Only aluminum and iron had CDI/ADI ratios greater than one.

Surface water samples at seven NPDES and perimeter monitoring locations at the K-25 Site were analyzed for 84 organic chemicals. All concentrations of organic chemicals were below the limits of detection, which ranged from 0.005 to 0.01 mg/L. Thirteen elements for which ADI values are available were detectable (Table 2.13). Of these, only lead at location K-1710 in Poplar Creek had a CDI/ADI ratio of slightly greater than one. However, the K-1710 sampling point is upstream of the K-25 Site, and therefore lead levels do not reflect K-25 Site operations. The ratio was less than one at stations downstream of K-1710 and in the Clinch River.

Chemicals in water can be accumulated by aquatic organisms that may be eaten by humans. Bluegill (sunfish) from the Clinch River were analyzed for mercury and PCBs (see Tables 6.3 and 6.4 of Vol. 2). The highest average concentration of mercury in bluegill, 0.11 mg/kg wet weight, was found at CRK 8.0. Assuming the average person eats 21 kg of fish per year (0.058 kg/day), the average daily intake of mercury would be 0.006 mg/day. This results in a CDI/ADI (0.006/0.021) ratio of 0.3. The calculated average intake by ingestion of both fish and water results in a CDI of 0.012 mg/day (0.006 mg/day from fish plus 0.006 mg/day from water at monitoring station K-1710) and a CDI/ADI ratio of 0.57, indicating an acceptable level of ingestion.

PCB concentrations in bluegill taken at three sites on the Clinch River were not quantifiable. Moreover, the lower limit of detection for water samples (0.0005 mg/L), and presumably for tissue samples, is the same as the MCL and greater than the SF. At the Y-12 Plant, the only site at which PCBs were monitored, water concentrations were below the limit of detection.

In reality, surface water monitoring stations are generally located within areas of DOE facilities that are not readily accessible to the general public. Thus, consumption of water from these points is unlikely.

Table 2.12. Chemical dose/acceptable daily intake comparisons for surface waters at ORNL locations—annual 1991 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
	Discharge Point: X13 (Melton Branch 1)		
Aluminum	<4.2	0.1	<42
Ammonia	0.078	68	0.001
Chloroform	<0.009[b]	0.1148	<0.082
Chromium	<0.022	0.35	<0.063
Copper	<0.018	2.6	<0.007
Fluoride	<2.2	4.2	<0.524
Iron	5.2	0.6	8.7
Lead	<0.0086	0.03	<0.287
Manganese	0.62	7.0	0.089
Mercury	<0.0001	0.021	<0.005
Nickel	<0.012	1.4	<0.008
Nitrate	<2.4	112	<0.021
Silver	<0.009	0.35	<0.026
Sulfate	170	800	0.213
Trichloroethylene	<0.009[b]	0.06	<0.157
Zinc	<0.06	14	<0.004
	Discharge Point X14 (White Oak Creek)		
Aluminum	<0.82	0.1	<8.2
Ammonia	0.098	68	0.001
Cadmium	<0.0046	0.035	<0.131
Chloroform	<0.005[b]	0.1148	<0.042
Chromium	<0.012	0.35	<0.034
Copper	<0.014	2.6	<0.006
Fluoride	<1.52	4.2	<0.362
Iron	<0.86	0.6	<1.43
Lead	<0.0086	0.03	<0.287
Manganese	0.092	7.0	0.013
Mercury	<0.0001	0.021	<0.005
Nickel	<0.0086	1.4	<0.006
Nitrate	<2.8	112	<0.025
Sulfate	72	800	0.090
Trichloroethylene	<0.009[b]	0.06	<0.157
Zinc	<0.054	14	<0.004
	Discharge Point X15 (White Oak Dam)		
Aluminum	2.4	0.1	24
Ammonia	0.18	68	0.003
Chloroform	<0.009[b]	0.1148	<0.080
Chromium	0.038	0.35	0.109
Copper	<0.016	2.6	<0.006
Fluoride	<1.5	4.2	<0.357
Iron	2.8	0.6	4.67
Lead	0.008	0.03	0.273
Manganese	0.32	7.0	0.046
Mercury	<0.0002	0.021	<0.008
Nickel	<0.01	1.4	<0.007
Nitrate	<2.2	112	<0.020
Silver	<0.01	0.35	<0.029
Sulfate	68	800	0.085
Trichloroethylene	<0.009[b]	0.06	<0.153
Zinc	<0.054	14	<0.004

[a]Values based on 1991 annual average sampling concentrations.
[b]Estimated.

Table 2.13. Chemical dose/acceptable daily intake comparisons for surface waters at K-25 Site perimeter and on-site monitoring locations—annual 1991 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
	West Fork Poplar Creek		
Copper	0.017	2.6	0.007
Lead	0.016	0.03	0.54
Manganese	0.324	9.8	0.033
Nitrate	0.626	112	0.006
Sulfate	76	800	0.095
Zinc	0.018	14	0.001
	Clinch River		
Manganese	0.149	7.0	0.021
Nitrate	0.64	112	0.006
Sulfate	38.5	800	0.048
Uranium	0.002	0.21	0.010
Zinc	0.02	14	0.001
	Monitoring Station K-716		
Chromium	0.026	0.35	0.074
Copper	0.017	2.6	0.006
Fluoride	0.356	4.2	0.085
Lead	0.016	0.03	0.52
Manganese	0.418	7.0	0.06
Mercury	0.002	0.021	0.105
Nickel	0.03	1.4	0.021
Nitrate	0.952	112	0.009
Sulfate	49.3	800	0.062
Uranium	0.006	0.21	0.029
Zinc	0.053	14	0.004
	Monitoring Station K-1513		
Cyanide	0.472	1.4	0.337
Fluoride	0.40	4.2	0.095
Lead	0.017	0.03	0.573
Manganese	0.076	7.0	0.010
Nickel	0.26	1.4	0.186
Nitrate	0.842	112	0.008
Sulfate	41.6	800	0.052
Zinc	0.038	14	0.003
	Monitoring Station K-1710		
Arsenic	0.014	0.07	0.206
Cadmium	0.005	0.035	0.137
Chromium	0.024	0.35	0.069
Copper	0.019	2.6	0.007
Fluoride	0.62	4.2	0.148
Lead	0.033	0.03	1.107
Manganese	0.756	7.0	0.108
Mercury	0.006	0.021	0.264
Nickel	0.032	1.4	0.023
Nitrate	2.45	112	0.023
Sulfate	62.8	800	0.079
Uranium	0.008	0.21	0.038
Zinc	0.060	14	0.004

Table 2.13 (continued)

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
	Monitoring Station K-1770		
Copper	0.010	2.6	0.004
Fluoride	0.2	4.2	0.048
Manganese	0.099	7.0	0.014
Mercury	0.0005	0.021	0.023
Nitrate	0.746	112	0.007
Sulfate	42.7	800	0.053
Uranium	0.002	0.21	0.010
Zinc	0.016	14	0.001

[a]Values based on 1991 annual average sampling concentrations.

Furthermore, as a pollutant moves downstream and the volume of water increases, the concentration of pollutant decreases.

Chemicals in Other Environmental Media

An important pathway of concern for human exposure to chemicals is through atmospheric deposition onto vegetation and subsequent transfer into beef and milk. Direct measurements for concentrations of chemicals in vegetation, beef, or milk in the vicinity of ORR facilities have not been made. As noted above, engineering estimates indicate that no sources on the ORR release reportable quantities of chemicals.

Direct Exposure

Direct exposure to chemicals does not represent a likely pathway of exposure at the ORR facilities. For airborne releases, concentrations off-site are too small to be a concern through the dermal exposure pathway. For aquatic releases, outfalls are generally located within areas of DOE facilities that are not readily accessible to the general public. Although exposures for the consumption of drinking water at the monitoring stations were calculated, public consumption of water from the outfalls or at the monitoring stations is highly unlikely.

2.2.3 Current-Year Summary

Analyses of exposure to waterborne inorganic chemicalss show that the majority of CDI/ADI ratios for on-site waters are less than one, indicating that intake of most chemicals would be below acceptable daily intake levels from drinking on-site waters. Off-site exposures would be 10 to 100 times lower because of dilution in the Clinch River. Two inorganic chemicals, aluminum and iron, which were above ADI, were also high in the reference samples, indicating that they were not contaminants from the ORR. Most organic chemicals were below the limit of analytical detection and should pose no risk to the public.

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3. AIRBORNE DISCHARGES, AMBIENT AIR MONITORING, METEOROLOGICAL MONITORING, AND EXTERNAL GAMMA RADIATION

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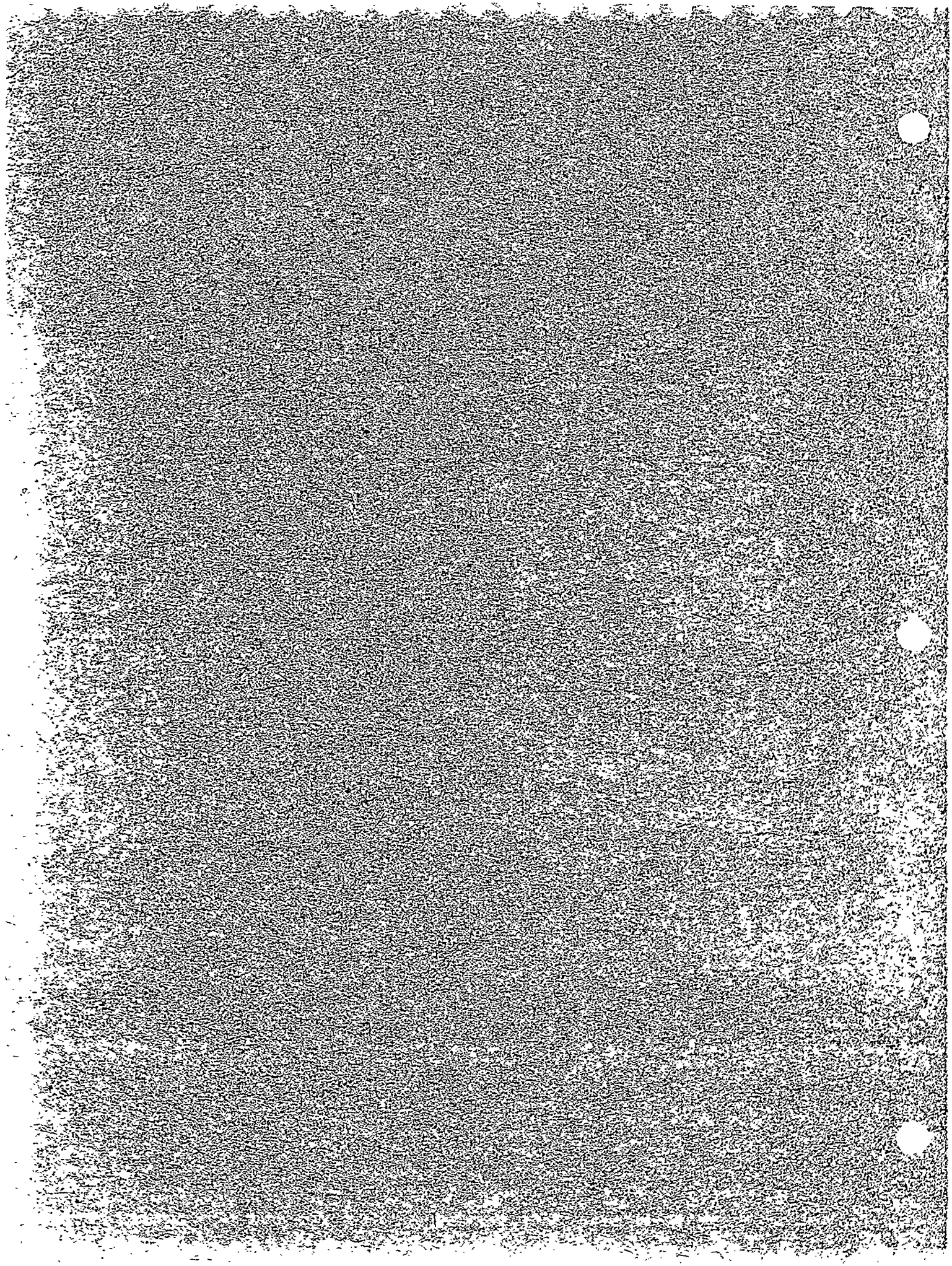

3. AIRBORNE DISCHARGES, AMBIENT AIR MONITORING, METEOROLOGICAL MONITORING, AND EXTERNAL GAMMA RADIATION

3.1 REGULATORY REQUIREMENTS

The DOE Oak Ridge facilities are subject to regulations issued by the TDEC Air Pollution Control Board and EPA as well as DOE orders. Nonradioactive emission sources are regulated by TDEC, and radioactive emission sources are regulated by EPA under the National Emission Standards for Hazardous Air Pollutants (NESHAP). The authority for these regulations is derived from the Tennessee Air Quality Control Act and the Clean Air Act (CAA).

The TDEC air pollution control rules regulate pollution sources to protect the public health and welfare and the environment. These rules include regulations for maximum allowable ambient air concentrations of certain pollutants, open burning, pollution sources such as coal-fired boilers and processes, fugitive emission sources, performance standards for new sources, and hazardous air pollutants. State-issued permits are required for air pollution sources with the exception of certain very small emission sources that are specifically exempt from permit requirements.

The EPA rules for radioactive emission sources limit the amount of exposure to radioactivity to the nearest or the most affected member of the public. The EPA sets the limit on exposure to radioactivity by first determining a safe exposure level and then adding a margin of safety. The dose to the most affected member of the public is determined by EPA-approved radioactive emissions dose modeling. The NESHAP regulations were reissued in December 1989. The ORR is currently not in compliance with the stack sampling criteria. A Federal Facility Compliance Agreement (FFCA) was signed in December 1991 by the DOE field office manager and is being implemented to achieve full compliance by December 1992.

DOE regulations governing airborne emissions are established in DOE orders 5400.1 and 5400.5, and DOE/ESH–0173T. Using the criteria in NESHAP regulations and DOE orders, major effluent sources are defined 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.

3.2 AIRBORNE DISCHARGES

Each 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 the 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. Ambient air monitoring is also conducted around the facilities and at three locations within surrounding East Tennessee communities to assess the impacts of ORR operations on the ambient air quality of the region.

The remainder of Sect. 3 describes airborne pollutants emitted from the Oak Ridge facilities during 1991. The subsections also describe the emissions sampling and monitoring performed at each facility and present data on measured pollutant concentrations at three locations within the surrounding communities. A brief section is also included on meteorological measurements conducted during 1991 at each facility. A discussion of atmospheric dispersion modeling and atmospheric radiological dose modeling is included in Sect. 2.

3.2.1 Y-12 Plant

Description

The release of contaminants into the atmosphere at the Y-12 Plant occurs almost exclusively as a result of plant production, maintenance and waste management operations, and steam generation. Most process operations are served by process ventilation systems that remove air contaminants from the workplace. More than 500 of these are permitted (Table 3.1, Vol. 2). Approximately 81 of these exhaust systems serve areas where depleted or enriched uranium is processed; they are monitored continuously for radioactive emissions. Twenty-eight of these samplers are equipped with alarm systems (breakthrough monitors) able to detect significant increases in the rate of emissions. Breakthrough monitors are located where a potential for excessive emissions exists in the event of a filter failure or process upset. Additionally, there are several hundred room air ventilation systems in plant buildings. These systems are typically not significant emission points for air pollutants because room air pollution concentrations are kept very low.

As illustrated in Figs. 3.1 and 3.2, atmospheric discharges from Y-12 Plant production operations are minimized through the extensive use of air pollution control equipment. High-efficiency particulate air (HEPA) filters are used to essentially eliminate particulate emissions (including uranium) from numerous production shops. HEPA filters remove more than 99% of the particulates from the exhaust gases. Exhaust gas scrubbers, baghouses, and other emission control equipment are used to reduce airborne discharges of other pollutants. Improvements continue to be made to the plant's exhaust ventilation systems to further reduce emissions. While many of these improvements involve the installation of new air pollution control equipment, material substitution and process modification projects are also being examined and implemented to reduce plant emissions and to comply with waste minimization strategies currently being pursued by plant operations.

A stack and vent survey has been initiated through the Engineering Division to identify and assign unique numbers to all emission points at the Y-12 Plant. Each stack and vent will be assessed as to its potential to emit hazardous materials considering both routine and accidental emissions. Those without any emission potential, such as steam vents, will not require further documentation. Emission estimates will be generated for the potentially hazardous points.

The focus of the initial stack and vent survey is the radionuclide area. All areas of the Y-12 Plant that handle radioactive materials have been screened. The individual buildings and processes have been prioritized based on their potential to emit. Estimates of emissions are being generated for unmonitored stacks and vents as they are identified.

The 1989 NESHAP regulation for radionuclides defines emissions sampling and reporting requirements for demonstrating compliance with the 10-mrem effective-dose-equivalent standard. Continuous emission sampling, using methods that comply with ANSI N 13.1 (1969, R-1982) standards, is required for any emission point with the potential to cause a public dose exceeding 0.1 mrem. Currently 65 of the Y-12 Plant's 81 continuously monitored stacks have the potential to emit radioactive effluents that contribute greater than 0.1 mrem/year effective dose equivalent to an off-site individual. Two other sources with this potential have been identified in the stack and vent survey. Plans are underway to equip these two stacks with the appropriate monitoring equipment prior to restart of operation.

In addition, a periodic confirmation measurement is required for all major sources. The EPA-approved, modified Method 5 measurement is conducted by trained and experienced personnel from the K-25 Site for the Y-12 Plant. The results of all continuous emissions measurements, as well as the calculated annual dose, must be reported annually to the EPA using the format specified in the regulation.

Although the Y-12 Plant airborne discharges were well within regulatory guidelines, the sampling methods and emission estimation methods used did

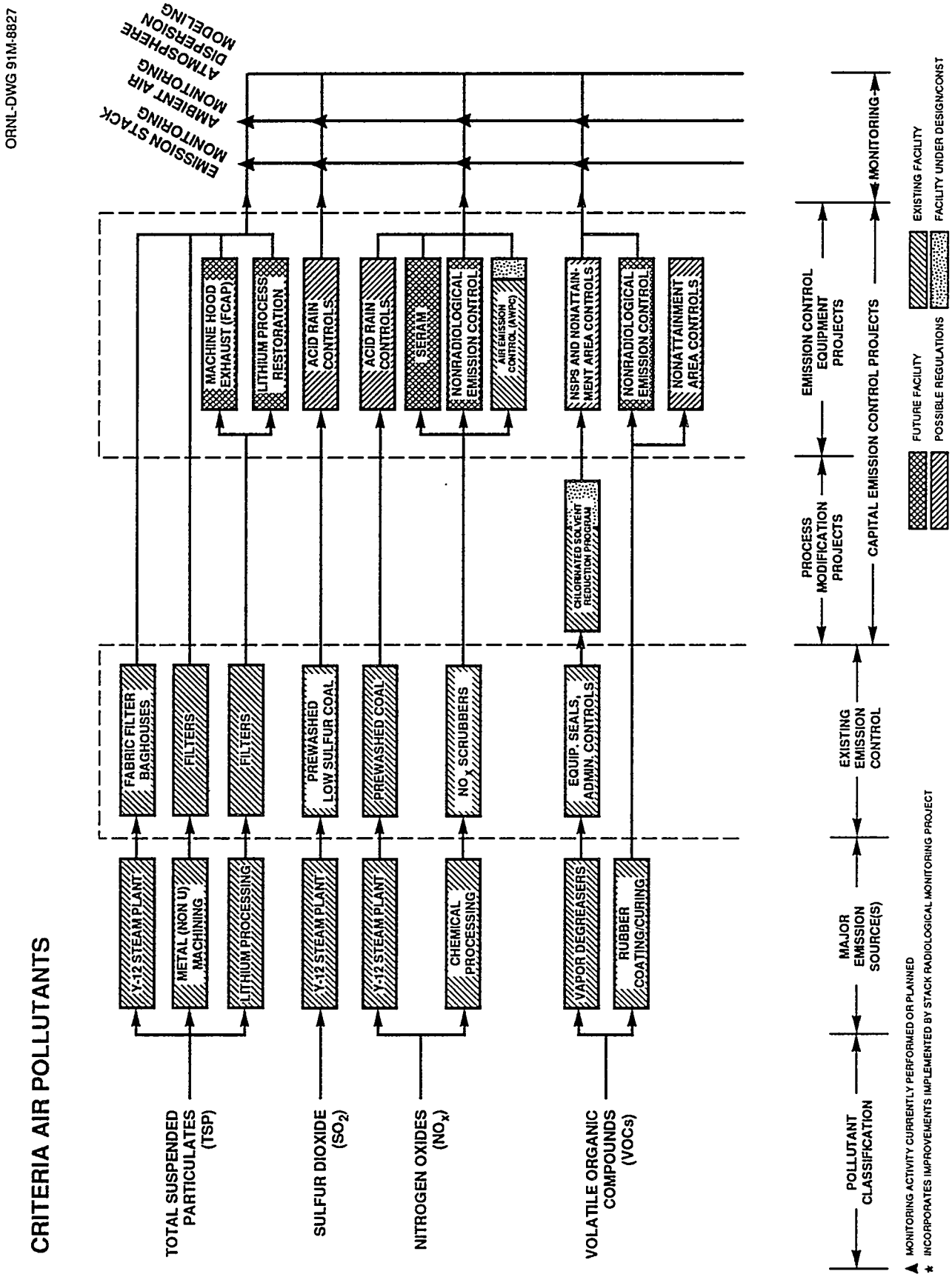

Fig. 3.1. Air pollution control program at the Y-12 Plant (criteria air pollutants).

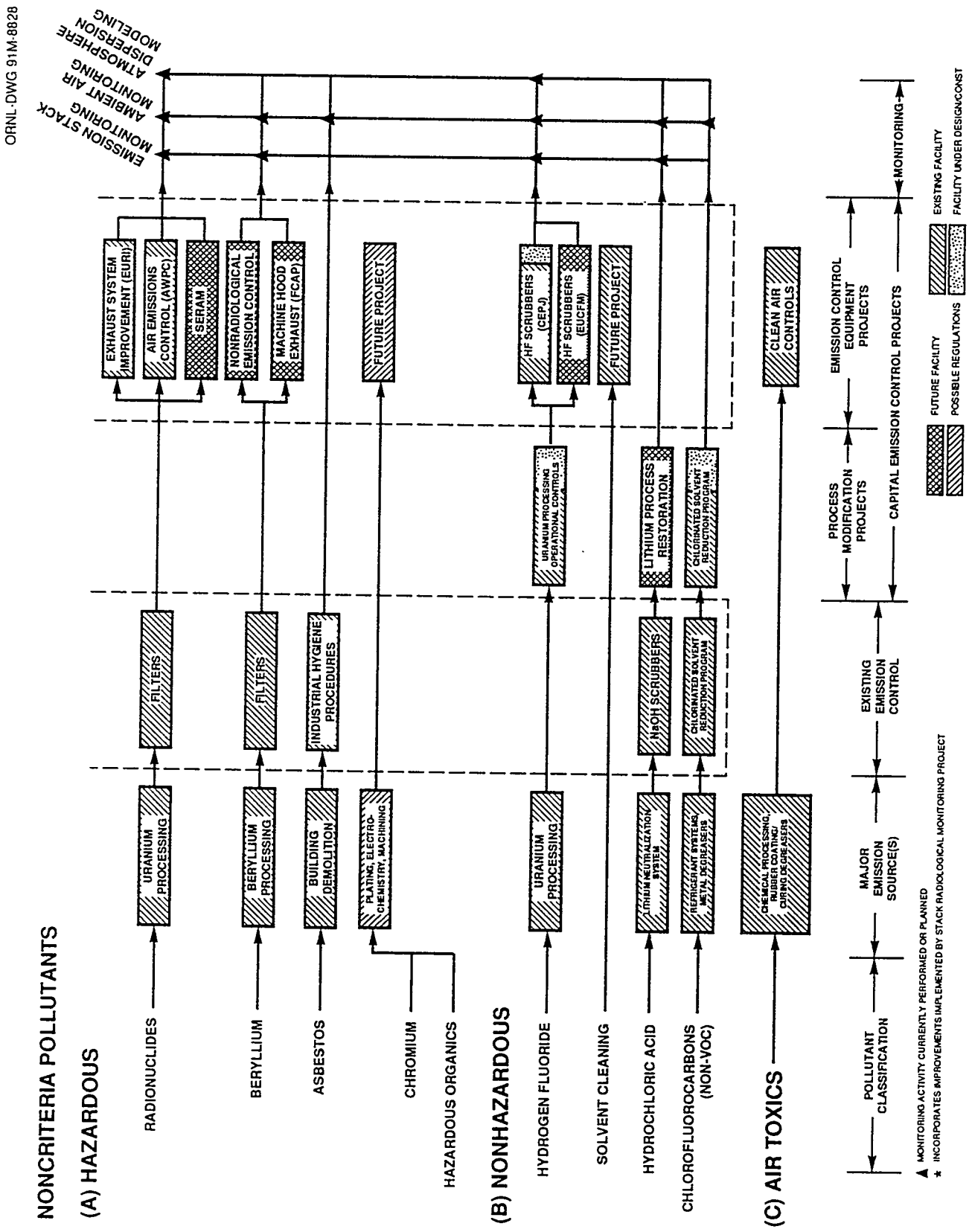

Fig. 3.2. Air pollution control program at the Y-12 Plant (noncriteria air pollutants).

methods and emission estimation methods used did not fully meet EPA requirements. A compliance plan was developed to document the acceptable estimation and sampling methods to be used. This plan was submitted to the EPA in May 1991, and an FFCA has been negotiated to implement the plan. As the plan is implemented, minor changes will be made in the stack sampling program and newly identified sources will be equipped with samplers as needed. Guidelines stated in Chapter 3 of DOE's *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (1991) will also be followed.

Summary

Y-12 Plant radiological uranium emission estimates are broken down in Table 3.1. Y-12 Plant monitored process emission totals were made using stack sampling data obtained from sampling equipment installed in March 1987 under the Stack Radiological Monitoring Project. Uranium stack losses are continuously measured on 81 process exhaust stacks by extracting a representative sample of stack gas through a multipoint sampling probe. Particulate matter (including uranium) is removed from the stack sample through filtration by a 47-mm-diameter paper filter. Sample filters are changed routinely at each location an average of three times per week and analyzed for total uranium by the fluorometric method in the Y-12 Plant Laboratory.

In addition, beginning in 1991, the sampling probes and tubing are removed quarterly, washed with nitric acid, and the wash collected and analyzed for total uranium. At the end of the year, the probe wash data is included in the final calculations in determining total uranium emissions from each stack.

Emissions from the unmonitored process exhausts were from seven emission points. Two of the sources, Stacks 112 and 115, are presently sampled by impinger-type samplers due to the corrosive conditions in the stacks. An action plan to upgrade both stacks has been developed and submitted to the EPA as required under the FFCA (Draft). The five additional unmonitored process exhausts are all categorized as minor emission sources, and estimates were generated according to EPA-approved calculation methods.

The estimate of emissions from room ventilation systems is made using health physics data on airborne radioactivity concentrations in the work areas. Any monthly concentration averages that exceeded 10% of the derived air concentration (DAC) as defined in the compliance plan were included in the annual emission estimate. The annual average concentrations are used with the design ventilation rates to arrive at the annual emission estimate. There were 24 ventilation areas from the enriched buildings and 4 ventilation areas from the depleted buildings that exceeded the DAC in 1991.

Radionuclides other than uranium are handled in millicurie quantities as a part of ORNL research activities at facilities in the Y-12 Plant. The releases from these activities are minimal and have a negligible impact on the total Y-12 Plant dose; therefore, only Y-12 Plant uranium discharges are shown in Table 3.1.

Table 3.1. 1991 Y-12 Plant airborne uranium emissions estimates[a]

Source of emissions	Quantity emitted	
	(kg)	(Ci)
Enriched uranium process exhaust (monitored)	0.6	0.039
Depleted uranium process exhaust (monitored)	20.2	0.007
Enriched uranium process exhaust (unmonitored)	0.1	0.005
Enriched uranium room exhaust (unmonitored)	0.2	0.010
Depleted uranium room exhaust (unmonitored)	2.4	0.001
Total	23.5	0.062

[a]See Table 2.2 for off-site committed dose equivalents resulting from Y-12 Plant uranium emissions.

Chemical Emissions

Emission estimates have been made for a number of major pollutant categories. These are itemized in Appendix A (see Table A.1), which addresses chemical releases and SARA Title III, Section 313.

Discussion

An estimated 0.062 Ci (23.5 kg) of uranium was released into the atmosphere in 1991 as a result of Y-12 Plant processing operations (Figs. 3.3 and 3.4). Because the specific activity of enriched uranium is much greater than that of depleted uranium, approximately 79% of the curie release was from emissions of enriched uranium particulate, whereas only 4% of the total mass of uranium released was from enriched uranium losses.

As illustrated in Fig. 3.3, 1991 Y-12 Plant uranium emissions estimates in total curies again decreased. This decrease in 1991 reflects a reduction in Y-12 Plant process activities, continued improvements in administrative controls of the process activities still operating, and recent improvements in contamination control throughout the Y-12 Plant, notable in the room exhaust estimates from health physics data. Only six buildings contained areas where uranium concentrations exceeded 10% of the DAC in 1991. Twenty-eight stacks with the greatest potential to emit significant amounts of uranium are equipped with breakthrough monitors, which alert operations personnel to process upset conditions or a decline in filtration system efficiencies. The breakthrough monitors have been instrumental in helping to reduce excessive emissions from several enriched process areas over the past few years. When an alarm is received, operations personnel take prompt action to reduce or stop the emission, such as shutting down a process, until the cause of the excessive emission can be identified and corrected.

The notable increase in depleted uranium process exhaust (from 4.3 kg in 1990 to 20.2 kg in 1992), was the result of a water-collection problem at the base of Stack 11, which extends from an underground tunnel. The excess water was drawn up the stack, resulting in a wet probe and wet stack samples for several days. While the samples are not considered valid in assessing the actual emissions from the stack at that time, the calculated emissions were included in the annual totals. This flooding occurred at the end of December 1990 and in early January 1991. The tunnel has been kept pumped free of water since that time.

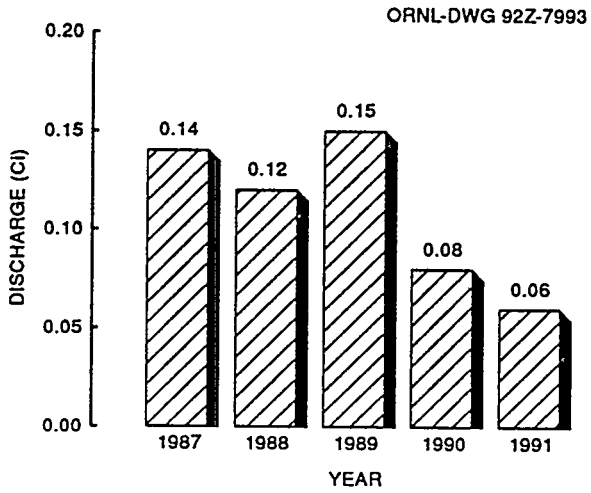

Fig. 3.3. Total curie discharges of uranium from the Y-12 Plant to the atmosphere, 1987–1991.

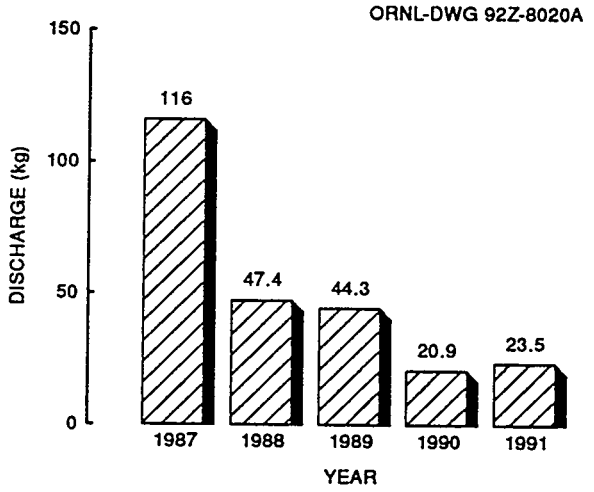

Fig. 3.4. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1987–1991.

3.2.2 Oak Ridge National Laboratory

Description

The major gaseous emission point sources for ORNL consist of the following four stacks located in Bethel and Melton valleys:

Building	Description
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
	3025 and 3026 areas cell ventilation system
7911	Melton Valley complex (High Flux Isotope Reactor, Radiochemical Engineering Development Center)

Figure 3.5 shows the locations of the four main stacks and of the other stacks whose emissions are routinely quantified.

Discharges from each stack 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 nonabsorbable gases.

Gaseous waste streams at ORNL consist primarily of ventilation air from contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. Many sources, mostly nonradioactive, are permitted by the TDEC Air Pollution Control Board. A list of air permits issued by TDEC for emission sources at ORNL is presented in Table 3.2 of Vol. 2. Most gaseous emissions are treated and filtered before discharge to the atmosphere. Typically, contaminated and potentially contaminated gaseous wastes are treated, then filtered with HEPA and/or charcoal filters before discharge to ensure that any radioactivity released is within acceptable levels.

Airborne Emissions Sampling

Each of the four major point sources is provided 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. 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, which must be evaluated using an on-line detector because those radionuclides cannot be quantitatively captured on a sampling medium.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. Included in minor sources are 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. For the purpose of this report, there are three stacks that have been classified as being minor sources and will be included in the data: these are 7025, 7512, and 7830. Other sources are being evaluated and will be included in future annual reports.

Sampling systems are being upgraded to meet the criteria in NESHAP regulations and DOE orders. The present sampling systems generally consist of 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 present sampling systems at stacks 2026 and 3020 do not have tritium traps.

Data sources for the various isotopes identified in the 1991 airborne emission source term are shown in Table 3.2 and are further discussed in the summary. Double entries in the table indicate isotopes that were captured by more than one sampling medium.

Summary

The 1991 radioactive airborne emissions data included 20 isotopes and 5 gross parameters. Table 3.2 provides a listing of isotopes and gross parameters and the media on which they were collected.

The charcoal canisters, particulate filters, and silica-gel traps were collected weekly. During 1991, the weekly tritium samples were composited biweekly for analysis. The 3039 area was sampled in each of the four main ducts feeding into the 3039 stack, resulting in four sets of data for that stack. For the purposes of this report, the 3039 area data were weighted proportionally according to each duct's contribution to the total stack flow and summed.

Charcoal canisters are a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantified eight additional adsorbable gases, as shown in Table 3.2.

Particulate filters were held for 8 days prior to analysis to minimize the contribution from

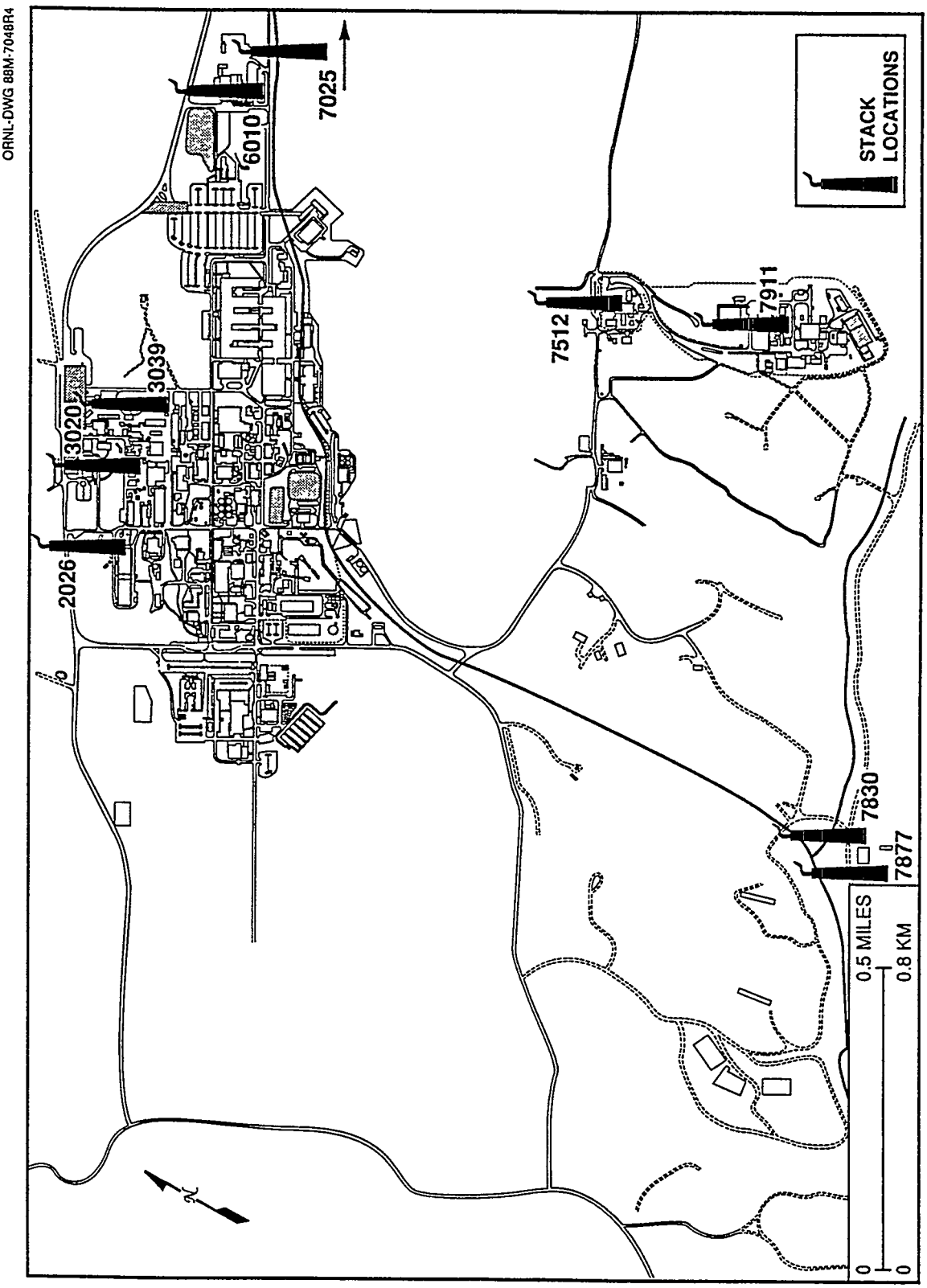

Fig. 3.5. Locations of major stacks (emission points) at ORNL.

Table 3.2. Data sources for airborne radioactive emissions from ORNL, 1991

Radionuclide	Charcoal filter	Weekly particulate filter	Particulate filter composite	Monitoring	Silica gel
^{194}Au	X		X		
^{7}Be			X		
^{82}Br	X				
^{60}Co	X	X	X		
^{137}Cs	X	X	X		
^{138}Cs	X	X			
Gross alpha		X			
Gross beta		X			
^{3}H					X
^{129}I	X				
^{131}I	X		X		
^{132}I	X				
^{133}I	X				
^{134}I	X				
^{135}I	X				
Noble gas				X	
^{191}Os	X		X		
^{212}Pb	X	X			
^{238}Pu			X		
^{239}Pu			X		
Total Sr			X		
^{228}Th	X		X		
^{230}Th			X		
^{232}Th			X		
Total U			X		

short-lived isotopes. A study conducted during 1989 and 1990 (Tardiff and Wolf in press) showed the short-lived gross alpha and gross beta signature of the stacks to be primarily associated with ^{220}Rn and its daughter products. The particulate filters are composited quarterly and analyzed for alpha-, beta-, and gamma-emitting isotopes, and these data are used for dose assessment. Compositing provides an opportunity to evaluate the radionuclides with lower specific activity. Identification and quantification of this group is initially confounded by the presence of short-lived isotopes.

Noble gas emissions from Stacks 3039 and 7911 were derived from real-time monitoring data. Noble gases are chemically inert and, consequently, cannot be trapped on a collecting medium for analysis. Instead, after the monitoring system gas stream has passed through the particulate filter and the charcoal filter, a part of the stream is pumped through a lead-shielded chamber that is equipped with a beta-gamma detector monitor. The implicit assumption is that the upstream collecting media have removed all but the noble gases. The noble gas monitoring data are accrued as total counts that can be converted to a count rate using the lapsed time. Each of the chambers has been calibrated with ^{85}Kr at two concentrations. The calibration results can be used to convert counts per minute into noble gas activity as ^{85}Kr. The 1991 noble gas emissions are based on the average counts-per-minute value for January–December 1991 and converted to an annual noble gas emission as ^{85}Kr equivalent using the calibration data.

Data from silica-gel samples were used to calculate tritium emissions from Stacks 7025, 7911, and 3039.

Radioactive Emissions

The total radioactive airborne emissions for ORNL are presented in Table 3.3. The table lists the total emission for each radionuclide and gross parameter and the percent of the total contributed by

Table 3.3. 1991 airborne radioactive emissions from ORNL

Radionuclide	Percent contribution by stack[a,b]								Total emission	
	2026	3020	3039	7025	7512	7830	7877[c]	7911	(μCi)	(10^6 Bq)
^{194}Au			100*						3,400	120
^{7}Be	2.8	1.7	90*			3.1*		2.8	7.2	0.27
^{82}Br	100*								880	33
^{60}Co	3.3*	0.024	97*			0.0012		<0.0001	200	7.2
^{137}Cs	14*	3.8*	78*			0.16*		4.1*	72	2.7
^{138}Cs								100*	290	11
Gross alpha	61*	6.2*	31*		0.67*	0.11*	0.013	1.2*	14	0.52
Grosss beta	0.52*	0.25*	99*		0.11*	0.015*	0.0024*	0.49*	1,800	66
^{3}H			99*	0.94*				0.10*	16,000[d]	590[e]
^{129}I			53		1.6	27*		18	15	0.57
^{131}I	<0.0001	0.0053	0.014		0.0045*	<0.0001	<0.0001	100*	46,000	1,700
^{132}I								100*	51	1.9
^{133}I	0.0037	<0.0001	0.0058		0.00079	<0.0001	<0.0001	100*	62,000	2,300
^{134}I								100*	51	1.9
^{135}I	<0.0001	<0.0001	<0.0001		0.0024	0.00025	<0.0001	100*	33,000	1,200
Noble gas			56					44	8,600[d]	320[e]
^{191}Os	0.00025*	<0.0001*	100*		0.00075*	<0.0001*		0.00031*	4.0[d]	1.5[e]
^{212}Pb	16*	16*	61*		0.17*	0.33*	0.00012*	6.8*	240,000	8,900
^{238}Pu	63*	34*	4.7			0.11		<0.0001	0.075	0.0028
^{239}Pu	44*	56*	0.32			<0.0001		<0.0001	0.36	0.013
^{228}Th	77*	12*	10*			0.31*		0.77	0.042	0.0016
^{230}Th	24*	36*	27*			0.83*		12*	0.014	0.00053
^{232}Th	15*	26*	43*			0.94*		16*	0.011	0.00042
Total Sr	3.0*	2.3*	93*			0.033*		2.0*	34	1.2
Total U[f]	26	16	11			18		29	0.074	0.0028

[a]Total percentages that exceed 100 are due to rounding.

[b]Values marked with an asterisk (*) represent emissions statistically determined to be significantly different from zero. Note that the variance used in the significance test is based only on the uncertainty associated with laboratory counting and does not include uncertainty due to the sampling process. No significance test was applied to emissions of uranium and noble gas.

[c]Isotopic analyses of particulate filters were not conducted.

[d]Values are curies.

[e]Values are in 10^{12} Bq.

[f]Total uranium emission was 0.10 g.

each stack. The percent values are based on summed emissions from each stack for the year. Sums for individual radionuclides were tested for statistical significance using laboratory counting uncertainties. If the 95% lower bound calculated from the variance of the sum is greater than zero, then the sum is determined to be significantly different from zero. In the table, percents derived from sums that were determined to be significant are marked with an asterisk.

Trends in historically analyzed emission parameters are presented in Figs. 3.6–3.9. The noble gas trend charts are based upon the gross count data from the noble gas monitoring systems. The noble gas source term was assumed to be 100% ^{85}Kr for Stack 3039 and 83% ^{133}Xe and 17% ^{85m}Kr for Stack 7911. These percentages are based on operations information. An assessment of the potential impacts of the emission source term to the public is presented in Sect. 2.

The noble gas source term for Stack 3039 has dropped significantly from the previous year's levels. This is due to a change in mission for ORNL. Prior to 1991, ORNL was the only commercial source of ^{85}Kr in the free world. Packaging operations for ^{85}Kr have been moved to the Idaho National Engineering Laboratory, ORNL's former supplier of the noble gas. Increases in the iodine signatures are associated with operations at the High Flux Isotope Reactor. Increases in the ^{3}H emissions are partially attributable to operations for the ^{3}H inventory from ORNL. Sampling instrumentation and methods for ^{3}H were improved during 1990; this may be partly responsible for the apparent increase in emissions.

Chemical Emissions

Total particulate and chemical emissions from any one emission point at ORNL are very low, except for the steam plant. Therefore, the air permits issued by the TDEC Air Pollution Control Board do not require sampling or monitoring at any of the permitted emission points except the steam plant. Estimates of major chemical emissions are included in Appendix A.

3.2.3 K-25 Site

Description

As a result of the K-25 Site operations, emission sources may release permitted quantities of various contaminants into the atmosphere. To ensure that these emissions are minimized and that full compliance with CAA requirements is maintained, a comprehensive air pollution compliance program has been implemented.

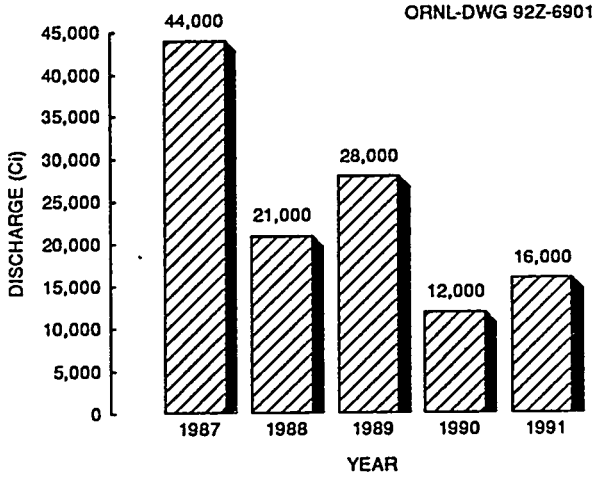

Fig. 3.6. Total discharges of ^{3}H from ORNL to the atmosphere, 1987–1991.

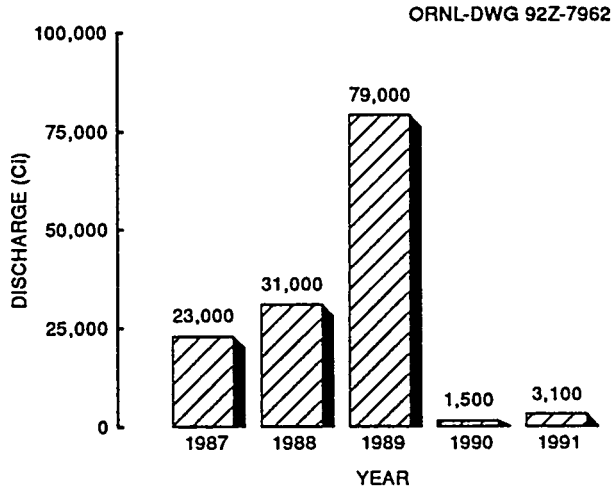

Fig. 3.7. Total discharges of ^{133}Xe from ORNL to the atmosphere, 1987–1991.

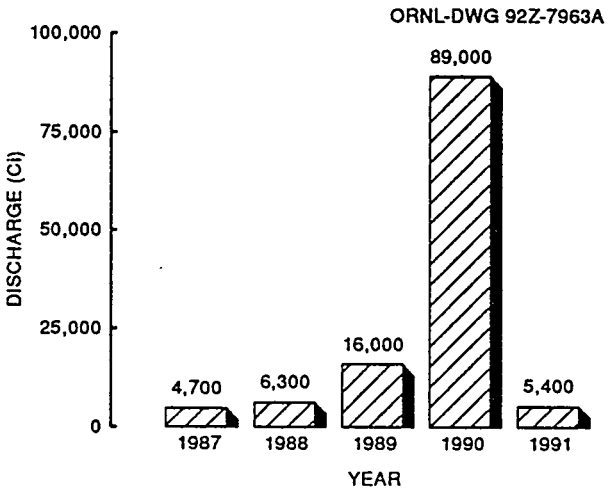

Fig. 3.8. Total discharges of ^{85}Kr from ORNL to the atmosphere, 1987–1991.

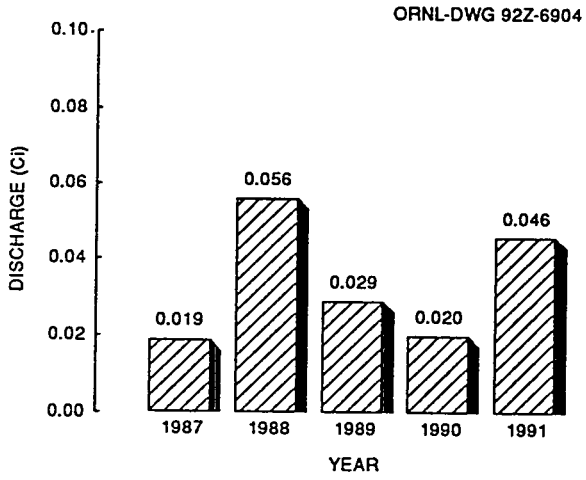

Fig. 3.9. Total discharges of ^{131}I from ORNL to the atmosphere, 1987–1991.

This program involves (1) maintenance of a flexible, well-documented environmental policy with regard to air pollution control; (2) continuous review of changes/modifications of air pollution regulations; (3) implementation of projects designed to keep the K-25 Site in full compliance with the CAA; and (4) operational and emissions monitoring to ensure compliance.

Many of these permitted sources are inactive because of the shutdown of the gas centrifuge development program and the gaseous diffusion process. Those sources that have been verified as being permanently removed from service were requested to have their permits rescinded. Future permitting activities will include updating inactive TDEC permits to include new processes. Table 3.3 in Vol. 2 lists air permits issued by TDEC for the K-25 Site.

Radioactive Emissions

The locations of airborne radioactive effluent release points at the K-25 Site are shown in Fig. 3.10. All radionuclide emissions were included in all dose modeling. Figure 3.11 describes the general types of air emission sources at the K-25 Site, and Fig. 3.12 depicts the air pollution control program strategy in detail.

Currently, the major operating radionuclide emission sources are the K-1015 laundry facility, the K-1420 disassembly area, and the K-1435 TSCA Incinerator. For the K-1435 TSCA Incinerator, the estimates of the amount of pollutants emitted are based on actual operating activity and continuous sampling. The estimates for radionuclide emissions from the various stacks at the K-1015 laundry are based on both actual 1991 operations and stack sampling data obtained in 1991.

The K-1420 disassembly area emissions were estimated from a material balance performed on the uranium present in the HEPA filter used to filter the process emissions.

The K-1435 TSCA Incinerator, which was built to thermally destroy PCBs and other organic hazardous wastes, has undergone several series of tests to meet the RCRA requirements. TDEC plans to modify the RCRA permit to include the conditions that were demonstrated during the trial burn.

The required TDEC air compliance tests for lead, beryllium, and nitrogen oxide emissions were completed, all permitting requirements were fulfilled, and operation began in March 1990. The incinerator began to burn waste in May 1990.

Reliability and maintainability testing was performed early in 1991 and DOE approval for full production was granted in April 1991. Full operation began in April 1991. The radioactive isotopes incinerated in the K-1435 TSCA Incinerator during 1991 were uranium, technetium, ^{137}Cs, ^{237}Np, ^{234m}Pa,

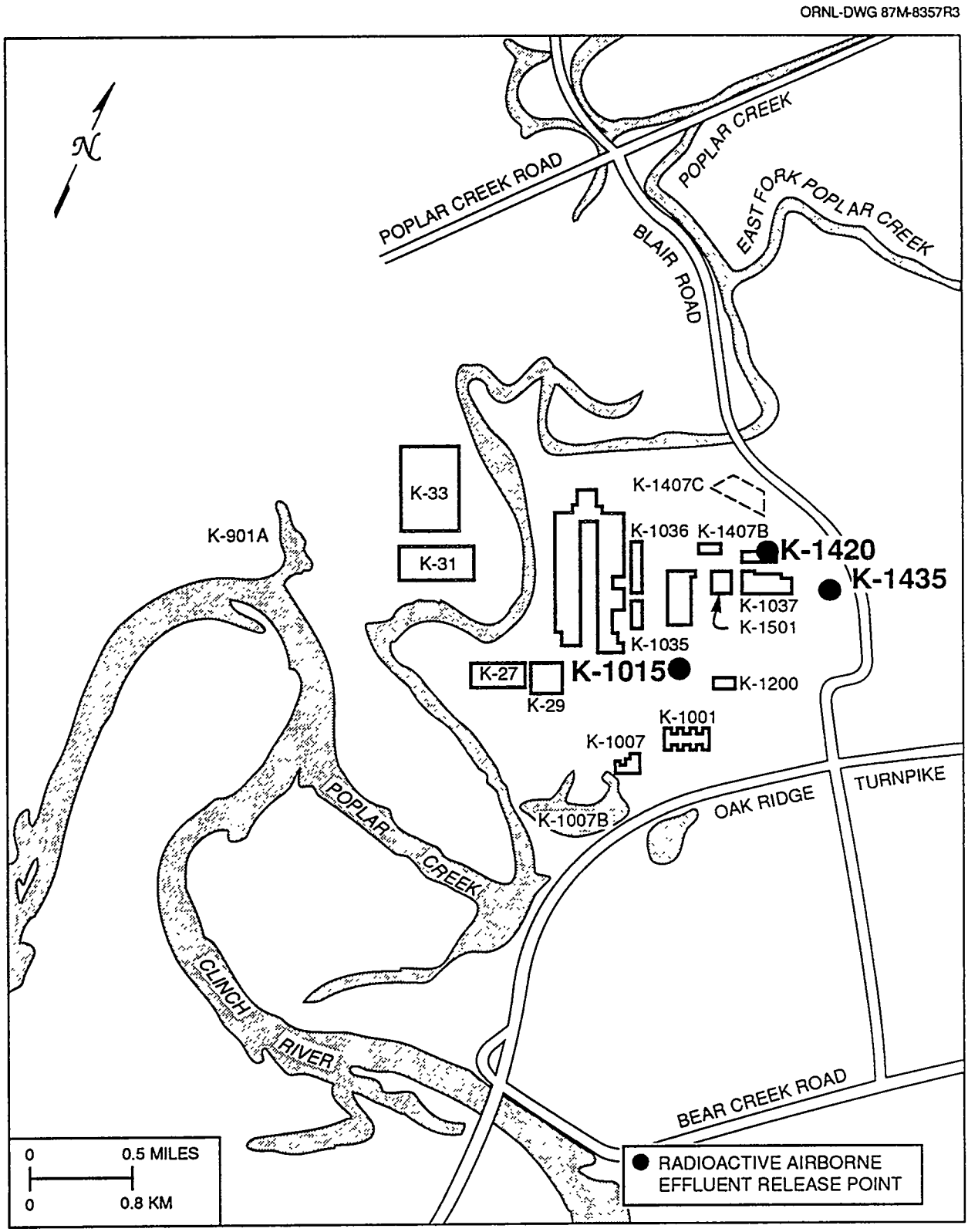

Fig. 3.10. Locations of radioactive airborne effluent release points at the K-25 Site.

ORNL-DWG 87M-7346R

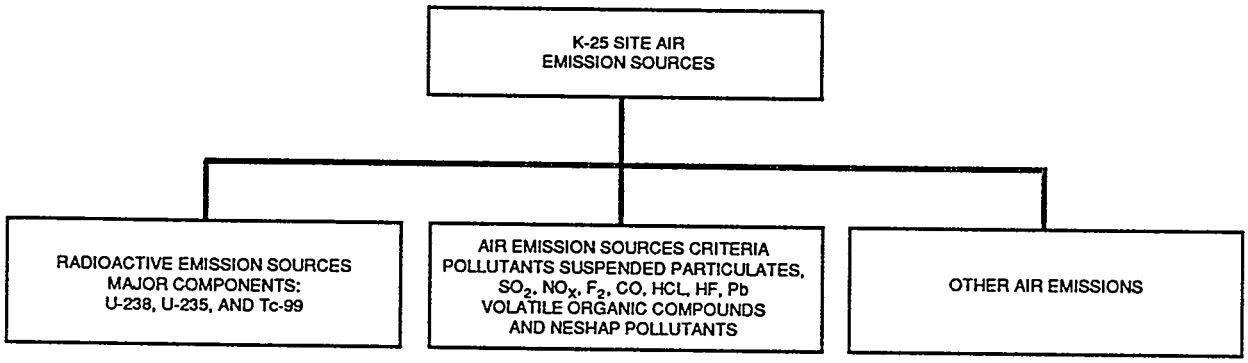

Fig. 3.11. Air emission sources at the K-25 Site.

ORNL-DWG 87M-7345R3

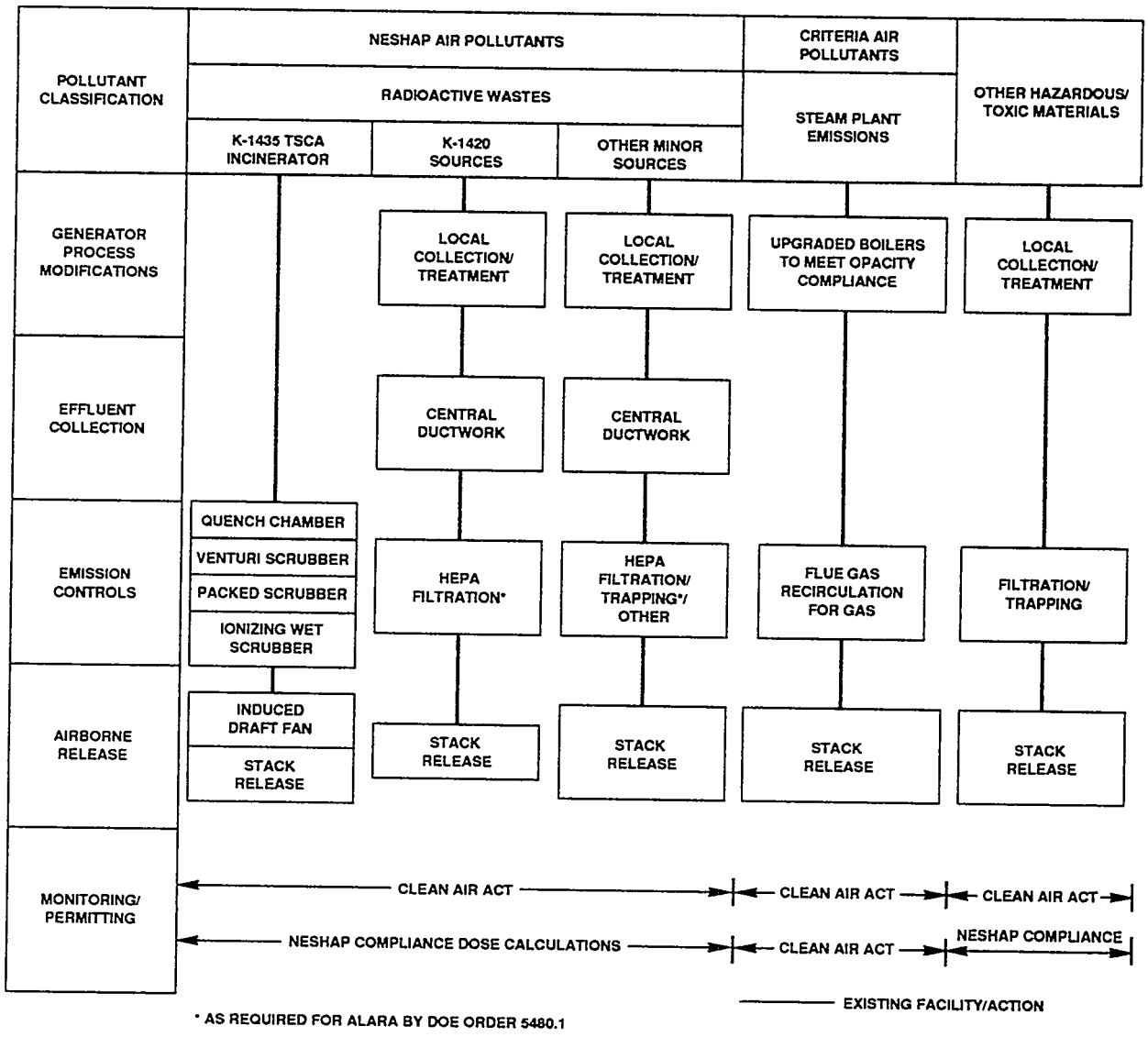

Fig. 3.12. Air pollution control program at the K-25 Site.

1991 were uranium, technetium, ^{137}Cs, ^{237}Np, ^{234m}Pa, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, and ^{234}Th. The emissions of uranium and technetium were well within the acceptable guidelines outlined in the application for the approval to construct the TSCA Incinerator—15,000 μCi/year for uranium and 394,000 μCi/year for technetium (see Table 3.4). In addition, carbon monoxide, carbon dioxide, and oxygen are continuously monitored to ensure that destruction efficiency for the incinerator is sufficient to destroy 99.9999% of organics.

Figures 3.13 and 3.14 compare the K-25 Site's discharges of uranium for 1991 with those of previous years. Uranium emissions for 1991 resulted almost entirely from operation and testing of the K-1435 TSCA Incinerator. Samples collected in 1991 detected ^{99}Tc in emissions from K-1015 and K-1435. Figures 3.15 and 3.16 compare the K-25 Site's discharges of ^{99}Tc for 1991 with those of previous years. Figures 3.13–3.16 indicate a large increase of ^{99}Tc and uranium emissions. This is due to the operation of the K-1435 TSCA Incinerator.

TSCA TRV Event

In December 1991, a TRV (thermal relief valve) event occurred because of a power loss at the K-1435 TSCA Incinerator. The systems designed to shut down the incinerator during a TRV event worked as designed. The release of radionuclides due to the TRV was estimated to occur for nine seconds. The estimated radionuclide emissions released are shown in Table 3.5. The effective dose equivalent from the TRV event was 1.4×10^{-5} mrem for the most effected resident of the K-25 Site and 8.1×10^{-7} mrem for the most effected resident of the ORR.

Chemical Emissions

There are no permitting requirements to sample or monitor all chemical emissions from the K-25 Site; however, estimates of the major gaseous chemicals emitted to the atmosphere in 1991 (including those that require reporting under SARA Title III, Sect. 313) are shown in Appendix A.

Several changes were made to the K-1501 steam plant in 1991. The existing coal-fired boilers were permanently removed from service. A new natural gas/number 2 fuel oil–fired boiler, with flue gas recirculation to control nitrogen oxides, began operation. Because sufficient natural gas was not always available during cold weather conditions in 1991, some number 2 fuel oil was burned during peak periods of use.

3.3 AMBIENT AIR MONITORING

In addition to stack monitoring and sampling conducted at the DOE Oak Ridge installations, an ambient air monitoring program has been developed to directly measure radiological parameters in the ambient air adjacent to the facilities. Ambient air monitoring provides direct measurement of airborne radionuclide concentrations in the environment surrounding the facilities, allows facility personnel to determine the relative level of radioactivity at the monitoring locations during an emergency condition, and also serves as a check on dose-modeling calculations.

The following sections discuss the ambient air monitoring network for the Energy Systems Oak Ridge installations. This network consists of a number of ambient air monitors located around each facility within the ORR and at two remote locations in the surrounding communities. With the exception of perimeter air monitors around the Y-12 Plant and the K-25 Site and TSCA ambient air monitors near the K-25 Site, all ambient air monitors were operated by ORNL during 1991. The following discussions include data summary tables in which 1991 ambient air monitoring results for each station are presented. For a more complete presentation of these data, see Vol. 2, Tables 3.4–3.12.

3.3.1 Y-12 Plant

Description

With the technical assistance of ORNL, the Y-12 Plant has developed a network of ambient air monitors located around the plant perimeter. These stations are to monitor ambient air quality at the plant boundaries to determine the off-site transport of air contaminants and to verify that plant ambient air quality meets air quality standards.

The Y-12 Plant operates 12 ambient air monitoring stations around the perimeter of the plant to routinely measure suspended uranium particulates. Ambient air fluoride sampling is also conducted continuously at 11 of the Y-12 Plant perimeter air

Table 3.4. Total radionuclide emissions during normal operations from the K-25 Site TSCA Incinerator for 1991

Contaminant	Emission (Ci)
Total activity	5.750×10^{-2}
^{237}Np	8.131×10^{-4}
^{238}Pu	-3.505×10^{-5}
^{239}Pu	5.379×10^{-5}
^{99}Tc	3.945×10^{-2}
^{228}Th	2.658×10^{-3}
^{230}Th	8.407×10^{-5}
^{232}Th	1.517×10^{-5}
^{234}Th	4.728×10^{-2}
^{137}Cs	5.515×10^{-4}
^{57}Co	4.147×10^{-7}
^{60}Co	-7.202×10^{-6}
^{95}Nb	1.456×10^{-6}
^{234m}Pa	1.727×10^{-1}
^{109}Cd	-2.798×10^{-6}
Total U	2.428×10^{-2}
^{234}U	1.049×10^{-2}
^{235}U	4.605×10^{-4}
^{238}U	1.333×10^{-2}

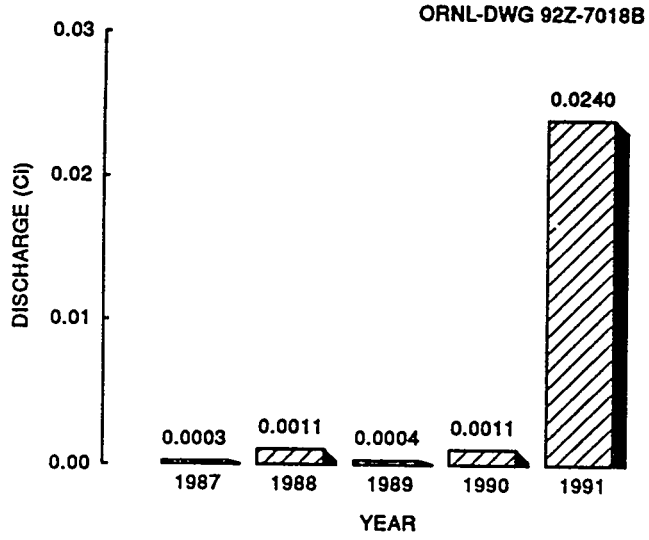

Fig. 3.13 Total curie discharges of uranium from the K-25 Site to the atmosphere, 1987–1991.

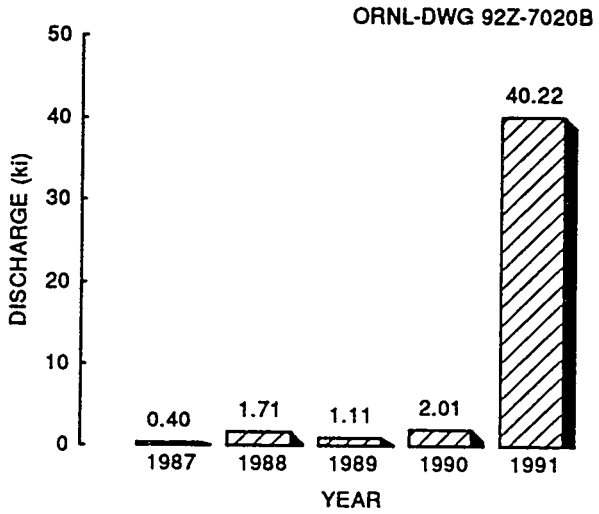

Fig. 3.14. Total kilograms of uranium discharged from the K-25 Site to the atmosphere, 1987–1991.

monitor for total suspended particulates (TSP) and for particles less than 10 μm in diameter (PM10). The locations of the ambient air monitoring stations operated by the Y-12 Plant are shown on Fig. 3.17.

Atmospheric fluoride is collected at 11 sites by absorption on 37-mm (1.5-in.) diam filters pretreated with potassium carbonate. The filters are analyzed by the Y-12 Plant Laboratory using the selective ion electrode method (EPA 340.2). Ambient uranium

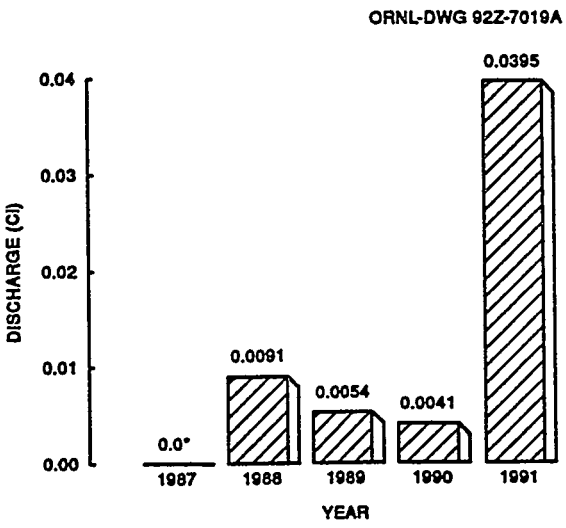

Fig. 3.15. Total curie discharges of technetium from the K-25 Site to the atmosphere, 1987–1991. (No technetium was detected in 1987.)

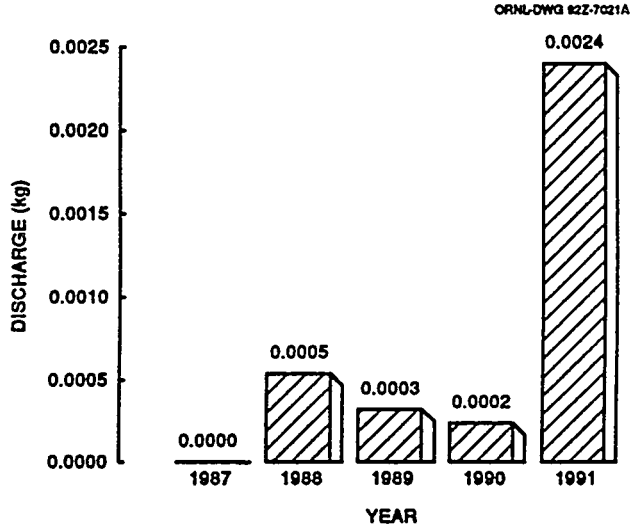

Fig. 3.16. Total kilograms of technetium discharges from the K-25 Site to the atmosphere, 1987–1991. (No technetium was detected in 1987.)

Table 3.5. Total radionuclide emissions during Dec. 20, 1991, TRV event from the K-25 Site TSCA Incinerator

Contaminant	Emission (μCi)
Alpha activity	0.154
Beta activity	0.263
Total U	0.176
^{99}Tc	−0.128
^{237}Np	0.080
^{238}Pu	-1.24×10^{-5}
^{239}Pu	1.39×10^{-3}
^{228}Th	6.66×10^{-3}
^{230}Th	7.98×10^{-3}
^{232}Th	2.65×10^{-3}
^{234}Th	0.161
^{234m}Pa	0.286
^{137}Cs	1.13×10^{-5}

sampling is conducted at these same 11 sites and also at an additional site constructed in 1987. Uranium particulates are collected on square 14-cm (5.5-in.) filters and analyzed in the Y-12 Plant Laboratory by alpha spectroscopy. Data obtained from ambient uranium and fluoride air sampling are used by Y-12 Plant personnel to assess ambient air quality within the plant and around the plant perimeter. Monitoring of area ambient air quality ensures that plant workers and the general public are adequately protected from potential hazards of stack and other emissions.

The Y-12 Plant monitors TSP in ambient air at the east and west ends of the site. Sampling for TSP consists of drawing air at a known rate through a preweighed filter paper for 24 h every 6 d. From a weight differential resulting from particle accumulation, a particle concentration (expressed in $\mu g/m^3$) can be calculated. These values are compared with the Tennessee primary and secondary ambient air quality standards. Sample results are not submitted to TDEC or EPA but are used as an internal measure of area ambient air quality. If a

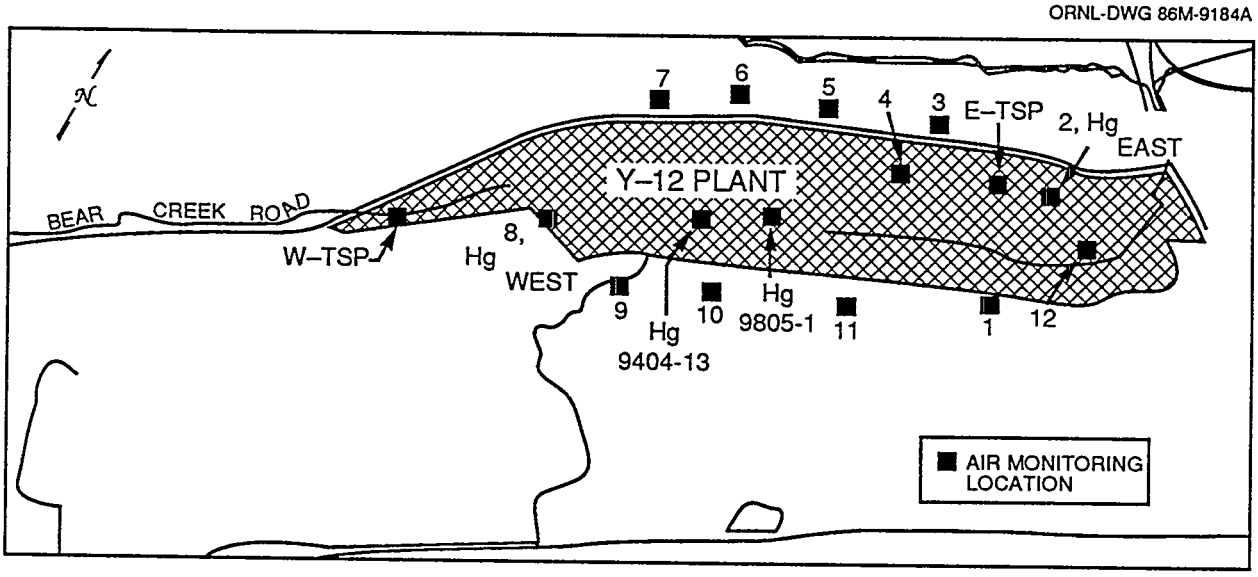

Fig. 3.17. Ambient air monitoring stations at the Y-12 Plant.

sample is found to exceed the state standard, Y-12 Plant personnel have the filter scrutinized under a microscope to determine the cause. In all previous cases, the particulate matter did not result from process emissions. Rather, the majority of the filter was covered with road dust, pollen, insects, and other particles arising from the natural environment.

In 1990, three special PM10 samplers designed to collect particles smaller than 10 microns were installed adjacent to the existing TSP samplers; one PM10 at the west site and two PM10s at the east site. The PM10s were brought online in the fall of 1990 and are being operated on the same schedule as the TSPs. Some data from the PM10s were collected in 1991. However, most results indicated a negative net weight. A study was conducted to determine the cause. As a result, changes have been made in handling the special quartz filters both in the field and in the lab. In addition, the lab has ordered a new scale for weighing the TSP and PM10 filters.

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 an 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. Airborne mercury 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 mercury monitoring stations (stations on the east and west ends of the plant and two stations near Building 9201-4) were established on-site in 1986 with an additional site added at New Hope Pond in August 1987. In February 1988, a control site was established at Rain Gage No. 2 on Chestnut Ridge in the Walker Branch Watershed. After collecting data for one calendar year to establish background concentrations and a seasonal pattern for the control site, the Rain Gage No. 2 site was discontinued. The New Hope Pond site was abandoned in 1989, several months after the closure of the pond.

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 six sites, airborne mercury was collected on charcoal by pulling air through a Teflon filter, followed by a flow-limiting orifice and a sampling tube packed with iodated charcoal. The charcoal sampling tubes were changed every 7 days. Average air concentration of mercury vapor for each 7-day sampling period was calculated

by dividing the total quantity of mercury collected on the charcoal by the total volume of air pulled through the tube. Mercury collected on the charcoal is analyzed by cold vapor atomic absorption spectrophotometry after digestion in nitric-perchloric acid.

Summary

Ambient air monitoring results for the Y-12 Plant perimeter air monitors are summarized in Tables 3.6–3.10. Table 3.6 shows the maximum, minimum, and average gross alpha and gross beta concentrations measured at each of the 12 stations during 1991. Similarly, the ^{234}U, ^{235}U, ^{236}U, and ^{238}U average concentrations are shown in Table 3.7. Table 3.8 shows similar data for ambient fluoride concentrations during 1991 as well as a comparison with the state standard for fluorides.

Table 3.9 and Fig. 3.18 present the mercury monitoring data summarized for the entire period from 1986 through 1991. Table 3.10 shows TSP data for the two Y-12 Plant TSP ambient air monitoring stations during 1991. More detailed data are available in Vol. 2, Tables 3.4–3.7.

Discussion

Ambient air concentrations of fluorides measured during 1991 at each of the Y-12 Plant perimeter air

Table 3.6. 1991 gross alpha and beta in air at the Y-12 Plant perimeter ambient air monitoring stations

Station	Number of analyses[a]	Concentration (10^{-15} μCi/cm^3)[b]		
		Max	Min	Av
		Gross alpha		
1	4	0.683	-0.02	0.431
2	4	0.801	0.220	0.568
3	4	0.944	0.385	0.752
4	4	0.760	0.533	0.673
5	4	0.960	0.790	0.874
6	4	0.641	0.213	0.496
7	4	0.765	0.297	0.506
8	4	0.691	0.337	0.546
9	4	0.603	0.458	0.517
10	4	0.781	0.277	0.574
11	4	0.602	0.253	0.449
12	4	0.692	0.206	0.493
		Gross beta		
1	4	7.105	1.741	5.091
2	4	7.834	5.326	6.884
3	4	7.914	5.577	7.005
4	4	6.062	4.695	5.636
5	4	7.392	5.711	6.628
6	4	6.840	5.844	6.314
7	4	6.755	4.804	5.970
8	4	7.122	5.180	6.509
9	4	7.818	5.308	6.831
10	4	7.963	5.164	6.878
11	4	6.997	5.680	6.386
12	4	7.693	5.669	6.839

[a]Gross alpha and gross beta radiation analyses are performed quarterly using a composite of sample filter papers changed out weekly throughout the quarter. For average uranium air concentration data, refer to Table 3.7 and Vol. 2, Sect. 3.

[b]To convert from 10^{-15} μCi/cm^3 to 10^{-11} Bq/cm^3, multiply by 3.7.

Table 3.7. 1991 uranium concentrations in air at the Y-12 Plant

Station	Number of analyses[a]	Concentration (10^{-15} μCi/cm^3)[b]			DCG[c] (%)
		Max	Min	Av	
		^{234}U			
1	4	0.872	0.064	0.302	0.97
2	4	0.284	0.096	0.200	0.32
3	4	0.620	0.069	0.374	0.69
4	4	0.981	0.214	0.582	1.09
5	4	1.371	0.681	1.014	1.52
6	4	0.472	0.340	0.382	0.52
7	4	0.486	0.235	0.382	0.54
8	4	0.664	0.159	0.320	0.74
9	4	0.244	0.103	0.199	0.27
10	4	0.167	0.082	0.125	0.19
11	4	0.256	0.084	0.148	0.28
12	4	0.243	0.066	0.134	0.27
		^{235}U			
1	4	0.0113	0.0075	0.0081	0.01
2	3	0.0071	0.0025	0.0042	<0.01
3	3	0.0208	0.0081	0.0161	0.02
4	4	0.0300	0.0038	0.0155	0.03
5	4	0.0469	0.0212	0.0338	0.05
6	4	0.0168	0.0041	0.0121	0.02
7	4	0.0218	0.0070	0.0119	0.02
8	4	0.0264	0.0032	0.0519	0.03
9	4	0.0136	-0.006	0.0061	0.01
10	4	0.0098	0.0031	0.0251	<0.01
11	4	0.0160	-0.000	0.0070	0.02
12	4	0.0136	0.0027	0.0346	0.01
		^{236}U			
1	3	0.0151	0.0029	0.0074	0.02
2	2	0.0036	0.0021	0.0029	<0.01
3	1	0.0052	0.0052	0.0052	<0.01
4	4	0.0225	0.0030	0.0090	0.02
5	4	0.0107	0.0034	0.0080	0.01
6	2	0.0136	0.0067	0.0102	0.01
7	3	0.0087	0.0057	0.0069	<0.01
8	4	0.0113	-0.0001	0.0036	0.01
9	2	0.0062	0.0028	0.0045	<0.01
10	3	0.0081	0.0026	0.0046	<0.01
11	4	0.0051	-0.000	0.0028	<0.01
12	3	0.0055	-0.0001	0.0093	<0.01

Table 3.9. Annual results of the Y-12 Plant airborne mercury monitoring program, 1986–1991

Site	Year	Number of samples	Mercury vapor concentration (μg/m^3)		
			Max	Min	Av

Table 3.7. (continued)

Station	Number of analyses[a]	Concentration (10^{-15} µCi/cm^3)[b]			DCG[c] (%)
		Max	Min	Av	
		^{238}U			
1	4	0.0453	0.0120	0.0244	0.05
2	4	0.0299	0.0131	0.0214	0.03
3	4	0.0372	0.0157	0.0233	0.04
4	4	0.0449	0.0093	0.0289	0.04
5	4	0.0397	0.0214	0.0341	0.04
6	4	0.0538	0.0164	0.0281	0.05
7	4	0.0508	0.0172	0.0326	0.05
8	4	0.1375	0.0388	0.0681	0.14
9	4	0.0501	0.0079	0.0347	0.05
10	4	0.0947	0.0188	0.0461	0.09
11	4	0.0615	0.0129	0.0295	0.06
12	4	0.0589	0.0032	0.0279	0.06

[a]Isotopic uranium determinations are performed quarterly using a composite of samples collected weekly throughout the quarter.
[b]To convert from 10^{-15} µCi/cm^3 to 10^{-11} Bq/cm^3, multiply by 3.7
[c]Percent DCG = Maximum × 100/derived concentration guide (DCG). The DCG is specified by isotope in DOE Order 5400.5; the most conservative values are used.

Table 3.8. 1991 fluorides in air at the Y-12 Plant

Station	Number of samples	Concentration (µg/m^3)				Percentage of standard[b]
		Max	Min	Av	Tenn. std.[a]	
1	45	0.1017	0.0051	0.0124	1.6	0.3163
2	50	0.0678	0.0066	0.0129	1.6	0.4097
3	50	0.0996	<0.0066	<0.0147	1.6	0.4143
4	41	0.1635	0.0049	0.0171	1.6	0.3065
5	48	1.1561	<0.0068	<0.0510	1.6	0.4272
6	43	0.0607	0.0045	0.0123	1.6	0.2798
7	46	0.0457	0.0047	0.0116	1.6	0.2920
8	49	0.0197	0.0046	0.0110	1.6	0.2874
9	40	0.0220	0.0041	0.0104	1.6	0.2555
10	50	0.0214	<0.0070	<0.0099	1.6	0.4379
11	50	0.0247	0.0046	0.0101	1.6	0.2878

[a]Tennessee standard 7-d average = 1.6 µg/m^3.
[b]Percentage of standard calculated using average fluoride concentration.

monitoring fluoride stations were well below TDEC standards, averaging less than 1% of the standards.

Ambient uranium isotope concentrations measured at each of the 12 perimeter air monitoring stations around the Y-12 Plant were also very low. Although there is no federal or state standard that applies to ambient uranium or uranium isotope concentrations, measured values are within guidelines set forth in DOE Order 5400.5.

Table 3.7 in Vol. 2 gives gross alpha and gross beta concentrations in air at the Y-12 Plant for 1991.

TSP samples collected at the Y-12 Plant indicated no exceedances of state primary or secondary standards in 1991.

With the exception of the site located at the west end of the Y-12 Plant, results of the mercury monitoring program show significant decreases (Student's t-test at the 1% level) in annual means for

Table 3.9. Annual results of the Y-12 Plant airborne mercury monitoring program, 1986–1991

Site	Year	Number of samples	Mercury vapor concentration ($\mu g/m^3$)		
			Max	Min	Av
Ambient No. 2 (east end of Y-12)	1986	34	0.058	0.003	0.011
	1987	52	0.033	0.001	0.009
	1988	52	0.036	0.003	0.010
	1989	52	0.012	0.003	0.006
	1990	52	0.018	<0.001	0.006
	1991	51	0.073	<0.001	0.008
Ambient No. 8 (west end of Y-12)	1986	27	0.034	<0.001	0.017
	1987	52	0.067	0.007	0.032
	1988	52	0.407	0.007	0.041
	1989	52	1.187	0.006	0.143
	1990	51	0.025	0.002	0.011
	1991	51	0.067	0.005	0.016
Bldg. 9404-13 (SW of Bldg. 9201-4)	1986	31	0.197	0.033	0.108
	1987	52	0.465	0.044	0.174
	1988	51	0.340	0.028	0.137
	1989	52	0.250	0.024	0.101
	1990	52	0.277	0.001	0.067
	1991	51	0.181	0.018	0.070
Bldg. 9805-1 (SE of Bldg. 9201-4)	1986	15	0.137	0.026	0.070
	1987	52	0.226	0.036	0.109
	1988	52	0.384	0.017	0.097
	1989	51	0.206	0.017	0.072
	1990	52	0.162	0.018	0.070
	1991	48	0.275	0.003	0.058
New Hope Pond[a]	1987	20	0.039	0.006	0.016
	1988	52	0.412	0.004	0.046
	1989	37	0.009	0.002	0.004
Rain Gage No. 2[b] (Chestnut Ridge)	1988	47	0.016	0.002	0.006
	1989	47	0.015	<0.001	0.005

[a]Site discontinued September 19, 1989.
[b]Site discontinued October 31, 1989.

Table 3.10. 1991 total suspended particulates in air at the Y-12 Plant TSP monitoring station

Station	Number of samples	Concentration ($\mu g/m^3$)					Number of exceedances
		Max	Min	Av	Tenn. Std.[a]	% Std.	
East	57	108.7	7.2	37.8	260	14.5	0
West	55	75.0	10.2	36.2	260	13.9	0

[a]The primary standard for TSP for the state of Tennessee is 260 $\mu g/m^3$/24 h. The secondary standard for the state of Tennessee is 150 $\mu g/m^3$/24 h.

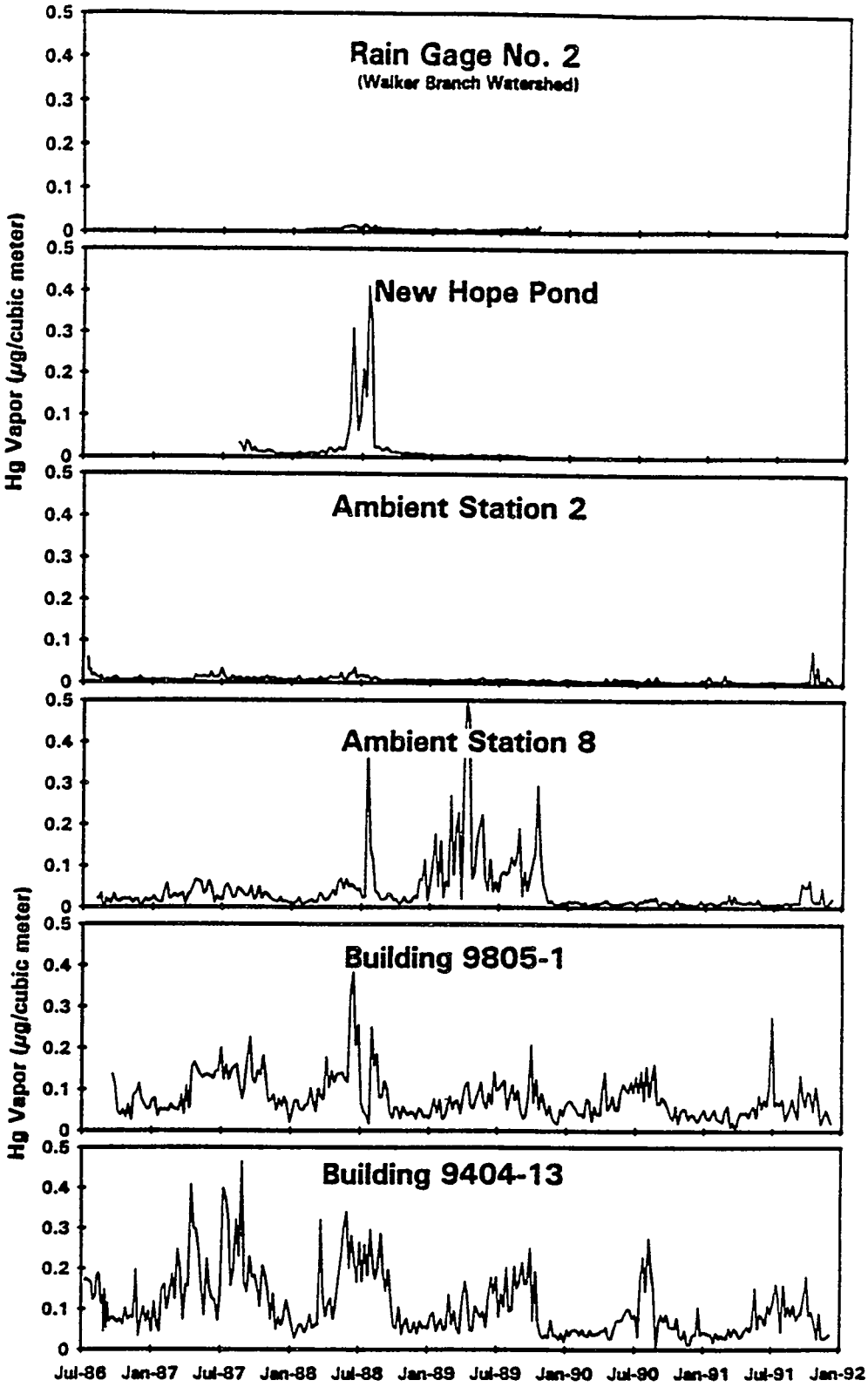

Fig. 3.18. Time trends in mercury vapor concentrations for five monitoring sites at the Y-12 Plant and for Rain Gage No. 2 at Walker Branch Watershed.

ambient mercury vapor measured at the plant sites during 1989, 1990, and 1991 when compared with the means for 1986–1988. The decrease in ambient mercury recorded at these sites from 1989–1991 is probably related to the 80% reduction in the tonnage of coal burned at the steam plant beginning in 1989 and to the completion prior to 1989 of several major engineering projects (e.g., New Hope Pond closure, the Perimeter Intrusion Detection Assessment System [PIDAS], Reduction of Mercury in Plant Effluent [RMPE], and Utility Systems Restoration) that may have temporarily elevated mercury air concentrations because of disturbances to contaminated soil and sediment. Concentrations of ambient mercury that showed an increase in 1989 at Ambient Station No. 8 at the west end of the plant have since decreased in 1990 and 1991 to the lowest annual averages measured for this site. Average annual concentrations of ambient mercury vapor in 1991 for the four Y-12 Plant sites still operating were found not to be significantly different (Student's t-test at the 1% level) from 1990 values. The seasonal pattern (Fig. 3.18) of higher mercury concentrations occurring in the warmer months of the year continued in 1991, being especially noticeable for the two sites located near Building 9201-4.

In summary, data for mercury in ambient air at the five Y-12 Plant monitoring locations suggest that the environment and human health are being protected from releases of mercury to the atmosphere. Although ambient mercury concentrations at the Y-12 Plant are elevated above natural background and occasionally may reach greatly elevated concentrations for short periods in localized areas, results indicate that on-site concentrations of mercury vapor are well below the NESHAP guideline of 1 g/m^3 (30-d average) and the American Conference of Governmental Industrial Hygienists' threshold limit value of 50 $\mu g/m^3$ (time-weighted average for 8-h workday and 40-h work week).

3.3.2 Oak Ridge National Laboratory

Description

The objectives for the ambient program are (1) to sample at stations that were most likely to show impacts of airborne emissions from the operation of ORNL, (2) to maintain surveillance of airborne radionuclides at the ORR perimeter, and (3) to collect reference data from remote locations. Figures 3.19 and 3.20 show the stations that are in the ORNL ambient air program. The specific stations associated with each of these objectives are as follows:

1. The ORNL perimeter air monitoring (PAM) network includes Stations 3, 7, 9, 20, 21, and 22 (Fig. 3.19).
2. The DOE ORR PAM network includes Stations 8 (tritium only), 23, 33, 34, 40, 41, 42, 43, 44, 45, and 46 (Fig. 3.19).
3. The remote air monitoring (RAM) network consists of Stations 52 and 58 (Fig. 3.20).

Sampling is conducted at each station to quantify levels of adsorbable gas (e.g., iodine), gross alpha, and gross beta. Stations 3 and 8 are equipped with samplers for measuring tritium. Sampling and analysis frequencies for each station are given in Table 3.11.

Airborne radioactive particulates are sampled biweekly by pumping a continuous flow of air through a 47-mm (1.88-in.) diam paper filter. The airborne adsorbable gases are collected biweekly using a canister containing activated charcoal that is downstream of the particulate filter. The charcoal canister is analyzed within 24 h after collection. To minimize artifacts from short-lived radionuclides, the filter paper is analyzed 8 d after collection. The initial and final dates, time on and off, and flow rates are recorded when a sample medium is mounted or removed. The total volume of air that flowed through the sampler is obtained from a flow totalizer, with the exception of tritium. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air sampled.

During 1991, biweekly samples for atmospheric tritium were collected from ORNL PAM Station 3 and ORR PAM Station 8 and composited every 4 weeks. Atmospheric tritium in the form of water vapor is removed from the air by silica gel. The silica gel is heated in a distillation flask in the laboratory to remove the moisture, and the distillate is counted in a liquid scintillation counter.

Annual composites of particulate air filters from the ORNL PAM stations (3, 7, 9, 20, 21, and 22), ORR PAM stations (23, 33, 42, 43, and 44), RAM stations (52 and 58), and some individual stations (34, 40, 41, 45, and 46) are analyzed for specific radionuclides. Annual compositing of the particulate

ORNL-DWG 88M-7874R4

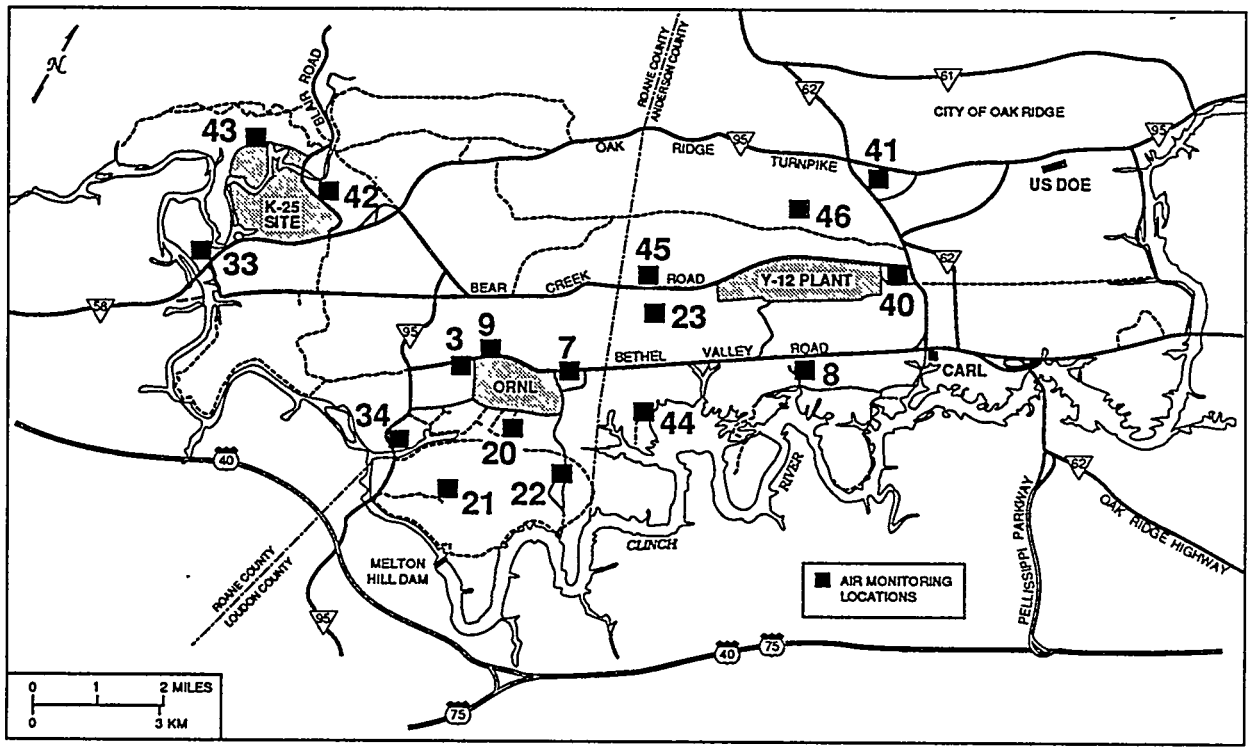

Fig. 3.19. ORR and ORNL perimeter air monitoring locations.

ORNL-DWG 87M-7047R4

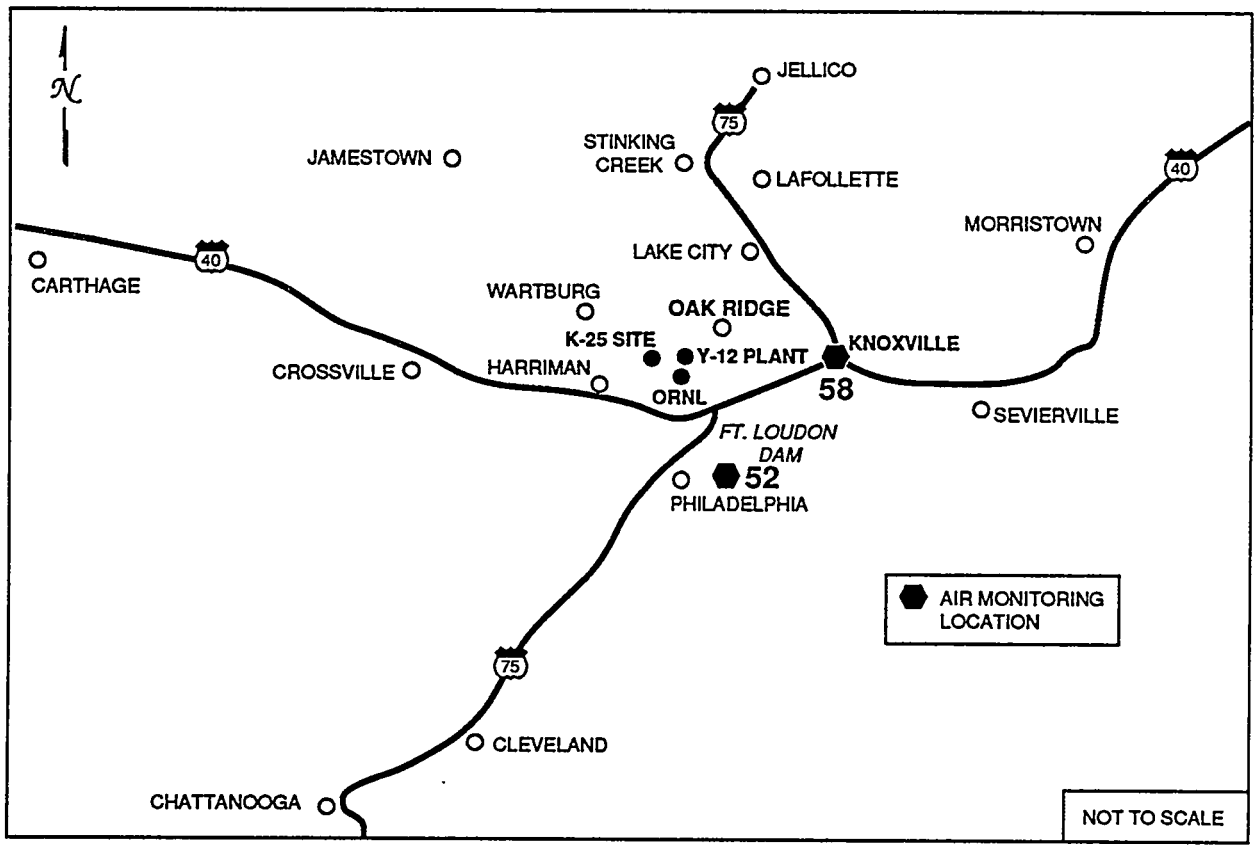

Fig. 3.20. Remote air monitoring locations.

Table 3.11. 1991 summary of collection and analysis frequencies of ORNL air monitoring stations

Station[a]	Parameter	Collection frequency	Type	Analysis frequency
3, 7, 9, 20, 21, 22, 23, 34, 40, 41, 44–46	^{131}I, gross alpha, gross beta	Biweekly	Continuous	Biweekly
33, 42, 43, 52, 58	Gross alpha, gross beta	Biweekly	Continuous	Biweekly
3, 8	Tritium	Biweekly	Continuous	Monthly
34, 40, 41, 45, 46, networks	^{60}Co, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, total Sr, ^{234}U, ^{235}U, ^{238}U	Biweekly	Continuous	Yearly

[a]See Figs. 3.19 and 3.20.

air filters for analysis of long-lived isotopes has been adopted because the data from previous years showed very low concentrations of these radionuclides.

Data summaries for individual monitoring stations are provided in Tables 3.8–3.12 in Vol. 2.

Summary

Annual data summaries are presented in Table 3.12 for 3 gross parameters and 12 radionuclides. As discussed previously, the data are divided into three groups. The ORNL PAM stations are designed to collectively assess the specific impact of ORNL upon the local air quality. The reservation PAM stations assess the impact of the entire ORR on air quality. Comparing these two sets of data provides insight into the relative impact of ORNL upon the local air quality as compared with other facilities on the reservation. The RAM stations provide information on reference concentrations of isotopes and gross parameters for the region. Many of the radionuclides in the data summary are naturally occurring isotopes commonly found in soil, water, and fossil fuels. It is highly unlikely that analyte concentrations at the RAM stations are impacted by the operations at ORNL or the ORR. By comparing the ORNL and ORR data with the RAM station data, the net impact of ORNL and the ORR upon the regional air quality can be assessed.

The data summary consists of the analytical parameters, total samples for the year for each parameter, the range of values, the average, and the standard error. The average concentration values for each analyte are tested for statistical significance using a calculated variance that includes variation from the sampling process and from the laboratory counting process. If the 95% lower bound calculated from the variance of the mean is greater than zero, then the mean is determined to be significantly different from zero. In the tables, averages that were determined to be significantly different from zero are marked with an asterisk.

Only one number is reported for the isotopes at the ORNL PAM and the RAM stations; this number represents the estimated average concentration for the year. For each isotope, the annual average concentration is divided by the derived concentration guide (DCG) for inhalation of that isotope, multiplied by 100, and presented in the table as the percent of the DCG, unless the percent is less than 0.01. In that case, the percent is reported as less than 0.01. A discussion of data conventions and the use of negative numbers as well as the definition of DCG is given in Sect. 1.

The gross alpha activity for each of the station networks is attributable to thorium and uranium isotopes, which are prevalent and naturally occuring in soils. The averages are slightly higher than the averages for 1990, which can probably be attributed to improved sampling equipment and maintenance.

The gross beta averages for 1991 are comparable to the averages for 1990.

Iodine-131 for ORNL and ORR was less than 0.01% of the DCG. There were no statistically different concentrations of ^{131}I among the ORNL and ORR stations. The tritium concentration for Station 3 was 0.17% of the DCG, and for Station 8 it was 0.20% of the DCG—an increase over 1990 data. This

Table 3.12 1991 radionuclide concentrations in air

Area[b]	Determination	Number of samples	Concentration (10^{-15} μCi/mL)[a]				
			Max	Min	Av[c]	Standard error	DCG (%)
ORNL PAMs	Gross alpha	136	10	0.45	2.4*	0.20	
	Gross beta	136	38	7.9	20*	0.45	
	^{3}H	13	1,400,000	14,000	170,000	110,000	0.17
	^{131}I	136	15	–12	0.0025	0.30	<0.01
	^{60}Co	1	0.014	0.014	0.014		<0.01
	^{137}Cs	1	0.0070	0.0070	0.0070		<0.01
	^{238}Pu	1	0.00021	0.00021	0.00021		<0.01
	^{239}Pu	1	0.00012	0.00012	0.00012		<0.01
	^{228}Th	1	0.0019	0.0019	0.0019*		<0.01
	^{230}Th	1	0.0016	0.0016	0.0016*		<0.01
	^{232}Th	1	0.0021	0.0021	0.0021*		0.030
	Total Sr	1	0.019	0.019	0.019*		<0.01
	^{234}U	1	0.024	0.024	0.024*		0.027
	^{235}U	1	0.0030	0.0030	0.0030*		<0.01
	^{238}U	1	0.014	0.014	0.014*		0.014
ORR PAMs	Gross alpha	233	18	0.36	2.5*	0.16	
	Gross beta	233	40	1.8	21*	0.37	
	^{3}H	13	920,000	27,000	200,000*	76,000	0.20
	^{131}I	160	23	–14	0.62*	0.32	<0.01
	^{60}Co	6	0.057	–0.019	0.011	0.011	<0.01
	^{137}Cs	6	0.068	0.0082	0.032*	0.0093	<0.01
	^{238}Pu	6	0.0014	–0.0014	0.00018	0.00046	<0.01
	^{239}Pu	6	–0.00022	–0.0027	–0.0012	0.00042	<0.01
	^{228}Th	6	0.0038	0.0018	0.0027*	0.00031	<0.01
	^{230}Th	6	0.0062	0.0019	0.0037*	0.00062	<0.01
	^{232}Th	6	0.0040	0.0021	0.0031*	0.00027	0.044
	Total Sr	6	0.12	0.0084	0.057*	0.021	<0.01
	^{234}U	6	0.16	0.0095	0.10*	0.027	0.11
	^{235}U	6	0.010	0.0028	0.0064*	0.0013	<0.01
	^{238}U	6	0.033	0.0042	0.021*	0.0041	0.021
RAMs	Gross alpha	40	5.9	0.41	1.8*	0.23	
	Gross beta	40	35	11	19*	0.90	
	^{60}Co	1	0.031	0.031	0.031		<0.01
	^{137}Cs	1	0.0034	0.0034	0.0034		<0.01
	^{238}Pu	1	0.0018	0.0018	0.0018		<0.01
	^{239}Pu	1	–0.0011	–0.0011	–0.0011		<0.01
	^{228}Th	1	0.0037	0.0037	0.0037*		<0.01
	^{230}Th	1	0.0030	0.0030	0.0030*		<0.01
	^{232}Th	1	0.0037	0.0037	0.0037*		0.053
	Total Sr	1	0.037	0.037	0.037*		<0.01
	^{234}U	1	0.0079	0.0079	0.0079*		<0.01
	^{235}U	1	0.00028	0.00028	0.00028		<0.01
	^{238}U	1	0.0053	0.0053	0.0053*		<0.01

[a]Multiply μCi/mL by 37×10^3 to convert to Bq/mL.

[b]See Figs. 3.19 and 3.20.

[c]Averages marked with an asterisk (*) are statistically greater than zero at the 95% level of confidence.

increase in consistent with the ORNL stack monitoring data. Neither isotope is sampled at the remote stations because concentrations have historically been below the analytical detection limits.

Two isotopes, ^{234}U and ^{238}U, exhibited elevated concentrations at the ORR PAM stations, as compared with the remote station data. Uranium-234 concentrations were the most elevated, but were only 0.11% of the DCG. The elevated value for ^{234}U is associated with ORR perimeter stations located in the vicinity of the Y-12 Plant.

A comparison of ORNL perimeter air sampling data with the remote air sampling data, using the percent DCG value (Table 3.12), shows that ORNL does not have a significant impact on the local air quality. A similar comparison for the ORR perimeter air sampling data shows that operations on the reservation are making a very small net contribution to the local airborne radioactivity. Airborne concentrations of radionuclides measured by the ORNL PAM stations and the ORR PAM stations ranged from less than 0.01 to 0.20% of the DCGs. No significant changes in the concentrations of these radionuclides were detected between the 1990 data and the 1991 data for the remote stations, although a slight increase was noted for thorium isotopes. Therefore, based on these data, ORR operations have a slight impact on the local air quality but have no significant impact on the regional air quality. The local impact is well below the DCG.

3.3.3 K-25 Site

Description

In 1986, the K-25 Site's ambient air monitoring program was reevaluated and a new system was designed to ensure improved efficiency and proper placement of monitors and to build monitors consistent with 40 CFR 58, Ambient Air Quality Surveillance. This system became operational January 1, 1987. The K-25 Site now has five ambient air monitoring stations, which are positioned in the predominant wind directions, as shown in Fig. 3.21. These monitors sample ambient air for 24 h every 6 d to be consistent with the 40 CFR 58 sampling schedule. Ambient air samples are analyzed for uranium, nickel, lead, chromium, and TSP. The results from these samples are evaluated monthly by station for all of these parameters.

In addition to the five ambient air monitoring samples, a PM10 ambient air particulate monitor was added to Station K4 to comply with sampler siting criteria as specified in 40 CFR 58. The collocated sampler has provided PM10 versus TSP particulate mass concentration comparison data as well as general information of particle size of collected samples. In addition, the PM10 ambient air samples are analyzed for uranium, nickel, lead, and chromium. This monitor has provided 4 years of comparison between the PM10 particulate data and the TSP monitoring data and 2 years of comparison for uranium, lead, chromium, and nickel.

In 1988, two additional ambient air monitoring stations were designed, sited, and installed at the K-25 Site. These stations were designed to detect PCBs, furans, dioxins, hexachlorobenzene, and uranium that may be accidently released because of possible operational upsets of the K-1435 TSCA Incinerator. The two stations are shown on Fig. 3.21 as TSCA1 and TSCA2.

The ambient air monitors are sampling ambient air 24 h/d, 7 d/week, as long as the TSCA Incinerator is operational (burning waste). During waste-burning operations, the samples are collected every 48 h and will be analyzed if certain predetermined abnormal operations occurred during that period. All samples are stored for a minimum of 30 d. During 1991, approximately 182 sets of samples were collected and stored. Each set included samples from TSCA1 and TSCA2. Analysis was performed on only one set of samples as a precaution—those from a power failure that caused a TRV to open, which upset waste-burning operations at the TSCA Incinerator. Samples from TSCA1 and TSCA2 were analyzed for uranium, PCBs, dioxins, furans, and hexachlorobenzene. Also, ambient air stations K1–K5 were operating during this event and their samples were analyzed.

Fluoride sampling was not conducted at the K-25 Site in 1991 because of the absence of emission sources. Fluoride sampling may be conducted in the future as needed if new processes emitting fluorine or fluoride become active.

Summary

Each monitor, K1–K5 and PM10, was sampled for each parameter 24 h every 6 d throughout the year. The number of samples per location for K1–K5

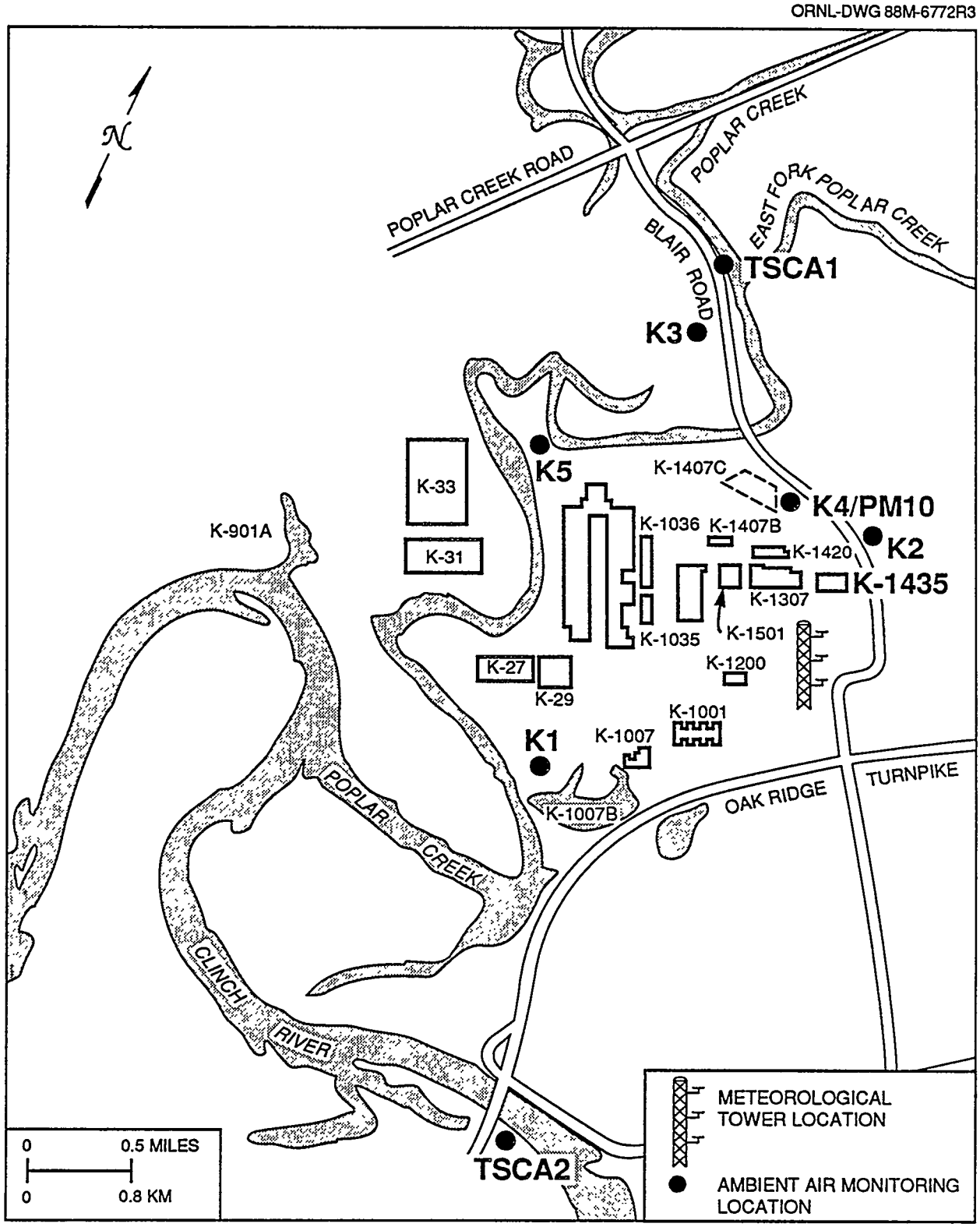

Fig. 3.21. Location of the K-25 Site ambient air monitors and meterological tower.

ranged from 55 to 59 for all pollutant parameters of interest. The number of samples taken by the PM10 monitor was 57 for particulate and 48 for other analysis.

As can be seen from the data summary tables, no standards were exceeded. In fact, for TSP, the highest single recorded level was approximately 63% of the secondary standard, but no average reading exceeded approximately 17% of the secondary standard. For uranium, the highest single recorded level was approximately 14% of the standard, and no average reading exceeded approximately 1% of the standard. For lead, the highest single recorded level was approximately 2% of the primary standard, but no average reading exceeded approximately 1% of the standard. Data for 1991 demonstrate results that are well within regulatory limits, although concentration averages are approximately double the 1990 ambient air sampling results. There are no ambient air standards for chromium and nickel, but chromium and nickel did show slight increases.

PM10 data indicate that the particle size has shifted toward a larger average particle diameter as indicated by a lower percentage of particles less than 10 μm diameter. The ratio of PM10 and K4 annual averages for TSP was 0.84 (1991) as compared to the 1990 ratio of 0.98. Also, particulate concentration levels for PM10 increased 253% over 1990. The 12-month average concentration has risen from approximately 8.3 (1990) to 21.0 m/m^3 (1991), but no single maximum reading exceeded approximately 36% of the primary standard. For lead, the 12-month average indicates that concentrations doubled over 1990 results; however, the single maximum concentration result during 1991 was less than 1% of the standard. The 12-month PM10 average concentration for uranium increased 476% over 1990 results; however, no single PM10 maximum concentration exceeded approximately 4% of uranium standards. Chromium and nickel showed negligible increases over 1990 results.

A 5-year summary of K-25 ambient air monitoring data for each analyzed parameter is shown in Figs. 3.22–3.26. Data for 1987–1991 is presented for stations K1–K5 (PM10 data is only available for 1989–1991). Five-year emission trends for TSP, lead, chromium, and nickel reflect variations in the general level of activity at the K-25 Site. Cutbacks in the late 1980s reduced employment levels and activities thus reducing automobile traffic at and around K-25. These variations are easily seen in TSP and lead monitoring analyses over the last 5 years and, to a lesser extent in analyses of chromium and nickel. Pollutant increases in 1991 are directly correlated with site activities that have increased automobile traffic significantly. The 2 years of PM10 data reflect a shift toward a larger particle size as indicated by a lower percentage of particles smaller than 10 μm diameter. Dust generated by increases in general site activities and traffic would account for the particle size shift.

The 5-year trend for uranium indicates the level of work at the K-25 Site. For the period 1987–1990, uranium operations at the K-25 Site were minimal, as reflected by the low ambient air levels detected. During the spring of 1991 the TSCA Incinerator began operations, which included burning low levels of radioactive wastes. The impact of this new source is indicated by the 1991 ambient monitoring results. Although 1991 uranium ambient air levels increased over the previous years, no single recorded level exceeded approximately 14% of the standard. The uranium impact on the K2 sampling station during 1991 is dramatically illustrated by average ambient air levels approximately double those detected at any other station. This is consistent with prevailing winds across the K-25 Site and the location of the K2 sampling station.

The analysis of samples taken of the TRV event at the TSCA Incinerator indicate no identifiable anomalies. Meteorological information indicated that the plume impacted the area of Station K2. TSCA1 and TSCA2 were not in the downwind direction of any potential "puff" from the opening of the TRV. TSCA1 and TSCA2 sample analysis showed no identifiable indications of any elevated ambient air pollutants that can be attributed to the TSCA Incinerator. Analysis of K2 data indicate that parameters are consistent with normal operating trends and no identifiable increases attributed to the TRV event were detected.

3.4 METEOROLOGICAL MONITORING

A network of meteorological observation towers provides data on the meteorological conditions and the transport and diffusion qualities of the atmosphere on the reservation. Data collected at the

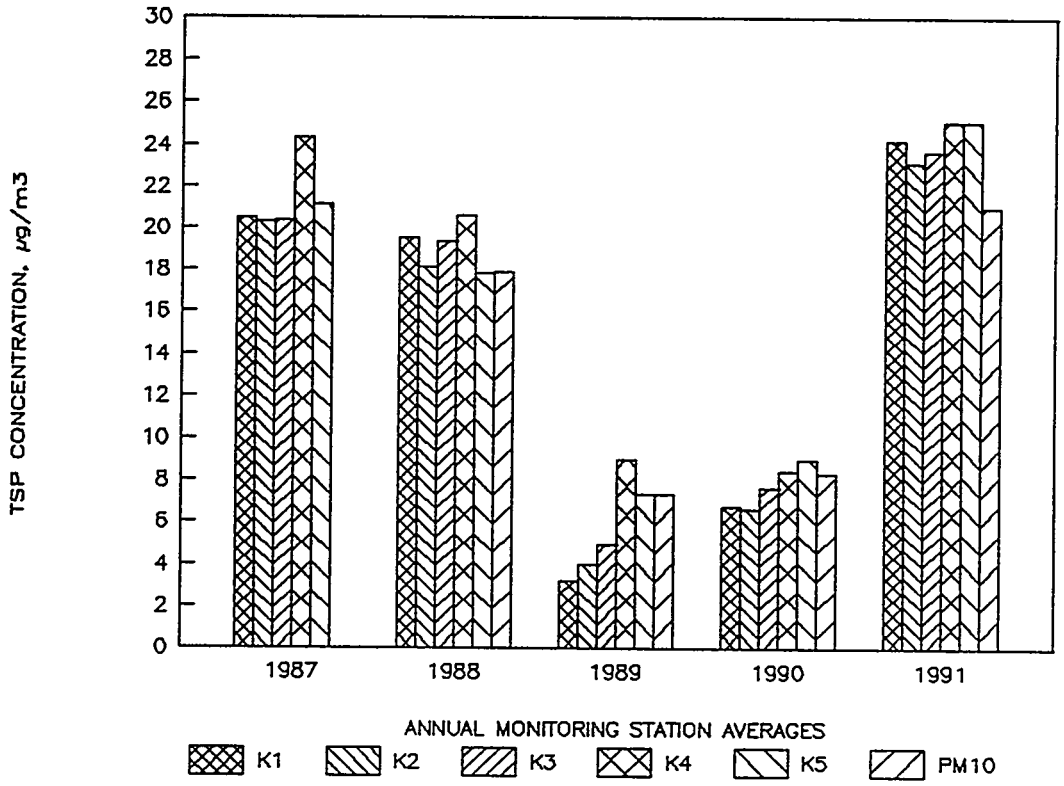

Fig. 3.22. K-25 Site ambient air monitoring network, 5-year trend of TSP results.

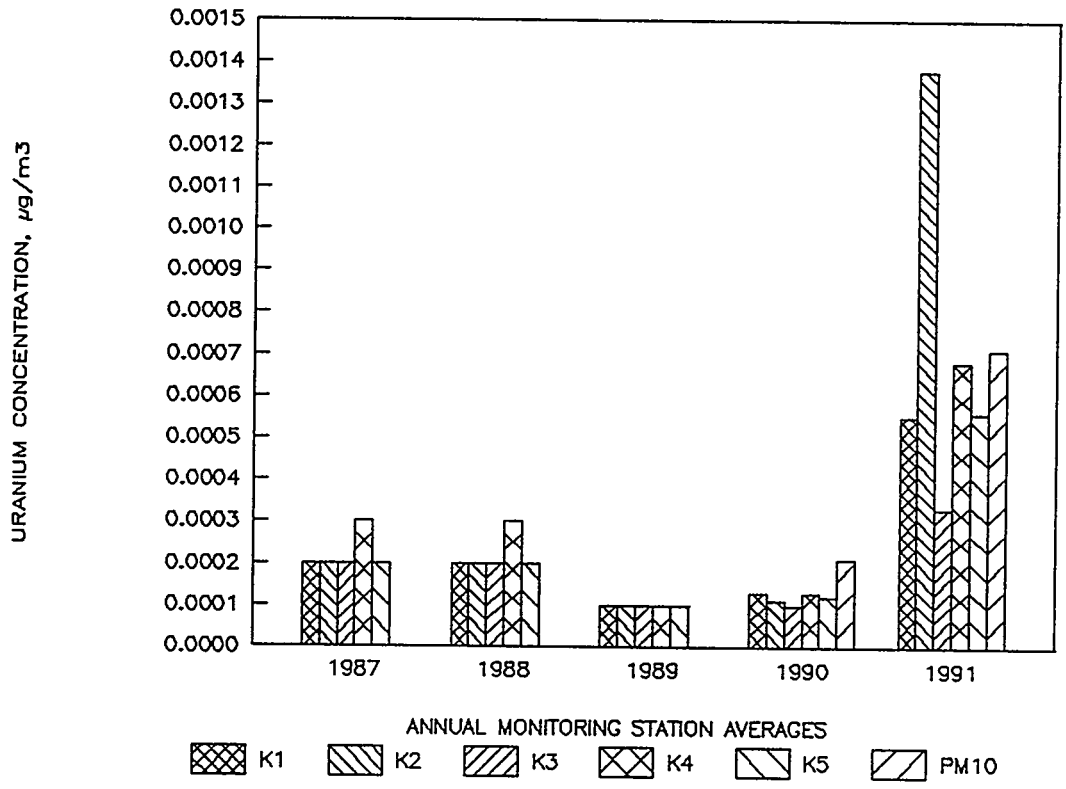

Fig. 3.23. K-25 Site ambient air monitoring network, 5-year trend of uranium results.

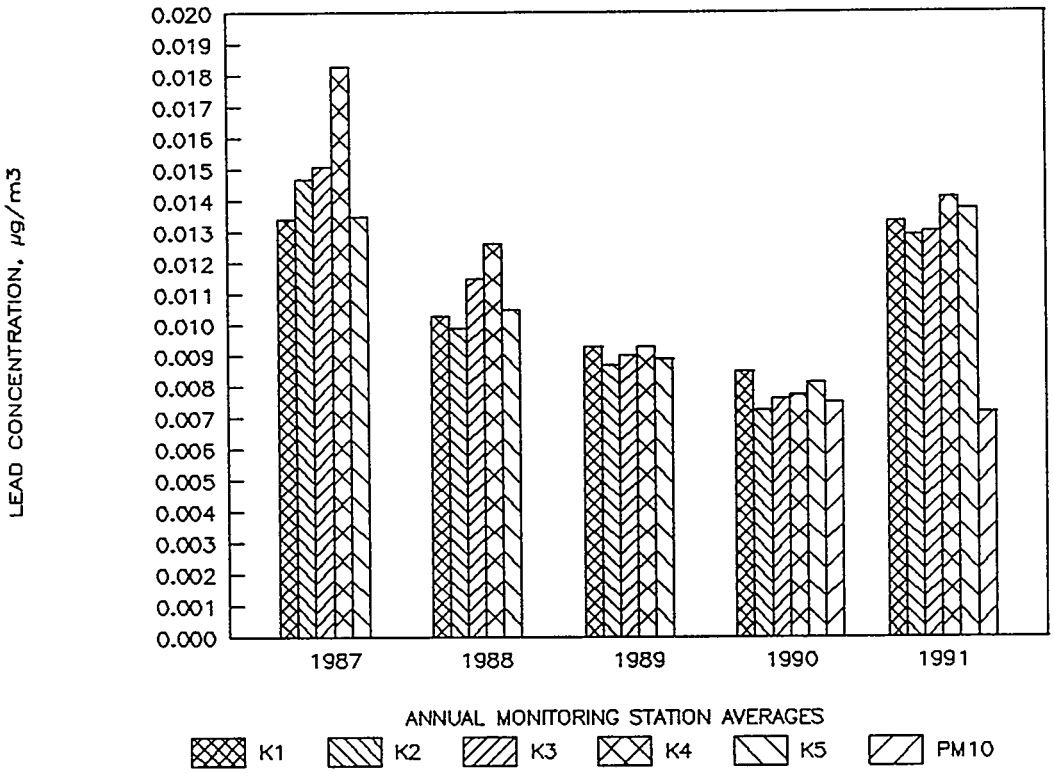

Fig. 3.24. K-25 Site ambient air monitoring network, 5-year trend of lead results.

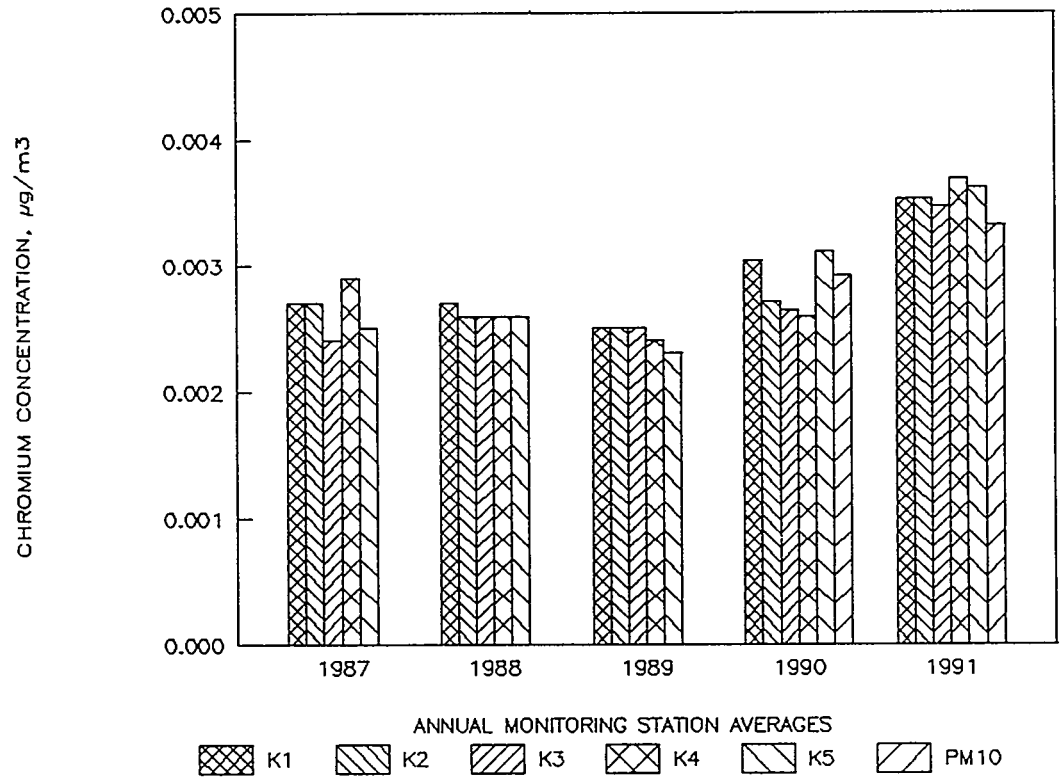

Fig. 3.25. K-25 Site ambient air monitoring network, 5-year trend of chromium results.

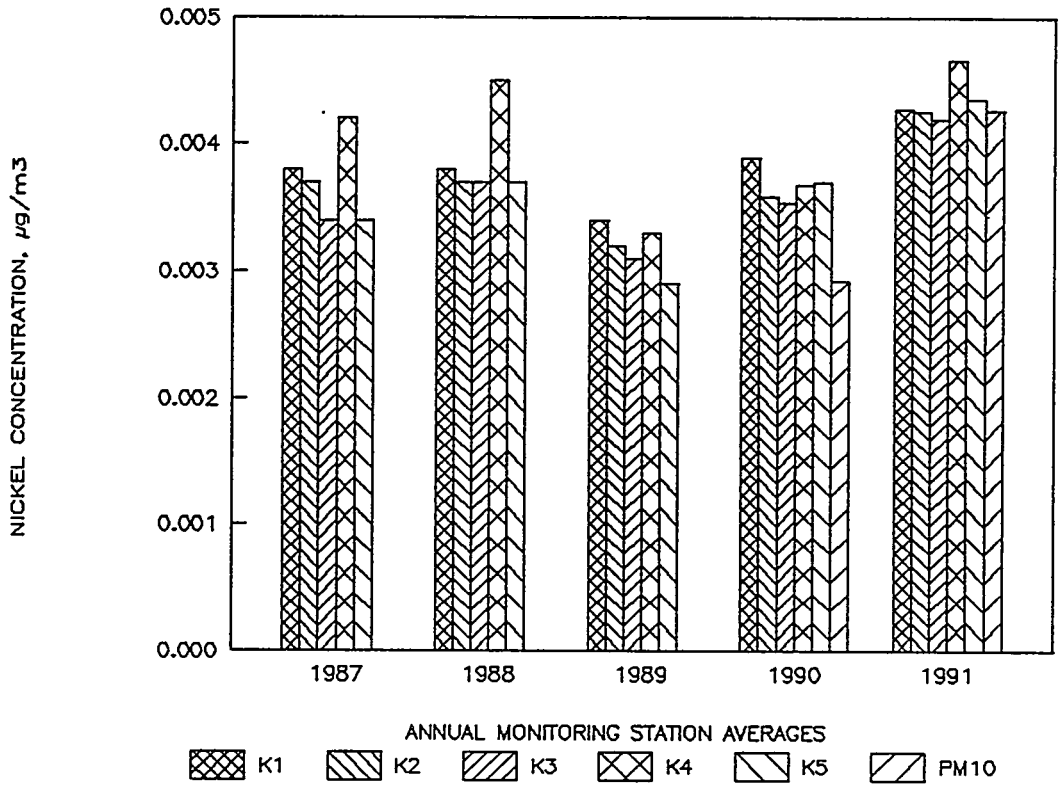

Fig. 3.26. K-25 Site ambient air monitoring network, 5-year trend of nickel results.

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.

3.4.1 Description

The meteorological monitoring network, depicted in Fig. 3.27, consists of one 60-m (196.8-ft) tower at the K-25 Site (MT1); one 100-m (328-ft) tower (MT2) and two 30-m (98.4-ft) towers (MT3 and MT4) at ORNL; and one 100-m (328-ft) tower (MT5) and one 60-m (196.8-ft) tower (MT6) at the Y-12 Plant.

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 10 m (32.8 ft) and at the top of the tower. At the 100-m (328-ft) towers, data are collected at intermediate [30- or 60-m (98.4- or 196.8-ft)] levels as well. At each measuring level at each tower, temperature, wind speed, and wind direction are measured; atmospheric stability (a measure of the dispersive capability of the atmosphere) is also measured at each tower. Precipitation, humidity, and solar radiation are measured at MT2 at ORNL.

Data from the towers are collected by a dedicated control computer at each site. The towers are polled and data are checked for validity against a predetermined set of parameters, summarized, and filed on disk. Fifteen-minute and hourly values are stored at each site for a running 24-h period. Only hourly data are routinely stored beyond 24 h. The meteorological monitoring data from all towers are checked quarterly, and summaries of data are developed as wind roses such as the data from MT2 presented in Fig. 3.28. Quarterly calibration of the instruments is conducted for each facility by outside contractors.

Fifteen-minute and hourly data are used directly from the facility computer or the central archival computer for emergency response purposes. The data are received at the emergency response computer dedicated telephone lines and are input to dispersion models. Annual dose estimates are calculated using archived data (i.e., either hourly values or summary

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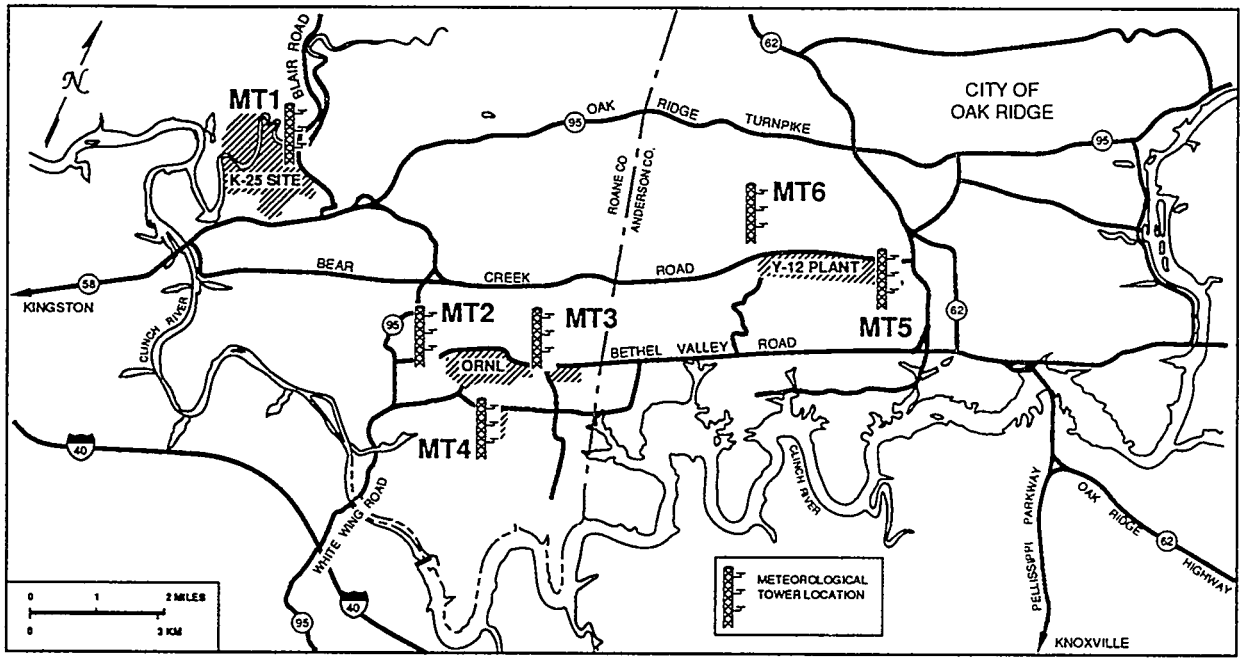

Fig. 3.27. ORR meteorological monitoring network.

tables of atmospheric conditions). In all cases, data quality is checked using predetermined values, and out-of-range parameters are marked as either questionable (requiring interpretation by a competent meteorologist) or invalid (not input to the dispersion models).

3.4.2 Summary

The data presented in Fig. 3.23 are typically from the ORNL 100-m tower (MT2) located east of the Y-12 Plant. Operational difficulties resulted in poor data capture for 1991 at MT2; consequently, the data for MTE (Y-12 Plant) are provided to give a more complete representation for the year. Wind roses from other tower locations are presented in Figs. 3.1–3.14 of Vol. 2. The information contained in Fig. 3.28 is useful in describing the meteorological conditions of the reservation.

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. Any material released in these valley winds would tend to stay within the valley. 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 more varied flows. However, somewhat weaker valley flows are noted in the K-25 Site area, particularly in locations near the Clinch River.

The winds measured on the reservation are dominated by low-wind-speed conditions. This characteristic is noted at all tower locations, as is the increase in wind speed with height at which the 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

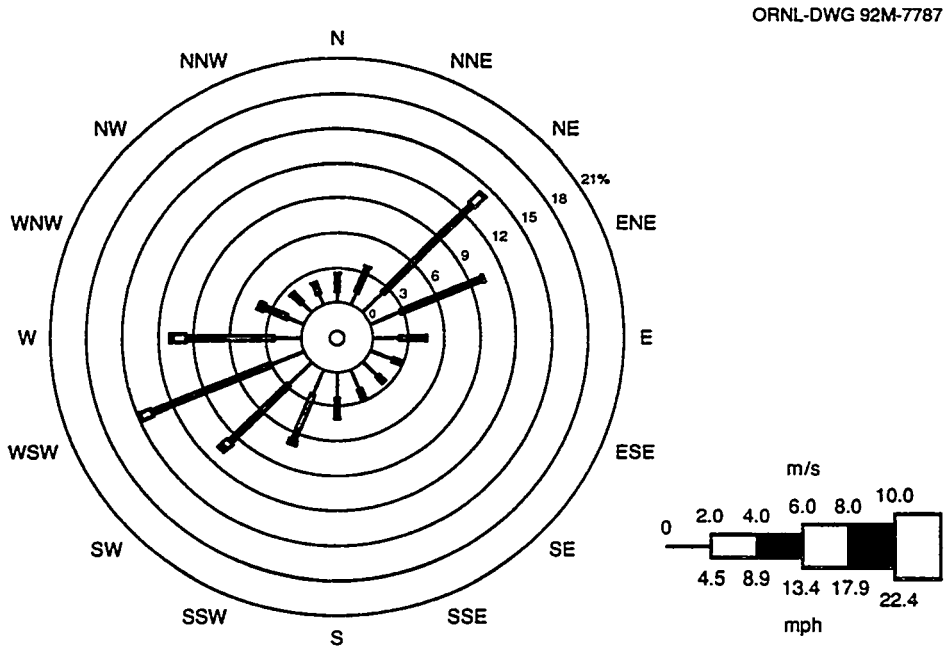

Fig. 3.28. 1991 wind rose for Y-12 Plant tower MTE (east) (100-m level), with 98.7% of possible data.

by various divisions. The data indicate the variability of regional precipitation, with high winter rainfall amounts resulting from frontal storms and uneven, but occasionally intense, summer rainfall associated with thunderstorms.

The average data capture efficiency across all 14 tower levels and locations was 89.1%. The maximum capture efficiency was 99.3%, and the minimum capture efficiency was 80.4%.

3.5 EXTERNAL GAMMA RADIATION

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

3.5.1 Sample Collection and Analytical Procedures

Gamma radiation measurements are made continuously at ORNL and ORR PAM stations (Fig. 3.19). Continuous readings of external gamma radiation are averaged over 10-min intervals for all stations. The real-time monitoring system provides an alert or alarm message if the reading is significantly above a preset background or expected value. These continuous monitoring data are not reported here. The values reported here are summarized from weekly averages of hourly averages that are, in turn, derived from the 10-min readings. A weekly average is considered valid if less than 25% of the hourly values are either missing or invalid because of instrument malfunction.

3.5.2 Results

Table 3.13 presents network summaries of external gamma radiation measurements. The average value for the ORNL PAM stations was 6.7 μR/h, and the average for the ORR PAM stations was 9.1 μR/h.

Data for individual ORNL stations and ORR stations are presented in Table 3.13, Vol. 2. Typical values for cities in the contiguous United States are usually between 5 and 20 μR/h. The median value published by EPA (1987) for cities in the United States during 1987 was 9.3 μR/h, with 75% of the values between 7.5 and 15 μR/h (the distribution is positively skewed). Any contribution to the external gamma signature by ORNL or the other facilities is not distinguishable at these PAM locations.

Table 3.13. 1991 external gamma radiation measurements

Location	Number of samples[a]	Exposure rate (μR/h)			
		Max	Min	Av[b]	Standard error[c]
		ORNL PAM stations[d]			
Network summary	11,881	260	0.00067	6.7*	0.038
		Reservation PAM stations[d]			
Network summary	54,376	16,000	0.00033	9.1*	0.32

[a]Real-time readings were collected at all stations at 10-min intervals. The number of samples indicate the total number of valid hourly averages during the year.

[b]Averages marked with an asterisk (*) are statistically greater than zero at the 95% level of confidence.

[c]Standard deviation from the mean.

[d]See Fig. 3.19.

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4. SURFACE WATER

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4. SURFACE WATER

The surface water regime of the ORR consists of the Clinch River, which forms the reservation boundary to the south and west; a series of subbasins of the Clinch River from Brashear Creek just below the K-25 Site to Scarboro Creek east of the Y-12 Plant; and the East Fork Poplar Creek basin, which forms the hydrologic boundary of the reservation to the north and east (Fig. 1.14). Four of the subbasins of the Clinch River are affected by operations of the facilities of the ORR. The Y-12 Plant is located in the Bear Creek and East Fork Poplar Creek subbasins. ORNL is located in the White Oak Creek subbasin, which includes Melton Branch. The K-25 Site is located in the Poplar Creek subbasin, which includes Mitchell Branch. Figure 4.1 shows the Clinch River, the ORR boundary, and the affected major subbasins of the Clinch River. Raccoon Creek, which is west of ORNL, also has been affected by the reservation, but not by current operations.

The inherent quality of surface water in the vicinity of the ORR is influenced by the geochemistry and soil-water interactions of the subbasins. As discussed in Sect. 1.4 (Geology) and shown in Fig. 1.11, the surface features and surface geology of the ORR are formed by the repetition of stratigraphic units of the Rome Formation, Conasauga Group, Knox Group, and the Chickamauga Group. These units contain various amounts of sandstones, siltstones, shales, dolomites, and limestones. Interactions of groundwater with the unique collection and composition of geologic units in each subbasin result in concomitantly unique surface water chemistry for each subbasin.

The surface water and geochemical relationships are summarized by McMaster (1967). The report provides data for 29 area streams, including Bear Creek, East Fork Poplar Creek, White Oak Creek, Melton Branch, and Poplar Creek upstream of the ORR. The emphasis of the sampling program was low, medium, and high base-flow conditions (i.e., stream flow that originates as groundwater versus overland runoff). Samples of this type will show the maximum impact of geochemistry on surface water. The information from this report is useful today because the geochemical impacts upon surface water change very slowly with time.

Data in the McMaster report show that the surface waters originating in the ORR subbasins affected by the facilities are of a carbonate-bicarbonate type with little or no influence from natural sulfates, nitrates, or chloride. The major cation in Melton Branch and Bear Creek is calcium at 65 to 80%; magnesium contributes 15 to 25%. This is characteristic of base flow derived from limestone formations. In contrast, White Oak Creek cations consist of 45% calcium and 55% magnesium, which is typical for base flow derived from dolomite. Contributions of sodium and potassium to the total cations for these three streams are less than 10%. East Fork Poplar Creek has an ion composition that is unique among the streams on the ORR. Total cations consist of 50% calcium, 30% sodium and potassium, and 20% magnesium. The anions consist of 65% carbonate-bicarbonate, 20% chloride, and 15% sulfate. East Fork Poplar Creek also originates in a limestone formation; the presence of sodium, potassium, and sulfate is probably a consequence of operations at the Y-12 Plant.

The data for Poplar Creek show the influence of the Cumberland Plateau geology. The anions for this stream are 55% carbonate-bicarbonate, 40% sulfate, and 5% nitrate and chloride. The major cations consist of 60% calcium and 30% magnesium. This type of surface water is generally derived from a shale, siltstone, sandstone geology. The contribution of sulfate to the ion balance is probably influenced by surface coal mining activity on the Cumberland Plateau (McMaster 1967).

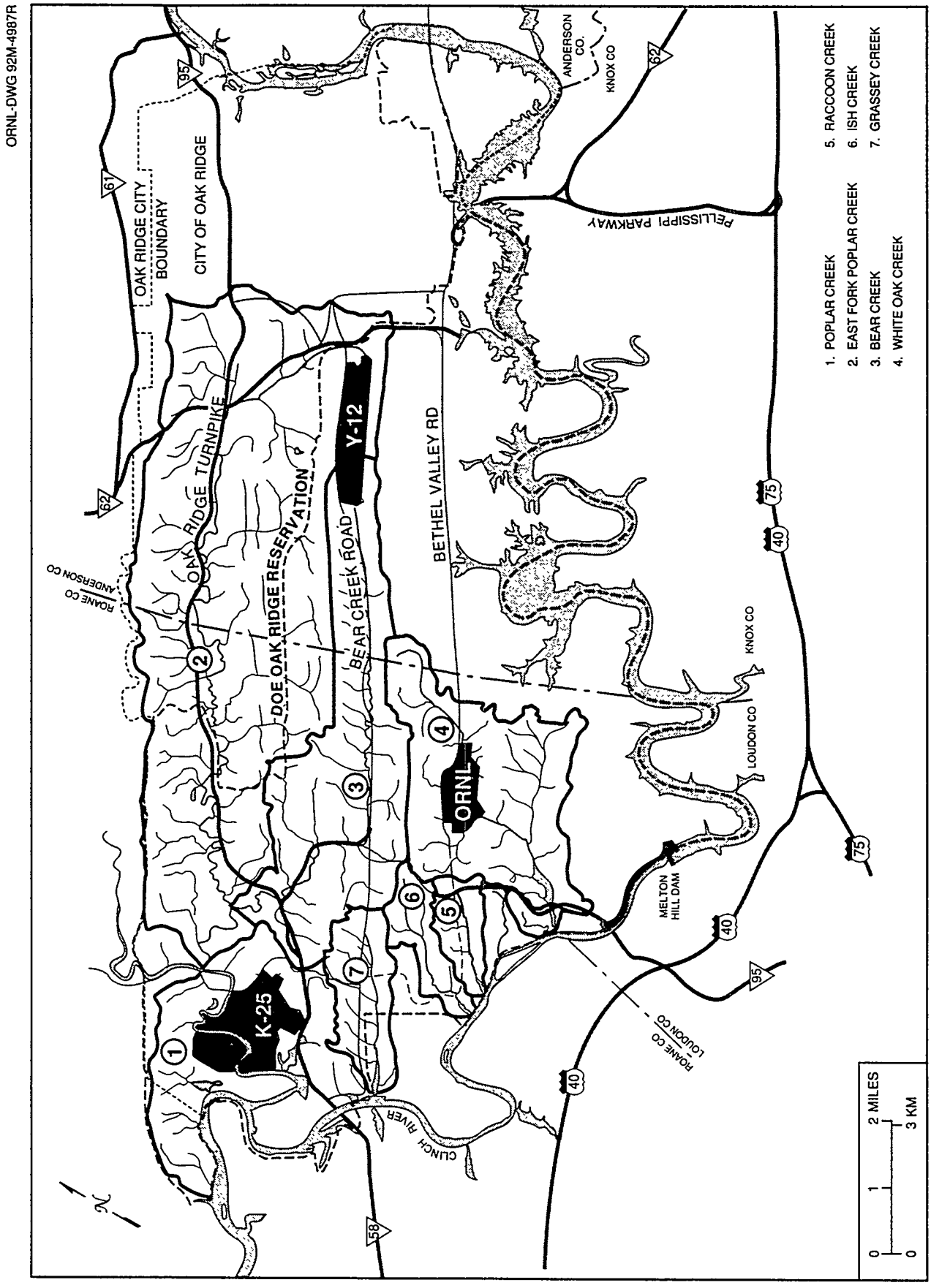


Fig. 4.1. Locations of ORR facilities with respect to drainage basins.

4.1 SURFACE WATER MONITORING PROGRAM GOALS

The purpose of the surface water monitoring program at the ORR is to assess the impacts of the facility effluents upon natural receiving waters and to estimate the potential impacts of these effluents on human health and the environment. These goals are addressed through effluent monitoring and environmental surveillance. Effluent monitoring is defined as the collection and analysis of effluents for the purposes of characterizing and quantifying contaminants and demonstrating compliance with applicable standards. In this definition "effluent" typically refers to a point source that emanates from a process; effluent monitoring samples are collected from point source discharges. Environmental surveillance is the collection and analysis of environmental media for the purposes of assessing potential impacts of facilities on members of the public and the environment. Environmental surveillance samples for surface waters consist of ambient water samples taken from the receiving streams. The facilities on the ORR also include diffuse effluent sources resulting from historic waste disposal and operations practices. These effluents are released through interactions of groundwater and surface water. The impacts of diffuse sources are integrated into the monitoring program through environmental surveillance samples collected downstream of the facilities.

4.2 REGULATORY AUTHORITIES

The body of regulations promulgated by the EPA to control impacts to surface water quality by toxic and hazardous chemicals are collectively known as the Clean Water Act (CWA) regulations. These regulations include the National Pollutant Discharge Elimination System (NPDES) requirements. EPA Region IV has remanded authority for NPDES to the state of Tennessee. The bases for the NPDES permits are the stream classifications and general water quality criteria authorized by the CWA regulations and established by the state. The classifications of the streams on and around the reservation are provided in Vol. 2, Table 1.3. The intent of NPDES permits is to establish effluent contamination limits that protect the classified uses of the surface waters.

Certain DOE orders address the control of radioactive constituents in effluents and ambient waters. DOE Order 5400.5 establishes criteria for radioactive effluents and dose conversion factors for exposure assessments. This order has been drafted as federal regulation 10 CFR 834; after the final rule making, this regulation will be enforceable in the same manner as the EPA regulations. DOE Order 5400.6 has been converted into a regulatory guide in support of 10 CFR 834. This document provides detailed technical guidance and requirements for effluent monitoring and environmental surveillance for radionuclides.

4.3 MONITORING PROGRAM OVERVIEW

Surface water monitoring on the ORR is conducted through the sampling and analysis of four functionally distinct types of water: reference surface waters, ORR surface waters receiving effluents, off-reservation surface waters, and effluents. The information presentations and discussions are organized by these functional types. All of the data summary tables are located in Volume 2 so the reader can easily scan the data while reading the text. Where a single sampling location serves more than one function, the data are combined and presented in a single table to provide a complete data picture. Tables 4.1, 4.2, and 4.3 provide overviews of the functional types of water samples and the sampling locations for each of the three facilities.

4.3.1 Reference Surface Waters

Locations that sample the natural surface waters are upstream of the various facilities on the ORR. These data can be used to assess water quality prior to the impacts of the ORR. The term "reference" is used instead of "background" because the latter typically implies an environmental medium that is pristine, or unaffected by human activities. The Clinch River is the major surface water system that is affected by the ORR. This river integrates many human activities upstream of the reservation. The net impact of the ORR can be evaluated by comparing the reference data to information from samples collected downstream of the facilities.

Table 4.1. Y-12 Plant surface water monitoring program overivew[a]

Sampling location	Reference surface waters	ORR surface waters receiving effluents	Off-reservation surface waters	Effluents
Upper Bear Creek		4.1, 4.2		
Diversion ditch		4.3		
Station 17		4.4		
Sanitary sewers				4.5, 4.6, 4.7
301				4.12
302				4.13
304				4.9
307				4.14
308				4.15
309				4.16
501				4.17
502				4.18
503				4.19
504				4.20
501/504				4.21
506				4.22
512				4.23
Cooling towers				4.24
623				4.25
Category I				4.26
Category II				4.27
Category III				4.28
Categort IV				4.29
Non-permitted outfalls				4.30

[a]The numbers in this table refer to Vol. 2 tables that depict the data retrieved from the specified location.

Table 4.2. ORNL surface water monitoring program overview[a]

Sampling location	Reference surface waters	ORR surface waters receiving effluents	Off-reservation surface waters	Effluents
WOC headwater	4.34, 4.32			
MHD	4.35, 4.33			
First Creek		4.40, 4.39		
Fifth Creek		4.41, 4.39		
NWT		4.44, 4.39		
WOD		4.55, 4.38	4.55[b]	
Raccoon Creek		4.45, 4.39		
7500 Bridge		4.42, 4.39		
WOC		4.54, 4.37	4.54[b]	
MB2		4.43, 4.39		
MB1		4.53, 4.36	4.53[b]	
Gallaher Water Plant			4.56, 4.58	
Kingston Water Plant			4.57, 4.58	
STP			4.50[b]	4.50, 4.47
CRYTF			4.51[b]	4.51, 4.48
NRWTF			4.52[b]	4.52, 4.49
Category I				4.66, 4.59
Category II				4.67, 4.60
Category III				4.68, 4.61
Steam plant				4.64, 4.62
Cooling towers				4.65, 4.63

[a]The numbers in this table refer to Vol. 2 tables that depict the data retrieved from the specified location and the sampling and analysis plans for that location.

[b]Concentrations in the Clinch River are estimated using flow ratios.

Table 4.3. K-25 Site water sampling program overview[a]

Sampling location (Sampling point)	Reference surface waters	ORR surface waters receiving effluents	Off-reservation surface waters	Effluents
Clinch River (K-1513)			4.75, 4.71	
Clinch River (Brashear Island)			4.73, 4.71	
Clinch River (K-1770)			4.77, 4.71	
West Fork Poplar Creek	4.72, 4.71			
Poplar Creek (K-1710)	4.76, 4.71			
Mitchell Branch	4.78, 4.71			
Poplar Creek (K-716)		4.74, 4.71		
TSCA and CNF (K-1407-J)				4.88, 4.82
Surface runoff steam plant (K-1407-E/F)				4.89, 4.82
K-1407-E/F Effluent, surface runoff, once-through cooling (K-1700)				4.83, 4.82
Sanitary sewer treatment (K-1203)				4.84, 4.82
Once-through water from cooling systems and fire water (K-1007-B)				4.85, 4.82
Surface runoff backwash from potable water treatment (K-1515C)				4.87, 4.82
Lime-softening sludges from fire water makeup, surface runoff (K-901-A)				4.86, 4.82

[a]The numbers in this table refer to Vol. 2 tables that depict the sampling and analysis plans and the data retrieved from the specified location.

4.3.2 ORR Surface Waters Receiving Effluents

Natural streams on the ORR receive effluents directly from discharge points. The effluent-receiving waters on the ORR include Bear Creek, McCoy Branch, Rogers Quarry, and East Fork Poplar Creek (EFPC) at the Y-12 Plant, White Oak Creek (WOC) and Melton Branch (MB) at ORNL, and Poplar Creek and Mitchell Branch at the K-25 Site. Samples from these streams are used to assess the impacts of the facilities on the natural water quality and to determine the contaminant concentrations in the streams prior to their dilution in the Clinch River.

Field measurements and sample collections are carried out at various effluent sources and on receiving streams on the ORR.

4.3.3 ORR Off-Reservation Surface Waters

Natural surface waters off the ORR are affected by the facilities through the integration of discharges from the affected basins. Samples of these waters provide empirical information regarding the concentrations of contaminants from the ORR in the Clinch and Tennessee rivers. Concentrations in the rivers can also be estimated by dividing tributary contaminant concentrations by the ratio of the tributary flow to the river flow.

4.3.4 Effluents

Liquid discharges from facility processes and weather-related discharges from areas such as building roofs and parking lots are called effluents. Under the requirements of the CWA, an NPDES permit has been issued to each of the three Oak Ridge facilities; these permits specify the effluent monitoring program for each of these point sources. There are as many as seven components to the NPDES permits at the Oak Ridge plants.

First, a plan for monitoring effluent characteristics is a primary requirement under the permit. Each plan must include methods for gathering basic information, as appropriate to the individual monitoring point, such as flow, temperature, pH, biochemical oxygen demand (BOD), total suspended solids (TSS), oil and grease (O&G), fecal coliform, etc. This part of the permit also includes specific contaminant monitoring requirements for organics and inorganics.

Next, each of the facilities is required under the special conditions of its NPDES permit to monitor ambient water locations and to assess the impacts of the facilities upon the receiving waters at or near the facility boundaries. Ambient water samples are typically analyzed for parameters identified in the NPDES effluent characteristics monitoring plans.

Each of the sites also must have a radiological monitoring plan (RMP) designed to monitor all outfalls that have the potential to discharge radioactivity to ambient waters. This plan typically includes effluent points and ambient water sampling locations. It coincides with the requirements of the DOE orders.

A fourth aspect of each site's NPDES permit is their toxicity control and monitoring programs (TCMPs). Each TCMP assesses the toxic impact of treatment facilities and ambient waters by exposing freshwater animals to water samples collected from the monitoring points. The results of the tests are used to estimate the wastewater's no-observed-effect concentration (NOEC).

Two EPA-approved toxicity tests are used to estimate a wastewater's NOEC: (1) the fathead minnow (*Pimephales promelas*) larval survival and growth test and (2) the *Ceriodaphnia* survival and reproduction test. These two tests, which are static renewal tests (i.e., the test solutions are replaced daily for each species), are described in detail by Horning and Weber (1985). A wastewater's NOEC is computed by comparing the responses of the animals exposed to a contaminant-free water (control water) with those of animals exposed to various concentrations of the wastewater (dilutions are made with the control water). The NOEC is the concentration of wastewater (expressed as a percentage of full strength) that does not adversely affect either fathead minnow larvae survival and growth or *Ceriodaphnia* survival and reproduction. The higher the NOEC, the less toxic and, therefore, the better the quality of the wastewater. If a wastewater's NOEC is less than 100%, the NOEC is compared with the estimated effluent concentration in the receiving stream to predict whether the wastewater will adversely affect aquatic biota in the receiving streams.

Biological monitoring and abatement programs (BMAPs) were developed to demonstrate that the interim effluent limits established by the NPDES permits for each facility protect the classified uses of the receiving streams (e.g., growth and propagation of fish and aquatic life). Information from the programs can also be used to evaluate remedial actions and new pollution abatement facilities from the perspective of ecological recovery in the affected waters.

Each BMAP consists of (1) ambient water toxicity testing conducted in the same manner as the TCMP, (2) contaminant bioaccumulation studies, (3) biological indicator studies including measurements of selected biochemical parameters and histopathological analyses, and (4) ecological

community surveys of fish and benthic invertebrates. These tasks use a variety of techniques, including laboratory bioassays, manipulative field experiments, and biotic surveys, to assess ecological effects at different levels of biological organization. Results for this program are provided and discussed in Sect. 6, Biological Monitoring.

Also required for the NPDES permits, the polychlorinated biphenyls monitoring plan (PCB Plan) specifically addresses the presence of PCBs in effluents and ambient waters for the purpose of identifying and eliminating any sources of PCB discharge to receiving streams. Sediment data associated with this program are reported and discussed in Sect. 7, Soil and Sediment Monitoring. An additional requirement for the ORNL NPDES permit is a mercury monitoring plan (Mercury Plan). The Mercury Plan specifically addresses the presence of mercury in effluents and ambient waters for the purpose of identifying and eliminating any sources of mercury discharging to receiving streams. Sediment data associated with this program are reported and discussed in Sect. 7, Soil and Sediment Monitoring.

4.4 1991 MONITORING PROGRAM RESULTS

4.4.1 Y-12 Plant

Reference Surface Waters

The three streams that are impacted by the Y-12 Plant, EFPC, McCoy Branch, and Bear Creek, originate within the plant site. Consequently, it is not possible to sample and analyze the waters of these streams prior to their being affected by the facility. However, streams on the ORR not affected by the Y-12 Plant operations are used for comparison purposes.

ORR Surface Waters Receiving Effluents

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. Various radiological and nonradiological parameters are monitored at the sites shown in Fig. 4.2.

Kilometer 12.4 (mile 7.7) on upper Bear Creek is monitored in response to Section IV, Part 4, of a

ORNL-DWG 90M-7951R

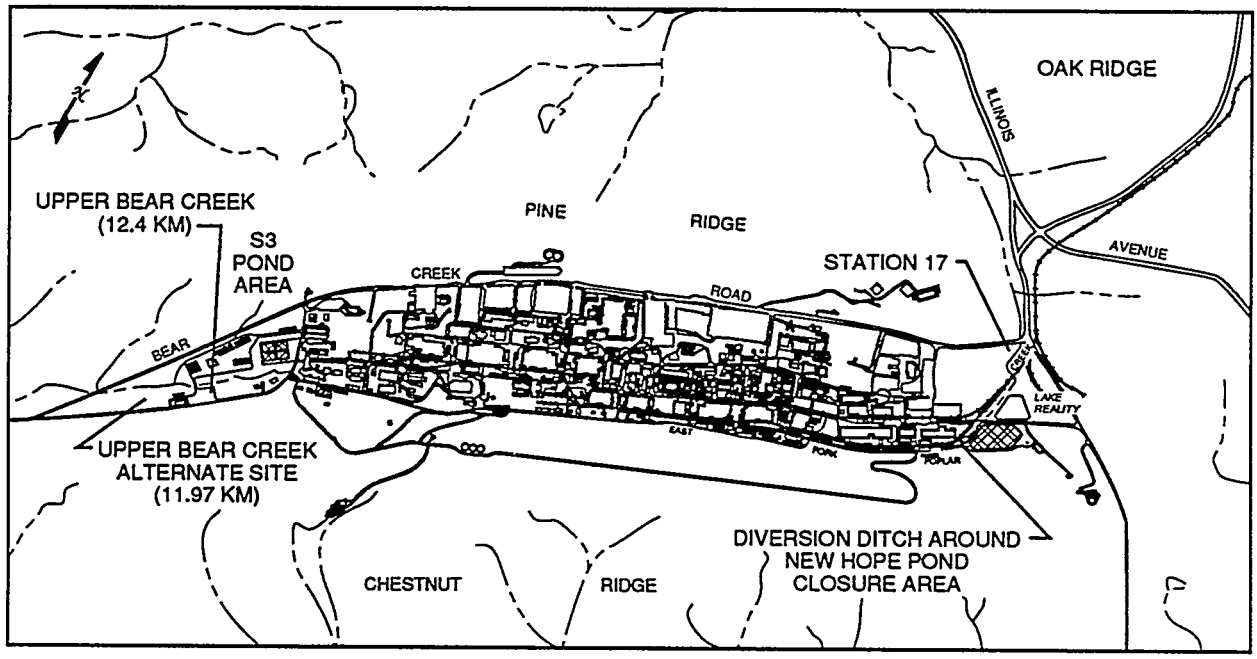


Fig. 4.2. Y-12 Plant non-NPDES routine surface water monitoring sites.

Memorandum of Understanding agreed to by DOE, EPA, and TDEC. 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 are reported monthly to TDEC as an attachment to the discharge monitoring report (DMR) required by NPDES. These sites were monitored once per week for the radiological and nonradiological parameters shown in Tables 4.1 and 4.2 in Vol. 2. Figure 4.3 shows data from 1987–1991.

A sampling point is located in the diversion ditch around the New Hope Pond Closure Area. Samples are taken here on a weekly basis for the radiological parameters shown in Table 4.3 in Vol. 2. In addition, Station 17, located near the junction of Bear Creek and Scarboro roads, is used to monitor EFPC downstream of Lake Reality but prior to its leaving the Y-12 Plant boundary. Weekly samples were obtained here for the radiological and nonradiological parameters listed in Table 4.4 of Vol. 2. Grab samples were obtained twice per day for mercury, 24-h composite samples were obtained every day of the week, and 72-h composites were collected over the weekends.

ORR Off-Reservation Surface Waters

Data sampling and analyses of off-reservation surface waters were completed by ORNL staff and are discussed in Sect. 4.4.2.

Effluents

The Y-12 Plant holds Industrial User's Permit Number 001 with the city of Oak Ridge. Table 4.4 details the permit requirements and compliance record for each outfall in 1991. This permit allows the Y-12 Plant to discharge wastewater to be treated at the Oak Ridge Wastewater Treatment Facility through two main sewerage lines into the Oak Ridge sanitary sewer system in accordance with effluent limitations, monitoring requirements, and other conditions set forth in the permit. The radiological and nonradiological parameters monitored and the results obtained for these sewer lines and for the biology sewer line are listed in Tables 4.5, 4.6, and 4.7 of Vol. 2. Table 4.8 in Vol. 2 shows the total

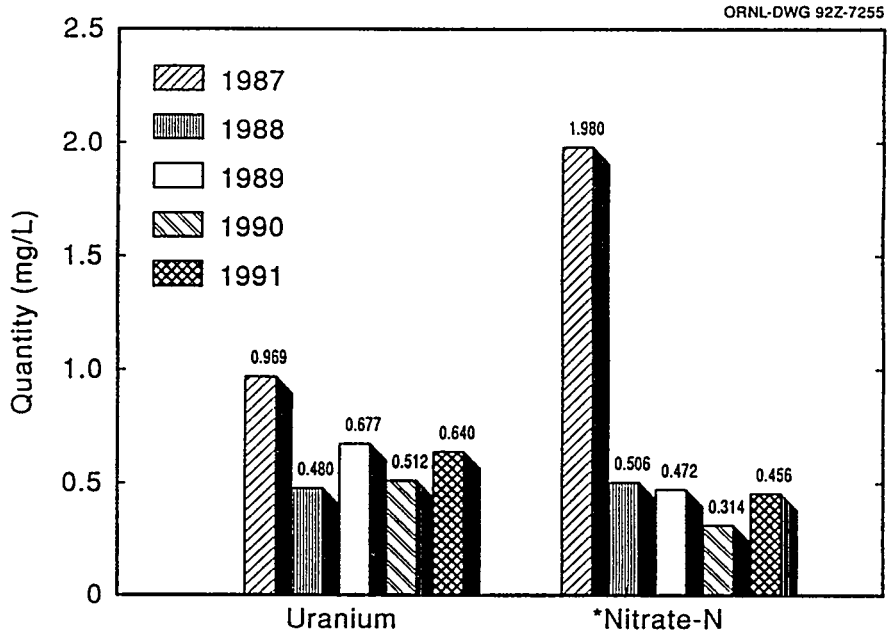


Fig. 4.3. Upper Bear Creek trend chart, 1987–1991.

Table 4.4. 1991 NPDES compliance at the Y-12 Plant

Discharge point	Effluent parameter	Effluent limits				Percent of compliance	Number 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	15
	pH (standard units)			*a*	8.5	100	16
	Total suspended solids			30.0	50.0	100	15
	Temperature (°C)				30.5	100	16
	Zirconium				3.0	100	15
302 (Rogers Quarry)	Oil and grease			10.0	15.0	100	53
	pH (standard units)			*a*	8.5	62	53
	Settleable solids (mL/L)				0.5	100	53
	Total suspended solids			30.0	50.0[b]	100	52
	Temperature (°C)				30.5	96	53
304 (Bear Creek)	Oil and grease			10.0	15.0	100	51
	pH (standard units)			*a*	8.5	100	53
307 (West Borrow Area)	Temperature (°C)					100	4
	pH (standard units)					100	4
	Oil and grease					100	4
	Total suspended solids					100	4
308 (East Borrow Area)	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	28
	Chromium, total	0.5	0.75	1.71	2.77	100	28
	Copper, total	0.6	0.9	2.07	3.38	100	28
	Cyanide, total	0.2	0.33	0.65	1.20	*c*	28
	Lead, total	0.12	0.19	0.43	0.69	100	28
	Nickel, total	0.65	1.1	2.38	3.98	100	28
	Oil and grease	7.1	14.2	26.0	52.0	100	28
	pH (standard units)			*a*	9.0	100	28
	Silver, total	0.07	0.12	0.24	0.43	100	28
	Temperature (°C)				30.5	100	28
	Total suspended solids	8.5	16.4	31.0	60.0	*c*	28
	Total toxic organics		0.6		2.13	100	28
	Zinc, total	0.4	0.7	1.48	2.61	100	28
502 West End Treatment Facility (WETF)	Cadmium, total	0.07	0.019	0.26	0.69	100	63
	Chromium, total	0.50	0.75	1.71	2.77	100	63
	Copper, total	0.60	0.92	2.07	3.38	100	63
	Cyanide, total	0.2	0.33	0.65	1.20	100	64
	Lead, total	0.12	0.19	0.43	0.69	100	63
	Nickel, total	0.65	1.10	2.38	3.98	100	63
	Oil and grease	7.1	14.2	26.0	52.0	100	64
	pH (standard units)			*a*	9.0	100	64
	Silver, total	0.07	0.12	0.24	0.43	100	83
	Temperature (°C)				30.5	100	64
	Total suspended solids	8.5	16.4	31.0	60.0	97	63
	Total toxic organics		0.6		2.13	100	24
	Zinc, total	0.4	0.7	1.48	2.61	100	63

Table 4.4 (continued)

Discharge point	Effluent parameter	Effluent limits				Percent of compliance	Number 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	100	158
	Copper, total	1.89	1.89	1.0	1.0	100	158
	Iron, total	1.89	1.89	1.0	1.0	100	158
	Zinc, total	1.89	1.89	1.0	1.0	100	158
	Oil and grease	28.4	37.9	15.0	20.0	98	158
	Total suspended solids	57.0	189.0	30.0	100.0	100	157
	Temperature (°C)				30.5	99	159
	pH (standard units)			*a*	9.0	98	159
Category I outfalls (precipitation runoff and small amounts of groundwater	pH (standard units)			*a*	8.5	100	22
Category II outfalls cooling waters, condensate, precipitation runoff, and building, roof, and foundation drains)	pH (standard units)			*a*	8.5	100	66
	Temperature[d] (°C)					100	66
Category III outfalls (process wastewaters)	pH (standard units)			*a*	8.5	98	42
Category IV outfalls (untreated process wastewaters)	pH (standard units)			*a*	8.5	94	106
504 Plating Rinsewater Treatment Facility	Cadmium, total	0.07	0.019	0.26	0.69	100	7
	Chromium, total	0.50	0.75	1.71	2.77	100	7
	Copper, total	0.60	0.92	2.07	3.38	100	7
	Cyanide, total	0.2	0.33	0.65	1.20	100	7
	Lead, total	0.12	0.19	0.43	0.69	100	7
	Nickel, total	0.65	1.10	2.38	3.98	100	7
	Oil and grease	7.1	14.2	26.0	52.0	100	7
	pH (standard units)			*a*	9.0	100	7
	Silver, total	0.07	0.12	0.24	0.43	100	7
	Temperature (°C)				30.5	100	7
	Total suspended solids	8.5	16.4	31.0	60.0	100	7
	Total, toxic organics		0.6		2.13	100	7
	Zinc, total	0.4	0.7	1.48	2.61	100	7
501/504 (Combined discharge Central Pollution Control Facility and Plating Rinse Water Treatment Facility)	Cadmium, total	0.07	0.019	0.26	0.69	100	5
	Chromium, total	0.50	0.75	1.71	2.77	100	5
	Copper, total	0.60	0.92	2.07	3.38	100	5
	Cyanide, total	0.2	0.33	0.65	1.20	100	5
	Lead, total	0.12	0.19	0.43	0.69	100	5
	Nickel, total	0.65	1.10	2.38	3.98	100	5
	Oil and grease	7.1	14.2	26.0	52.0	100	5
	pH (standard units)			*a*	9.0	100	5
	Silver, total	0.07	0.12	0.24	0.43	100	5
	Temperature (°C)				30.5	100	5
	Total suspended solids	8.5	16.4	31.0	60.0	100	5
	Total toxic organics		0.6		2.13	100	5
	Zinc, total	0.4	0.7	1.48	2.61	100	5

Table 4.4 (continued)

Discharge point	Effluent parameter	Effluent limits				Percent of compliance	Number of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
623 (Steam Plant fly ash sluice water)	pH (standard units)			[a]	8.5	94	50
506 (9204-3 sump pump oil)	Temperature (°C)				30.5	90	52
	Oil and grease			10.0	15.0	100	52
	pH (standard units)			[a]	8.5	98	52
508 (Experimental mobile wastewater treatment facility)	Mercury, total			0.002	0.004	[e]	[a]
	pH (standard units)			[a]	9.0	[e]	
	Total suspended solids			30.0	45.0	[e]	
510 (Waste Coolant Processing Facility)	Biochemical oxygen demand	1.33	2.65			[e]	
	Oil and grease			15.0	20.0	[e]	
	pH (standard units)			[a]	9.0	[e]	
	Temperature (°C)				30.5	[e]	
	Total suspended solids			30.0	50.0	[e]	
512 (Groundwater Treatment Facility)	Oil and grease			[a]	15	100	21
	Iron, total			[a]	1.0	100	21
	pH (standard units)			[a]	9.0	100	continuous
Miscellaneous discharges (cooling tower blowdown)	Chromium, total				1.0	100	62
	Copper, total			0.5	1.0	100	62
	Free available chlorine			0.2	0.5	98	63
	pH (standard units)			[a]	8.5	100	63
	Temperature (°C)			35	38	100	63
	Zinc, total			0.5	1.0	100	62
Miscellaneous discharges (demineralizers)	pH (standard units)			[a]	8.5	[e]	
	Total suspended solids			30	50	[e]	

[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 because of a laboratory administrative error.
[d]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.
[e]No discharge.

uranium and associated curies released from the Y-12 Plant as a liquid effluent during 1988, 1989, 1990, and 1991.

Development of an RMP for the Y-12 Plant is required by the NPDES permit. This plan was developed and submitted to TDEC in 1987. Monitoring activities under this plan began during the third quarter of 1987.

The plan addresses compliance with the NPDES permit and the "as low as reasonably achievable" (ALARA) philosophy for radioactive discharges in liquid effluents. The monitoring program is designed to monitor effluents at treatment facilities, other point and area source discharges, and in-stream locations. Known or suspected radioactive materials and indicator parameters are monitored. The treatment facilities that are monitored are shown in Fig. 4.4.

They include the Central Pollution Control Facility (CPCF), the WETF, the Steam Plant Wastewater Treatment Facility (SPWTF), and the Plating Rinsewater Treatment Facility (PRTF). Point and area discharges include outfalls 109, 135, and 147. The in-stream location for 1991 was outfall 304, Bear Creek. These data are summarized in Table 4.9 in Vol. 2.

The radium data appear abnormal in proportion to other radionuclides because of the susceptibility of this radiochemical method to background noise. Activity counts in the spectral region for radium are influenced by naturally occurring radioactivity. Thus, although no radium peak is observed by gamma spectrometry, several activity counts are influenced by background.

DOE Order 5400.5 requires all DOE facilities to maintain radionuclide effluents at ALARA levels. Consistent with this policy, the Y-12 Plant will continue to operate in a manner that complements the ALARA philosophy. The Y-12 Plant ALARA program includes an aggressive plan to identify and minimize sources of radioactive discharges via various monitoring programs.

Over the past few years, significant changes in the interpretation of existing environmental legislation have impacted the environmental management program at the Y-12 Plant. Until 1977, EPA had total responsibility for enforcing the CWA at federal facilities such as the Y-12 Plant. Under the EPA, the Y-12 Plant had one NPDES permit with four perimeter outfalls: one at the outlet of New Hope Pond, one west of the main plant site on Bear Creek (at Highway 95), one at the outlet of Rogers Quarry, and one at the outlet of Kerr Hollow Quarry. While operating under the EPA NPDES permit, the Y-12 Plant regularly achieved compliance with the effluent discharge criteria.

In 1977, amendments to the Federal Water Pollution Control Act (FWPCA) allowed the states to establish their own water quality criteria. By law, these criteria took precedence over any EPA-issued NPDES permits. The current NPDES permit issued May 25, 1985, is a reflection of the 1977 amendments to the FWPCA and the Y-12 Federal Facilities Compliance Agreement (FFCA) signed by EPA and DOE on April 17, 1985. This current NPDES permit combines water quality and industrial best available technology (BAT) effluent limitations for the metal finishing and steam electric power generation industries with emphasis on biological and toxicological monitoring. The Y-12 Plant is committed to achieving effluent characteristics that are better than those specified by BAT. The effluent limitations for each treatment facility may be adjusted if the treated effluent results in in-stream toxicity as determined by TCMP or if EFPC does not display a healthy ecological system as determined by BMAP.

Another condition of the Y-12 NPDES permit is the development and implementation of a PCB Plan for the Y-12 Plant. This plan specifies sampling locations and frequencies to identify PCB sources. A summary of these data can be found in Table 4.10 in Vol. 2.

The Y-12 Plant NPDES-permitted outfalls are identified in Table 4.11 in Vol. 2. This permit requires sampling and analysis at 14 serially numbered outfalls, approximately 195 categorized outfalls, and approximately 30 miscellaneous discharges. Analytical results for Y-12 Plant NPDES discharge points for 1991 are summarized in Tables 4.9 and 4.12–4.30 in Vol. 2.

Discharges from the Y-12 Plant processes affect water quality and flow in EFPC before entering the Clinch River. Discharge of coal bottom ash slurry to the McCoy Branch watershed from the Y-12 steam plant occurs only when coal is in use. Bear Creek water quality is affected by area source runoff and groundwater discharges. The Y-12 Plant is committed to providing treatment for a variety of wastewaters discharged to area streams. Discharges 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 existing Y-12 Plant NPDES Permit expired in May 1990. An application for permit renewal was submitted to TDEC/EPA in November 1989. This application contains an extensive collection of proposed monitoring points and subsequent categories. This collection consists of 72 Category-I-type outfalls (uncontaminated precipitation runoff and groundwater), 66 Category-II-type outfalls (roof drains, cooling-water discharges, condensate, and other effluents previously monitored), 4 plant site outfalls, 5 treatment facilities, 20 cooling-tower

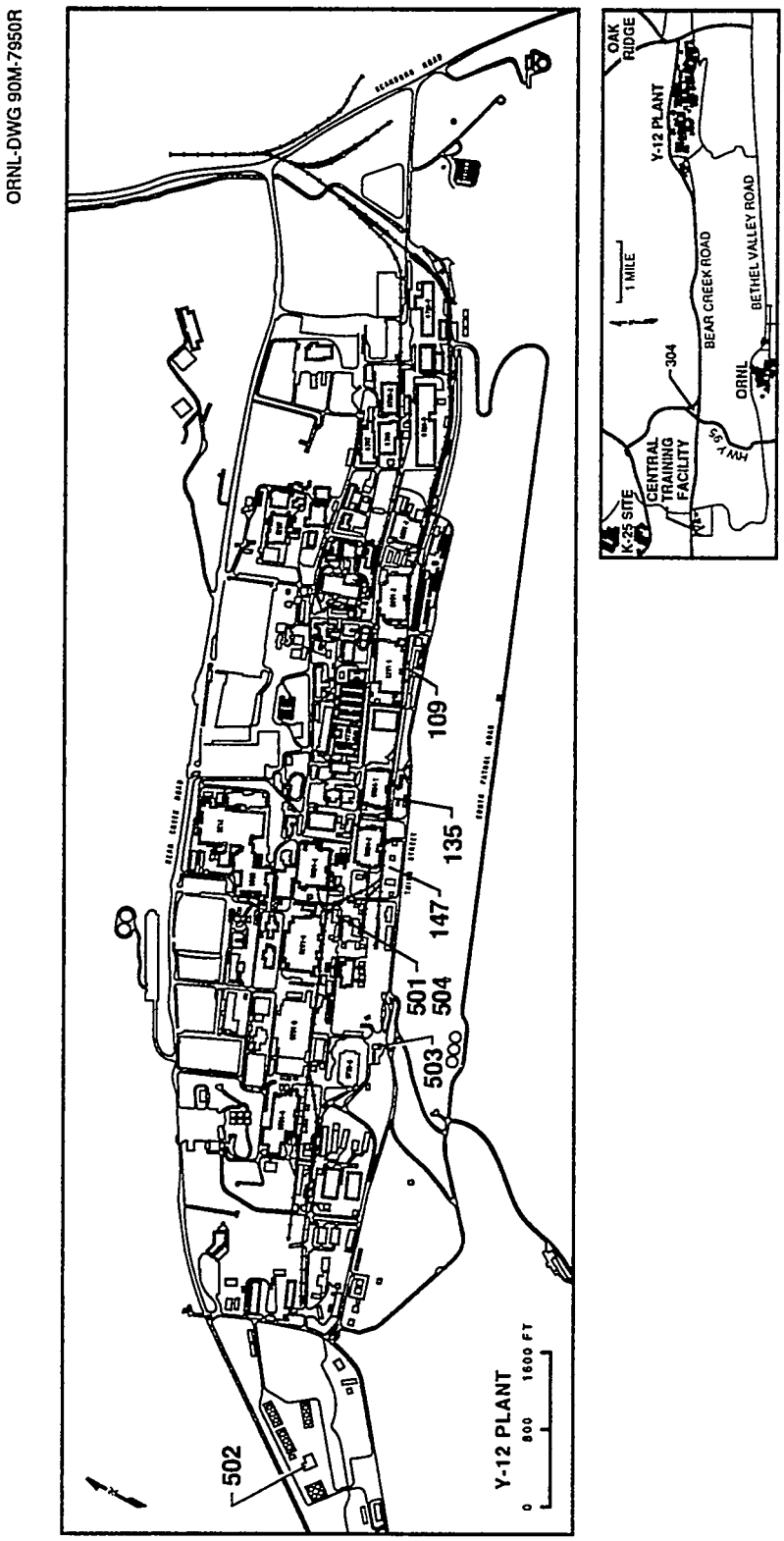


Fig. 4.4. Y-12 Plant NPDES radiological monitoring plant locations.

discharges, 1 ash sluice-water discharge, 40 miscellaneous discharges, and 58 miscellaneous outfalls, for a total of 266 outfalls.

A network of storm drains that discharge into EFPC covers the entire area of the Y-12 Plant. This system gathers rainfall from the adjacent hillsides, parking areas, roof drains, and the flow from the testing of the fire protection system. In the past, interconnecting with the storm drainage system were numerous discharges and laboratory drains within the buildings, building floor drains, and drains from accumulation tanks outside the buildings. Efforts to improve the water quality of streams receiving Y-12 Plant discharges are ongoing and have resulted in eliminating numerous process discharges to EFPC.

There are 18 major cooling tower systems and 6 small air-conditioning towers currently in operation at the Y-12 Plant. Approximately 1380 million L (359 million gal) per year of water are required as makeup for the 18 major cooling tower systems. About 550 million L (143 million gal) per year are discharged as blowdown into EFPC, and 830 million L (216 million gal) are lost as evaporation.

In 1991, three areas of noncompliance with the plant NPDES permit were creek outfalls, Rogers Quarry, and wastewater treatment facilities. Noncompliances with the NPDES permit are summarized in Fig. 4.5. Observations at creek outfalls accounted for 33% of the total number of NPDES noncompliances during 1991, which is an increase from 18% in 1990. Approximately 30% of the increase in noncompliances is believed to be the result of the increased surveillance along EFPC. A full-time employee was designated as the "creek walker" in March 1991. This employee's responsibilities consist of walking the creek from Lake Reality to the north/south pipes (the location at which the EFPC becomes state waters) approximately three times per day looking for changes in creek conditions or visible discharges from outfalls (e.g., foam or oil). In addition, a field crew of fisheries biologists surveyed the EFPC from the Bear Creek Road crossing to the north/south pipes each workday in 1991.

Rogers Quarry accounted for 26% of the total number of NPDES noncompliances during 1991,

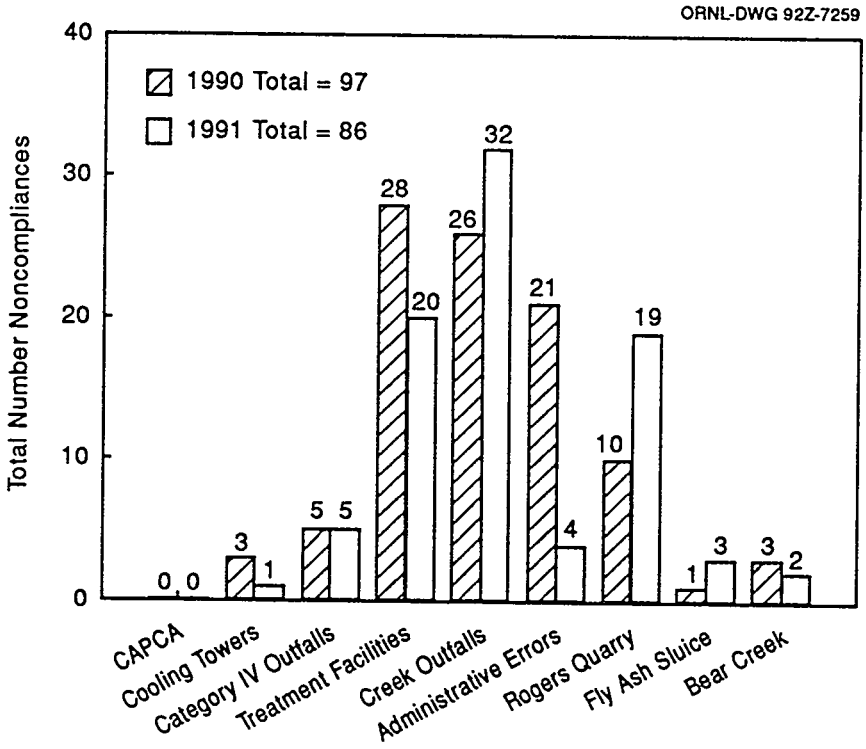


Fig. 4.5. Y-12 Plant NPDES noncompliance status comparison and sources of noncompliances.

which is an increase from 10% in 1990. The reason for the slightly elevated pH of the discharge from Rogers Quarry is increased algae growth in the quarry. As the 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 results in a slightly elevated pH. This phenomenon is caused by natural events and occurs in most lakes and ponds in East Tennessee. The reason for the increase in noncompliances from 1990 to 1991 is believed to be because the Y-12 steam plant has significantly decreased the amount of coal ash disposed of in the quarry. The clarity of the water has improved significantly, allowing sunlight to penetrate deeper into the quarry, thus allowing for more algae growth. In an attempt to stop pH noncompliances at the quarry, a subsurface discharge pipe has been installed at the outlet to the quarry. The subsurface discharge pipe allows for deeper, lower pH water to be discharged.

Wastewater treatment facilities accounted for 23% of the total number of NPDES noncompliances during 1991, which is an improvement from 29% in 1990. The majority of the 1991 wastewater treatment facility noncompliances occurred at two locations, the SPWTF and the ORNL Building 9204-3 Sump Pump Oil Separator. Better operational controls and preventative maintenance programs as well as the elimination of specific influent wastewaters have corrected the noncompliances at these two facilities.

In accordance with Part III of the NPDES permit issued to the Y-12 Plant, the plant is required to develop and implement a TCMP. Under the TCMP, various permitted discharges are evaluated for toxicity.

Results of the toxicity tests of wastewaters from three treatment facilities (CPCF, SPWTF and PRTF), one cooling tower, and one Category IV discharge (the Evaporator Process Condensate) are given in Table 4.31 of Vol. 2. For each wastewater, the table shows the month the test was conducted, the NOEC for fathead minnows and/or *Ceriodaphnia*, and the in-stream waste concentration (IWC).

Wastewater from the PRTF was not toxic (NOEC = 100%) to fathead minnows, and had an NOEC of 30% for *Ceriodaphnia*. The IWC for this wastewater is estimated to be approximately 1.4%, and therefore it is unlikely that the treated effluent from the PRTF would adversely affect the aquatic biota in the EFPC. The SPWTF wastewater had NOECs for fathead minnows and *Ceriodaphnia* of 100% and 12%, respectively, under normal flow conditions. The IWC for this wastewater is estimated to be 11%; it is therefore unlikely that the wastewater would adversely affect the aquatic biota of EFPC. The SPWTF effluent was also tested under high-flow conditions with no significant change in the IWC.

Wastewater from Cooling Tower 9409-22 (Outfall 622) was tested once during the year. The wastewater was not toxic to either fathead minnows or *Ceriodaphnia* (NOEC = 100%).

The toxicity test performed for the CPCF resulted in a low NOEC for fathead minnow and *Ceriodaphnia*, 1% and 6% respectively. These results were inconsistant with the higher NOEC values normally found with this effluent. An investigation of process operations was initiated, and a new toxicity test was scheduled for CPCF in February 1992.

Within the context of the TCMP, progress continues to be made toward the elimination and treatment of the Evaporator Process Condensate. A toxicity reduction evaluation is being performed to identify the toxic constituent in this effluent so that additional treatment may be applied. This effluent is scheduled to be converted to total recycle during process modifications in 1993. The Evaporator Process Condensate was tested three times using *Ceriodaphnia* and two times using the fathead minnows. In all tests, the NOEC was greater than the IWC, indicating it was unlikely that this effluent would adversely affect the aquatic biota of EFPC.

4.4.2 Oak Ridge National Laboratory

Reference Surface Waters

Monthly surface water samples are collected at two sampling locations for the purpose of determining background concentration levels before the influence of ORNL effluents. The two locations are Melton Hill Dam (MHD) above ORNL's discharge point into the Clinch River (with the exception of the cooling tower, roof, and parking lot runoff at the 7600 area) and WOC headwaters above the point where ORNL discharges to WOC (see Fig. 4.6). Tables 4.32 and 4.33 in Vol. 2 provide the sampling and analysis plans for these locations.

Tables 4.34 and 4.35 in Vol. 2 contain summaries of the analytical results. The entries in the column for

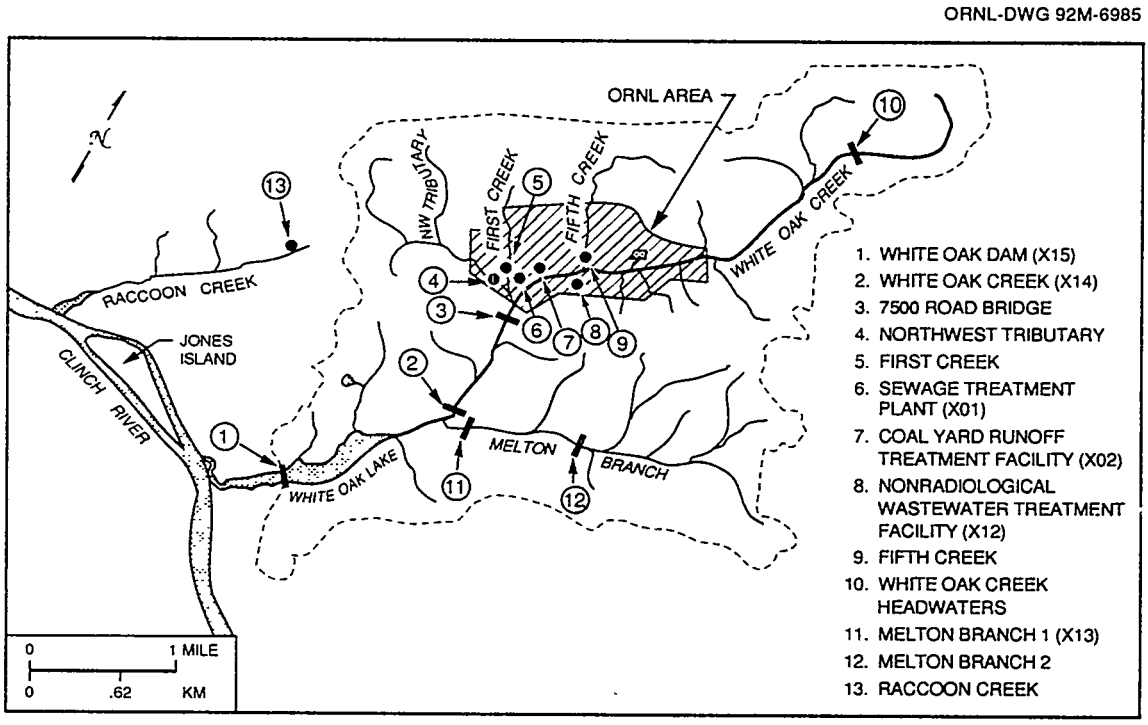


Fig. 4.6. ORNL surface water and reference sampling locations.

mean concentration that are significantly greater than zero are followed by an asterisk. In performing this test for nonradionuclides, the various prefixes associated with the observed data are disregarded. Thus, the reader should consider the number of detected values to assess the practical significance of the statistical test result. The last column in the table contains the mean as a percentage of a reference value when the following are true: (a) the parameter is a contaminant or an indicator of contamination, (b) the parameter has a reference value (excluding turbidity and pH), and (c) the observed mean is significantly greater than zero. The reference values used come from the National Primary or Secondary Drinking Water regulations or are 4% of the DCGs for radionuclides found in DOE Order 5400.5, which is equivalent to EPA's 4 mrem/year drinking water standard (see Tables 5.1–5.11, Vol. 2).

There is reasonably good agreement between parameters measured at WOC headwaters and MHD. Only mean concentrations for the inorganic elements aluminum, iron, and manganese exceeded reference values (secondary drinking water limits). Concentrations of these magnitudes are commonly associated with the hydrogeology of the Clinch River.

ORR Surface Waters Receiving Effluent

Surface water samples are collected from six streams near ORNL: WOC, MB, First Creek, Fifth Creek, Northwest Tributary (NWT), and Raccoon Creek (Fig. 4.6). Table 4.2 identifies each sampling location for ORR surface waters receiving effluent at ORNL, the data summaries, and the sampling and analysis plans for the various sampling locations. The mean concentrations for the year that are significantly

greater than zero in the data summaries are followed by an asterisk. In performing this test for nonradionuclides, any prefixes associated with the observed data are disregarded. Thus, the reader should consider the number of detected values out of the total number of results in order to assess the practical significance of the statistical test result.

Concentrations of metals, anions and other contaminant indicators measured at the NPDES ambient surface water stations MB1, WOC, and White Oak Dam (WOD) were compared to averages of reference values calculated from the MHD and WOC headwater results. Constituent concentration averages that exceed the reference location averages by more than 35% are considered as elevated over the reference value. This criterion is a compromise between EPA's duplicate sample acceptance criterion of 20%, which assumes identical samples, and areal changes in water chemistry that are unrelated to contaminant sources. At Melton Branch 1 (MB1), WOC, and WOD, excess sulfate, fluoride, and zinc were detected. In addition, at WOD, the final release point from the ORR, excess chromium, aluminum, iron, manganese, total organic carbon, O&G, phosphorus, and total dissolved solids (TDS) were detected. WOC results are comparable with those at WOD, but MB1 metals are more like those found in the reference waters.

Five times the analytical detection limit was used as a nominal rule for assessing the presence of organic contaminants. As such, no significant organic contamination was found at the three NPDES ambient surface water stations.

DOE's DCGs provide screening values for considering BATs for liquid waste containing radionuclides discharged to surface water. The annual average concentration of each radionuclide can be expressed as a percentage of the DCG and is used here to provide a reference. Summing the percentages for a station then provides a means to compare the NPDES ambient surface water stations and the other ORNL surface water sampling stations to the BAT criteria and to each other. The DCG for ^{90}Sr was used to evaluate total radioactive Sr discharges.

The order of the stations from highest to lowest on the percentage sums is MB1, WOD, First Creek, WOC, 7500 Bridge, Fifth Creek, NWT, Raccoon Creek, and MB2. The summed percent BAT and the contributing radionuclides for the stations exceeding 5% BAT are as follows:

Location	% DCG	% contribution to % DCG by radionuclide			
		Sr-total	^{3}H	^{137}Cs	^{60}Co
MB1	67	40	27		
WOD	31	19	7	4	<1
First Creek	29	29			
WOC	19	13	2	3	
7500 Bridge	13	8	<1	5	

Releases of ^{137}Cs result from process discharges as well as elevated flow at the ambient stations because of heavy rainfall can resuspend ^{137}Cs-contaminated creek sediments. Although there is a process-related contribution of total radioactive strontium from the Sewage Treatment Plant (STP) and the Nonradiological Wastewater Treatment Facility (NRWTF), the primary sources are more diffuse and are probably the result of past activities and subsurface input. A similar diffuse source for ^{60}Co may explain the significant nonzero concentration at WOD.

Average ^{3}H concentrations at MB1, WOC, and WOD were lower in 1991 than in 1990, significantly so at MB1 and WOC. Most of the tritium is believed to come from solid waste storage area 5 (SWSA 5). However, there is a process-related contribution from NRWTF. Otherwise, average concentrations observed in 1991 were comparable to those reported in 1990.

Mercury in the Aquatic Environment

The Mercury Plan of the NPDES Permit was designed to identify, locate, and minimize all sources of mercury contamination into ORNL waters. The 1988 and 1989 monitoring data provided a basis to recommend to DOE and TDEC the elimination of nonstrategic sampling locations. No action has been taken by TDEC on that recommendation to date. The 1991 data confirm the need to implement this request.

Water and sediments were sampled semiannually during the first and fourth quarters of 1991. The sediment data are presented in Sect 7. A total of

160 sets of triplicate water samples were collected for the year. Sampling was conducted in Melton Valley, WOC, First Creek, and Fifth Creek (Figs. 4.7 and 4.8). These data are presented in Table 4.46 in Vol. 2.

The state of Tennessee promulgated revised standards for general water quality in September 1991. The streams listed above are in the use classification for fish and aquatic life. The criteria for mercury under this classification are 2.4 μg/L maximum concentration and 0.012 μg/L continuous concentration. The 1991 data can be compared to the new maximum concentration criteria, but the laboratory detection limit for these analyses exceeded the continuous criteria by a factor of 4.2. Consequently, an evaluation of continuous levels of mercury through the interpretation of the average and minimum data relative to the new criteria is not possible.

Table 4.46 in Vol. 2 presents the maximum, minimum, average, and standard error for each sampling location. Of the 80 locations that were sampled, 22 had maximum values that were higher than the analytical detection limit of 0.05 μg/L. Most of these results are from samples taken from a WOC reach that extends from near its confluence with NWT to the east end of Building 4500-S. These data ranged from 3.8% to 12.9% of the maximum concentration criteria. Two locations in both First Creek and Fifth Creek also had mercury concentrations above the detection limit. The Fifth Creek results were 4.6% and 10% of the maximum criteria, and the First Creek data ranged from 2.1% to 4.2% of the maximum criteria. No mercury was detected in at the sampling locations in MB.

PCBs in the Aquatic Environment

A PCB Plan was developed and implemented in compliance with the CWA and the ORNL NPDES permit to assess potential movement of PCBs in on-site drainage systems and the potential for discharge to off-site receiving waters. To establish a baseline for environmental concentration data, duplicate water samples were collected quarterly and sediment samples were collected semiannually from locations depicted in Figs. 4.9 and 4.10. The sediment data are presented in the Sect. 7. The concentrations of PCBs in water (by Aroclor) in 1991 were below the analytical detection limit at all sampling locations, with the exception of locations 2 and 4,

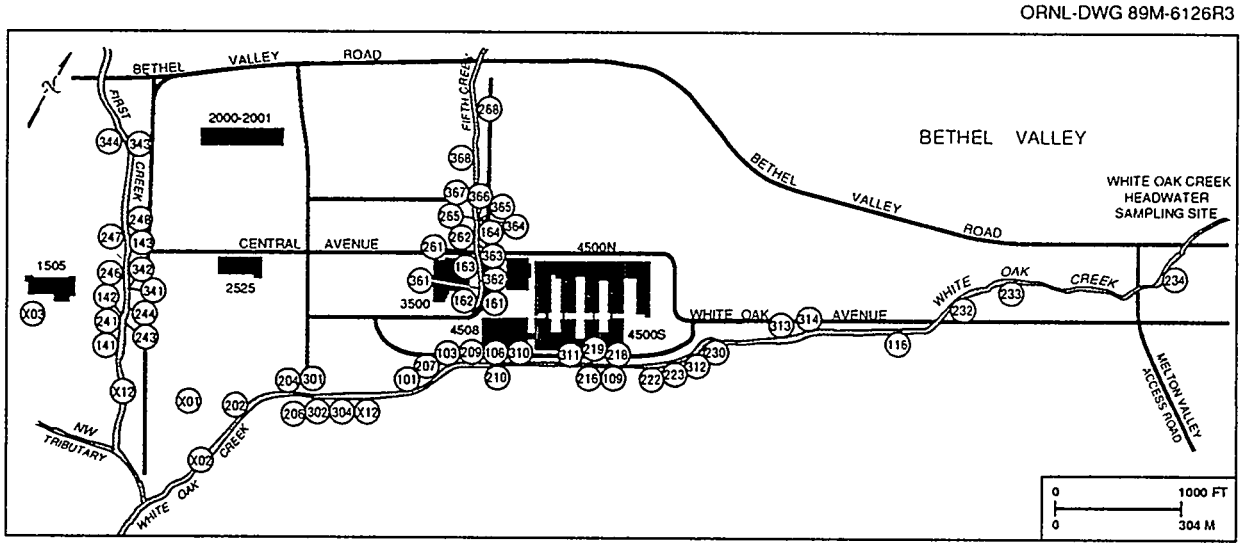


Fig. 4.7. Map of water sampling locations for mercury in the ORNL area. The circled numbers show the sample locations.

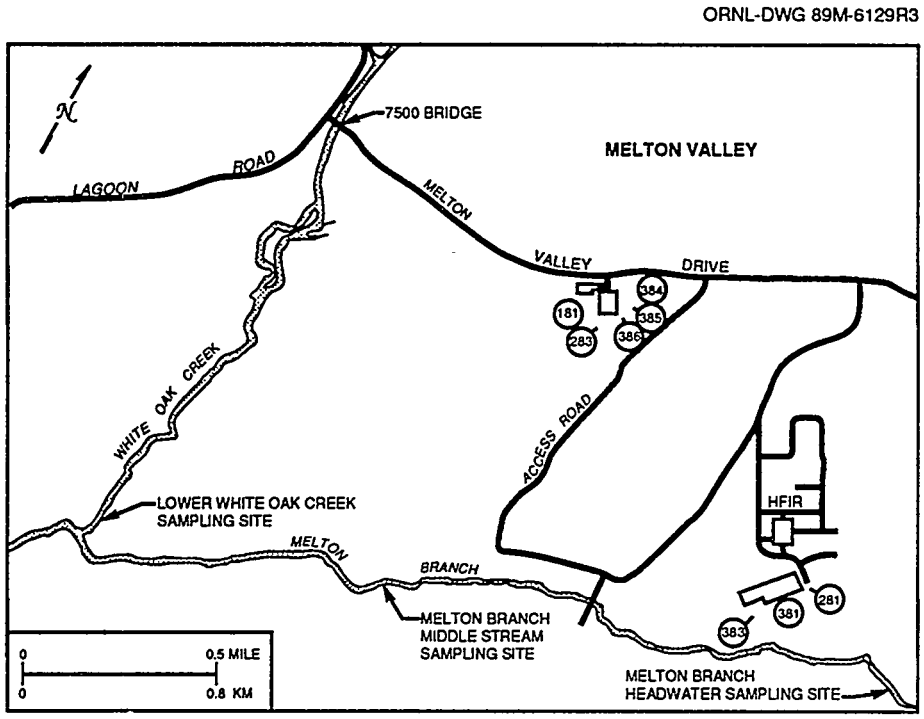


Fig. 4.8. Map of water sampling stations for mercury in the ORNL Melton Valley complex. The circled numbers show the sample locations.

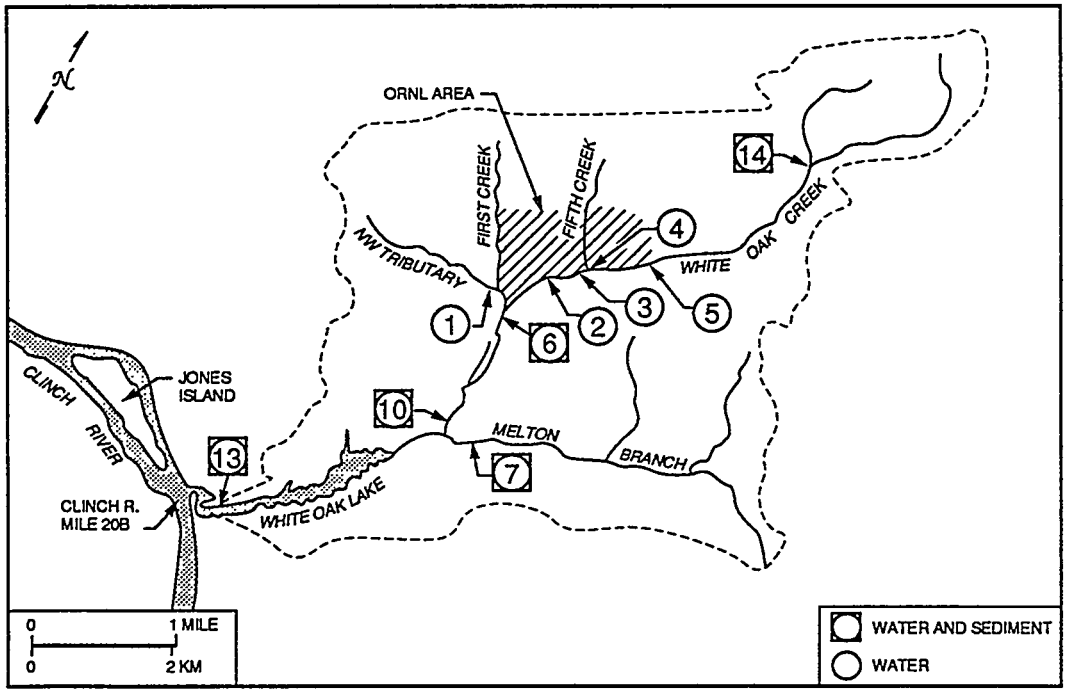


Fig. 4.9. Sample locations for PCB and TOC (sediment only) analyses in the ORNL area.

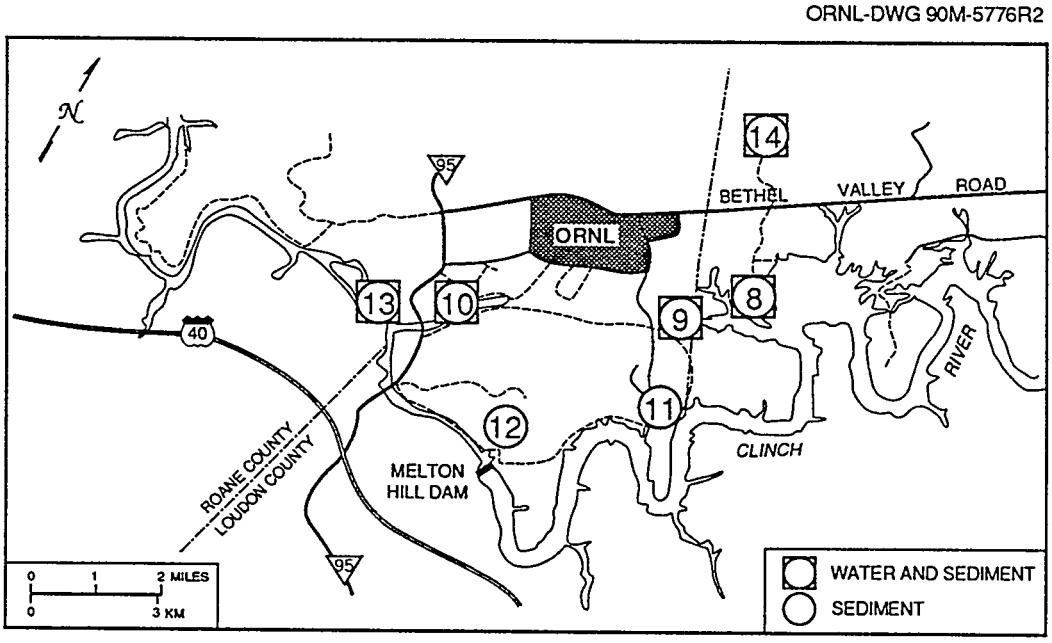


Fig. 4.10. Sample locations for PCB and TOC (sediment only) analyses in the greater ORNL area.

shown on Fig. 4.9. These data consisted of estimated values (below the limit of quantitation) of 0.90 and 0.40 µg/L respectively. Since all of the data values except those noted above were below the detection limit, a data table for the results is not provided.

Off-Reservation Surface Waters

The ORNL program for assessing impacts to the Clinch and Tennessee rivers consists of empirical data from treated water samples at the Kingston and the K-25 Site (Gallaher) potable water treatment plants; calculated Clinch River concentrations of effluents from STP, the Coal Yard Runoff Treatment Facility (CYRTF), and NRWTF; and calculated Clinch River dilutions of ambient measurements at MB1, WOC, and WOD. Sampling and analysis plans for these sites are identified in Table 4.2. Other programs, such as the Clinch River RCRA Facility Investigation, also conduct sampling and analysis campaigns on these rivers. The reader is directed to the DOE-OR Environmental Restoration Program for additional information regarding these other data.

The data tables for STP, CYRTF, NRWTF, MB1, WOC and WOD, Tables 4.50–4.55 in Vol. 2, contain concentrations of the effluent and ambient data as a percentage of drinking water limits (DWLs) or 4% of the DCG is after dilution by the Clinch River. Four percent of a DCG equivalent to EPA's 4 mrem/year drinking water standard. These percent DWL values reflect the dilution that occurs in the Clinch River and show the potential impact of water at a sampling location outside the ORR. The maximum, minimum, and average ratio of the sampling station flow to the Clinch River flow is provided in the header of each data table. Except for some metals with secondary DWL's, no maximum Clinch River concentration exceeded 1% of a DWL.

Tables 4.56 and 4.57 in Vol. 2 contain results for radionuclides measured at Gallaher and Kingston during 1991. The annual radionuclide summaries for the off-site surface water monitoring locations show that no average concentration exceeds 13% of a drinking water reference value. Values obtained during 1991 were comparable to those measured during 1990.

Effluents

The ORNL NPDES permit (TN0002941) became effective on April 1, 1986. Table 4.5 details the permit requirements and compliance record for each outfall in 1991. The existing permit expired in March 1991; the conditions of the expired permit remain in effect until a new permit is negotiated. The permit application was submitted in September 1990 and awaits action from TDEC.

Sampling and analysis frequencies at these locations are varied, as indicated by the sampling and analysis plans located in Vol. 2 and identified in Table 4.2. In addition to the effluent points, three ambient locations are included in the permit. They are WOD, WOC, and MB1. Effluent limits have been placed on the STP; the CYRTF; the NRWTF; MB1 (X13); WOC (X14); WOD (X15); Categories I, II, and III outfalls; and the miscellaneous source discharges. Discharge limits are also placed on pH for most of the outfalls.

Compliance with the NPDES permit for the last three years is summarized by the major effluent groups in Fig. 4.11. A detailed summary of the NPDES compliance at ORNL for 1991 is given in Table 4.5, which provides a list of outfalls, parameters measured for which there is a permit limit, the discharge limitations, the number of noncompliances, and the percentage in compliance for 1991. The percentage is based on the total number of observations and total number of noncompliances for a particular parameter at a particular outfall.

At the STP (discharge point X01), the compliance rate was greater than 95% for all parameters measured. The 1991 noncompliances of O&G parameters were based on three excursions. The additional noncompliances were based on monthly-average and mass-load calculations that were influenced by the individual excursions.

The TSS noncompliance was attributed to adverse conditions caused by an unusually heavy rainfall event in March 1991. The chlorine limit noncompliance was attributed to a temporary excursion in the chlorine level in the STP effluent.

Category I and II outfalls include storm drains and parking lot and roof drains that are not contaminated by any known activity, nor do they discharge through any oil/water separator or 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 noncompliances for O&G, as well as TSS, at a number of these outfalls. A study is being conducted to investigate the feasibility of various alternatives to control the noncompliances at Category I and II outfalls. Additional studies are currently under way with regard to new storm water regulations promulgated by the EPA in January 1992.

For one O&G noncompliance at CYRTF, no certain cause was found. One O&G noncompliance was attributed to heavy rainfall during June 1–4, 1991. The noncompliances of pH and iron limits were attributed to adverse conditions resulting from an unusually heavy rainfall in February 1991.

The pH limit noncompliance situation at the ORNL steam plant (SP2519) continued in 1991. An earlier ORNL investigation indicated that the pH standard was not actually being violated by the discharge at the point of entry to the receiving stream. As allowed by ORNL's NPDES permit, an application was submitted to TDEC requesting that permit limits be adjusted accordingly. In February and December 1991, ORNL conducted additional checks on this situation; no violation of pH or temperature water quality standards was detected. ORNL then submitted correspondence to DOE indicating that SP2519 monitoring would be discontinued.

The noncompliances for copper at the cooling towers were based on one excursion and a quarterly-average influenced by the excursion. WOD fell between the Tennessee acute and chronic water quality criteria for the maximum concentration of mercury (0.000080 mg/L) in January 1991.

All data collected for the NPDES permit are also summarized monthly for reporting to DOE-OR and to the state of Tennessee. These summaries are submitted to DOE in monthly DMRs. Summaries of sampling for the NPDES permit are found in Tables 4.50–4.55, and 4.64–4.68 of Vol. 2.

Effluent concentrations of metals, anions and other contaminant indicators were compared to averages of reference values calculated from the MHD and WOC headwaters results. Effluent constituents that exceed the reference location averages by 35% or more are identified as contaminant contributions to ambient surface water by that effluent point. The 35% criterion is a

Table 4.5. 1991 NPDES compliance at ORNL

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent of compliance
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)		
X01 (Sewage Treatment Plant)	Biochemical oxygen demand (summer)	8.7	13.1	10	15	0	100
	Biochemical oxygen demand (winter)	17.4	26.2	20	30	0	100
	Total suspended solids	26.2	39.2	30	45	1	99.4
	Ammonia (N) (summer)	3.5	5.2	4	6	0	100
	Ammonia (N) (winter)	7.8	11.8	9	13.5	0	100
	Oil and grease	8.7	13.1	10	15	8	95
	Dissolved oxygen				6.0[a]	0	100
	pH (standard units)				9.0[b]	0	100
	Residual chlorine				0.5	1	99.4
	Fecal coliform, geometric mean			1000[c]	5000[c]	0	100
X02 (Coal Yard Runoff Treatment Facility)	Temperature, °C				30.5	0	100
	Total suspended solids				50	0	100
	Oil and grease			15.0	20.0	5	88.6
	Chromium, total			0.2	0.2	0	100
	Copper, total			1.0	1.0	0	100
	Iron, total			1.0	1.0	3	92.7
	pH (standard units)				9.0[b]	2	96.2
	Selenium			0.22	0.95	0	100
	Zinc			1.0	1.0	0	100
X12 (Nonradiological Wastewater Treatment Facility)	Temperature, °C				30.5	0	100
	Total suspended solids	93.9	182	31	60	0	100
	Oil and grease	30.3	45.4	10	15	0	100
	Total toxic organics		6.45		2.13	0	100
	Cyanide, total	1.97	3.64	0.65	1.20	0	100
	Cadmium, total	0.79	2.09	0.26	0.69	0	100
	Chromium, total	5.18	8.39	1.71	2.77	0	100
	Copper, total	6.27	10.24	2.07	3.38	0	100
	Lead, total	1.30	2.09	0.43	0.69	0	100
	Nickel, total	7.21	12.06	2.38	3.98	0	100
	pH (standard units)				9.0[b]	0	100
	Silver, total	0.73	1.30	0.24	0.43	0	100
	Zinc, total	4.48	7.91	1.48	2.61	0	100

Table 4.5 (continued)

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent of compliance
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)		
Category I	Oil and grease			10	15	3	85.7
	pH (standard units)				9.0[b]	0	100
	Temperature, °C				30.5	0	100
	Total suspended solids			30	50	7	66.7
Category II	Oil and grease			10	15	18	91.4
	pH (standard units)				9.0[b]	1	99.5
	Total suspended solids			30	50	28	86.4
Steam Plant (SP2519)	pH (standard units)				9.0[b]	1	66.7
	Temperature, °C			35	38	1	66.7
Cooling systems	Chlorine				0.2	0	100
	Chromium				1.0	0	100
	Copper			0.5	1.0	2	96.4
	Temperature, °C			35	38	0	100
	Zinc			0.5	1.0	2	96.4
	pH (standard units)				9.0[b]	0	100

[a]Minimum.

[b]The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units. It shall be monitored (1) by a weekly grab sample taken at the effluent for discharge points X01, X02, and X12; (2) on a continuous basis at X12; (3) by a monthly grab sample taken at the effluent for discharge points X13, X14, and X15; (4) once per year by a grab sample taken at each of the Category I outfalls; (5) once per quarter by a grab sample taken at the effluent for pH at each of the Category II outfalls; and (6) once per quarter at SP2519. At the same time, a sample will be taken in the stream immediately downstream of every discharge point except X13, X14, X15, and SP2519. There are no numeric limits for downstream pH; however, the state has maintained that the downstream pH shall not be less than 6.0 standard units nor greater than 9.0 standard units.

[c]Colonies per 100 mL.

compromise between EPA's duplicate sample acceptance criterion of 20%, which assumes identical samples, and the fundamental differences in water chemistry between natural waters and effluents.

Excess zinc over reference levels is found in the STP effluent. Elevated sulfate, O&G, selenium, arsenic, zinc and chromium as well as lower levels of iron, TSS, and manganese are found in the CRYTF effluent. At the NRWTF, excess sulfate, fluoride, nitrate, and zinc and lower levels of iron were found.

Five times the analytical detection limit was used as a nominal rule for assessing presence of organic contaminants. As such, no significant organic contamination was found at the effluent points.

DCGs provide screening values for considering the BAT for liquid waste containing radionuclides discharged to surface water. The annual average concentration of each radionuclide can be expressed as a percentage of the DCG. The BAT is to be implemented at a location if the sum of the percentages for all radionuclides in the effluent exceeds 100%. The DCG for ^{90}Sr was used to evaluate total radioactive Sr discharges. This is a conservative approach because ^{90}Sr has a greater dose impact per unit amount than ^{89}Sr. No percentage sum exceeded 100% at the point source locations or ambient NPDES sampling stations.

Radionuclide measurements were taken at two of the point source sampling locations; the percentage sums at these locations were NRWTF (44%) and STP (25%). The contributors to the signature at NRWTF were ^{137}Cs (900 pCi/L average, 30% of DCG), total radioactive Sr (130 pCi/L average, 13% of DCG), and ^{3}H (32,000 pCi/L average, 2% of DCG). At STP the

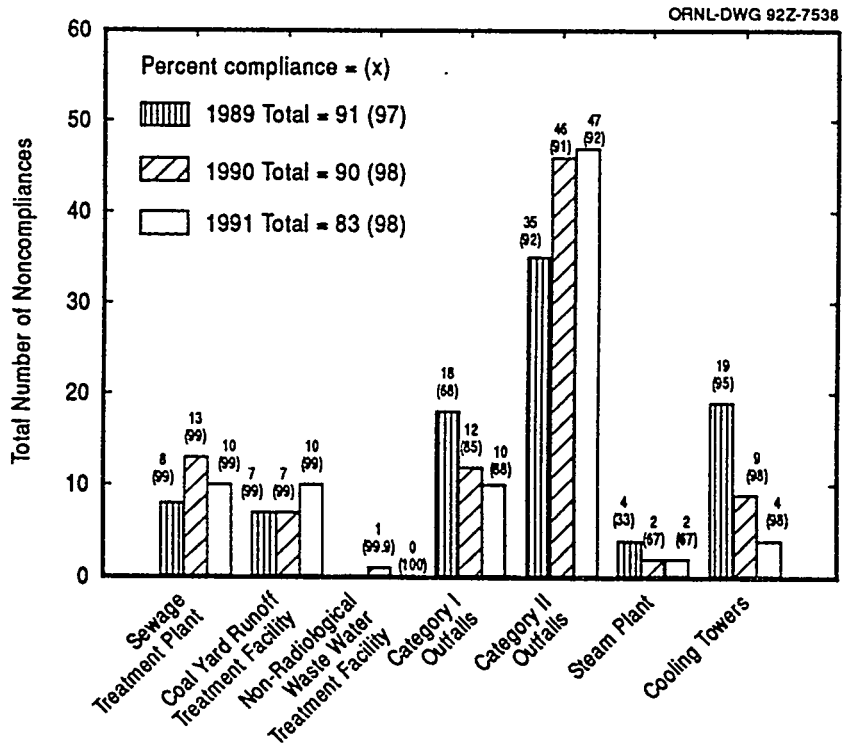


Fig. 4.11. ORNL NPDES noncompliance status comparison and sources of noncompliances.

contributor was total radioactive Sr (250 pCi/L average, 25% of DCG).

Of the 227 gross beta measurements taken on the Category I and II outfalls in 1991, 3 exceeded 810 pCi/L. One was at an outfall to WOC just below the confluence with Fifth Creek, one at an outfall to First Creek, and the third at an outfall to Melton Branch in the area around the High Flux Isotope Reactor. Elevated levels of gross beta activity are believed to be related to historic contamination, which is being addressed by the Environmental Restoration Program (ERP) for ORNL.

The average total radioactive Sr concentration at STP was significantly higher in 1991 than in 1990. Although not highly significant, there were increased concentrations of ^{137}Cs, total radioactive Sr, and ^{3}H at the NRWTF during 1991 over those observed in 1990. Otherwise average concentrations observed in 1991 were comparable to those reported in 1990.

Toxicity Control Monitoring Program

Under the TCMP, wastewater from the STP, the CYRTF, and the NRWTP was evaluated for toxicity. In addition, two ambient, instream sites were evaluated; one site is located on MB (permit point X13) and the other on WOC (permit point X14; see Fig. 4.6).

The results of the toxicity tests of wastewaters from three treatment facilities (CYRTF, STP, and NRWTP) and two ambient stream sites are given in Table 4.69 of Vol. 2. This table provides, for each wastewater and ambient water, the month the test was conducted and the wastewater's NOEC (the concentration that did not reduce fathead minnow survival or growth, or *Ceriodaphnia* survival or reproduction) for fathead minnows and *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 4.70 Vol. 2.

During 1991, the CYRTF was tested once, the STP was tested six times, and the NRWTP was tested three times. The CYRTF wastewater's NOEC for fathead minnows was 100% and for *Ceriodaphnia* was 6%; the wastewater's IWC ranged from 0.0% to 4.0% during April (based on critical low flow rate of WOC). Based on these tests, it is therefore unlikely that wastewater from the CYRTF would adversely impact the aquatic biota of WOC during 1991. The STP wastewater's NOEC for *Ceriodaphnia* was 12% during January and less than 6% during March. At

this time, the IWC of the STP was greater than the NOEC (Table 4.69 of Vol. 2). Thus, effluent from the STP may have adversely impacted the aquatic biota of WOC. A toxicity control plan was implemented and the frequency of testing was increased. Tests conducted in June, August, and September showed a decrease in toxicity: NOECs ranged from 25% to 100%. During these tests, the IWC of the wastewater (14.0% to 21.3%) was 1.2 to 3.6 times less than the NOEC. Thus, no adverse affect on the aquatic biota was likely to occur during these test periods, and the toxicity of the STP effluent during January and March was transient. Full-strength wastewater from the NRWTP was not toxic to either species during the June test. During the December test, however, the NOEC for *Ceriodaphnia* was less than 6% (fathead minnow testing was dropped as per guidelines in the NPDES permit). A confirmatory test conducted in January 1992 showed that the effluent was again non-toxic (NOEC equaled 100%). Thus, the toxicity of effluent from NRWTP during December was also transient.

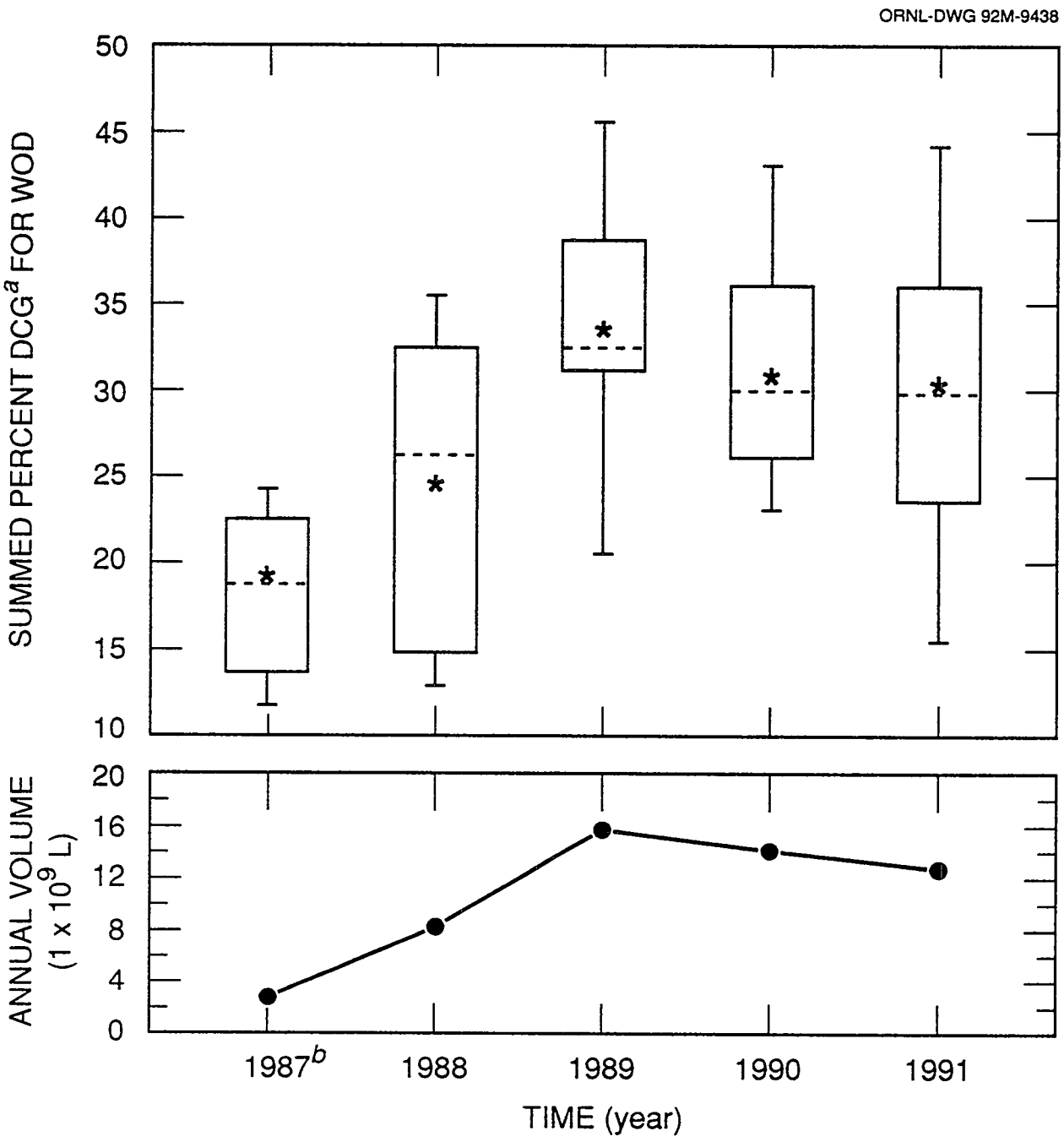
During 1991, the Melton Branch (X13) and White Oak Creek (X14) sites were tested seven times each. The two ambient waters were not toxic to *Ceriodaphnia*. Minnow survival or growth was lower than controls (NOEC less than 100%) during three tests of X13 and during one test of X14. In each case, however, a test conducted the following month showed that the water was nontoxic. Because survival (but not growth) was significantly lower than controls in two cases and mortality was often replicate-specific (e.g., 100% mortality in one replicate and 0% mortality in another), it is hypothesized that a bacterial or fungal pathogen in the water contributes to mortality. This hypothesis will be evaluated in 1992 by treating the water with ultraviolet light to destroy any pathogens. A complete summary of survival and reproduction of *Ceriodaphnia* and of survival and growth of fathead minnows in the ambient waters of WOC and its tributaries is included in the *Sixth Annual Report on the ORNL Biological Monitoring and Abatement Program* (Loar in press).

Multiyear Trends

One of the ways to put the surface water information into perspective is to compare the 1991 results to previous years. Figure 4.12 shows box plots of the information at WOD over the last 5 years. Each box plot is an annual statistical summary of the monthly summed percent of the DCGs including ^{3}H, total radioactive strontium as ^{90}Sr, ^{137}Cs, and ^{60}Co. The mean, median, 5th, 25th, 75th, and 95th percentiles are identified. The percentiles are a nonparametric way of evaluating how the monthly values for a given year are related. In this case, the median is the middle measurement of the year's data. Half of the other values are larger than the median and half of the other values are smaller than the median. The 25th percentile is the monthly value for which 25% of the data are less than that value and 75% of the data are greater than that value. An example of how to read the plot is as follows: for 1988, the mean summed percent of the DCGs was 24.5. The median value was 25.8 percent. The 25th and 75th percentiles were 15.4% and 32.9%, respectively. The 5th and 95th percentiles show the range of the values for the year without be biased by outlier, or anomalous, results as would be the case with the maxima and minima. Below the box plots is a plot of the total annual flow for each of the years. The first year, 1987, is represented by the last 7 months' data for the year in both the box plot and the total flow.

These graphics show that the monthly summed DCGs at WOD have varied over the last 5 years, and that this variation has coincided with the variation in measured total stream flow. Supporting analysis of the data for tritium and total radioactive strontium indicate that concentration and total discharge increase and decrease with flow at the monthly scale of evaluation. The total discharge of these radionuclides is influenced by the amount of water moving through the system and the concentration of the contaminants also increases with the amount of water moving through the system. The data for ^{60}Co and ^{137}Cs show little change in concentration over the range of flows. Therefore the increase in discharge for these radionuclides appears to the related primarily to the increase in the amount of water that is moving through the system; concentration is fairly constant.

The highest 95th percentile for the summed DCGs during the last 5 years is 45.3%. This means that during this particular month the summed concentrations of these radionuclides were at 45.3% of the criterion in DOE Order 5400.5. Exceeding the



[a]Sum includes ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium as ^{90}Sr.

[b]Includes the last 7 months of the year.

Fig. 4.12. Surface water summed percent DCGs and annual discharge volumes for White Oak Dam.

criterion of 100% of the summed percent DCGs would initiate an evaluation of the BAT to reduce these emissions. All releases to the environment are subject to the principle of environmental ALARA; reductions in effluents is a continuous mission regardless of achieving compliance with the DCG standard.

The dynamics of water flowing through the system influencing the concentration and discharge of contaminants is assumed to be largely because of interactions of baseflow and stormflow with the inactive disposal areas at the facility. As remedial actions isolate these areas from surface water and shallow groundwater, these relationships should diminish.

4.4.3 K-25 Site

Reference Surface Waters

Reference surface waters are sampled and analyzed for compliance with DOE orders 5400.1 and 5400.5. Perimeter monitoring includes both water quality parameters and radionuclides. The purpose is to document the K-25 Site's impact on the surrounding streams and to differentiate the impact from that of other sites.

During 1991, grab samples were collected once a quarter at the following locations: the Clinch River, West Fork Poplar Creek, and Mitchell Branch source. At K-1513, K-716, K-1710, and K-1770, 24-h composite samples were collected once each month. All samples were analyzed for radiological and nonradiological parameters.

Table 4.71 in Vol. 2 lists radiological data from the ambient surface water surrounding the K-25 Site. Figure 4.13 shows the sampling locations.

The concentration of radioactivity in the perimeter surface waters of the K-25 Site are well below the DCGs and drinking water standards.

Tables 4.72–4.78 in Vol. 2 give the water quality parameter data for the ambient surface water surrounding the K-25 Site. Figure 4.13 depicts the sampling locations. The K-25 Site does not appear to affect any parameters when data from Poplar Creek and Clinch River, both upstream and downstream from the site, are compared.

Mitchell Branch has been designated by TDEC as a biologically impacted stream. Sources of these impacts have been identified as (1) residual chlorine and temperature from once-through cooling with sanitary water, (2) process discharges with high levels of TDS, and (3) organic contaminants from groundwater. Ambient data from Mitchell Branch sources (Table 4.78 in Vol. 2) must be compared with K-1700 NPDES monitoring (Table 4.83 in Vol. 2) to review the impact of plant streams on Mitchell Branch water quality. Several projects that address the toxicity of these sources to Mitchell Branch were initiated in fiscal year (FY) 1991 and additional projects are being pursued.

Installation of dechlorination units at three storm drains along Mitchell Branch has almost completely removed the toxicity in the stream that was associated with total residual chlorine. Repopulation of the middle reaches of Mitchell Branch has occurred since the installation of the units.

ORR Surface Waters Receiving Effluents

Surface water samples are collected at effluent discharge points as part of the CWA requirements and DOE orders. NPDES water sampling locations and perimeter ambient water sampling locations under K-25 Site responsibility are shown in Fig. 4.13. Table 4.79 of Vol. 2 lists sampling locations, sample type, the agency requiring the sample, and the NPDES identification number where applicable.

NPDES effluent monitoring is specified in the K-25 Site NPDES permit TN0002950. This permit expired in February 1989, and application for a new permit was submitted by the K-25 Site to TDEC as required. The K-25 Site has written authorization from TDEC to continue to operate under the conditions of the expired permit until a renewed permit is issued. Negotiations between TDEC and the K-25 Site regarding the permit renewal are in progress, and a draft permit has been issued. Issuance of a final permit is expected in 1992. The isotopic analyses for radioactivity in both ambient surface water and NPDES programs are based on past and current plant operations.

Samples are collected and analyzed for radiological constituents along with NPDES samples. Each K-25 Site location is listed in Table 4.80, Vol. 2, along with the sampling frequency and sampling method.

The K-25 Site's original mission was uranium enrichment. Until the 1950s, activities were very specific, and uranium was the principal radionuclide

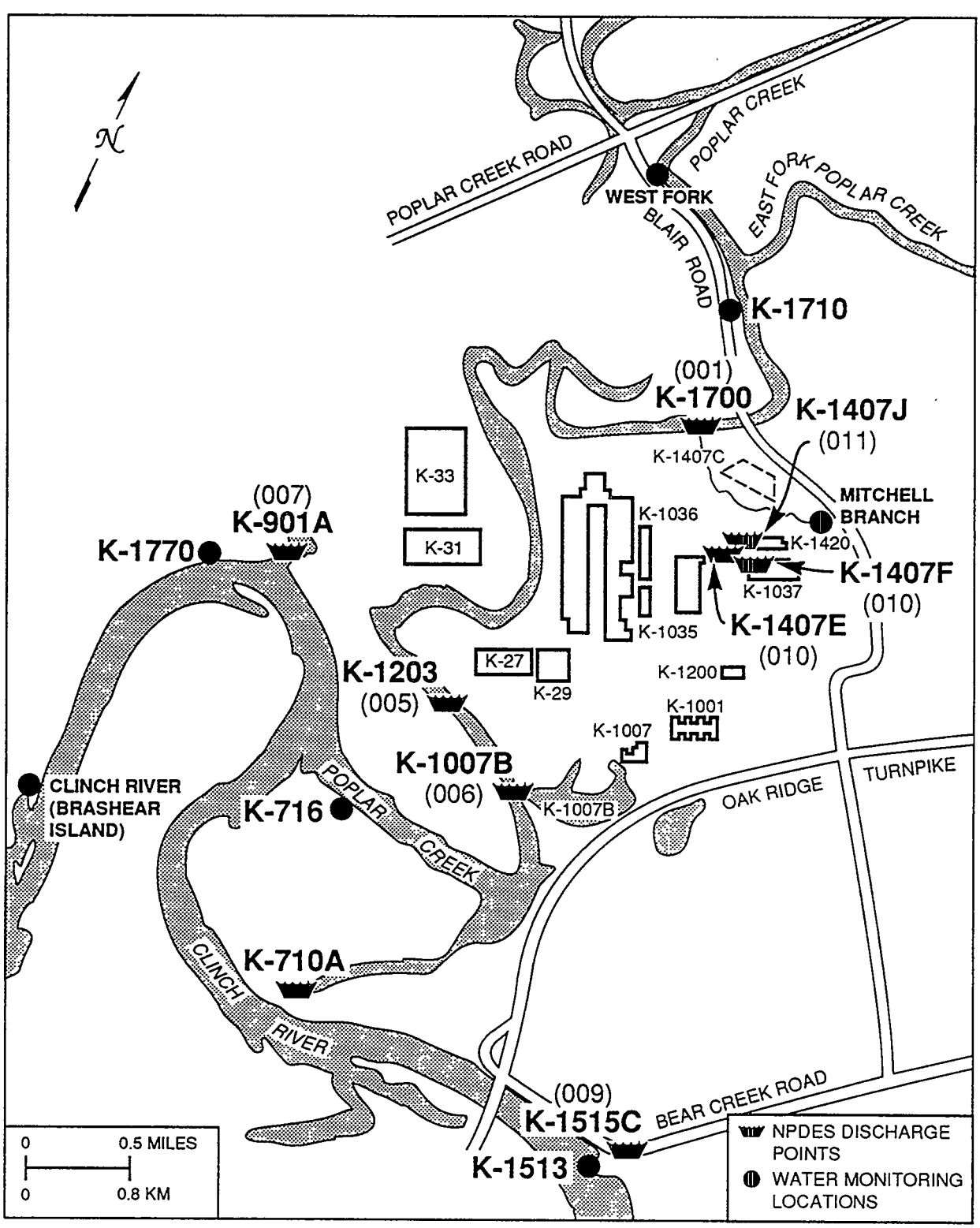


Fig. 4.13. K-25 Site NPDES and perimeter monitoring locations.

introduced into the plant area. During the 1950s, reactor return feed material was processed at the plant, and this activity introduced transuranic and fission products into the plant facilities. The radioisotopes specifically encountered were technetium, cesium, neptunium, and plutonium. The uranium enrichment process has now been shut down, and radioactive materials are no longer being introduced into the process. If additional isotopes are introduced to the plant site, monitoring of effluents will be reassessed.

The K-1700 and K-1407-J NPDES point (Fig. 4.13) have the greatest potential for radioactive emissions because of the facilities operating nearby. The K-1203 sewage plant has the second greatest potential for radioactive emissions, followed by the K-1407-E/F ponds. K-1007-B and K-901-A ponds have the least potential because no process effluents entering these ponds should contain radioactivity. The K-1515-C NPDES point receives backwash from the sanitary water plant. The intake for this facility is on the Clinch River; therefore the potential for contamination from the K-25 Site does not exist, although contamination from the Clinch River concentrates in the filter backwash.

With the exception of K-1515-C, all NPDES discharge points are grab sampled monthly for total alpha, beta, and gamma activity. If any monthly total activity values are above 30 pCi/L, an isotopic analysis is conducted on the monthly grab sample. Isotopic analyses include identification and quantification of ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{99}Tc, ^{137}Cs, ^{237}Np, ^{238}Pu, and ^{239}Pu. These data are transmitted quarterly to the state with the DMRs. In addition, as part of the K-25 Site Environmental Surveillance Program, isotopic analyses are performed on monthly composite samples taken at all NPDES discharge points with the exception of K-1515-C.

The data indicate that radiological effluents are within the DCGs in DOE Order 5400.5 at all effluent locations (see Table 4.82 in Vol. 2). Uranium, determined by wet chemistry analysis, is reduced and presented by isotope in the Vol. 2 tables. Most values are well below the DCG. At K-1407-J, ^{234}U is approximately 75% of the DCG, and ^{238}U is approximately 33% of the DCG. These values are higher than the 1990 data. The increase of activity at K-1407-J is because of testing and operations of the TSCA Incinerator. The effluent from the scrubber blowdown (off-gas cleaning system) makes up the majority of this discharge. K-1407-J exceeds 100% of the DCGs when summed; therefore, a BAT analysis is required by DOE Order 5400.5.

ORR Off-Reservation Surface Waters

Data sampling and analyses of off-reservation surface waters were completed by ORNL staff and are discussed in Sect. 4.4.2.

Effluents

The current NPDES permit for the K-25 Site has eight authorized discharge points (Fig. 4.13). Table 4.6 details the permit requirements and compliance records for each outfall in 1991. Samples are collected at seven of the eight outfalls and at three internal wastewater discharges. The eighth outfall is a package sewage plant that has been shut down, and it is not monitored. Overall, a 99.9% compliance rate was maintained with the NPDES permit during 1991.

All process water discharges from the plant pass through an NPDES monitoring point. However, many storm drains, some with noncontact cooling water discharges, are not currently required to be monitored at an NPDES sampling point. The NPDES permit for the K-25 Site is currently in the process of renewal and is scheduled for final issuance by TDEC in 1992. Monitoring of all storm drain outfalls at the facility will be a requirement of the renewed permit. In addition, several projects are being pursued to remove cooling water discharges from the plant storm drain system. Since the K-25 Site has been in standby mode, the major decreases in liquid discharges have been the result of the elimination of blowdown from both the recirculating cooling water (RCW) system and the centrifuge development cooling towers and a decrease in sewage effluent. The discharges are described according to their NPDES outfalls in Tables 4.81 and 4.84–4.89 of Vol. 2. Individual parameters are listed by annual values. The variety of parameters measured at K-1407-J is required to characterize this effluent for new treatment facilities' discharges. Most organics are below detection limits. Figure 4.14 summarizes the K-25 NPDES noncompliances. Each K-25 Site location is listed in Table 4.80 of Vol. 2 along with sampling frequency and sample type. All analyses are performed according to EPA-approved procedures.

Table 4.6. 1991 NPDES compliance at the K-25 Site

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percent compliance
		Daily av (mg/L)	Daily max (mg/L)	Daily av (kg/d)	Daily max (kg/d)		
001							
K-1700 discharge	Aluminum		1.0		16	7	93
	Chromium	0.050	0.080	0.80	1.2		100
	Nitrate–N		20		310		100
	Suspended solids[a]	30	50	470	780		100
	Oil and grease	10[b]	15	160	230		100
	pH, standard units		6.0–9.0				100
	Lead	0.0080	0.93	0.12	14		100
	Zinc	0.12	1.5	1.86	246		100
	Color		*c*				*d*
005							
(K-1203 sanitary treatment facility)[e]	Ammonia nitrogen	5.0	7.0	12	17.3		100
	BOD	15	20	37	49.5	2	99
	Chlorine, residual		0.24			1	99
	Dissolved oxygen	5.0[b]					100
	Fecal coliform, No./100 mL	200	400			10	94
	pH, standard units		6.0–9.0				100
	Suspended solids	30	45	74	110	5	97
	Settleable solids, mL/L		0.50			1	99
	Unpermitted discharge—untreated sewage	*d*	*d*	*d*	*d*		*d*
(K-1007-B holding pond)	COD	20	25	120	150	5	95
	Chromium, total		0.050		0.30	1	98
	Dissolved oxygen	5.0[b]				2	99
	Fluoride	1.0	1.5	6.1	9.1		100
	Oil and grease	10	15	61	91		100
	pH, standard units		6.0–9.0				100
	Suspended solids[a]	30	50	182	304	1	99
007							
(K-901-A holding pond)	Chromium, total		0.05		0.68	2	96
	Fluoride	1.0	1.5	4.2	6.3		100
	Oil and grease	10	15	42	63		100
	pH, standard units		6.0–10				100
	Suspended solids[a]	30	50	125	210	8	93
	Dissolved oxygen	5[b]				18	95
	Visible solids		*c*				*d*

Table 4.6 (continued)

Discharge point	Effluent parameters	Effluent limits				Number of noncompliances	Percent compliance
		Daily av (mg/L)	Daily max (mg/L)	Daily av (kg/d)	Daily max (kg/d)		
009							
(K-1515-C sanitary water plant)	Suspended solids[a]	30	50	34	51	1	98
	Aluminum	5.0	10	5.7	11	1	98
	Sulfate		1400		1600		100
	pH, standard units		6.0–9.0				
Storm drain	Unpermitted Discharge		*c*			7	*d*
011							
(K1407-J)[f,g]	Cadmium	0.26	0.69				100
	Chromium	1.71	2.77				100
	Copper	2.07	3.38				100
	Lead	0.43	0.69				100
	Silver	0.24	0.43				100
	Zinc	1.48	2.61				100
	Cyanide	0.65	1.20				100
	TTO		2.13				100
	Oil and grease	26	52				100
	Nickel	2.38	3.98				100
	TSS	31	60				100
	PCB, μg/L		0.014			1	98
	pH, standard units		6.0–9.0				100
010							
(K-1407-E and K-1407-F)	Temperature		30.5				100
	TSS		50				100
	Oil and grease	15	20				100
	Chromium	0.2	0.2				100
	Copper	1.0	1.0				100
	Iron	1.0	1.0			4	74
	Zinc	1.0	1.0				100
	PCB (μg/L)		0.014			1	93
	pH, standard units		6.0–9.0				

[a]Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface runoff resulting from precipitation.

[b]Daily minimum.

[c]No discharge.

[d]Not applicable.

[e]Because of the small flow rates at the K-710-A sanitary treatment facility (discharge point W27), a rapid sand filter was installed May 1, 1978, eliminating the surface discharge and the need for monitoring.

[f]During the characterization of this effluent point more data are obtained and reported but are not subject to limits at this time.

[g]Permit limits for Discharge Point 011 are monthly averages.

The K-25 Site operates one sanitary sewage system—an extended aeration treatment plant with a rated capacity of 2.3 million L/d (0.6 Mgd) and a current use of approximately 1.1 million L/d (0.3 Mgd). Treated effluent from the main plant is discharged into Poplar Creek.

Because of their remoteness and low volume of use, outlying facilities such as the power house area, rifle range, and water treatment plant use septic tanks with drain fields. The power house area has a packaged treatment plant with a rated capacity of 76,000 L/d (19,760 gal/d); however, this facility has

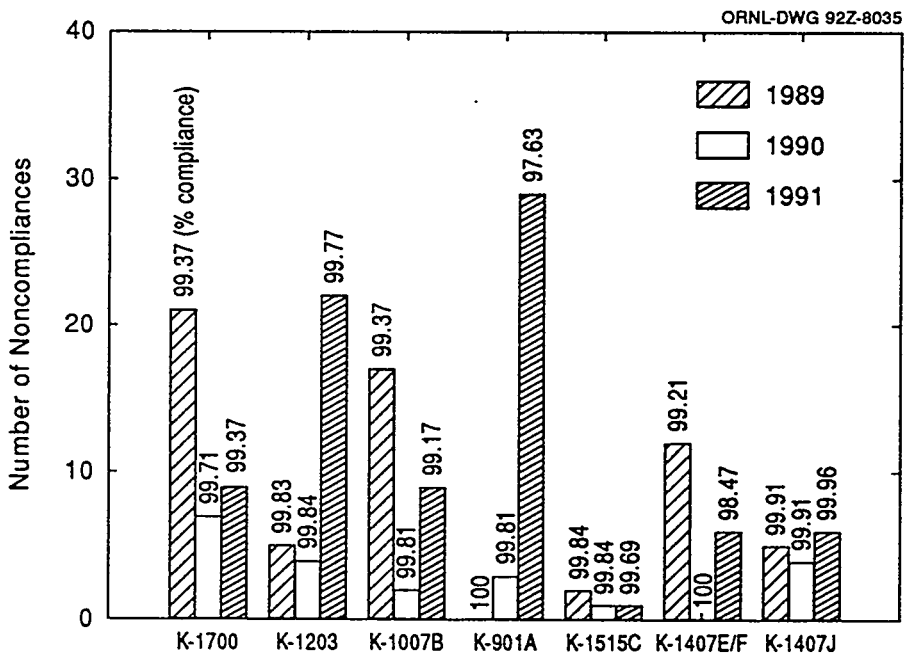


Fig. 4.14. K-25 Site NPDES noncompliance status comparison and sources of noncompliances.

been shut down and is not being monitored. It is included in the NPDES permit as an inactive outfall but will be deleted from the renewed permit.

Surface runoff within the K-25 Site is drained by Mitchell Branch and Poplar Creek, which flow into the Clinch River.

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 two of the active five cooling towers regularly discharge blowdown to the storm drain system. These discharges will be monitored at the appropriate storm drains when the renewed NPDES permit is issued.

As required by the 1986 NPDES permit modification, the K-1407-B Pond was removed from service in November 1988, and the permitted NPDES point was split to accommodate the two effluent streams from the Central Neutralization Facility (CNF). One stream contains small quantities of uranium contamination from the uranium recovery facility, metals from the metal cleaning facility, and effluents from the TSCA Incinerator; the other contains only coal pile and steam plant effluents. These wastestreams receive treatment at the CNF before discharge. In November 1988, the coal pile effluents and steam plants began discharging through K-1407-E and K-1407-F ponds. These ponds are considered as one NPDES discharge location in the current permit because they contain similar treated effluents and discharge alternately (Fig. 4.13). In September 1989, the K-1407-J discharge was redirected from Mitchell Branch to Poplar Creek to eliminate any impact to the Mitchell Branch aquatic community.

In March 1991, following verbal approval from TDEC, discharge from the K-1407-E and -F ponds was ceased as a routine operation. Instead, the coal pile and steam plant wastewaters were routed through the CNF for additional treatment and discharged through the K-1407-J settling basins to Poplar Creek. This treatment and discharge scenario was implemented because of the inability to effectively remove the iron in the wastewater with treatment and discharge through K-1407-E and -F ponds and to reduce the impact to Mitchell Branch resulting from the discharge of the effluent from these ponds. Monitoring of the K-1407-J settling basin effluent was increased to include parameters characteristic of

the coal pile and steam plant wastewaters and this supplemental data was reported on the monthly DMR's.

It is believed that noncompliances for aluminum at K-1700, chemical oxygen demand (COD) and dissolved oxygen at K-1007-B, as well as noncompliances for suspended solids and dissolved oxygen at K-901-A, are all caused by natural phenomena. As evidenced by the draft of the NPDES permit, which is currently in the process of renewal, these outfalls will be reclassified as ambient monitoring stations with no numerical limitations.

The remaining noncompliances were process-related conditions or administrative problems and were addressed individually. When noncompliances of this type occurred, procedures and field activities were reviewed, projects were initiated, and changes were made to help eliminate future occurrences.

Three noncompliances for iron and one for PCBs occurred at K-1407-E and -F ponds. The majority of the coal pile, the runoff from which comprises most of the treated effluent discharged to the pond, was removed during 1991. When the coal pile area is reclaimed removed, discharge from the ponds will cease and closure of the ponds will be initiated.

Four unpermitted discharges to storm drains occurred because of spills, pipeline breaks, and inappropriate storm drain connections.

All NPDES noncompliances were reported under the Occurrence Reporting System (ORS). Corrective actions to prevent reoccurrence were documented and tracked under the ORS.

In accordance with Part IV of the 1986 NPDES permit modification issued to the K-25 Site, the plant was required to develop and implement a TCMP. Under the TCMP, wastewater from the K-1407-E and K-1407-F ponds and K-1407-J basins were evaluated for toxicity every 2 months.

The results of the toxicity tests of wastewaters from K-1407-E/F and K-1407-J are given in Table 4.90 of Vol. 2. This table provides, for each wastewater, the month the test was conducted and the wastewater's NOEC for fathead minnows and *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 4.91 of Vol. 2.

Wastewater from the K-1407-E/F ponds was tested one time during the year. The NOEC for the fathead minnows was 100%, and the NOEC for the *Ceriodaphnia* was 50%. Because the IWC of this wastewater may be 100% during dry periods, the results of the toxicity tests show that the wastewater may adversely affect the aquatic biota in Mitchell Branch.

Because of the toxicity of the effluents of the K-1407-E/F ponds and also because of the inability of the CNF to consistently treat the effluents to ensure the maximum permitted level of 1.0 mg/L iron was not exceeded, an alternative treatment and discharge method was initiated in March 1991. This alternative treatment method involved rerouting the coal pile runoff and stream plant wastewaters that would normally be treated and discharged through the K-1407-E/F ponds to the other treatment units of CNF for additional treatment and discharge through the K-1407-J settling basins to Poplar Creek. Verbal approval was received and written approval requested from TDEC for this alternative discharge method in February 1991 before it was initiated.

Wastewater from the K-1407-J Basin was tested six times during the year. The NOEC for the fathead minnows was always 100%, and it was never less than 50% for *Ceriodaphnia*. Beginning in September 1989, this wastewater was discharged to Poplar Creek where it has an IWC of approximately 1%. Therefore, it is unlikely that this wastewater will adversely affect the aquatic biota in Poplar Creek.

Beginning with the toxicity tests conducted in April 1991 and continuing for all tests for the remainder of the year, the effluent from the K-1407-J basins included treated coal pile runoff and steam plant wastewater that had previously been discharged through the K-1407-E and -F ponds.

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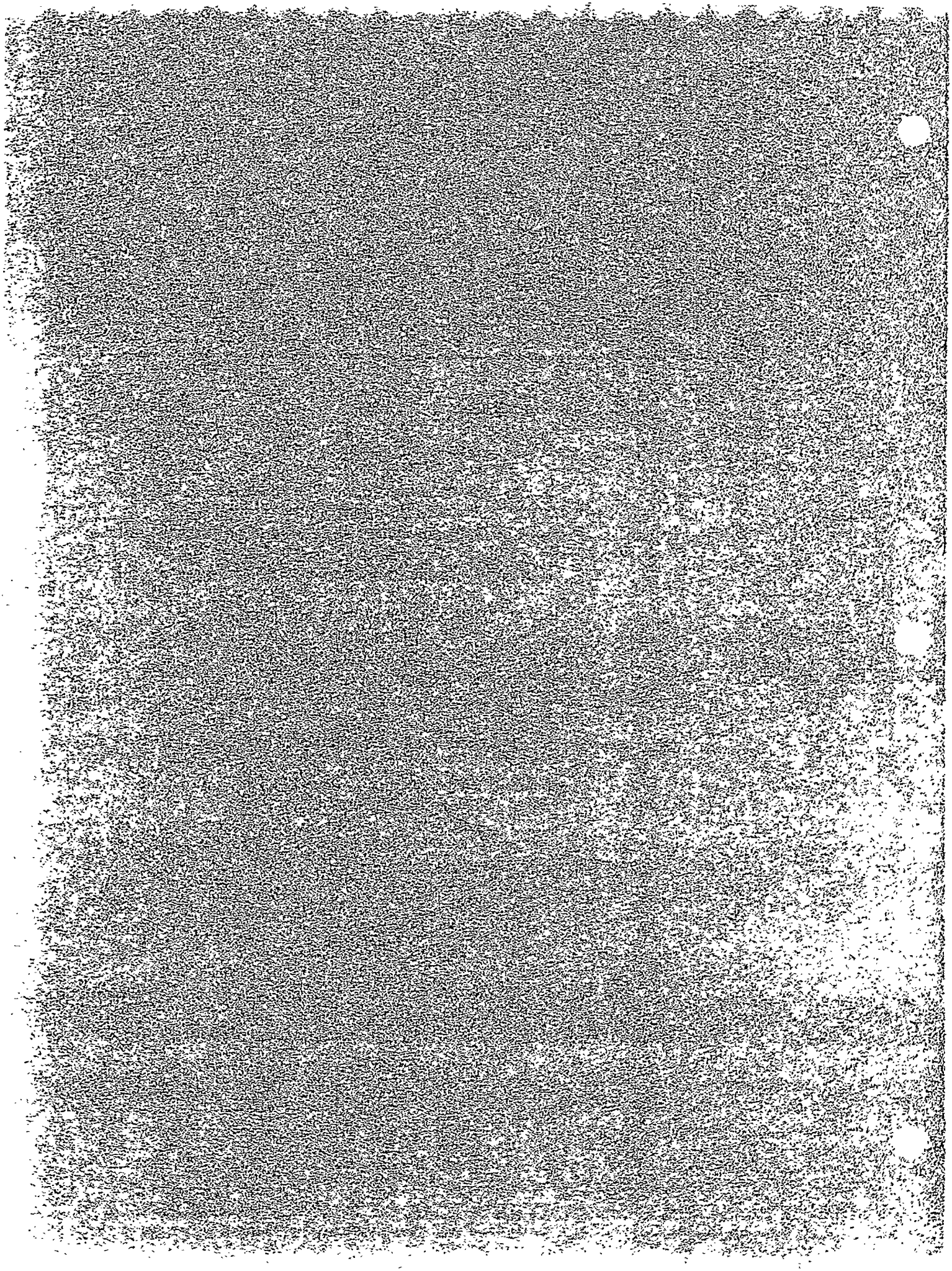

5. GROUNDWATER

The quality of the nation's groundwater resources is seen as a serious and pressing issue, and public awareness of the need to protect these resources has increased dramatically in the last decade. Public sentiment is reflected in legislation enacted by Congress mandating that actions be taken to protect water resources from contamination. These statutes have been codified into regulations by the EPA and equivalent programs on the state level. Two such programs promulgated by Congress and administered by the state of Tennessee and the EPA are RCRA and CERCLA. Specifically targeting the protection of groundwater from contamination by hazardous wastes, these regulations guide groundwater monitoring at the DOE plants in Oak Ridge.

Groundwater suitable for most uses is potentially available nearly everywhere in Tennessee. Although in the Oak Ridge area the majority of the population does not rely on groundwater for potable supplies (approximately 94% of households in the surrounding five county area utilize public water sources), groundwater does provide for domestic, irrigation, and industrial uses. Consequently, groundwater must be viewed as both a potential pathway for exposure to hazardous wastes, and as a mechanism for contaminant transport. Monitoring programs established on the ORR are intended to comply with established regulatory requirements and to provide for an assessment of groundwater contamination and transport on and off the ORR.

The following sections provide an overview of groundwater hydrology on the ORR, a summary of regulatory requirements for groundwater monitoring, a description of the groundwater monitoring systems established for the ORR, and a discussion of groundwater monitoring results for 1991.

5.1 GROUNDWATER HYDROLOGY

The following discussion provides an overview of current understanding of groundwater occurrence and flow on the ORR in order to provide a rationale for the reservation's groundwater monitoring programs. This discussion is global in nature and is based upon the recently developed conceptual model for the ORR (Solomon et al. 1992).

5.1.1 Hydrogeologic Framework of the ORR

Groundwater on the ORR occurs both in the unsaturated zone as transient, shallow subsurface stormflow and as an underlying unconfined water table aquifer. The stormflow zone and water table aquifer are separated by an unsaturated, or vadose, zone of variable thickness. The water table aquifer is typically first encountered in either the regolith or competent bedrock at shallow depths near surface water features and deeper in higher topographic positions, and due to an absence of confining layers, 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 are defined 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. These flow zones are shown in Fig. 5.1. The divisions within the saturated zone are vertically gradational and are not separated by distinct boundaries, but reflect an overall decrease in flux (rate of flow) with depth. The greatest flux is associated with the stormflow zone and the smallest with the aquiclude.

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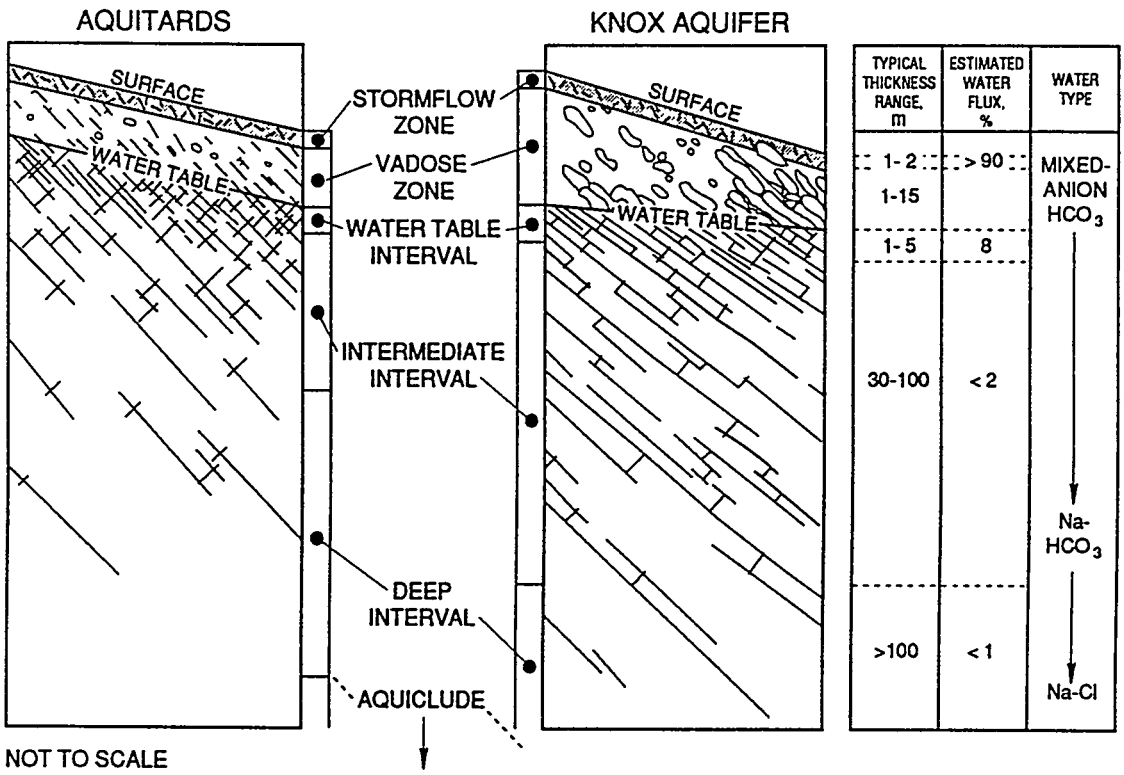

Fig. 5.1. Schematic vertical relationships of flow zones of the ORR, estimated thicknesses, water flux, and water types.

Because of the inherent differences between bedrock types (and therefore saprolites and soils developed through in-place weathering of bedrock), two broad hydrologic units are identified on the ORR based on stratigraphy: aquitards and the Knox aquifer. Figure 5.2 is a generalized map showing surface distribution of the Knox aquifer and the ORR aquitards. While there are some similarities in geologic and hydrologic characteristics, many fundamental differences exist. Most waste areas on the ORR are located in areas underlain by the aquitards.

The Knox Group and the Maynardville Limestone of the Conasauga Group, composed mostly of massive carbonate rocks, constitute the Knox aquifer. Flow in this aquifer is dominated by a combination of fractures and solution conduits that control flow over substantial areas and through which relatively large quantities of water may move relatively long distances. Active groundwater flow occurs at greater depth in the Knox aquifer and flow paths are significantly longer than in the aquitards. The Knox aquifer is the primary source of base flow in streams; all large springs on the ORR discharge from the Knox aquifer. Yields of some wells penetrating larger solution conduits 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, mainly siltstone, shale, sandstone, and thinly bedded limestone of low to very low permeability in which flow is dominated by fractures. The Chickamauga Group consists predominantly of limestones that, although displaying some solution features, generally have properties similar to the aquitard formations as opposed to the Knox aquifer formations. The typical yield of a well in the aquitards is less than 2 gal/min and base flow of streams draining areas underlain by the aquitards is poorly sustained.

Unsaturated Zone Hydrology

A vadose zone exists throughout the ORR except where the water table is at land surface (such as along perennial stream channels). The thickness of the vadose zone is greatest beneath ridges, and thins

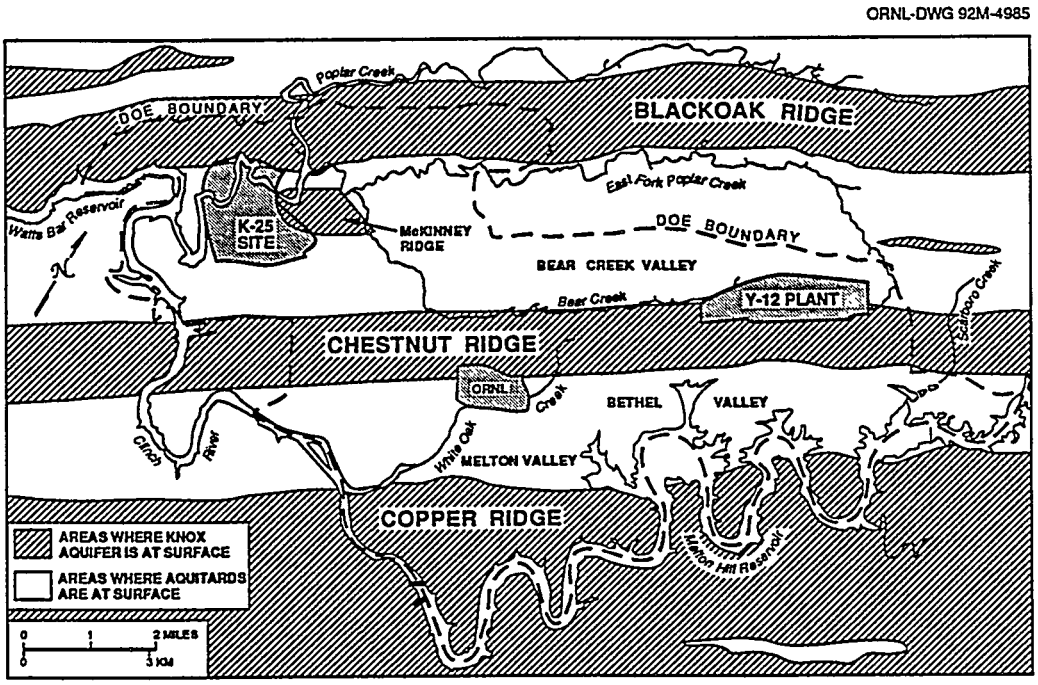

Fig. 5.2. Surface distribution of aquitards and the Knox aquifer on the ORR.

towards valley floors. Beneath ridges underlain by the Knox aquifer (Copper Ridge, Chestnut Ridge, McKinney Ridge, and Blackoak Ridge), the vadose zone commonly is greater than 30 m (100 ft) thick, whereas beneath ridges underlain by the Rome Formation (Haw Ridge and Pine Ridge) the vadose zone is typically less than 15 m (50 ft) thick. The vadose zone consists of regolith characterized by clay and silt derived from the weathering of bedrock materials and which has significant water storage capacity. Most recharge through the vadose zone is episodic and occurs along discrete permeable features (such as relict bedrock fractures) that may become saturated during rain events, even though surrounding micropores remain unsaturated and contain trapped air. During recharge events, flow paths in the vadose zone are complex, controlled by the orientation of structures of the materials, such as relict fractures. Between recharge events, flow rates decrease dramatically, and water movement is predominantly vertical, driven by gravity toward the water table. Typically by design, wastes generated on the ORR are placed within the vadose zone.

Groundwater occurs in the vadose zone as localized, transient, perched water lenses of limited extent (particularly in the vadose zone overlying the Knox aquifer) and 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, during rainfall events the stormflow zone partially or completely saturates and then transmits water laterally, following very short flowpaths to adjacent surface drainageways. When the stormflow zone becomes completely saturated, overland flow occurs. Between rainfall events, as the stormflow zone drains, flow rates decrease dramatically and water movement becomes nearly vertical toward the underlying water table along the length of the stormflow zone.

The transmissive capability of the stormflow zone is attributed to large pores (root channels, worm bores, relict fractures) that comprise only 0.2% of the total void volume of the stormflow zone. Because most of the water mass resides within less transmissive small pores, movement of solutes from large pores into small pores substantially reduces contaminant migration rates relative to fluid

velocities in the large pores. Stormflow is primarily a transport mechanism in undisturbed or vegetated areas where it intersects shallow waste sources. However, while most buried wastes are well below the stormflow zone, a commonly observed condition known as bathtubbing can occur in some trenches, in which the excavation fills with water and may overflow into the stormflow zone. In any event, all stormflow ultimately discharges to surface water features on the ORR and the stormflow zone does not involve long distance transport of contaminants.

Saturated Zone

As shown in Fig. 5.1, the saturated zone on the ORR can be divided into four vertical 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 1.5-m-thick layer of closely spaced, well-connected fractures near the water table (the water table interval) as shown on Fig. 5.3.

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/mile^2. 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/mile^2.

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/d; however, the center of mass of a contaminant plume typically migrates at a rate less than 0.2 ft/d.

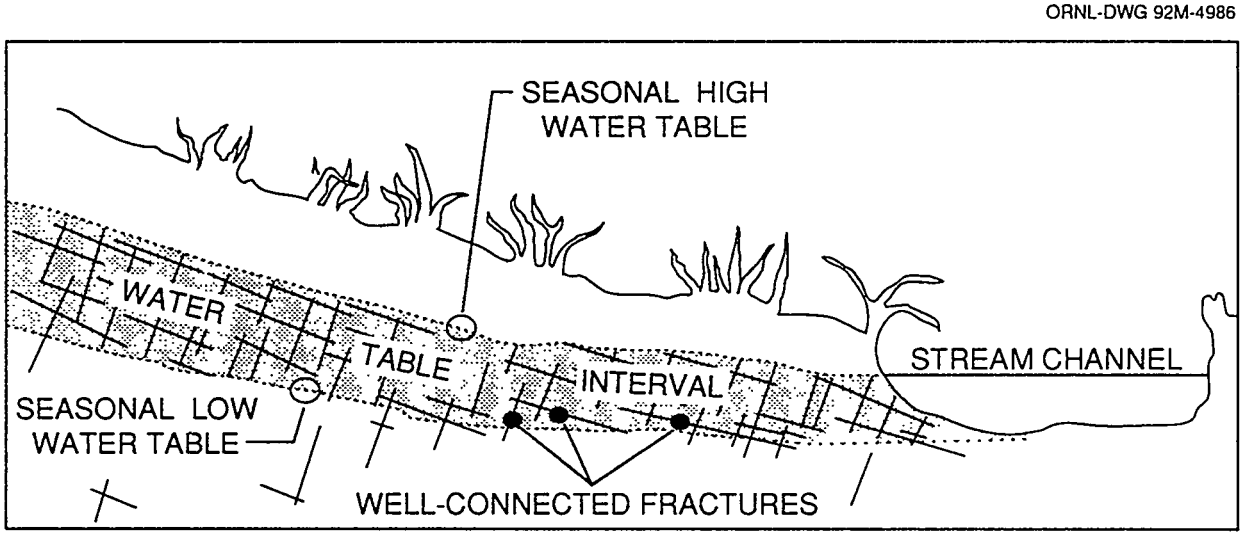

Fig. 5.3. Water table interval schematic.

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 three dimensions. In the Knox aquifer a few hydrologically dominant 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 to a Na-HCO_3 water type. 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, but data are not sufficient to allow generalizations. Although the geochemical mechanism responsible for this change in water types is not entirely quantified, it most likely is related to water residence time.

In the deep interval of the aquitards, small quantities of water are transmitted through discrete fractures.

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 have no potential for water supply. The specific storage of the bedrock aquitard is small, and as a result some hydraulic heads in the deep interval respond to precipitation events, even though the associated water flux is small. Although transfer of solutes between fractures and micropores of the matrix blocks is an important process in the deep interval, the total matrix porosity is less than that of any of the overlying zones, thereby reducing the retarding effect on contaminant migration rates relative to more shallow zones.

In the aquitards, saline water characterized by total dissolved solids (TDS) ranging up to 275,000 mg/L and chlorides generally in excess of 50,000 mg/L (ranging up to 163,000 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, and it is believed to approach 305 m (1000 ft) in portions of Bear Creek Valley 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.

5.1.2 Groundwater Flow

Many factors influence groundwater flow on the ORR. Topography, surface cover, geologic structure, and lithology 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. 5.1. As an example, the overall decrease in open fracture density with depth results in a decreased groundwater flux with depth. Bedding-plane and strike-parallel fracture orientations give rise to preferential groundwater movement along strike, toward cross-cutting tributary drainageways.

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 modelling (Zehner and Tucci, in press) suggests 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 the bulk of 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. However, 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.

Migration rates of contaminants transported in groundwater are strongly influenced by natural chemical and physical processes in the subsurface (including diffusion, adsorption, etc.). 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 that store contaminants in the subsurface are likely to be less effective in the Knox aquifer than in the aquitards due to flow along solution features.

In the deep interval of the aquitards, small quantities of water are transmitted through discrete fractures.

5.1.3 Groundwater Monitoring Considerations

Because of the complexity of the hydrogeologic framework on the ORR, groundwater flow and therefore contaminant transport is largely unpredictable on a local scale. Consequently, plume delineation in the classical sense using monitoring wells (such as between two given wells) is not feasible on the ORR on a local scale. Bulk solute transport via groundwater within the ORR can best be assessed over time by monitoring surface water quality because stormflow and the majority of groundwater discharge to surface water drainages on the ORR. 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.

5.2 REGULATORY REQUIREMENTS

5.2.1 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 postclosure 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 postclosure 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. 5.4. 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.

5.2.2 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 solid waste management unit 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

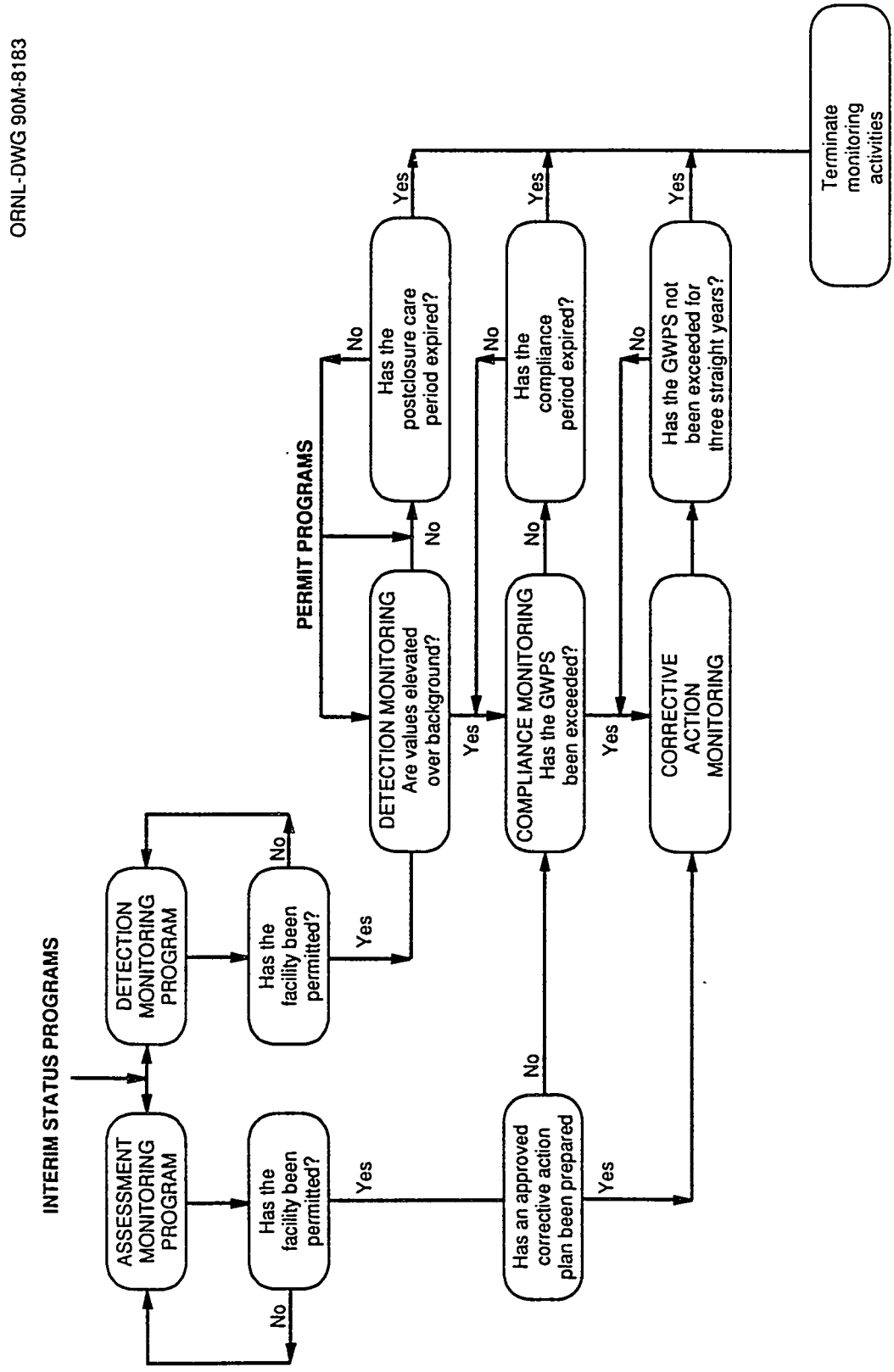

Fig. 5.4. Relationship between interim status monitoring and permit monitoring programs.

unit are summarized for the Y-12 Plant, ORNL, and the K-25 Site in later sections of this report.

5.2.3 Groundwater Surveillance Monitoring Program on the ORR

The technical objectives of groundwater monitoring under either the detection or assessment monitoring programs are similar in nature:

- collect piezometric head (water level) measurements to support estimates of the rate and direction of groundwater flow;
- obtain representative water samples from the geologic strata;
- determine the reference water chemistry of each hydrogeologic unit from analysis of samples collected upgradient of waste disposal areas;
- evaluate the current impact of waste disposal activities on the groundwater through a comparison of analyses from samples collected upgradient and downgradient of the disposal area or through changes in values at a given location over time;
- identify the hazardous waste or hazardous waste constituent(s) present should contamination be detected; and
- delineate the extent of contamination and the rate of migration.

The groundwater surveillance monitoring program being implemented at the DOE facilities has 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 distribute analytical results.

Thus, the groundwater surveillance monitoring program for the ORR, while disposal site- and facility-specific, contains a number of common components (Fig. 5.5) that are interrelated and coordinated to allow both time- and cost-effective project management.

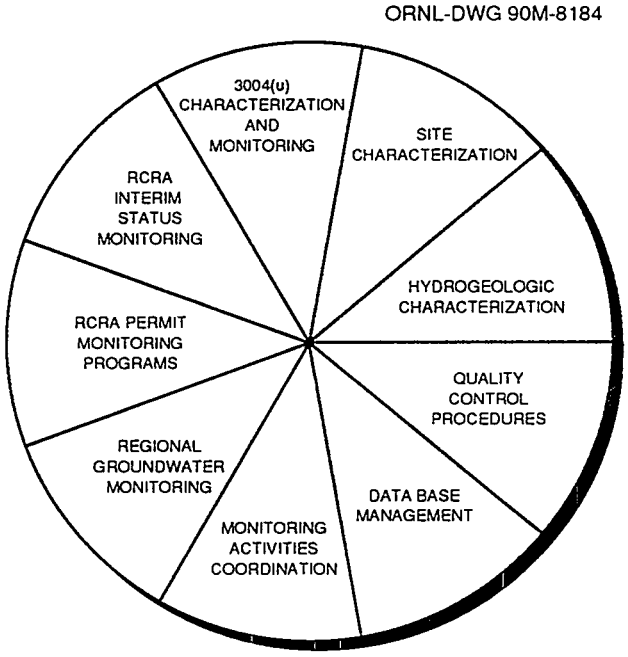

Fig. 5.5. Components of Oak Ridge Reservation groundwater surveillance program.

5.3 GROUNDWATER MONITORING WELL SYSTEMS

The ORR has more than 1000 groundwater monitoring wells. Because of the enormous volume of data taken annually from these wells, only the results for detected analytes and results that do not meet applicable standards are shown in this report. Tables 5.1–5.11 in Vol. 2 outline the applicable standards. Tables 5.12–5.31 in Vol. 2 provide data summaries for the various groundwater sampling programs.

5.3.1 Y-12 Plant

5.3.1.1 Background

The Y-12 Plant poses unique and challenging problems to the development and implementation of a comprehensive monitoring program. Historically, data have been collected to meet several objectives: monitoring to meet permit requirements; characterization at or surrounding particular waste sites; detection and assessment monitoring to meet RCRA regulatory requirements; and, finally, monitoring to determine the overall water quality and flow patterns in the area. With the negotiation of a Federal Facility Agreement (FFA) and the placing of the ORR on the National Priorities List (NPL), CERCLA has been identified as the lead regulatory requirement and RCRA as an applicable or relevant and appropriate requirement (ARAR). As part of the transition to the CERCLA regulatory environment, 1991 annual groundwater monitoring reports formerly required under RCRA have been provided on an information only basis and no longer as a RCRA requirement.

Data collected to date suggest the intermingling of contaminant releases from multiple, unrelated waste sites that are regulated by overlapping regulatory programs. To address the various objectives for the collection of data and to ensure a technical consistency to the data collection and evaluation process, the Y-12 Plant Comprehensive Groundwater Monitoring Plan has been developed and is being implemented. The basis for the development of this plan is the hydrogeologic systems that control the rate of transport of contaminants. In this plan, the Y-12 Plant has been subdivided into three distinct hydrogeologic regimes based on topography, surface water drainage, and groundwater flow patterns.

The Y-12 Plant is located in Bear Creek Valley (BCV), which is flanked on the north by Pine Ridge and on the south by Chestnut Ridge (directions in this report are in reference to the Y-12 Plant grid systems). To assess groundwater quality at the Y-12 Plant, BCV has been divided into the Bear Creek Hydrogeologic Regime (BCHR) and the Upper East Fork Poplar Creek Hydrogeologic Regime (UEFPCHR). A topographic and hydrogeologic divide located near the west end of the Y-12 Plant separates the two hydrogeologic regimes. The Chestnut Ridge Hydrogeologic Regime (CRHR) is designated as the third hydrogeologic regime.

Since 1987 the Y-12 Plant has issued Groundwater Quality Assessment reports (GWQARs) to TDEC as required for RCRA interim status units on assessment and detection monitoring. These reports have been used as a forum to present data, data interpretations, and monitoring program modifications. Beginning in 1989, the format for issuing these reports was modified such that a GWQAR was issued for each hydrogeologic regime. Moreover, the 1989 GWQARs were completed in two parts for BCHR and UEFPCHR. Part I contained all the assessment data obtained in the previous calendar year, along with a calculated rate of migration, and was submitted to TDEC by the March 1 reporting deadline. The evaluation and interpretation of the assessment data were included in Part II of the GWQAR, which was submitted to TDEC in June 1990. This two-part reporting convention has been continued for the 1990 and 1991 assessment data. The GWQAR for CRHR has been historically issued as a single document and has addressed groundwater contamination at the Chestnut Ridge Security Pits, the only confirmed source of groundwater contamination in the CRHR. However, in 1991 the two-part reporting convention used for the BCHR and UEFPCHR was extended to the CRHR. The 1991 CRHR GWQAR addresses groundwater quality data from multiple waste disposal sites within the regime. With the transition to the CERCLA regulatory environment, these reports for 1991 were issued for information only, not as a regulatory requirement.

5.3.1.2 Program modifications implemented in 1991

Components of the comprehensive groundwater monitoring program at the Y-12 Plant for 1991 are summarized in Table 5.1. Analytical analyses completed in 1991, which represent a 16% increase in the number of individual analyses reported over the same reporting period for 1990, are summarized in Table 5.2.

In addition to the previously discussed reporting changes, other modifications to the assessment monitoring program were proposed in Part II of the 1990 GWQAR for implementation in 1991. These modifications included the following:

- exit pathway monitoring;
- performing a soil gas survey at Chestnut Ridge Security Pits (CRSP);
- installing additional monitoring wells at the plant's perimeter;
- including selected surface water sampling locations in the assessment program; and
- initiating a dye-tracer study at CRSP.

Groundwater samples collected during the 1991 assessment monitoring program were analyzed for the parameters and constituents shown in Table 5.1. This list was prepared from 1986 base program monitoring data and assessment data collected in 1987–1990. It reflects efforts to focus the assessment program on actual groundwater contaminants (i.e., those constituents detected at concentrations above background levels or in excess of applicable water quality standards), as well as to establish a standardized suite of analytical parameters for all samples collected at the Y-12 Plant. Additional uranium isotopic data and radiochemical measurements were taken at selected sites to further define background water quality and to confirm previous results. A standard suite of trace metals were routinely analyzed by inductively coupled plasma (ICP). The analysis of some metals including arsenic, selenium, and lead are subject to interferences when analyzed by ICP. The interferences are usually caused by high iron and aluminum concentrations that are ubiquitous in soil and rock and are naturally present in most groundwaters. Therefore, ICP data are not considered conclusive for these elements unless confirmed by a second analysis, atomic absorption (AA). The AA analysis is often necessary to meet detection limits for regulatory standards. Historical AA data indicate that lead is present in some Y-12 Plant groundwaters. Thus, lead continues to be analyzed by AA. On the other hand, arsenic and selenium continued to be monitored via ICP for program consistency, although evaluation of previous years' AA data has not confirmed these elements to be present in concentrations above background levels.

To minimize the potential for cross contamination between wells, samples were collected in the predetermined sequence that reflects a protocol of sampling from background wells to the most contaminated wells for a sampling event at a given site. Several new monitoring wells have been installed in the BCHR and UEFPCHR to help delineate contaminant plume boundaries and to establish an exit-pathway monitoring well network. Exit-pathway monitoring wells were completed at various depths in the Maynardville Limestone, which is believed to be the principal conduit for contaminant migration in the BCHR. The screened interval of these wells was set to intersect specific stratigraphic zones thought to be more susceptible to solution cavity development. The down-dip extensions of those zones were specifically targeted as they would be the most likely pathways for transport in deeper portions of the Maynardville Limestone.

The quarterly collection of surface water samples from Bear Creek was also included in the 1991 assessment program. Surface water samples were analyzed for the standard list of parameters. Background surface water samples were collected from one site (NT-13), located in a tributary to Bear Creek, that has not been impacted by waste management activities in the Bear Creek Valley Waste Disposal Area (BCVWDA). Four downstream sampling locations were also included: Bear Creek kilometer (BCK) 0.63, BCK 4.55, BCK 9.4, and BCK 11.97. The rationale for the selection of these sampling locations is provided in Table 5.3.

5.3.1.3 Waste site descriptions

Background information regarding the waste sites located within each hydrogeologic regime is provided in the following subsections. A description

Table 5.1. Summary of the groundwater surveillance program at the Y-12 Plant, 1991

Unit name	Regulatory status[a]	Interim status		Permit			Parameters monitored[b]	Monitoring wells/ sampling stations	Sampling frequency
		Detection monitoring	Assessment monitoring	Detection	Operating	3004(u)			
Bear Creek Hydrogeologic Regime									
Bear Creek springs							Standard+U	5	Quarterly
Bear Creek surface water							Standard+U	5	Quarterly
Exit pathway - Traverse A							Standard	3	Quarterly
Exit pathway - Traverse B							Standard	6	Quarterly
Exit pathway - Traverse W							Standard	3	Quarterly
Lysimeter demonstration site							Standard	8	Quarterly
Oil landfarm	RCRA	1985	1986	*c*		*c*	Standard+^{3}H+ ^{99}Tc+Sr+U+^{237}Np+^{241}Am	31	Quarterly
Rust spoil area	3004(u)	*c*		*c*		1987	Standard+^{129}I+^{3}H+ ^{99}Tc+Sr+^{137}Cs	8	Quarterly
S-3 ponds site	RCRA	1985	1986	*c*		*c*	Standard+^{129}I+^{3}H+ ^{99}Tc+Sr+U+^{237}Np+ ^{238}Pu+^{239}Pu+^{241}Am	16	Quarterly
Spoil Area I	3004(u)	*c*		*c*		1987	Standard+^{3}H+U	6	Quarterly
U.S. Geological Survey Sites							Standard	3	Quarterly
Y-12 Plant burial grounds	RCRA	1985	1986	*c*		*c*	Standard+^{3}H+PHE+ ^{99}Tc+Sr+U+^{237}Np+^{241}Am	58	Quarterly
Chestnut Ridge Hydrogeologic Regime									
Ash disposal basin	3004(u)	*c*		*c*			Standard+TOC+TOX	4	Quarterly
Security pit	RCRA	1985	1988	*c*		*c*	Standard+U	17	Quarterly
East Chestnut Ridge waste pile	RCRA	*c*			1988	*c*	Standard	4	Quarterly
Kerr Hollow Quarry	RCRA	1985		*c*		*c*	Standard+PHE+ TOC+TOX	7	Quarterly

Table 5.1 (continued)

Unit name	Regulatory status[a]	Interim status		Permit			Parameters monitored[b]	Monitoring wells/ sampling stations	Sampling frequency
		Detection monitoring	Assessment monitoring	Detection	Operating	3004(u)			
Chestnut Ridge Hydrogeologic Regime (continued)									
Sanitary Landfill II					1986		Standard+ Cy+COD+TOC+TOX	3	Quarterly
Sanitary Landfill II expansion							Standard+ Cy+COD+TOC+TOX	8	Quarterly
Industrial Landfill III	3004(u)	*c*		*c*		1988	Standard+ Cy+COD+TOC+TOX+U	7	Quarterly
Industrial Landfill IV	3004(u)	*c*		*c*		1988	Standard+ Cy+COD+TOC+TOX+U	5	Quarterly
Rogers Quarry[d]	3004(u)	*c*		*c*		1985	Standard+BNA	4	Quarterly
Sediment disposal basin	RCRA	1985		*c*		*c*	Standard+ BNA+PHE+ TOC+TOX+U	10	Quarterly
United nuclear site	3004(u)	*c*		*c*		1985	Standard+TOC+U	6	Quarterly
East Fork Poplar Creek Hydrogeologic Regime									
Beta-4 Security Pit[d]	3004(u)	*c*		*c*		1985	Standard+TPH+U	4	Quarterly
New Hope Pond	RCRA[e]	1985	1988	*c*		*c*	Standard+ ^{3}H+^{99}Tc+Sr+U	18	Quarterly
Rust Garage Area							Standard+TPH	2	Quarterly
S-2 site							Standard+^{99}Tc+U	4	Quarterly
S-3 ponds site	RCRA	1985	1986	*c*		*c*	Standard	4	Quarterly
Underground storage tank Program							Standard+ ^{3}H+^{99}Tc+Sr+TPH+U+ ^{237}Np+^{241}Am	19	Quarterly

Table 5.1 (continued)

Unit name	Regulatory status[a]	Interim status		Permit			Parameters monitored[b]	Monitoring wells/ sampling stations	Sampling frequency
		Detection monitoring	Assessment monitoring	Detection	Operating	3004(u)			
East Fork Poplar Creek Hydrogeologic Regime (continued)									
U.S. Geological Survey sites							Standard+U	9	Quarterly
Waste coolant facilities							Standard	8	Quarterly
Y-12 Salvage Yard[d]	3004(u)	*c*		*c*		1985	Standard+U	4	Quarterly

[a]The appropriate regulatory authority for groundwater monitoring at the Y-12 Plant (RCRA or CERCLA) is a matter of contention between DOE and TDEC. The lead regulatory authority for these sites is expected to transition to CERCLA, with RCRA as an ARAR.

[b]Standard: Standard Monitoring Program
Cadmium, chromium, and lead by Atomic Absorption Spectrometry
Volatile organics
Elemental analyses by Inductively Coupled Plasma
Mercury
Gross alpha and beta
Fluorometric uranium
Field measurements: conductivity, pH, redox, dissolved oxygen, and temperature
Inorganics and miscellaneous parameters: pH, conductivity, TSS, TDS, turbidity, alkalinities, chloride, nitrate-N, sulfate, fluoride.

Additional Parameters:

- ^{3}H: Tritium
- ^{99}Tc: Technetium-99
- ^{129}I: Iodine-129
- ^{137}Cs: Cesium-137
- ^{237}Np: Neptunium-237
- ^{238}Pu: Plutonium-238
- ^{239}Pu: Plutonium-239
- ^{241}Am: Americium-241
- U: Isotopic uranium (^{234}U, ^{235}U, ^{238}U)
- Sr: Strontium
- Cy: Cyanide
- BNA: Semivolatile organics
- COD: Chemical oxygen demand
- PHE: Phenols
- TOC: Total organic carbon
- TOX: Total organic halide
- TPH: Total petroleum hydrocarbons

[c]Not applicable.

[d] Wells installed for plant site characterization program; authority transferred to 3004(u) in 1986.

[e]Site is treated like a RCRA site.

Table 5.2. Summary of groundwater analyses at the Y-12 Plant during 1991

Analytical procedure	Parameter measured	Number of samples run	Number of items reported
Elemental analyses			
	ICAP	2,257	55,565
	AAS	2,258	6,774
	HG	2,248	2,248
	U	2,258	2,258
Inorganic analyses		1,129	10,158
	Phenols	57	57
	Cyanide	72	72
	Chemical oxygen demand	72	72
Organics			
	Volatile	1,128	38,351
	Acid/base-neutral	42	2,730
	TPH	88	88
Field measurements		1,131	6,595
Laboratory replicates			
	Conductivity and pH	1,135	2,705
	TOC and TOX	176	830
Radiochemical analyses			
	Gross alpha and beta	1,130	2,260
	Isotopic uranium	207	621
	Alpha emitters	16	31
	Beta emitters	75	157
Total		15,479	131,572

of each site and a short narrative regarding the history of assessment activities are presented.

Upper East Fork Poplar Creek Hydrogeologic Regime

The UEFPCHR encompasses the Y-12 Plant complex, extending west from New Hope Pond (NHP) to a topographic and hydrologic divide located near the west end of the plant and which separates the UEFPCHR from the BCHR (Fig. 5.6). Waste-management sites and petroleum fuel underground storage tanks (USTs) in the UEFPCHR that are addressed in this document are shown on Fig. 5.7.

New Hope Pond (NHP)

Constructed in 1963 at the east end of the Y-12 Plant (Fig. 5.7), NHP regulated the flow and quality of water in Upper East Fork Poplar Creek (UEFPC) before exiting the Y-12 Plant, and it provided a contingency for control of accidental spills of oils or other substances (PEER Consultants 1989). While in operation, discharge from the pond averaged approximately 8 Mgd. Water-quality sampling was performed in accordance with the conditions set forth in NPDES Permit No. TN002968. Operation of NHP ceased on November 8, 1988.

In 1973, sediment removed from NHP was placed in the Chestnut Ridge Sediment Disposal Basin (CRSDB). Through 1988, sediments from the inlet diversion ditch were periodically removed and disposed in the CRSDB. These sediments contained PCBs, mercury, and uranium, but Extraction Procedure Toxicity analyses indicated that they did not exhibit the characteristics of a hazardous waste (Saunders 1983; Kimbrough and McMahon 1988a and 1988b). Approximately 25,000 cubic yards of sediment remained in NHP when it was closed in 1988. Closure was completed in accordance with the standards defined for RCRA regulated landfills. Sediments in the pond were stabilized by the addition of coarse aggregate and the site was covered with a multilayer low-permeability cap (Energy Systems

1988a). Final closure of NHP was certified by TDEC on December 11, 1990.

Lake Reality was constructed immediately downstream of NHP (Fig. 5.7) and began operation on November 8, 1988. Water in UEFPC enters Lake Reality from an extension of the NHP inlet diversion ditch and exits through a weir in the west berm. The total surface area of Lake Reality is about 2.5 acres, and the average water depth is approximately 7 ft. During normal operations, Lake Reality contains approximately 6 million gal of water (Lee Wan & Associates 1989).

Beta-4 Security Pits

The Beta-4 Security Pits are near the northwestern boundary of the UEFPCHR (Fig. 5.7). The site was used from 1968 to 1972 for classified disposals of uranium and uranium alloys, scrap metal containing depleted and enriched uranium, organic compounds, acids, and miscellaneous debris (Welch et al. 1987).

Waste Coolant Processing Area

The Waste Coolant Processing Area is in the west-central portion of the Y-12 Plant (Fig. 5.7) and is an area used to treat waste coolants collected from various shops within the plant complex. The site originally consisted of the Waste Machine Coolant Biodegradation Facility (WMCBF), an unloading/storage area, and a treatment basin/effluent drain field (Murphy 1989). Operation of the WMCBF ceased in 1985 when it was replaced with a new treatment unit, the Waste Coolant Processing Facility (WCPF) (Murphy 1989). The original unloading/storage area was retained as part of the WCPF, but the WMCBF and the treatment basin/effluent drain field were closed in accordance with a RCRA closure plan (Stone and McMahon 1988); TDEC certified final closure of the WMCBF on November 23, 1988.

S-2 Site

The S-2 Site is in the southwestern portion of the UEFPCHR on the northern flank of Chestnut Ridge (Fig. 5.7). The site was an unlined earthen reservoir

Table 5.3. Description of surface-water monitoring stations included in the Exit-Pathway Monitoring Program

Monitoring station	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.
BCK 9.40	Represents surface-water discharge from area of Bear Creek watershed impacted by waste-disposal activities.
BCK 11.97	Represents surface-water discharge from area of S-3 Site, Rust Spoil Area, and Spoil Area I. Includes discharge from Tributary NT-1 and Spring SS-1, which probably receives groundwater inputs from S-3 Site contamination.

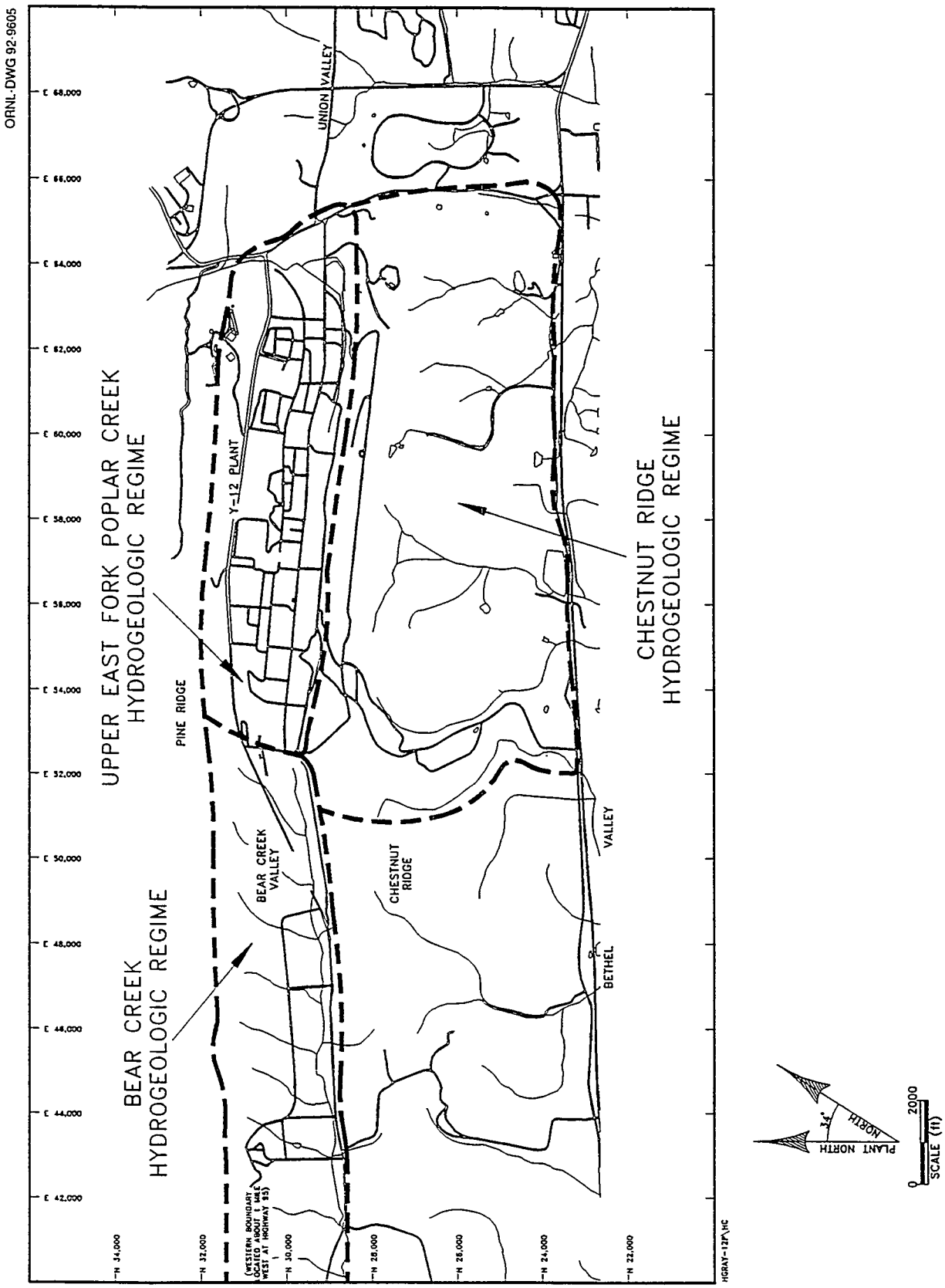

Fig. 5.6. Hydrogeologic regimes at the Y-12 Plant.

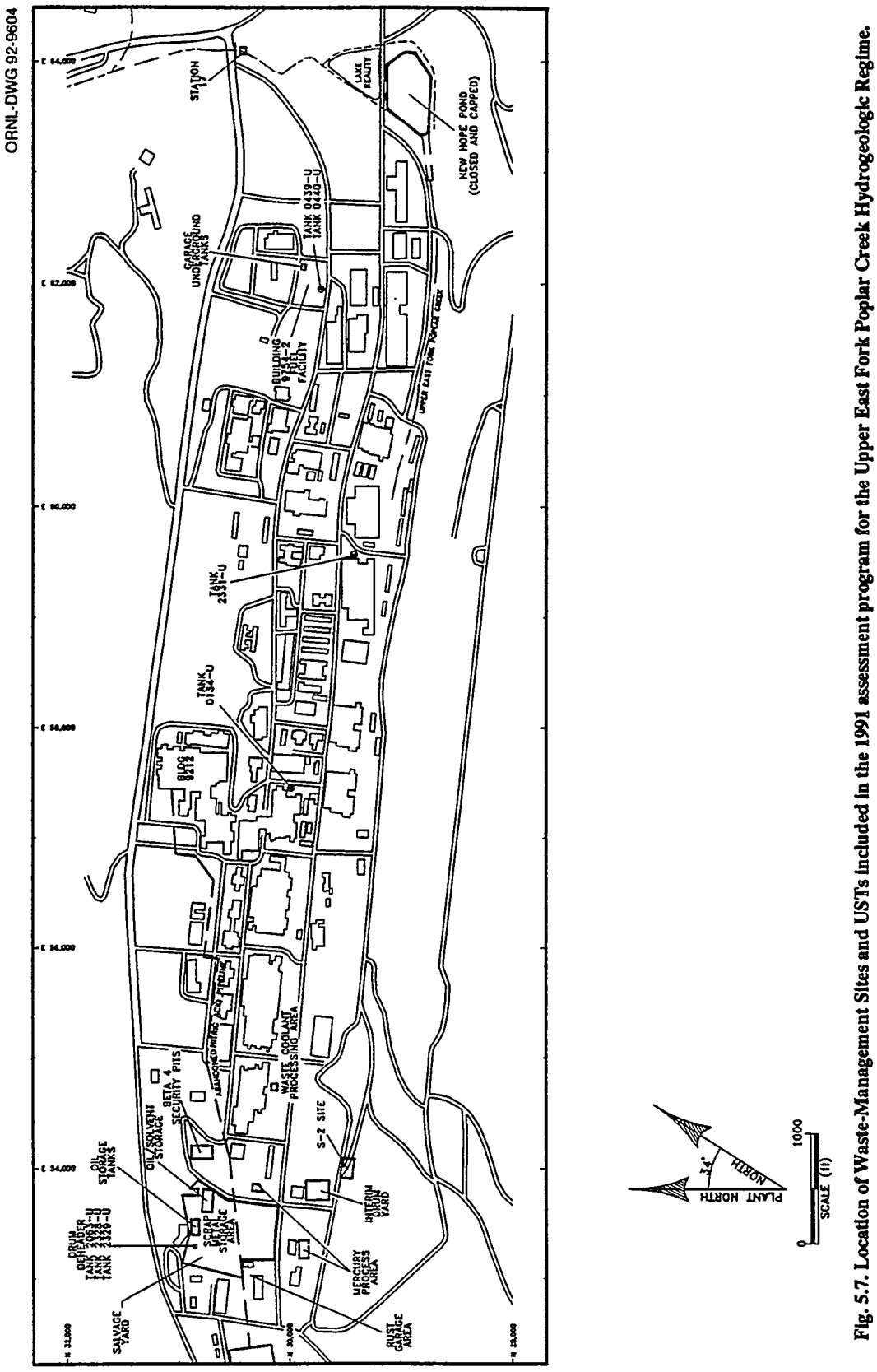

Fig. 5.7. Location of Waste-Management Sites and USTs included in the 1991 assessment program for the Upper East Fork Poplar Creek Hydrogeologic Regime.

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).

Y-12 Salvage Yard

The Y-12 Salvage Yard is in the northwestern portion of the UEFPCHR (Fig. 5.7). Waste-management sites in the Y-12 Salvage Yard include the Scrap Metal Storage Area, the Oil/Solvent Drum Storage Area, the Oil Storage tanks, the Drum Deheader, and three concrete sumps designated as Tanks 2063-U, 2328-U, and 2329-U (Fig. 5.7).

The Salvage Yard Scrap Metal Storage Area has been used from 1950 to the present for the 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).

Before being closed, 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). The combined total storage capacity of both areas was approximately 175,000 gal. 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. Although the downslope side of the site was diked, the gravel/soil base of the dike may have permitted infiltration of spilled material into the subsurface (Welch et al. 1987).

Operation of the Salvage Yard Oil Storage tanks began in 1978 when a 6000-gal tank was installed to store PCB-contaminated oil. 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).

The Salvage Yard Drum Deheader operated from 1959 to 1989 and was used to cut off the tops and to crush empty drums collected from various locations throughout the Y-12 Plant. The deheader is in a small shed with a concrete floor. Before deheading, the drum contents were emptied into other drums contained within a small sump (Tank 2063-U). Tank 2063-U was about 2 ft wide, 4 ft long, 2 ft deep, and had a total capacity of about 130 gal. Spills and overflows that occurred when the liquids were poured into the storage drums were contained in Tank 2063-U and transferred through a connecting drain pipe to other sumps designated as Tanks 2328-U and 2329-U. Liquids still present when the drums were deheaded flowed into a floor drain connected to Tanks 2328-U and 2329-U (Stone 1989a).

Located adjacent to each other, Tanks 2328-U and 2329-U were separated by a rubber baffle. Each tank was about 8 ft long, 4 ft wide, 4 ft deep, and had a total capacity of about 950 gal. The tops of the tanks were open at the ground surface. Consequently, rainwater and surface runoff would occasionally collect in the tanks. The baffle between the tanks helped to separate the oils and solvents from the rainwater and runoff. Once separated, the water was released through a drainpipe to the Y-12 Plant stormwater drainage system. The remaining oils and solvents were periodically pumped out, as necessary, and treated or disposed in the Bear Creek Burial Grounds Waste Management Area (Stone 1989a).

Leak tests were performed for Tanks 2063-U, 2328-U, and 2329-U in March 1989, and respective leak rates of 0.46, 0.14, and 0.14 gal/h were determined. All of these rates exceeded the maximum allowable leak rate established under the TDEC UST regulations, and the tanks were subsequently excavated. Soils near the tanks contained elevated concentrations of cadmium, lead, and mercury, and detectable levels of volatile organics and PCBs (Stone 1989a).

Interim Drum Yard

The Interim Drum Yard is located in the southwestern portion of the UEFPCHR (Fig. 5.7). The site is currently a graveled, covered, and diked outdoor storage area 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. The southern portion of the site has been closed in accordance with a TDEC-approved RCRA closure plan (Willoughby et al. 1988).

Abandoned Nitric Acid Pipeline (ANAP)

The Abandoned Nitric Acid Pipeline (ANAP) is located in the northwestern portion of the UEFPCHR within the Y-12 Plant compound (Fig. 5.7). Used between 1951 and 1983, the pipeline originally transported effluent derived from operations in Buildings 9212 and 9206 to the S-3 ponds. Subsequently, the pipeline was connected to the uranium recovery process lines from the H-1 Foundry (Building 9998). During its operation, an estimated 5500 gpd of effluent, which generally consisted of nitric acid with uranium in solution, was pumped through the pipeline to the S-3 ponds. A RCRA facility investigation plan prepared for the ANAP contains a detailed discussion of its operational history (Geraghty & Miller, Inc. 1989a).

Available construction drawings indicate that the ANAP was constructed of 1.5- to 3-in. diam No. 347 stainless-steel pipe. Some sections of the pipeline may have been constructed of 6-in. diam stainless steel. The pipeline was buried up to 14 ft below ground level, and sections that passed over water or sewer lines were encased in concrete. According to drawings generated during the construction of the Y-12 Plant Perimeter Intrusion Detection and Alarm System (PIDAS), sections of the pipeline may have been abandoned and rerouted during its operational period (Geraghty & Miller, Inc. 1989a).

Mercury Process Spill Areas

The Mercury Process Spill areas are near the west end of the Y-12 Plant (Fig. 5.7). These are areas where large quantities of elemental mercury were routinely handled during the extraction process for lithium isotopes at the Y-12 Plant between 1955 and 1962. The potential for spills or leaks of mercury existed at these sites, and an RFI plan for the sites was submitted to the EPA in December 1989 (Turner et al. 1989).

Coal Pile Trench

The Y-12 Plant disposed of uranium and nonuranium materials in 1965 and 1966 by burying them in the Coal Pile Trench located beneath the present coal pile at the steam plant. The Coal Pile Trench was constructed in the summer of 1965 and consists of a trench 161 ft long, 14.5 ft wide, and 15 ft deep. The trench received material from August 9, 1965, through September 1965 and from July 11, 1965, through September 29, 1966. Approximately 1,750,000 kg (1,930 tons) of depleted uranium and depleted uranium alloys are reported to have been buried over this time. Also, the trench contains at least 318 kg (0.35 tons) of carbon products, 147 kg (0.16 tons) of molybdenum, 576.9 kg (0.64 tons) of thorium, and 78,713 kg (87 tons) of other nonuranium materials.

Building 81-10

The Building 81-10 area is located south of the UEFPCHR and is adjacent to the PIDAS security system. The building was originally built as a tin shed, but in the late 1950s and early 1960s it housed a roasting furnace that was used for recovery of mercury from sludges, wastes, contaminated soils, and other scrap materials. During operation, an estimated 3000 lb of mercury was spilled on the building's concrete foundation, beneath it, and on the ground. Building 81-10 and its sumps were cleaned in 1971.

Underground Storage Tanks (USTs)

Several petroleum fuel USTs are located within the UEFPCHR. Investigations to assess product releases from these tanks are performed in accordance with the rules of TDEC Division of Underground Storage Tanks, Chapter 1200-1-15, *Underground Storage Tank Program*. Descriptions of the USTs are provided in the following sections.

9754-2 Fuel Facility. The Building 9754-2 Fuel Facility, located in the eastern portion of the UEFPCHR (Fig. 5.7), was used from 1978 to 1989 to dispense gasoline and diesel fuel. The site had two USTs: a 20,000 gal unleaded gasoline tank (Tank 0439-U) and a 10,000-gal diesel tank (Tank 0440-U). Both tanks were in an unlined gravel-filled pit about 12 ft deep. The top of the tank pit was open to precipitation, and water that entered the pit was

drained to a nearby collection basin through a 12-in. diam concrete pipe (Welch 1989).

In June 1989, free product was observed in the collection basin connected to the tank pit. A sump was subsequently excavated adjacent to the tank pit to facilitate free product recovery and removal of contaminated groundwater. Free product and contaminated water were regularly pumped from the sump for several weeks (Stone 1989b). A recovery well was then installed downgradient of the tank pit, but no free product was observed in the well (Stone 1989c).

Gasoline and diesel fuel spills and leaks at the site have been documented. Spills typically occurred when the tanks were overfilled. Gasoline leaks from the fill pipe for Tank 0439-U and the discharge line were confirmed during leak testing and subsequent tank excavation. During excavation of Tank 0440-U, it was noted that leaks from an associated discharge line had occurred (Welch 1989). Both tanks were excavated in September 1989. Two additional monitoring wells were installed in September 1990 as part of an ongoing UST site investigation (Eaton and Ingram 1991).

Garage Underground Tanks. The garage underground tanks were located about 100 ft north of the old Building 9754 Fuel Facility (Fig. 5.7), which went into service in 1944. The site originally contained a 10,000-gal diesel fuel tank and a 10,000 gal leaded gasoline tank. A 20,000-gal unleaded gasoline tank was installed at the site in 1975. The tanks gravity fed three 1,000-gal tanks at dispenser islands in front of former Building 9754. Individual diesel fuel and gasoline dispensers were installed west of Building 9754 for emergency purposes. Product releases from overfilling the gravity-feed system have occurred.

The three large USTs at the site were converted to waste oil storage in 1978. These tanks were subsequently removed in October 1989 and the tank site is currently undergoing RCRA closure. Also in 1978, the three 1,000-gal dispenser tanks were emptied and the emergency dispensers were removed. The dispenser tanks are being closed under UST regulations in conjunction with closure of the Building 9754-2 Fuel Facility (Stone 1989b).

Tank 2331-U. Tank 2331-U was a 560-gal steel tank used to store gasoline. The tank and its associated piping were installed in 1973 to serve gasoline-powered equipment in Building 9201-1 (Fig. 5.7). A leak test performed in September 1988 indicated that the tank was leaking. The tank was subsequently emptied and service was discontinued until its removal in December 1988. Soils near the tank pit reportedly contain detectable levels of toluene and xylenes (Welch 1989b). In August 1989 a monitoring well was installed downgradient of the tank pit to facilitate detection and recovery of free product. Although petroleum odors in the well were noted, no free product was observed (Stone 1989d). Three additional monitoring wells were installed in October 1990 as part of an ongoing UST site investigation.

Tank 0134-U. Tank 0134-U was a steel tank with a capacity of 117 gal that was used to store gasoline for emergency electrical power generation at Building 9204-2 (Fig. 5.7). The tank was installed in the mid-1960s and was removed from service in 1982. When the tank was excavated in August 1989, several holes were observed in the sides of the tank. Follow-up investigations at the site indicated that volatile organics were present in soils and groundwater in the area (Stone 1989e). A monitoring well was subsequently installed within the tank pit to facilitate free-product detection and recovery. No free product was observed, but petroleum odors in the well were noted (Stone 1989f). An additional well was installed in 1990 as part of an ongoing UST site investigation.

Rust Garage Area

The Rust Garage Area is located in the northwestern portion of the UEFPCHR about 650 ft east of the S-3 Site (Fig. 5.7). Building 9720-15, which houses the Rust Garage, was used as a vehicle and equipment maintenance shop and is currently used as a paint shop. Industrial products containing hazardous constituents that are stored 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.

Building 9754-1 at the Rust Garage Area was originally a fueling station for DOE fleet vehicles. Four petroleum fuel USTs with associated piping were located at the site: a 12,000-gal gasoline tank (Tank 1222-U), an 8,000-gal gasoline tank (Tank

2082-U), a 12,000-gal diesel fuel tank (Tank 1219-U), and a 1,000-gal gasoline tank (Tank 2068-U) located about 150 ft east of the three larger USTs. Tank 2068-U was connected to Tanks 1222-U and 2028-U with a transfer line encased in concrete. All four tanks at the site were excavated in December 1989.

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 September 1987. Temporary piezometers were installed during early 1988 to facilitate detection of the leaks, and free product was observed in at least one of these piezometers (Geraghty & Miller, Inc. 1988a). Monitoring wells were installed at the site in 1990 as part of a UST site investigation (Eaton and Van Ryn 1991).

Bear Creek Hydrogeologic Regime (BCHR)

Located west of the Y-12 Plant in BCV, the BCHR is bound to the north by Pine Ridge and to the south by Chestnut Ridge. The regime encompasses the portion of BCV extending from the west end of the Y-12 Plant to the western end of the Bear Creek Burial Grounds waste management area (WMA) (Fig. 5.6). Figure 5.8 shows the locations of waste management sites in this regime.

S-3 Site

The S-3 Site is next to the west end of the Y-12 Plant (Fig. 5.8), just west of the groundwater flow divide separating the BCHR from the UEFPCHR. Constructed in 1951, the site originally consisted of four unlined surface impoundments covering an area of roughly 400 × 400 ft. The original pond excavations did not extend into bedrock, and each pond had a storage capacity of about 2.5 million gal (Geraghty & Miller, Inc. 1988b).

Wastes discharged into the ponds consisted primarily of 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, and miscellaneous liquid wastes (mop waters) associated with routine clean-up and operations at the Y-12 Plant. Waste disposal at the site ceased in 1984 (Geraghty & Miller, Inc. 1988b).

In 1988 the S-3 ponds were closed as a landfill in accordance with a TDEC-approved RCRA closure plan (Energy Systems 1988b). When closed, the ponds contained 2 to 5 ft of sludge produced during in-situ denitrification and neutralization of wastewater in the ponds, and a small volume of contaminated sediments removed from Bear Creek downstream of the site. The sludge was not leachable in weak acid and groundwater (Geraghty & Miller, Inc. 1988b). During closure, the sludge and sediments were stabilized with coarse aggregate and the ponds were covered with a low-permeability engineered cap. Construction of an asphalt parking lot over the cap completed final closure of the site. TDEC certified final closure of the site on November 15, 1990.

Oil Landfarm Waste Management Area

The Oil Landfarm WMA is approximately 1 mile west of the Y-12 Plant (Fig. 5.8), and consists of the Oil Landfarm, the Boneyard, the Burnyard, the Chemical Storage Area, and Sanitary Landfill I.

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 volatile organic compounds (VOCs). Approximately 1 million gal of waste oil were applied to soils at the site between 1973 and 1982 (Geraghty & 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 1988c). TDEC certified final closure of the site on December 15, 1990.

The Boneyard was used for the disposal of magnesium chips and construction debris (e.g., concrete) in unlined shallow trenches. The magnesium chips were placed in the trenches and burned, and residues were covered with soil and compacted. Filled trenches were covered with top soil and seeded with grass (Geraghty & Miller, Inc. 1988c).

The Burnyard consisted of two unlined trenches about 300 ft long by 40 ft wide. Between 1943 and 1968, various types of refuse (including pesticide containers, metal shavings, solvents, oils, and laboratory chemicals) were burned in the trenches.

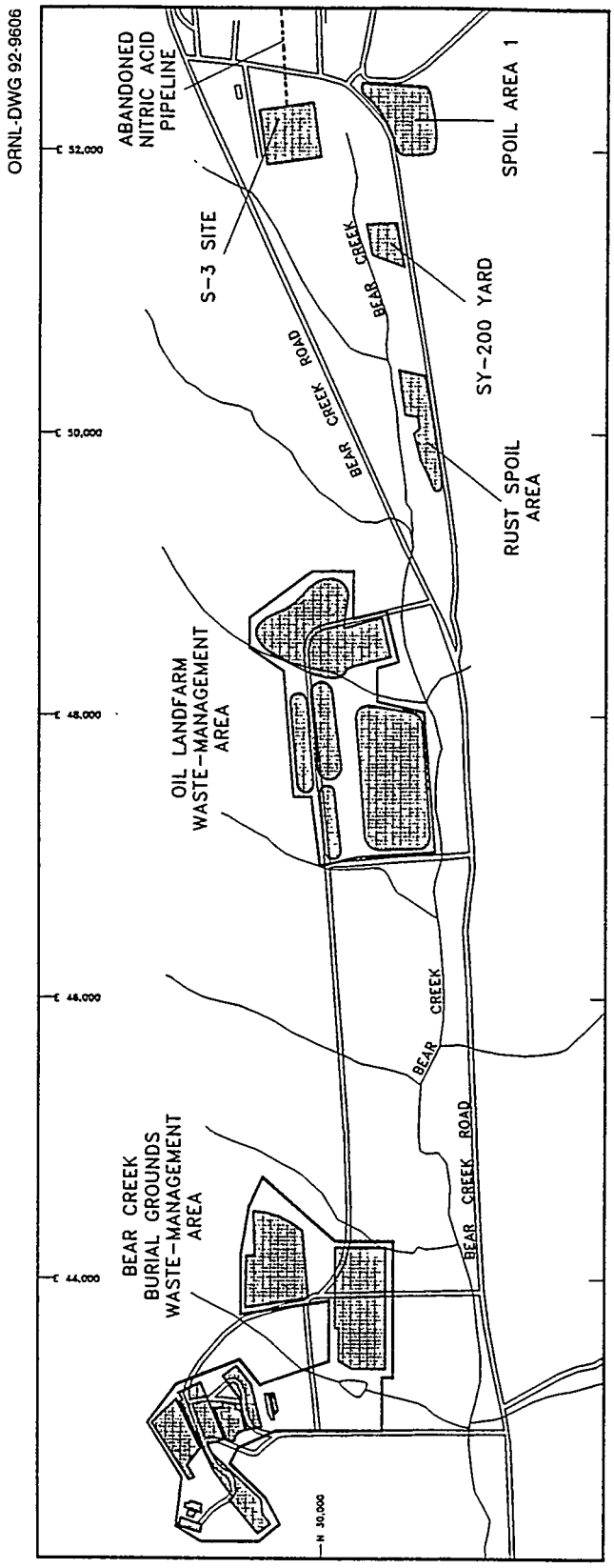

Fig. 5.8. Bear Creek Valley waste-management sites.

Some residues may have been buried in the Boneyard (Geraghty & Miller, Inc. 1988c).

The Chemical Storage Area was constructed on top of the Burnyard and used as an area for releasing compressed gas from cylinders with leaking or damaged valves, and for disposal of reactive or explosive laboratory chemicals. Gas in the damaged cylinders was allowed to leak into the atmosphere or was bled off; corrosive gases were bled through neutralizing slurries. Laboratory chemicals disposed at the site included acids, bases, organics, water-reactive compounds, and shock-sensitive compounds such as picric acid. The chemicals were handled to induce the expected reaction or explosion, and remaining liquids were discharged into a small unlined surface impoundment (Geraghty & Miller, Inc. 1988c).

Sanitary Landfill I is south of the Oil Landfarm next to Bear Creek. TDEC permitted the 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 the site started in 1968, and the site contained about 105,000 tons of waste when disposal activities ceased in 1982 (Geraghty & Miller, Inc. 1988c). In 1983 the site was graded and capped in accordance with a TDEC-approved closure plan (Bailey 1983).

Bear Creek Burial Grounds Waste Management Area

The Bear Creek Burial Grounds WMA is approximately 2 miles west of the Y-12 Plant (Fig. 5.8), and it 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 disposal unit consisted of multiple trenches excavated 14 to 25 ft below grade that were used for disposal of liquid and/or solid wastes. Perforated stand-pipes installed vertically in some trenches were used for liquid waste disposal; rock and gravel were backfilled around the standpipes for support and to maximize the drainage rate. 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 at the site included salts, metals (primarily beryllium and uranium) and metal oxides, metal saw-fines, and asbestos. Although some disposal units currently receive nonhazardous solid wastes, all hazardous waste disposal activities ceased in 1981 (Geraghty & Miller, Inc. 1988d).

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 1988d and 1988e). TDEC certified final closure of Burial Ground A (North and South) on December 15, 1989. Certification of final closure of Burial Ground C was requested from TDEC on December 27, 1990. TDEC certified final closure of Oil Retention ponds No. 1 and 2 on November 15, 1990, and December 11, 1990, respectively.

Abandoned Nitric Acid Pipeline (ANAP)

Only a small section of the ANAP lies within the BCHR (Fig. 5.8); most of the pipeline is within the Y-12 Plant complex in the UEFPCHR.

Spoil Area I

Spoil Area I is located on the northern slope of Chestnut Ridge, west of the Y-12 Plant near the intersection of Old Bear Creek Road and West Patrol Road (Fig. 5.8). The 5-acre site has been used since about 1980 for disposal of nonradioactive construction debris. TDEC permitted the site in 1986 (Permit No. DML011030012) for disposal of rubble and other noncombustible, stable solid wastes (Tennessee Department of Health and Environment 1986). The site has received approximately 100,000 cubic yards of debris, including asphalt, brick, concrete, roofing materials, brush, steel rebar, rock, and tile. An RFI plan prepared for the site contains a detailed discussion of its operational history (Battelle Columbus Division 1989a).

SY-200 Yard

The SY-200 Yard is located south of Bear Creek near the base of the northern slope of Chestnut Ridge, approximately 0.5 mile west of the Y-12 Plant (Fig. 5.8). Operated from the 1950s to 1986, the SY-200 Yard was a 300 by 200 ft 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 RFI plan for the site contains a detailed discussion of its operational history (Geraghty & Miller, Inc. 1989b).

Rust Spoil Area

The Rust Spoil Area is a 5.4-acre site located west of the SY-200 Yard (Fig. 5.8) that was used between 1975 and 1983 by Rust Engineering for the disposal of solid wastes (spoil) generated during various renovation, maintenance, and construction operations at the Y-12 Plant. Less than 100,000 cubic yards of nonradioactive construction debris are estimated to have been disposed at the site. Waste materials were primarily soil fill, masonry, and concrete with steel rebar, but materials containing solvents, asbestos, mercury, and uranium also may have been disposed at the site (Battelle Columbus Division 1989b). Closure of the site was completed in 1984 in accordance with a TDEC-approved closure plan (MCI Consulting Engineers 1983). An RFI plan for the site contains a detailed discussion of its operational history (Battelle Columbus Division 1989b).

Chestnut Ridge Hydrogeologic Regime (CRHR)

The CRHR is south of the Y-12 Plant, and is flanked to the north by BCV and to the south by Bethel Valley Road (Fig. 5.6). 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 southwest of the western end of the Y-12 Plant. The following sections contain brief descriptions of the waste-management sites in the CRHR. The locations of these sites are shown on Fig. 5.9.

Chestnut Ridge Security Pits (CRSP)

Located on the crest of Chestnut Ridge south of the central portion of the Y-12 Plant (Fig. 5.9), the CRSP were operated between 1973 and 1988. When in operation, the site was a series of trenches used for the disposal of classified hazardous and nonhazardous wastes. The disposal trenches were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Typically, several trenches were opened simultaneously to allow for the segregation of wastes in separate cells. After a trench was filled, it was covered with 6 to 12 in. of soil. Particularly reactive materials were disposed in six auger holes, each about 2 ft in diam and 10 ft deep, located at the eastern end of the site (Butz and Stoner 1983).

The CRSP contain an estimated 3,950 tons of waste materials. Detailed waste inventories are classified, but an unclassified inventory listed ten major wastes types that included acids, fiberglass, beryllium, biological material, debris, heavy metals, inorganics, organics, thorium, and uranium (Energy Systems 1984).

Disposal of hazardous waste in the CRSP ceased in December 1984 and disposal of nonhazardous waste ceased on November 8, 1988. Closure of the site is described in a TDEC-approved RCRA closure plan and involved the construction of a low-permeability engineered cap over the disposal trenches (Energy Systems 1988f). The site was certified closed by TDEC on December 15, 1989.

Chestnut Ridge Sediment Disposal Basin (CRSDB)

The CRSDB is southeast of the east end of the Y-12 Plant (Fig. 5.9). Beginning in 1973 the site received soil and sediment that was periodically dredged from NHP, a closed surface impoundment at the east end of the Y-12 Plant. Soils and sediments removed from NHP contained PCBs, mercury, and uranium. Results of Extraction Procedure Toxicity analyses showed that the soils did not exhibit the characteristics of a hazardous waste (Saunders 1983; Kimbrough and McMahon 1988a and 1988b). Between November 1987 and April 1988 the CRSDB also received mercury-contaminated soils from several locations in the Y-12 Plant. In 1989 the CRSDB was closed in accordance with a TDEC-approved RCRA closure plan. TDEC certified final closure on December 15, 1989.

Kerr Hollow Quarry

The Kerr Hollow Quarry (KHQ) is located near the south-central portion of the CRHR (Fig. 5.9) and was a source of stone construction material in the 1940s until it filled with water and was abandoned. From the early 1950s, KHQ was used for the disposal of reactive materials from the Y-12 Plant and ORNL.

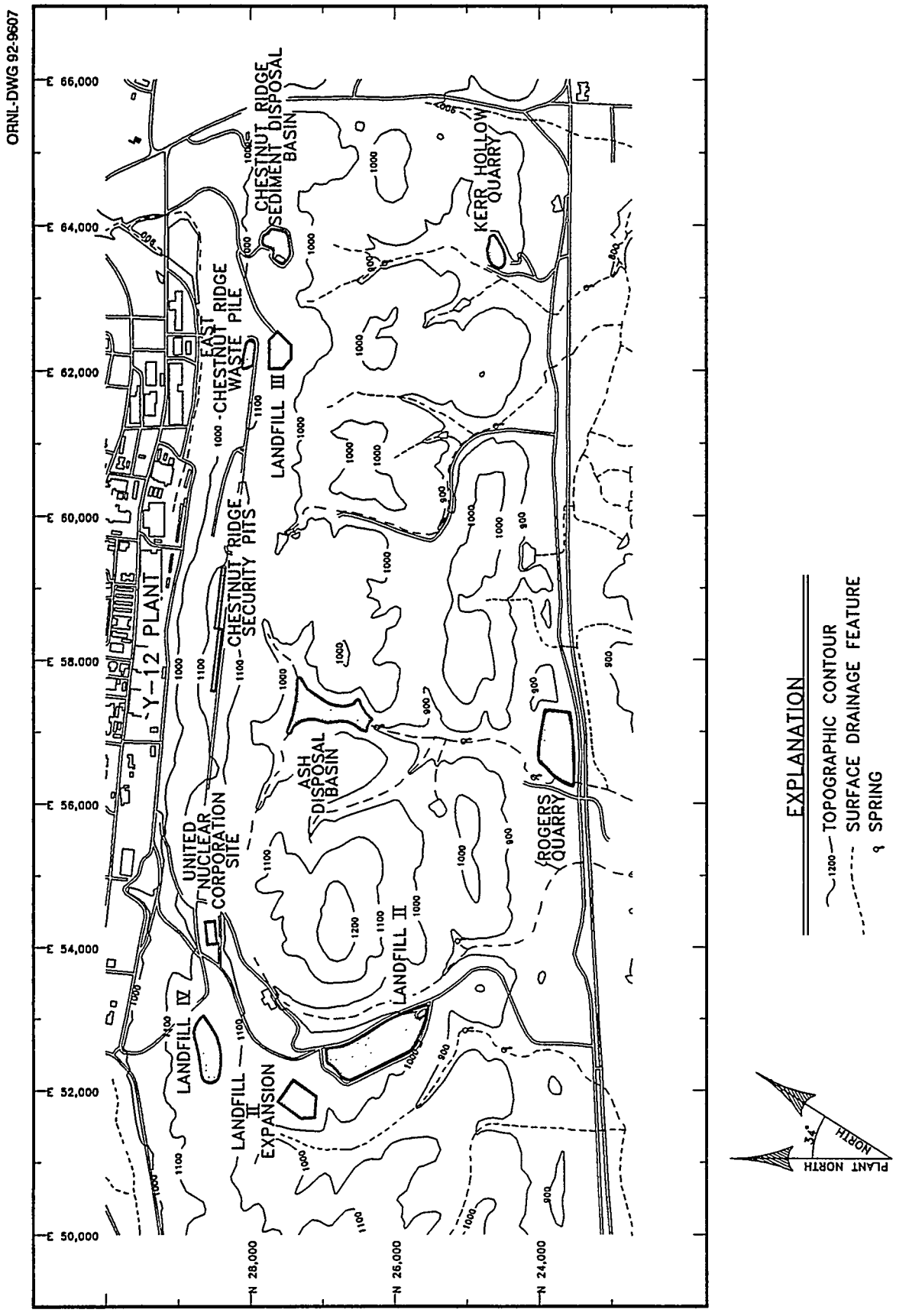

Fig. 5.9. Waste management sites in the Chestnut Ridge Hydrogeologic Regime.

Disposal of these materials at the site ceased in November 1988. The site is currently undergoing closure under RCRA.

East Chestnut Ridge Waste Pile

The East Chestnut Ridge Waste Pile (ECRWP) is a lined 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 CRHR near the CRSDB (Fig. 5.9).

United Nuclear Corporation Site

The United Nuclear Corporation (UNC) Site lies on the crest of Chestnut Ridge southeast of the west end of the Y-12 Plant (Fig. 5.9). The site was a landfill excavated about 32 ft deep (Smith et al. 1983) and received nitrate contaminated low-level radioactive wastes, and contaminated equipment packaged in 55 gal drums and in boxes. Approximately 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 Record of Decision (ROD) was signed on June 28, 1991.

Ash Disposal Basin

The Ash Disposal Basin (ADB) is on the southern flank of Chestnut Ridge about 0.5 mile south of the Y-12 Plant (Fig. 5.9). The basin was created in 1955 by the construction of an earthen dam across a northern tributary of McCoy Branch. Fly-ash slurry from the Y-12 Steam Plant was pumped into the ADB until it was filled in July 1967. Since then, the fly-ash slurry bypasses the ADB through an emergency spillway on the eastern abutment and discharges directly into McCoy Branch, which has been diverted to direct the slurry into Rogers Quarry (King et al. 1989). An RFI Plan contains details of the operational history of the ADB (Battelle Columbus Division 1988).

Rogers Quarry

Rogers Quarry is located in the southwest portion of the CRHR about three miles west of KHQ (Fig. 5.9). The quarry was used from the 1940s through the late 1950s as a source of stone-construction material, and was abandoned in the early 1960s when it filled with water. It currently receives fly-ash slurry from the Y-12 Steam Plant that is discharged into McCoy Branch (King et al. 1989).

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 (SWDF) located near the western end of the CRHR (Fig. 5.9). The landfill is used as a disposal site for combustible and decomposable solid waste and construction spoil material from the Y-12 Plant, the K-25 Site, ORNL, and DOE prime contractors in Oak Ridge. These wastes include 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 (Fig. 5.9), but the expanded area has not received any wastes.

Groundwater monitoring at the site is performed in accordance with a monitoring plan approved by the TDEC. Monitoring results obtained since 1982 show that groundwater at the site contains low levels of VOCs.

Industrial Landfill III

Industrial Landfill III, also known as the Chestnut Ridge Borrow Area Waste Pile, is located near the eastern end of the CRHR (Fig. 5.9). The site 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 characteristic 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 (TCLP) testing was submitted to TDEC for review in September 1991 (Science Applications International Corporation 1991).

The landfill excavation is approximately 70 ft wide, 10 to 12 ft deep, and 200 ft long. The bottom and walls of the pit are lined with polyvinyl chloride and the bottom is sloped to facilitate drainage. Perimeter channels divert surface runoff and a plastic liner on top of the pile restricts infiltration. Approximately 3,000 cubic yards of soil are now

stored at the facility. 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 SWDF located near the west end of the CRHR (Fig. 5.9) that has been operated since 1989 for disposal of nonhazardous, nonradioactive industrial wastes. Wastes disposed at the site include cardboard, plastics, rubber, scrap metal, wood, paper, and special wastes. Based on current waste volumes, the site is expected to receive approximately 12,000 ft^3 of waste per year. Groundwater quality monitoring has been performed at the site since 1987, and contaminant releases to groundwater have not been detected.

Three categories of sites are located within the CRHR: (1) RCRA interim status units, (2) individual solid waste management units (SWMUs) and solid waste disposal units, and (3) TDEC-permitted SWDFs. The waste sites located within the CRHR are shown on Fig. 5.9. Of the waste disposal sites located in the CRHR, only the CRSP have been confirmed as a source for groundwater contamination.

5.3.1.4 Monitoring wells installed in CY 1991

In CY 1991, 27 new groundwater monitoring wells were installed. Table 5.4 lists the sites and number of monitoring wells installed. The sites are divided into two categories. Category I sites are those monitoring sites requiring additional data to delineate the extent of groundwater contamination. Wells installed in Category II locations are for the purpose of monitoring potential exit pathways for groundwater contamination.

5.3.1.5 Summary of groundwater quality conditions at the Y-12 Plant

Groundwater quality at the Y-12 Plant has been impacted by four types of contaminants: nitrate, VOCs, metals, and radionuclides. Of these, nitrate and VOCs are the most pervasive, although data obtained since 1988 suggest that the extent of some radionuclides may also be significant. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low pH groundwater at the west end of the plant in the vicinity of the S-3 Site.

Additional monitoring wells installed in 1991 have served to define groundwater quality conditions better at the Y-12 Plant. In the BCHR, horizontal plume boundaries are essentially defined, in the bedrock formations that directly underlie waste disposal units. Additional data has been acquired regarding the vertical extent of these plumes. In the UEFPCHR, plume boundaries in both horizontal and vertical directions have not been completely defined. The CRSP is the only known source of groundwater contamination in the CRHR. Horizontal plume boundaries at the CRSP are generally defined, although the vertical extent of contamination has yet to be established.

5.3.1.6 Upper East Fork Poplar Creek Hydrogeologic Regime

The objectives of the 1991 groundwater quality monitoring program in the UEFPCHR were (1) to further define contaminant plume boundaries and (2) to expand the exit-pathway monitoring well network in the Maynardville Limestone.

Table 5.4. Y-12 Plant monitoring wells installed in 1991

Site	Category	Wells installed
Bear Creek Hydrogeologic Regime	I	0
Upper East Fork Poplar Creek Hydrogeologic Regime	I	2
Chestnut Ridge Hydrogeologic Regime	I	5
Exit-Pathway Monitoring	II	20

Plume Delineation

The primary groundwater contaminants in the UEFPCHR are nitrate, VOCs, trace metals, and radionuclides. Sources of nitrate, trace metals, and radionuclides are the S-2 Site, the ANAP, and the S-3 Site. Although it is located west of the hydrologic divide that separates the UEFPCHR from the BCHR, the S-3 Site has contributed to groundwater contamination in the western part of the regime. A mound in the water table created by the 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 UEFPCHR include the S-3 Site, several sites located within the Y-12 Salvage Yard, the Waste Coolant Processing Area (WCPA), and several petroleum USTs (Fig. 5.9). Concentrations of VOCs in the UEFPCHR have remained relatively constant since 1988 (Fig. 5.10).

Nitrate

Nitrate concentrations exceeded the 10 mg/L MCL during 1991 in a large part of the western portion of the UEFPCHR (Fig. 5.11). Groundwater containing nitrate concentrations as high as 10,000 mg/L occurs in the unconsolidated zone and at shallow bedrock depths just east of the S-3 Site.

The areal 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 (Fig. 5.11). Nitrate has traveled farthest in groundwater in the Maynardville Limestone.

The influence that buried stream channels and subsurface drains have on nitrate movement in the unconsolidated zone is evident. These features provide permeable conduits that apparently intercept groundwater and cause abrupt decreases in nitrate concentrations.

Trace Metals

Concentrations of barium, cadmium, chromium, lead, and mercury exceeded MCLs during 1991 in samples collected from monitoring wells at the S-2 Site, the Y-12 Salvage Yard, the WCPA, the 9754 and 9754-2 Fuel facilities, and NHP. 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 metal concentrations near the Y-12 Salvage Yard, the S-2 Site, and at NHP. The maximum concentrations of these metals were 58 mg/L for barium, 5.0 mg/L for cadmium, 13.6 mg/L for chromium, 0.3 mg/L for lead, and 0.12 mg/L for mercury.

Volatile Organic Compounds

Because of the many source areas, VOCs are the most widespread groundwater contaminants in the UEFPCHR. Dissolved VOC plumes in the regime generally consist of two types of compounds: chlorinated solvents and petroleum hydrocarbons. The highest concentrations of dissolved chlorinated solvents (about 18,000 μg/L) are found at the WCPA and the highest dissolved concentrations of petroleum hydrocarbons (about 50,000 μg/L) occur in groundwater in the Y-12 Salvage Yard near the Rust Garage Area.

The 1991 monitoring results generally confirm 1990 findings of a continuous dissolved VOC plume in groundwater in the unconsolidated zone that extends about 4,000 ft eastward from the S-3 Site to Tank 2331-U (Fig. 5.12). Additionally, the 1991 data confirm preliminary 1990 results identifying the Fire Training Facility as a VOC source area. Isolated "pockets" of VOCs in the unconsolidated zone also are present in groundwater at the Building 9754 and 9754-2 Fuel facilities and NHP.

Results obtained during previous years suggest that NHP is not the source of VOCs in the wells at the site. Data obtained during 1991 support this observation. Groundwater sampled from new exit-pathway monitoring wells installed upgradient of the site contains the same VOCs found in wells downgradient of the site. The upgradient source of these VOCs has not been established.

Radionuclides

As in the BCHR, the primary alpha-particle-emitting radionuclides are uranium, isotopes of radium, neptunium, and americium. The primary beta-particle-emitting radionuclide is technetium.

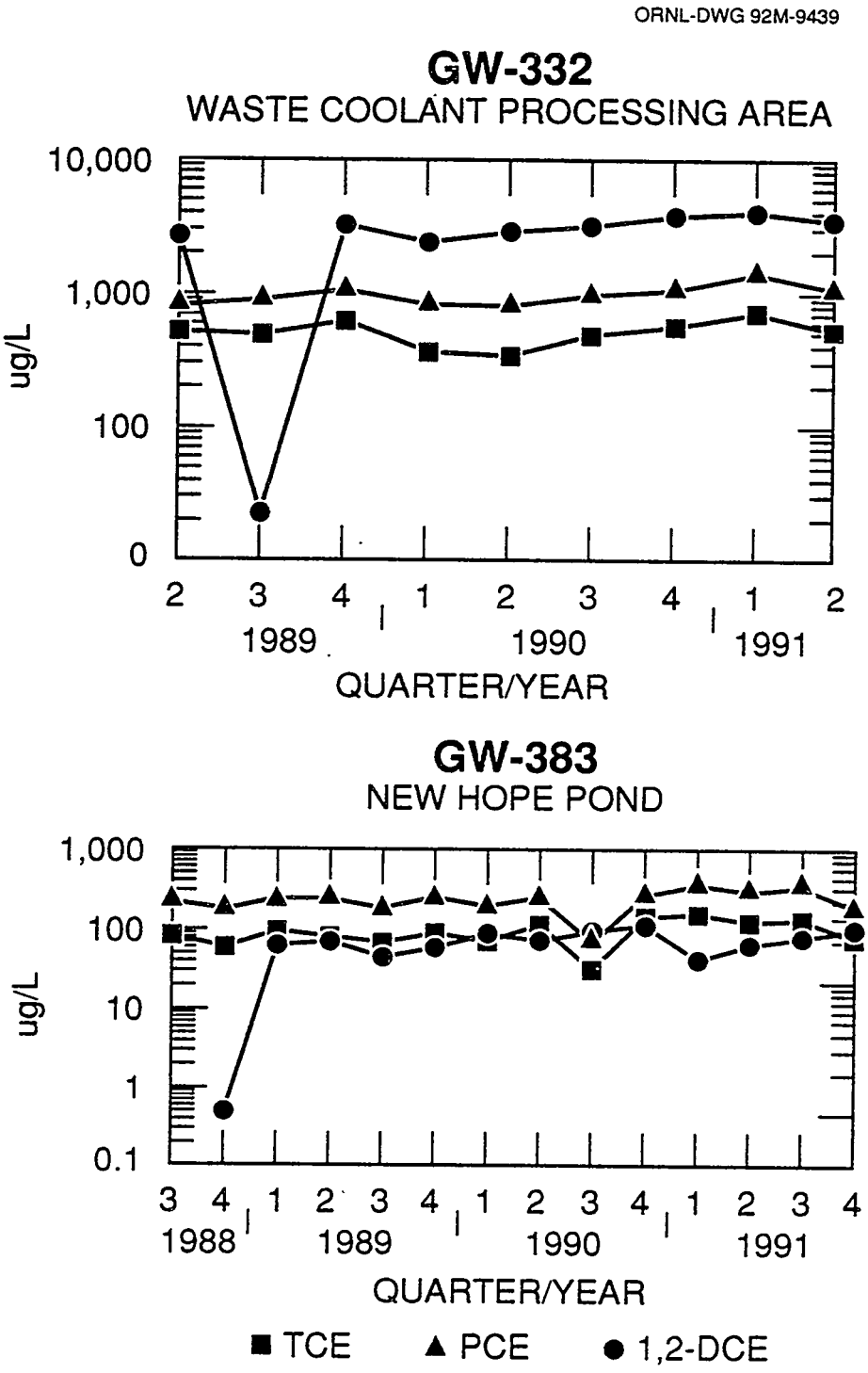

Fig. 5.10. Concentrations of VOCs in selected monitoring wells in the Upper East Fork Poplar Creek Hydrogeologic Regime.

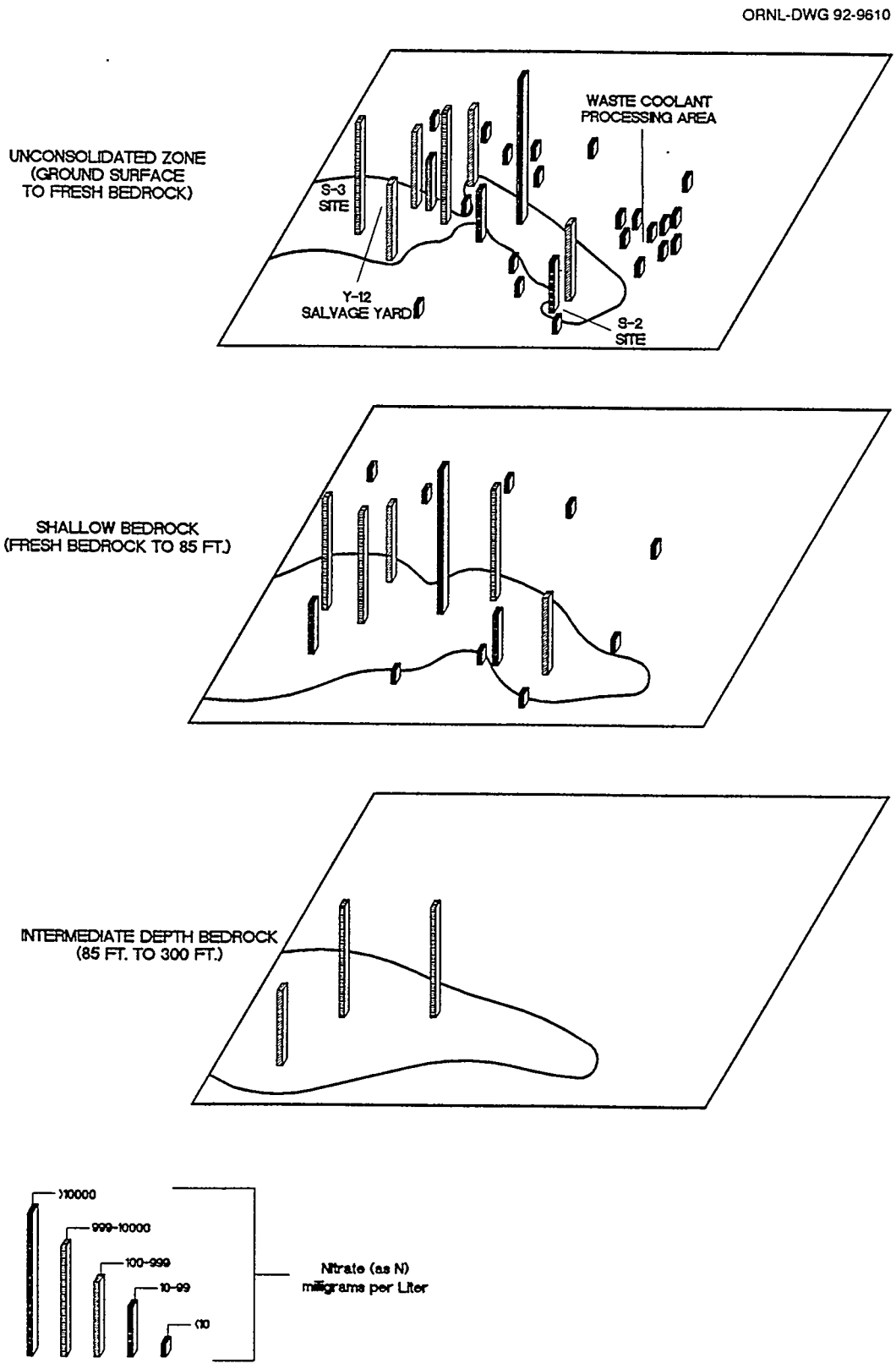

Fig. 5.11. Nitrate (as N) in groundwater in the Upper East Fork Poplar Creek Hydrogeologic Regime.

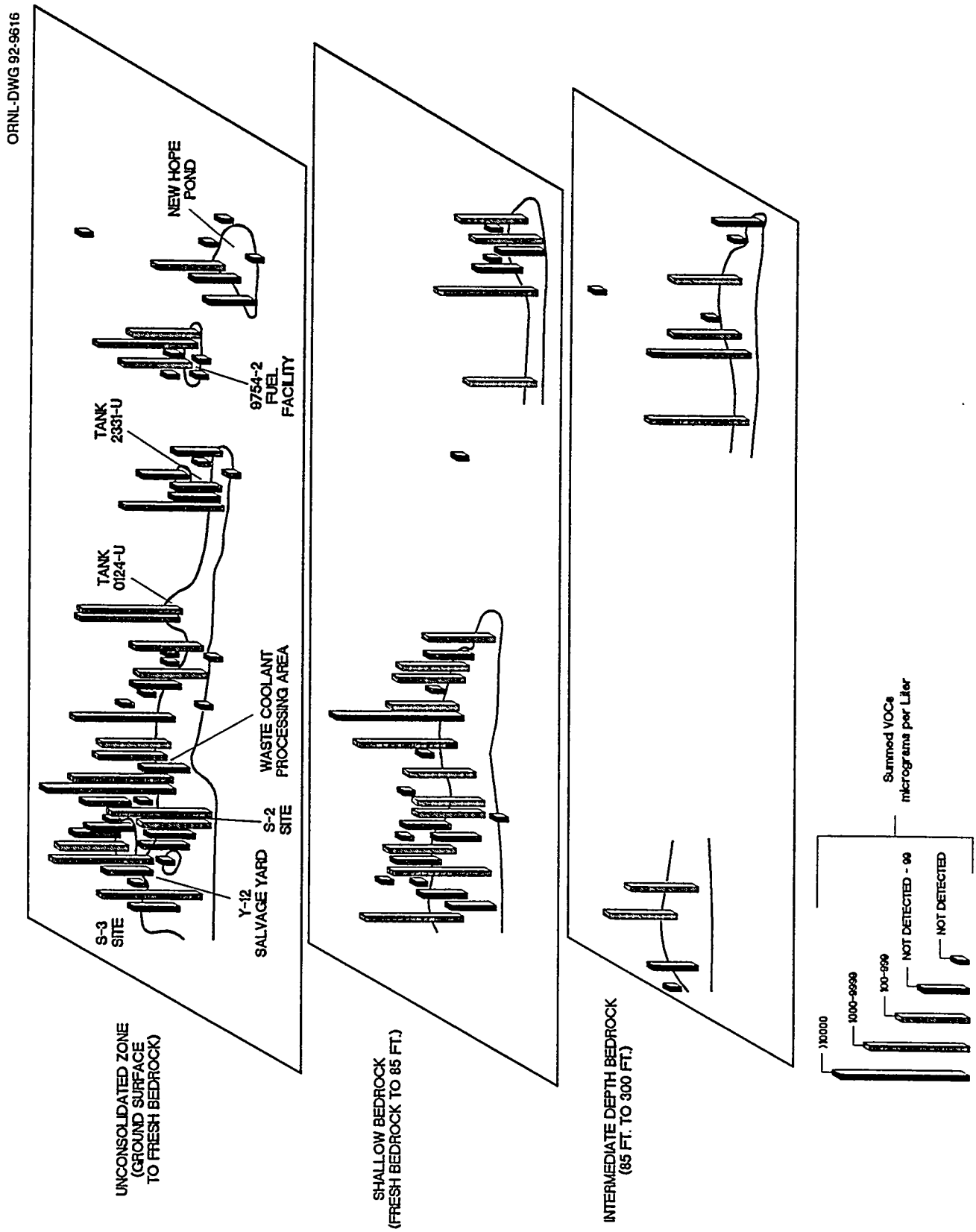

Fig. 5.12. Volatile organic compounds in groundwater in the Upper East Fork Poplar Creek Hydrogeologic Regime.

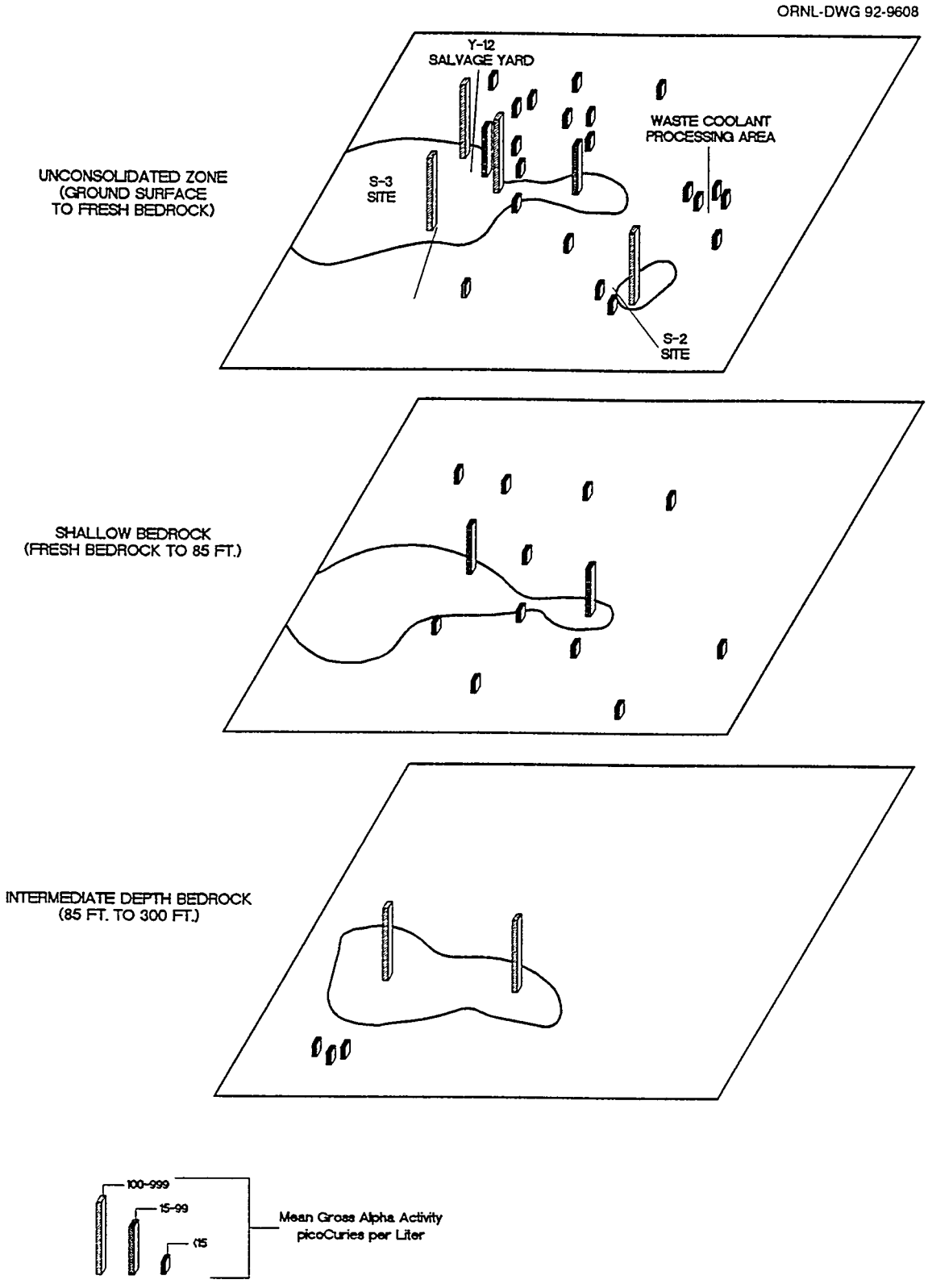

Fig. 5.13. Gross alpha activity in groundwater in the Upper East Fork Poplar Creek Hydrogeologic Regime.

Groundwater with gross alpha activity above 15 pCi/L occurs primarily in the western portion of the UEFPCHR (Fig. 5.13). Previous data have also suggested an area of elevated gross alpha activity west of NHP. Gross alpha activity exceeding the MCL is most extensive in groundwater in the unconsolidated zone. In the bedrock, gross alpha activity exceeds 15 pCi/L primarily near the Y-12 Salvage Yard.

Elevated gross beta activity in groundwater in the UEFPCHR is generally more extensive than gross alpha activity, particularly in the bedrock (Fig. 5.14). In general, gross beta activity exceeds 50 pCi/L in groundwater only in the western part of the regime. The extent of elevated gross beta activity probably reflects the greater mobility of the beta-emitting radionuclides.

Exit-Pathway Monitoring

Only groundwater in the Maynardville Limestone is monitored as part of the exit-pathway monitoring in the UEFPCHR. Surface-water quality in UEFPC is regularly monitored in accordance with various NPDES permits.

As in the BCHR, efforts to expand the exit-pathway monitoring well network in the Maynardville Limestone were continued during 1991, and a total of four wells were installed along one dip-parallel traverse across the formation. Data obtained from these wells suggest that transport is greatest in the Maynardville Limestone and that there is an upgradient source of the VOCs in groundwater at NHP.

5.3.1.7 Bear Creek Hydrogeologic Regime

Groundwater monitoring efforts in the BCHR during 1991 were the same as those for UEFPCHR: (1) to delineate contaminant plume boundaries and (2) to expand the network of exit-pathway monitoring wells in the Maynardville Limestone.

Plume Delineation

The primary groundwater contaminants in the BCHR 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 WMA. Sources of VOCs include the S-3 Site, the Rust Spoil Area, Oil Landfarm WMA, and the Bear Creek Burial Grounds WMA; the latter two sites are the principal sources.

Contaminant plume boundaries are essentially defined in the bedrock formations that directly underlie many waste disposal areas in the BCHR, particularly the Nolichucky Shale. The elongated shape of the contaminant plumes in the BCHR is the result of transport of the contaminants parallel to strike in the Maynardville Limestone. A review of historical data suggests that contaminant concentrations in the BCHR have remained relatively constant since 1986 (Fig. 5.15).

Nitrate

Data obtained during 1991 indicate that nitrate concentrations exceed the 10 mg/L MCL in an area that extends west from the S-3 Site for several thousand feet down the BCV (Fig. 5.16). During 1991, the highest nitrate concentrations occurred 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.

As shown on Fig. 5.16, the horizontal extent of the nitrate plume is essentially defined in groundwater in the upper part of the aquifer (less than 100 ft below the ground surface). Data obtained from several exit-pathway monitoring wells installed during 1991 suggest that the nitrate plume in groundwater in the Maynardville Limestone extends farther down BCV than previously thought.

Vertical plume boundaries are not as well defined (Fig. 5.16). Typically, nitrate concentrations exceed the MCL in groundwater in the upper 300 ft of the aquifer. 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.

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 BCHR.

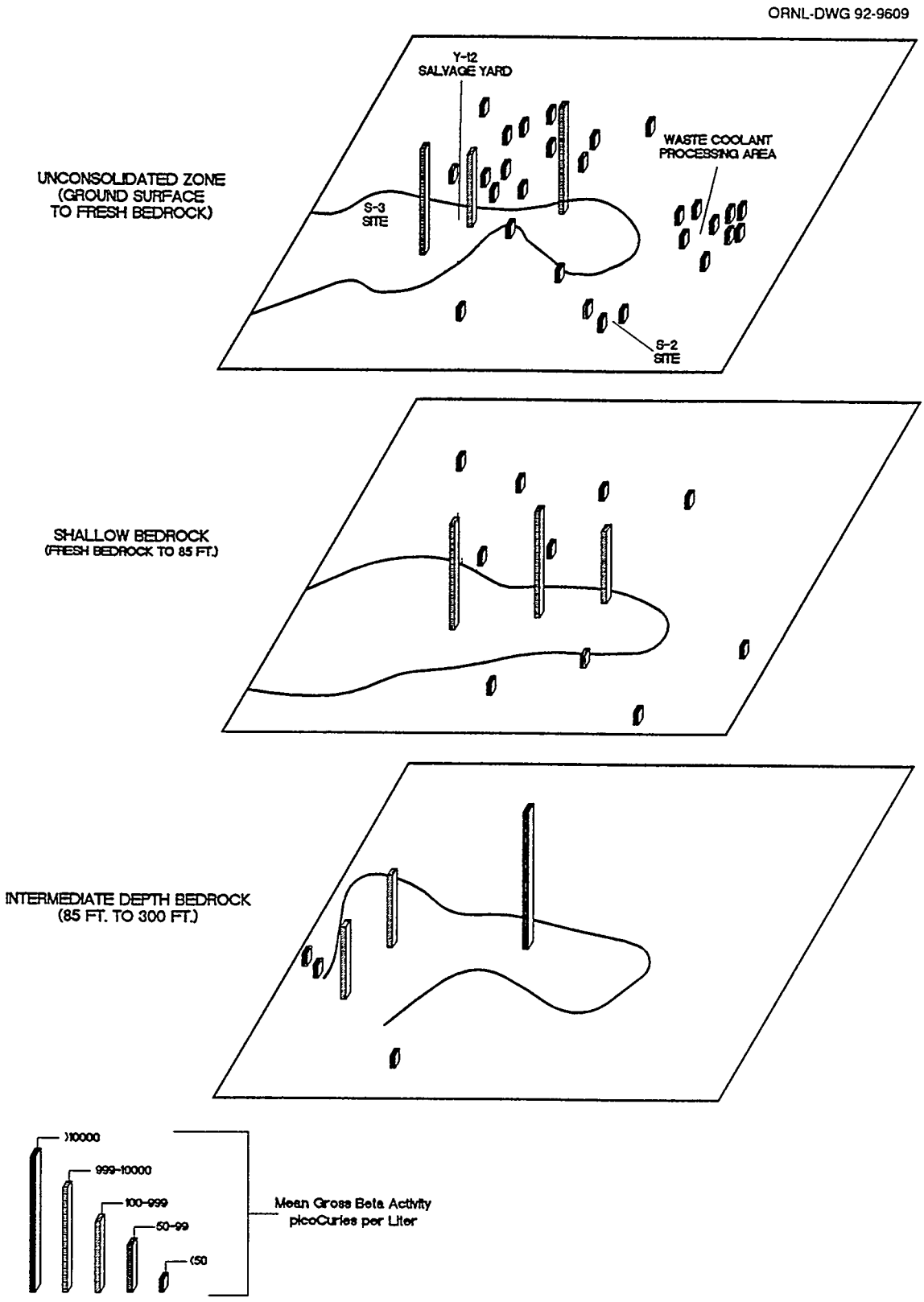

Fig. 5.14. Gross beta activity in groundwater in the Upper East Fork Poplar Creek Hydrogeologic Regime.

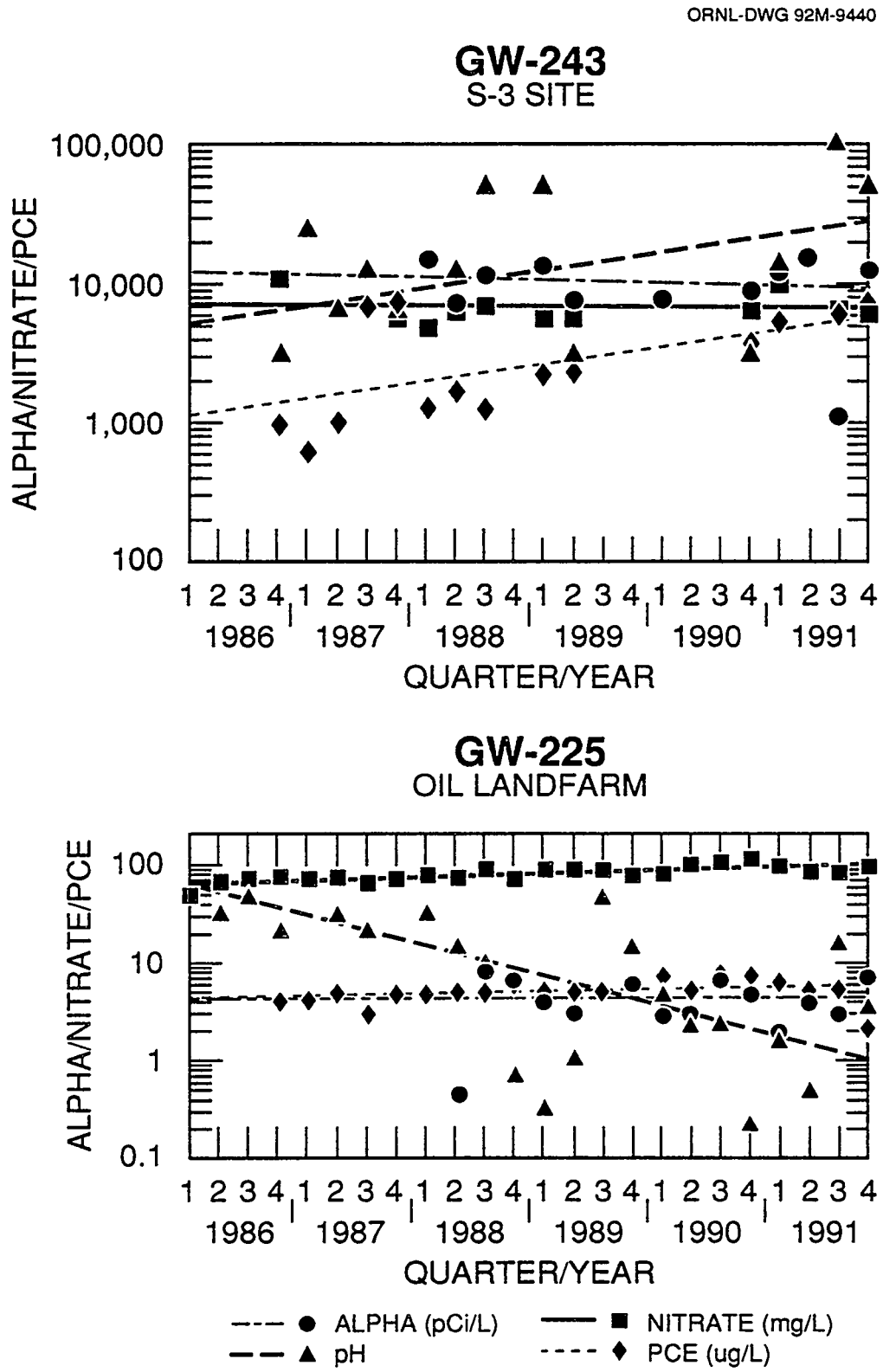

Fig. 5.15. Concentrations of selected contaminants in monitoring wells GW-243 and GW-255 in the Bear Creek Hydrogeologic Regime, 1986–1991.

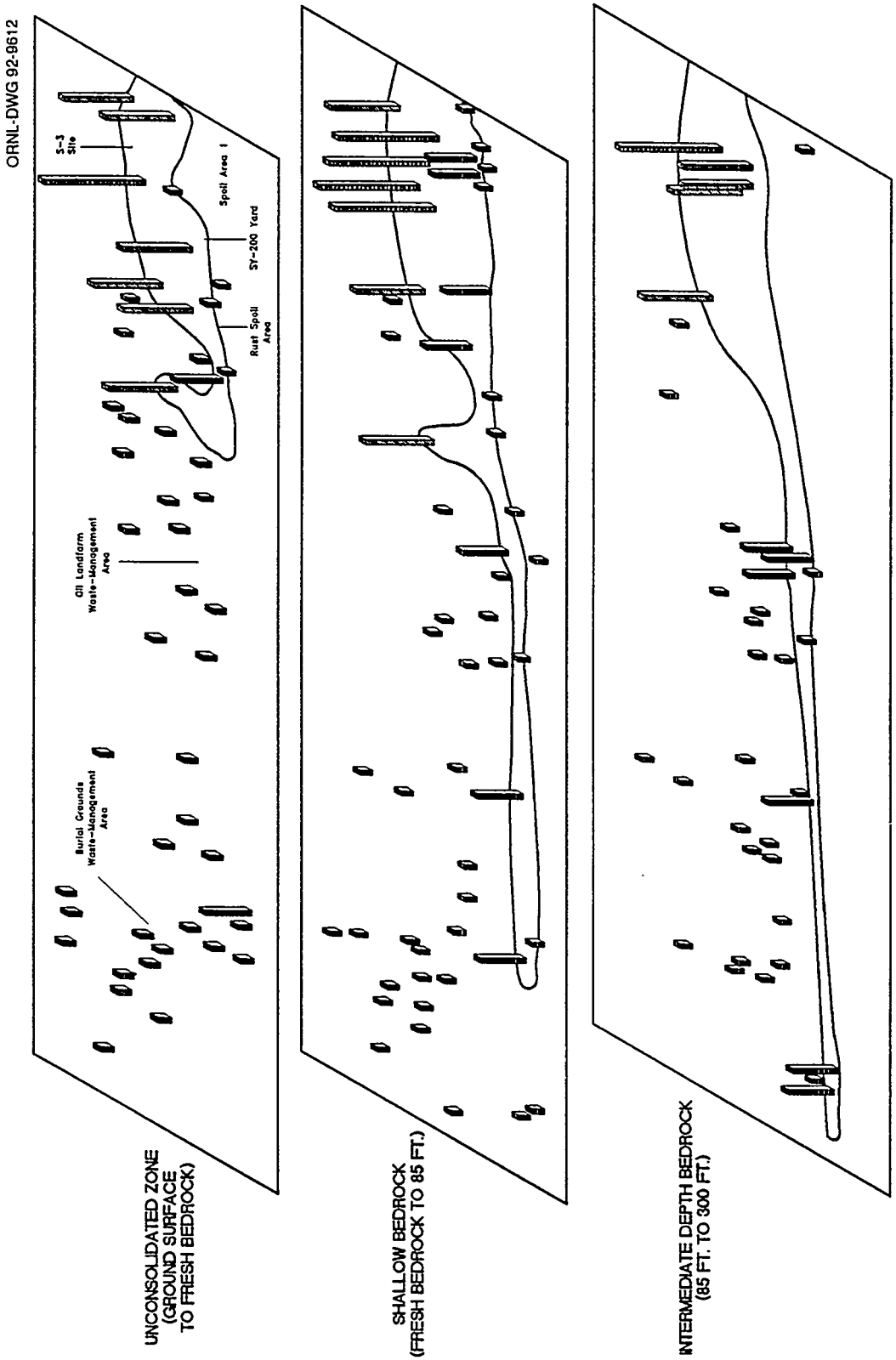

Fig. 5.16. Nitrate (as N) in groundwater in the Bear Creek Hydrogeologic Regime.

Trace Metals

Barium, cadmium, chromium, lead, and mercury have been identified from previous monitoring as the principal trace metal contaminants in groundwater in the BCHR. During 1991 the concentrations of these metals exceeded MCLs or natural (background) levels primarily in low pH groundwater at shallow depths near the S-3 Site. Disposal of acidic liquid wastes at this site reduced the pH of the groundwater, which allows the metals to remain in solution. Elsewhere in the BCHR where more neutral pH conditions prevail, only sporadic occurrences of elevated trace metal concentrations are evident.

Based on the 1991 data, the highest concentrations of the principal trace metal contaminants, except chromium, were reported for samples from wells at the S-3 Site. Groundwater near this site contained the highest concentrations of barium (390 mg/L), cadmium (4.0 mg/L), lead (1.3 mg/L), and mercury (0.11 mg/L) in the BCHR. Chromium was detected at 0.71 mg/L in one monitoring well at the Bear Creek Burial Grounds WMA. These findings are consistent with previous data.

Other trace metal contaminants in the BCHR 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. Based on the 1991 data, the groundwater in this area contains the highest concentrations of beryllium (2.0 mg/L), boron (10 mg/L), copper (3.2 mg/L), cobalt (3.5 mg/L), nickel (22 mg/L), and total uranium (46 mg/L) in the BCHR.

Volatile Organic Compounds

Like nitrate, VOCs are widespread in groundwater in the BCHR. 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 WMA. The extent of dissolved VOCs in the groundwater in the BCHR and the distribution of VOC concentrations within the plumes are illustrated on Fig. 5.17.

Groundwater in the unconsolidated zone that contains detectable levels of VOCs occurs primarily within about 1,000 ft of the source areas (Fig. 5.17). The highest VOC concentrations (greater than 10,000 μg/L) in the unconsolidated zone occur at the Bear Creek Burial Grounds WMA.

The extent of the dissolved VOC plumes is greater in the underlying bedrock (Fig. 5.17). Although the plumes generally do not extend more than 1,000 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 show that the VOC plume in the Maynardville Limestone extends farther west than previously reported. At shallow bedrock depths, an apparently continuous dissolved VOC plume extends for about 7,000 ft westward from the S-3 Site to just east of the Bear Creek Burial Grounds WMA. A continuous VOC plume is also present in the intermediate depth bedrock intervals in the Maynardville Limestone, but data obtained during 1991 show that the plume extends farther westward than in the shallow bedrock.

Radionuclides

Uranium, neptunium, americium, and isotopes of radium have been identified as the primary alpha-particle-emitting radionuclides in the BCHR. 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 BCHR during 1991 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from a well exceeded 15 pCi/L (the MCL for gross alpha activity), then one or more of the alpha-emitting-radionuclides 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 on Fig. 5.18, groundwater with elevated levels of gross alpha activity occurs in the unconsolidated zone between the S-3 Site and the Rust Spoil Area. In the bedrock gross alpha activity

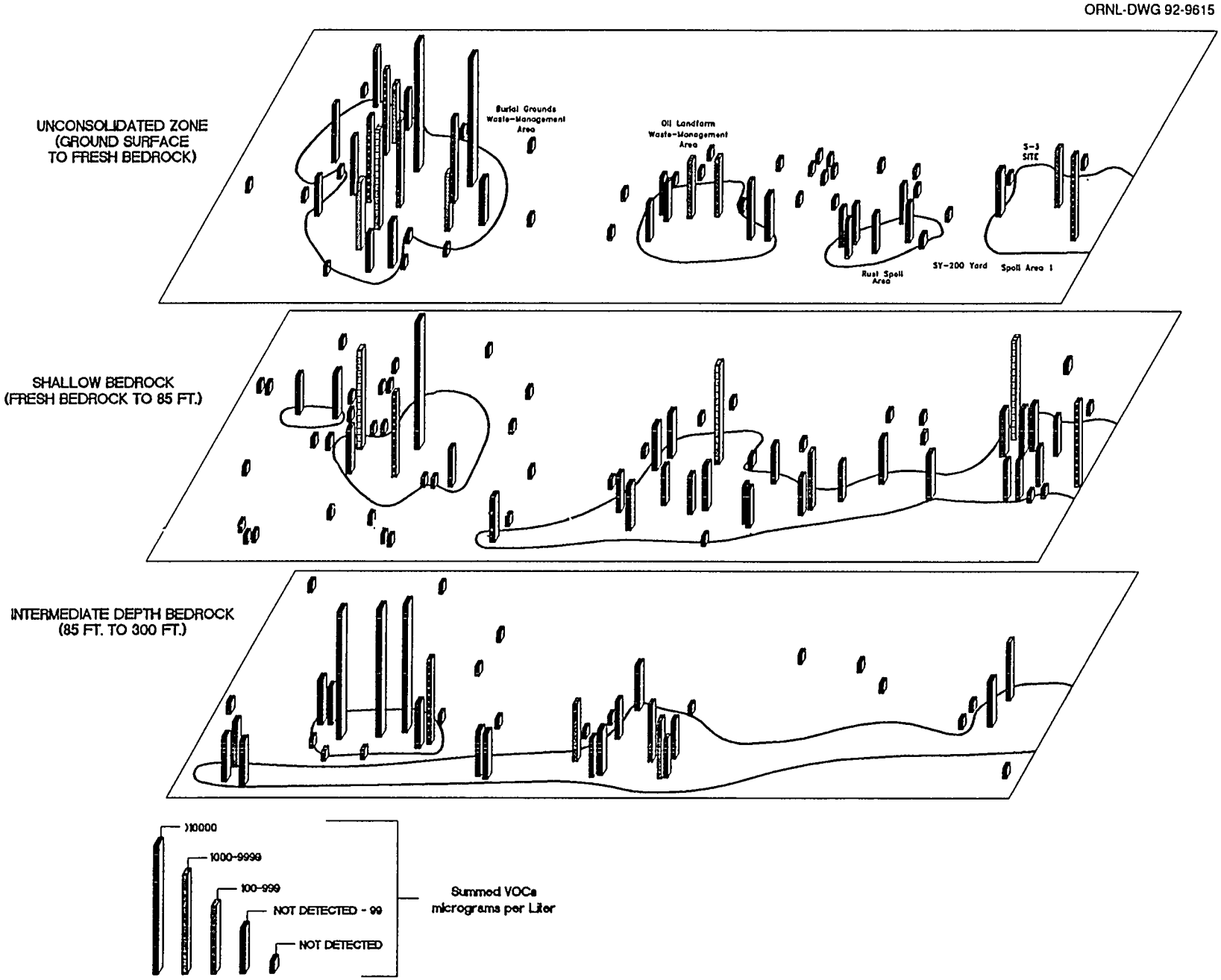

Fig. 5.17. Volatile organic compounds in ground r in the Bear Creek Hydrogeologic Regime.

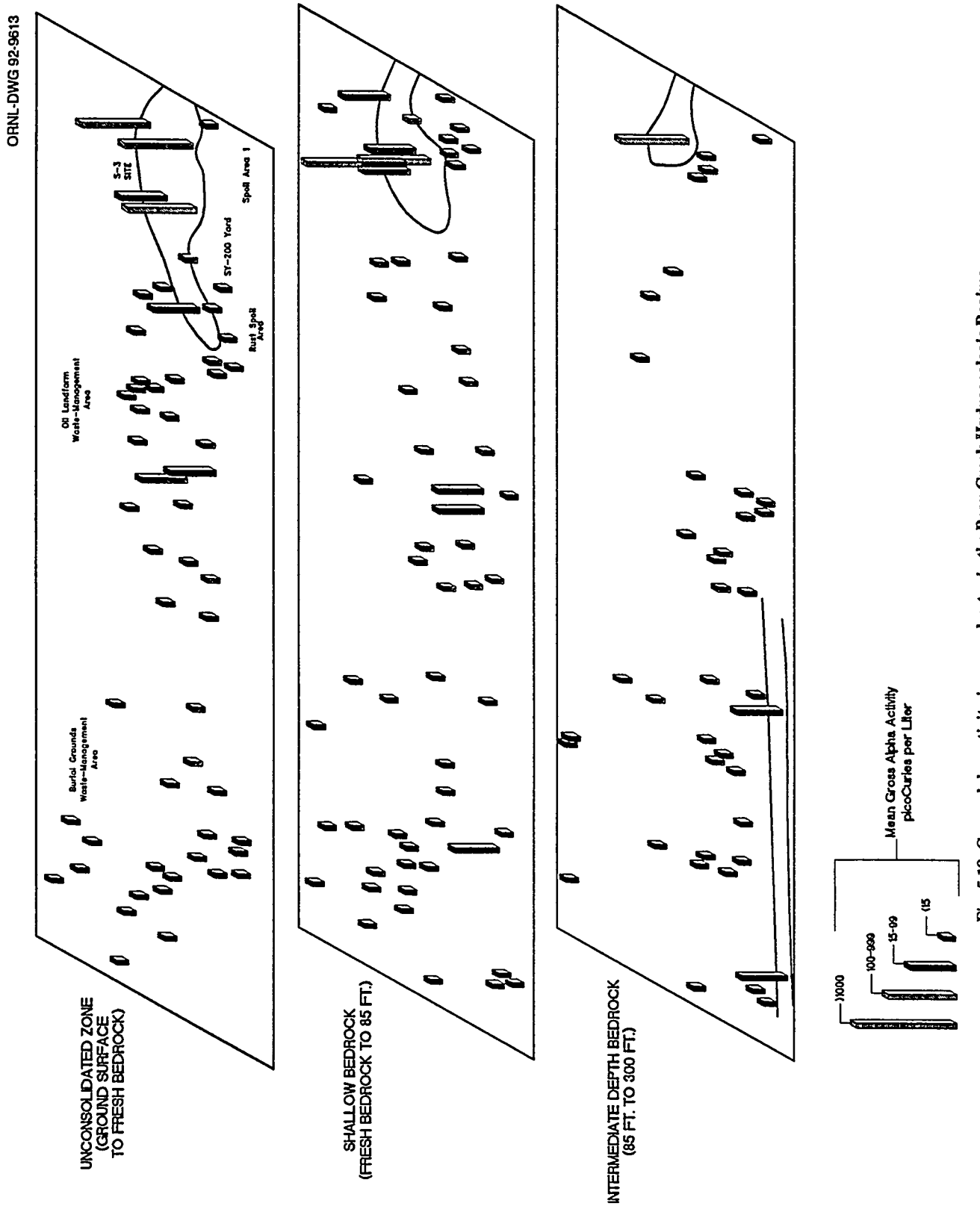

Fig. 5.18. Gross alpha activity in groundwater in the Bear Creek Hydrogeologic Regime.

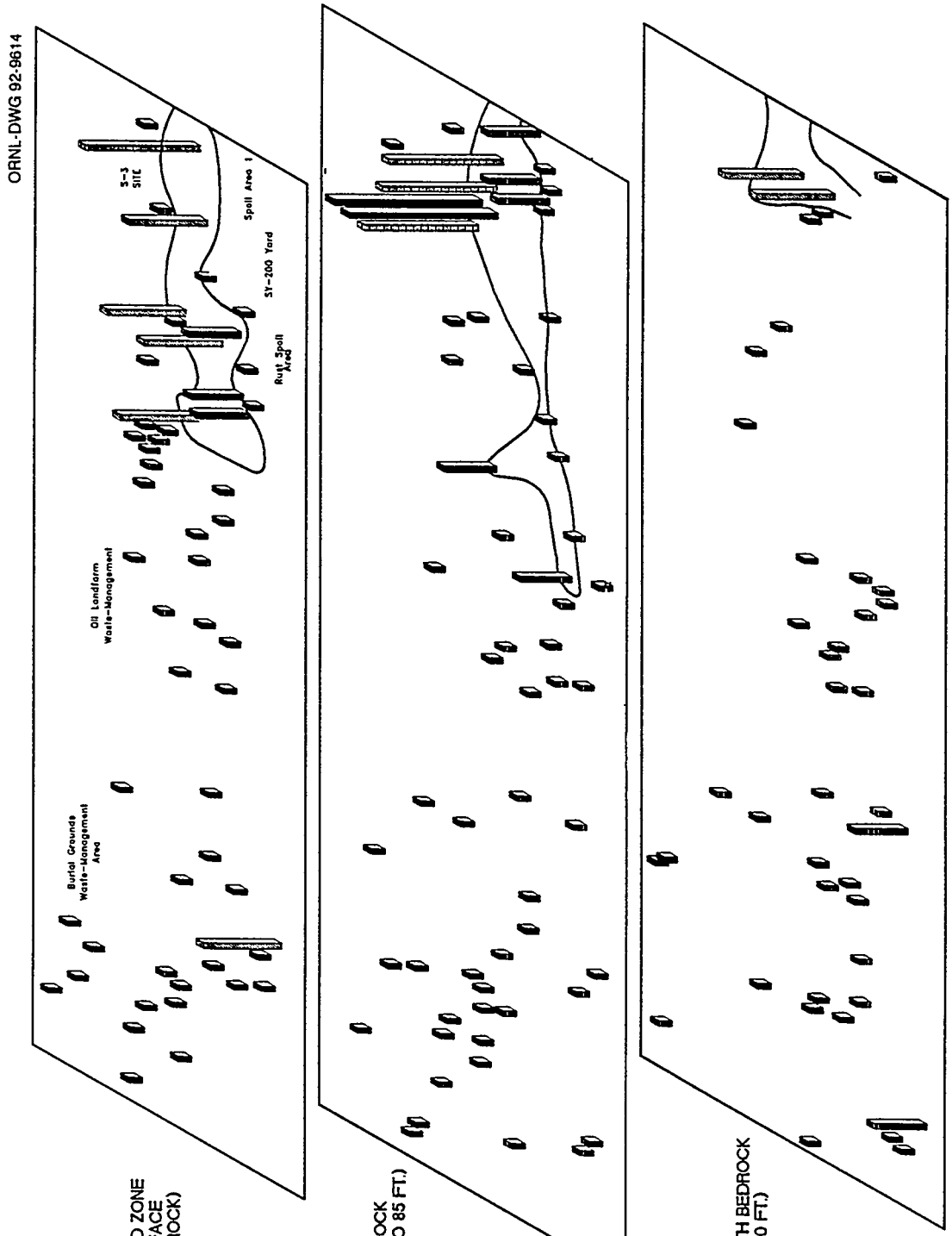

Fig. 5.19. Gross beta activity in groundwate the Bear Creek Hydrogeologic Regime.

exceeds 15 pCi/L in groundwater in the Nolichucky Shale near the S-3 Site and the eastern side of the Oil Landfarm WMA. Data obtained from exit-pathway wells installed in 1991 show that gross alpha activity in groundwater in the Maynardville Limestone exceeds the MCL for several thousand feet west of the S-3 Site.

The extent of gross beta radioactivity in groundwater in the unconsolidated zone is about the same as that of gross alpha radioactivity (Fig. 5.19).

During 1991, gross beta activity exceeded 50 pCi/L in groundwater at shallow depths in the Maynardville Limestone from south of the S-3 Site to the west of the Oil Landfarm WMA. At intermediate bedrock depths in the Maynardville Limestone, the elevated gross alpha activity extends farther west, possibly as far as the Bear Creek Burial Grounds WMA.

Exit-Pathway Monitoring

Exit-pathway monitoring began in 1989 to provide data on the quality of groundwater and surface water exiting the BCHR. The Maynardville Limestone is the primary exit pathway for groundwater. Bear Creek, which flows across the Maynardville Limestone in much of the BCHR, 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. Efforts to expand the exit-pathway monitoring well network in the Maynardville Limestone were continued during 1991. A total of 16 wells were installed along 3 dip-parallel traverses, or pickets, across the formation. Shallow wells along each picket were drilled to intercept specific stratigraphic zones thought to be susceptible to dissolution. Deeper wells were installed to monitor the down-dip projection of these zones.

Groundwater quality data obtained during 1991 from the exit-pathway monitoring wells suggest that the horizontal and vertical extent of groundwater contamination in the Maynardville is greater than previously reported. Nevertheless, the 1991 data obtained from wells located along the westernmost picket indicated that contaminated groundwater generally does not occur beyond the western side of the Bear Creek Burial Grounds WMA.

Surface water samples were collected quarterly from a northern tributary of Bear Creek (the background location), from four springs that discharge groundwater to the creek, and from four points along the main creek channel (Fig. 5.20). A preliminary review of the 1991 data indicates that water in upper reaches of Bear Creek contains many of the compounds found in the groundwater. However, the concentrations in the creek rapidly decrease with distance downstream of the waste disposal sites.

Nitrate concentrations in Bear Creek exceeded the MCL during 1991 from south of the S-3 Site to west of the Bear Creek Burial Grounds at BCK 9.40. The average nitrate concentration in surface water samples collected from the farthest downstream point (BCK 0.63 at 4 mg/L), which is located just upstream of the confluence of Bear Creek and East Fork Poplar Creek, was below the MCL but above background (about 0.2 mg/L).

Low concentrations of VOCs (less than 10 μg/L) were detected in surface water samples collected from the upper reaches of Bear Creek. Compounds detected in samples from the creek were trichloroethene, tetrachloroethene, and 1,2 dichloroethene. Each of these compounds are primary components of the VOC plumes in groundwater in the regime.

Based on the 1991 data, uranium and strontium are the most common trace metal contaminants in Bear Creek. Concentrations of both metals exceeded background levels throughout reaches of the creek upstream of BCK 9.40. Moreover, uranium concentrations in the creek exceeded background levels at the farthest downstream sampling point (BCK 0.63).

Annual average gross alpha activity exceeded 15 pCi/L at all the sampling points along Bear Creek. Gross beta activity exceeded 50 pCi/L at each sampling location upstream of BCK 9.40 and was above background levels at the sampling stations downstream of BCK 9.40.

5.3.1.8 Chestnut Ridge Hydrogeologic Regime

The objectives of the 1991 groundwater monitoring program were (1) to delineate the vertical boundary of the VOC plume at the CRSP and (2) to continue monitoring for contaminant releases at the other waste managements sites in the regime. Groundwater quality data obtained in the CRHR during 1991 support previous monitoring results. The

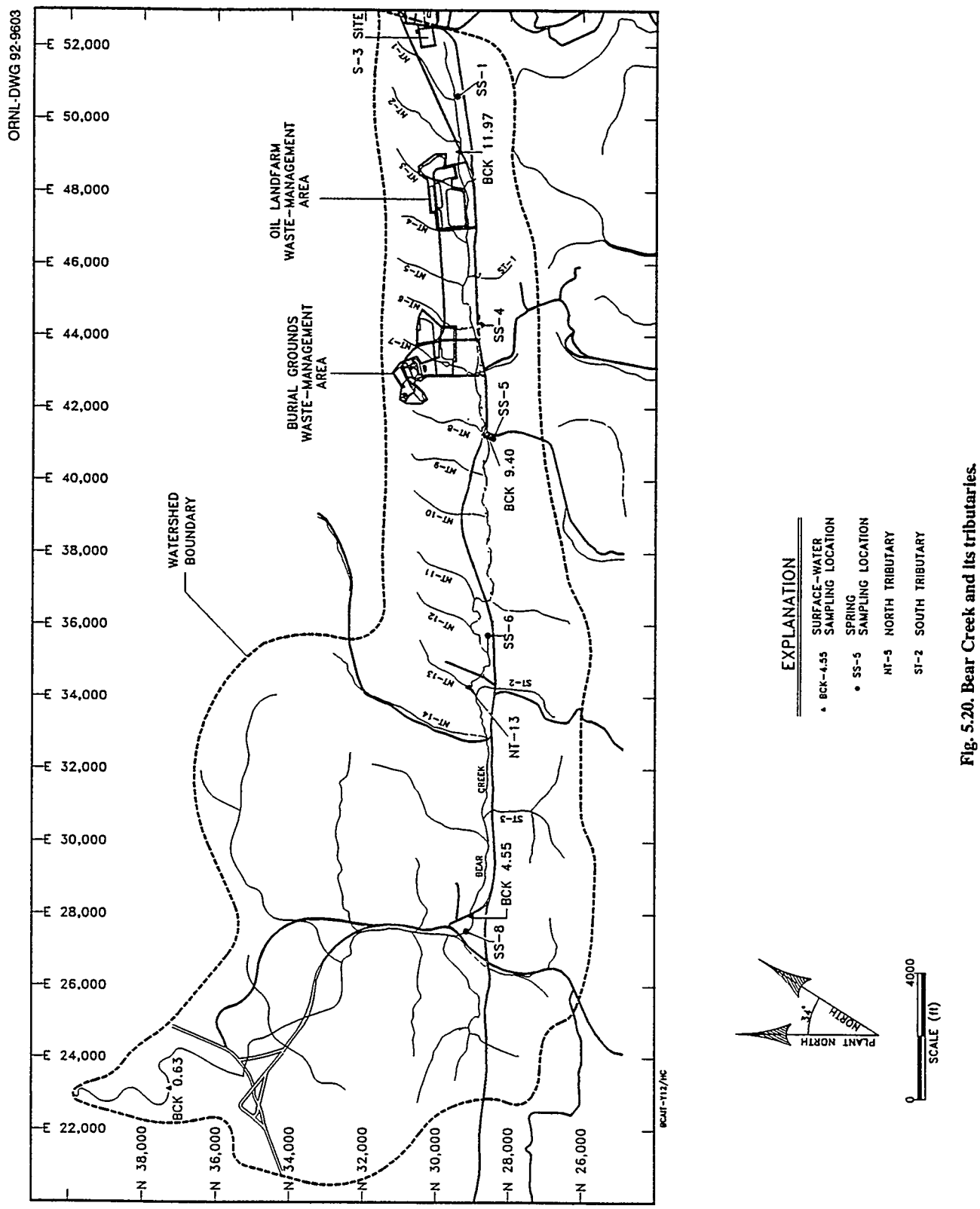

Fig. 5.20. Bear Creek and its tributaries.

only contaminants detected in the regime were VOCs; nitrate concentrations were within background levels in all wells, trace metal concentrations sporadically exceeded MCLs only in a few wells, and the annual average gross alpha and gross beta activities were below 15 and 50 pCi/L, respectively, in all wells.

Efforts to delineate the extent of VOCs in groundwater at the CRSP have been in progress since 1987. Groundwater quality data obtained during 1991 do not suggest any significant changes in the overall composition or extent of the VOC plume at the site.

There are two distinct VOC plumes in groundwater at the CRSP. In the eastern portion of the site the VOC plume is characterized by high concentrations of 1,1,1-trichloroethane. Tetrachloroethene is the principal component of the VOC plume in the western portion of the site. The distinct difference in the composition of the plume is probably related to differences in the types of wastes disposed in the eastern and western trench areas.

The highest VOC concentrations reported during 1991 for wells at the CRSP (about 500 μg/L) are consistent with previous data. A review of historical data suggests that VOC concentrations in groundwater at the site have generally decreased since 1988 (Fig. 5.21).

The extent of the VOC plume at the CRSP is reasonably well defined in the upper part of the aquifer (Fig. 5.22). Defining the vertical extent of the plume was an objective of the 1991 assessment program. To achieve this goal, a monitoring well (GW-742) was installed at the site to a depth of 420 ft. The well was completed late in the fourth quarter of 1991 and sampled during the first quarter of 1992. Low concentrations of VOCs were detected in groundwater samples collected from wells at Industrial Landfills II and III, the ECRWP, the ADB, and KHQ (Fig. 5.22).

Chloroform and methylene chloride were detected in samples from Well GW-295 at Industrial Landfill III and Well GW-293 at the ECRWP. Both compounds are common laboratory reagents and these results may be artifacts of sampling and analysis.

Samples collected from a monitoring well (GW-512) located upgradient of the ADB contained low levels (less than 2 μg/L) of 1,1,1-trichloroethane. This compound is a primary component of the VOC plume upgradient of the site at the CRSP, which is the probable source of 1,1,1-trichloroethane in Well GW-512.

Monitoring well 1085, located near Industrial Landfill II, contained low concentrations of several VOCs including 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, tetrachloroethane, and 1,1,1-trichloroethane. These compounds have been detected in previous samples collected from the well. The source of these compounds has not been identified.

Well GW-142 at KHQ contained low levels (less than 1 μg/L) of tetrachloroethane. Samples collected from a second well at the site (GW-144) contained low concentrations (less than 5 μg/L) of tetrachloroethane and carbon tetrachloride. Comparable concentrations of these compounds have been reported for samples collected from these wells since the third quarter of 1990. Significance of these results are being evaluated in light of the ongoing detection monitoring activities.

5.3.2 Oak Ridge National Laboratory

5.3.2.1 Background

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes, and (2) piezometer wells used to characterize groundwater flow conditions. ORNL has established an Environmental Restoration Program (ERP) to provide comprehensive management of areas 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 remedial action site because their boundaries are indistinct and 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 group of multiple sites that are geographically contiguous and/or occur within hydrologically defined areas. WAGs allow the establishment of a suitably comprehensive groundwater and surface water monitoring system in

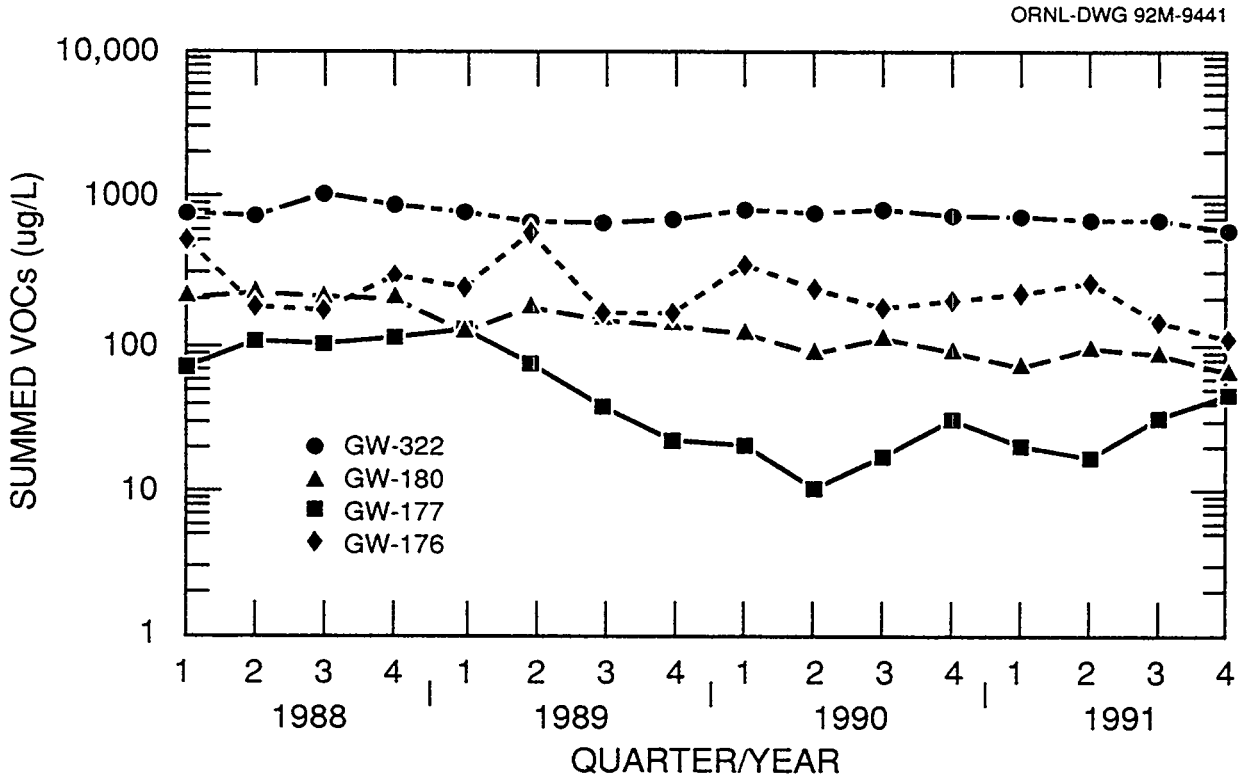

Fig. 5.21. Concentrations of volatile organic compounds in monitoring wells at the Chestnut Ridge Security Pits, 1988–1991.

a far shorter time than that required to deal with every facility, site, and SWMU individually. Some WAGs share common boundaries, but each WAG represents distinct small drainage areas within which similar contaminants may have been introduced. Monitoring data from each WAG will 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. 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 are being considered separately (instead of expanding the area of the WAG). Water quality monitoring wells are being established around the perimeter of the WAGs determined to have a potential for the release of contaminants. Table 5.5 lists the 20 WAGs at ORNL and the number of potential remedial action sites within each WAG. Figure 5.23 shows the location of each of the 20 WAGs.

WAG 1

WAG 1, the ORNL main plant area, contains about one-half of the remedial action sites identified to date by the ERP. WAG 1 lies within the Bethel Valley portion of the WOC drainage basin. The boundaries of the basin extend to the southeast and northeast along Chestnut Ridge and Haw Ridge. The WAG boundary extends to the water gap in Haw Ridge. The total area of the basin in Bethel Valley is approximately 2040 acres. The location of WAG 1 is shown in Fig. 5.23. Bedrock beneath the main plant area is limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group (see Sect. 1.4).

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 over 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 SWMUs are related to ORNL's solid and liquid radioactive waste management operations.

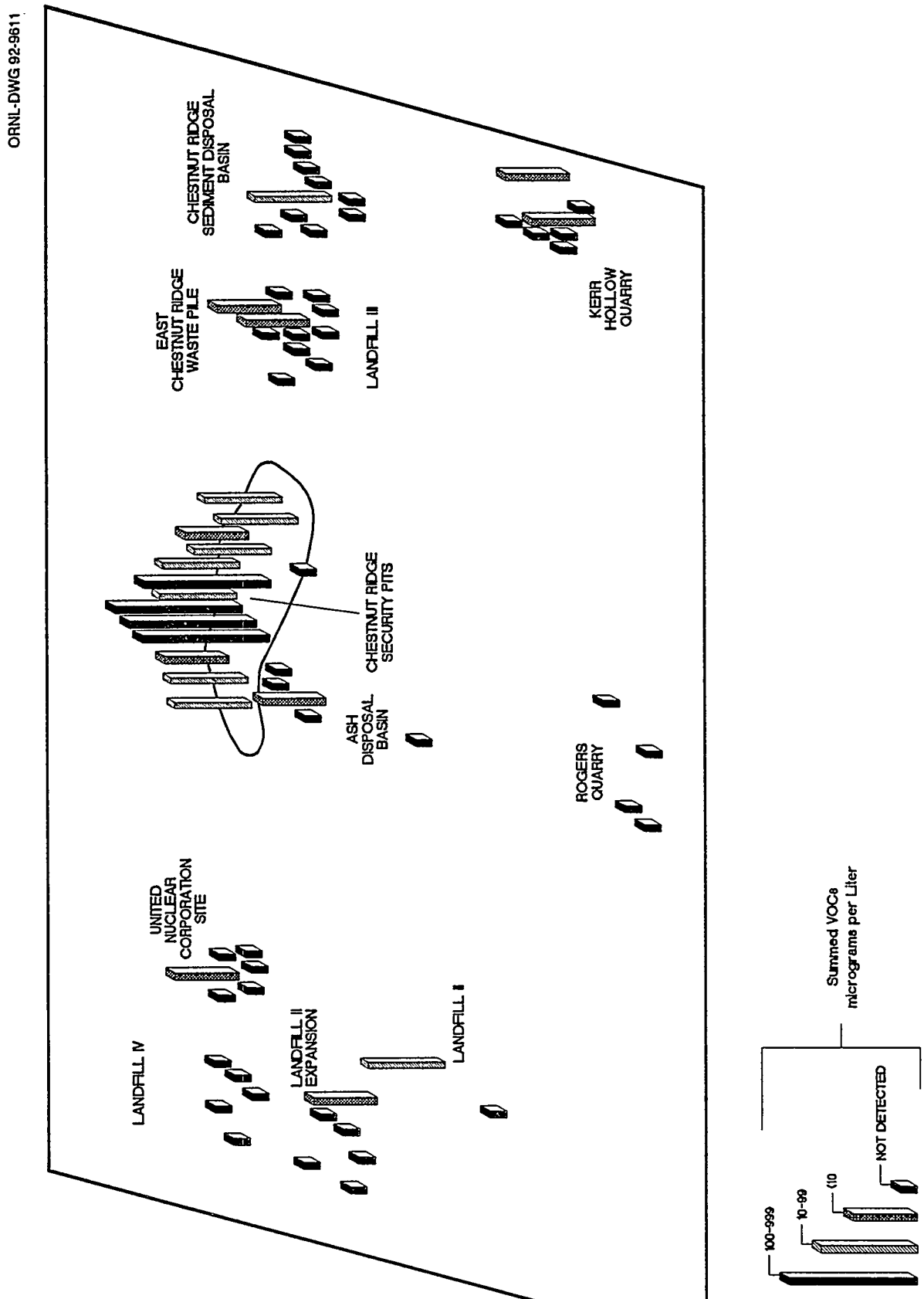

Fig. 5.22. Volatile organic compounds in groundwater in the Chestnut Ridge Hydrogeologic Regime.

WAG 2

WAG 2 is comprised of WOC 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 SWMUs: one which is the area encompassed by the stream channels of WOC and Melton Branch and the other includes White Oak Lake, White Oak Dam, and the embayment. The location of WAG 2 is shown in Fig. 5.23.

In addition to natural drainage, WOC has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the NRWTF, the STP, and a variety of process waste holdup ponds throughout the ORNL main plant area (WAG 1). It also receives groundwater discharge and surface drainage from WAGs 3, 4, 5, 6, 7, 8, 9, and 17.

There is little doubt that WAG 2 represents a source of continuing contaminant release (radionuclides and/or hazardous chemicals) to the Clinch River. While 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 3

WAG 3 is located in Bethel Valley about 1 km (0.6) mile west of the main plant area (Fig. 5.23). WAG 3 is composed of three SWMUs: 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, but it continued to be used as an

Table 5.5. Summary of ORNL waste area groupings, 1991

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	LLW pits and trenches area	19
8	Melton Valley area	35
9	Homogeneous reactor experiment (HRE) 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 (TSF)	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 land farm	1
	Total	279
	Additional Sites	
c	Surplus-contaminated facilities	29

[a]*Source:* July 18, 1991, letter from Lanny Bates, Director Environmental Restoration, to Robert Sleeman, DOE-OR.
[b]Principal sites located underground beneath WAG 5.
[c]Not applicable.

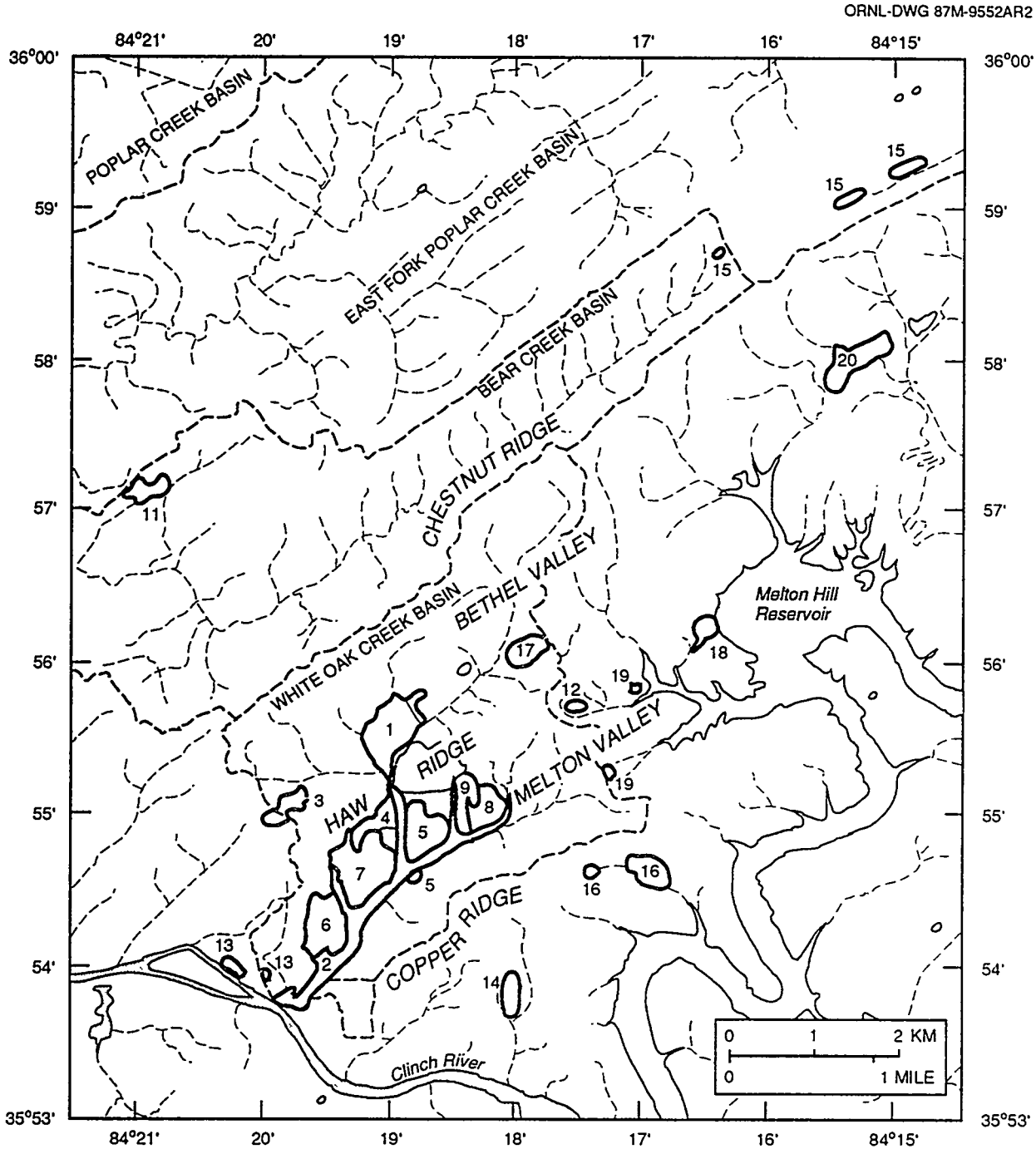

Fig. 5.23. Locations of ORNL waste area groupings (WAGs).

above-ground scrap metal storage area until 1979. Sometime during the period 1946–1949, radioactive solid wastes removed from SWSA 2 were buried at this site. In 1979, most of the scrap metal stored above ground at SWSA 3 was either transferred to other storage areas or buried on-site in a triangular-shaped disposal area immediately south of SWSA 3.

Records of the composition of radioactive solid waste buried in SWSA 3 were destroyed in a fire in 1961. Sketches and drawings of the site indicate that alpha and beta-gamma wastes were segregated and buried in separate areas or trenches. Chemical wastes were probably also buried in SWSA 3 because there are no records of disposal elsewhere. Although the information is sketchy, the larger scrap metal equipment (tanks, drums, etc.) stored on the surface at this site was also probably contaminated. Because only a portion of this material is now buried in the Closed Scrap Metal Area, it is not possible to estimate the amount of contamination that exists in this SWMU.

The Contractors' Landfill was opened in 1975 and is used to dispose of various uncontaminated construction materials. No contaminated waste or asbestos is 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 4

WAG 4 is located in Melton Valley approximately 0.8 km (0.5 mile) southwest of the main ORNL plant site (Fig. 5.23). It is comprised of 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 contaminated wastes in 1951. From 1955 to 1963, Oak Ridge was designated by the Atomic Energy Commission (AEC) as the Southern Regional Burial Ground; as such, SWSA 4 received a wide variety of poorly characterized wastes (including radioactive waste) from approximately 50 agencies. These solid wastes consisted of paper, clothing, equipment, filters, animal carcasses, and related laboratory wastes. Approximately 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.

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 from 1954 to 1975. 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

WAG 5 is located directly south of the ORNL main plant in Melton Valley (Fig. 5.23). Geologically, WAG 5 is within the White Oak Mountain thrust block and is underlain by strata of the Middle to Late Cambrian Conasauga Group. This WAG contains 28 sites, 13 of which are tanks that were used to store liquid LLW 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 (TRU) 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 (PWTP). At present, 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 AEC. At the time SWSA 5 burial operations were initiated, a portion of the site, approximately 10 acres, was set aside for the retrievable storage of TRU 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 SWMUs: (1) SWSA 6, (2) the emergency waste basin, and (3) the explosives detonation trench. The location of WAG 6 is shown in Fig. 5.23. SWSA 6 is located in Melton Valley, northwest of White Oak Lake and southeast of Lagoon Road and Haw Ridge. The site is approximately 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. A variety of radioactive and chemical wastes were buried in trenches and auger holes. The emergency waste basin was constructed in 1961 to provide storage of wastes that could not be released from ORNL to WOC. The basin is located northwest of SWSA 6, and has a capacity of 15 million gal. To date the basin has not been used. Radiological sampling of the small drainage from the basin has shown the presence of some radioactivity. The source of this contamination is not known.

WAG 6 was the first WAG to be investigated at ORNL by the Environmental Restoration Program. The RCRA Facility Investigation Report for WAG has been completed and is documented in 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 (Fig. 5.23). The major sites in WAG 7 are the seven pits and trenches used from 1951 to 1966 for the disposal of liquid LLW. 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 acid solutions containing enriched uranium (primarily) from Homogeneous Reactor Experiment (HRE) fuel.

WAG 8

WAG 8 is located in Melton Valley, south of the main plant area (Fig. 5.23), and is comprised of 35 SWMUs that are associated with the reactor facilities in Melton Valley. The SWMUs consist of active LLLW collection and storage tanks; leak/spill sites; a contractors soils area; radioactive waste ponds and impoundments; chemical and sewage waste treatment facilities; a chemical-waste SWSA, and a mixed-waste SWSA. WAG 8 includes the Molten Salt Reactor Experiment (MSRE) facility and the High Flux Isotope Reactor (HFIR), the Transuranium Processing Plant, and the Thorium-Uranium Recycle Facility (TURF).

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, drainage from the compartmental areas of filter pits, etc.

WAG 9

WAG 9 is located in Melton Valley about 1 km (0.6 miles) southeast of the ORNL main plant area (Fig. 5.23) and northeast of WAG 8. WAG 9 is comprised of three SWMUs: the HRE 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 the treatment of sewage from Building 7501.

Because of the small number of groundwater monitoring wells in WAG 8 (9 wells) and WAG 9 (2 wells), they are sampled together. The analytical results for the two WAGs are also reported together.

WAG 11

The White Wing Scrap Yard (WAG 11) is a roughly 30-acre, largely wooded area located in the McNew Hollow area on the western edge of East Fork Ridge (Fig. 5.23). 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 occurs southwest of the fault and overlies the younger Ordovician age Chickamauga Limestone northeast of the fault. There is only one SWMU in WAG 11.

White Wing Scrap Yard was used for the above-ground 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, and assorted large pieces of steel, stainless steel, and aluminum, as well as reactor cell

vessels removed during the 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 a combination of the disposal of contaminated materials in ORNL's SWSA 5 and 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.

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 required to support ORNL's routine and experimental operations. It is comprised of eight SWMUs: 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.

5.3.2.2 ORNL 1991 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. One hundred seventy-three perimeter monitoring wells have been installed for the WAGs. As remedial investigations proceed, characterization wells will be installed inside the WAG perimeters to investigate contaminant transport.

SWSA 6 is the only currently operating disposal area for low-level radioactive waste at ORNL. Interim-status assessment monitoring of groundwater under RCRA regulations was conducted semiannually for 1991. The remaining WAGs are currently remedial action sites regulated under RCRA 3004(u), which does not specify sampling schedules. ORNL has plans to sample groundwater quality monitoring (GQM) wells at the remaining WAGs on a semiannual schedule.

In December 1989, a groundwater quality assessment plan (GWQAP) was submitted through DOE for transmission to TDEC and EPA. The plan describes the general field investigation approach for assessment monitoring and the detailed sampling and analysis plan to be used in defining the horizontal and vertical extent of the contaminant plume, characterization of contaminants, and rates and directions of movement. The first annual *Groundwater Quality Assessment Report for SWSA 6 for 1990* was submitted to TDEC in March 1991. The report recommended a revised sampling strategy based on results of the analyses. Ten wells were sampled quarterly for volatile organics and radioactivity parameters. The other 16 wells were sampled quarterly for indicator parameters.

5.3.2.3 ORNL groundwater monitoring results

ORNL groundwater data are summarized for each WAG in Tables 5.15–5.25 of Vol. 2. The results for detected analytes are presented by well type (i.e., upgradient and downgradient). Each table presents the number of analytes detected out of the total number of samples, summary statistics for those detected, and the number of values that exceeded regulatory reference values. Various prefixes with different meanings precede the maxima and minima, "J" (below quantification, estimated), "B" (found in the associated laboratory blank), "JB" (estimated and found in associated laboratory blank), "E" (value exceeded instrument calibration range, estimated), and "Y" (value from reanalysis after dilution when

calibration range exceeded). Five times the analytical detection limit was used as a rough rule for assessing the presence of organic contaminants.

All radionuclide values are corrected for background. The presence or absence of a radionuclide was determined by comparing the corrected value to its counting uncertainty. A value exceeding 1.645 times its estimated standard error was declared greater than zero and considered to be a detected value.

Groundwater and its related quality are not regulated like other environmental media (e.g., surface water by NPDES, air by CAA). Consequently, there are no mandated groundwater quality criteria. In an effort to provide a basis for evaluation of analytical results and for assessment of groundwater quality at ORNL WAGs, drinking water limits and DOE DCGs have been used in preparation of the data tables in Vol. 2 and their related discussions in Vol. 1. It should be emphasized that, while drinking water limits are used herein, it is unrealistic to assume that members of the public are going to drink groundwater from ORNL WAGs.

Sampling and analyses have been conducted for several years at WAG 6 and WAG 1. WAG 6 is an active disposal area, and WAG 1 is considered a high-priority location for investigation. The investigations at the other WAGs have been initiated in order to collect preliminary data. They are lower priority sites and consequently are represented by less information at this time.

WAG 1 Results

The 27 perimeter wells in WAG 1 have been sampled six times, including once in March 1991. A summary of the analytical results is presented in Table 5.15 of Vol. 2. Well 817 was dry during the sampling period; results for the remaining 26 wells are summarized in the table.

Radionuclides have been detected in a number of the wells: ^{3}H, total radioactive strontium, ^{234}U, gross alpha, and gross beta activities above drinking water limits. The highest levels of radioactivity continue to be observed in Well 812, located in the northwest plant area. Gross alpha activity (260 pCi/L unfiltered, 300 pCi/L filtered) apparently consists mainly of ^{234}U (300 pCi/L unfiltered and filtered) and, to a lesser extent, ^{235}U and ^{238}U—both less than 10 pCi/L. Gross beta activity at Well 812 (14,000 pCi/L unfiltered and filtered) apparently consists mainly of total radioactive strontium (6,800 pCi/L unfiltered, 6,500 pCi/L filtered). The other wells containing elevated gross beta activity are 806, 830, 829, and 946 in the southwest plant area, where observed concentrations of total radioactive strontium exceeded the drinking water limit for ^{90}Sr. Concentrations of ^{3}H at Well 830 have steadily decreased from levels above drinking water limits to less than 5% of the drinking water limit in 1991.

Most of the downgradient and one of the upgradient wells show evidence of volatile organic contamination. Trichloroethane was detected at one downgradient well (813) in the northwest main plant area. Its tested level of 6 μg/L slightly exceeds the primary drinking water limit of 50 mg/L. Pesticides and PCBs were detected at a few of the downgradient wells and one upgradient well. None of the results for metals exceeded the primary drinking water standards.

WAG 2 Results

The 18 perimeter wells at WAG 2 were sampled for the first time during June 1991. A summary of the analytical results is presented in Table 5.16 of Vol. 2. At WAG 2, most of the downgradient wells are to the west and downstream. The upgradient wells are to the east and upstream. As was discussed in Section 5.3.2.1, WAG 2 receives contamination from many other WAGs, and this seems to be reflected in the data for many of the WAG 2 wells. For example, four of the WAG 2 wells that exhibited high levels of ^{3}H are Well 1152 (270,000 pCi/L unfiltered, 300,000 pCi/L filtered), an upgradient well south of WAG 8; Wells 1191 (180,000 pCi/L unfiltered and filtered) and 1190 (57,000 pCi/L unfiltered and filtered), downgradient wells south of WAG 6; and Well 1156 (130,000 pCi/L unfiltered, 120,000 pCi/L filtered), a well downgradient of WAG 5. All of the WAG 2 wells show evidence of radioactive contamination, including gross alpha and gross beta activity and ^{3}H. In addition to the four wells that had elevated levels of ^{3}H, gross alpha activity slightly above primary drinking water limits was detected at Well 1152 (19 pCi/L filtered), south of WAG 8. At Well 1191, south of WAG 6, the elevated gross beta activity concentration (1,600 pCi/L unfiltered and filtered)

apparently consists mainly of total radioactive strontium (860 pCi/L unfiltered, 760 pCi/L filtered). The total radioactive strontium concentration (9.5 pCi/L) at upgradient Well 1153, east of WAG 8, exceeds the primary drinking water limit of 8.0 pCi/L. The elevated levels of tritium and total radioactive strontium in the perimeter wells at WOD are believed to be the result of surface water underflow at the dam, not groundwater contamination.

Low levels of volatile organic contamination were detected at more than half of the wells, but none exceeded regulatory limits. Nitrate (13 mg/L unfiltered) was detected at a level that exceeded primary drinking water limits at downgradient Well 1192, south of SWSA 6. Chromium (0.063 mg/L unfiltered) and nickel (0.18 mg/L unfiltered and filtered) were detected at levels slightly above Tennessee general water quality criteria at Well 1192. No other wells had results for metals that exceeded regulatory limits.

WAG 3 Results

The 15 perimeter wells at WAG 3 were sampled for the first time during August 1991. A summary of the analytical results is presented in Table 5.17 in Vol. 2. Well 1247 was dry during the sampling period; results for the remaining 14 wells are summarized.

WAG 3 is located on a north-facing slope with its upgradient wells to the south. The long axis of the site runs east–west; consequently, most of the downgradient wells are along the northern border. Total radioactive strontium is present along the entire perimeter of the site, including the upgradient locations. Values exceeding the primary drinking water limit were observed on the northern perimeter at Wells 994 (650 pCi/L unfiltered, 620 pCi/L filtered), 993 (150 pCi/L unfiltered, 130 pCi/L filtered), 992 (140 pCi/L unfiltered and filtered), and 997 (100 pCi/L unfiltered, 84 pCi/L filtered). Apparently, the gross beta signatures are mainly attributable to total radioactive strontium. The data for the east and northeast boundaries show evidence of volatile organic and radioactive contamination, including trichloroethane (18 μg/L at Well 985, which exceeds the primary drinking water limit), ^{3}H, and gross alpha activity (16 pCi/L unfiltered at well 985, which exceeds the primary drinking water limit). The data for the northwest boundary show the presence of 1,1,1-trichloroethane and ^{3}H (32,000 pCi/L unfiltered and filtered at Well 994, which exceeds the primary drinking water limit). None of the results for metals exceeded the primary drinking water standards.

WAG 4 Results

The 15 perimeter wells at WAG 4 were sampled for the first time in 1991—once between March and April, the second time in December. A summary of the analytical results is presented in Table 5.18 in Vol. 2. WAG 4 is located on a south-facing slope with its upgradient wells to the north. The long axis of the site runs east–west. Consequently, the downgradient wells are along the southern border. All of the WAG boundaries show evidence of volatile organic and radioactive contamination, including gross alpha and gross beta activity and ^{3}H. The eastern boundary shows the highest levels of radioactivity; and the highest ^{3}H values in Wells 958 (7,800,000 pCi/L to 11,000,000 pCi/L) and 957 (6,200,000 pCi/L to 7,800,000 pCi/L). Values in other wells on that boundary range up to 510,000 pCi/L. Concentrations of radioactive strontium value were highest in Well 956 (510 pCi/L to 590 pCi/L), while other values observed did not exceed 35 pCi/L.

Concentrations of 1,1-dichloroethene, 1,2-dichloroethene, trichloroethene, and vinyl chloride are present on the east boundary. In particular, Wells 954 and 958 show levels of 1,2-dichloroethene up to 490 μg/L, 1,1-dichloroethene values up to 24 μg/L, trichloroethene levels up to 170 μg/L, and vinyl chloride levels up to 1,400 μg/L.

Nickel was detected at levels slightly above Tennessee general water quality criteria at five downgradient wells on the eastern boundary. No other wells had results for metals that exceeded regulatory limits. Fluoride was detected once at a level that exceeded primary drinking water limits at one eastern downgradient well.

WAG 5 Results

The 22 perimeter wells at WAG 5 were sampled during June and July 1991. A summary of the analytical results is presented in Table 5.19 in Vol. 2. (In addition to the following discussion of WAG 5

results, the discussion of WAG 2 results raises the possibility of contamination of WAG 2 from WAG 5.) Wells in WAG 5 have been sampled twice.

WAG 5 is the main source of ^{3}H seepage to Melton Branch. Tritium contamination is particularly prevalent on the south and west boundaries (Wells 969-977), with values ranging from 760,000 pCi/L at Well 970 to 260,000,000 pCi/L at Well 973. The exception to this is Well 972 (180,000 pCi/L), the closest neighbor to Well 973.

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; concentrations range up to 540 pCi/L at Well 975.

Alpha activity above drinking water standards was observed on the south and west boundaries with the highest concentrations at Wells 977 and 978 (150 pCi/L).

VOC were detected on the south and west boundaries, including 1,2-dichloroethene, vinyl chloride, trichloroethene, benzene, and carbon disulfide. At Well 978 vinyl chloride was measured at 4,700 µg/L, 1,2-dichloroethene at 2,600 µg/L, trichlorothene at 40 µg/L, and benzene at 29 µg/L.

WAG 6 Results

Ten of the 26 perimeter wells at WAG 6 are of major concern with respect to volatile organic and radioactive contamination, and they were sampled during February, September, and December 1991. The remaining 16 wells were sampled during February and December 1991. A summary of the analytical results is presented in Tables 5.20 and 5.21 in Vol. 2. (In addition to the following discussion of WAG 6 results, the discussion of WAG 2 results raises the possibility of contamination of WAG 2 from WAG 6.)

Results obtained during the 1991 sampling periods were comparable to those obtained during 1988 and 1989 detection monitoring and 1990 assessment monitoring.

The 10 wells of major concern are wells on the northeast perimeter or are additional wells east of SWSA 6 in WAG 2 adjacent to WAG 7. Volatile organic compound contamination is apparently isolated in the area around Wells 842 and 841. During 1991, 1,2-dichloroethane (11 µg/L to 19 µg/L), carbon tetrachloride (40 µg/L–65 µg/L), and trichlorothene (220 µg/L–330 µg/L) were detected at Well 842 above drinking water limits. Trichloroethene was measured above the drinking water limit (7 µg/L) at Well 841 during the third sampling period.

Elevated levels of ^{3}H are found along the eastern and southern perimeters ranging up to 120,000 pCi/L at Well 842 within SWSA 6, and up to 2,100,000 pCi/L at Well 1243 to the east of SWSA 6. Total radioactive strontium has been detected above drinking water limits at the wells of concern up to 54 pCi/L at Well 841. Cobalt-60 was found at levels exceeding drinking water limits only in the wells to the east of SWSA 6, up to 970 pCi/L at Well 1243.

WAG 7 Results

The 16 perimeter wells at WAG 7 were sampled for the second time during April and May 1991. A summary of the analytical results is presented in Table 5.22 of Vol. 2.

Hydrogen-3 appears to be prevalent in most wells but is highest along the west perimeter next to SWSA 6 (up to 1,100,000 pCi/L at Well 1076).

Wells 1078 and 1079 have gross beta activity that is not attributable to radioactive strontium, ^{60}Co, or ^{137}Cs. In 1990, ^{99}Tc was determined to be the source of additional activity; however, ^{99}Tc analysis was not performed in 1991.

Nickel was detected at levels slightly above Tennessee general water quality criteria at two downgradient wells. No other wells had results for metals that exceeded regulatory limits. Fluoride and nitrate were detected at levels that exceeded primary drinking water limits at three downgradient wells.

WAGs 8 and 9 Results

The 11 perimeter wells at WAGs 8 and 9 were sampled for the first time during May and June 1991. A summary of the analytical results is presented in Table 5.23 in Vol. 2. (In addition to the following discussion of WAGs 8 and 9 results, the discussion of WAG 2 results raises the possibility of contamination of WAG 2 from 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 four are between WAGs 8 and 9.

All of the perimeter wells show evidence of radioactive contamination. On the northwest perimeter, Well 1088 has ^{3}H contamination (68,000 pCi/L) and Well 1087 has total radioactive strontium contamination (up to 810 pCi/L). Total radioactive strontium levels exceed the drinking water limits at the wells between the WAGs (up to 760 pCi/L at Well 1096).

The data for two of the wells between the WAGs indicate the presence of gross beta activity attributable to total radioactive strontium. The data for most of the downgradient wells show evidence of volatile organic contamination. None of the data for the upgradient wells show evidence of volatile organic contamination. The results for metals do not exceed the primary drinking water standards.

WAG 11 Results

WAG 11 has gently rolling terrain. Upgradient wells are located north, east, and south of the WAG. The 11 perimeter wells were sampled in October and November 1991. A summary of the analytical results is presented in Table 5.24 of Vol. 2. Gross alpha and gross beta activity contamination is present along the entire perimeter of the site, including the upgradient locations. The data for the western boundary indicate the presence of ^{3}H and trichloroethene. The southeast boundary shows evidence of volatile organic contamination. Cadmium, chromium, and mercury were detected at levels slightly above Tennessee general water quality criteria at one downgradient well. No other wells had results for metals that exceeded regulatory limits.

WAG 17 Results

The eight perimeter wells at WAG 17 were sampled for the first time during April 1991. A summary of the analytical results is presented in Table 5.25 in Vol. 2. WAG 17 is located on a northwest facing slope with its upgradient wells on the eastern border and downgradient wells on the western border. The data for the east and west boundaries show evidence of radioactive contamination, including gross alpha and gross beta activity and ^{3}H. Gross alpha activity at Well 1197 (24 pCi/L) was the only value to exceed drinking water limits. The data for the southeast and southwest boundaries show evidence of volatile organic contamination. The contamination is primarily in Well 1201, but some is also present in Well 1202. The pollutants include trichloroethene; vinyl chloride; benzene; 1,2-dichloroethene; 1,1-dichloroethene; acetone; and tetrachloroethene. None of the results for metals exceeded the primary drinking water standards.

5.3.2.4 Future ORNL groundwater quality monitoring activities

The GWQAP for SWSA 6 will continue to be implemented in 1992. Wells 840-844, 847, and 1242 and 1243 will be sampled quarterly to further understand the extent of contamination at SWSA 6. The remaining wells at SWSA 6 will be sampled semiannually during 1992.

WAG 1, WAG 5, and WAG 7 will be sampled semiannually during 1992.

The planned sequence for sampling and analysis of groundwater from the remaining seven WAGs is based on the nature and inventory of contaminants at the WAG; near-term release potential; position relative to other potential, hydrologically upgradient sources; regulatory considerations; and costs and funding availability. The sequence as presently projected is WAGs 4, 2, 17, 8, 3, 9, and 11.

5.3.3 K-25 Site

5.3.3.1 Background

Groundwater monitoring is conducted at the K-25 Site by the Groundwater Protection Program (GWPP) for three basic reasons: (1) to meet DOE requirements and evaluate the effects of plant operations on groundwater, (2) to comply with RCRA interim status and permit requirements, and (3) to support the K-25 Site ERP efforts to characterize the extent and severity of contamination caused by past practices. All three monitoring categories are integrated to develop an effective plantwide groundwater monitoring strategy. Presently, the K-25 Site includes 204 groundwater monitoring wells within 14 operable units and two RCRA sites. The entire K-25 Site has been coordinated into 13 natural, hydrogeologically defined WAGs for GWPP investigative purposes. Table 5.6 lists the 13 WAGs

Table 5.6. Summary of K-25 Site Waste Area Groupings (WAGs)

WAG	Description	Waste Management Sites	Number of wells
1	K-1700 Area	K-1407-A K-1407-B K-1407-C K-1070-B K-1401 K-1413 K-1420 K-1070-C,D K-1503	53
2	K-1004 Area	K-1070-C,D K-1414 K-1004-J K-1004-Drain K-1004-L K-1004-N K-1007	57
3	K-1099 Area	K-1099	1
4	K-1064 Area	K-1064-G	12
5	K-1410 Area	K-1410	2
6	K-1232 Area	K-1232	6
7	K-27/29 Area	K-27/29 K-832-H K-1203	12
8	K-1070-F	K-1070-F	5
9	K-31/33	K-31 K-33 K-862-E K-892-G,H K-892-J	22
10	K-901-A Area	K-901-A K-1070-A	18
11	K-770 Area	K-770	7
12	K-720 Area	K-720	4
13	K-1085 Area	K-1085	5

and the number of individual sites within each WAG. Figure 5.24 shows the locations of each of the WAGs.

Analyses of samples from many groundwater wells throughout the plant area indicate high concentrations of iron and manganese in the groundwater. In general, these constituents are not considered when assessing contamination of the area because they occur naturally in high concentrations in the underlying geologic formations. Summaries of the 1991 groundwater monitoring data for the K-25 Site are presented in Tables 5.26–5.30 of Vol. 2. These data tables include the parameters for which concentrations above detection limits were identified. The reference values used in the table include recent MCLs and primary and secondary drinking water standards.

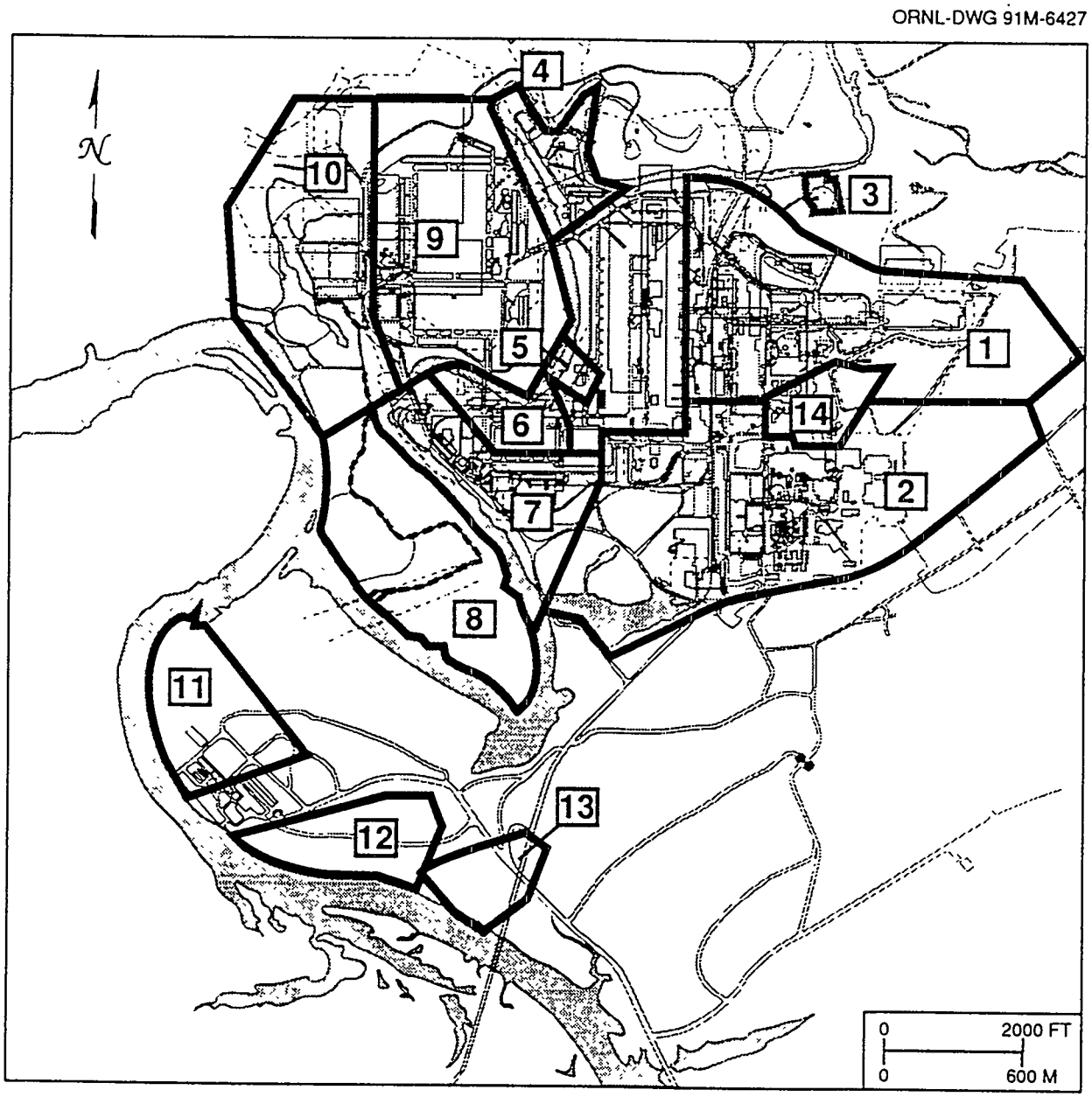

Fig. 5.24. Locations of waste area groupings (WAGs) in the K-25 Site area.

WAG 1

K-1407-B Pond

The K-1407-B Pond is a RCRA interim status unit currently in detection monitoring. This surface impoundment was used for settling the metal hydroxide precipitates generated during the neutralization and precipitation of metal-laden solutions treated in the K-1407-A Neutralization Pit. Potential contaminants are heavy metals. The unit was removed from service during 1988 and is undergoing RCRA closure. A postclosure permit application has been submitted to TDEC.

Data that had indicated an increase of conductivity and total organic halogens (TOX) were analyzed in the report, *K-1407-B and K-1407-C Surface Impoundment False Positive Groundwater Assessment.* The report was approved by TDEC on March 10, 1989, and describes laboratory analyses from samples collected between November 1987 to December 1988. According to its recommendations, the monitoring program for both the B and C ponds was modified to remove the possibility for future false-positive readings.

K-1407-C Pond

The K-1407-C Pond is a RCRA interim status unit currently in detection monitoring. This surface impoundment was used primarily for storing potassium hydroxide scrubber sludge, although sludges from B-Pond also were placed here prior to 1973. Potential contaminants are heavy metals. The C-Pond is undergoing RCRA closure. The monitoring program for this unit also was changed to a modified detection program. This monitoring program for the C-Pond was approved on July 11, 1988.

K-1413 process lines and sumps

The K-1413 area includes four components: the K-1413-C Neutralization Pit, two smaller pits (sumps) located to the north and east of the K-1413 building, the lines from the pits to the K-1401 Acid Line, and the storm drains in the vicinity of the K-1413 building. The capacity of each of the sumps is about 500 to 1000 gal (1893 to 3785 L). Corrosive wastewater and metal hydroxides drain from the two sumps to K-1407-A for neutralization. Potential contaminants at the site include organic solvents and uranium from early uranium fluorination activities at the site.

K-1401 acid line and degreaser tanks

The K-1401 acid line is an underground vitreous clay pipeline used to transport corrosive fluids from the K-1491 degreaser tanks to the K-1407-A Neutralization Pit for neutralization. The K-1401 degreaser tanks are stainless steel tanks in brick-lined pits within a large concrete structure in the K-1401 building. Equipment is lowered into the tanks for degreasing, and trichloroethane is used as the solvent. Both of these facilities are still in use.

K-1420 oil storage area and process lines

The K-1420 oil storage area consists of a paved area 50 (15.2 m) by 275 ft (84 m), located 75 ft (23 m) north of the K-1420 building. Uranium-contaminated oil is stored at the facility in 19-L (5-gal) buckets for transfer to 55-gal (209-L) drums and is then transported to the waste-oil decontamination facility inside K-1420. The K-1420 process lines are underground pipelines that once connected K-1420 to the K-1407-B Pond for transport of radioactive liquid. One of the abandoned pipelines was found to contain PCBs, mercury, and uranium.

K-1503 Neutralization Pit

The K-1503 Neutralization Pit was used for neutralization of corrosive liquids generated in water-softening operations in the past. Currently, it is used only as a sump for temporarily holding corrosive liquids. It is approximately 10 ft^2 (3.1 m^2) by 12 ft (3.7 m) deep.

WAG 2

K-1414 Fuel Storage Center

The K-1414 Fuel Storage Center has had three steel USTs containing automotive fuel. One 5500-gal (20,818-L) tank contains unleaded gasoline, a second 12,000-gal (45,420-L) UST contains methanol, and the third UST was removed after it was found to be leaking diesel fuel in February 1987. An Environmental Assessment and a Remedial Action Program (RAP) were completed in 1989. The RAP was submitted to TDEC and was conditionally approved. A bioremediation system for this site has

been designed. Remedial activities are scheduled to begin in 1992.

K-1004 area laboratory drain, K-1004-l vaults, and K-1004-N cooling tower basin lines and RCW lines

The K-1004 area laboratory drain carries wastes from several laboratories to the K-1007-B Holding Pond. The drain was used for disposal of laboratory wastes prior to receipt of an NPDES permit in 1984. The drain is now used for disposal of rinse water only.

The K-1004-L vaults contain concrete casks that were used in the 1950s and 1960s for storage of reactor return samples. The K-1004-N cooling tower basin is a 30- to 40-year-old above-ground tank that is 21 ft (6.4 m) long by 21 ft (6.4 m) wide by 3 ft (0.9 m) deep. The K-1004-L RCW lines circulated cooling water between the K-1004-L building and the K-1004-N cooling tower. Potential contaminants are chromium zinc, phosphate, other heavy metals, and radioactivity.

K-1007 underground gasoline storage tank

The K-1007 gasoline storage tank was a 250-gal (946-L) tank located north of the K-1007 building. The top of the tank was 6 to 8 ft (1.8 to 2.4 m) below ground. Gasoline was observed in the soil surrounding the tank when it was excavated and removed in 1986. Contaminants expected from this source are volatile organic aromatics (VOAs), petroleum hydrocarbons, and lead.

WAG 3

WAG 3 consists of the area surrounding K-1099, Blair Road Quarry. The quarry is cut into the west end of east-trending McKinney Ridge and was used for burning radioactive-contaminated paper and wood prior to 1970.

WAG 4

WAG 4 consists of the K-1064-G Burn Area/Peninsula Storage Area, which was used in the 1950s and 1960s for burning 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.

WAG 5

WAG 5 consists of the K-1410 Neutralization Pit, a 15,800-gal (59,803-L) concrete tank used from 1975 to 1979 for the neutralization of nickel-plating solutions prior to discharge to Poplar Creek. Some of the other chemicals known to be included are nickel sulfate, degreaser bath, acid, and corrosive solutions.

WAG 6

WAG 6, the K-1232 Treatment Unit, consists of eight above-ground steel tanks and four in-ground concrete tanks used for pH adjustment and chemical precipitation of hazardous wastes. Potential contaminants include nitrates, heavy metals, organics, and uranium.

WAG 7

K-27 and K-29 RCW lines

Two RCW lines located in the WAG 7 are being investigated for possible groundwater contamination caused by leakage. RCW lines are underground steel pipes that circulated treated cooling water between the cooling tower basins and the process buildings. RCW lines K-27 and K-29 are buried from 3 to 10 ft (1 to 3 m) below grade and range from 16 to 64 in. (41 to 163 cm) in diam. Most were in use from the 1950s to 1985. Potential contaminants include chromium, zinc, phosphate, other heavy metals, and radioactivity.

K-832-H cooling tower basin

K-832-H is one of the cooling tower basins being evaluated for possible groundwater contamination. The basins are large, rectangular, concrete basins that are 300 to 400 ft (91.4 to 121.9 m) long, 50 to 65 ft (15 to 20 m) wide, and 13 to 16 ft (4 to 5 m) deep (mostly below grade). Capacities range from 2.4 to 5.8 million gal (9.1 to 22 million L). The basins underlie cooling towers and were used for recirculating chromate, zinc, and phosphate-treated cooling water.

WAG 8

WAG 8, 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, roofing material, concrete, asphalt, and asbestos. These materials were thought to be uncontaminated, but disposal records were not kept prior to 1977.

WAG 9

K-31 and K-33 RCW lines

Two additional RCW lines, K-31 and K-33, are being investigated for possible groundwater contamination by leakage.

K-862-E, K-892-G and H, and K-892-J cooling tower basins

Cooling tower basins K-862-E, K-892-G and H, and K-892-J are also being evaluated for possible groundwater contamination.

WAG 10

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. The pond was built in the early 1970s and was in use until 1985 for settling chromium-hydroxide (trivalent chromium) precipitates generated by electrochemical treatment of chromated RCW blowdown. The pond contains sludge composed of these chromium-hydroxide precipitates along with lead, nickel, copper, and uranium.

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 wastes were emptied into auger holes and trenches or buried in drums. Potential contaminants include chemicals, radioactivity, heavy metals, and some organics and oils.

WAG 11

WAG 11 consists of the K-770 Scrap Yard, which has been used since the 1960s for storage of radioactively contaminated scrap metal. Potential contaminants include radioactivity, PCBs, mercury, and asbestos.

WAG 12

The K-720 Fly Ash Pile (WAG 12) is located southwest of the K-25 Site near the east bank of the Clinch River. Fly ash was generated during the 1940s and 1950s by the nearby coal-powered steam plant. The pile covers an area of 4 to 6 ha (10 to 15 acres). Potential contaminants include heavy metals, sulfates, and radioactivity.

WAG 13 (K-1085 Firehouse Burn Area)

The K-1085 Firehouse Burn Area (WAG 13) 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 by burning waste oil in metal pans and excavated pits. Potential contaminants include waste oils, solvents, heavy metals, and uranium that may have contaminated the oils and petroleum products.

5.3.3.2 K-25 Site groundwater results

WAG 1 Results

Analytical results for WAG 1 data are summarized in Table 5.26 of Vol. 2.

K-1407-B Pond

Samples are usually collected at K-1407-B Pond wells semiannually, during the first and third quarters of the year. After first quarter sampling, the wells were resampled on three subsequent occasions (March 21, June 25, and July 10) and analyzed for total organic carbon (TOC), TOX, and VOCs. Monitoring Well UNW-4 was resampled on two separate occasions (June 25 and July 10) for the same constituents. In March and September, statistically significant concentrations of manganese were noted. However, the manganese concentrations are considered to be a reflection of the natural groundwater quality. Well UNW-5 also exhibited statistically significant concentrations of cadmium for the September sampling event. In accordance with the modified detection program, this well was resampled in December 1991. The second set of samples from this well indicated that the high cadmium concentration noted earlier was probably the result of sampling or laboratory error.

The upgradient well for the B-Pond, UNW-1, has shown significant increases in specific conductance. A trend of increasing specific conductance at this well has been noted since 1987, and it has been hypothesized to be indicative of approaching contaminants from an upgradient source.

K-1407-C Pond

Sampling for this site took place in March and September, as it did for the B-Pond. The results of statistical analysis selected parameters at the K-1407-C Pond indicated significant concentrations of manganese at Well UNW-9 for both the March and September sampling events. Also, a significantly higher concentration of iron was detected in UNW-10 compared to the background iron concentration in the same well. The observed increases in manganese and iron concentrations in downgradient wells are thought to reflect natural variation in geologic, chemical, and seasonal effects.

Wells in WAG 1, other than K-1407-B and K-1407-C ponds, were sampled once in June 1991. BRW-7, located adjacent to K-1407-B Pond exhibited high levels of volatile organics such as trichloroethene, 1,1,1-trichloroethane, and total 1,2-dichloroethene.

WAG 2 Results

Analytical results for WAG 2 data are presented in Table 5.27 of Vol. 2. Trichloroethene was detected in 17 of the 40 samples analyzed, with a maximum value of 340 μg/L at BRW-38.

WAG 3 Results

Analytical results for WAG 3 data are presented in Table 5.28 of Vol. 2. One monitor well exists in the Blair Road Quarry, and it shows little evidence of contamination. Analyses for radionuclides result in gross alpha values that are slightly above the primary drinking water levels.

WAG 4 Results

From all samples analyzed, only gross alpha and gross beta values were detected above drinking water standards in WAG 4. Analytical results for WAG 4 data are presented in Table 5.29 of Vol. 2.

WAG 10 Results

Analytical results for WAG 10 data are presented in Table 5.30 of Vol. 2. Carbon tetrachloride was found above detection limits in 6 of 21 samples and exceeded MCLs. Trichloroethene, 1,1,1-trichloroethane, and 1,1-dichloroethene were also detected the above MCLs. Gross alpha and gross beta were the only radioactivity values to exceed reference values.

5.3.3.3 Future K-25 Site Groundwater Protection Program activities

Few, if any, of the existing wells are considered to provide water-quality data truly representative of background conditions. This lack of background water-quality data makes interpretation of chemical data from the existing wells difficult. Eight proposed background wells have been located with the intent of intercepting each of the primary geologic units underlying the K-25 Site. An unconsolidated zone well will be paired with a bedrock well at each of four locations.

Four additional monitoring wells are proposed to complete the perimeter monitoring wells needed to intercept groundwater as it exits the K-25 Site. These four wells will be installed as two unconsolidated and bedrock well pairs.

5.4 PLUGGING AND ABANDONMENT

An open borehole or well may provide a potential route for surface contamination to enter previously uncontaminated groundwater. Transfer or spread of contamination from one zone to another occurs when an open borehole provides a pathway for contaminated water in an aquifer to enter or mix with that in an uncontaminated aquifer. Mixing in the subsurface can confuse monitoring results and spread contamination. To minimize the potential for groundwater cross-contamination, a program was initiated to identify, plug, and abandon unused, unnecessary, or damaged boreholes.

5.4.1 Y-12 Plant

On April 18, 1988, DOE received conditional approval from the TDEC of a plugging and abandonment procedure for selected groundwater wells at the Y-12 Plant.

In 1991, 19 existing groundwater monitoring wells were plugged and abandoned due to one or more of the following reasons:

- wells were not constructed to the standards outlined under current state and/or federal guidance documents,
- wells were damaged beyond repair, or
- wells were located in areas that impeded site operations or new construction.

Eleven of the plugged and abandoned wells were located in the UEFPCHR, two were located in the BCHR, and six were in the CRHR.

5.4.2 Oak Ridge National Laboratory

No wells were plugged and abandoned during 1991, but planning efforts were completed for activities to be initiated at SWSA 6 beginning in 1992 (Stansfield, R. G., et al.). At SWSA 6, 69 monitoring wells required for adequate closure monitoring will be retained at the site and approximately 699 wells will be plugged and abandoned.

A comprehensive inventory of all wells in the ORNL area was begun in late 1991 to identify wells that could be candidates for plugging and abandonment in the future. The inventory will be used in the development of a comprehensive plan for plugging and abandonment of wells not required by closure monitoring plans or ORNL programs.

5.4.3 K-25 Site

No wells were plugged and abandoned at the K-25 Site during 1991.

5.5 OFF-SITE MONITORING

In 1989, ORNL implemented a long-term, off-site residential drinking water quality monitoring program. The objective of the program, designed in conjunction with Energy Systems' Environmental Compliance (EC) Organization and the DOE Environmental Protection Division, is to document water quality from groundwater sources near the ORR. It also is used to evaluate the impact of DOE-OR plant operations on the quality of these groundwater sources.

Twenty-one wells 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. The selected wells, two located on the ORR and the others off-site, were sampled twice during 1991. Parameters used for monitoring include volatile organics; selected atomic absorption metals (As, Hg, Pb, Se); inductively coupled argon plasma metals; anions (fluoride, chloride, sulfate, nitrate, and nitrite); total fluorometric uranium; and the radioactive parameters gross alpha activity, gross beta activity, total radioactive strontium, ^{99}Tc, ^{3}H, and radionuclides observed in a gamma scan. These data are presented in Table 5.31 of Vol. 2.

Four of the wells had analyte concentrations that exceed primary drinking water standards. Those analytes were fluoride in one well (both sampling periods), nitrate in one well (both sampling periods), and total radioactive strontium in one well during the January sampling period. The high fluoride and accompanying high pH most likely result from natural chemical reactions that can occur in deep wells that penetrate the Conasauga geologic group. High nitrate concentrations often result from nearby farming operations.

In general, radionuclide concentrations listed for the off-site groundwater sampling locations are within normal ranges and well below drinking water standards. Two anomalous measurements of total radioactive strontium have occurred; however, the elevated levels have not been reproducible in the same sample, nor have they occurred in other samplings of the same wells.

Organic compounds were detected, but none was measured at levels near a primary drinking water standard. No values from off-site wells exceeded EPA's general risk assessment guidelines of ten times the detection limit for common laboratory contaminants or five times the detection limit for other organic compounds. At one well on the ORR boundary, toluene was detected at 56 µg/L, roughly 5% of the maximum contamination level. Two subsequent samplings of the well showed no toluene above the EPA guidelines for reporting.

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6. BIOLOGICAL MONITORING

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6. BIOLOGICAL MONITORING

Air and water are the principal dispersal media for Oak Ridge DOE facility releases. However, the environmental surveillance programs also include biotic media that may be affected by these releases or that may provide pathways of exposure to people. This section gives a summary of the media sampled, the types of analyses performed, and the sampling and analysis frequencies for the biological samples.

6.1 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 can be grazed daily by a cow, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

6.1.1 Sample Collection and Analytical Procedures

The 1991 milk sampling program consisted of monthly grab samples collected from five locations in the vicinity of the ORR. Figure 6.1 shows the locations of the stations.

Milk samples are analyzed at ORNL for ^{131}I by gamma spectrometry and for total radioactive strontium (^{89}Sr and ^{90}Sr) by chemical separation and low background beta counting.

6.1.2 Results

Concentrations of ^{131}I and total radioactive strontium in milk are summarized for the 1991 data in Table 6.1. The average values were converted to effective dose equivalents and are presented in Sect. 2 of this report. These results are consistent with data from previous years. The location-specific data are included in Tables 6.1 and 6.2 of Vol. 2.

6.2 FISH

Fish ingestion is also a pathway for contaminant uptake in humans. Prior to 1985, five species of fish were measured for PCBs, mercury, and radionuclide concentrations: bluegill, catfish, bass, carp, and crappie. The highest mercury and PCB concentrations were found in carp, and the next highest were found in bluegill. For several of the radionuclides, concentrations were highest in bluegill. Because of this and because of the large number of available fish, bluegill were collected during 1991 for tissue analysis to estimate concentrations for dose assessment models. Additional information on bioaccumulation of contaminants by fish is provided in the discussion of the Biological Monitoring and Abatement Programs (BMAPs), Sect. 6.5.

6.2.1 Sample Collection and Analytical Procedures

Bluegill (*Lepomis macrochirus*) were collected twice during the year for muscle tissue analyses of radionuclides, mercury, and PCBs by ORNL. Sampling locations included three Clinch River kilometer (CRK) locations (Fig. 6.2). The first location was CRK 40.0 (river mile 24.8), which is above Melton Hill Dam and serves as a background location for the DOE facilities. It is above all the Oak Ridge DOE facilities' outfalls with the exception of those from the ORNL 7600 area, the radioactive effluents from which are negligible. The second sampling location was CRK 33.3 (river mile 20.6), which is ORNL's discharge point from White Oak Creek to the Clinch River. The third location was CRK 8.0 (river mile 5), which is downstream from both ORNL and the K-25 Site.

The radionuclides of primary concern at ORNL regarding fish consumption are total radioactive

Table 6.1. 1991 ORNL radionuclide concentrations in raw milk[a]

Analysis	Number of samples	Concentration (pCi/L)			
		Max	Min	Av[b]	Standard error[c]
^{131}I	50	1.4	–2.2	–0.0065	0.10
Total Sr[d]	50	11	0.81	3.6*	0.31

[a]See Fig. 6.1.
[b]An asterisk (*) indicates that the average is significantly greater than zero at 95% confidence level.
[c]Standard error of the mean.
[d]Total radioactive strontium ($^{89}Sr + {}^{90}Sr$).

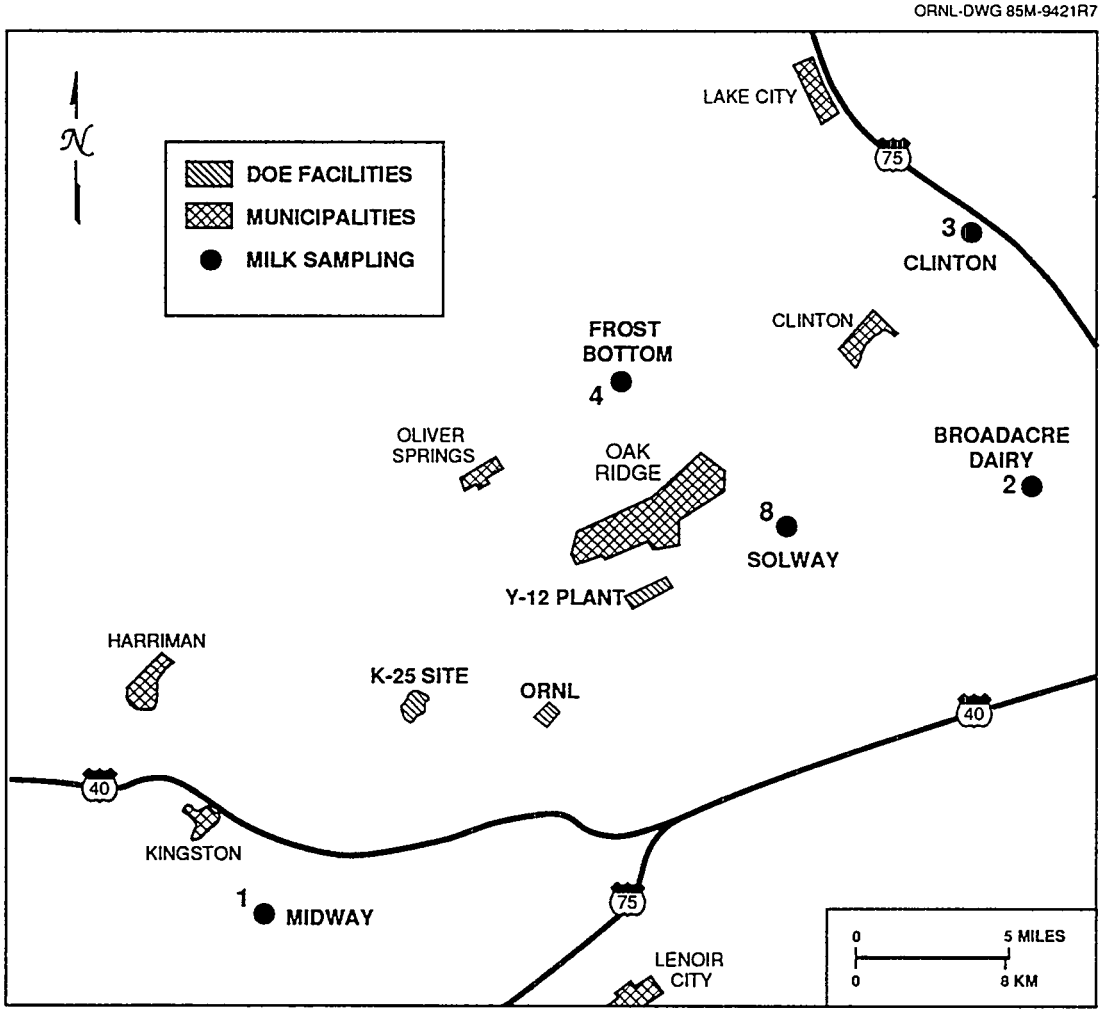

Fig. 6.1. Map showing milk sampling stations.

strontium and ^{137}Cs. These two isotopes typically result in the highest dose to man from ingestion of fish. Radionuclide concentrations were determined on at least three composites of six to ten fish per sampling period. Mercury and PCB concentrations were measured in six individual fish from each sampling location during each period. Each fish was filleted, and the muscle tissue was used for analysis. Composite samples were ashed and analyzed for the radionuclides that have typically contributed to the majority of the potential radionuclide dose to humans.

The ash typically constitutes 1% of the original sample. DOE Order 5400.1 requires that concentrations be reported in pCi/g ash weight. The 1991 concentration data have also been converted to a wet weight basis; they are presented in Vol. 2, Table 6.5.

6.2.2 Results

Concentrations of mercury, total PCBs, ^{60}Co, ^{137}Cs, and total radioactive strontium in bluegill collected in the Clinch River are given in Table 6.2, which provides a summary of the highest, lowest, and average concentrations of these parameters observed in bluegill from any of the three Clinch River locations sampled. Information regarding potential health impacts associated with these data is provided in Sect. 2.

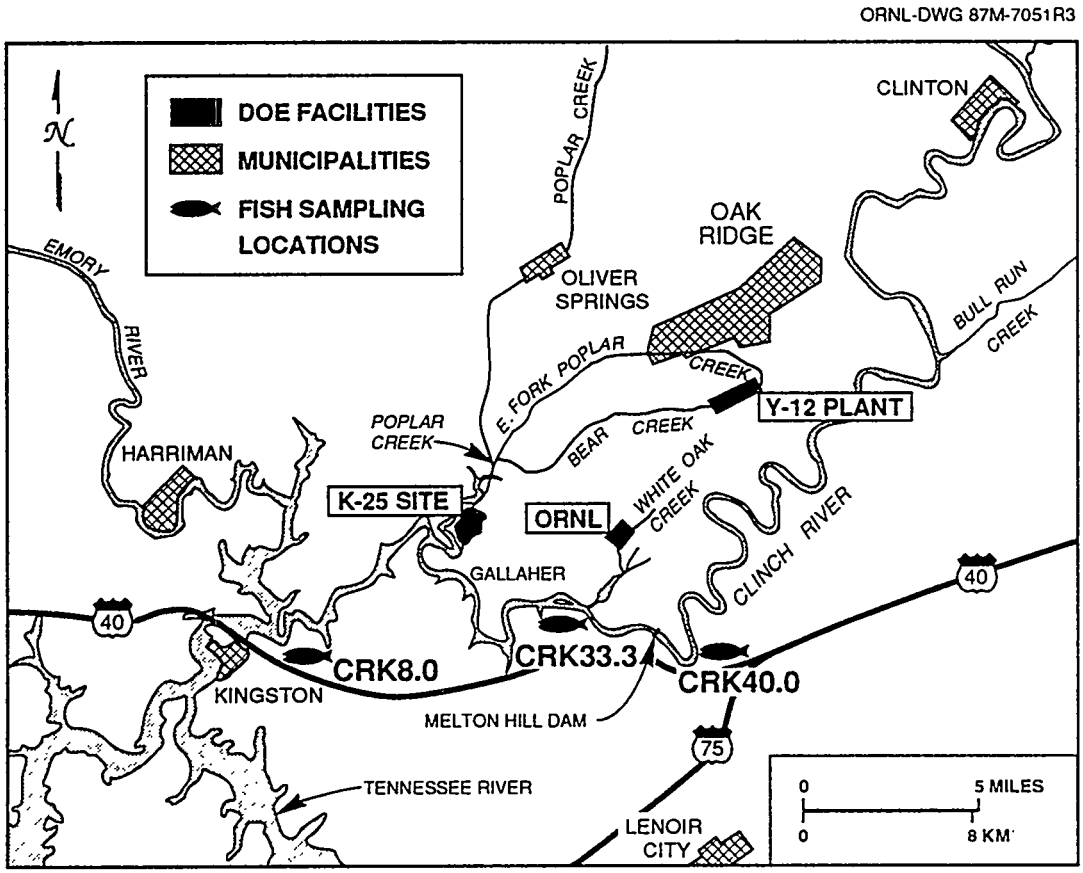

Fig. 6.2. Fish sampling locations along Clinch River.

Table 6.2. 1991 tissue concentrations of Clinch River bluegill[a]

Analysis	Number of samples	Concentration[b]			
		Max	Min	Av[c]	Standard error[d]
Hg	36	0.15	0.023	0.063	0.0062
Total PCB	36	<1.5	-0.012	<0.48	0.079
^{60}Co	18	0.35	-0.24	0.048	0.039
^{137}Cs	18	21	0.32	7.0*	1.5
Total Sr[e]	18	5.6	-0.054	0.94*	0.36

[a]See Fig. 6.2.

[b]Radionuclides are in pCi/g ash weight. Mercury and PCB units are μg/g wet weight.

[c]For radionuclides, an asterisk (*) indicates that the average is significantly greater than zero at the 95% confidence level.

[d]Standard error of the mean.

[e]Total radioactive strontium (^{89}Sr and ^{90}Sr).

Annual mercury concentrations in bluegill from the three Clinch River sampling locations are given in Table 6.3 of Vol. 2. An analysis of variance test was used to compare concentrations of parameters in fish from the different locations. Mercury concentrations were significantly higher in fish from CRK 8.0 (river mile 5) than CRK 33.3 (river mile 20.7) and CRK 40.0 (river mile 25). The highest concentration of mercury was measured at CRK 8.0 (0.15 μg/g wet weight). This relationship among the locations is consistent with data from 1990.

Total PCB concentration summaries for bluegill for 1991 are given in Table 6.4 of Vol. 2. Of the 36 individual fish samples that were analyzed for total PCB, the minimum values at CRK 8.0 and CRK 33.3 were laboratory estimates. The minimum value at CRK 40.0 was estimated by the laboratory and also found in the blank.

Annual summaries of radionuclide concentrations in Clinch River fish are given in Table 6.5 of Vol. 2. Cobalt-60 and total radioactive strontium values for fish from CRK 33.3 were higher than the other two stations and were statistically significant at the 95% confidence level. Concentrations of ^{137}Cs in fish were significantly higher in fish collected at CRK 33.3 (river mile 20.7) than in fish from the other two locations.

6.3 ORR DEER POPULATION

The seventh annual DOE–Tennessee Wildlife Resources Agency–managed deer hunts were held during the final quarter of 1991. Analytical Chemistry Division (ACD) personnel assisted by student members of the Wildlife Society (University of Tennessee chapter) performed most of the necessary operations at the checking station. The radiological surveillance of the harvest continues to be the responsibility of ACD personnel.

The basic conduct of the managed hunts for 1991 was similar to those of previous years. One archery hunt was held (October 19–20) as were two shotgun/muzzle-loader hunts (November 9–10 and December 14–15). During the archery hunt 142 deer were taken, and 334 were killed during the two gun hunts. From the total harvest of 476 animals, 266 (56%) were bucks and 210 (44%) were does. The size of the 1991 harvest is similar to that of 1990, when 442 deer were taken. The heaviest buck had 8 antler points and weighed 208 lb. The greatest number of points (22 and 12) were found on two bucks that weighed 85 lb and 139 lb, respectively. The heaviest doe weighed 115 lb.

Soft tissue (liver or muscle) radioactivity concentrations of ^{137}Cs continued to be low and acceptable. None of the harvest exceeded 1.0 pCi/g.

(The confiscation limit is 5 pCi/g.) The maximum concentration of ^{137}Cs was 0.93 pCi/g. Strontium-90 concentrations in bone exceeded 30 pCi/g (the confiscation limit) in 7 deer, which is 1.5% of the 476 harvested.

6.4 VEGETATION

No vegetation samples were taken at the ORR during 1991.

6.5 BIOLOGICAL MONITORING AND ABATEMENT PROGRAMS

6.5.1 Monitoring Contaminant Concentrations

The 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 these 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.

Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are associated with discharges at all three facilities. Concentrations of these substances in redbreast sunfish (*Lepomis auritus*) have been monitored twice yearly at five sites in EFPC downstream from the Y-12 Plant (Fig. 6.3) since 1985. A clear trend of decreasing mercury concentrations in sunfish with increasing distance below the New Hope Pond/Lake Reality discharge remains apparent (Fig. 6.4), and the mean concentrations of mercury in fish at specific sites have not exhibited an increasing or decreasing trend relative to concentrations observed in the mid 1980s, except at East Fork Poplar Creek kilometer (EFK) 23.4, the site nearest the Y-12 Plant. Lower mercury concentrations were observed in redbreast sunfish at EFK 23.4 in 1990–1991 than were typical

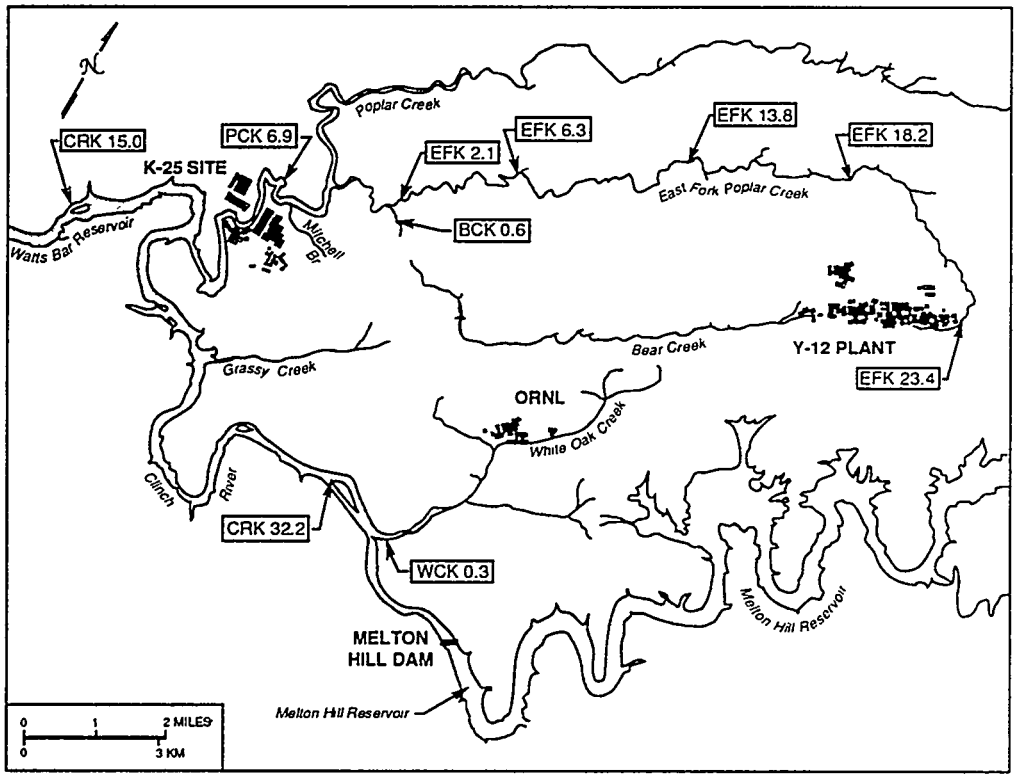

Fig. 6.3. Locations of channel catfish and redbreast sunfish collection sites for BMAP bioaccumulation studies.

of the 1986–1989 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 EFPC, a result in 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 similar pattern of decreasing concentrations with distance downstream is apparent for PCBs in redbreast sunfish (Fig. 6.5). PCB concentrations found in EFPC sunfish in 1990–1991 fell within the range observed in previous years. As a result of the colonization of Lake Reality and EFPC upstream from Lake Reality following its construction, it was possible to obtain sunfish from sites upstream from EFK 23.4 for the first time. Redbreast sunfish from EFPC above Lake Reality averaged 1.16 μg/g PCBs in May 1991, and bluegill from Lake Reality averaged 0.94 μg/g. The high concentrations in fish at these sites indicate the importance of the industrialized portion of the Y-12 Plant as a source in relation to contaminated sediment and soil downstream from Lake Reality.

Bluegill and other sunfish collected in fall 1990 were again found to indicate the presence of multiple sources of PCB and mercury contamination (Figs. 6.6 and 6.7) on the ORR. Elevated concentrations of mercury were clearly evident in fish from EFPC, Poplar Creek, Bear Creek, Mitchell Branch, and White Oak Creek (WOC). The mean mercury concentration in fish from the Clinch River below the mouth of Poplar Creek was lower than that observed in 1989, and similar to those found in 1987 and 1988. Mean concentrations at other sites were similar to those observed previously. The mean concentration of mercury was highest at EFK 18.2 in the city of Oak Ridge but did not exceed the FDA limit (1 μg/g) at any site.

The pattern of PCB contamination observed in this study resembles that of mercury (Fig. 6.7). The highest mean concentrations were found in Bear Creek (BCK 4.5), Mitchell Branch at the K-25 Site, EFPC (EFK23.4), and WOC (WCK 2.3) at ORNL.

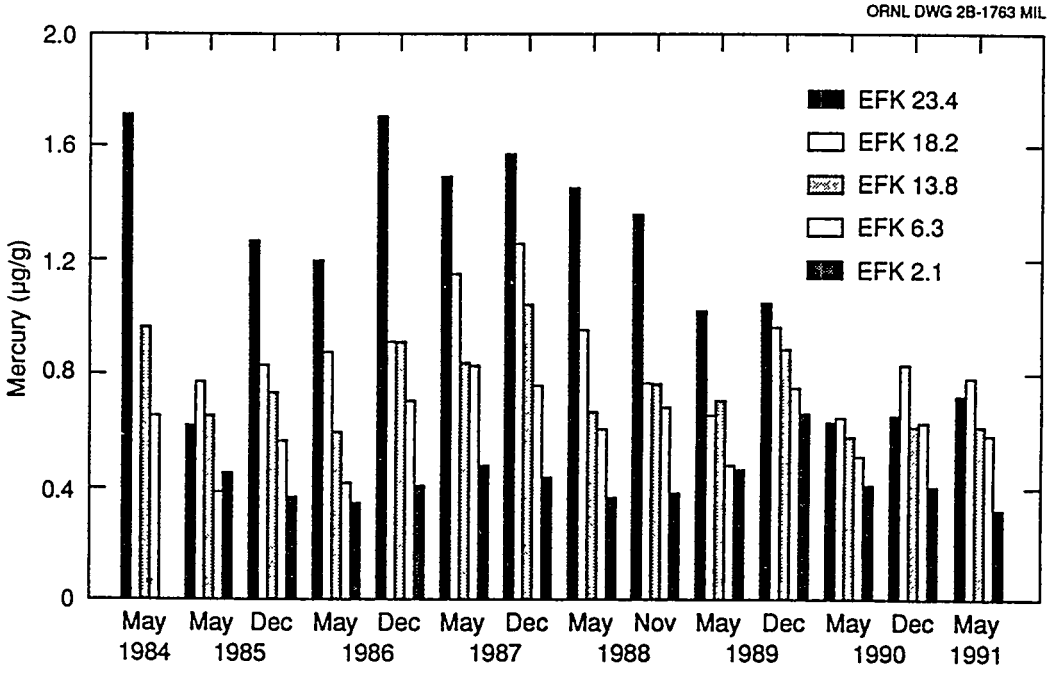

Fig. 6.4. Average concentrations of mercury in redbreast sunfish (n = 8) collected at sites in East Fork Poplar Creek, 1984–1991. The 1984 data are from the Oak Ridge Task Force study (TVA 1985).

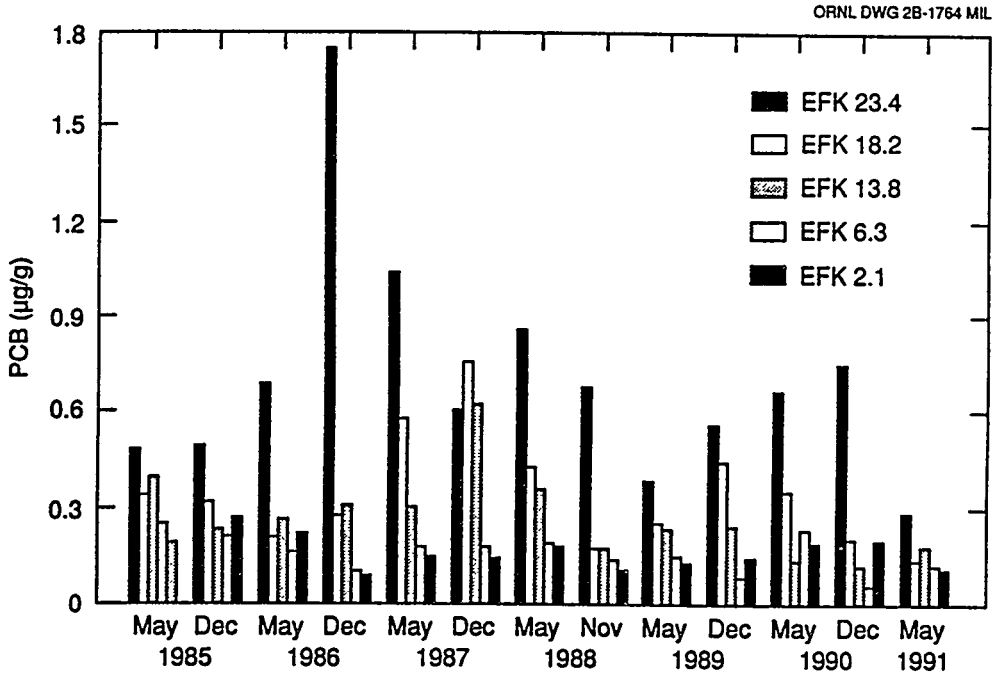

Fig. 6.5. Average concentrations of PCBs in redbreast sunfish (n = 8) collected semiannually at sites in East Fork Poplar Creek, 1985–1991.

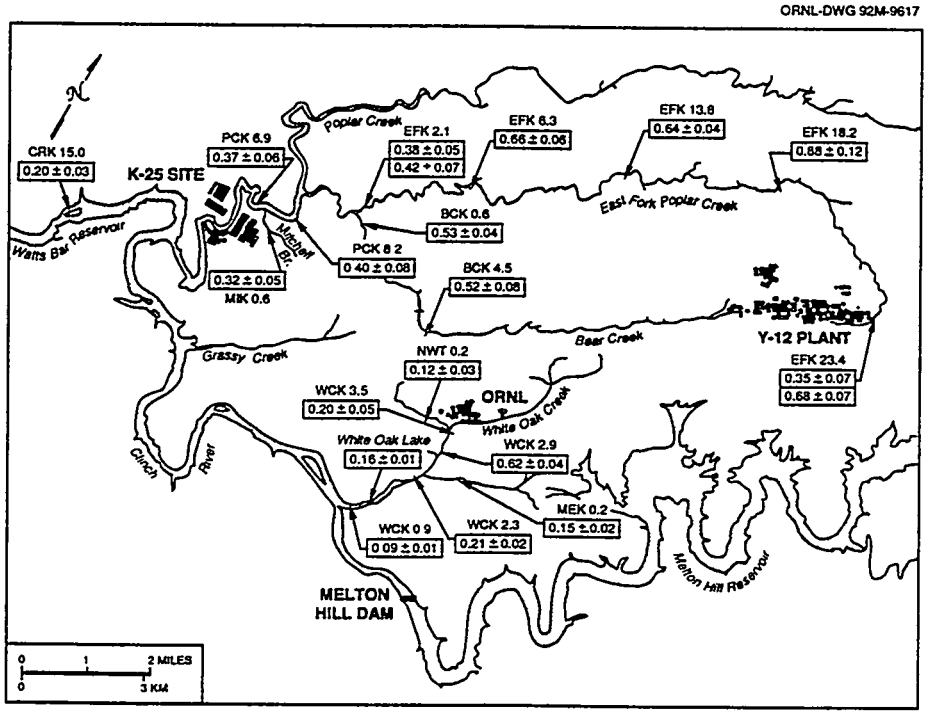

Fig. 6.6. Average concentrations (± 1 SE) of mercury (µg/g, wet weight) in sunfish collected in fall 1990 at sites on the ORR. Fish are redbreast sunfish (*L. auritus*) at MIK 0.6, EFK sites (bottom values where two appear) and WCK 2.3; rock bass (*Ambloplites rupestris*) at BCK sites; and bluegill (*L. macrochirus*) at the remaining sites.

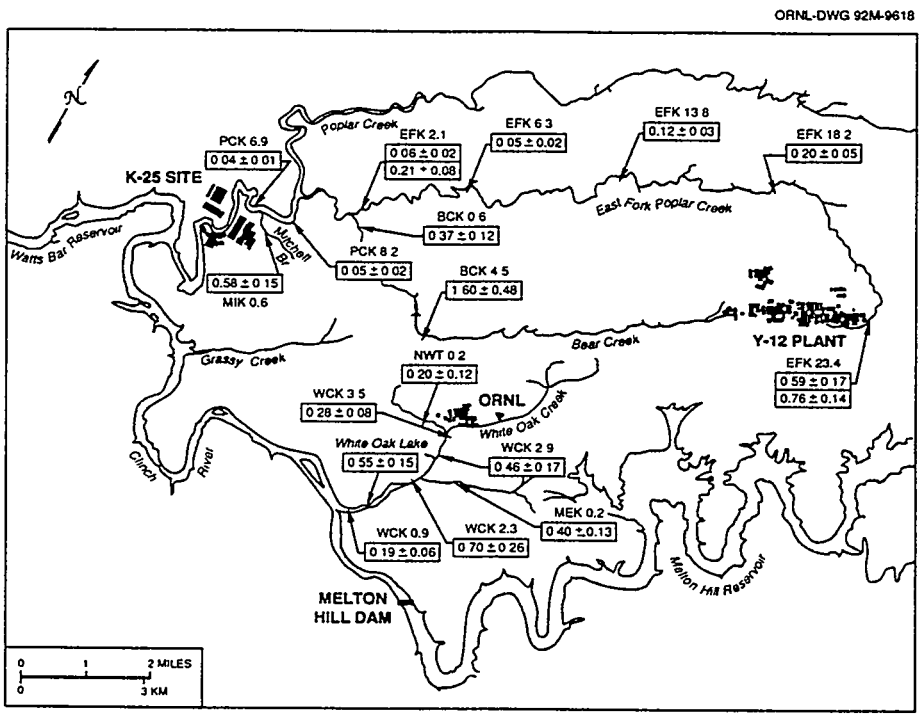

Fig. 6.7. Average concentrations (± 1 SE) of PCB (μg/g, wet weight) in sunfish collected in fall 1990 at sites on the ORR. Fish are redbreast sunfish (*L. auritus*) at MIK 0.6, EFK sites (bottom values where two appear) and WCK 2.3; rock bass (*Ambloplites rupestris*) at BCK sites; and bluegill (*L. macrochirus*) at the remaining sites.

PCBs were elevated in fish throughout WOC below ORNL and EFPC below the Y-12 Plant, and in at least the lower reaches of Poplar Creek, Melton Branch, Mitchell Branch, and Bear Creek.

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 and carp do. Channel catfish (*Ictalurus punctatus*) have been found to contain PCBs approaching the Food and Drug Administration (FDA) limit (2 μg/g) in several reservoirs in East Tennessee, including Watts Bar Reservoir (TVA 1985). As a result of finding that PCB concentrations exceeded the FDA limit in all channel catfish collected in WOC embayment in 1984 by the Oak Ridge Task Force, annual PCB monitoring in this species was initiated in 1986. Routine collection sites are depicted in Fig. 6.3; sites were selected to provide the ability distinguish the relative importance of PCB sources in the WOC and Poplar Creek drainages in contributing to PCB concentrations in Clinch River catfish. Mean PCB concentrations in channel catfish collected from these sites have remained similar over the 1986–1991 period, with highest concentrations generally occurring in WOC embayment (Table 6.3). Construction of a flow restrictor at the mouth of WOC in 1991 and 1992 is expected to substantially impede movement of catfish in and out of the embayment, reducing its importance as a source of PCBs to the population of fish in the adjacent reach of the Clinch River. However, isolation of a population of catfish in WOC embayment is likely to result in higher mean concentrations of PCBs in fish from that site in the future than has been typical of the past 5 years.

Chlordane contamination was again observed in clams placed in cages in WOC in 1991. As was also the case in previous years, chlordane was not elevated in fish collected from WOC. The concentrations in clams were again lower than those previously observed, suggesting slow recovery from an episodic release. Mean concentrations remain highest near the apparent source between the 6000 and 7000 areas at ORNL.

6.5.2 Indications of Ecological Recovery in Three Receiving Streams near DOE Oak Ridge Facilities

The BMAPs for the three DOE Oak Ridge facilities include a task to assess the impacts of plant operations on fish communities of receiving streams. A major component of this task is the estimation of fish abundance at selected sites. Abundance (as measured by density per unit area) reflects the ecological suitability of a site for fish and can be used to identify both short- and long-term impacts on the community and any recovery of the community resulting from remedial actions. Estimates of fish community abundance have been made twice yearly (spring and fall) since 1985. Data for several monitoring sites are plotted in Fig. 6.8, including EFPC at EFK 23.4, Bear Creek at BCK 12.4, and WOC at WCK 3.9.

The site at EFK 23.4 is located just downstream of the Y-12 Plant and below the outfall of Lake Reality, a small, lined basin. Fish abundance was extremely low during the first year of monitoring, but a large increase was observed in fall 1986. During 1985–1986, the Central Pollution Control Facility became operational at the Y-12 Plant. For the next 4 years, fish abundance remained relatively stable (2 to 4 fish/m^2). By November 1988, two additional waste treatment facilities were added at the Y-12 Plant, and flow was routed through the newly constructed Lake Reality while the old basin (New Hope Pond) was eventually closed and capped. A second, large increase in density occurred in fall 1990, which may have been associated with the maturation of Lake Reality and an increase in the export of nutrients and food downstream. Presently, the densities of fish just below the lake are among the highest observed in BMAP. Although still occasionally impacted by adverse water quality, the recovery of the fish community in this reach of stream suggests there has been an overall improvement in water quality below the Y-12 Plant.

The site at BCK 12.4 is located in the headwaters of Bear Creek just below the S-3 ponds. The ponds, which were capped in 1989, consisted of four 0.40-ha, unlined basins constructed in 1951 for the disposal of nitrate wastes (nitric acid and nitrate salts); they were designed to maximize evaporation and percolation rates. Recovery of the fish community at BCK 12.4 was much slower than at EFK 23.4 due to the greater degradation of water quality and to the adverse impacts of high sediment loading. By fall 1989 however, a substantial increase

Table 6.3. Changes from 1986 to 1991 in average concentrations of PCBs (μg/g, wet wt) and fraction of fish exceeding the Food and Drug Administration (FDA) limit, for channel catfish from White Oak Creek embayment (WCK), the Clinch River (CRK), lower Poplar Creek (PCK), and Melton Hill Reservoir (MHR)

Site	1986	1987	1988	1989	1990	1991
			PCBs			
WCK 0.3	1.30	1.59	0.96	1.54	3.56	3.60
CRK 32.2	1.01	1.61	0.58	1.20	0.31	1.38
MHR	0.46	0.81	0.52	0.28	0.41	0.29
PCK 6.9	—	—	0.71	1.07	0.92	0.68
CRK 15.0	—	—	0.50	0.79	0.88	1.08
			Fraction over FDA limit			
WCK 0.3	3/12	2/8	2/8	4/8	4/8	6/8
CRK 32.2	0/8	2/8	1/8	1/8	0/8	1/8
MHR	0/6	1/7	0/10	0/8	0/8	0/8
PCK 6.9	—	—	0/8	1/8	1/8	0/8
CRK 15.0	—	—	0/9	1/8	1/8	1/8

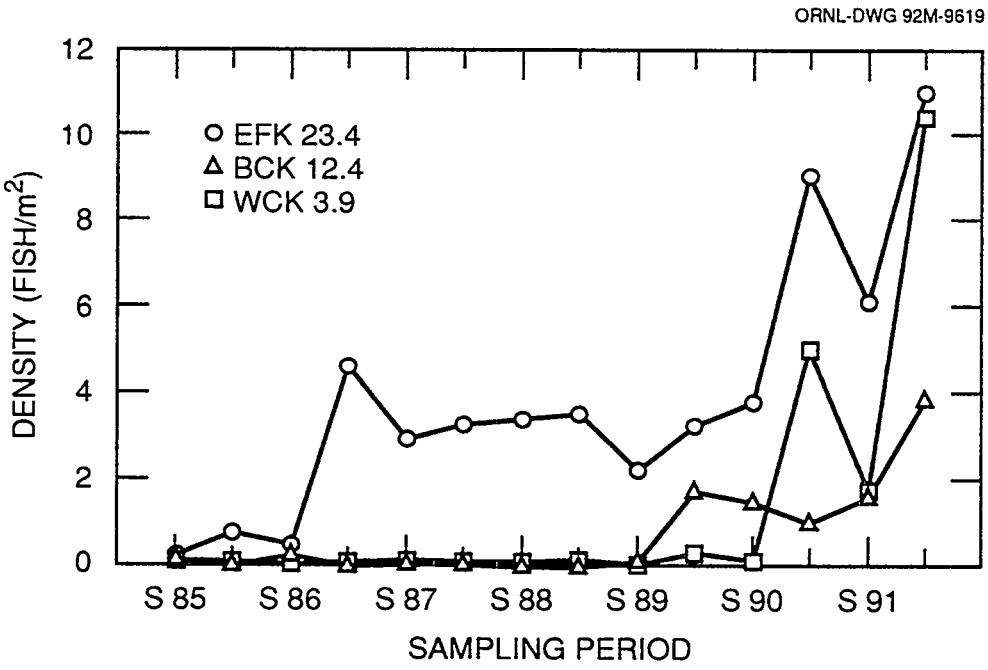

Fig. 6.8. Fish community density at East Fork Poplar Creek site EFK 23.4, Bear Creek site BCK 12. 4, and White Oak Creek site WCK 3.9, spring 1985 to fall 1991.

was observed in both fish abundance and the number of species. Further recovery of the fish community at BCK 12.4 may depend as much on erosion control and reductions in siltation, as improvements in water quality.

Unlike EFK 23.4 and BCK 12.4, the site at WCK 3.9 is located at ORNL within the main plant area and downstream of several tributary streams. Until fall 1990, density never exceeded 0.3 fish/m^2. However, on March 30, 1990, a new wastewater treatment facility became operational at ORNL, eliminating many untreated discharges to WOC. High fish densities have been observed at WCK 3.9 in the past year, reaching levels rarely found at other BMAP sites. The dramatic increase in abundance at WCK 3.9 was limited to a few species; if recovery continues, additional species should be observed.

The BMAP sampling revealed a similar pattern of recovery at all three sites. Each site is located just downstream of plant operations and has received significant adverse impacts in the past. Improvements in waste disposal operations, including construction of new treatment facilities and closure of settling basins, reduced the instream toxicity at each site. Changes in water quality resulted in noticeable increases in fish community abundance and often fish species richness. Increased abundance is the first stage in the recovery of a stressed community, indicating conditions that are favorable for successful reproduction and survival of the more tolerant fish species.

6.6 STUDY OF REPRODUCTIVE BIOLOGY OF TENNESSEE DACE: IMPLICATIONS FOR MANAGEMENT OF RESERVATION STREAMS

The Tennessee dace (*Phoxinus tennesseensis*) has been classified as a species "deemed in need of management" by the state of Tennessee and was recently recognized as a distinct species from the more widely distributed mountain redbelly dace (*P. oreas*). Under this classification, it is illegal to knowingly destroy the species' habitat, and a special permitting process must be followed before any

significant habitat alteration can occur. Localized populations of Tennessee dace have been found in only 28 streams in the U.S., including Bear Creek and other streams on the ORR. Several of these populations were identified many years ago and some may now be extirpated. Indeed, the highest population densities may occur in ORR streams. Because life history information on the Tennessee dace is not available, a study was initiated to describe its reproductive biology. Such information is important because changes in streamflow or sediment load associated with environmental restoration activities can potentially disrupt spawning and adversely affect larval survival.

Tennessee dace were collected monthly from a 5-km section of Bear Creek between October 1988 and September 1989 and measured for reproductive parameters such as total egg numbers and size. Field observations of spawning behavior were conducted in 1989 and 1990, and nest sites were evaluated for size and structure.

Data on various reproductive parameters indicated that spawning in 1989 occurred from late March through early May and was completed by late May. Total egg counts of Tennessee dace were low and similar to those of other *Phoxinus* species. Egg size-frequency distributions indicated the presence of at least two clutches (groups of mature eggs) during the spawning season. Direct observations of spawning behavior indicated aggregations of more than 100 individuals in association with shallow gravel nests in stream riffles. Any disturbance that increased sediment loading to the nest dispersed the spawning aggregation, and spawning did not resume until clean gravel was reestablished.

The data obtained on the reproductive biology of the Tennessee dace suggest the species is vulnerable to several potential impacts. For example, observations in the field showed individuals to be sensitive to siltation; they actively seek areas of clean gravel for nests. Because the nest sites are in shallow water, any reduction in streamflow may reduce the available spawning habitat. Also, the low number of mature eggs per female combined with a short life span (2 to 3 years) implies that the Tennessee dace populations may be dependent on a successful reproductive effort at least once every 2 years. Consequently, remedial action alternatives that involve a reduction in stream discharge (e.g., pumping and treating contaminated groundwater without returning the water to the original stream), or an increase in amount or duration of sediment runoff to streams because of inadequate erosion control measures could have a significant adverse impact on local populations of the Tennessee dace.

6.7 GROWTH AND SURVIVAL OF CLAMS IN EAST FORK POPLAR CREEK

From 1989 through 1991, the fingernail clam (*Sphaerium fabale*), has been used for in situ bioassays as an indicator of water quality in EFPC. Like all mussels and clams, *S. fabale* is a filter feeder, feeding on suspended and/or deposited particulate matter. It is very abundant in some streams in the Clinch River drainage (e.g., Brushy Fork in Anderson County and Beaver Creek in Knox County), which means a reliable source of specimens is available for use in the bioassays. Like other mollusks, this species lends itself readily to bioassays because it apparently tolerates excessive handling and survives well in "caged" conditions. Although its sensitivity to specific contaminants is not known, this species appears to be more sensitive to water quality degradation than *Corbicula fluminea*, a nonnative species commonly used in contaminant uptake studies. For example *C. fluminea* has been used in bioaccumulation studies in EFPC and, unlike *S. fabale*, is relatively unaffected (growth or mortality) by conditions at EFK 23.4 just downstream of the Y-12 Plant.

Each year, several sites in EFPC and several relatively undisturbed reference sites have been used in these bioassays. Sites common to each study have included two sites in EFPC (EFK 23.4 and EFK 13.8) and two reference sites, including one each in Brushy Fork (BFK 7.6) and Hinds Creek (HCK 20.6). In 1989 and 1991, one site in Bull Run Creek (BRK 20.0) was used as an additional reference station; in 1990 and 1991, a reference site in Beaver Creek (BVK) was used; and in 1990, an additional site in upper EFPC (EFK 24.4) was used. Clams used in the 1989 study were obtained from Brushy Fork, and clams used in the 1990 and 1991 studies were obtained from Beaver Creek.

For studies in 1989 and 1990, individually marked clams ranging in length from approximately 7.2 to 9.0 mm were placed into 8 in. × 10 in. white

plastic photographic trays partially filled with fine gravel and covered with a piece of nitex netting (mesh size of 2 mm). Four trays containing 15 marked clams each were anchored securely to the streambed at each site with wire and rebar (total of 60 clams per site). For the 1991 study, individually marked clams ranging in length from approximately 9.3 to 10.9 mm were placed in individual clear, plexiglass chambers containing netting/screen on the ends and filled one-third full of fine gravel. Eight chambers were attached side-by-side with panduit cable ties to each of four flat pieces of plexiglass, which were anchored securely at each site with rebar and wire (total of 32 clams per site). At intervals of 3 weeks (1989 and 1990) or 2 weeks (1991), the length of each clam was measured to determine growth; mortality was noted; and each clam was returned to its original container. Each study lasted between 110 and 150 days.

Survival of clams in the reference streams and at EFK 13.8 just above the city of Oak Ridge Wastewater Treatment Facility was very similar in all 3 years (Fig. 6.9). At EFK 24.4 within the Y-12 Plant, mortality was relatively rapid, and all clams were dead after approximately 60 days. This experiment was repeated later in 1990 (data not shown) with similar results (i.e., 100% mortality at EFK 24.4 and greater than 90% survival at all other sites after about 75 days). The results obtained on survival of clams at EFK 23.4 just below Lake Reality during the 3-year period were not clear. Mortality of clams at this site in 1989 and 1991 was rapid. In both years, mortality was highest during about the first 3 weeks but relatively low thereafter. In 1990, however, clam mortality at EFK 23.4 was low in both the initial (Fig. 6.9) and follow-up study (data not shown) and similar to survival at EFK 13.8 and the reference sites.

Within each year, growth of clams in the reference streams was similar and always substantially greater than that at any site in EFPC (Fig. 6.9). Growth of clams placed at EFK 13.8 and EFK 23.4 was very similar in all three years, while at EFK 24.4, clams did not grow during their brief survival period. In general, clams at EFK 13.8 and EFK 23.4 grew steadily for about the first 35 to 40 days of exposure but grew very little during the remainder of the study. In contrast, clams in the reference streams tended to grow considerably and steadily throughout the entire exposure period of each study.

In conclusion, similar patterns in growth and survival of clams between years at EFK 13.8 suggest that although water quality is not poor enough at this site to significantly affect survival, growth at this site is reduced relative to that at the reference sites. It is not known if this effect on growth is because of some unnatural phenomenon, such as industrial effluents or nonpoint source pollution (e.g., urban and agricultural runoff), or because of natural phenomena, such as insufficient quantities or quality of food. At EFK 23.4, the consistently low growth rate combined with occasionally high initial mortality followed by periods of minimal mortality suggest (1) the presence of a low-level chronic stress (either unnatural, natural, or a combination of both) and (2) the occurrence of infrequent periods when the water in upper EFPC is acutely toxic. The high mortality in both tests at EFK 24.4 in 1990, a year in which mortality at EFK 23.4 was low and similar to that at the reference sites, suggests that the water at EFK 24.4 was also acutely toxic in 1989 and 1991. Although EFK 24.4 was not tested in those years, mortality was high in both years at EFK 23.4, a site which is located about 1 km downstream of EFK 24.4.

6.8 EFFECT OF CHLORINATED DISCHARGES ON PCB ACCUMULATION IN CLAMS

Uncontaminated Asiatic clams (*Corbicula fluminea*) were placed in cages and transplanted into area streams from 1987 to 1990 to help locate and evaluate sources of PCB contamination in receiving waters. The results of clam accumulation monitoring to date suggest that clams are effective monitors of PCBs and other organic contaminants under most conditions. PCB monitoring using clams was successful in locating a source of PCB contamination in Mitchell Branch in 1987, a small creek where the monitoring of suitable resident organisms was not possible. However, clams placed in chlorinated reaches immediately downstream of ORNL and the Y-12 Plant consistently underestimated the PCB contamination at the sites, based on the amount of PCBs found in fish and sediment at those sites.

A field experiment was conducted in March 1991 to investigate the effect of a chlorinated discharge on clam growth, valve movement, and PCB

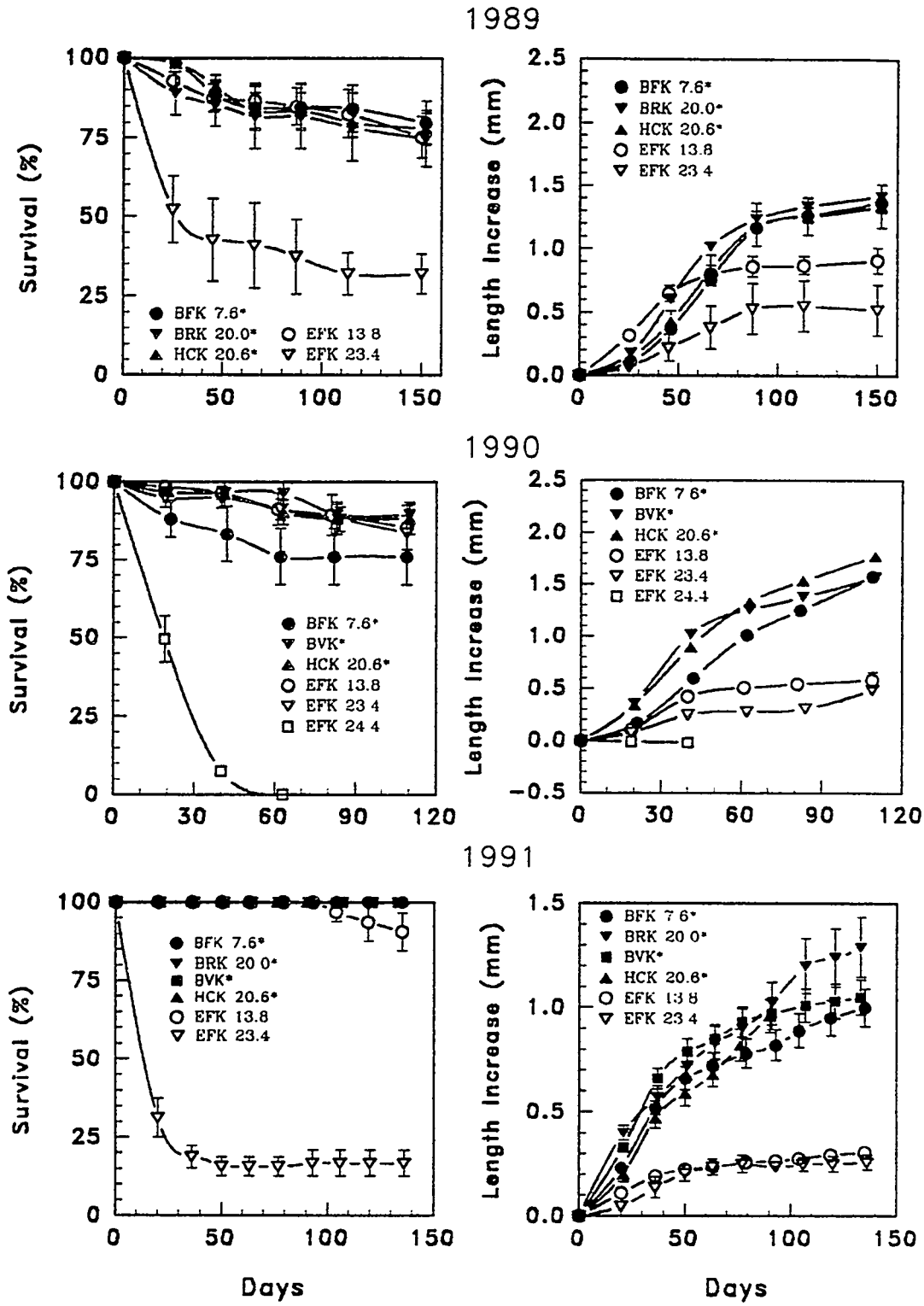

Fig. 6.9. Survival and growth of sphaeriid clams (*Sphaerium fabale*) placed in East Fork Poplar Creek (EFK) and four off-site reference streams, Beaver Creek (BVK), Brushy Fork (BFK 7.6), Bull Run Creek (BRK 20.0), and Hinds Creek (HCK 20.6), 1989–1991. An asterisk (*) beside a site name indicates that it is a reference site.

accumulation. Two flow-through tanks were placed alongside the chlorinated reach of upper EFPC; one tank received untreated water from EFPC (total residual chlorine ranged from 0.02 to 0.07 mg/L over the length of the experiment), the other tank received EFPC water treated with thiosulfate to remove all the chlorine in the water. After 4 weeks of exposure, clams placed in dechlorinated EFPC water grew more in length and weight, opened their valves approximately three times more often, and accumulated substantially higher PCB concentrations (mean = 0.63 μg/g) than in clams placed in unaltered EFPC water (mean = 0.11 μg/g). These results suggest that clams used as bioaccumulation monitors for PCB contamination in waters with low chlorine concentrations close their shells to avoid chlorine exposure, causing less filtering/feeding time, and consequently less food, water, and PCB uptake.

This study revealed that transplanted Asiatic clams can substantially underestimate the PCB contamination at a site when even very low levels of chlorine are present. If caged clams cannot be placed outside the chlorine gradient, other factors such as water quality, clam condition, and the amount of PCB contamination in other stream components (sediment and fish) need to be evaluated when interpreting clam monitoring results.

6.9 CANADA GEESE ON WHITE OAK LAKE

Waterfowl censuses conducted from 1987 to 1990 indicated that Canada geese were not routinely observed on White Oak Lake (WOL). However, when numerous reports were received of a flock of geese leaving the lake early in the morning during the winter months, additional monitoring was initiated to determine if geese were spending the night on the lake. On November 28, 29, and 30, and on December 2 and 4, 1990, the frequency of observations of the lake was increased and extended to include early morning and late evening hours. Approximately 200 geese were observed roosting in the shallow backwaters of upper WOL.

A large number of these geese (e.g., 69 on December 2) were wearing collars with identification numbers that had been placed on them during July 1989 and June 1990. The geese left WOL between 0700 and 0800 in three to five separate groups. They returned late in the evening and remained overnight. On November 28, a group of 82 geese, including 21 with collars, was observed at the recreational area immediately above Melton Hill Dam less than 2 hours after they were observed on WOL. This pattern was observed on several occasions. On December 5, a large flock of 109 geese was observed on a farm pond near Clinch River mile 17 (CRM 17). Five of these geese were wearing collars with numbers that were observed on WOL that same morning.

Canada goose feces collected from the recreational area near the boat ramp at Melton Hill Dam and from the area around the farm pond at CRM 17 were analyzed for gamma-emitting radionuclides. Traces of ^{60}Co and ^{137}Cs were detected in the feces, indicating that the geese had been feeding on radioactively contaminated food (Table 6.4).

On December 8 and 9, 1990, a drake mallard duck and a Canada goose were collected with firearms from WOL, and the breast tissue, liver, bone, and crop contents of the birds were analyzed for ^{60}Co and ^{137}Cs (Table 6.5). Based on limited observations of WOL, it appears that the lake is not a primary feeding site for the geese. This supposition is supported by the relatively low concentrations of ^{60}Co

Table 6.4. Concentration (pCi/g dry wt) of gamma-emitting radionuclides detected in Canada goose feces

Radionuclide	Melton Hill Dam recreational area	Farm Pond CRM 17.0
$^{7}Be^{a}$	3.2	1.8
^{60}Co	2.2	0.1
^{137}Cs	1.8	3.3
$^{40}K^{a}$	1.2	6.8

[a]Naturally occurring radionuclide.

Table 6.5. Concentrations of ^{60}Co and ^{137}Cs (pCi/g wet wt) in various tissues of a Canada goose and a mallard duck collected from White Oak Lake

	Canada goose		Mallard duck	
	^{60}Co	^{137}Cs	^{60}Co	^{137}Cs
Tissue				
Breast	0.02	3.3	1.7	4.5
Liver	0.2	2.1	0.1	4.6
Bone	ND[a]	2.3	ND[a]	3.1
Crop contents	0.9	2.0	4.5	15.7

[a]ND = not detectable.

and ^{137}Cs in its tissue of the one goose collected from the lake; however, additional data are needed on geese that use the lake. The mallard had relatively high concentrations of both ^{60}Co and ^{137}Cs in its crop contents, indicating that it had been feeding in the lake.

An individual consuming the breast tissue of the goose (1000 g) or the mallard (300 g) would receive an effective dose equivalent of less than 1 mrem (0.01 mSv). The presence of mallards on the lake does not present the same problem as the geese. Previous studies showed that migratory waterfowl such as mallards, which are passing through the area on their way to southern wintering grounds, use the lake for a short period of time and then depart, but during the winter, resident geese appear to be using the upper end of the lake on a routine basis.

After the single goose was collected by firearms, the geese have not been observed on the lake, although this behavior may be only temporary. Therefore, a propane cannon, which can be programmed to fire periodically, was installed on the upper end of the lake in January 1991 to deter the geese from using the lake. The lake was monitored after the cannon was installed to determine its effectiveness in reducing the number of waterfowl on the lake (Fig. 6.10). A dramatic decrease in the number of waterfowl on the lake was observed after the cannon was installed. However, this decrease cannot be attributed completely to firing of the cannon because the number of waterfowl on WOL usually decreases significantly in late January and February, when waterfowl began pairing up for nesting.

Prior to the installation of the cannon, gadwalls and mallards were the most common species on the lake. After the cannon was installed, there was a decrease in the number of species on the lake (Fig. 6.11). Geese were not normally observed during the weekly census because they left the lake early in the morning to spend the day elsewhere. Mallards and black ducks, which had been present during the same period of time the previous year, were not seen on the lake after the cannon was installed. Their absence may reflect behavioral differences (e.g., wariness of gunfire) between these and the gadwalls and coots. Overall, the effect of the cannon has been to reduce the number and species of waterfowl on WOL. Its effectiveness in preventing the geese from using the lake may be attributed, in part, to the limited hunting that occurred prior to installation of the cannon.

REFERENCES

Tennessee Valley Authority (TVA). 1985. *Instream Contaminant Study, Task 4: Fish Sampling and Analysis,* report to U.S. Department of Energy, Oak Ridge Operations Office, Tennessee Valley Authority Office of National Resources and Economic Development, Knoxville, Tenn.

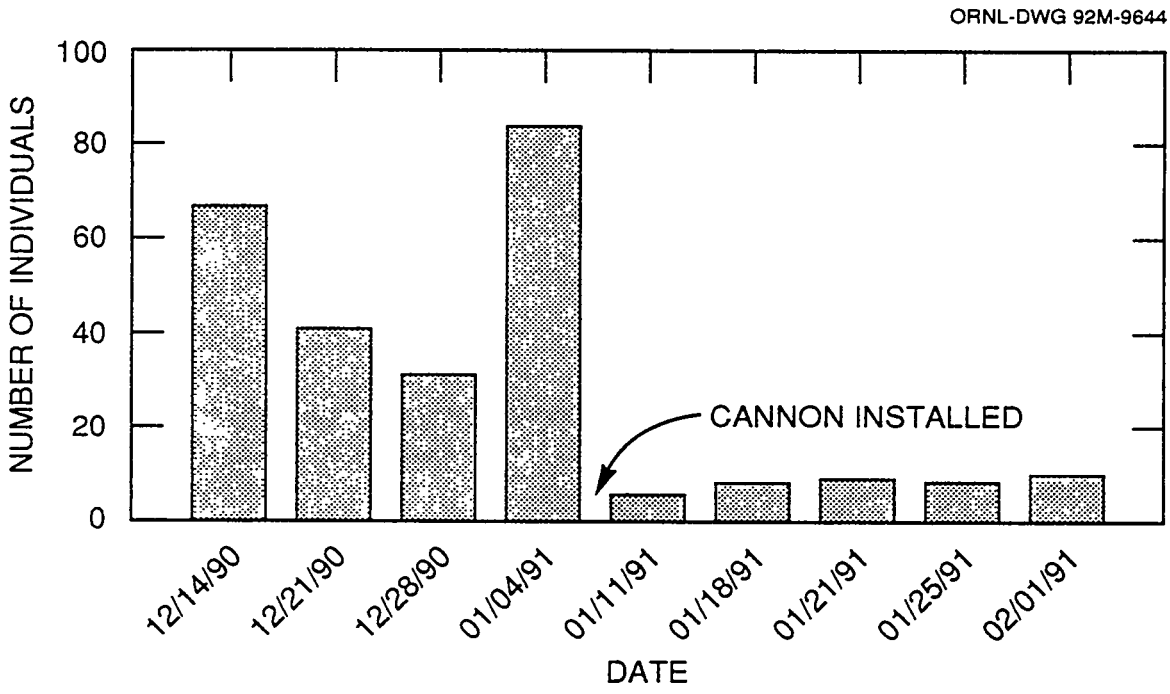

Fig. 6.10. Total number of waterfowl observed on White Oak Lake before and after installation of a propane cannon.

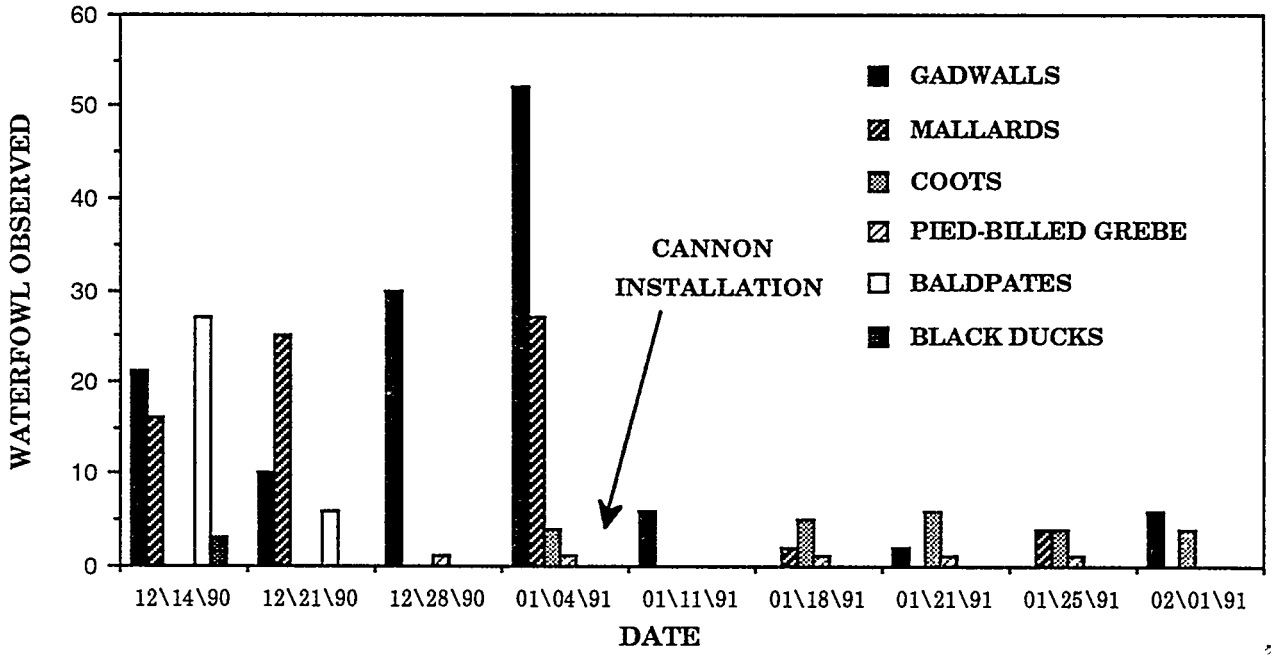

Fig. 6.11. Distribution of waterfowl species on White Oak Lake before and after the installation of a propane cannon.

7. SOIL AND SEDIMENT MONITORING

7.1 Soil 7-3

7.1.1 Sample Collection and Analytical Procedures 7-3

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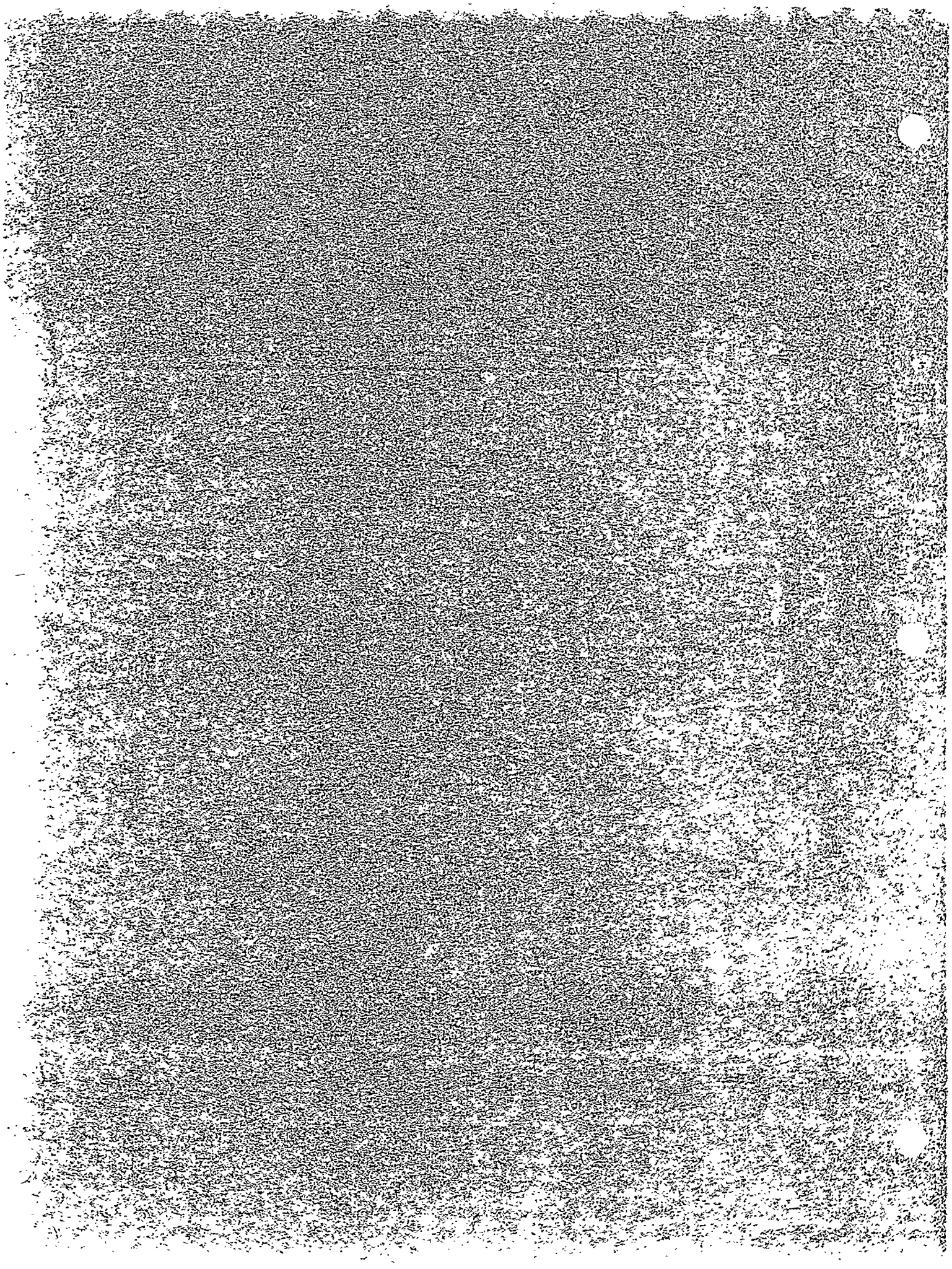

7. SOIL AND SEDIMENT MONITORING

7.1 SOIL

Soil samples from noncultivated areas provide a measure of the quantity of radioactivity or other pollutants that have been deposited from the atmosphere.

The concentrations of radionuclides in soil vary because of differences in rainfall patterns and the mechanics of transport in different types of soil. The rate of migration in soil also varies significantly from one radionuclide to another. For example, strontium tends to migrate through soil more freely than does either cesium or plutonium. In addition, chemical separation of radionuclides such as strontium and plutonium from soil samples is complicated by the heterogeneity of the soil and the difficulty of stripping ions from the soil. Therefore, individual measurements may not be representative of large areas. Average concentrations of several samples provide a better measure of soil radionuclide concentrations. Thus, three samples are collected from each sampling point annually.

Soil samples were collected at the ORNL and Y-12 Plant perimeter air monitoring stations and at the K-25 Site perimeter. Table 7.1 provides a summary of the locations sampled and frequencies of sampling and analysis for the Y-12 and ORNL perimeter soil samples. Figure 7.1 depicts soil sampling locations at the K-25 Site perimeter.

7.1.1 Sample Collection and Analytical Procedures

Soil samples were collected at the ORNL and Y-12 Plant perimeter air monitoring stations and at the K-25 Site perimeter once during 1991. The three samples collected at each location were randomly selected from the four cardinal directions at each of the stations. Each sample was a cube measuring 30 cm in each dimension. All samples were dried and pulverized prior to analysis.

7.1.2 Results

Summary concentrations of radionuclides in soils for each of the facility perimeters are presented in Table 7.2. All results are reported on a dry weight basis. Network summaries of the metals analyses are provided in Tables 7.1 and 7.2 in Vol. 2. Summary concentrations of radionuclides, total radioactive strontium, and metals at each of the stations within each network are given in Tables 7.3–7.11 in Vol. 2. The data from 1990 and 1991 were compared using a

Table 7.1. Summary of collection and analysis frequencies of soil sampling in 1991

Station[a]	Parameter	Collection frequency	Sample type	Analysis frequency
3, 7, 9, 20, 21, 40, 45, 46	Total Sr,[b] ^{239}Pu, gamma scan, ^{238}Pu, ^{234}U, ^{235}U, ^{238}U metals	Annually	Grab	Annually

[a]See Fig. 3.19.
[b]Total radioactive strontium (^{89}Sr + ^{90}Sr).

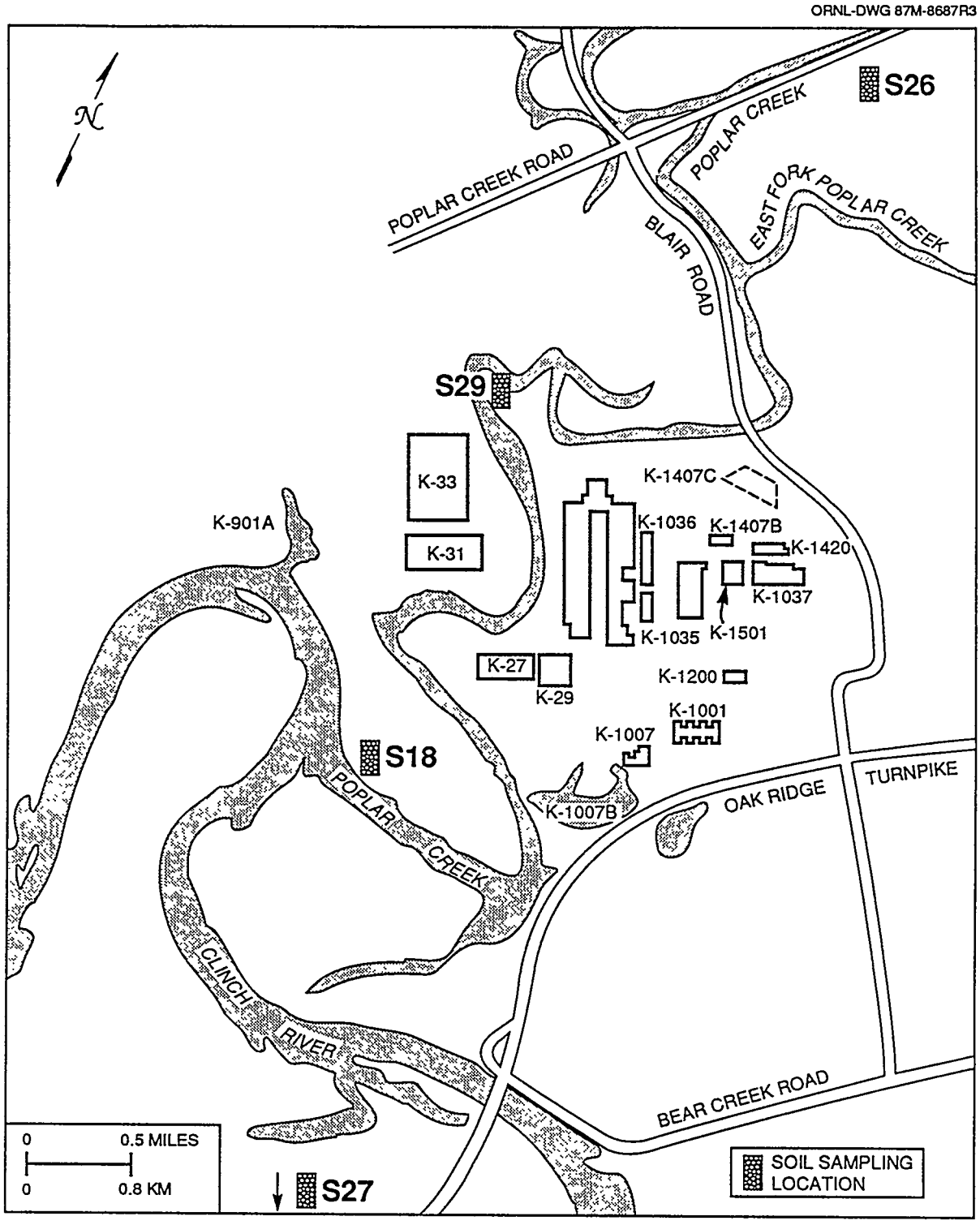

Fig. 7.1. Soil sampling locations around the K-25 Site.

Table 7.2. 1991 concentrations of radionuclides in soil at ORNL air stations

Analyte	Number of samples	Concentration (pCi/g dry wt)			
		Max	Min	Av[a]	Standard error[b]
		ORNL perimeter stations[c]			
^{60}Co	15	0.089	–0.014	0.023*	0.0085
^{137}Cs	15	4.1	–0.011	0.92*	0.26
G-Alpha	15	8.9	3.2	6.4*	0.47
G-Beta	15	27.0	4.3	14.0*	1.5
^{40}K	15	26.0	4.1	13.0*	1.9
^{238}Pu	15	0.046	–0.02	0.0039	0.0042
^{239}Pu	15	0.17	–0.018	0.028*	0.012
^{228}Th	15	1.0	0.30	0.62*	0.053
^{230}Th	15	0.76	0.092	0.35*	0.049
^{232}Th	15	0.73	0.23	0.44*	0.034
Total-Sr	15	1.8	0.027	0.53*	0.11
^{234}U	15	0.95	0.16	0.47*	0.053
^{235}U	15	0.19	0.0027	0.046*	0.012
^{238}U	15	0.76	0.097	0.30*	0.040
		Oak Ridge Reservation stations[c]			
^{60}Co	9	0.062	–0.051	0.0039	0.011
^{137}Cs	9	0.97	0.11	0.40*	0.10
G-Alpha	9	2.2	0.95	1.5*	0.13
G-Beta	9	3.0	1.3	1.9*	0.19
^{40}K	9	21.0	6.8	14.0*	1.7
^{238}Pu	9	0.0081	–0.012	–0.0003	0.0022
^{239}Pu	9	0.0030	–0.0057	–0.00099	0.00098
^{228}Th	9	0.20	0.059	0.11*	0.013
^{230}Th	9	0.11	0.043	0.063*	0.0063
^{232}Th	9	0.15	0.049	0.078*	0.0095
Total-Sr	9	0.054	–0.0027	0.031*	0.0062
^{234}U	9	0.81	0.12	0.36*	0.073
^{235}U	9	0.043	0.0073	0.022*	0.0043
^{238}U	9	0.59	0.076	0.26*	0.063
		K-25 Site perimeter			
^{234}U	12	7.84	0.30	1.77	2.33
^{235}U	12	0.54	0.025	0.14	0.18
^{238}U	12	4.59	0.26	1.015	1.27

[a]An asterisk (*) indicates that the average is significantly greater than zero at the 95% level of confidence.
[b]Standard error of the mean.
[c]See Fig. 3.19.

t test at 95% confidence. Significant differences between the two years of data exist for the ORR stations. In all cases, the 1991 value of the difference is less than in the previous year. Because the radionuclides in question have long halflives, it is likely that these differences are due to the variability of the soils being sampled. The 1991 data are similar to the 1989 data, which suggests that the 1990 results were anomalously high. The uranium concentrations around the Y-12 Plant's perimeter were higher than around ORNL's perimeter. This is typical for soil data from these locations. These data are similar in magnitude to the data from the remote stations from 1988, except for the elevated uranium values around the Y-12 Plant.

7.2 SEDIMENT

Figure 7.2 shows locations in ORNL streams where sediment samples were collected in triplicate in March and November, 1991, and analyzed for mercury. The average concentration of mercury detected for each site is given directly on the map. Figures 7.3 and 7.4 show locations of duplicate sampling conducted in February and October for analysis for TOC and PCBs. Figure 7.5 identifies specific PCB Aroclors detected at individual sampling locations. Table 7.3 summarizes the concentrations of each Aroclor detected over all sampling locations. Data summaries of PCBs detected at each sampling location are provided in Table 7.12 of Vol. 2.

The mercury results for 1991 are consistent with data from previous years. The PCB results are of similar magnitude to last year but occurrence of PCB is much reduced. Data for successive years will be necessary to determine whether this is a change in the aquatic environs or an anomaly of sampling and analysis.

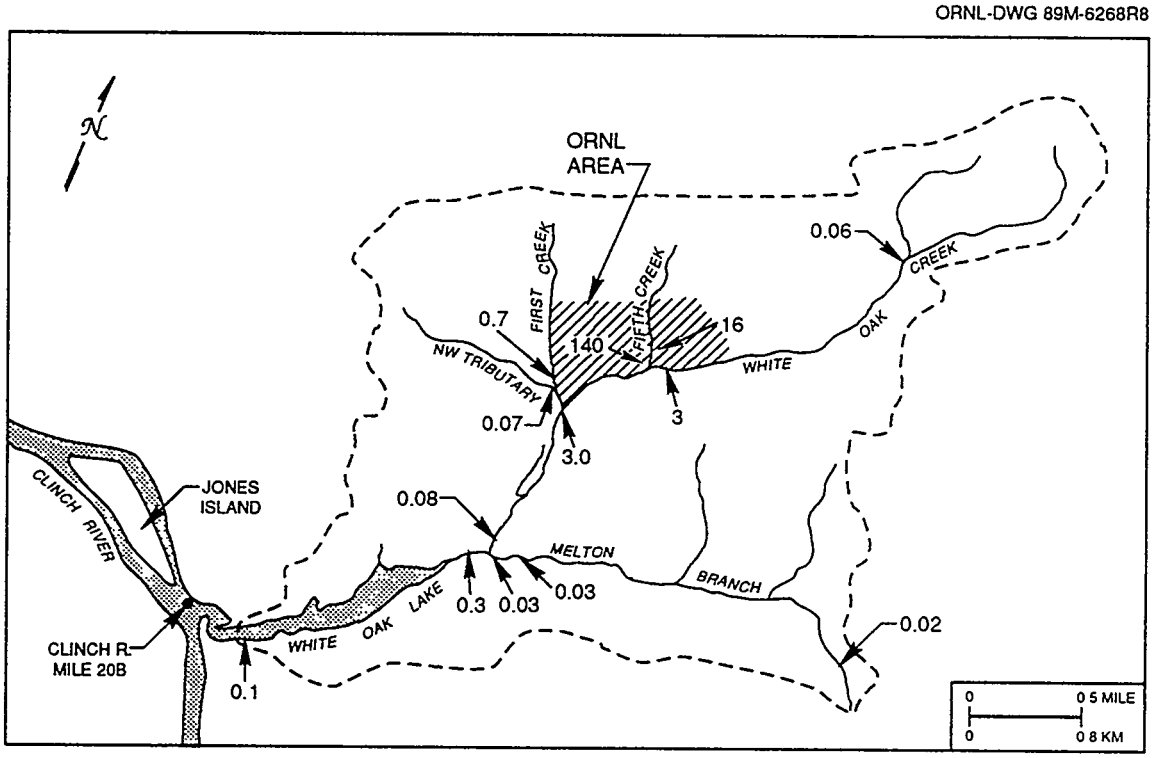

Fig. 7.2. Map of locations in ORNL streams sampled for mercury in sediments. Values are average mercury concentrations expressed in mg/kg (n = 6).

ORNL-DWG- 90M-5777R

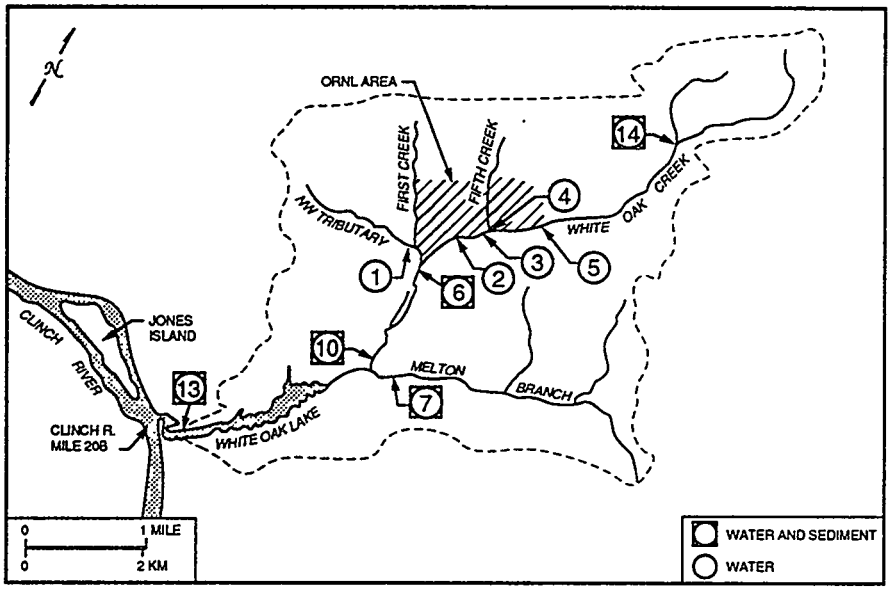

Fig. 7.3. Sample locations for PCB and TOC (sediment only) analyses in the ORNL area.

ORNL-DWG 90M-5776R2

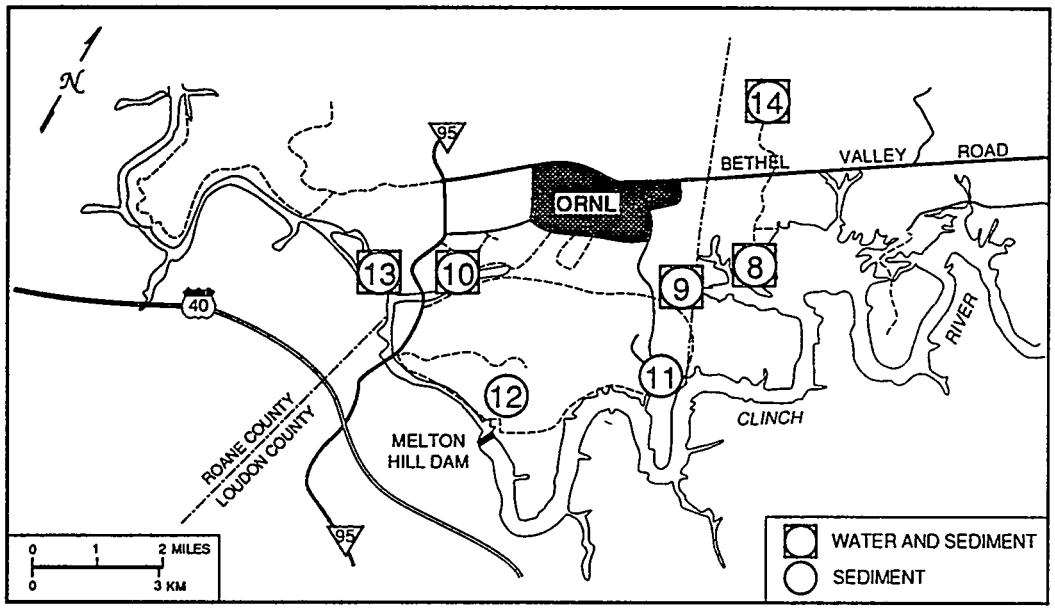

Fig. 7.4. Sample loactions for PCB and TOC (sediment only) analyses in the greater ORNL area.

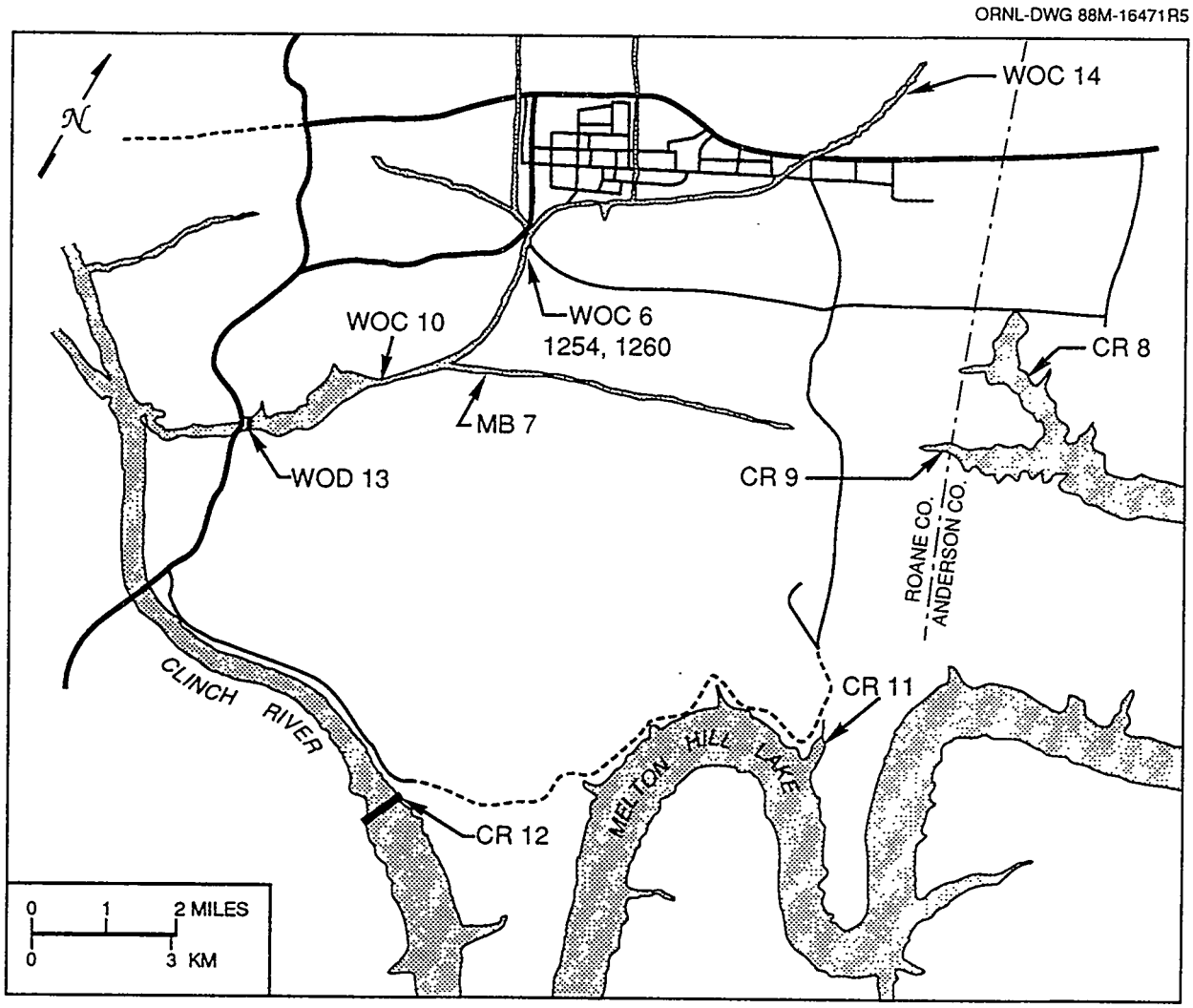

Fig. 7.5. PCB sediment sampling locations and Aroclors detected.

Table 7.3. Summary of ORNL PCB concentrations detected in sediment in the ORNL area, 1991

Analysis	Number detected	Number of samples	Concentration (μg/kg)			
			Max	Min	Av	Standard error[a]
Aroclor-1016	0	36				
Aroclor-1242	0	36				
Aroclor-1254	2	36	560	370	460	95
Aroclor-1260	1	36	360	360	360	
Aroclor-1221	0	36				
Aroclor-1232	0	36				
Aroclor-1248	0	36				

[a]Standard error of the mean.

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8. SPECIAL STUDIES

Many environmentally related special studies are conducted on the ORR annually. This chapter includes those studies that are not directly associated with the annual environmental monitoring activities but may be of special interest to some readers. The studies were submitted for publication by the site most directly involved with each study.

8.1 Y-12 PLANT

8.1.1 Y-12 Spill Report

The Y-12 Plant had a total of 143 recorded spills or releases of various types of materials during CY 1991. This compares with 103 spills or releases recorded during CY 1989 and 151 spills or releases recorded in CY 1990. Of the 143 spills recorded in CY 1991, 27 were reportable under either the Clean Water Act or CERCLA (Figs. 8.1 and 8.2).

As in CYs 1989 and 1990, many of these spills involved petroleum products (Fig. 8.3). Each recorded spill event was investigated by the Y-12 Plant Spill Coordinator to determine the potential environmental impact caused by the spill, to assist with the cleanup of the spill, and to suggest ways to prevent the same type of spill from recurring. Cleanup operations were generally performed by trained staff members of the Y-12 Plant Waste Transportation, Storage, and Disposal Department. All cleanup operations and disposals of cleanup materials were handled according to Y-12 Plant standard operating procedures. The Y-12 Plant Environmental Management Department (EMD) reports spill events to various levels of Y-12 management, DOE, and other governmental agencies as appropriate.

Several measures have been taken to prevent spills in the Y-12 Plant. Guidelines were developed and implemented in CY 1990 that require secondary containment for materials stored in drums. As part of the revisions to the Y-12 Plant Spill Prevention, Control, and Countermeasures Plan that were made in CY 1990, several tanks and structures were identified that need some type of secondary containment. These conditions were assessed, and remediation began in CY 1991. Also, efforts were undertaken in CY 1991 to identify transformers that have inadequate or nonexistent secondary containment. Corrective actions for these problems began late in CY 1991.

8.1.2 Floodplains and Wetlands Studies

In response to findings from the October 1989 Compliance Assessment (Tiger Team) of the Y-12 Plant, two special studies were initiated. The studies are focusing on the applicability of the DOE floodplain and wetland review requirements contained in 10 CFR parts 1022.5 and 1022.11.

A reservation-wide wetlands study was completed during 1991 and was issued as a new volume in the resource management plan for the ORR, ORNL-6026/V1-17. In addition, a wetlands survey of the Y-12 Plant was completed and issued as *Results of the Y-12 Area Rare Plant and Wetlands Survey.*

A floodplains assessment was also completed during 1991. This assessment, which was conducted by TVA, was compiled in *Flood Analyses for Department of Energy Y-12, ORNL, and K-25 Plants.* This study addresses floodplains for areas adjacent to both EFPC and Bear Creek. The data presented in the report are being mapped. The floodplains/wetlands location and characterization data will be used in siting new facilities and determining the impacts of planned operations or development.

8.1.3 Identification of Processes that Discharge to Surface Waters

Efforts are continuing to identify miscellaneous sources that may be targeted for rerouting of water or

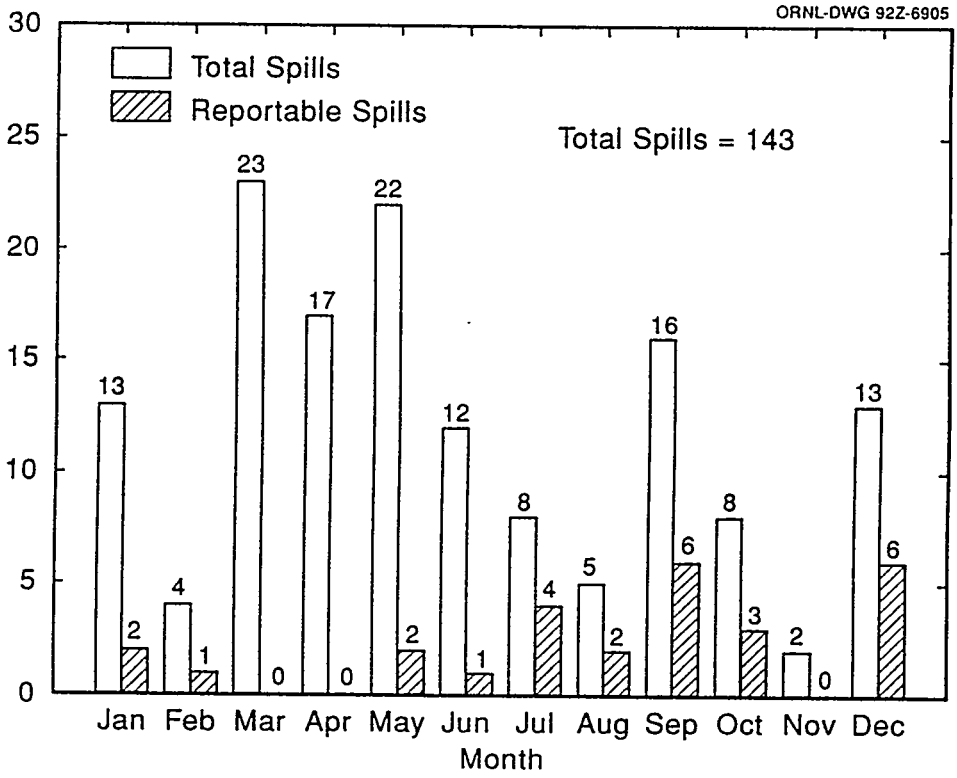

Fig. 8.1. 1991 Y-12 Plant spills summary (including CERCLA and CWA violations).

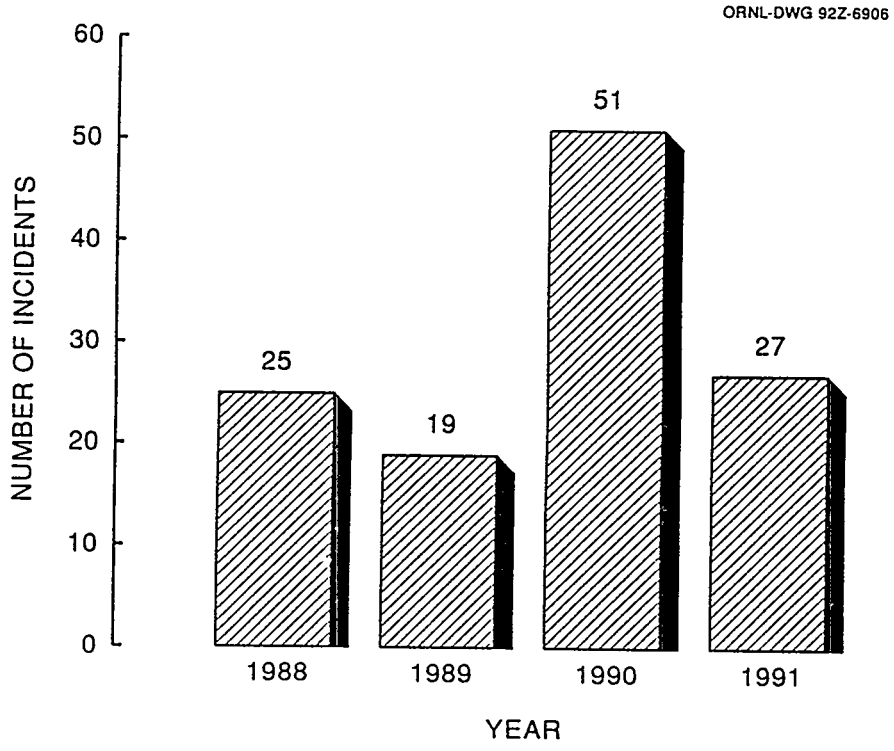

Fig. 8.2. Y-12 Plant reportable environmental releases.

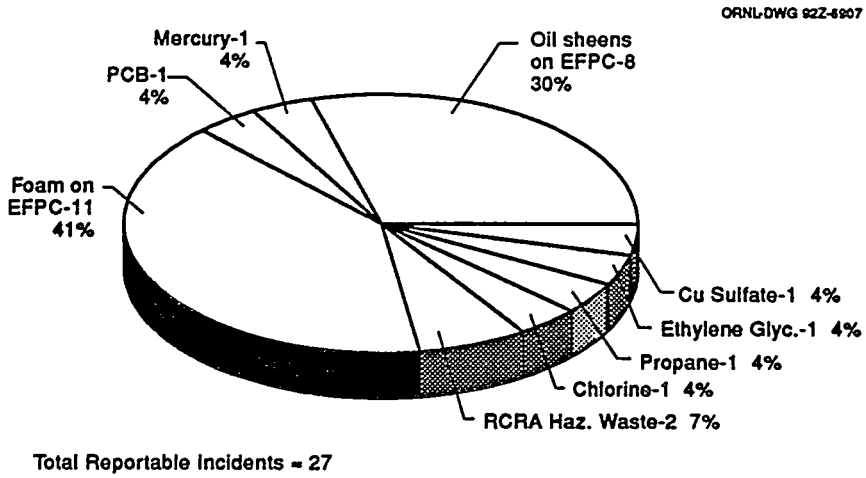

Fig. 8.3. Y-12 Plant reportable environmental releases by percentages.

alternate treatment and disposal. One major undertaking is rerouting or eliminating a number of sinks that are tied to the storm drainage system. The storm drainage system in major process buildings was surveyed (1989–1991) in an effort to reduce the potential for accidental releases to EFPC. This study has been expanded to include a verification survey that implements a significant dye testing effort to ensure the ultimate discharge destination of all sinks in approximately 74 plant process buildings.

The study focuses on characterizing and verifying of drain routing for all sinks at the Y-12 Plant. The discharges from lavatory sinks are connected to the sanitary sewer, as are many nonlavatory sinks in over 400 buildings within the plant. However, some nonlavatory sinks are tied to the storm sewer system that discharges to EFPC.

Currently, administrative controls in place at the Y-12 Plant prevent disposal of chemicals in sinks. Many of the sinks identified as discharging to the EFPC have been blocked off and their use discontinued until they can be rerouted. Each division has at least one Environmental Officer who trains the employees in the proper use and disposal of chemicals and wastes. Polytanks and/or other containers are now required for routine disposal of chemicals. In addition, substitutions are made whenever a less-toxic chemical can be used to minimize potential effects resulting from spills or inadvertent disposal. The goal of the sink identification project is to identify sinks on building drawings, characterize possible discharges from those sinks, and determine the appropriate routing and/or treatment for that discharge. This major effort will result in all sinks being separated from EFPC.

8.1.4 East Fork Poplar Creek Area Source Pollution Assessment and Control Program

The Y-12 Plant NPDES permit requires evaluation of area source discharges from within and around the plant to determine their impact on the water quality of EFPC. Area source discharges, also referred to as nonpoint source pollution, result when uncontaminated surface water or groundwater flows over or through contaminated surfaces and results in the transfer of pollutants to a receiving stream. To characterize area source discharges into EFPC and to

develop a plan for their control, the Y-12 Plant has developed an area source pollution assessment and control plan for EFPC with the assistance of Camp, Dresser, and McKee, Inc.

Sampling of EFPC has demonstrated that nonpoint source pollution has a significant impact on instream water quality. To quantify pollutant transport into EFPC from area source discharges and to locate sources of these discharges, a comprehensive sampling program was conducted from September 1988 to April 1989. The major goals of this program were to identify locations of potential area source discharges, to determine pollutant loadings from these sources, and to identify appropriate corrective actions. The comprehensive sampling program consisted of flow monitoring and water quality sampling at 12 sites within the Y-12 Plant and within the EFPC drainage basin. Sampling intervals included a number of storm events ("wet weather" samples) as well as sampling during normal flow periods ("dry weather" samples). By comparing the water quality during the different weather conditions, sources and impacts of nonpoint source pollution can be evaluated.

In assessing parameters of greater concern in EFPC, those that exceeded applicable water quality standards for multiple events and multiple stations were selected.

To comply with these standards, six target reduction scenarios were identified: (1) a 99% reduction in total residual chlorine loads from all EFPC point source contributions, (2) a 96% reduction in nitrate loads from west groundwater contributions, (3) a 70% reduction in copper loads from west groundwater contributions to EFPC, (4) a 90% reduction in iron loads from all EFPC nonpoint source contributions, (5) a 25% reduction in copper loads from all EFPC nonpoint source contributions, and (6) a 98% reduction in the groundwater mercury loads from the east portion of the plant and a 70% reduction in the nonpoint source contributions to EFPC. Feasibility studies to analyze methods to reduce these contaminants will constitute the next phase of the Area Source Pollution Assessment and Control Program. A chlorine reduction feasibility study was completed identifying the major chlorine contributing outfalls to the EFPC. Dechlorination stations are being installed at three outfalls contributing the most chlorine to the EFPC (see Sect. 8.1.6, EFPC Dechlorination Effort, for more details).

8.1.5 Treatment for Category IV Discharges

Category IV discharges are classified as outfalls that contain untreated process water under the Y-12 Plant's current (extended) NPDES permit. The permit requires the application of best management practices (BMPs) to reduce to a minimum the pollutants contained within each discharge. In addition, the permit imposes toxicity testing requirements on each discharge. If the toxicity testing demonstrates that wastes are discharged in toxic amounts, then a toxicity control plan is to be developed and implemented.

All 22 Category IV discharges—with the exception of the Building 9202 Catch Basin and Sanitary Landfill 2—have either been treated or are no longer discharging to area surface streams. As a result of negotiations with city of Oak Ridge officials, photographic rinsewaters have been rerouted to the city sanitary sewer treatment facility.

The catch basin at Building 9202 contains mostly once-through cooling water and steam condensate used in heating. It was originally classified as a Category IV discharge because laboratory sinks were also connected to the basin. Plans are being formulated for disconnecting all sinks from the storm drain network. Currently, administrative controls are used for managing the sinks. This discharge was reclassified as a 700 Series–Miscellaneous Source Discharge in the November 1989 NPDES application. The justification for this change was based on the strict administrative controls and the negative toxicity results from the numerous toxicity tests conducted between 1985 and 1991. Based on chemical analysis and toxicity tests that have not demonstrated any significant contamination, the precipitation runoff from Sanitary Landfill 2 has also been reclassified in the NPDES permit application.

8.1.6 EFPC Dechlorination Effort

The Y-12 Plant has numerous once-through cooling units used in several plant processes and 18 cooling towers, all contributing to the EFPC flows and low-contaminant loading. Based on preliminary flow balance calculations of Y-12 Plant discharges to EFPC, the once-through cooling units and cooling

towers contribute more than 70% of the dry-weather flow monitored at EFPC, of which more than 60% can be attributed to once-through cooling water. The sources of once-through cooling water are variable discharges located throughout the storm drain system.

A feasibility study was initiated to determine the most significant potential sources of residual chlorine and to evaluate alternatives that effectively reduce chlorine residual levels to water quality criteria at EFPC. Outfalls 21, 135, and the north-south pipes were determined to be the biggest contributors of residual chlorine to the creek. Several treatment methods were considered for the reduction of chlorine at these outfalls, and dechlorinating the effluent with sulfur dioxide was determined to be the most feasible.

The dechlorination process consists of sulfur dioxide being drawn from a cylinder and passed through a pressure-regulating valve into a sulfonator that measures the sulfur dioxide feed into an ejector. Water from the outfall flows through a venturi located in the ejector creating a small vacuum that draws the SO_2 gas into solution with water. The ejector then conveys the SO_2 gas through the piping and equipment to the point of application. A diffuser then disperses the solution.

Two dechlorination units will be installed. The larger of the units will be located near the north-south pipes and will dechlorinate the effluent from outfall 135 and the north-south pipes. Construction and installation is expected to be complete at the end of March 1992. The second unit will be installed at outfall 21 and is expected to be on line by the end of May.

8.1.7 Aquatic Life Survey

A surveillance program to assess the physical condition and mortality of aquatic life in EFPC was initiated on July 18, 1990, and extended through CY 1991. As a result, several related studies were begun and are progressing in an effort to extract causes contributing to adverse impacts on the stream aquatic life. Personnel from the Environmental Sciences Division at ORNL, the Environmental Management Department at the Y-12 Plant, several Y-12 Plant operations groups, and various other industry consultants outside the ORR have contributed to this undertaking. Among the studies being performed are assessments in the areas of pathology and toxicology.

The program includes routine daily visual inspections, including holidays and weekends as necessary, that topographically follow the EFPC from Bear Creek Road through the diversion channel to the north/south pipes. In addition, water sampling at various sites along EFPC has been enacted to monitor the water quality, with heavy emphasis being placed on chlorine, pH, temperature, ammonia, and dissolved oxygen.

Numerous actions under way to determine the cause of adverse impacts include (1) a committee to review plant discharges, (2) continuance of the Biological Monitoring and Abatement Program and the Toxicity Control and Monitoring Program, (3) the initiation of several corrective activities aimed at reducing chlorine levels in EFPC, (4) a drain/source survey, and (5) in-depth streamside surveys studying the toxicity of chlorine in the creek as it applies to aquatic life.

8.1.8 Rogers Quarry Effluent Quality

Rogers Quarry has received coal fly ash and bottom ash from the Y-12 Steam Plant since 1965. The Y-12 Plant has implemented alternative coal ash disposal methods to eliminate the discharge of coal ash slurry to McCoy Branch (upstream of Rogers Quarry) and Rogers Quarry. These methods included (1) the interim measure of burning 80% natural gas instead of coal at the steam plant (initiated in December 1988), (2) the extension of the ash sluice pipeline directly to Rogers Quarry, thereby bypassing McCoy Branch (completed in November 1989), and (3) construction of a facility to handle fly ash in the dry state (completed in May 1990). Fly ash makes up about 80% of total ash production. In 1991 only bottom ash was sluiced to the quarry. Overall ash disposal in the quarry has been reduced by over 95% since these measures were undertaken. Efforts are under way to eliminate bottom ash by 1993.

As expected, the general effluent quality of Rogers Quarry continued to improve in 1991 in response to the greatly reduced inputs of coal ash. Concentrations of sulfate, arsenic, and selenium, constituents of coal ash that may be released after disposal, have decreased in the quarry effluent to near-background levels (for sulfate) or nondetectable levels (for arsenic and selenium). Figure 8.4 illustrates the trend in weekly sulfate concentrations in the quarry effluent since 1986. As noted in Sect. 4

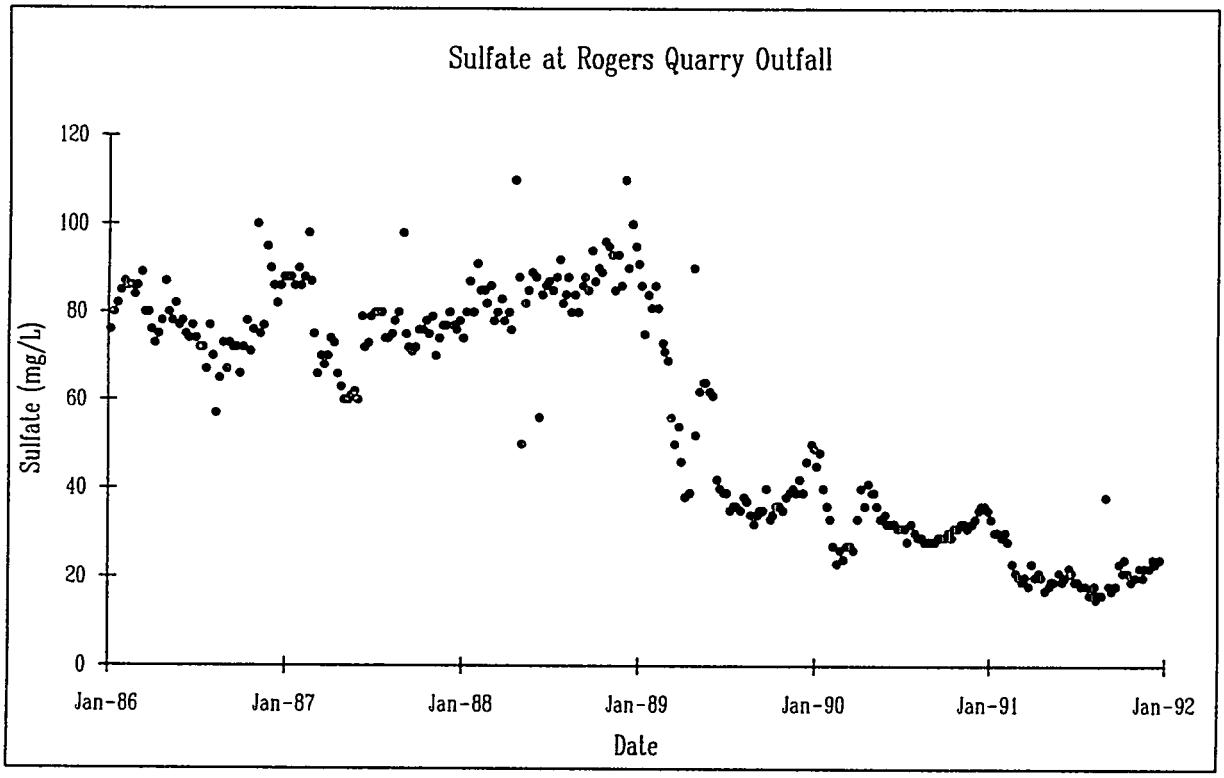

Fig. 8.4. Sulfate concentrations in Rogers Quarry effluents.

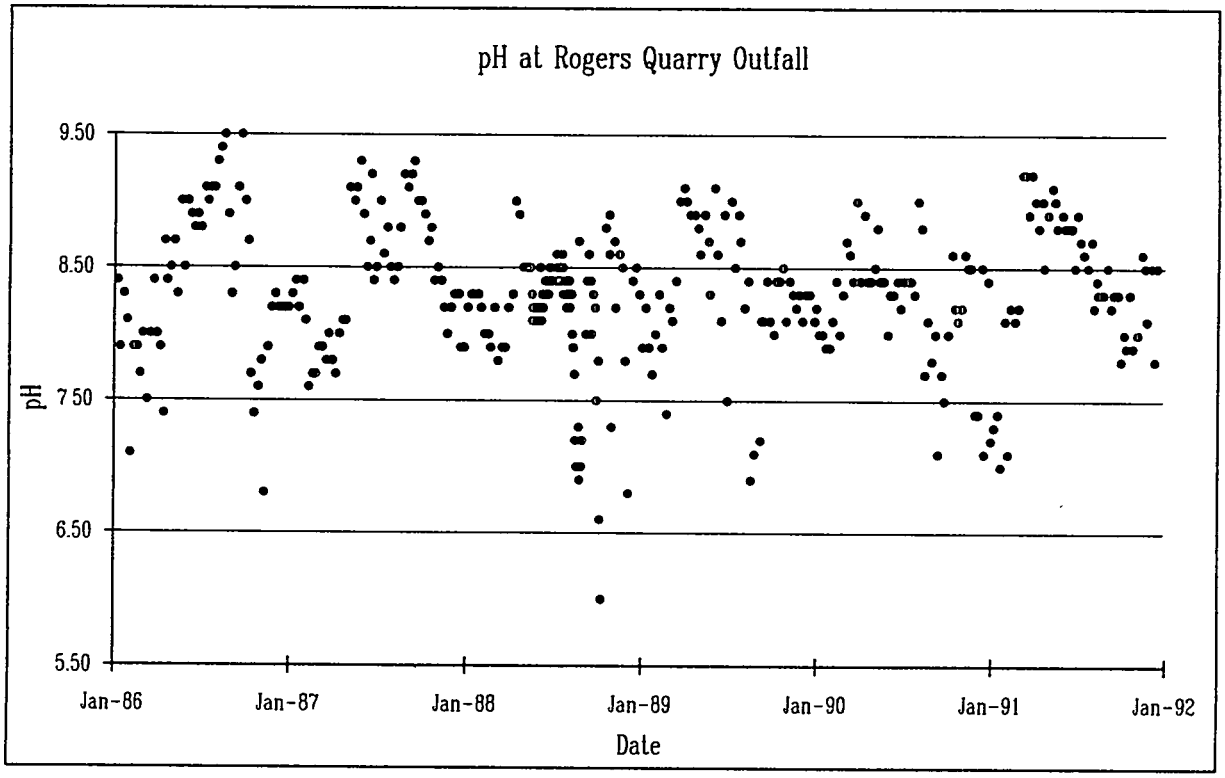

Fig. 8.5. Rogers Quarry effluent pH values.

and illustrated in Fig. 8.5, effluent pH values have continued to frequently exceed the NPDES limit value of 8.5, especially during the spring, summer, and fall in spite of the greatly reduced coal ash loading. Special investigations during 1991 demonstrated again that the pH excursions were because of algal growth in the quarry and are natural phenomena that occur in other surface waters on the ORR.

Monitoring of the effluent and water balance of Rogers Quarry is planned to continue until the ash slurry is completely eliminated. Biological monitoring studies of McCoy Branch, both upstream and downstream of Rogers Quarry, began in 1989 and will continue to document recovery.

8.1.9 Discharge of Special Nuclear Materials to the Sanitary Sewer

A review of the Y-12 Plant discharge of special nuclear materials to the sanitary sewer was initiated in June 1991. This review, which was completed in September, also included an investigation of the total amount of radionuclides released into the sanitary sewer.

The investigation concluded that the amounts of special nuclear materials, as well as the total amount of radioactivity, were below limits of applicable technical regulations as established by DOE, the Nuclear Regulatory Commission, and EPA. Also, the amount of total uranium discharged to the sanitary sewer decreased during 1991. As a result of this study, the sewage effluent sampling frequency was changed to weekly.

8.1.10 Secondary Containment Assessment

During the summer of 1991 a program was initiated to evaluate spill prevention needs and spill control facilities. During this year, emphasis has been placed on assessing spill containment areas at the Y-12 Plant.

The first step in this assessment was to gather information on secondary containment problems. This was accomplished by obtaining inspection reports from the Equipment Testing and Inspection Division (ET&I); by reviewing the survey of outdoor tanks conducted by a subcontractor, Roy F. Weston, Inc. (1991); and EMD personnel conducting visual inspections. All dikes and tanks that ET&I reported as unsatisfactory were included on the initial list of secondary containment problems. The worst cases described in the Weston survey were also included in this initial list. On-site inspections were conducted to determine which problems were of highest priority.

The second step involved notifying the operators of the deficiencies of dikes and tanks under their management. Operators were required to furnish the following information:

1. current construction plans to repair or replace the dikes/tanks in question:
2. funding source to be used to perform the repair or replacement of the dikes/tanks and whether the funding has been secured; and
3. a written schedule for completion of repair or replacement or plans and a written schedule for removing from service dikes/tanks that are not scheduled for repair or replacement.

All dikes and tanks that were identified in this initial assessment have been repaired and are either now in satisfactory condition or have action plans in place to correct the deficiencies identified.

8.1.11 Analysis of Sanitary Sewer Flow

During the summer of 1991 a study was conducted to assess the flow of water from the Y-12 Plant sanitary sewer to the Oak Ridge sewage treatment plant. The information collected would be used to provide a basis for determining how often the wastewater flow could be expected to exceed the new Y-12 Plant sanitary wastewater discharge permit flow limit of 1.4 Mgd.

A year's worth of flow data recorded by the city of Oak Ridge at city station 4 was studied along with rainfall amounts during the same period to determine the effect of large rains on sewer flows. Based on the information gathered, the flow rate for a year with average amounts of rainfall was estimated to be 0.03 m^3/s (650,000 gal/d). In general, flows only exceeded 1.0 MGD on days when rainfall exceeded 1.5 in. Precipitation during the 356 days of 1990 that were studied measured 1.518 m (59.78 in.). Rainfalls as large as 0.04 m (1.5 in.) occurred ten times, and large rains caused the sewer flows to swell above 1.0 Mgd only 5% of the time. Flows greater than 1.3 Mgd only occurred 1% of the time.

The study determined that the permit limit of 1.4 Mgd will not be exceeded unless unusually large amounts of precipitation occur. Flow and rainfall data will continue to be collected for future studies, and attempts will be made to establish trends between large rainfalls and elevated flows. The Y-12 Plant flow-monitoring equipment at the city station has been adjusted to total the flows daily instead of weekly to provide additional data. Many of these data will also be important indicators of reductions in flow once some of the once-through cooling waters, steam condensate, and other uncontaminated waters are rerouted from the sanitary sewer to the storm sewer.

8.1.12 Mercury Study in East Fork Poplar Creek for Methylation and Bioaccumulation in Fish

An experiment was designed to assess the role of sediment-associated mercury in fish contamination. Four cylindrical concrete enclosures, each 2 m (6.5 ft) in diameter, were placed in the channel of EFPC where it enters Lake Reality to measure directly the accumulation of methylmercury by fish exposed to mercury-contaminated sediments. Methylmercury is the form of mercury accumulated by biota that is produced by the action of microbes on inorganic mercury. Mercury was present in the EFPC water and absent in the groundwater made to flow through the enclosures. Fish were also exposed to the two water sources in tanks containing no sediments. Measurements of aqueous-phase mercury concentrations and speciation were made throughout the experiment.

Preliminary results suggest that the bioaccumulation of mercury in EFPC is a highly seasonal process. Fish exposed to contaminated sediments in both experimental treatments accumulated little mercury over the October–November period, even though they fed and grew over that time. Aqueous-phase concentrations of the methylmercury were very low in all treatments and indicated little production of this substance over the period. Further investigations of methylmercury production and bioaccumulation under summertime conditions are planned. Additionally, source studies conducted by the Environmental Restoration Division (ER) of mercury releases at the Y-12 Plant are planned to start in FY 1992. It is vital to understand the role of mercury-contaminated EFPC sediment in maintaining unacceptable concentrations of mercury in fish before deciding on the need for remedial measures such as dredging or stream relocation.

8.1.13 Fish Kill Investigations

On July 18, 1990, three (minnow-sized) dead fish were found in EFPC just downstream of Lake Reality during a routine survey conducted as part of the BMAP. During the follow-up surveys performed along the creek within the Y-12 Plant site boundaries for several days afterward, additional dead fish were found. Daily fish surveys have been performed since the initial sighting and have resulted in the recovery of approximately 2750 dead fish from EFPC through CY 1991. Daily surveys have also indicated that fish populations in EFPC have dramatically increased. This provides evidence that the upper reaches of the stream have begun recovery, but water quality may not yet be consistently adequate to fully protect aquatic life and fish propagation.

Several actions are under way in an effort to determine the causes of the ongoing fish kill and some individual fish kills that are not believed to be associated with the chronic problem. ORNL scientists who have been performing autopsies on various species of fish taken from these kills have speculated that elevated levels of chlorine in EFPC may have been a factor in the fish deaths. Streamside experiments to evaluate fish responses to chlorine stress have indicated that certain fish are susceptible to increased mortality given the current levels of chlorine in EFPC. Other factors are known to be involved and are being studied with the help of the U.S. Fish and Wildlife Service.

A committee consisting of personnel from various Y-12 Plant divisions and ORNL's Environmental Sciences Division has been examining the sources of discharges from the Y-12 Plant. The Y-12 Plant's Quality Division is in the process of analyzing data for the purpose of deriving statistical trend information that would allow identification of possible problem areas. Appropriate corrective actions will be taken, based on the findings of this committee. Daily surveys of EFPC will continue as will extensive sampling of the creek at various locations.

The reduction of chlorine from EFPC is being pursued directly in three different projects that will allow the Y-12 Plant to meet compliance levels as provided by the state of Tennessee. These projects

include elimination of nonpermitted plant drains, treatment of once-through cooling water discharges, and significant reduction of cooling tower blowdown. Other projects are in progress that will directly reduce pollutant loadings that are currently being seen in the creek. These include the Treatment Plant Discharges Project, Non-Point Source Pollution Control Project, and Rehabilitation of the Sanitary Sewer.

8.1.14 Monitoring by Westbay Multiport Measuring Systems at the Y-12 Plant

DOE's increased emphasis on assessing the environmental impact of past waste-disposal practices at all of its facilities has caused an increase in activities that delineate site-specific groundwater flow regimes and contaminant migration pathways. The complex geologic and hydrologic relationships at the Y-12 Plant require a more detailed understanding of the three-dimensional properties of groundwater flow regimes than can be obtained by conventional monitoring activities. Thus, as part of groundwater characterization activities conducted by the Environmental Surveillance Section of the Oak Ridge Y-12 Plant EMD, five existing deep coreholes were instrumented with multiport monitoring systems to provide greatly enhanced resolution of the hydraulic and hydrochemical properties of the groundwater system within Bear Creek Valley. With a multiport system, it is possible to measure hydraulic head and hydraulic conductivity and to collect water samples from multiple levels within a single borehole.

The coreholes range in depth from 183 to 388.7 m (599 to 1275 ft) (King and Haase 1987). Four of the coreholes (GW-132 through GW-135) are along a line traversing Bear Creek Valley and the northern flank of Chestnut Ridge near the western end of the Y-12 Plant; the fifth corehole (GW-131) is located along a geologic strike with GW-135 on Chestnut Ridge near the eastern end of the Y-12 Plant.

On the basis of geophysical logs and packer testing results (King and Haase 1989), seven to ten sampling zones, 6 to 7.6 m (20 to 25 ft) long, were selected in each well. The zones were chosen to potentially sample at least one of the following features: (1) fluids from fractures or fracture zones, (2) matrix fluids with long residence times, (3) potential changes in fluid chemistry with depth, and (4) potential water chemistry signatures associated with a particular rock type (Dreier 1990). Each sampling zone contains a pumping port, which allows the interval to be purged, in addition to a measurement port for collecting samples and measuring pressure in the zone. As a result, both pressure data and water samples are obtained from sampling zones.

The sampling zones are isolated from each other by one to three additional zones containing measurement ports, from which only pressure data are collected. Thus, using data from both the sampling and measurement zones, it is possible to acquire a very detailed pressure profile (25 to 41 measurements) from each well.

To date, four sets of pressure measurements have been collected. Although there are significant differences in the head profiles among the five wells, the general trend of the profiles for a given well is similar for each set of measurements. The pressure data suggest that lithologies and geologic structure, in part, control transient variations in hydraulic head as well as local and valley-wide hydraulic head distributions. In general, recharge is topographically driven from the ridges, as is expected in this region. Discharge patterns are disturbed by the presence of an artificially induced, isolated pressure bulge within the Nolichucky Formation but do show convergent flow to the Maynardville Limestone. This observation is consistent with the hypothesis that the Maynardville Limestone is a hydraulic drain for Bear Creek Valley. Within the Maynardville, flow directions have not been definitively determined, but flow is apparently horizontal with a local downward component. Flow along-valley is to the east from the S-3 ponds area to Scarboro Road.

Preliminary water chemistry results indicate evidence of regional-scale compositional changes in groundwater associated with increased residence time. Water types in the Bear Creek Valley–Chestnut Ridge system include (1) calcium/magnesium bicarbonate, (2) sodium bicarbonate, (3) calcium/magnesium sulfate, (4) calcium/sodium/magnesium sulfate, and (5) sodium chloride (Fig. 8.6). With increasing depth, and presumably increasing flow path length, the dominant cation changes from calcium/magnesium to sodium. An analogous change occurs in dominant anion from bicarbonate to chloride in the shale-dominant lithologies and from bicarbonate to sulfate to chloride in the

carbonate-dominant lithologies. The carbonate units are further distinguished from the shale units by the absence of sodium bicarbonate water and the stratification of calcium/magnesium sulfate water, both of which may be attributed to the mineralogy of the carbonates.

Groundwater samples obtained from GW-134 contain elevated nitrate concentrations in comparison to known background levels observed elsewhere in Bear Creek Valley. The downdip migration of contaminated water from the S-3 ponds is hypothesized to be responsible for the nitrate contamination. Infiltration of dense acidic wastewater through the unlined base of the ponds resulted in immediate reactions (primarily with calcite) in limestone intervals within the Nolichucky Formation. It is further hypothesized that the very reactive, dense wastewater was able to preferentially and aggressively attack calcite vein fillings and limestone beds and to proceed to migrate down the structural dip. The presence of an additional volume of water in the groundwater system (the wastewater) locally elevates the fluid pressure, and the increased pressures are expected to dissipate very slowly, apparently on the order of years. This process could explain the presence of the anomalous pressure bulge observed in GW-134. Because the source of the elevated fluid pressure no longer exists, the flow system is expected ultimately to return to a static pre-S-3 ponds configuration.

8.1.15 Groundwater Exit Pathways

The Maynardville Limestone is considered to be the primary pathway for groundwater leaving the Y-12 Plant boundaries. Hence, a monitoring-well program (the Maynardville Project) has been developed in which new wells are installed to intersect and monitor important groundwater pathways, commonly located in solutionally enlarged zones in the Maynardville Limestone.

It is believed that fractured intervals in the Nolichucky Shale, over which many waste sites are placed, feed into the Maynardville Limestone, thus allowing rapid transport of groundwater from the Y-12 Plant. The rationale for the Maynardville Project is to locate potential exit pathways of groundwater, to study the features of this groundwater system, and ultimately to provide hydrogeologic information to help minimize the potential impacts of contaminants to human health and the environment.

Exit pathway monitoring of groundwater is accomplished through the installation of monitor well clusters along parallel traverses (pickets) oriented perpendicular to the strike of the Maynardville Limestone. Each picket was planned to consist of

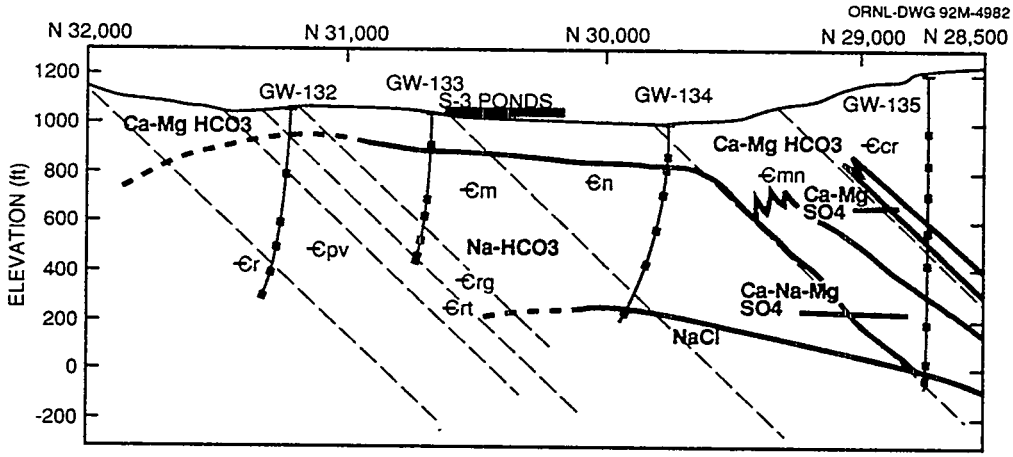

Fig. 8.6. Water types in the Bear Creek Valley—Chestnut Ridge system.

three deep wells, generally less than 300 ft, which would penetrate all members of the Maynardville, provide stratigraphic overlap between the wells, and monitor three different water-bearing zones within the Maynardville. Once the three major wells in a picket had been drilled, logged, and evaluated, additional water zones were selected for study with the objective of monitoring several different water-bearing zones within each picket. One or two additional wells were drilled next to each deep well in a picket to form well clusters used to study different water zones at a variety of depths.

As of February 1992, 27 wells, in 5 pickets, had been completed; lithologies described; geophysical logs obtained; cross sections constructed; water zones identified; and well bore purging completed. The five pickets that have been completed are pickets A (three deep wells), B (six wells), C (eight wells, see Fig. 8.7), J (four wells), and W (six wells). Pickets A, B, C, and W are located on the western side of BCV; picket J is located on the east end of BCV. No geochemical analyses were available as of February 1992.

Six different lithologic zones have been identified in the Maynardville Limestone based on lithologic and gamma log characteristics. Wells sample all zones at various depths. Numerous water zones were encountered in all wells drilled in this study, with some intersecting cavities, the largest of which is about 15 m (50 ft) high (GW-733 in picket J).

Correlation of water-bearing zones between different wells is accomplished based on the position of the interval within the stratigraphic column, with locations being identified as a function of depth below lithologic contacts. Specific water intervals can be correlated within lithologic zones. The correlations usually involve only two to four wells, and many wells that penetrate the same lithologic zone do not show correlations. For example, of a total of 12 wells drilled into zone 6, 5 different wells in 4 different pickets intersected a water-bearing interval at 3 m (10 ft) below the zone 6/5 contact. The additional seven wells that penetrated zone 6 did not encounter a water interval at 3 m (10 ft) below the zone 6/5 contact.

Another water interval [18 m (60 ft) below the zone 5/4 contact] was encountered in two wells. The depth of this interval below ground surface in one well was 45.1 m (148 ft), whereas it was approximately 200 m (650 ft) below the surface in the other well. In general, there appears to be a decrease in water-bearing intervals with depth below ground

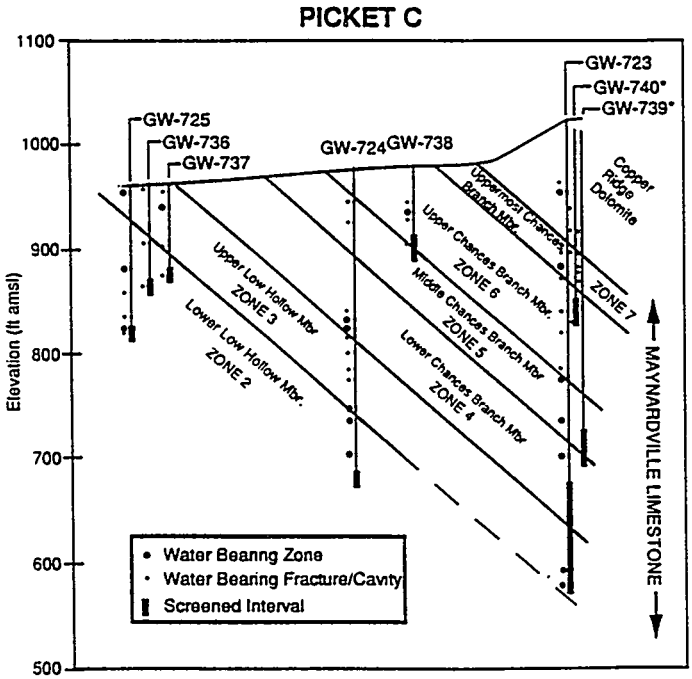

Fig. 8.7 Picket C of the groundwater exit pathways study for the Maynardville Limestone.

surface, yet as the previous example indicates, this is not always the case.

Zone 6 of the Maynardville appears to be the most prolific water-bearing zone, with zone 2 being the next most prolific. All water-bearing intervals in zone 6 occur at depths less than 74.4 m (244 ft), with a greater number of water intervals being encountered in wells drilled on the flanks of Chestnut Ridge. Water-bearing intervals in zone 2 occur at depths up to 151 m (495 ft), with a greater number of water intervals being encountered in wells drilled in the floor of BCV; however, this observation is a function of location of drill holes, because very few wells drilled on Chestnut Ridge are drilled deep enough to encounter zone 2.

In summary, there is no consistent correlation of water-bearing intervals with depth below ground surface, lithology, or well location (valley or ridge). However, larger water volumes are generally produced from the shallower [less than 30 m (100 ft)] water-bearing intervals within BCV in all Maynardville zones. Additional studies are required to better evaluate possible correlations of water-bearing intervals in the Maynardville and to determine if different base levels of the local karst system through time are important in controlling the location of water-bearing intervals in the Maynardville.

8.1.16 Voluntary Reduction of Hazardous Air Pollutants

Title III of the Clean Air Act Amendments of 1990 provides a six-year extension for complying with the Maximum Achievable Control Technology (MACT) standards for hazardous air pollutants (HAPs) to any facility that commits to a 90% gaseous emission reduction (95% for particulate) of HAPs prior to promulgation of the applicable MACT standards. The HAP emission reduction is relative to a 1987 (or later) baseline, and sufficient evidence must be available to demonstrate that the baseline emissions are not artificially inflated. The reduction must be based on verifiable mass balance calculations or measurements that are available and auditable. In addition, the reduction must be achieved before proposal of the applicable MACT standards or not later than January 1994 for those facilities entering into an enforceable commitment with the EPA.

An initial review of the available air emission data and the known emission reduction projects with planned completion dates prior to 1994 indicates that a voluntary reduction agreement may be feasible for the Y-12 Plant and should be investigated further. A plant-wide Productivity Improvements Process (PIP) review for the voluntary reduction of HAPs at the Y-12 Plant has been initiated. The PIP team will perform a review of the HAPs emitted by the Y-12 Plant, the currently proposed projects involving HAPs, areas using HAPs for which a reduction project has not been proposed, and the consequences of entering into a voluntary reduction agreement. Based on this review, HAP sources with a potential for early reduction will be selected and an enforceable commitment prepared. Upon completion, the enforceable commitment will be submitted to Y-12 Plant management for review prior to determining whether the Y-12 Plant should enter the commitment.

8.1.17 High Efficiency Particulate Air (HEPA) Filter Systems Review

The Y-12 Plant is developing a checklist for reviewing all existing HEPA filter systems in the Y-12 Plant against the criteria required by ES-5.6-6 "Bag-In/Bag-Out High Efficiency Particulate Air Filter System" to determine what deficiencies exist. The checklist will provide a method for rating the deficiencies of the existing HEPA filter systems in order to set priorities for the corrective actions required to meet the criteria of ES-5.6.6. A method will be developed to utilize the checklist to perform a survey of all HEPA filters systems in the Y-12 Plant.

A HEPA Filter Review Team has been organized to review existing HEPA filter systems in the Y-12 Plant which cannot be in-place dioctyl phthalate (DOP) leak tested. The review team consists of personnel from the Maintenance and Utilities Division, the Engineering Division, and the Health, Safety, Environment, and Accountability Division. The purpose of the team is to review existing HEPA filter systems upon request by the responsible operations division and to determine if a HEPA filter system can be downgraded to a lower efficiency filter or exempted from the requirements of initial or annual in-place DOP leak testing. The review will consider the purpose of the HEPA filter, the type and amount of material collected by the HEPA filter, and

the federal, state, DOE, and Y-12 Plant criteria that apply to the use of HEPA filters. All members of the team must be in agreement to issue an exemption or a downgrade of a HEPA filter system. Any HEPA filter system denied an exemption or a downgrade must be modified to allow for in-place DOP leak testing. All decisions resulting from the review of a HEPA filter system are documented in writing to the responsible operating division.

8.1.18 Stratospheric Ozone Protection Plan

The Y-12 Plant is developing a Stratospheric Ozone Protection Plan to minimize emissions and eventually phase out use of regulated ozone-depleting substances as required by Title VI of the Clean Air Act Amendments of 1990. A working group has been formed that includes representatives from all areas of the Y-12 Plant responsible for purchasing or using ozone-depleting substances. The main element of the Y-12 Plant Stratospheric Ozone Protection Plan will be a data base consisting of the release data and the reduction plans for each source of ozone-depleting substances at the Y-12 Plant.

8.1.19 NESHAP Emission Source Survey

The Y-12 Plant is developing a comprehensive emission source survey to identify potential NESHAP polluting sources. The study is designed to document stack and vent locations throughout the plant. The processes that feed into these stacks and vents are identified, and a characterization of the emissions is also generated. The study includes actual field surveys that result in as-built process flow diagrams and drawings.

Because of the importance of radionuclide regulations on the Y-12 Plant, the initial emphasis of the NESHAP survey is concentrated on airborne radioactive emissions. All buildings that handle radioactive material have been ranked by their suspected potential to emit contaminants. The majority of radioactive processes are vented through monitored stacks where emission estimates are generated from stack data. However, several stacks and process areas have been discovered that are not tied in with the monitored systems. Independent estimates are being generated for these areas.

The last area of the radionuclide survey is fugitive room emissions in uranium processing areas. These calculations are based on Health Physics measurements and room air exchange rates. The majority of the process areas are vented through monitored stacks, but the remainder is contributing small amounts of fugitive emissions to the plant totals.

8.1.20 Ambient Air Monitoring Station Upgrades

The Y-12 Plant created a BMP plan to upgrade the current uranium and fluoride ambient air samplers located at the plant. The plan includes a site evaluation to determine if any new samplers need to be installed as well as an upgrade program for the current monitors. The site evaluation is expected to take place in FY 1992. A lack of funds has delayed the upgrade to the samplers.

8.1.21 Emissions Excursions for Stacks 36 and 42

A team of Operations and Plant Support personnel identified corrective actions required to prevent radioactive effluent releases from Stacks 36 and 42 on Building 9212 at the Y-12 Plant. Equipment and processes were reviewed to determine likely sources of the releases, which exceeded the Y-12 Plant internal administrative limits and the DOE reporting limits for emissions from these stacks.

Among the corrective actions are instituting increased operating administrative controls, including continuous monitoring of the stack sampler data acquisition monitors for any increasing trends in emission rates. This observation was used to identify changes in process emissions at the onset and allowed time for adjustment to operations and/or identification of potential sources before the plant emission limits were exceeded. In addition, stricter controls, upgrades to operational procedures, and education of operating personnel to the impact of changes in process parameters to exhaust rates were initiated.

Although administrative controls and increased operational awareness would aid in reducing the frequency and magnitude of stack emissions, additional environmental control equipment would be required to further minimize the occurrences. Maintenance Work Requests for modifications to the stacks included the installation of a HEPA Filter System and Demister for Stack 36 and a HEPA Filter System for Stack 42. The new installations will

eliminate incidents of excursions beyond permitted daily limits and also reduce the total annual emissions from the stacks.

The emission controls will be used until the Air Emissions Control Project, which was initiated in 1985, is brought on line. This project was to provide environmental control upgrades for Buildings 9212 and 9206. These upgrades included modifications and improvements to the exhaust systems serviced by Stacks 36 and 42. The project upgrades include installation of new scrubbers for the wet processes along with high-efficiency particulate filters. Completion of this project was scheduled for September 1989; however, monetary constraints and the absence of safety documentation have caused delays. The revised completion of this project is currently scheduled for the second quarter of CY 1993.

8.1.22 Historical PCB Spills

Historical PCB spills are defined in 40 CFR 761.120 as those occurring prior to May 4, 1987. The EPA recognizes that historical spills will require site-by-site evaluation because of the probability of more pervasive PCB contamination than fresh spills and because old spills are generally more difficult to clean up than fresh spills (especially on porous surfaces such as concrete). Therefore, spills occurring before May 4, 1987, are to be decontaminated to requirements established at the discretion of EPA.

Several areas at the Y-12 Plant have revealed PCB concentrations in excess of allowable levels. The sources of the contamination were removed prior to May 4, 1987, therefore constituting historical spills. Three such areas are Building 9215 M-Wing, Building 9215 O-Wing, and Building 9202 trench. After attempts to clean the areas were not successful, proposals were submitted to EPA Region IV for review.

Included in the proposals submitted to EPA are (1) a scope of work, (2) a detailed history of PCB usage and concentration of PCBs in each area, (3) all sampling and clean-up efforts completed, (4) the future utilization plans for the areas, (5) the proposed actions to be undertaken in order to utilize the areas, (6) a schedule, (7) estimated costs incurred in the proposal, and (8) the ultimate long-term restoration of the areas.

8.1.23 Y-12 Plant Waste Minimization Program

Process Waste Assessments (PWAs) are being conducted as part of the ongoing program to identify, screen, and analyze options to reduce the generation of waste. A PWA determines the amount of material for a workplace that is disposed of as waste during work operations. It provides a summary of hazardous materials usage and waste production and identifies those processes and operations that need to be improved or replaced to promote waste minimization. The assessment provides a basis for prioritizing the specific modifications to site processes or other waste minimization options developed during the assessment.

Assessments of all waste-generating operations at the site are and continue to be conducted by PWA teams organized by the Waste Minimization Working Team and the Waste Minimization Implementation Manager. The assigned leader of each PWA team is an intermediate-level employee who has line responsibility, familiarity with the site's production and waste management operations, and proven technical and problem-solving abilities. The rest of each assessment team is drawn from line, staff, or subcontractor organizations who can furnish the types of specialized expertise needed to conduct the assessment.

Completion of the flow diagrams, material balances, and related narratives continually permits the identification of process inefficiencies that may be modified or corrected to reduce waste generation. These waste minimization opportunities are constantly being evaluated and identified with specific projects, which, as implemented, reduce the volume and toxicity of the waste streams. As appropriate, each team continues to report the data and findings from its assessment and to recommend options for waste minimization. In identifying waste minimization options, the PWA teams concentrate first on source reduction options and then on recycling technologies.

A number of activities carried out within the routine operations at the Y-12 Plant may qualify as waste reduction activities, although they were not conceived or implemented for the sole purpose of complying with waste reduction requirements. Other programs have been implemented for the sole purpose of controlling the presence of certain compounds or wastes.

The chlorinated solvent reduction program has been a twofold effort at the Y-12 Plant. The first effort was the replacement of vapor degreasers that used chlorinated solvents with ultrasonic cleaners using detergent and water. At least two areas made this substitution before accounts were kept of the usages. The second effort has been the replacement of "squirt bottle" or specialty operations with other organic solvents. The following areas have substitutes in effect. (The usage data is based on 1987 values. These efforts followed another major effort in which perchloroethylene used as a machining coolant was changed to a mixture of propylene glycol, water, and borax).

Several project teams throughout the site have achieved considerable success in waste reduction and minimization activities. Following are five significant waste minimization/reduction projects.

1. elimination of mixed RCRA/radioactive wipes from shop floor operations by elimination of chlorofluorocarbon solvents;
2. trichloroethane waste stream reduction;
3. elimination of hazardous chemicals and waste in the Y-12 graphic arts department;
4. installation of rapid access process for color photographic prints and viewgraphs; and
5. aluminum nitrate waste minimization.

Efforts to improve the waste tracking system at the Y-12 Plant are in progress, with completion of the first phase of the new system scheduled for December 1991. The first phase will facilitate the collection of data that are segregated by cause of generation. Such data will be more representative of waste-reduction efforts and their impact on waste generation of specific waste types.

The Y-12 Waste Minimization/Reduction Program continues to mature. Programs will be instituted routinely, as resources permit. The recent changes in the program leadership and organization have strengthened the program. Also, the anticipated results from the PWAs and the collaboration with the pollution prevention awareness team should assist in making informed decisions regarding resources and direction.

8.1.24 DNAPLs at the Y-12 Plant*

In January 1990, accumulations of dense, nonaqueous phase liquids (DNAPLs) were discovered at depths of about 83.5 m (274 ft) below ground surface along the southern border of Burial Ground A–South within the Bear Creek Burial Grounds Hazardous Waste Disposal Unit at the Y-12 Plant. A preliminary investigation was initiated to obtain information on the mode of occurrence and distribution of the DNAPLs and to determine its behavior in fractured rock such as that underlying the Bear Creek Burial Grounds.

The primary constituent found in DNAPL samples recovered from the discovery monitoring wells in the burial grounds area is perchloroethylene (PCE), with lesser amounts of trichloroethylene (TCE) and other chlorinated solvents.

Movement of DNAPLs in fractured rocks is complex and difficult, if not impossible, to quantify with certainty. Depending on the fracture patterns within a rock mass, the pathways of downward movement of DNAPLs may be direct or indirect. At the Bear Creek Burial Grounds site, the pathways are likely indirect. Because of the complex geology of the area and uncertainty as to the quantities and location(s) of DNAPL release(s), the pathways of DNAPL migration and the present subsurface configuration of DNAPL accumulations cannot be determined.

Given the history of the Bear Creek Grounds, where DNAPLs were disposed of a number of years ago, DNAPL migration is not likely to be occurring at present. The situation is expected to remain static as long as the hydrogeological system in the immediate vicinity of the DNAPL occurrences is not hydraulically disturbed. In recognition of this constraint, ongoing characterization activities are following a conservative strategy designed to define the outer extent of the dissolved plume. More detailed characterization of the sites of DNAPL accumulation

*Haase and King (1990).

that will avoid hydraulic disturbance of the system are being planned.

8.2 OAK RIDGE NATIONAL LABORATORY

8.2.1 Miscellaneous ORNL Spills

During 1991, ORNL had a total of 125 spills or releases of various types of materials (Figs. 8.8–8.10) compared with 109 for 1986, 92 for 1987, 119 for 1988, 91 for 1989, and 135 for 1990. ORNL has defined a spill as any material outside its containment vessel. A spill is not necessarily a release to the environment; it may be to the floor, a laboratory bench, or a secondary containment structure. Emphasis is placed on spill reporting and investigation to prevent any environmental releases. Members of the ORNL Office of Environmental Compliance and Documentation investigated each spill or release to determine the environmental impact, to provide input for reducing any harmful effects, and to assist with cleanup efforts. Cleanup activities were conducted by staff members of the ORNL Hazardous Waste Operations Group. All cleanup materials were disposed of according to ORNL procedures.

ORNL reports all spills via the electronic mail system to various levels of ORNL management as soon as possible after the spill; updates are provided as necessary. This reporting system has resulted in an increased awareness of spills by ORNL staff members. Additional reporting, if required, is done under ORNL Occurrence Reporting System as required by DOE Order 5000.3A, *Occurrence Reporting and Processing of Operations Information.*

As in previous years, many of the spills involved petroleum products. Efforts to enhance spill prevention, especially releases to storm drains, included training for more than 900 ORNL Plant and Equipment Division personnel as part of their quarterly safety meeting, and increased monitoring of construction activities and storage areas where these types of spills often occur. The monitoring and site assessment activities, conducted by Field Interface Staff, also provided an opportunity to detect and prevent other potential environmental problems. Of the 125 spills, 62 were less than a gallon in quantity, and 8 were greater than 500 gallons.

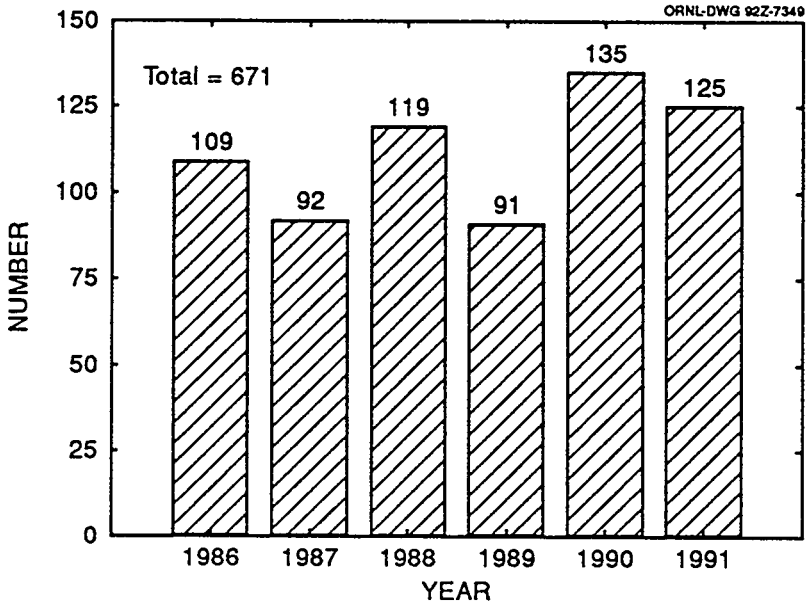

Fig. 8.8. ORNL spill summary, 1986–1991.

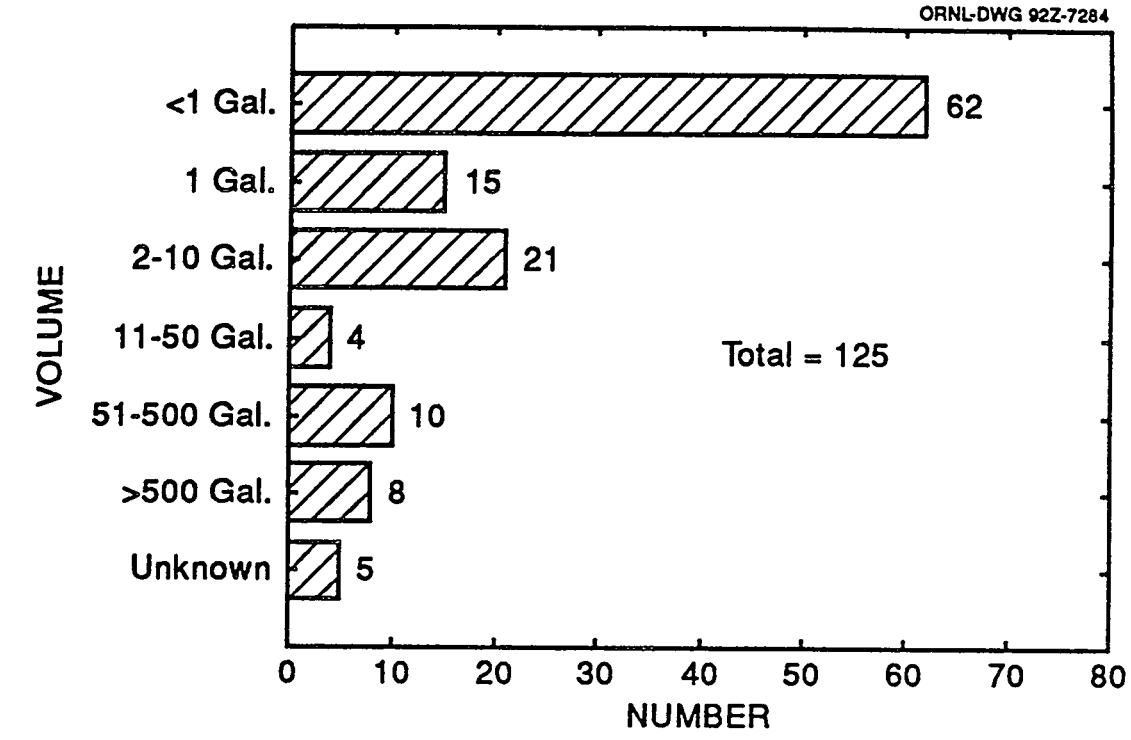

Fig. 8.9. 1991 ORNL spill summary (volume frequency).

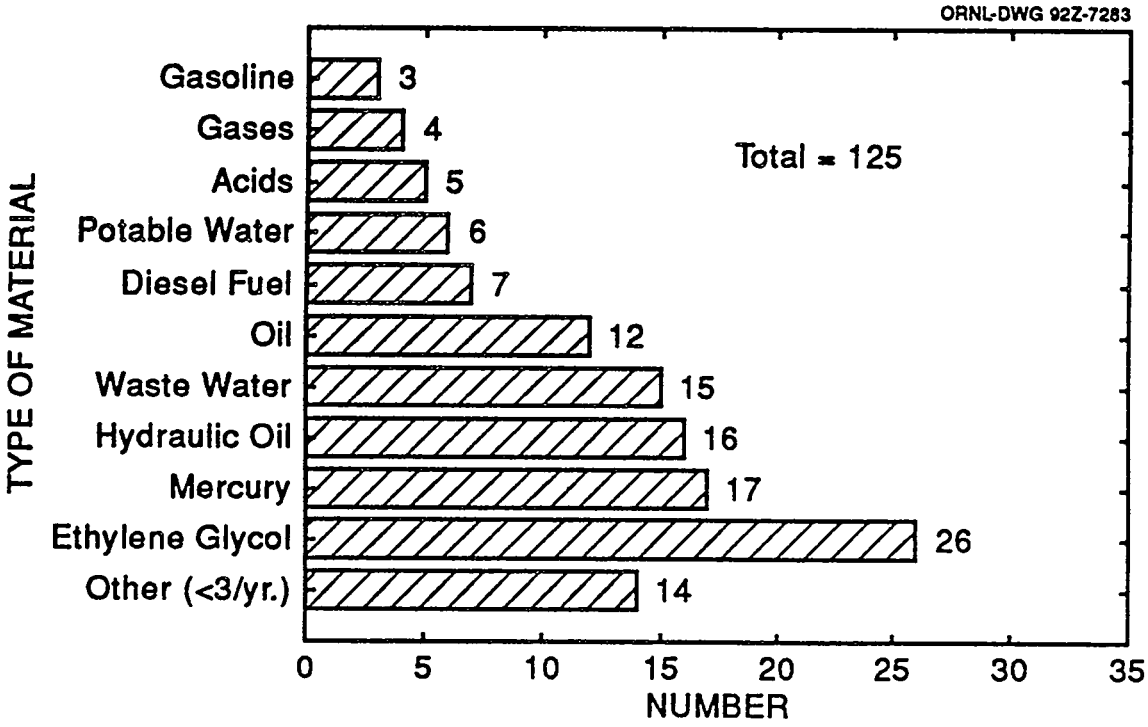

Fig. 8.10. 1991 ORNL spill summary (material frequency).

8.2.2 Modeling Bed Load Transport in White Oak Creek by Using ^{137}Cs Inventories

Bed load sediments of White Oak Creek (WOC) below the Process Waste Treatment Plant (PWTP) have been labeled by historical releases of ^{137}Cs to depths greater than 25 cm. The WOC streambed acts as a sink for ^{137}Cs because of irreversible sorption onto bed load sediments. During major storm events, streamflow transports bed load sediments downstream. Because the bulk of ^{137}Cs in WOC is fixed to sediments, the rate of sediment transport downstream becomes an important parameter in assessing the dispersal of ^{137}Cs through the fluvial system.

The net downstream transport of several different streambed sediment size fractions in WOC was quantified by collecting streambed cores from several locations within a 550-m reach, sectioned into 2-cm intervals and wet sieved into various size components (from 1–2 to 8–16 mm). Sediment within this size range includes the bulk of sediment in WOC. The separate size fractions were then analyzed for ^{137}Cs, and each size fraction and core location was inventoried. The integrated ^{137}Cs activity is the total activity of the core to depth of bed load scour for a particular size fraction. This inventory is due both to contaminated sediment transported to that location and to subsequent ^{137}Cs sorption directly from stream water. A model of ^{137}Cs transport and distribution in the WOC streambed was formulated that incorporates bed load celerity as well as sorption dispersion, advection, and radioactive decay of ^{137}Cs (Sobocinski et al. 1990).

Results indicate that the bed load of WOC undergoes several transport events per year when threshold velocities exceed base flow (~0.22 m^3/s) by a factor of 5. Sediment transport velocities decrease with increasing grain sizes. The model indicates mean sediment velocities of 265, 215, 170, and 160 m/year for the 1-to-2–, 2-to-4–, 4-to-8–, and 8-to-16–mm fractions, respectively. These rates are similar to rates observed elsewhere. Based on these transport rates, a 30-cm scour depth, and a normal number of storm events per year, bed load transport will flush the contaminated 1-to-16–mm fraction out of the study reach within 1 to 6 years after the sources of ^{137}Cs contamination are eliminated. This has important implications for predicting downstream transport of contaminants in this system.

8.2.3 Sorption Characteristics of ^{137}Cs in White Oak Creek Streambed Gravels

Sediments in WOC contain elevated concentrations of ^{137}Cs that are derived from water discharging from PWTP at ORNL. The ^{137}Cs concentrations on the bed-load sediments at a particular point in the stream are the result of in situ sorption of ^{137}Cs as well as the transport of sediment from upstream locations. The sorption of ^{137}Cs by stream sediments in WOC considerably decreases the concentration of ^{137}Cs in the water by the time it is discharged into the Clinch River, so the dynamics of ^{137}Cs sorption characteristics of WOC bed-load sediments onto the streambed gravels were examined.

The study was conducted during low-streamflow conditions, which predominate during most of the year. The streambed studied is below the PWTP and is dominated by gravels composed of chert (23%), limestone (43%), and shale (35%). The size distribution of the dominant components range from less than 0.1 to 64 mm, with a medium grain size of nearly 8 mm. Because gravels greater than 1-mm size fraction have uniform mineralogies, these were selected for sorption investigations.

To determine the sorption characteristics of the gravels, reciprocal transplant experiments were performed. Uncontaminated gravels from remote locations were transferred to WOC, whereas contaminated gravels from WOC were transferred to noncontaminated zones. These gravels were placed in slotted pipes and were suspended above the streambed as well as inserted vertically into it.

These investigations reveal that ^{137}Cs is significantly sorbed onto WOC gravels, not only at the streambed surface but penetrating to some 20 to 40 cm below the gravel-water interface (Cerling et al., 1990). Sorption was found to be surface related (higher ^{137}Cs on smaller size fraction) as well as dependent on the lithology of the material. On a 2- to 4-mm size fraction, shale contained about 83% of the ^{137}Cs activity, compared with 8% for chert and 9% for limestone. Desorption of ^{137}Cs by sediments in WOC is insignificant on a time scale of 6 years and appears to be essentially irreversible.

The sorption of ^{137}Cs by streambed gravels in WOC results in a considerable decrease in the element's water concentrations, diminishing by 50% over a 1000-m reach of streambed and significantly

reducing the discharge of ^{137}Cs into off-site environments.

8.2.4 In Situ Vitrification of a Simulated Radioactive Seepage Trench

In situ vitrification (ISV) is one method used to stabilize contaminated soils in place. ISV was developed by Pacific Northwest Laboratory (PNL) and patented for DOE. The technology involves inserting four electrodes in a square array into the contaminated soil and applying an electrical potential to the electrodes. The soil is heated to above its melting point, and the molten zone expands with time to encompass the contaminated zone. After cooling, the resulting solid material is usually a mixture of glass and crystalline material that has a significantly higher resistance to leaching than did the original soils. Nonvolatile elements (most radionuclides and metals) are dissolved into the melt or encapsulated in glass if their solubility in the melt is low. Organic compounds tend to be pyrolyzed, with the decomposition products diffusing to the surface and combusting on exiting the molten zone. A hood is placed over the vitrification zone to collect off-gas particulates and volatiles into a processing trailer that scrubs contaminants from the off-gas.

ISV was successfully tested on a simulated seepage trench at ORNL during May 1991. The test trench was a 1/4-scale model representative of seven seepage trenches and pits used at ORNL from 1951 through 1966 to dispose of over one million curies of radioactive liquid wastes. The pits and trenches are currently undergoing remedial investigations and/or feasibility studies to identify potential technologies that may be used to clean up and/or stabilize these old contaminated sites. ISV is a leading technology candidate because of the high risks associated with any options that require retrieval and because of the high-quality waste form it produces.

A test trench (1.8 m long 0.9 m wide 1.8 m deep) was constructed in reconstituted native soil using crushed dolomitic limestone with a radioactive tracer, consisting of sludge taken from an inactive seepage pit, placed at the bottom contact between the limestone and soil at a depth of approximately 1.8 m. Radioactivity (~14 mCi) in the sludge tracer consisted predominantly of ^{137}Cs and ^{90}Sr with lesser amounts of ^{60}Co, ^{241}Am, and $^{239,240}Pu$. The mobile pilot-scale ISV equipment was transported from the Hanford Site to ORNL and then assembled. The four graphite electrodes were placed in a square pattern 1.1 m apart. During the test, a total of 29 MWh of power was applied over 127.5 h to produce a melt approximately 2.6 m deep with an estimated mass of 13.5 Mg. Eighty-seven thermocouples, six optical pyrometers, eight heat flux sensors, and five pressure sensors were placed within and around the melt zone. These were used to monitor the size and shape of the melt and other key parameters to evaluate the performance of ISV for application to actual waste sites.

The measured operating temperature of the melt ranged from approximately 1150 to 1500°C and was highly dependent on the power being applied to the electrodes. A temperature plateau lasting 20 h was observed during cooling at a temperature of approximately 1150°C. The latent heat of crystallization released during this thermal arrest was interpreted to be the source of energy that caused temperatures in the surrounding soil to rise well after power had been discontinued (60 h). During melting, approximately 2.7% of the ^{137}Cs volatilized from the melt and was captured quantitatively on a HEPA filter that had been designed into the off-gas containment system especially for this purpose. No other radionuclides were observed to volatilize.

The ISV material was cored after cooling and was observed to be extensively crystallized with an almost complete absence of glass-like material. The crystalline material is a mixture of calcium-magnesium-silicate (diopsidic pyroxene) and calcium-aluminum-silicate (plagioclase feldspar), with a lesser amount of potassium-aluminum-silicate (potassium feldspar). The reasons for the unusual lack of glass are not known with certainty yet but are probably related to bulk composition, abundance of nucleation sites, and cooling history of the melt. The leach resistance of the ISV material is being tested via standard leach tests, and it is anticipated that the crystallization will not significantly degrade the quality of the waste form.

8.2.5 Grout Curtain at Seepage Trench 7

Several corrective actions were taken in 1985 and 1986 at the site of ORNL radioactive liquid waste seepage trench No. 7 in an effort to reduce the discharge of radionuclides, mostly ^{60}Co, from a groundwater seep on the eastern side of the site. First,

the asphalt cap over the trench was doubled in size and its runoff diverted away from the site to the west. Second, the buried waste transfer line to the trench was excavated and capped and its pipe trench dammed with clay backfill. These actions were designed to reduce groundwater recharge in the area that might be the source of water to the seep. Third, a series of grout injections were carried out at 1.5-m (5-ft) intervals along a perimeter line on the eastern and northern edges of the site.

A total of 280 m^3 (65,500 gal) of lime–fly ash grout was injected at 303 locations at depths up to 12 m (40 ft) in an effort to seal relict contaminated strata with probable hydrologic connection to the seep. However, the grout formulation specified in the contract would not set to a detectable compressive strength nor would the grout samples exhibit a reduction in hydraulic conductivity during over a year of observation. Thus, the material specification for the grout was inappropriate for the desired effect of in situ hydrologic isolation. Core sampling at the site revealed that the grout flowed into the soil formation along discrete thin layers (i.e., along fractures probably enlarged by the grout injection pressure). Only three grout layers, with a maximum thickness of 0.06 cm (0.024 in.), were found in over 27 m (90 ft) of core from three locations along the grout injection line. Thus, this grouting action would have little potential to achieve containment of radionuclides that leach from contaminated strata.

8.2.6 Groundwater Fracture Flow Studies

Fractures in soil and bedrock influence groundwater flow and contaminant transport, and several studies have been initiated to help quantify where hydrologically active fractures occur and how interactions between fractures and the surrounding matrix can both speed and slow solute movement.

Field studies include use of a borehole flowmeter that can measure flow to a well at discrete intervals. In most wells tested, the majority of the water enters the wells in one or two zones . These are believed to be hydrologically active fractures. Fracture spacing seems to be on the order of 3 m (10 ft) in shallow wells and on the order of 15 m (50 ft) in wells over 15 m (50 ft) deep.

Groundwater modeling that incorporates fracture flow processes on the ORR has been initiated. One of the most important processes in this hydrogeologic setting is matrix diffusion, or the movement of solutes from fractures to the surrounding matrix because of the concentration gradient. Two sites have been investigated with this model. The first system is a set of wells 60 m (200 ft) deep in Melton Valley that have been monitored for tritium and ^{14}C as natural tracers of groundwater age. The tritium value indicates the water is less than 50 years old, whereas the ^{14}C indicates water 3,000 to 30,000 years old (younger water occurring beneath the recharge area). Matrix diffusion modeling can explain the age discordance, given assumptions about tritium input, fracture spacing (consistent with the borehole flowmeter results), and retardation of carbon. The tritium could be moving along a fast flow path in a fracture, and only the first arrival has been detected. The ^{14}C has been diffusing into the matrix for many years, reaching a steady-state value that reflects an average rate of travel, but not the fast flow paths.

The second study site for matrix diffusion modeling is in SWSA 5. Storage of tritium contamination in the matrix because of diffusion helps explain why there has been a continuous release of tritium from this site for many years. Samples have been collected along a continuous core, and both groundwater and pore water show a smooth variation in concentration, similar to a diffusion profile. A better understanding of the diffusion rate and fluxes will help predict whether contamination can be flushed over a period of decades or centuries and will indicate feasible remediation technologies that consider this secondary source in the matrix.

8.2.7 Hydrologic Monitoring in the White Oak Creek Watershed

Collection of hydrologic data for the WOC watershed began with facility planning studies in the early 1940s and has developed into a long-term program of environmental research and monitoring activities required to cope with ORNL's unique waste management needs. Hydrologic data available for water year 1991 (October 1990–September 1991) were derived largely from ongoing studies of the ORNL Environmental Restoration Program (ERP) and from the continuing monitoring program conducted by the ORNL Environmental Surveillance and Protection (ESP) Section of the Office of Environmental Compliance and Documentation (OECD). Much of the current monitoring is

associated with the NPDES permit for ORNL operations (Permit Number TN0002941).

Precipitation data, probably the most important climatic factor in hydrologic studies, are available for several stations located in the vicinity of the watershed. The period of record varies from station to station. The National Oceanic and Atmospheric Administration, Atmospheric Turbulence and Diffusion Laboratory (NOAA/ATDL) monitoring station is the closest long-term meteorological station; its records date from 1947 to the present. It is located in Oak Ridge about 15.4 km (9.6 miles) north of the center of the watershed.

The quantity and variations in runoff and streamflow are provided by precipitation, dependent upon rainfall intensity, soil condition, ground cover, slope and runoff coefficient. It is also the source for replenishment to the groundwater system. Maximum, mean, and minimum annual precipitation for stations near ORNL during the period 1954–1983 were 190.0, 132.6, and 89.7 cm (74.8, 52.2, and 35.3 in.), respectively. Monthly precipitation at the NOAA/ATDL station generally ranges from 13.46 to 15.75 cm (5.3 to 6.2 in.) during the wettest months (January–March) and from 7.37 to 9.65 cm (2.9 to 3.8 in.) during the driest months (August–October). The mean annual runoff for streams in the ORNL area is 56.6 cm (22.3 in.) of water. The remaining mean annual precipitation, about 76.2 cm (30 in.), is consumed by evapotranspiration.

Annual precipitation for water year 1991 at nine sites in the vicinity of the WOC watershed ranged from 142.5 to 157.7 cm (56.12 to 62.08 in.). Annual precipitation measured at the NOAA/ATDL station for the period was 158.6 cm (62.44 in.). The long-term mean for the NOAA/ATDL station, which is based on the period of record from 1948 through 1990, is 137.2 cm (54.02 in.).

Data on surface-water flow and quality are collected at a number of sites in the WOC flow system as part of the ESP monitoring and compliance program, in numerous studies of the ERP, and in a number of independent studies. Some periodic water quality data are also collected as part of the Biological Monitoring and Abatement Program (BMAP) that is required by the NPDES permit.

Flow in WOC in the main ORNL plant area is augmented by the disposal of water imported for plant processes, potable supplies, and sanitary use. The nature of the flow is complex because of the effects of storm drainage, leakage into and out of an extensive system of underground pipes, and the increased permeability of disturbed subsurface materials along pipelines and within construction sites. Water is supplied to the ORNL plant site from the DOE water treatment plant at an average rate of approximately 4.0 Mgd [6.19 cubic feet per second (cfs)]. This water is then distributed to ORNL facilities through two separate systems: potable and process. Of the total amount of imported water, 38% [1.53 Mgd (2.37 cfs)] is lost to the atmosphere as evaporation. The remaining 62% [2.47 Mgd (3.82 cfs)] is subsequently discharged to the WOC surface-water system. These discharges are categorized under the ORNL NPDES permit.

Data on streamflows in the vicinity of WOC are collected by the Environmental Sciences Division (ESD), ESP, and the U.S. Geological Survey (USGS). Daily streamflow data are collected at nine sites in the WOC system and are available in the ERP Numeric Data Base (NDB). Three sites—White Oak Dam (WOD), WOC, and Melton Branch (MB)—are operated by ESP as part of the NPDES permit requirements. Six sites are currently operated by the USGS as part of ERP studies to isolate individual contributions from upstream hydrologic units and for application in modeling studies. An additional ESP site (the WOC headwater monitoring station) has been established on WOC, upstream of Bethel Valley Road, to monitor background water quality and flow in the headwaters area. This site is upstream of any influence from the ORNL facilities.

Stream discharge data are also being collected by ESD's Hydrology Group at nine sites. These sites include redundant monitoring at the four ESP stations to assist with evaluation and mitigation of problems with discharge measurement. Extensive upgrades of the monitoring systems at all four sites are being evaluated for future implementation. Independent monitoring of discharge at five additional surface-water stations includes two sites on tributaries that drain the pits and trenches area northeast of White Oak Lake, one site that drains SWSA 4 to the south into WOC, and two sites (Ish and Raccoon creeks) outside the WOC watershed to the west of State Highway 95.

Early discharge data collected by the USGS at WOD (1953–55 and 1960–64), WOC (1950–53 and

1955–64), and MB (1955–64) indicate average annual discharges of 13.5, 9.62, and 2.50 cfs, respectively. Streamflow data collected by ESD's Hydrology Group for the 1991 water year indicate average annual discharges at the same three sites of 17.10, 12.99, and 3.66 cfs. Discharge at all three sites was above average for the year [by a greater percentage at MB (46%) than at WOC (35%), and both by a greater percentage than at WOD (27%)]. This is most likely attributable to the incongruity and briefness of the three periods of record and the increased contribution of process water discharges to the WOC system since 1964.

8.2.8 Cesium-137 Concentrations in the Surface Sediments of Watts Bar Reservoir

The Clinch River and Watts Bar Reservoir are being investigated as part of the Clinch River ERP to assess the potential risk to human health and the environment associated with off-site contamination downstream from the DOE Oak Ridge facilities. Preliminary scoping studies and the results of the first phase of the Clinch River Remedial Investigation (CRRI) indicate that ^{137}Cs is the primary radionuclide of concern associated with Clinch River and Watts Bar Reservoir sediments. This sediment contamination resulted primarily from ^{137}Cs releases to the Clinch River from the DOE ORR during the mid-to-late 1950s.

The analysis of sediment cores collected during the CRRI scoping studies showed that the most highly contaminated sediments are located in deep-channel areas and are isolated 40- to 80-cm below the sediment surface. The potential for human contact with these deep-water sediments is very low; however, the potential for human contact with surface sediments located in shallow, near-shore areas of the reservoir is much greater. Therefore, recent sampling and analysis efforts have focused on determining the concentrations of ^{137}Cs in surface sediments throughout the reservoir. To date, approximately 900 surface-sediment samples collected between Melton Hill Dam and Watts Bar Dam have been analyzed.

In Norris Reservoir, located on the Clinch River upstream of the DOE ORR, surface sediments contain ^{137}Cs concentrations ranging from 0.1 to 1.0 pCi/g. These "reference" concentrations from Norris Reservoir sediments originated from the atmospheric testing of nuclear weapons conducted internationally in past decades, and not from releases from the DOE Oak Ridge facilities.

By far, the highest ^{137}Cs concentrations in the Clinch River–Watts Bar Reservoir system occur in the sediments of the White Oak Creek Embayment (WOCE) located near ORNL and within the boundaries of ORR. White Oak Creek is the primary surface water drainage for the ORNL area. Concentrations of ^{137}Cs in the WOCE sediments are about 1000 times greater that any observed in the Clinch River or Watts Bar Reservoir. High levels of ^{137}Cs contamination (45,000 pCi/g) were discovered in WOCE surface sediments in August 1990, and a time-critical CERCLA removal action was initiated immediately to achieve control of these contaminated sediments and to prevent their erosion and transport downstream into the Clinch River. Progress on the WOCE removal action is described elsewhere in this section.

With the exception of the WOCE, the highest concentrations of ^{137}Cs in surface sediments are found in the deep-channel areas of the Clinch River arm of Watts Bar Reservoir. In the 32-km (20-mi) segment of the Clinch River downstream from the mouth of White Oak Creek, only two locations have been identified where surface-sediment concentrations exceeded 15 pCi/g. At two additional locations, ^{137}Cs concentrations were from 10 to 15 pCi/g, and 20 locations had concentrations ranging from 5 to 10 pCi/g. Most of these locations are in river-channel sediments, where exposure to humans is unlikely. The 15 pCi/g concentration represents a screening level above which human health risk could be of potential concern (i.e., a 1/10,000 probability of an excess cancer occurring), assuming conservatively that an individual was exposed directly to the contaminated sediment for 2000 h/year for 30 years.

Downstream of the confluence of the Clinch and Tennessee rivers, ^{137}Cs concentrations in Watts Bar Reservoir surface sediments are consistently low. Only one deep-water sample below this point (CRM 0, TRM 567.5) exceeded 5 pCi/g, and most ranged from 0–3 pCi/g. The higher concentrations (greater than 3 pCi/g) occurred in sediment samples from deep-water sites. Surface-sediment samples collected from tributary rivers and streams (e.g., the Tennessee, Emory, and Piney rivers and King and Whites creeks) have consistently shown low ^{137}Cs concentrations (less than 3 pCi/g).

Characterization of the Clinch River and Watts Bar Reservoir sediments is continuing. These data are made available to an interagency working group formed to ensure that permit applications for various reservoir-use activities (e.g., dredging, boat dock installation, seawall construction, armoring of the shoreline, and marina development) are reviewed for their potential for disturbance of contaminated sediments in Watts Bar Reservoir. The working group is chaired by the TDEC and includes representatives from the EPA Region IV, TVA, the U.S. Corps of Engineers, and DOE.

8.2.9 Progress on the White Oak Creek Embayment Time-Critical Removal Action

Located on the ORR, WOC is the primary surface water drainage for the ORNL area. WOC and its tributaries flow through the ORNL area, into White Oak Lake, into the 1.3-km WOCE, and off-site into the Clinch River. The drainage area of WOC is 16.8 km^2 (4150 acres). The White Oak Lake dam is the last control point for effluent discharges from ORNL.

Risk-screening analyses conducted during the scoping phase of the Clinch River Remedial Investigation identified the WOCE as a high-priority site for further characterization and potential remediation. In August 1990, analysis of a sediment core collected from the lower portion of the WOCE revealed higher than expected levels of ^{137}Cs contamination (45,000 pCi/g dry sediment) at the sediment surface. Additional samples of WOCE surface sediment, collected and analyzed to better define the extent of the contamination, confirmed that relatively high levels of ^{137}Cs activity (ranging from less than 3,000 to about 20,000 pCi/g; average = about 10,000 pCi/g) existed in the surface sediments of the lower embayment.

These results produced immediate concern because the contaminated WOCE surface sediments were susceptible to erosion and transport off-site into the Clinch River. Agreement was reached among the multiple agencies involved (DOE, EPA Region IV, TDEC, TVA, and the U.S. Corps of Engineers) that a time-critical removal action pursuant to the provisions of CERCLA and the National Contingency Plan (NCP) should be initiated immediately to achieve control of the contaminated WOCE sediments and to prevent their transport off-site into the Clinch River.

Numerous uncertainties existed concerning both the regulatory and procedural requirements for on-site, time-critical response actions at federal facilities. To resolve these uncertainties, immediate actions were undertaken to (1) involve and achieve consensus among all appropriate state and federal agencies, (2) review relevant federal and state regulations to identify required actions, notification and permit requirements, applicable or relevant and appropriate regulatory requirements (ARARs), and their associated schedules, and (3) verify the applicability of the identified ARARs, procedural requirements, and reporting requirements to DOE on-site response actions.

An accelerated site characterization program and an alternatives evaluation were conducted in parallel with the evaluation of regulatory and procedural issues associated with the WOCE time-critical removal action. The construction of a coffer-cell-type sediment-retention structure at the mouth of WOC was selected as the preferred interim action to achieve control of the WOCE sediments (Fig. 8.11). Preconstruction site preparation was initiated in March 1991, and construction of the sediment-retention structure began in early June. Closure of the sheet-pile walls across the mouth of WOC and initial control of the contaminated WOCE sediments were achieved in late July (Fig. 8.12). Construction activities are continuing with reinforcement and stabilization of the structure, rock armoring of the creek and river banks, jet grouting of the bottom of the coffer cells, and installation of a concrete cap and rock anchors.

Throughout the WOCE project, minimization of potential disturbance and transport of the contaminated WOCE sediments and minimization of waste generation have been primary considerations. Additionally, environmental monitoring of water quality downstream of the construction site has been conducted throughout the preconstruction and construction activities.

DOE's Environmental Restoration and Waste Management Program is encouraging proactive interim remedial actions to achieve risk reduction and to prevent off-site contamination. Interim response actions, conducted under the provisions of CERCLA and the NCP, provide a viable mechanism for

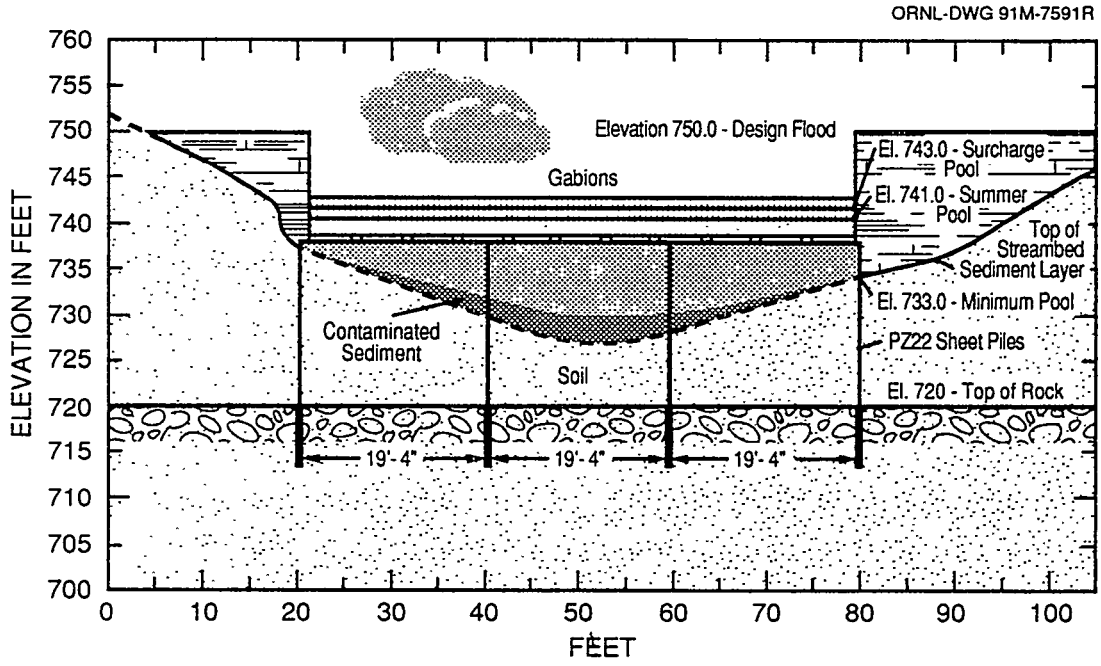

Fig. 8.11. White Oak Creek Embayment Sediment-Retention Structure.

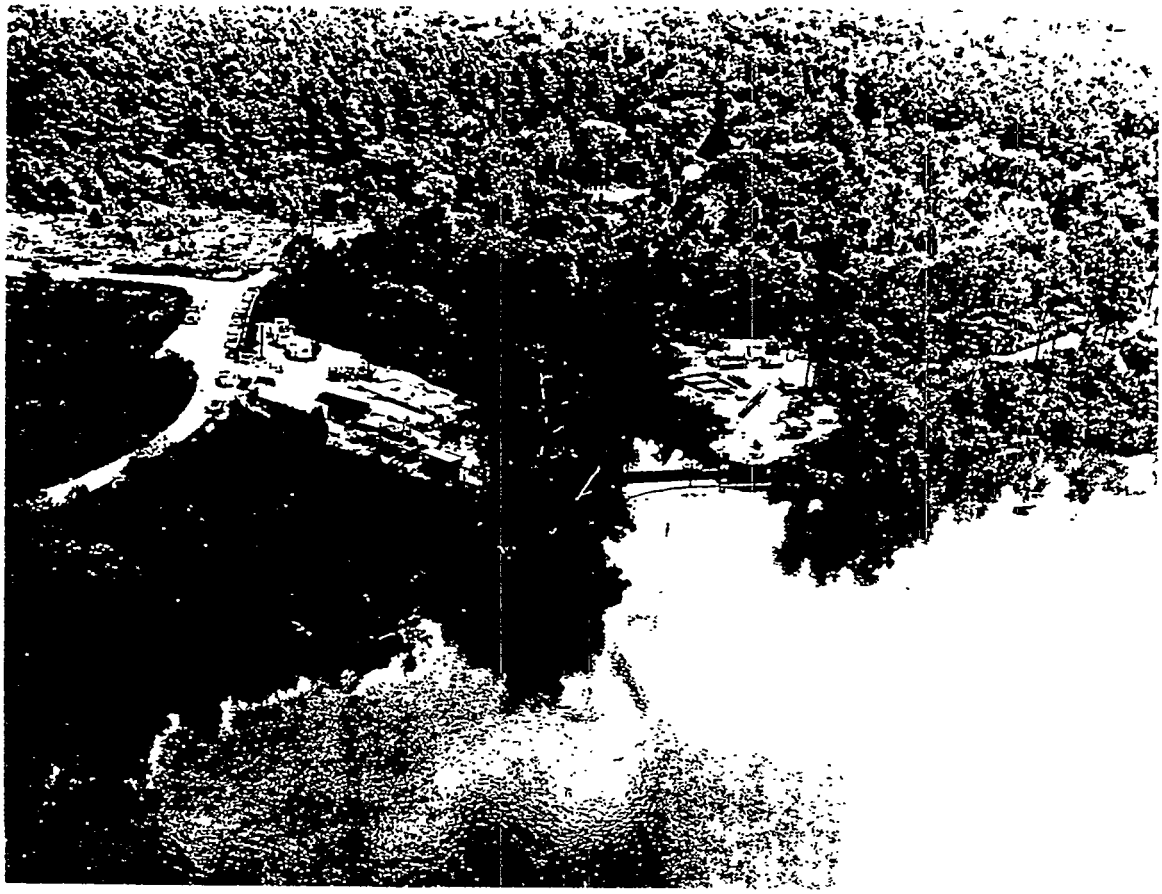

Fig. 8.12. The coffer-cell-type sediment-retention structure at the mouth of White Oak Creek.

achieving these objectives. The time-critical CERCLA removal action being conducted at the WOCE on the DOE ORR provides an initial example of the application of this mechanism and a useful model for conducting similar interim response actions at federal facilities.

8.3 K-25 SITE

8.3.1 Dechlorination in Mitchell Branch

Elevated levels of total residual chlorine (TRC) were identified as the major source of toxicity in Mitchell Branch through monitoring efforts associated with the BMAP for the stream and through investigations conducted in response to fish kills that occurred there in 1988 and 1990. The fish kills were attributed to the inadvertent activation of a backup cooling system that used sanitary (drinking) water containing between 1.0 and 2.0 mg/L TRC. The backup system was used for removal of waste heat. It discharged to Mitchell Branch through the storm drain system. As a result of the fish kills, the backup cooling system was manually valved off, and a nonchlorinated water source was established for the system.

Investigations of toxicity in the stream resulted in the identification of other sources of elevated TRC levels from continuous discharges of once-through cooling water from heating and air-conditioning systems that use sanitary water. Tables 8.1 and 8.2 summarize the results of toxicity tests of K-25 Site wastewaters for 1991. Although the impact of these discharges was not significant enough to result in fish kills, they were estimated to contribute as much as 30% of the flow to Mitchell Branch under normal conditions. Because the stream is a zero-flow stream during periods of below-normal precipitation, once-through cooling waters can account for nearly 100% of the stream's flow and thus significantly impact aquatic life.

An engineering project was designed to eliminate or reroute the chlorinated discharges to Mitchell Branch. The project was initiated in April 1991, and studies conducted as part of the project identified several systems within three buildings that discharged chlorinated water to the stream. These discharges will be rerouted from the storm drain system to other on-site systems. Completion of the project is scheduled for June 1992.

An interim, short-term project to remove the impact of the chlorinated water discharges was developed and initiated in June 1991. The project involved the installation of dechlorination units at three storm drains along Mitchell Branch that were identified as having elevated TRC levels in their effluent. The units are flow-through feeder systems that use sodium sulfite tablets to remove the TRC from the discharge. Written maintenance procedures were implemented to prevent failure of the units. The units are inspected daily, and routine sampling is conducted at the outfalls for TRC, sulfite, chemical oxygen demand, and dissolved oxygen to ensure that the feed rate of the tablets is controlled effectively. Since activation of the units in June 1991, repopulation of the middle reaches of Mitchell Branch, where fish and aquatic communities were not previously supported, has occurred. In addition, the removal of the significant toxic effect of TRC in the stream has eliminated its masking effect and facilitated the identification of other minor toxicants. The dechlorination units will remain in place until completion of the long-term engineering project in June 1992. The units will be reused at other locations at the K-25 Site where chlorinated discharges are identified as having an impact on other receiving streams.

8.3.2 K-25 Site Tiger Team Assessment

The Tiger Team Environmental Subteam identified 103 findings as part of the Tiger Team Assessment of the K-25 Site that was conducted from November 12, 1991, through December 18, 1991. None of the findings represented an immediate risk to public health or the environment, nor did they warrant an immediate cessation of operations. Of the 103 findings, 99 were attributed to the K-25 Site contractor operations, 3 to the Oak Ridge Field Office, and 1 to the DOE program office. Of the 99 site findings, 89 represent problems that potentially could have resulted in not meeting the requirements of federal or state of Tennessee regulations or DOE orders. Seventeen findings represent conditions where best management practices were not incorporated into environmental management at the site. Nearly 80% of the findings identified by the Environmental Subteam were fully or partially identified by the K-25 Site Self-Assessment. Corrective actions were already under way for many of the findings. As a result of the

Table 8.1. 1991 toxicity test results of the K-25 Site wastewater

K-25 Site outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)
K-1407-E/F (010)	Feb.	100	50
K-1407-J (011)	Feb.	100	50
	April	100	50
	June	100	50
	Aug.	100	100
	Oct.	100	50
	Dec.	100	100

[a]No-observed-effect concentration.

Table 8.2. 1991 average water quality parameters measured during toxicity tests of the K-25 Site wastewaters

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

K-25 Site outfall	Test date	pH (standard units)	Conductivity (μs/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1407-E/F	Feb.	7.7	2287	58	631
K-1407-J	Feb.	7.7	2979	61	596
	April	7.8	8663	122	359
	June	7.9	1601	163	443
	Aug.	8.1	2187	224	456
	Oct.	7.9	3114	143	555
	Dec.	7.8	2327	136	589

Tiger Team Assessment, management plans will be upgraded to include the additional Tiger Team input.

Key Findings

Three key environmental findings were identified. Each key finding is a higher tier deficiency developed from the environmental findings that represent significant K-25 Site environmental program weaknesses and potential liabilities.

The key environmental findings were as follows:

- Environmental Program Implementation—The K-25 Site has not fully implemented all the requirements of DOE Orders in an integrated system to ensure environmental compliance. Systems are not fully developed within individual environmental programs, fully integrated between programs, or coordinated with ORR programs. Weaknesses were identified within programs, between programs, and between the K-25 Site and the ORR
- Environmental Surveillance–The K-25 Site has not effectively implemented a comprehensive Environmental Surveillance Program, sampling plans, and procedures. This concern was identified in all media evaluated during the Tiger Team Assessment. Of special concern is the radiological environmental surveillance and contamination control program.
- The National Environmental Policy Act–Secretary of Energy Notice (SEN)-15-90 and DOE 5440.1D have established the

framework and performance objectives by which National Environmental Policy Act (NEPA) is to be implemented in line organizations. Management systems designed to meet these goals at the K-25 Site, the DOE K-25 Site Office, the DOE-OR, resident Uranium Enrichment (UE), Nuclear Energy (NE), and the landlord Environmental Restoration and Waste Management (EM) have been ineffective in ensuring compliance with these performance objectives.

Response Approach

The response approach to the environmental Tiger Team findings was the development of corrective actions plans with two areas of focus—the programmatic and the individualistic. The key findings are the basis for the programmatic view; the 103 findings, the individualistic view. The individual findings are symptoms of the fundamental K-25 Site environmental deficiencies reflected in the key findings.

Lessons learned in the DOE complex indicate that recurrence is likely if individual deficiencies are corrected and the higher tier deficiency is not corrected. As a result, the corrective action plans developed for the environmental discipline are integrated plans. Findings were studied from two perspectives during the development of the plans. First, the actions necessary to correct the specific findings were identified. Corrective actions plan authors were then challenged to address the key findings and to integrate plans within individual environmental disciplines, between environmental disciplines, and, where possible, between the management and organization and the health and safety disciplines. Many actions developed to address a single finding were applicable to other findings. As a result, plans exist that are interwoven to ensure correction of the higher tier deficiencies and minimization of potential recurrence. Implementation of these corrective action plans is contingent on funding availability.

Root Causes

In addition to correction of higher- and lower-tier deficiencies, the development of the integrated corrective action plans focused on identified root causes. Correction of root causes at higher and lower tiers provides assurance that potential recurrence is minimized. Primary root causes identified for the environmental findings include the following:

- Resource Management—The development and implementation of several environmental programs were adversely impacted by a shortage of resources. Appropriate short-term and long-term staffing and resource needs are identified and will be requested.
- Written Procedures and Documents—The K-25 Site has not fully developed or implemented comprehensive program plans, policies, or procedures in accordance with DOE orders and Energy Systems requirements. The preparation or revision of program plans will be required to resolve 61 environmental findings. Additionally, the preparation or revision of policies, standards, or procedures will be required to resolve 69 environmental findings.
- Managerial Methods—Managerial methods are attributable to most environmental findings. The most frequently identified categories include undefined roles and responsibilities; inadequate or undefined policies; inadequate or undefined procedures; and proceeding with an accepted risk that resulted in inadequate plans, policies, or procedures.

Summary

The corrective plans for the 103 environmental findings contain 581 actions. The actions, due to the integration of the plans, actually represent 340 unique activities. Cross-referencing information is provided within the action plans to reflect the integration. The corrective action plans were analyzed to assess the impact the Tiger Team Assessment will have on K-25 Site environmental operations. Results of these analyses are presented in the following sections.

Environmental Staffing Requirements

The corrective actions for 56 environmental findings identify the need for Energy Systems staffing increases at the K-25 Site. The corrective

action plans have been developed from an integrated K-25 Site Environmental Program perspective. As a result, an estimated 13 full-time equivalent Energy Systems personnel, above current staffing levels, satisfy the needs identified in the 56 findings. Identified are increases in the Site Program Management Organization, Quality Division, Environmental Management Department, and the Waste Management Division. Descriptions of the 13 identified staff positions include the following:

- Site Program Management Organization—one person to function as the K-25 Site facility owner of inactive waste sites and orphaned facilities;
- Quality Division—one person to serve as the K-25 Site Calibration Control Manager;
- Environmental Management Department—one person to develop and manage the K-25 Site radiological environmental surveillance program; one person to implement the K-25 Site environmental ALARA program, manage dose assessments, and assist with DOE environmental radiological compliance issues; one person to manage the K-25 Site NPDES Best Management Practices Program and the Spill Prevention, Control, and Countermeasures Program; one person to assist in the implementation of the K-25 Site Clean Water Act Compliance Program; one person to develop the K-25 Site Toxic and Chemical Materials Program; three persons—one engineer and two database personnel—to develop and implement validation programs for K-25 Site environmental monitoring and surveillance data;
- Waste Management—one person to develop and maintain the K-25 Site Waste Management Program Plan that satisfies requirements of 5820.2A; and one person to oversee underground storage tank management on the K-25 Site.
- The two Waste Management Division personnel cited are in addition to the Fiscal Year 1992 authorized level referenced in one finding corrective action step. Similarly, the corrective actions for six environmental findings identify the need for additional DOE staffing.

Environmental Program Development Requirements

One of the Tiger Team's key findings was the need to further develop and implement the K-25 Site environmental management program. Not all requirements of DOE orders have been integrated into site operations. To provide the structure necessary to integrate these requirements, program plans will be prepared. These plans will identify regulatory requirements, roles and responsibilities, schedule requirements, and procedural requirements. The need for a more complete environmental program was most evident in the toxic and chemical materials, air, waste management, and surface water disciplines. Fifteen upper-tier K-25 Site program plans will be prepared or revised to establish overall program structure and include the following:

- Asbestos Management Program Plan,
- Air Program Management Plan,
- Groundwater Protection Program Management Plan,
- Environmental Restoration/Remedial Action Program Plan,
- Environmental Surveillance Plan,
- Soil Contamination Program Management Plan,
- Clean Water Act Program Management Plan,
- NPDES Best Management Practices Program Plan,
- NPDES Biological Monitoring Program Plan,
- Spill Prevention, Control, and Countermeasures Plan,
- Waste Minimization and Pollution Prevention Awareness Plan,
- Toxic and Chemical Materials Management Program Plan,
- PCB Program Management Plan, and
- Waste Management Plan.

Additionally, an estimated 36 lower-tier plans will be prepared or revised to promulgate requirements into specific operations. This total of 51 plans will address 59 environmental findings. Additionally, the need to develop or revise an estimated 75 policies, standards, or procedures is identified in the response to 69 environmental findings. It is anticipated that as the plans outlined

above are developed, the number of required procedures and required actions will increase.

Training Requirements

Training of site personnel on policies, standards, and requirements is recognized as a primary communication process necessary to effectively implement requirements of the environmental program. An estimated 14 training programs will be developed or revised in response to 26 environmental findings.

Evaluations

In response to 31 environmental findings, an estimated 17 unique surveys or inventories will be performed to either baseline the current operations or to establish the scope of corrective actions required. These evaluations have the potential to increase the actual final costs required to resolve the Tiger Team findings and include the following:

- stack and vent survey,
- high efficiency particulate air filter survey,
- injection well survey,
- environmental surveillance pathways analysis,
- secondary containment assessment,
- oil-filled equipment containing polychlorinated biphenyls inventory,
- satellite and 90-day accumulation areas survey,
- cited inactive waste sites for Preliminary Assessment/Site Inspection or Remedial Investigation/Feasibility Study requirements,
- soil column discharges survey, and
- backflow prevention device survey.

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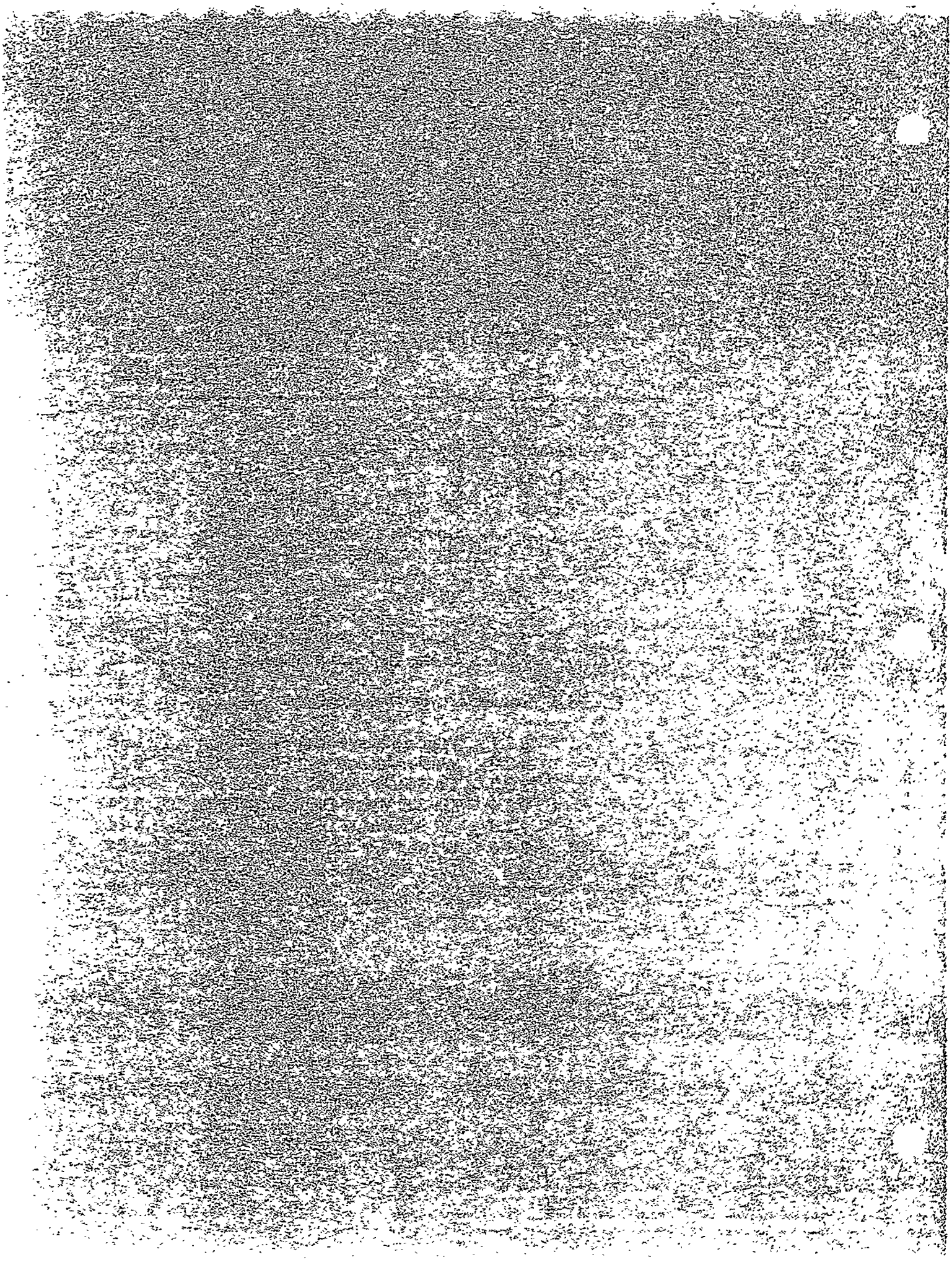


9. SOLID WASTE MANAGEMENT PROGRAM

9.1 DESCRIPTION

9.1.1 Purpose

The goal of the solid waste management program is to handle solid wastes according to procedures that protect the health and safety of on-site personnel and the public, protect the environment, and minimize long-term liability. To meet this goal, the potential for environmental release of wastes must be minimized. Therefore, solid waste management activities are conducted in compliance with state and federal regulations and conform to good industry practices, which in some cases are more protective than the practices mandated by the regulations.

The solid waste management program encompasses treatment, storage, transportation, and disposal of nonhazardous, conventional radioactive, infectious, and hazardous solid wastes. The terms *solid* and *hazardous* are used as defined in the RCRA. A *solid waste* is a solid, liquid, or gas that is discarded, abandoned, or, in some cases, reused by recycling or burning for energy recovery. *Hazardous wastes* are a subset of solid wastes that RCRA designates and regulates as hazardous. Mixed wastes contain both hazardous and radioactive components.

9.1.2 Regulations and Guidance

This section describes the regulations that govern the management of solid waste and the DOE orders that implement these regulations.

9.1.2.1 Federal and state compliance

RCRA, enacted in 1976, is the primary regulation governing solid waste management activities. RCRA regulates the generation, transportation, treatment, and disposal of hazardous wastes and regulates facilities that conduct these activities. Source materials, special nuclear materials, and by-product materials are excluded from RCRA. However, hazardous wastes that are contaminated with radioactive material are regulated by both RCRA and the Atomic Energy Act (AEA). Hazardous wastes are defined in RCRA by specific source lists, nonspecific source lists, characteristic hazards, and discarded commercial chemical product lists. Other portions of RCRA pertinent to the Oak Ridge installations include standards for accumulation areas; standards for transporters of hazardous waste; standards for owners and operators of hazardous waste treatment, storage, and disposal facilities; permit requirements for treatment, storage, or disposal of hazardous wastes; inspections; federal enforcement; hazardous waste site inventory; and corrective action requirements.

To stay in compliance with RCRA, the Oak Ridge installations must submit permit applications to environmental regulators for each hazardous waste treatment, storage, or disposal facility. Part A permit applications (interim status) were submitted in 1980 and have been revised periodically. Part B permit applications (operating) have been submitted or are being revised for RCRA units that will continue to operate after November 8, 1992. Treatment, storage, or disposal units obtain interim status through the Part A permit application and approval process and are required to meet the design and management standards for interim facilities set forth in RCRA. Facilities receive full permit status through the Part B Permit application and approval. Facilities with interim status have the option to file for closure and cease operations instead of filing for a Part B permit application, which requires more stringent standards. Several of the DOE TSDs have already received Part B operating permits.

Revised or new RCRA Part A and Part B applications are submitted as new storage, treatment, or disposal units are needed for the management of hazardous wastes. The TSCA governs the labeling,

handling, and disposal of wastes or articles containing PCBs. The Clean Water Act requires use of BMPs and compliance with the NPDES permit, and the Clean Air Act requires compliance with air emissions standards.

9.1.2.2 DOE orders

Management of radioactive wastes, waste by-products, and radioactively contaminated facilities is governed by DOE Order 5820.2A, which applies to all DOE elements, contractors, and subcontractors that manage radioactive waste as defined in the AEA of 1954 (as amended). Guidelines are provided for characterization, storage, and disposal of high-level radioactive wastes, low-level waste (LLW), TRU wastes, wastes contaminated with naturally occurring radionuclides, and decommissioning wastes.

Hazardous and mixed waste management at the Oak Ridge facilities is conducted under DOE orders 5400.1 and 5400.3, as well as the AEA, the RCRA of 1976, and its Tennessee equivalent, the Tennessee Hazardous Waste Management regulations. DOE Order 5400.1 requires that hazardous waste generated by DOE-funded activities be managed in an environmentally acceptable manner. DOE Order 5400.3 provides the requirements for hazardous waste management programs implemented at DOE-funded installations. The AEA of 1954, as amended, dictates provisions for establishing regulations that govern processing and use of source, by-product, and special nuclear materials.

9.1.3 Compliance Activities

9.1.3.1 Y-12 Plant

The Y-12 Plant submits applications to environmental regulatory agencies for all hazardous waste treatment, storage, and disposal facilities. Overall, the Y-12 Plant expects to receive six permits for hazardous waste facilities, including the one existing permit.

Information required for a Part B permit application includes general facility description, waste characterization, and analysis plans; information on processes generating the waste; procedures to prevent hazards; contingency plans; and closure and postclosure plans. After negotiation and acceptance of Part B, the Y-12 Plant facilities will be fully permitted under RCRA and subject to stringent guidelines specified in 40 CFR Part 264. The facilities are inspected regularly by EPA, TDEC, DOE, and/or internal auditors to ensure RCRA compliance.

In CY 1990, four Y-12 Plant RCRA facilities were closed in accordance with TDEC-approved closure plans. These were the New Hope Pond, S-3 Ponds, Oil Retention Ponds, and C-West. Closure activities are under way on an additional two disposal areas as a part of the Closure and Post Closure Activities project. The two facilities are Kerr Hollow Quarry and the Walk-in Pits.

Nonhazardous, nonradioactive solid waste disposal sites are permitted in accordance with the Tennessee Solid Waste Disposal Act. To meet the requirements of the act, documentation that included construction drawings and design and operating plans was submitted to the regulators for approval; subsequently, permits were issued for the Y-12 Centralized Sanitary Landfill II, the Y-12 Spoil Area I, and Industrial Waste Landfill IV. All regulated facilities are inspected periodically by the regulators. Applicable discharges to surface waters are throughly monitored discharge points that comply with the plant's NPDES permit.

An Environmental Assessment (EA) for the Y-12 Steam Plant Ash Disposal Project has been prepared and submitted to DOE headquarters for approval. The EA evaluates alternatives for disposal of dewatered bottom ash as well as for nonradioactive, nonhazardous, industrial, and sanitary wastes generated at the Y-12 Plant, the K-25 Site, and ORNL. The Y-12 Steam Plant Ash Disposal (SPAD) project includes the construction of Industrial Landfill V to replace Y-12 Central Sanitary Landfill II. The Y-12 SPAD project will also provide Construction/Demolition Landfill VII for disposal of construction/demolition wastes.

9.1.3.2 Oak Ridge National Laboratory

Waste storage, treatment, and disposal activities are regulated by TDEC and EPA through interim status and operating permits. ORNL operates several hazardous waste treatment, storage, and disposal facilities, which operate under interim status, as well as the Hazardous Waste Storage Building (Building 7652) and the TRU Concrete Cask Storage Facility 7855, which operate according to two RCRA Part B

permits granted by TDEC. Overall, ORNL expects to receive 4 Part B permits for hazardous waste facilities, which will include revisions to the two existing permits. Several RCRA units are being closed or will initiate closure in CY 1992. Chemical and mixed wastes are regulated through these permits. Y-12's Centralized Sanitary Landfill II (SLF II) is used for the disposal of nonhazardous materials such as fly ash and construction debris. It operates under a permit from the TDEC Division of Solid Waste Management. Aqueous process wastes are treated on-site in the process wastewater treatment facility, which discharges to surface water through a monitored discharge point that must comply with ORNL's NPDES permit. The NPDES permit is regulated by TDEC and EPA.

Radioactive waste disposal must comply with DOE orders. RCRA requires that the potential for environmental release of radioactive materials be investigated and corrective actions taken. Therefore, all waste-handling activities are regulated and inspected for compliance by state and federal agencies as well as through internal audits.

TRU wastes generated at ORNL are being placed in retrievable storage. Current activities center around certification of contact-handled (CH) waste, planning and designing of a repackaging and certification facility for remote-handled (RH) wastes, and planning for shipment of wastes to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

9.1.3.3 K-25 Site

During 1988, the K-25 Site elected to file for closure and ceased RCRA operation of four facilities. The plant also filed a permit-by-rule request for two facilities. In September 1989, the K-25 Site received 11 permits from TDEC. Ten of these permits are for RCRA storage units, and one is for closure of 1407-B Pond. All permits became effective in 1991. It is expected that the State will combine these permits into only three permits, which would be for the TSCA Incinerator, the TSCA Incinerator storage unit, and all other storage units.

TSCA regulations govern the labeling, handling, and disposal of wastes that contain PCBs. PCB wastes that contain radioactive contamination cannot be disposed of by commercial facilities. These wastes will be disposed of at the K-1435 Incinerator. Other environmental regulations also impact solid waste management activities. CWA requires the use of BMPs and compliance with NPDES. CAA requires permitting of air emissions.

9.1.4 Program Strategy

Overall corporate strategies for the management of radioactive, hazardous, and mixed wastes have been developed for Energy Systems. These strategies are based on the following guiding principles.

- Reduce the quantity of waste generated.
- Minimize the amount of wastes stored on site.
- Characterize and certify the wastes prior to storage, processing, treatment, or disposal.
- Use on-site storage where this can be shown to be safe and cost-effective until a final disposal option is selected.
- Determine the effectiveness of promising technologies in the solution of local problems.
- Maximize the involvement of private-sector contractors in conducting technology demonstrations and in implementing successful technologies.

More specifically, the radioactive waste management program is based on the following technical assumptions.

- Waste will be segregated by half-life and hazard consistent with the overall waste management strategy.
- The level of containment required and, therefore, the type of treatment and/or disposal required will be a function of the half-life and hazard, including potential mobility, of the waste.
- Engineered features cannot be relied on to contain long-half-life wastes without surveillance, remediation, and long-term maintenance.
- Management of long-half-life wastes must rely on concentration limits, natural features, and institutional control and/or perpetual care to provide for the maintenance of engineered features and to protect against intrusion.

TRU wastes will be managed in accordance with the TRU Waste Program strategy, which relies on certification and packaging at the site and shipment to WIPP for ultimate disposal.

LLW will be managed in accordance with DOE Order 5820.2A, "Radioactive Waste Management." The general strategy for management of LLW is being defined by the Reservation Waste Management Division (RWMD).

The primary goal of the strategy for LLW is the management and ultimate disposal of solid radioactive waste in a manner that protects the environment and public health and safety at all times. For the disposal of LLW, the strategy establishes dose-based performance objectives that protect the public, minimize releases, and reduce the probability for the need to do remedial actions after the disposal facilities are closed. The key components of the strategy are

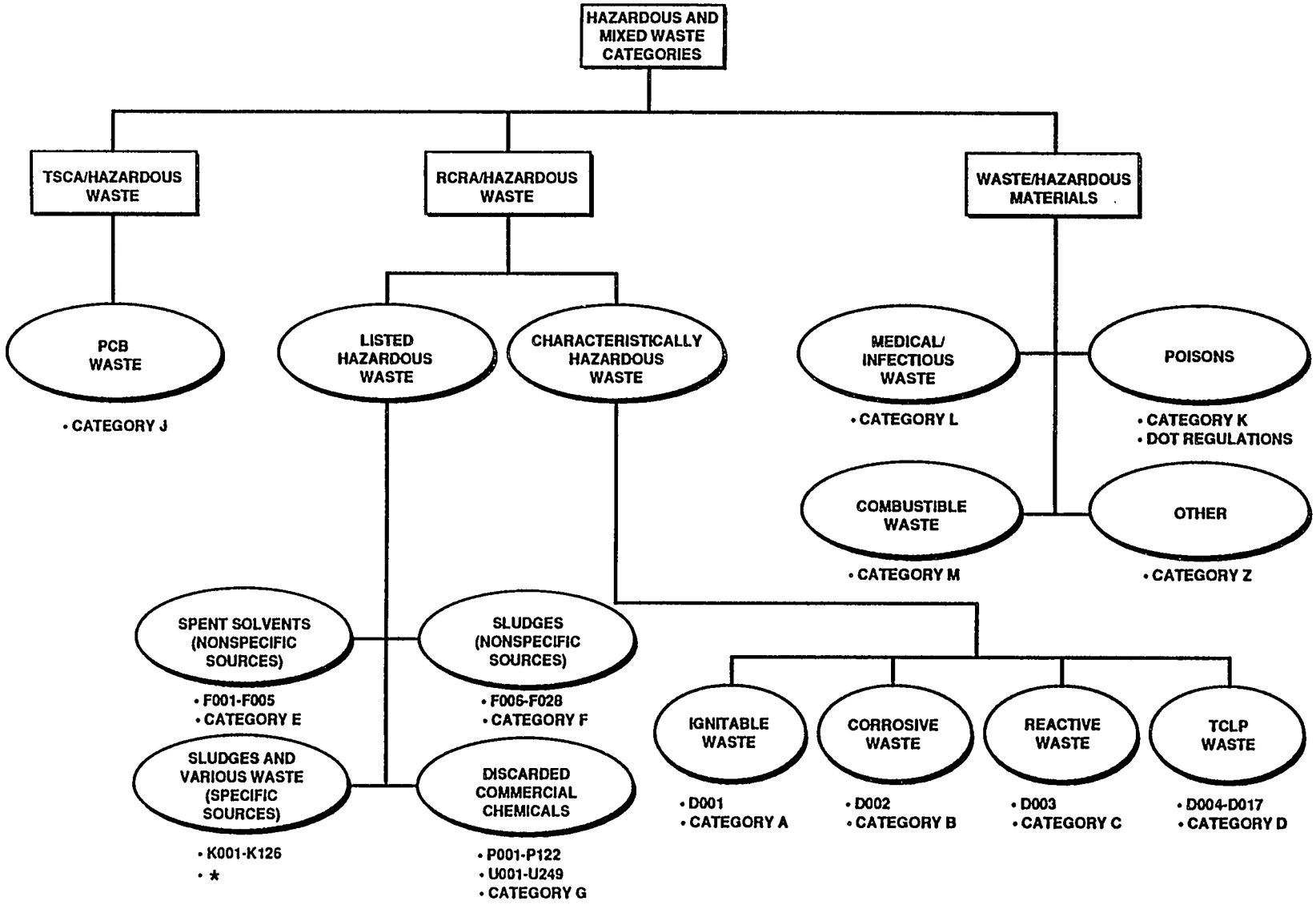
- the dose-based performance objectives for disposal of LLW,
- a waste classification system for managing different wastes to meet the dose-based performance objectives,
- the planned use of engineered features and barriers,
- the waste acceptance criteria (WAC) for each disposal site for achieving the dose-based performance objectives for that specific site with appropriate engineered features,
- a waste certification program for ensuring that the wastes for disposal meet the applicable WAC,
- the use of pathways analysis modeling to establish radionuclide concentration limits for the WACs and to predict whether a selected site and technologies will achieve the performance objectives, and
- phased implementation.

Using this general strategy, Energy Systems has proposed five classes of LLW.

1. **Below regulatory concern (BRC) waste.** LLW that is suitable for disposal in a sanitary/industrial landfill and will not expose any member of the public to an effective dose equivalent of more than 4 mrem/year at the time of disposal.
2. **Class L-I waste.** LLW that is suitable for disposal using sanitary/industrial landfill disposal technology and will not expose any member of the public to an effective dose equivalent of more than 10 mrem/year at the time of disposal.
3. **Class L-II waste.** LLW primarily containing fission product radionuclides with half-lives of 30 years or less that is suitable for disposal in engineered facilities designed to isolate the waste from the environment and public for a period of time sufficient to allow for the decay of radionuclides to such a level that any member of the public will not be exposed to an effective dose equivalent of more than 10 mrem/year.
4. **Class L-III waste.** LLW consisting of radionuclides that have long half-lives and will be disposed of in facilities having permanent intruder protection.
5. **Class L-IV waste.** LLW not suitable for disposal on the ORR and that would require either treatment to reduce the level of contamination to a level consistent with any of the other waste classifications or shipment to an off-site LLW disposal facility.

The general strategy to be followed for the management of hazardous and mixed wastes will ensure the continuation of present management operations while simultaneously initiating a technology development and demonstration program for current and future problem waste streams. Fundamental to this general strategy are the following components: (1) waste stream identification and evaluation; (2) waste minimization/reduction; (3) on-site storage/treatment of RCRA hazardous wastes; (4) on-site storage/treatment of mixed wastes; (5) technology demonstrations; (6) delisting, detoxification, and mobility reduction; and (7) waste disposal activities.

The Hazardous Waste Development, Demonstration, and Disposal (HAZWDDD) Program developed a general classification system based on the RCRA and TSCA regulations (Fig. 9.1). Treatment options are evaluated for each category of problem waste using process flowcharts. Where technology currently exists, preferred treatment options are identified. When proven technologies do not exist, studies, evaluations, or technology



* Not categorized for HAZWDDD because none of these listed wastes is produced at the Energy Systems sites.

Fig. 9.1. Hazardous and mixed waste categories developed for the HAZWDDD Plan.

demonstrations will be conducted. In general, the preferred treatment option for categories A (ignitables), E (spent solvent), J (PCB wastes), L (medical/infectious waste), and M (combustibles) is incineration. For category D (TCLP-toxic wastes), the preferred option is stabilization (surface decontamination, followed by stabilization, for surface-contaminated wastes), and the preferred option for category F (sludges) is thermal treatment and/or stabilization. The preferred treatment option(s) for categories B (corrosives), C (reactives), K (poisons), U (unknown), and Z (hazardous, but not EPA-listed) depend on complete waste characterizations.

Mixed wastes are currently being placed in interim storage as new technologies for treatment and disposal are identified and evaluated. Solid LLW, with the exception of some special-case wastes, is currently being containerized and shipped to a commercial facility for volume reduction prior to being placed in interim storage at the K-25 Site. These wastes are being stored until treatment/disposal facilities consistent with the LLWDDD are available and can be used.

PCB waste is managed to ensure compliance with PCB regulations and to minimize the risk of CERCLA or civil liabilities. It is Energy Systems policy to comply with the letter and spirit of the PCB regulations. In certain instances where the intent of the rule can clearly be met but where the letter of the rule may create substantial hardships, the EPA regional administrator may be petitioned for a waiver. Such petitions will be made through DOE.

An Environmental Impact Statement (EIS) is presently being prepared that addresses the general waste management strategies and specific LLW disposal facilities on the ORR. DOE Order 5820.2A for radioactive and mixed waste management was issued in September 1988. The order has had and will continue to have a significant impact on radioactive and mixed waste management operations. The K-25 Site's implementation plan for the order was submitted to DOE in April 1989, and the waste management plan for the order was submitted in January 1990. These plans identify the actions, schedules, and costs necessary to eliminate noncompliances with the order.

9.1.4.1 Y-12 Plant

Current strategy for solid waste management consists of waste reduction, storage, treatment, delisting, and disposal. Each concept is an integral portion of the overall waste management strategy. Current disposals, however, are limited to the on-site disposal of industrial/sanitary waste. The use of commercial disposal facilities has been suspended until a program that meets the recently imposed DOE performance objective of "no added radioactive contamination (No Rad Added)" has been developed and approved by DOE. Mixed waste storage is necessary to ensure compliance with environmental regulations while treatment and disposal techniques are identified and implemented and the delisting process is pursued. Also, proper identification, characterization, and classification of waste materials are essential to ensure that waste management activities are performed safely, efficiently, and in compliance with applicable regulations, guidelines, and policies.

Solid waste as categorized at the Y-12 Plant is listed in Table 9.1. RCRA hazardous wastes are candidates for commercial recovery or disposal programs; mixed wastes, which contain both RCRA hazardous and radioactive components, are not candidates for commercial recycling or disposal. Under the DOE "No Rad Added" performance objective, however, hazardous waste is being stored until approval to ship for off-site disposal has been granted by Energy Systems and DOE.

Ideally, after strategy implementation, most solid wastes that are generated will be conventional sanitary/industrial wastes. When this is not possible, prudent management will minimize the amount of other wastes present. Six major waste-minimization options are available at the Y-12 Plant: segregation, material substitution, process innovation, mechanical volume reduction, recycling or reuse, and treatment. These options are not mutually exclusive and may be combined to suit the specific needs.

To properly characterize wastes and determine the appropriate storage or disposal modes, a comprehensive system of administrative controls, inspections, sampling, analysis, and monitoring is used. Sampling and analytical programs are in place for hazardous, nonhazardous, and mixed waste streams. In addition to characterization by sampling, low-level waste monitoring for bulk wastes is

Table 9.1. Y-12 Plant waste generation summary for 1991

Waste	Quantity (kg)
Sanitary/industrial[a]	8,425,372
Asbestos/BeO	
Uncontaminated	517,177
Contaminated	57,522
Hazardous[b]	868,055
Mixed	3,283,314
PCB	275,652
PCB/uranium	28,966
Low-level contaminated waste[c]	1,070,178
Scrap metal	
Uncontaminated	1,381,349
Contaminated	950,080
Classified	29,190
Nonhazardous liquids[d]	1,324,789

[a]This includes construction/demolition spoil and fly ash.
[b]This does not include Steam Plant regeneration waters.
[c]This category consists of industrial wastes.
[d]This category consists of mop waters and other nonhazardous liquids. It does not include the Steam Plant Wastewater Facility wastewater.

accomplished using external radiation monitors or by Health Physics personnel using applicable DOE orders as guidelines.

Also, to improve characterization of potentially low-level radioactive waste streams, the Y-12 Plant continues with procurement, installation, and testing of more effective waste monitoring equipment, including a crated waste assay monitor, gamma spectroscopy, and waste curie monitors.

A variety of disposal options are available to manage the wastes generated at the Y-12 Plant. On-site treatment for disposal/storage includes oxidation of uranium machine turnings; batch physiochemical treatment of liquid wastes; biodenitrification of aqueous nitrate waste; and baling of solid, low-level radioactive wastes. On-site disposal capability includes shallow land burial for solid, noncontaminated, industrial waste and discharge through NPDES discharge points after treatment for aqueous wastes. Off-site disposal options will include disposal of hazardous waste by commercial vendors if the DOE "No Rad Added" performance objective can be met. Off-site treatment of LLW (non-RCRA/TSCA) is now being accomplished through a contract with a commercial treatment facility. After treatment (i.e., incineration/supercompaction) the waste is stored at the K-25 Site or returned to the Y-12 Plant for storage. Long-term storage options include storage in warehouses, tanks, and vaults at the Y-12 Plant, as well as storage of Y-12 Plant wastes in buildings at the K-25 Site. More detailed information on each of these options is presented in Sect. 9.3.2.

Several LLWDDD-related, Y-12 Plant–sponsored technology demonstrations have been completed, including supercompaction, shape alteration, and the laboratory characterization task of the Uranium Lysimeter Demonstration. Demonstrations that were well into the planning or implementation phases in 1990, however, were halted in 1991 because of a lack of funding. These included a BRC demonstration and field testing of the Uranium Lysimeter.

Some activities planned under the now-defunct HAZWDD program, however, have been continued and are currently planned through FY 1992. Technology demonstrations are being funded so that commercially available treatment processes can be tested on Y-12 Plant wastes. Priority is being given to work on waste streams for which no disposal outlet has been identified. The program will include full-scale commercial treatment efforts pending the outcome of treatability studies. Soils contaminated

with mercury and/or chlorinated organic compounds are wastes included in this program.

Demonstrations for removal of hazardous or radioactive constituents in soils have been completed. Results of the demonstrations will be evaluated for further use in applying this technology to larger-scale treatment projects. A single demonstration has been completed to initiate an evaluation of incineration technology for LLW. Final results of the demonstration indicated that incineration of combustible low-level radioactive waste is feasible. A full-scale low-level waste volume reduction project was initiated in 1990 that used the incineration technology.

A project is currently under way to evaluate the potential for delisting a sludge generated by hazardous wastewater treatment facilities at the Y-12 Plant. The preliminary sampling and analytical results were favorable, but the EPA suggested that a more rigorous sampling method be used. Work to devise and implement such a method is in progress.

Demonstrations for the removal of hazardous and radioactive constituents in sludges from wastewater treatment facilities and from oils and solvents used at the Y-12 Plant have been completed. Final results indicate that conventional treatment technologies can be utilized to reduce one of the constituents so that the waste is no longer considered mixed.

9.1.4.2 Oak Ridge National Laboratory

Wastes are identified initially through their generating processes and can be grouped into the broad categories shown in Fig. 9.2. Although knowledge of the generating process often helps in identifying the waste constituents, this depth of characterization is not always sufficient to allow for proper waste handling. Therefore, more detailed waste characterization is often conducted before storage, treatment, or disposal. Wastes are analyzed using standard EPA and DOE-approved analytical methods. In addition, all wastes are checked for radioactive contamination.

It is ORNL policy to minimize all categories of wastes by reducing waste volume and/or toxicity, thereby reducing the need for waste treatment and disposal and their potential environmental consequences. This reduction can be achieved through process modification, segregation, minimization, or recycling.

One example of process modification that effectively reduces the amount of hazardous waste generated is a procedural change in the Analytical Chemistry Division. Many chemical analyses are now done on small-volume samples using small volumes of solvents for extractions, which reduces the total volume of waste solvent generated.

Waste segregation is used to minimize the generation of solid low-level radioactively contaminated wastes. By providing collection barrels for both radioactive and nonradioactive wastes, the volume of wastes that requires handling as radioactive waste has been reduced. Before these procedures were implemented, radioactive and nonradioactive wastes were discarded in the same barrel. This contaminated the nonradioactive portion and required special disposal of an inflated amount of waste.

ORNL's procurement policy is an example of minimization. In the past, researchers took advantage of the reduced cost of bulk purchasing; however, the excess purchased was often discarded as waste. By purchasing only the quantity of a chemical needed, less waste is produced.

Examples of recycling include making unneeded chemicals available to others rather than discarding them as wastes; using acceptable waste corrosives in a neutralization facility in place of new acids and bases; and recovering silver from silver-bearing photographic wastes.

Despite these efforts, some wastes will be produced. Minimizing the impact on public health and the environment is the goal of the waste management program. To achieve this goal, some wastes, such as sanitary wastes, are treated on-site while others, such as low-level solid wastes, are disposed of on-site in SWSAs. Off-site treatment is the best management option for many hazardous and PCB-contaminated wastes. Most hazardous laboratory and PCB-contaminated wastes are incinerated in permitted facilities. Although more expensive than land disposal, destruction by incineration is preferable for minimizing long-term liability. Transuranic waste and mixed waste are in long-term storage on-site until appropriate storage, treatment, or disposal options become available. Solid waste management strategies depend on the type of waste and are chosen because they are the most prudent approaches currently available.

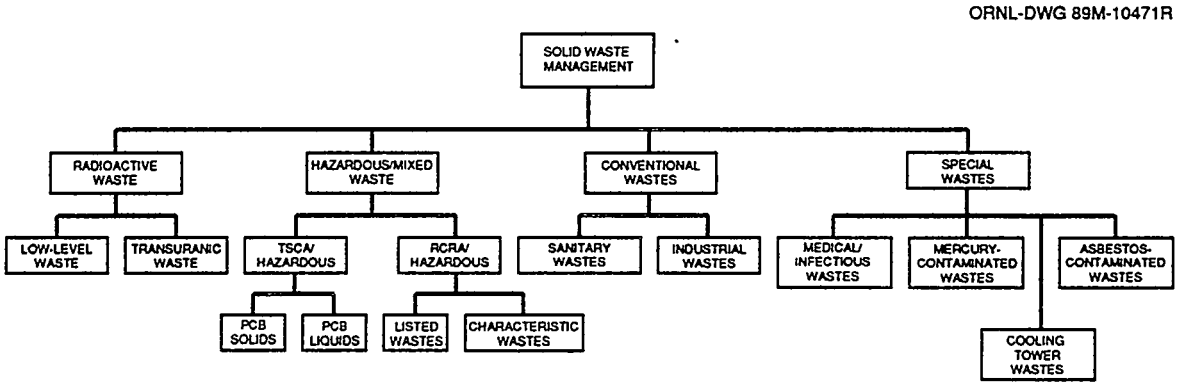


Fig. 9.2. Categories of solid waste sources and flow of mixed wastes.

9.1.4.3 K-25 Site

The strategy for the management of solid waste consists of treatment, storage, disposal, waste reduction, and/or delistings of all waste streams generated at the K-25 Site. Waste streams are evaluated using process knowledge and analytical waste characterization. Samples are collected and analyzed using EPA- and DOE-approved methods. Radioactive analyses are performed on an as-needed basis, with surveys and scans performed on suitable materials and configurations.

The K-25 Site policy mandates minimization of waste generated while achieving compliance with applicable environmental regulations. Five waste reduction options are used at the K-25 Site: segregation, material substitution, process innovation, mechanical volume reduction, and recycling/reuse. These options may be used alone or in combination to address specific goals.

The K-25 Site management supports the waste reduction program. Excellent examples of the program at work include the procedure for procuring hazardous materials, the use of waste assay monitors to reduce the volume of LLW requiring management (i.e., storage), and the conversion to gas-fired boilers to reduce opacity excursions and, in effect, reduce or eliminate fly ash production. In the past, hazardous materials were purchased in larger quantities to take advantage of the less expensive bulk rates. However, a hidden cost of this procurement method was the expense of disposal of the excess material. Current procedure for the purchase of hazardous materials requires the approval of the Plant Hazardous Materials Coordinator. This minimizes the purchase of excess hazardous materials, thus minimizing the need to dispose of excess quantities.

Several treatment, storage, and disposal options are available to manage the wastes generated at the K-25 Site. On-site storage facilities are available for LLW, RCRA wastes, and mixed wastes. On-site treatment capabilities include the K-1435 TSCA Incinerator, the Central Neutralization Facility, and other facilities for neutralization, precipitation, and stabilization. The K-25 Site utilizes the Y-12 Plant Centralized Sanitary Landfill II for disposal of sanitary/industrial solid wastes. On-site disposal includes discharge of aqueous wastes through NPDES discharge points after treatment. Off-site

disposal options include disposal of RCRA hazardous and nonregulated wastes by commercial vendors. Waste assay monitors have also been purchased and are being used to screen solid, potentially radioactive waste to determine the potential to manage it as sanitary/industrial waste. This, in effect, allows valuable storage space to be dedicated to those wastes actually requiring long-term management. All boilers at the K-25 Site are being converted to gas fired to eliminate opacity excursions; a secondary derived benefit of the conversions is the curtailment of fly ash production.

9.2 WASTE GENERATION

9.2.1 Types of Wastes Generated

Following is a brief summary of the types of wastes generated at ORR.

Sanitary/industrial wastes. Industrial trash consisting of paper, wood, metal, glass, plastic, etc., coupled with large volumes of construction/demolition debris and small volumes of sanitary/food wastes from cafeteria operations. Also included in this category is fly ash from steam plant operations and other special wastes. This is regulated by the Tennessee Solid Waste Management Act (TSWMA).

RCRA hazardous wastes. Solid wastes (including gases and liquids) that are defined as hazardous by RCRA regulations as a consequence of being a listed waste or having a hazardous characteristic. Hazardous wastes include chemicals that are characteristically hazardous or listed by RCRA in 40 CFR 261.30 and TN 1200-1-11.02(4). These wastes are managed in accordance with DOE Orders 5400.1 and 5400.3 and state and federal regulations.

Mixed wastes. RCRA hazardous wastes that are also contaminated with low-levels of uranium or other radioactive material.

PCB wastes. PCB oils or materials that have been contaminated with PCBs. These are regulated by TSCA. These waste streams may or may not be radioactively contaminated. Radioactively contaminated waste cannot be disposed of through commercial disposal facilities. Any TSCA waste that is radioactively contaminated is placed in storage pending future disposal at the K-1435 Incinerator.

Low-level radioactive wastes. Solid wastes (including liquids) that are composed of isotopically depleted uranium metal or oxide or that contain low levels of uranium or other radioactive contamination. LLW are managed according to DOE Order 5820.2A and AEA.

Asbestos/beryllium oxide wastes. Solid wastes that have been contaminated with either asbestos or beryllium oxide, which classifies the waste as a special waste. The waste may also be contaminated with low levels of uranium or other radionuclides

Scrap metal. Derived primarily from demolition activities. The scrap may be either nonuranium contaminated or contaminated with low levels of uranium or other radionuclides.

Classified wastes. Classified wastes include liquid and solid streams containing materials that, for security reasons, are restricted by DOE criteria. Classified wastes are managed in accordance with DOE Order 5632.1. These wastes could be contaminated with low levels of radioactivity.

Medical wastes. Medical and infectious wastes include contaminated bandages, sharps, and culture media. These wastes are placed in biological disposal containers and autoclaved to destroy any biologically active organisms. The waste is then landfilled at the Y-12 Centralized Sanitary Landfill II.

Nonhazardous wastes. All other types of wastes (including liquids) that are nonhazardous or nonradioactive, or both.

Material access area (MAA) wastes. Wastes that are removed from MAAs include combustible and compactible materials (paper, wood, wipes, etc.) and noncombustible and noncompactible materials (dirt, concrete, block, rubble). 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.

9.2.2 Waste-Generating Activities

9.2.2.1 Y-12 Plant

Major waste-generating activities at the Y-12 Plant include construction/demolition activities that produce large volumes of contaminated and noncontaminated wastes, including lumber, concrete, metal objects, soil, and roofing materials. Wastes contaminated with hazardous materials are also generated by construction/demolition activities.

Machining operations use stock materials, including steel, stainless steel, aluminum, depleted uranium, and other metals to produce significant quantities of machine turnings and fines as a waste product.

The Y-12 Steam Plant produces steam by burning coal, which produces fly ash and bottom ash as a waste product.

Industrial trash, both noncontaminated and uranium contaminated, is generated by daily operations throughout the plant. These operations include janitorial services, floor sweeping in production areas, and production activities.

In addition, plating waste solutions are generated by metal-plating operations, and reactive wastes and waste laboratory chemicals are generated from various laboratory activities.

Liquid process wastes are generated from multiple processes throughout the plant. Sludges are generated as a result of treating process wastes at multiple sites, and waste oils and solvents are generated from machining and cleaning operations.

Contaminated soil, soil solutions, and soil materials are generated from closure activities associated with RCRA closures. (See Table 9.1 in Vol. 2.)

These are only a few of the industrial-type activities at the Y-12 Plant that are generating waste streams at the site. A summary of waste generation for 1991 is given in Tables 9.1 and 9.2.

9.2.2.2 Oak Ridge National Laboratory

Because ORNL is a research facility, it has many diverse waste-generating activities, each of which may produce only a small quantity of waste. Isotope production, utilities, and support functions such as photography are additional sources of waste. A summary of waste generation for 1991 is given in Table 9.3.

Hazardous wastes are generated in laboratory research, electroplating operations, painting and maintenance operations, descaling, demineralizer regeneration, and photographic processes.

Mixed wastes are generated by research projects and some facility operations. Facility renovation and demolition activities produce asbestos. Although the electrical system has been largely converted to a non-PCB system, PCB-contaminated wastes, including fluorescent light ballasts and capacitors, are still occasionally discarded. Additionally, Energy Systems policy requires that waste materials containing greater than 2 ppm PCBs be managed according to TSCA requirements.

Nonhazardous wastes result from ORNL maintenance and utilities. For example, the steam plant produces nonhazardous sludge. Scrap metals are discarded from maintenance and renovation activities and are recycled when appropriate. Construction and demolition projects also produce nonhazardous industrial wastes. All nonradioactive medical wastes are autoclaved to render them noninfectious and are sent to the Y-12 Plant Sanitary Landfill. Isotope production and research activities generate a variety of low-level radioactive and transuranic wastes, as shown in Table 9.4. Remedial action projects also produce wastes requiring proper management.

9.2.2.3 K-25 Site

Enrichment, maintenance, decontamination, and research and development (R&D) activities have generated a wide variety of waste at the K-25 Site. Until August 1985, the primary function of the site was the enrichment of uranium in the ^{235}U isotope.

Table 9.2. Y-12 Plant radioactive waste data for 1991

Radionuclide	Activity (mCi)
^{235}U	5.8
^{238}U	17
^{232}Th	0
^{99}Tc	0
^{237}Np	0

Table 9.3. 1991 ORNL waste generation summary

Waste	Volume (m^3)	Weight (kg)
Hazardous		65,898.24
Sanitary		
Radiological		
Nonradiological		15,240
Industrial		
Mixed		19,273.08
PCB		
Radiological		7,193.61[a]
Nonradiological		14,964.0[b]
Transuranic		
Contact handled	10.36	3,358.8[c]
Remote handled	5.43	1,270.0
Low level		
Waste water	543,480 gallons	
Asbestos		
Radiological	29.87	5,014.8
Nonradiological		19,229
Scrap metal		
Radiological	129.32	31,012.8
Nonradiological		*d*
Miscellaneous		36,970.09
Nonhazardous		
Miscellaneous		
Radiological	0	0

[a]Of this amount, 3,615.21 kg was also classified as hazardous.
[b]Of this amount, 4,512.07 kg were also classified as hazardous.
[c]Of this amount, 474.8 kg were also classified as hazardous.
[d]Estimate not available.

Uranium is the predominant radionuclide found in the K-25 Site waste streams.

Trace quantities of ^{99}Tc, ^{237}Np, and ^{239}Pu may have also been present in some of the waste streams because these radionuclides were present in UF_6 reactor return feed material that was shipped to the K-25 Site for enrichment.

Solid low-level wastes are generated by discarding radioactively contaminated construction debris, wood, paper, asbestos, trapping media, and process equipment and by removing radionuclides from liquid and airborne discharges.

Currently, low-level solid wastes are being stored at the K-25 Site for future disposal.

All contaminated scrap metal is stored aboveground at the K-770 scrap metal facility until further disposal methods are evaluated.

Sludges contaminated with low-level radioactivity are generated by settling and scrubbing operations and were stored in K-1407-B and K-1407-C ponds in the past. Sludges have been removed from these ponds in the past. Sludges have been removed from these ponds and portions have

been fixed in concrete at K-1419 and stored above ground at K-1417.

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. Free liquid (water with pH of 12) on top of the concrete in the drums was found to be causing the corrosion.

A Commissioner's Order was issued by TDEC in September 1991 for noncompliances regarding the storage of the raw and stabilized sludges.

An action plan has been implemented to decant and/or dewater the mixed waste contained in the drums. Implementation of the Pond Waste Management Program action plan, coordinated with state and federal regulators, began in 1991 and will continue through February 1993. A total of 45,000 drums of stabilized material and 32,000 drums of raw sludge must be processed and moved to storage facilities that meet regulations governing mixed wastes.

Of the 77,000 total drums, 10,000 are currently stored in K-25 vaults and 67,000 are located at K-1417A and B drum storage yard. The plan calls for all containers to be transferred to and stored in new (K-1065 site) and existing (K-31 and K-33 buildings) facilities.

Work started February 3, to process the remaining 5,428 stabilized drums in K-25 vaults and to transfer them to building K-31. The preparation of the 37,000 stabilized drums at the K-1417A and B yard has also begun. All 45,000 drums of stabilized material must be transferred into compliant storage by October 30, 1992.

The remaining 32,000 drums containing raw sludge will be reduced by a dewatering process, repackaged into compatible containers, and placed into compliant storage in new facilities constructed at the K-1065 site. This effort is scheduled for completion by February 28, 1993.

The transfer and storage of the drums is being performed by K-25 employees. Subcontracts for bulk storage containers and pallets and the processing of stabilized drums were awarded in the first quarter of FY 1992. A contract to dewater and process containers of sludge will be awarded sometime in the spring.

As the K-25 vaults are emptied of drums, the facilities are immediately turned over to the Mixed Waste Storage Expansion Project. The objective of this program is to prepare the vaults for storage of wastes covered under RCRA and of mixed wastes generated by K-25, X-10, and Y-12. The schedule calls for an average of one vault a month to be made

Table 9.4. 1991 ORNL radioactive waste data

Radionuclides	Curies
^{241}Am	0.024774
^{243}Am	0.000151
^{244}Am	0.000610
^{14}C	0.015475
^{144}Ce	0.000042
^{249}Cf	0.015500
^{252}Cf	1.696800
^{242}Cm	0.070000
^{244}Cm	1.435666
^{60}Co	34.207813
^{134}Cs	3.498655
^{137}Cs	1,045.419221
^{152}Eu	143.412941
^{154}Eu	0.689990
^{155}Eu	0.029000
^{55}Fe	0.004000
^{3}H	0.018962
^{125}I	0.006030
^{131}I	0.000248
^{192}Ir	0.001910
^{40}K	0.000074
^{85}Kr	0.000250
^{22}Na	0.001100
^{63}Ni	0.000010
^{191}Os	0.067830
^{194}Os	0.095200
^{32}P	0.001441
^{210}Pb	0.000400
^{147}Pm	0.015060
^{195}Pt	0.000170
^{238}Pu	0.000170
^{239}Pu	0.408125
^{242}Pu	0.000000
^{226}Ra	0.676344
^{222}Rn	0.000034
^{106}Ru	0.001000
^{35}S	0.002191
^{90}Sr	71.560026
^{179}Ta	0.0004970
^{99}Tc	0.001540
^{228}Th	0.000000
^{230}Th	0.000000
^{232}Th	0.000722
^{233}U	0.204590
^{234}U	0.000021
^{235}U	0.002823
^{238}U	0.010217
^{188}W	0.168747
Total curies	1,303.775312

available for this purpose. A total of 30 vaults are planned through 1994.

To prepare the vaults for storage of RCRA and mixed wastes, a process called BLASTRAC is used. This process decontaminates the vault floor and also allows adherence of an epoxy sealant. PVC containment dykes are installed, and the floor is coated with epoxy. As a result of this preparation, the vault contains any leaks that may occur from drums.

The primary generator of radioactively contaminated liquid waste is the K-1435 TSCA Incinerator. This waste stream is currently being treated at the K-1407-H CNF.

Other waste streams generated at the K-25 Site include RCRA hazardous chemicals and materials, PCB articles and items, industrial/sanitary wastes, waste oils and solvents, and remedial action type wastes.

All waste streams generated at the K-25 Site are managed according to applicable state and federal regulations and DOE orders (see Table 9.5). Several waste management facilities are already in place. Changing laws and regulations have made it necessary to upgrade several facilities and to design and construct new facilities that reflect the most recent environmental technology.

Table 9.5. K-25 Plant waste generation summary for 1991

Waste	Quantity
Sanitary/industrial (m^3)	3,921
Construction/demolition spoil (m^3)	4,215
Asbestos/BeO	
Uncontaminated (m^3)	88
Contaminated (m^3)	10
Hazardous[a] (kg)	54,822,532
Mixed[b] (kg)	46,300,459
Low-level contaminated waste[b] (m^3)	361
Scrap Metal	
Uncontaminated (m^3)[c]	39
Contaminated (m^3)[c]	616
Classified (kg)	100

[a]Includes 8,420,000 kg of hydrogen softener blowdown from the steam plant and 45,517,004 kg of TSCA Incinerator waste water.

[b]May include some PCB-tainted waste. Also includes 45,517,004 kg of TSCA Incinerator waste water.

[c]Noncompacted volume.

9.3 WASTE MANAGEMENT ACTIVITIES

9.3.1 Waste Management System

Special forms specifically designed for each plant are used to document and track wastes. A list of these forms follows.

Y-12	Form UCN-2109	Request for Transfer, Storage, and Disposal of Wastes
ORNL	Form UCN-13698	Request for Disposal/
	Form UCN-2822	Storage of Waste
	Form TX—5352	Materials and Equipment
K-25	Form UCN-12463	Request for Disposal/ Storage of Waste Materials and Equipment

Wastes must be adequately characterized through chemical analyses or process knowledge to determine appropriate treatment, storage, and disposal options. This is documented on the appropriate forms depending on waste type. Additional forms may be used at the sites to document special waste streams such as classified wastes, asbestos/beryllium oxide, and spoil materials.

A Health Physics staff member surveys the waste for radioactivity. Waste generation is reduced by recycling and segregation whenever feasible. The waste transportation group at each site checks the form for accuracy, assigns a hazard class and the EPA hazardous waste number, if appropriate, and transports the waste to the appropriate hazardous waste management facility. The waste operations groups maintain an inventory for each storage facility.

Information concerning waste generation, storage, transportation, and disposal activities is maintained on computerized and/or manual data bases. Data from the forms and other documentation

are compiled to ensure compliance with all applicable state and federal regulations and to promote efficient waste management operations.

Computer-based data bases facilitate waste tracking and the generation of waste management reports. Hard copies of forms are kept on permanent file.

9.3.2 Waste Management Facilities

9.3.2.1 Y-12 Plant

Nonhazardous

The Y-12 SLF II is a TDEC-permitted facility that became operational in 1983. It serves the K-25 Site, ORNL, the Y-12 Plant, and other DOE prime contractors and their subcontractors in the Oak Ridge area. Combustibles, decomposable materials, and other industrial wastes are permitted for disposal in SLF II, as are certain special wastes such as asbestos, beryllium oxide, aerosol cans, fly ash, and others. These materials are disposed of in large trenches, and a clay cover is applied daily. This facility is operated as described in Report Y-EN 618, *Design and Operating Procedures for the Y-12 Centralized Sanitary Landfill II* (McDermott 1991).

The Y-12 Spoil Area I is a shallow land burial facility for the disposal of noncontaminated rubble and construction spoil, including asphalt, brick, block, brush, concrete, dirt, rock, tile, and other similar materials. Although currently inactive, this TDEC-permitted facility was operated in accordance with Report Y/IA-167, *Design and Operating Procedures for the Y-12 Spoil Area I* (Bailey and Jones 1984). A closure plan for the facility has been submitted to TDEC for approval.

The Chestnut Ridge Borrow Area Waste Pile serves as a storage/disposal area for soils with low concentrations of mercury and is operated in accordance with Report Y/TS-62, *Design and Operating Procedures for the Chestnut Ridge Borrow Area Waste Pile* (Energy Systems 1984). The facility is covered with a synthetic liner and has run-on and runoff protection.

The current plans are to seek closure of this site under TDEC Solid Waste Management rules for special wastes.

Lake Reality is a lined containment basin with a surface area of approximately 2 acres. The pond serves to enhance the water quality of East Fork Poplar Creek downstream of the Y-12 Plant.

Industrial Landfill IV is a TDEC-permitted landfill for disposal of nonhazardous, nonradioactive, classified solid wastes from the Y-12 Plant.

The salvage yard is used for the staging and public sale of nonradioactive, nonhazardous scrap metal. Sales have been suspended, however, until procedures to meet the DOE "No Rad Added" performance objective have been written and approved.

Oil Storage OD6 is a 113,562-L (30,000-gal) tank that was used to collect clean oils before sale to the public. This facility is no longer operational.

Rogers Quarry is used as a settling pond for bottom ash sluiced from the steam plant. The use of Rogers Quarry for ash settling will be discontinued when the Steam Plant Ash Disposal (SPAD) Line Item is completed in FY 1993. At that time, bottom ash will be collected in a dedicated ash-handling system and disposed of in Industrial Landfill V, which will be constructed under the SPAD project.

The UNC Landfill is a surface storage area for nitrate-contaminated sludges and soils. Plans for closure of this facility have been approved. The closure activities are described in the Report Y/IA-200, *Closure Plan for the United Nuclear Corporation Waste Disposal Site* (Bailey et al. 1989).

The Sludge Handling Facility (T-118) was designed and constructed to provide water filtration and sludge dewatering in support of a storm sewer cleaning and relining project. Filtered water was reused by the sewer cleaning contractor, and the dewatered sludge was stored in specially constructed containers for future disposal. The facility began receiving material during the winter of 1986 and was removed from operation at the end of the project during the fall of 1987.

The Plating Rinsewater Treatment Facility (PRTF) (T-036) provides neutralization, electrochemical treatment, chemical precipitation, carbon adsorption, and filtration for nonuranium plating rinse waters from plating operations.

The Steam Plant Wastewater Treatment Facility (SPWTF) provides flow equalization, pH adjustment,

chemical precipitation, clarification, and sludge dewatering for coal pile runoff, ion-exchange regeneration wastewater, boiler blowdown, and demineralizer waste. The wastewater, which is considered to be RCRA-hazardous prior to treatment, is rendered nonhazardous by the SPWTF and discharged to East Fork Poplar Creek.

RCRA Hazardous/Mixed

The East Chestnut Ridge Waste Pile is a lined waste pile with leachate collection used for the storage of contaminated soils and spoil materials.

Kerr Hollow Quarry was used for the disposal of water-reactive and shock-sensitive chemicals. The facility is currently being closed.

The RCRA Staging and Storage Facility is a compartmentalized warehouse used for the staging of RCRA wastes before off-site shipment.

The Salvage Yard Oil/Solvent Drum Storage Area (OD2) was a diked storage area where drums of oils and solvents were staged pending disposal. An approved RCRA closure has been performed on this facility.

The security pits were deep trenches used for disposal of classified wastes. Hazardous materials were disposed in this facility prior to 1984. This facility was closed under RCRA guidelines.

Building 9720-9 is a warehouse used for storage of flammable as well as nonflammable hazardous waste.

The Interim Storage Yard is a gravel storage yard used to store drums of hazardous waste pending final disposition. A small portion of the yard has been closed in accordance with a TDEC-approved closure plan.

The Biodenitrification Facility uses biodenitrification reactors and recovery/feed tanks to biologically denitrify uranium-contaminated liquid wastes.

The Cyanide Treatment Facility is a batch facility for the destruction of cyanide in plating wastes. The destruction occurs in drums under an exhaust hood.

The Waste Coolant Processing Facility (WCPF) is a biodegradation and storage facility for waste coolants.

The West End Treatment Facility (WETF) is a wastewater treatment facility designed to biologically denitrify nitrate-bearing liquid wastes and to physicochemically treat the resulting solutions to remove inorganic contaminants. Unit operations at WETF include pH adjustment, degassing to precipitate uranium, flocculation and precipitation to remove heavy metals such as nickel and zinc, and carbon adsorption. WETF treats approximately 1 million gal of wastewater per year. Effluent from WETF is discharged to East Fork Poplar Creek.

The Central Pollution Control Facility (CPCF) is a wastewater treatment facility that employs physicochemical unit processes to remove oil and grease, heavy metals, and trace organics from nonnitrate-bearing wastewaters generated at the Y-12 Plant. Approximately 1 million gal of wastewater per year is treated at the CPCF and discharged into East Fork Poplar Creek.

Building 9212 Tank Farm consists of tanks used to store acid and caustic wastes.

The Waste Oil/Solvent Storage Facility is a tank facility that provides 200,000 gal of bulk storage for uranium-contaminated oils and solvents and PCB-contaminated materials as well as nonuranium contaminated materials.

The Liquid Organic Waste Storage Facility is a bulk and drum storage facility that provides 113,562 L (30,000 gal) of bulk storage and storage for about 300 drums of solvents.

PCBs and PCB/Uranium

Oil Drum Storage Area OD3 had two 22,712-L (6000-gal) tanks, which were used to store PCB-contaminated oils. These tanks are part of a larger area that also contained drums. All of the site has been closed with the exception of the tanks.

Building 9418-9 Storage Tank

Building 9418-9 contains a 14,000-gal, below-grade, diked tank used for storage of PCB-contaminated mineral oil. The dike for this tank is 1-ft-thick concrete with no drains and a sump pump.

Waste Oil/Solvent Storage Facility (OD9)

The Waste Oil/Solvent Storage Facility (OD9) is a permitted RCRA/TSCA hazardous waste storage facility. It consists of a diked area supporting five 40,000-gal tanks, a tanker transfer station with five centrifugal transfer pumps, and a drum storage area. Three tanks house PCB waste contaminated with

uranium, one tank contains nonradioactive PCB wastes, and one tank holds RCRA hazardous wastes. Likewise, a diked and covered pad furnishes space for 35 drums. Wastes assigned to this facility are first stored at OD8 (Building 9811-1 RCRA Storage Facility) to await laboratory results. The diked area contains additional space for a sixth 40,000-gal tank. This facility is projected to be used until the year 2010 due to the anticipated lack of disposal outlets for uranium-contaminated organic liquids. The fire-suppression system at this facility will be upgraded during FY 1992 to comply with DOE Order 5480.7.

Garage Oil Storage Tanks

Three garage oil storage tanks have been drained and removed from the ground as part of a closure plan initiated in 1989. One of the three tanks formerly contained PCB-contaminated oil. Closure has not been completed.

Building 9404-7 PCB Drum Storage Facility

Building 9407-7 is a TSCA storage facility in which solid PCB-contaminated materials are the only wastes accepted. These wastes may also be contaminated with uranium. Storage of liquid and/or hazardous waste is not permitted. Storage containers must comply with the specifications of 49 CFR 178.8, 178.82, and 178.115. The facility provides for spill containment and has a capacity for 496 drums. Building 9404-7 is located south of Building 9204-1.

RCRA/PCB Warehouse (Building 9720-9)

The RCRA/PCB Warehouse supplies a drum storage area for mixed and/or PCB wastes, including an area designed to contain flammable wastes. The western half, which contains space for approximately 1500 drums, stores both PCB and RCRA hazardous waste. However, a diking upgrade is planned to allow for the handling of RCRA materials.

The facility's eastern half is not currently in use. Upgrades to the ventilation, diking, and fire-suppression systems will comply with RCRA, TSCA, and DOE standards and will allow for mixed and PCB waste storage. The design of these modifications is complete and construction will begin if NEPA approval is obtained.

RCRA and PCB Container Storage Area (Building 9720-58)

Building 9720-58 is a warehouse facility used to stage and store PCB-contaminated equipment (transformers, capacitors, electrical switchgear, etc.) and nonreactive, nonignitable RCRA waste contaminated with uranium. Waste containers received at Building 9720-58 include 30- and 55-gal drums, 330- and 660-gal portable tanks, B-25 boxes, and self-contained PCB equipment. An overhaul of the fire-suppression system is planned for FY 1992 to meet requirements of DOE Order 5480.7. In addition, improved ventilation and diking systems will be added during 1993 to conform with RCRA and TSCA standards.

Liquid Storage Facility (LSF)

The LSF is a hazardous waste storage facility built during the Bear Creek Burial Ground closure activities. The LSF, located in Bear Creek Valley approximately two miles west of the Y-12 Plant, is used for collection and storage of groundwater and other wastewaters received from the Seep Collection Lift Station, the Storage Facility, tankers, polytanks, and the diked area rainwater accumulation. Feed streams may contain oil contaminated with PCBs, volatile and nonvolatile organic compounds, and heavy metals. Processing and storage equipment include:

- two 75,000-gal bulk storage tanks,
- 6000-gal oil storage tank,
- gravity separator,
- filtering unit,
- composite sampling station, and
- tanker transfer station.

The wastewater travels through the gravity separator, cartridge filters, and composite sampling station prior to storage in the bulk tanks. A reinforced concrete dike surrounds all equipment to provide spill containment. After sufficient wastewater accumulates in the bulk storage tanks, it is processed at the Groundwater Treatment Facility. A new leachate collection system that will collect and pump Burial Ground hazardous waste seepage to the LSF is under construction and will begin operation in FY 1992.

Flammable Mixed Waste Storage Facility (OD10)

The Flammable Mixed Waste Storage Facility (OD10) contains four 6500-gal and two 3000-gal stainless steel tanks for storage of ignitable nonreactive liquids, including those contaminated with PCBs and uranium. In addition, a diked and covered storage area provides space for 1000 drums of material. The facility is capable of segregating various spent solvents for collection and storage. Major solvent waste streams are transferred to tanks until commercial resale, disposal, or incineration of the K-25 Site takes place. A fire suppression modification of this facility is planned for FY 1992 to fulfill the requirements of DOE Order 5480.7.

Solid Storage Facility (SSF)

The SSF provides 17,500 sq. ft of storage space for PCB- and uranium-contaminated soil. The facility also contains a synthetic liner for leachate collection and leak detection system. Collected leachate is transferred to the Liquid Storage Facility for pretreatment. The SSF is currently undergoing the RCRA Part B permitting process. No additional wastes are being added to the facility.

Oil Landfarm Soil Storage Facility

This facility contains approximately 550 cubic yards of soil contaminated with PCBs and volatile organics. The soil was excavated from the Oil Landfarm and Tributary 7 in 1989. The soil is contained in a covered, double-lined concrete dike with a leak-detection system. The leak-detection system will soon be modified to enhance detection capabilities.

Low-Level Radioactive

Bear Creek Burial Ground, a shallow land burial facility, has been used primarily for the disposal of low-level uranium-contaminated waste, although it has received RCRA and TSCA wastes. During 1991, only low-level uranium-contaminated trash was disposed of in the burial ground. Shallow land burials in Bear Creek Burial Ground were terminated during June 1991. The facility was operated in accordance with Report Y/IA-169, *Design and Operating Plan for the Extension of Y-12 Plant Burial Ground A for the Disposal of Low-Level Radioactive Solid Waste* (Bailey and Manuel 1986).

Closure activities began in November 1988 on many of the areas used for disposal of RCRA and TSCA wastes; these activities are continuing. In addition Y/IA-210, *Best Management Practices Plan for Waste Management Activities in the Bear Creek Burial Grounds* (Bailey et al. 1989), has been prepared, and identified activities have been and are being implemented. The objective of these actions is to eliminate disposals in Bear Creek Burial Ground. Some of these actions were initiated in 1987 and included on-site volume reduction of some solid wastes and subsequent shipment to the K-25 Site for storage. A volume reduction contract was placed in 1991 with a commercial facility that utilizes incineration and/or supercompaction prior to shipment to the K-25 Site for storage.

The Uranium Oxide Vaults (S-114) are two concrete vaults used for the storage of uranium oxide and metals.

The Waste Feed Preparation Facility compacts solid, uranium-contaminated wastes into bales for shipment to a commercial facility for further volume reduction prior to being placed in interim storage at the K-25 Site.

The Trash Monitoring Facility is an external radiation monitoring facility that is used to select the proper disposal facility for bulk solid wastes.

9.3.2.2 Oak Ridge National Laboratory

RCRA-regulated and PCB wastes are managed in storage facilities until they can be shipped off site for treatment and/or disposal. Energy Systems policy defines any material containing greater than 2 ppm PCBs as PCB waste. Several RCRA facilities operate under interim status (7651, 7652, 7653, Tank 7830A) while permit applications are under review by TDEC. Others operate under interim status but are scheduled for initiating closure in 1992 (7025, 7555, New Hydrofracture Surface Facilities, and the Reactive Chemical Facility). The Hazardous Waste Storage Facility, Building 7652, permit application was approved by TDEC in October 1986.
PCB-contaminated and/or hazardous wastes are temporarily stored at Building 7507, and PCB-contaminated and/or mixed wastes are stored on the 7507W Storage Pad. TRU waste is stored in the

TRU Retrievable Storage Facilities, 7823, 7826, 7834, 7855, and 7879.

Few hazardous wastes are treated in on-site facilities. The Chemical Detonation Facility treats small amounts of wastes that would be dangerous to transport off-site. Explosives such as aged picric acid are detonated in the detonation facility.

The landfill receives nonhazardous industrial materials such as fly ash and construction debris. Asbestos and general refuse are managed in the Y-12 Plant Sanitary Landfill. ORNL's SWSA 6 receives low-level solid radioactive waste, including radioactively contaminated asbestos.

Numerous satellite accumulation areas and several 90-day areas are used across ORNL for accumulating wastes by the generator until a sufficient quantity exists to be transferred to a permitted or interim status storage facility.

9.3.2.3 K-25 Site

The K-770 scrap metal storage facility consists of a 2.8-ha (6.9-acre) tract of land used for storing low-level radioactively contaminated scrap metal. Ferrous and nonferrous materials are generated at the K-25 Site and transported to the storage yard. At present, only containerized material is being accepted at the scrap yard.

The K-770 clean scrap yard provides storage for nonradioactive scrap metal. The scrap metal is stockpiled at K-770 before being sold to the public.

The K-726 PCB storage facility is located inside the K-770 scrap yard. This facility consists of a diked concrete block building with an approximately 225-m^2 (2430-ft^2) storage space and is used primarily for the storage of low-level uranium-contaminated PCB waste that may also contain combustible and/or flammable liquids. The current management scheme for these wastes is treatment at the K-1435 Incinerator.

The K-306-1 RCRA storage facility is a 288-m^2 (3110-ft^2) area used for radioactively contaminated RCRA/PCB waste. These wastes are also designated for treatment at the K-1435 Incinerator. When the PCB waste is removed, this facility will be used for storage of RCRA waste sludges generated at the Y-12 Plant.

K-306-1-a is designated as a stand-alone PCB facility for only PCB storage.

The K-311-1 container storage area provides storage for approximately 51 tons of lead wastes generated during previous Y-12 Plant operations. This facility is a 225-m^2 (2400-ft^2) enclosed building. Stored wastes include lead ingots, lead slag, and lead carbonate contaminated with low-level radioactive contaminants.

The K-1419 sludge fixation facility is used for mixing hazardous and mixed inorganic wastes with concrete to form a solid mixture that can be stored aboveground at K-1417. The facility consists of a storage tank area for wastes and a series of storage tanks for nonhazardous feed materials, feed tanks, and mixers. The waste sludges and liquids are mixed with cement and fly ash according to the fixation recipe to stabilize them. The fixation recipes are specific for each waste type.

The K-1417 casting and storage yard, which has a storage area of 1.2 ha (3 acres), is used for storage of drummed solidified sludges generated at the K-1419 facility. Casting activities can be performed either at K-1419 or in the casting area of K-1417. A truck and equipment washing system collects runoff and spills from the casting area.

The K-306-1 vault 23A hazardous waste storage facility provides storage capacity for about 3000 208-L (55-gal) drums and is used primarily for storing sludges generated during treatment of Y-12 Plant wastewaters at either K-1232 or Y-12 Plant facilities. The drums are sealed, labeled, identified, and inventoried either before or immediately following transport to K-306-1, vault 23A.

The K-305-6 vaults 19 and 19B hazardous waste storage facility offers a storage capacity for 8050 208-L (55-gal) drums. This facility is also used primarily for the storage of K-25 pond waste sludges generated from the closure of the K-1407-B pond. The containers are sealed, labeled, identified, and inventoried either before or immediately following transport to K-305-6.

The K-1420-A flammable waste storage tank is a 113,562-L (30,000-gal) tank that was modified to store low-flash-point and high-vapor-pressure wastes. The waste types stored in this facility include flammable solvents, gasoline, and paint waste. Only drummed waste that has been identified can be stored at this facility. The waste stored in this tank at the present and in the future will be disposed of at the K-1435 Incinerator.

The K-1425 waste oil/hazardous waste/PCB storage facility consists of container and tank storage areas. The container storage building capacity is 480 208-L (55-gal) drums, and the tank storage area consists of four 85,275-L (22,500-gal) tanks in a dike. Wastes stored in this facility include oils, solvents, water, and organics. These wastes may be RCRA regulated, contain PCBs, and/or be radioactively contaminated. Wastes stored in this facility are and will be treated at the K-1435 Incinerator.

The K-1435 TSCA Incinerator consists of storage tanks, dikes, and the incinerator. The maximum storage capacity for waste is 1,040 208-L (55-gal) drums. The tank storage capacity is 3.48×10^5 L (0.9×10^5 gal). The incinerator system consists of a liquid, solid, and sludge feed system; a rotary kiln incinerator; and a secondary combustion chamber.

The wastes treated at this facility include oils, solvents, chemicals, sludges, aqueous waste, and solids. The majority of waste treated at the K-1435 Incinerator cannot be treated by commercial incinerators because of radioactive contamination. All waste sent to K-1435 for incineration must be fully characterized and identified. DOE has approved a chain-of-custody system for all waste received from off-site.

During 1988, the performance test of the K-1435 TSCA Incinerator was completed and shakedown testing was begun. These tests continued through 1989. The incinerator began burning wastes in April 1991.

The K-1302 gas cylinder storage facility has been designated for storage of compressed gas cylinders. These gases are commercial products that are to be discarded or treated. The facility has a maximum storage capacity of about 100 ft^3 (2.8 m^3) of gas.

The K-1036-A storage dike is used for solvents and waste oil storage. The oil has recently been determined to be regulated by RCRA, with possible radioactive contamination. This facility has a maximum waste storage capacity of about 2,000 208-L (55-gal) drums. After proper characterization, this waste is designated for treatment at the K-1435 Incinerator.

Low-level storage vaults used for storage of nonhazardous radioactively contaminated waste generated at the K-25 Site include K-303-5, K-309-2, and vault 15A. The K-310-3 low-level storage vault is used for storage of nonhazardous radioactively contaminated waste generated at the Y-12 Plant. The K-310-2 low-level storage vault is used for storage of nonhazardous radioactively contaminated waste generated at ORNL. Vault 15A may also be used for storage of nonhazardous radioactively contaminated waste from ORNL and the Y-12 Plant.

The K-711 storage facility has a maximum storage capacity of about 1800 208-L (55-gal) drums. The majority of the wastes stored at K-711 have been designated for treatment at the K-1435 Incinerator, and primarily consists of waste oils and solvents generated at the DOE facility at Fernald, Ohio, and at other DOE facilities.

The K-1202 storage tank facility is used for storage of flammable or nonflammable RCRA regulated liquids that are radioactively contaminated. These wastes are designated for treatment at the K-1435 TSCA Incinerator.

The K-1025-C storage facility is used to store out-of-date or off-specification laboratory chemicals that will be disposed of through off-site commercial facilities. These wastes may be either RCRA or non-RCRA, but they must be nonradioactive and non-PCB wastes that are approved for off-site disposal.

K-310-1 vault in the K-25 building is used to store RCRA regulated sludges and ash from the operation of the K-1035 incinerator.

K-302-4 vault 8 is being used for storage of RCRA and mixed wastes from the K-25 Site and the Y-12 Plant.

Vault 8A HW storage is located in the K-25 Building at the K-25 Site and is approximately 350 ft by 50 ft in area. It is used for the storage of hazardous wastes from the K-25 Site and the Y-12 Plant.

K-301-1 vault 4 is approximately 200 ft by 58 ft in area and is divided into three even sections. An 8-in. curb runs between the sections, as well as along the perimeter of the unit, to contain any spills or leaks that may occur. The three individual sections are dedicated to storage of laboratory waste acids, bases, and organics.

K-301-1 vault 4A is approximately 170 ft by 58 ft in area. An 8-in. curb runs along the perimeter of the unit to contain any spills or leaks that may occur. The waste stored in this vault consists of sludges and incinerator ash.

K-301-2 vault 4B is approximately 200 ft by 58 ft in area. An 8-in. curb runs along the perimeter of the unit to contain any spills or leaks that may occur. The waste stored in this vault consists primarily of photographic waste (fixer, developer, and toner) and incinerator ash.

K-303-4 vault 10B is approximately 360 ft by 58 ft in area and is used for the storage of PCB-contaminated soil and Zorball. An 8-inch curb runs along the perimeter of the unit to contain any spills or leaks that may occur.

Prior to startup of the WETF and the CPCF at the Y-12 Plant, significant flows of Y-12 Plant wastewater were processed at the K-1232 Treatment Facility. Currently, a limited amount of treatment of K-25 Site wastewater is occurring at the K-1232 facility, but additional K-25 Site waste streams are being identified for subsequent treatment. The K-1232 facility provides for chemical precipitation and pH adjustment of wastewaters. The treatment process takes place in tanks to which various feed chemicals are added and mixed with the wastewaters. The waste is then dewatered through centrifugation and the leachate is trucked to the K-1407-H CNF. When the facility was used for treatment of Y-12 Plant waste streams, the settled sludges were collected, dewatered, drummed, and transported to RCRA storage facilities on site, and the liquid effluent was discharged from the lagoons through an NPDES discharge point located at the K-1203 Sewage Treatment Facility. The K-1203 NPDES permit does not accommodate the source streams that are presently being treated at the K-1232 facility (i.e., BMP wastes and K-1420 plating wastes); therefore, all discharges must currently pass through the CNF.

The facility consists of a drive-through building, with processing tanks located on the north side and centrifuges and other process tanks located on the south side, and external, inground concrete tanks, K-1232-A, -B1 and -B2, and -C, plus above-ground and diked tanks K-1232 -D, -E, -F, and -F-114.

The K-1407-H Waste Treatment Facility (WTF) or the Central Neutralization Facility (CNF) provides pH adjustment and chemical precipitation for several aqueous streams throughout the K-25 Site. The main purpose of the CNF is to treat wastewater to ensure compliance with the requirements of NPDES discharge limits on pH, heavy metal concentrations, and suspended solids. The treatment system consists of two 25,000-gal reaction tanks and a 60,000-gal sludge-thickener tank. Acidic wastes are neutralized with a hydrated-lime slurry, and basic wastes are neutralized with sulfuric or hydrochloric acid. The hydrated lime bin and acid tanks are located at the facility. Waste streams from K-1401, K-1420, K-1435, K-1501, and miscellaneous laboratories and process operations are received at the CNF. Most of the radioactively-contaminated wastewater treated at the CNF is generated at the K-1435 TSCA Incinerator from the wet scrubber blowdown. Treated effluents are discharged through the K-1407-J NPDES point. The contaminated sludges that precipitate in the sludge-thickener tank will be stored in an approved aboveground storage area at the K-25 Site. The CNF is physically divided into two distinct sections for treating both hazardous and nonhazardous waste streams.

9.3.3 On-Site Treatment

Compaction/baling of solid, low-level, and uranium-contaminated wastes from the Y-12 Plant is conducted at the Waste Feed Preparation Facility.

Dewatering is being made available for nonnitrate waste sludges at the CPCF and for nitrate waste sludges at the WETF.

Wastewaters generated at the Y-12 Plant are typically treated at the West End Treatment Facility, the CPCF, the SPWTF, or the WCPF. The WCPF is designed to biologically degrade machine cutting coolants. Effluent from the WCPF is taken to the CPCF or WETF for final treatment and discharge.

Cyanide destruction by batch reaction under a hood is performed at the Cyanide Treatment facility.

Oxidation of uranium machine turnings is performed at the Chip Oxidation Facility.

The on-site waste treatment quantities at the Y-12 Plant are shown in Table 9.1 of Vol. 2.

On-site treatment at ORNL includes elementary neutralization and detonation facilities. Quantities and types of wastes processed at ORNL during 1991 are presented in Table 9.2 in Vol. 2.

On-site treatment facilities at the K-25 Site include the K-1435 TSCA Incinerator, K-1407-N CNF, K-1419 sludge fixation, and the K-1232 treatment facility. See Sect. 9.3.2.3 for descriptions of these treatment units. Quantities and types of

Table 9.6. K-25 Site on-site waste treatment data for 1991

Type	Quantity	Treatment	Residue type	Quantity (kg)
Nonhazardous	19.2×10^6 (gal)	Neutralization	None	
Hazardous	13.3×10^6 (gal)	Neutralization Metal precipitation	Hazardous sludge	93,949
RCRA/TSCA	1.2×10^6 (kg)	Incineration	Ash	7,297

waste treated at these facilities are shown in Table 9.6.

Treatment of the current inventory of contaminated scrap metal at the K-25 Site (as well as at Portsmouth, Paducah, and Fernald DOE facilities) is expected to occur over the next 3 to 5 years as part of a comprehensive DOE Scrap Metal Program to be managed through the K-25 Site. Under this program, the scrap metal will be processed for beneficial reuse where possible or be size-reduced for disposal.

9.3.4 On-Site Waste Disposal Activities

On-site waste disposal quantities for the Y-12 Plant and ORNL in 1991 are shown in Tables 9.3 and 9.4 in Vol. 2.

The only on-site disposal unit for ORNL is SWSA 6.

Currently, there are no on-site disposal facilities being operated at the K-25 Site. The Reservation Waste Management Division (RWMD) has been established and assigned the responsibility to design, construct, and operate all new low-level waste disposal facilities for the ORR. The RWMD is physically located at the K-25 Site. The new LLW disposal facilities will be developed in concert with the strategy originally developed by LLWDDD and will serve waste generators from all three DOE facilities on the ORR. The Low-Level Waste Disposal Facilities (LLWDF) project will provide new disposal facilities at a new centralized location of the ORR for BRC, Class L-I, and Class L-II low-level wastes, providing capacity up to 40 years. The LLWDF will utilize state-of-the-art disposal technologies, including lined trenches with leachate collection treatment capabilities for BRC/Class L-I wastes and tumulus confinement disposal units for Class L-II wastes. As currently scheduled, these facilities are expected to be operational in 1996.

9.3.5 Off-Site Waste Disposal

All off-site disposals of hazardous wastes were halted in 1991 until procedures addressing a DOE performance objective of "No Rad Added" have been developed and approved.

Incineration is the preferred method for off-site treatment or disposal of wastes, particularly PCB wastes; however, landfills and other types of disposal are used as needed. For instance, PCB-contaminated transformer carcasses cannot be incinerated and must be sent to a landfill.

Off-site disposal, as listed in Tables 9.5, 9.6, and 9.7 in Vol. 2, is arranged through the Transportation and Purchasing departments. Unless special circumstances warrant otherwise, all such disposals were awarded to the lowest qualified bidder. Commercial transporters or transportation provided by the disposal firm was used to move the waste from the site. All incoming and off-site shipments of wastes conformed to U.S. Department of Transportation (DOT) criteria for such shipments. The criteria included packaging, manifesting, and shipping requirements. All containers were required to meet DOT shipping requirements. Packages and vehicles were inspected and inventoried before shipment.

Contracts were made only with approved commercial disposal contractors to ensure safe and environmentally sound operations. Contractor approval was based on a site visit and evaluation that included scrutiny of areas such as financial responsibility, operating procedures, regulatory compliance history, recordkeeping and reporting,

training and qualifications, and security and emergency procedures. Each commercial contractor was evaluated every two years.

The K-770 clean scrap yard provides storage for nonradioactive scrap metal. The scrap metal is stockpiled at K-770 before being sold to the public.

9.3.6 Waste Placed in Storage

In some cases, wastes cannot be disposed of, either immediately or in the foreseeable future. Storage requirements fall into two categories, short-term storage for those wastes awaiting off-site shipment or treatment, and long-term storage for wastes, such as mixed wastes, that are being stored pending future disposal decision.

Wastes are stored on-site for several reasons. Recyclable materials such as mercury and silver-bearing photographic wastes are stored before recycling, while other hazardous wastes are stored until sufficient quantity is accumulated for an off-site shipment. Mixed wastes are stored until incinerator capacity is available locally to destroy them or until other treatment and disposal methods can be identified for wastes which cannot be incinerated. Many of these wastes will be treated in the K-1435 TSCA Incinerator, which began operation in 1990.

Information on wastes stored at the three plants is given in Tables 9.8–9.14 in Vol. 2.

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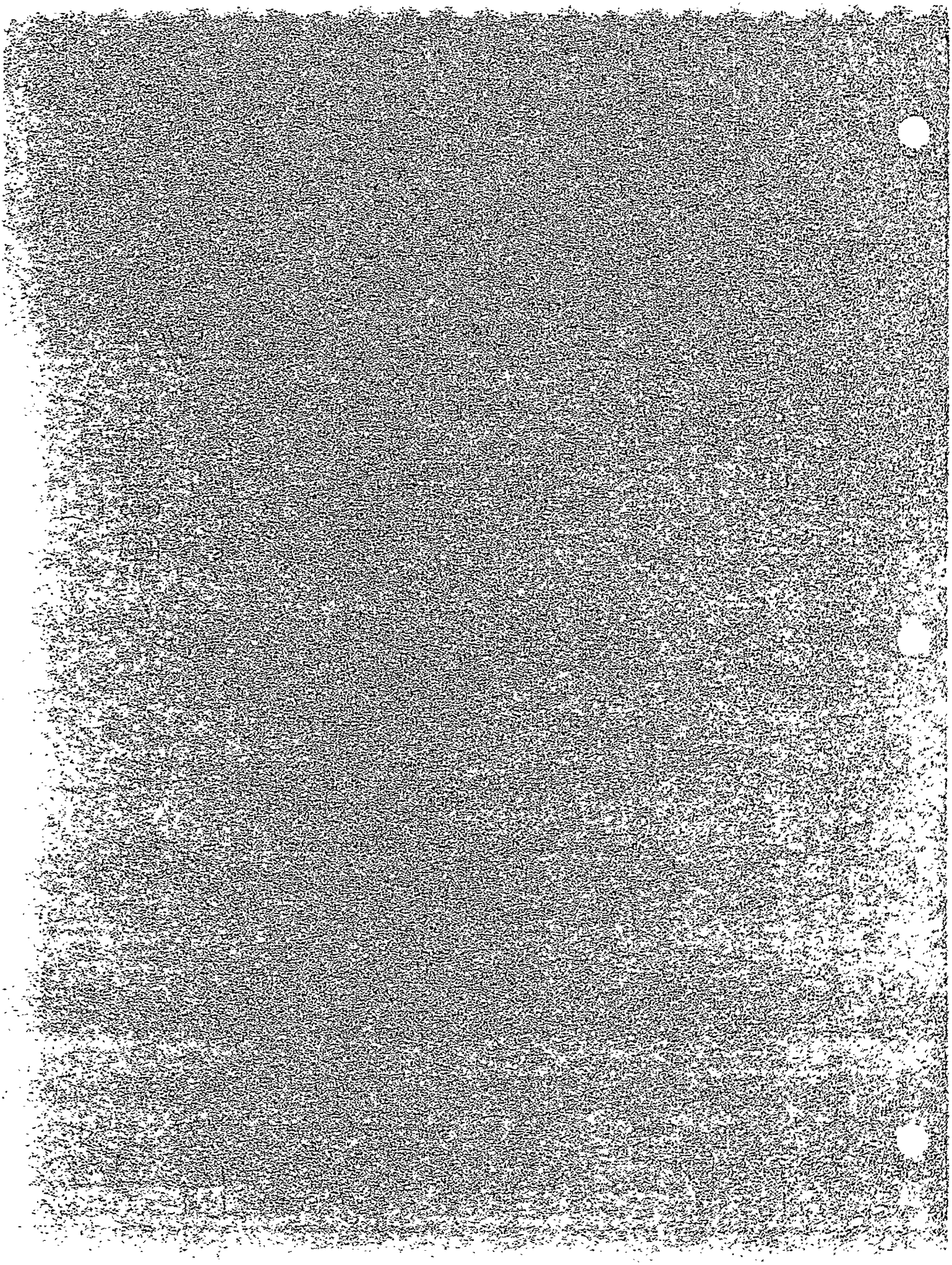

10. QUALITY ASSURANCE

An adequate quality assurance (QA) program for environmental monitoring requires the identification, quantification, and control of all sources of error associated with each step in the monitoring program to prevent errors. Factors to consider as sources of error or variance include those associated with sample collection, sample handling and preparation, analysis, data reporting, and record keeping. Thus, QA requires systematic control of all phases of the monitoring process.

Energy Systems installations participate in both internal and external quality control (QC) programs. Internally, QC is maintained through procedures and checks that include the following practices:

- use of standardized surveillance procedures;
- use of standard operating procedures (SOPs) for sample collection and analysis;
- use of chain-of-custody and sample tracking procedures to ensure traceability, defensibility, and integrity of samples and data;
- instrument calibration and verification;
- background measurements at sample source and in the laboratory;
- resolution checks and detector alignment for determination of gamma emitter radionuclides;
- yield determinations for radiochemical procedures;
- duplicate analyses for precision checks;
- use of standards to determine accuracy;
- technician and analyst training and qualification; and
- spiked and surrogate sample analysis to determine matrix effects.

Preparation of SOPs is a continually evolving process. In 1988, procedures for sampling activities were compiled, reviewed internally, and submitted to Region IV EPA for review and comment. The document, *Environmental Surveillance Procedures Quality Control Program* was revised to reflect the EPA comments. EPA has approved this document for use by Energy Systems. Sample collection procedures addressing each of these areas are generally in place within each Energy Systems installation. Although much work has focused on the development of sampling plans containing proper design and collection procedures, additional efforts are needed. Methods and technologies are changing rapidly, and evaluation and incorporation of these must continue.

Each installation maintains SOPs, which are reviewed and updated periodically, for the collection and analysis of environmental samples. The analytical laboratories use certified standards from EPA or DOE or materials traceable to the National Institute of Standards and Technology (NIST) to establish accuracy, to calibrate instruments, to determine yields for radiochemical procedures, and to standardize methods.

QA and QC officers are appointed to work with the analytical laboratories to monitor the quality of analytical data. The QA/QC officers administer a program that generates QC samples of known composition, and these samples are submitted to the laboratories on an established periodic basis. These samples are prepared using EPA, NIST, or other reliable materials and are submitted as samples of unknown value to the analyst. Additionally, organizations responsible for collecting environmental samples submit blank, equipment rinse, standard, and spiked samples with environmental samples to confirm the integrity of the samples and/or to validate analytical results. These internal programs form the basis for ensuring reliable results on a day-to-day basis and facilitating programs for training sampling technicians and laboratory analysts.

In addition to internal QC programs, analytical laboratories at Energy Systems installations participated in several external QA programs in 1991 (see Sect. 10.2).

10.1 FIELD SAMPLING AND MONITORING

10.1.1 Basic Concepts and Practices

Statistically based sampling is typically used because it is not possible to measure the total amount of a contaminant in an environmental media. Samples of the media are collected and a representative contaminant concentration is estimated. An aggregate of sampling units into which an area is divided is called the population of sampling units. For example, if contaminants in pond sediments are of interest, then the population is the entire bottom sediment of the pond. If the bottom sediments are then divided into sampling units of equal size, the sampling units collectively constitute the entire population. A group of sampling units selected from the entire aggregate as representative of the whole population forms a sample (if they are composited) or a set of samples. The units forming a composite sample are typically of equal size, are taken within a defined period of time, and are selected to represent the whole population of sampling units.

Proper and cost-effective application of QA/QC cannot be accomplished without knowing the objectives of the program and the precision and confidence levels expected of the data. Once adequate sampling designs and collection procedures are in place, the quality objective is to collect the sample according to the specified procedure without altering the true nature of the sample.

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. Topics addressed include

- 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.

Field QC samples are collected to evaluate and validate sampling data. These control samples generally include field preservative blanks, equipment rinses, trip blanks, and duplicate samples. Tables 10.1 and 10.2 of Vol. 2 provide examples of these types of field QC samples.

10.1.2 Air Monitoring

10.1.2.1 Y-12 Plant

Air sampling methods written for the Y-12 Plant detail the preparation of sample filters and air sampling for ambient monitoring of TSP, uranium, and fluorides and procedures for continuous sampling of stack emissions. Continuous flowmeters for stack sampling are in a quarterly recall program for calibration certification by the Y-12 Plant Maintenance Department. Meteorological tower sensors are calibrated quarterly by a subcontractor. The flowmeters for TSP samplers are calibrated quarterly by the Y-12 Plant Maintenance Department. Samplers for sulfur dioxide were checked daily by technicians, certified by the Maintenance Department, and subjected to quarterly audits by the state until this monitoring was terminated in August 1990. Field blanks and spiked samples are routinely submitted with each set of fluoride samples.

10.1.2.2 Oak Ridge National Laboratory

ORNL has SOPs for sampling airborne emissions and ambient air. These procedures include chain-of-custody, analytical requests, recording field data, disposition of forms, collecting sampling media, and reporting system failures. Calibration of flow measuring and totalizing instrumentation is conducted every 6 months. Routine maintenance is performed annually. Calibration and maintenance of the meteorological monitoring system is performed quarterly. These procedures are controlled by the Surveillance and Protection Section in the Office of Environmental Compliance and Documentation.

10.1.2.3 K-25 Site

The ambient air monitoring program at the K-25 Site has procedures in place for monitor maintenance, sampling, and analysis for each parameter of interest. These procedures are in the Environmental Management Department's *Operating and QA Manual*, which is reviewed and updated as determined by Environmental Management in conjunction with the Maintenance Division and Analytical Chemistry Department.

Procedures that address the requirements for emission monitoring for each operational stack at the K-25 Site are complete. All stack sampling at the K-25 Site is conducted according to EPA procedures or modifications of those procedures developed by the K-25 Site Quality and Technical Services Organization. Modifications are developed only if the original EPA procedures cannot be used for a particular application or have not been developed for a specific parameter. Such modifications are based on best available information in the field of emissions monitoring for a particular situation. The flowmeters for TSP samplers are checked weekly and recalibrated as needed by K-25 instrument mechanics. Trip blanks and laboratory blanks are submitted with each set of air samples.

10.1.3 Water Monitoring

10.1.3.1 Y-12 Plant

Water samples are collected in accordance with EPA guidelines and protocols for appropriate containers, preservation techniques, and chain-of-custody requirements (40 CFR Pt. 136, July 1, 1987). Sampling methods are continually being upgraded to provide the best available techniques and equipment (e.g., automated samplers, flowmeters, and real-time monitoring of specific parameters in various wastewater streams).

Field blanks, field replicates, and rinse waters from equipment decontamination are routinely submitted to the laboratory to validate the reliability of a sampling technique. SOPs have been written that document the sample collection methods and ensure that appropriate techniques for installation, calibration, decontamination, and maintenance of sampling equipment are addressed. Field water quality instruments are calibrated according to manufacturer's instructions once every 4 hours of use each day and are checked weekly for general condition of membranes and filling solution as applicable. They also receive routine maintenance on a recall program every 6 months.

10.1.3.2 Oak Ridge National Laboratory

ORNL has SOPs for the collection of NPDES and other surface water samples. Chain-of-custody procedures and sample tracking are used for all NPDES and other surface water samples. Field water-quality instruments are standardized daily and calibrated every 2 weeks, or more frequently if needed. Sample containers, preservation methods, and holding times conform to 40 CFR Pt. 136 requirements.

10.1.3.3 K-25 Site

A QA/QC manual is being developed by the Environmental Management Department that will include water monitoring activities at the K-25 Site. This manual will cite procedures and activities that must exist within the plant laboratory, maintenance, and operation groups to ensure the overall quality of the program. Monitoring descriptions will be separated for NPDES and perimeter surface water and for radiological and nonradiological monitoring. Chain-of-custody procedures are used on all samples collected. Laboratory sampling and instrument maintenance and calibration procedures are used to maintain control of monitoring activities. A standard practice procedure for NPDES sampling provides for QA by requiring field blanks, duplicate samples, and equipment blanks to validate sampling reliability.

10.1.4 Groundwater Monitoring

Sampling and analysis plans for the ORR groundwater monitoring programs adhere to EPA protocols and guidelines. Procedures for sampling methods (i.e., bailing, Bennett pumps, bladder pumps) have been written that address necessary QA concerns such as field instrument calibration, decontamination methods, and chain of custody. Field replicates, field blanks, equipment rinses, and laboratory spikes are used to validate the precision and accuracy of field and laboratory techniques.

These procedures are reviewed and accepted by TDEC and EPA personnel during their respective audits of the program.

All compliance groundwater monitoring at permitted and interim status facilities is performed in compliance with the requirements set forth by EPA in 40 CFR Pt. 264/265 and Tennessee rule 1200-1-11-.05(6). Sample containers, preservatives, maximum allowable holding times, and collection methods are based on acceptable procedures as outlined by EPA.

10.1.5 Biological Monitoring

Although much literature and numerous regulatory requirements apply to the collection of certain types of samples (i.e., surface water and groundwater samples), standard protocols for the collection of most biological samples do not exist. Careful consideration must therefore be given to each type of sampling to be performed. Standard collection procedures using accepted QA/QC techniques have been developed, documented, and followed to ensure data of reproducible and known quality.

ORNL has developed SOPs for the collection of milk and fish samples at all the Oak Ridge facilities. Milk samples are collected on a monthly basis, and three composites of six to ten fish are collected at each location during each sampling period to estimate confidence limits based on statistical considerations.

A K-25 Site QA manual contains the procedures for the sampling and field chain of custody of vegetation, soil, and stream sediments in the surrounding area. These procedures are reviewed yearly and revised as needed. The QA/QC for analysis of the biological monitoring samples is handled by the internal laboratory QA program described in Sect. 10.2.

10.1.6 Soil and Sediment Sampling

Soil/sediment sampling is another area in which considerable variability exists in the way sampling plans are designed and samples are collected. The type of soil/sediment to be sampled, the objective of the sampling effort, the parameters of concern, and many other considerations must be taken into account before an adequate sampling plan can be developed.

10.1.6.1 Y-12 Plant

As noted in Sect. 10.1.1, samples must be taken that are representative of the entire area and that address the regulatory and scientific objectives of the plan. Hence, the Y-12 Plant adheres to the fundamental statistical sampling concepts outlined by EPA (1986). A statistician reviews the sampling approach to verify that the resulting data will meet the intended objective. For RCRA closure activities, detailed S&A plans have been developed. Field blanks, field replicates, and equipment rinses are routinely submitted to the laboratory; additional personnel are being trained in soil and sediment sampling techniques.

To ensure proper documentation of field activities in support of impending RFI studies at the Y-12 Plant, current sampling methods have been documented by the Energy Systems Environmental Surveillance Procedures Quality Control Program and approved for use by EPA Region IV.

10.1.6.2 Oak Ridge National Laboratory

EPA provides guidance in the collection of soil samples for potential hazard evaluation and presents QA considerations that apply to soil sampling. ORNL uses these documents and many others when developing sampling plans and procedures for the collection of soil and sediment samples. SOPs are used for routine soil sampling such as collection of soils around the ORNL perimeter air monitoring stations.

10.1.6.3 K-25 Site

The K-25 Site has a QA plan, QAP04-31-005, that contains final references for soil around the facility. The sampling department follows the procedures provided in the ESP manual ESH/586/87-2170611 for sampling soil. These procedures are reviewed yearly and revised as needed. QA and QC for the analysis of the soil samples are handled by the K-25 Site analytical laboratory QA program described in Sect. 10.2.

10.1.6.4 K-25 Site Analytical Environmental Support Program

Analytical Environmental Support Group (AESG) programs involve the coordination and

implementation of analytical laboratory and field QA and QC for environmental studies. The group provides an integral QA and QC support function to both Energy Systems and the Work for Others programs. AESG provides QC support to the Hazardous Waste Remedial Actions Program (HAZWRAP) organization in its implementation of remedial activities at Air Force, Air National Guard, Navy, and other government installations. AESG is the Navy representative for the integration of laboratory QA and QC for remedial investigations at Naval bases and has been working with the Army Material Command at the Rocky Mountain Arsenal (RMA). The group also supports Energy Systems Environmental Restoration Division (ERD) programs and the Energy Systems Analytical Project Office (APO). In addition, AESG has been actively involved with the development and directions being taken by the DOE Laboratory Management Branch (LMB).

The AESG programs involve several aspects related to analytical chemistry, sample collection, and field geology. AESG has identified QA and QC program requirements and developed detailed QC program plans for HAZWRAP, Navy, and ERD organizations. It has an established sample proficiency evaluation and auditing program for analytical laboratories subject to approval by each of these sponsors. This review process is capable of cross utilizing information obtained. AESG provides complete review services for all program documents, including work plans, sampling and analysis plans, laboratory QA plans, project QA plans, final reports, and deliverables. The group has developed, and is currently implementing, comprehensive field surveillances for HAZWRAP, RMA, and ERD projects.

In support of these programs, AESG conducted the following routine activities during fiscal year 1991:

1. Evaluated over 60 commercial analytical laboratories across the nation. Included in this process is a review of the laboratory QA plans; the preparation, submittal, and evaluation of performance samples; and on-site laboratory audits. More than 100 laboratories are currently in various stages of the review program.
2. Reviewed more than 1100 project-related documents, including project work plans, project QA plans, sampling and analysis plans, site investigation reports, laboratory monthly project reports, final project reports, and decision documents.
3. Conducted 47 field-sampling surveillances and audits.

The ERD developed and delivered initial draft versions of *Quality Control Requirements for Field Measurements* and *Requirements for Quality Control of Analytical Data*. The ERD also completed an initial review and follow-up reviews of the Portsmouth Technical Services Division's Environmental Safety and Health Analytical Services radiological capabilities for support of RCRA Facility Investigations. This review assisted the laboratory in successfully passing an EPA Region V audit.

AESG activities conducted for the general benefit of Energy Systems include

1. Providing leadership to, and participating in, the Subcommittee on Analytical Procedures Five Plant Review to the Analytical Needs Assessment Team. Presented subcommittee findings and recommendations to the assessment team and delivered a final written report.
2. Developing and implementing the K-1417 Drum Storage Yard Precipitation Runoff Sampling Plan.
3. Continuing support to develop and implement sampling and analysis plans for the TSCA operation and waste acceptance and the pond waste management environmental monitoring program and drum sampling process.
4. Developing and implementing a sampling plan to characterize drums of raw pond sludge.
5. Participating in the review team effort to procure an Analytical Chemistry Price Agreement through commercial facilities, RFP-36-VE-380.

AESG also participated in three organizational and developmental meetings with the DOE LMB to define tasks and goals related to its efforts, and AESG developed and delivered an initial draft of *DOE Environmental Measurement Quality Assurance Requirements.*

10.1.7 Solid Waste Monitoring

The solid waste monitoring activities are governed by Tennessee's Hazardous Management

Regulation Chapter 1200-1-11, which is in conformance to 40 CFR, Pt. 260-27.

The sampling procedures incorporate unified, up-to-date information on sampling procedures specified in EPA's manual SW-846, second edition, and applicable state and EPA documents.

10.2 ANALYTICAL QUALITY ASSURANCE

The Energy Systems analytical laboratories have well-established QA/QC programs, and the highly trained and well-qualified staffs are provided with excellent equipment and facilities. Current, approved analytical methodologies employing good laboratory and measurement 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, participate in several external QC programs, and use statistics to evaluate performance. QA and QC are thus a daily responsibility of all employees.

10.2.1 Internal Quality Control

QC is a key feature in analytical QA. 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 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 the analysis of environmental samples associated with regulatory requirements are consulted (see Tables 10.3 through 10.7 of Vol. 2).

State-of-the-art computer systems and programs, such as the "AnaLIS" program developed by employees in the K-25 Site laboratory, are used to report and track data and manage QC activities. This system provides for the recording of internal control data on known standards and the calculation of spike recoveries while ensuring that personnel have been certified before performing an analysis.

Analyses are performed using EPA, American Society for Testing and Materials (ASTM), Standard Methods for the Examination of Water and Wastewater, or other approved procedures. Analysis methods and minimum QA requirements are dictated by state and EPA regulatory requirements, DOE orders, and established laboratory QA programs.

Radionuclide monitoring, an important responsibility for the Oak Ridge plants, is supported by analytical measurements generally derived from state-of-the-art methods and instrumentation. High-purity germanium and lithium-drifted germanium detectors with standard counting configurations are used for identification of gamma-emitting radionuclides in environmental samples. Alpha-emitting radionuclides are identified with surface barrier alpha detectors, and gross alpha and beta activities are measured with proportional counting systems.

Quality control is ensured by using standard materials from NIST or other reliable sources for calibration, yield/efficiency determinations, spike recoveries, isotopic dilution, and other techniques. Backgrounds are measured periodically for corrections, and instrument responses and efficiencies are routinely established.

Nonradiological and classical wet chemical analysis methods are used to analyze environmental samples. Routine calibration and standardization, replicate analyses, spike additions, and analysis of blanks all support the internal QC efforts.

These internal programs are the mainstay of analytical QC and are the basis for ensuring reliable results on a day-to-day and batch-to-batch basis. The total effort in these programs is at least 10 to 20% of the laboratory effort (in accordance with EPA expectations).

QA/QC measurement control programs external to the sample analysis groups have single, blind control samples submitted to the analytical laboratories to monitor performance. Reliable suppliers such as NIST, EPA, and DOE are the sources for these standards. 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.

10.2.2 External Quality Control

In addition to the internal programs, all Energy Systems installations are directed by DOE and 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.

Currently, three national programs for certification/qualification exist for analytical laboratories: the Contract Laboratory Program (CLP) for Superfund work, the Drinking Water Supply Program, and the National Institute for Occupational Safety and Health (NIOSH) Program for Industrial Hygiene Analyses. Each of the DOE-OR installation laboratories participates in one or more of these programs. The K-25 Site laboratory participates in all three. Additionally, the DOE-OR installation laboratories all participate in the annual EPA Discharge Monitoring Report QA Study.

Results from the Y-12 Plant laboratory participation in the NIOSH program are listed in Table 10.8 of Vol. 2. Of the 112 measurements for 1991, 10 were unacceptable. The 10 unacceptable results were all from measurement of organic parameters and were a result of problems associated with a new instrument and autosampler. The equipment was removed from service for further evaluation.

Results from the K-25 Site laboratory participation in the NIOSH program are listed in Tables 10.9 and 10.10 of Vol. 2. Of the 112 measurements for 1991, 3 were rated unacceptable.

10.2.2.1 Radiological Quality Control

Energy Systems laboratories participated in several external radiological QC programs in 1991. Each installation has provided results from its participation in these programs.

EPA Intercomparison Radionuclide Control Program

The EPA Intercomparison Radionuclide Control Program is administered by the EPA Environmental Monitoring System Laboratory at Las Vegas (EMSL-LV). The state of Tennessee requires participation in this control program for drinking water laboratory certification of radionuclide analysis. These samples consist mainly of water and air filters. Results are furnished to the state for evaluation relating to drinking water laboratory certification. Failure to obtain an overall satisfactory rating can lead to the removal of a laboratory from the certified status.

Results for each of the laboratories participating in this program are shown in Tables 10.11 through 10.13 of Vol. 2. The EMSL-LV program calculates a normalized standard deviation for each laboratory based on all reported results. Based on their criteria, any reported value above three deviations is considered unacceptable. The Y-12 Plant laboratory had 30 results rated as acceptable and 3 results rated as unacceptable. An unacceptable result for a gross alpha measurement was the result of a calculation error. Specific cause for the other two unacceptable results could not be determined. The ORNL laboratory had 36 results rated as acceptable and 2 rated as unacceptable. Based on ORNL's performance in this program in 1989, the state of Tennessee granted certification to the Environmental Radiochemical Analysis Laboratory through September 12, 1992. Of the 33 results evaluated for the K-25 Site, 5 were determined to be outliers and 2 were determined to be unacceptable.

DOE Environmental Measurements Laboratory (EML) Radionuclide Quality Assessment Program

A Radionuclide Quality Assessment Program is administered by DOE's EML in New York. Various matrix samples, such as soil, water, air filters, and vegetation, are submitted semiannually for an analysis of a variety of radioactive isotopes, with a statistical report submitted by EML for each period. Results for each of the laboratories participating in the program in 1991 are shown in Tables 10.14

through 10.18 of Vol. 2. All matrices, except filters, are actual materials obtained from the environment at a DOE facility. Results for each of the laboratories generally compared well with the accepted values.

The detection limits and precision depend on the counting equipment at each lab. These samples are usually near the detection limits; thus, results with ratio values of 0.5 to 1.5 as compared with reference values are acceptable data.

The parameters measured vary among laboratories because of the equipment at each laboratory. The K-25 Site tests for all parameters that the existing radionuclide equipment can detect. In the March study, 3 of the 23 evaluated samples were rated unacceptable. In the September study, 2 of 17 evaluated results were unacceptable.

In the May 1991 program, the Y-12 Plant laboratory had 31 results rated as acceptable and 2 results rated as unacceptable. Cause for the unacceptable results could not be determined. In the September program, eight results were rated as acceptable and none were rated as unacceptable.

ORNL had 38 acceptable results and 1 unacceptable result in March 1991; and 30 acceptable results and 1 unacceptable result in September 1991.

10.2.2.2 Nonradiological Quality Control

DOE-OR installation laboratories participated in several external nonradiological QC programs in 1991. Each installation has provided results from its participation in these programs.

Proficiency Environmental Testing (PET) Program

In 1991, all Energy Systems analytical laboratories participated in the PET Program. Control samples were supplied by Analytical Products Group, Inc., a commercial supplier. Energy Systems analytical laboratories and WMCO at Fernald, Ohio, analyzed samples at two concentration levels (a high and a low concentration denoted as level 1 and level 2) on a monthly basis. All data were reported to the supplier from each of the six laboratories. The commercial supplier provided a report of the evaluated data, which included a percent recovery of the referenced value, deviation from the mean of all reported data, and other statistical information. Investigators at each laboratory analyzed only those parameters required on the installation's NPDES permit or parameters analyzed on a routine basis.

The vendor for the PET control program also provides a "corporate" (i.e., six-laboratory) report that compares the data from laboratories within the corporation with those of other corporate laboratories. As part of the purchase contract, the data from the six laboratories within the DOE-OR complex (five Energy System plants and the Feed Materials Production Center Laboratory) are evaluated, and a report is issued to each of the laboratory QA/QC managers. This management summary report shows problems encountered by specific laboratories.

The laboratories were statistically evaluated by PET to determine acceptability of analytical data. Data within 1.96 standard deviations are acceptable, data between 1.96 and 2.58 standard deviations are marginal, and data of more than 2.58 deviations are unacceptable.

Tables 10.19 through 10.26 of Vol. 2 show results for each of the three Oak Ridge laboratories. Data for two unknown concentrations (QC samples) or levels are reported.

For the level-1 inorganic samples in 1991, the Y-12 Plant had 554 results listed as acceptable, 8 at the warning level, and 4 listed as unacceptable. In the organics package, 35 results were acceptable, 2 were at the warning level, and 5 were unacceptable. In the level-2 inorganics, 558 were acceptable, 7 were at the warning level, and 4 were unacceptable. Organics had 34 acceptable results, 3 warning-level results, and 4 unacceptable results.

The unacceptable measurements for conductivity were the result of an improper application of the temperature correction factor. Those for fluoride were the result of an error in reading from the calibration plot. The hexavalent chromium measurements were from a problem in alignment of the optical beam. No specific cause could be determined for the unacceptable lead result. The organic measurements rated as unacceptable were the result of problems with instrument stability.

For the level-1 inorganic samples in 1991, the ORNL Plant had 403 results listed as acceptable, 2 at the warning level, and 2 listed as unacceptable. In the organic package, 269 results were acceptable, 2 were at the warning level, and 9 were unacceptable. In the level-2 inorganic, 405 were acceptable, 2 were at the warning level, and 2 were unacceptable. Organics had

268 acceptable results, 3 warning-level results, and 9 unacceptable results.

No specific cause could be determined for the 4 unacceptable measurements in the inorganic package because the internal standards that were analyzed along with the PET samples were within their acceptance range. The organic measurements rated as unacceptable were caused by a reversal of level-1 and level-2 samples.

In 1991, the K-25 Site participated in analyzing the inorganic parameters for this program. For the level-1 analytes, there were 514 acceptable ratings, 11 warning ratings, and 6 unacceptable ratings. There were 516 acceptable ratings, 8 warning ratings, and 7 unacceptable ratings for the level-2 analytes.

The conductivity results were unacceptable because the values for the level-1 samples and the level-2 samples were switched. Hexavalent chromium was missed due to the poor precision of the method used. Aluminum and sodium were missed because of contamination problems. No specific cause for the unacceptable antimony result could be determined.

EPA Discharge Monitoring Report Quality Assurance Study

EPA conducts a national QA program in support of the NPDES program. All holders of major NPDES permits are required to participate. EPA furnishes the QC samples and evaluates the results. The state of Tennessee receives the results from the Energy Systems Oak Ridge laboratories participating in this study for evaluation, and the Oak Ridge installations are required to inform the state of Tennessee of any necessary corrective actions.

Tables 10.27 and 10.28 of Vol. 2 show the results for the Y-12 Plant and the K-25 Site. Of the 29 measurements by the Y-12 Plant laboratory, the arsenic and lead results were unacceptable. Analytical data associated with both measurements were reviewed. No specific cause could be determined. ORNL has not yet received a score for DMR 11. A probable cause may be the expiration of a DOE/EPA contract. All results for the K-25 Site were acceptable with the exception of mercury, ammonia-nitrogen (caused by electrode problems), and TOC (caused by instrument problems).

Water Supply Laboratory Performance Quality Control Program

The Y-12 Plant, ORNL, and K-25 Site laboratories are certified by the state of Tennessee for drinking water analysis, but drinking water samples for the K-25 Site are sent off-site for analysis. To maintain its 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 QC samples. The state also performs an on-site audit at a set frequency. The samples are furnished by EPA-Cincinnati, and the results are evaluated by EPA-Athens (Region 4) and furnished to the state. To maintain the qualified status, the laboratories must satisfactorily analyze the QC samples furnished on a routine schedule.

The Y-12 Plant laboratory performed 69 measurements. Not all were required for certification purposes. Sixty-four measurements were rated as acceptable, and five were rated as unacceptable. The laboratory performs a follow-up investigation on each unacceptable result. One unacceptable result was caused by a calculation error. No apparent causes were determined for the others (Table 10.29 of Vol. 2).

In 1991, ORNL and the K-25 Site participated in the multilaboratory study for the analysis of water pollution samples that is administered by EPA's EMSL-LV. ORNL analyzed four sets of samples (Tables 10.30 to 10.33 of Vol. 2) in 1991.

The K-25 Site analyzed two sets of samples in 1991. In WP-026 unacceptable results were obtained for one pH sample and both total organic carbon samples because of instrument problems (Tables 10.34 and 10.35 of Vol. 2). All other results were acceptable.

In 1991, set WS-027 was analyzed. Data for the set is shown in Table 10.36 of Vol. 2. Only two analytes for this study were unacceptable. The K-25 Site participated in WS-028, but the evaluation of the results is not available at this time.

10.2.2.3 Environmental Protection Agency Contract Laboratory Program

The CLP is administered by the EPA CLP–Sample Management Office at Alexandria, Virginia, in cooperation with the EPA 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 protocol requirements for laboratory operation. This protocol is an acceptable protocol for investigative, remedial, and monitoring studies of Superfund sites.

The K-25 Site laboratory has been qualified by EPA for CLP work since 1985, and ORNL began operating under the protocol in 1987. Analysis of quarterly performance samples is mandatory for certification. Results of laboratory performance are shown in Tables 10.37 through 10.40 of Vol. 2. At ORNL, the average score for the inorganic laboratories was 80.5%. This percentage only includes the first and second quarter inorganic sample results. The third and fourth quarter inorganic samples were not analyzed because of ICP instrument problems. The organic laboratories received a score of 91.7% on the second quarter samples. EPA did not send first quarter organic samples because of budget problems. Scores have not been received for the third and fourth quarters organic samples because of a possible expiration of an EPA/DOE contract. At the K-25 Site, the first quarter organic data and inorganic data for the second and third quarters of 1991 were returned to EPA too late for scoring. Therefore, no data for these quarters are available. The average score for two quarters for the inorganic laboratories was 39.9%, and that for the organic laboratories was 76.6%. Scores are based on a maximum 100 point system.

10.3 AUDITS, REVIEWS, AND ASSESSMENTS

10.3.1 Y-12 Plant

10.3.1.1 External regulatory

Regulatory agencies conducted several reviews at the Y-12 Plant during 1991 (Table 10.41 of Vol. 2). Reviews conducted by TDEC included RCRA inspections, Compliance Evaluation Inspection (CEI) of the groundwater monitoring program, TSCA inspections, permitting inspections, and solid waste management compliance inspections. No major findings or areas of concern were identified during the inspections. Action plans have been developed to address any findings noted during the inspections.

10.3.1.2 Department of Energy

Activities are continuing to address findings identified during the DOE Headquarters Environmental Survey. The preliminary report of findings was received from DOE Headquarters in December 1987, and an action plan to address the findings was submitted to DOE-OR in February 1988. In addition, a quarterly report is issued to DOE-OR updating the status of on-site activities related to the survey findings.

DOE-OR conducted an Environmental, Safety, Health, and QA appraisal of the Y-12 Plant in July 1990. In their report, the appraisal team noted 62 environmental findings. Action plans have been developed to address these findings.

The Tiger Team Compliance Assessment of the Y-12 Plant was conducted from September 25 to October 20, 1989. During the assessment, 62 environmental findings were identified. As indicated in the Tiger Team's draft report, none of the problems identified was of a nature that indicated that continued operation of the facility would present an undue risk to public health or the environment. Action plans have been developed for these findings. The *Semiannual Status Report for the September 1989 Tiger Team Compliance Assessment* (Y/AD-617) was issued in November 1991.

10.3.1.3 Internal reviews

The Y-12 Plant laboratory has a program for internal audits of methods, programs, and procedures. A system has been established for audit scheduling and reporting. Audit responses are logged and corrective actions monitored. Analytical procedures are issued by the Laboratory Administrative Services Group to each laboratory area through a system of controlled methods manuals. The Y-12 Plant laboratory is beginning the process of rewriting all procedures in the format recommended by the ASTM.

In 1987, a subcommittee of the Five-Plant Environmental Analysis Committee was established to eliminate all the discrepancies in the systems of nomenclature that exist in the Energy Systems facilities. The problem has been compounded by

EPA's practice of calling a compound by different names in various references—for example, tetrachloroethane and tetrachloroethylene. This has led to much confusion for lay readers of technical reports. The subcommittee continued its efforts at standardizing the names of organic and inorganic analysis parameters in CY 1988. The list of organic parameters with associated CAS numbers has been greatly expanded to cover all monitoring programs. The list of inorganic parameters has been reviewed and amended several times. Recommendations for adoption were made.

10.3.2 Oak Ridge National Laboratory

In 1991, ORNL experienced numerous audits/inspections and reviews related to environmental sampling and data management, sample analysis, waste management, and QA. These audits and reviews consisted of audits by outside regulatory agencies such as the EPA and TDEC, audits and reviews by DOE-OR, and internal audits by Energy Systems.

10.3.2.1 External regulatory

Table 10.42 of Vol. 2 summarizes the major environmentally related audits and reviews of ORNL by outside regulatory agencies. Of the nine audits conducted by regulatory agencies, no new findings were identified. Areas of potential concern and observations have been resolved or are scheduled for resolution pending availability of resources.

Tiger Team Assessment

From October 22, 1990, to November 30, 1990, a group of approximately 80 specialists representing DOE-HQ 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/state regulations pertaining to environmental protection. A total of 70 deficiencies were identified; 43 represented nonconformance with procedural and/or regulatory requirements and 27 involved best management practices.

An action plan that addressed corrective measures for each of the Tiger Team findings was prepared, and, after a number of revisions, it was approved by DOE Secretary Watkins on October 19, 1991. In the time since the Tiger Team review, ORNL has been actively completing those corrective actions that have adequate funding. Where funding is not available, it has been requested.

10.3.2.2 Internal reviews

In addition to EPA, the state of Tennessee, and DOE audits and reviews, Energy Systems and ORNL organizations external to the divisions and groups responsible for environmental concerns at ORNL performed numerous audits and reviews of the environmental program at ORNL.

These audits and reviews focused on the environmental program, record keeping, health and safety, QA, contingency plans, and storage of toxic and hazardous waste. In many cases, these audits and reviews led to improved operating procedures and management practices.

10.3.3 K-25 Site

The K-25 Site laboratory was reviewed by Martin Marietta corporate and Energy Systems technical personnel. Two main deficiencies were noted: (1) samples were analyzed past regulatory holding times without the data being flagged on each analyte, and (2) some analytes were measured using nonspecified EPA analytical methods; for example, NPDES nitrate was analyzed using EPA-300 when the Federal Register requires EPA-354.1.

The root causes for the holding times problem were heavy sample loads and too many samples for the existing equipment. Corrective actions included sending excess samples to a commercial laboratory and employing more laboratory analysts. A program to track holding times will enable the program manager to better schedule the sample load for a laboratory section. The problem with the analytical methods resulted from a misinterpretation of a letter received from Region IV authorizing the use of EPA Method 300 for water analysis. All the project QC plans for sampling and analysis have been reviewed. Corrective actions were made where necessary in the listing of analytical procedures employed for each type of sample. Surface water analyses require different EPA procedures than groundwater analyses.

10.3.3.1 External regulatory

Table 10.43 of Vol. 2 summarizes the major environmental audits and reviews of the K-25 Site.

DOE conducted a RCRA surveillance audit in February 1991. The major finding was the lack of a plan for personnel to follow when performing sampling of the materials in RCRA containers.

A Comprehensive Groundwater Monitoring Evaluation was performed by the TDEC in March. Corrective actions were taken to address sampling and field audit findings.

The November DOE Tiger Team assessment was conducted from November 12 to December 18 for the entire K-25 Site. The Environmental Subteam identified 103 findings, none of which presented an immediate risk to the public health or the environment or warranted immediate cessation of operations. Most of these findings resulted from potentially not meeting the requirements of federal, state of Tennessee, or DOE orders. The remaining problems represent areas where best management practices are not incorporated into environmental management. Concern about insufficient environmental surveillance were addressed, as were ineffective NEPA policies and procedures. The Safety and Health Subteam has addressed a total of 165 concerns. No category I were detected. The Management Subteam reported 25 findings.

10.3.3.2 Internal reviews

In addition to the EPA, TDEC, and DOE audits and reviews, Energy Systems and the K-25 Site organizations perform audits and reviews of the environmental programs at the K-25 Site. These audits and reviews focus on record keeping, laboratory and sampling procedures, and storage of hazardous materials and waste. These have led to improved operating procedures and management practices.

An Oak Ridge K-25 Site environmental assessment of groundwater monitoring was performed in March 1991. Several findings were identified associated with labeling, safety, and waste removal from 90-day accumulation areas. These findings have been addressed and the problems corrected. It was also noted that empty chemical containers must be properly rinsed before disposal. This problem was addressed and corrected.

An internal K-25 Site assessment was performed in March and addressed the K-791, K-792, K-1003, K-1004, K-1006, K-1095, K-1407, K-1416, and K-1515 areas. This review was performed by an Environmental Assessment Team and presented to the Environmental Issues Evaluation Team (EIET). The findings that were addressed and corrected in this assessment include RCRA 90-day temporary storage requirements, labeling, and waste disposal of chemical containers.

A major Corporate Audit was held in August in preparation for the November DOE Tiger Team Audit. The Corporate Audit corrective actions addressed holding-time problems, improper labeling, unavailable SOPs, nonstandardized chain-of-custody procedures, calibration, carcinogens, and insufficient training.

10.4 DOCUMENTATION QUALITY ASSURANCE

At the request of the project coordinator, the Energy Systems Publications Division assists each Energy Systems site by coordinating the compilation, editing, and reproduction of its data. This volume is part of a set of four volumes designed to fulfill the annual environmental data reporting requirements for all Energy Systems sites.

The Publications Division appoints a team of editors and electronic publishers to produce the documents. Draft volumes are produced in the spring for internal review and for comment by DOE, then a final copy is printed for delivery before the June 1 deadline. For each draft and for the final copy, the editors are responsible for ensuring the quality of the document and for ensuring that all submitted materials are included and accurately reflect the text and data as submitted. The quality and technical accuracy of submissions are the responsibility of the site coordinator.

The editors follow a set of procedures that addresses recording submissions of entries (including text, figures, and tables) and recording the status of submissions (in production, being proofread, etc.). The recordkeeping measures are based on the submissions required for the previous year's report (determined from the table of contents) plus any

alterations agreed upon by the project coordinator and site coordinators. Tracking sheets for data tables and figures are also kept.

All text, tables, and figures are edited, and questions are directed to the site or project coordinator. All final copy is proofread for accuracy and fidelity to copy. Draft copies of the entire volume are submitted to the site coordinator for technical review and approval.

APPENDIXES

Appendix A: Chemical Releases of the Oak Ridge Reservation Facilities, 1991 Environmental Report A-1

Appendix B: Errata for Oak Ridge Reservation Environmental Report for 1990 ..... B-1

Appendix C: Statistical Treatment of Random Uncertainties C-1

Appendix A

CHEMICAL RELEASES OF THE OAK RIDGE RESERVATION FACILITIES, 1991 ENVIRONMENTAL REPORT

INTRODUCTION

In addition to indicating the concentrations of various chemicals present in the environment near DOE facilities, in recent years the annual environmental reports have contained an estimate of the quantities of certain chemicals being emitted to the environment. This appendix contains an expanded list of chemicals with information regarding the types of releases, the estimated quantities released, the major processes contributing to the releases, and a brief description of the basis of estimates for calendar year (CY) 1991. Radiological chemical releases for CY 1991 are not included in this appendix; they are reported in the applicable chapters of this report.

DISCUSSION

Three categories of chemical releases at each DOE facility are reported in this appendix: (1) SARA 313, (2) other large-inventory chemicals, and (3) steam plant emissions. The SARA 313 chemicals are summarized from the information currently being compiled for the SARA Title III, Section 313, report required by SARA 1986. This report is submitted on July 1 of each year for the previous calendar year and contains chemicals on the EPA toxic substance list.

Currently, 309 specific chemicals and 20 chemical categories must be reviewed and possibly reported under SARA Section 313. If any of these chemicals were manufactured in excess of 25,000 lb, processed in excess of 25,000 lb, or "otherwise used" in excess of 10,000 lb at a facility during CY 1991, the chemical must be reported. In many instances, the estimate of quantities released was obtained via material balance calculations, monitoring data, or engineering calculations. In some cases, no quantitative monitoring data, or emission factors were readily available, and release estimates were based on "best engineering judgment." Material balance calculation was the principal method used to derive the quantity released. Information obtained from air permits, rate of operation, quantities used, and known treatment efficiencies was used to estimate quantities released into the environment. Typically, assumptions based on engineering judgment were required to perform the calculations when all variables were not known. Considerable manpower was expended reviewing chemical inventory information and estimating the quantities released to the environment.

Information contained in this appendix may not coincide with the information to be reported for all chemicals under SARA, Title III, Section 313. The SARA 313 report must be submitted to EPA and TEMA no later than July 1, 1992. The information for this appendix was generated in the March/April timeframe, and some additional refinements were in progress. It is imperative that the additional two months (May and June) be used to ensure compliance under SARA Title III, the community right-to-know law.

The second category of chemicals reported in this appendix is "other large-inventory chemicals." This listing is included to provide the reader with additional chemical information not reportable under SARA 313. Note that this is not a complete listing of all chemicals that may have been released at a site.

This list was developed to better inform the reader of additional chemicals used and released at each site and that may be of interest to the general public.

The third category, "steam plant emissions," is release estimates of certain pollutants from the coal- and/or gas-fired steam plants located at each site.

Chemical release information is included for the Oak Ridge Y-12 Plant (Table A.1), ORNL (Table A.2), and K-25 Site (Table A.3).

DISCLAIMER

Information contained within the 1991 Environmental Report (ER) pertaining to toxic chemical releases at the Y-12 Plant may not coincide with those to be reported under SARA, Title III, Section 313. The latter report, known as the Toxic Release Inventory (Form R), is to be submitted no later than July 1, 1992, to the EPA and TEMA. These forms furnish information on environmental releases (e.g., air, water, and land) of specific toxic chemicals manufactured, produced, or otherwise used at the Y-12 Plant during calendar year 1991. The data collection and review effort necessary to ensure that the numbers furnished for the ER in April will be identical to those submitted in July on the Toxic Release Inventory Forms cannot be made. It is imperative that the additional two months be utilized to ensure compliance under SARA, Title III, the community right-to-know law. Elements requiring additional effort that may result in revision of release numbers are as follows:

- addressing mixtures (i.e., trade name products) containing toxic constituents at 1% or greater and carcinogens at 0.1% or greater;
- tracking bulk acid product distribution systems to identify sources of air emissions for comparison with waste effluents;
- cross-referencing SID numbers and RCRA waste stream numbers with process areas for material balance;
- confirming operational times of certain processes for use in air emission calculations; and
- cross-checking hazardous material purchases against reported material usage for each process area.

Table A.1. Y-12 Plant chemical release information, 1991

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313		
Chlorine	Air-point	113/51	Stack emissions	Engineering calculations
	Air-fugitive	829/377	ooling towers	Material balance
	Water-E. Fork	37/17	Cooling towers	Monitoring
	Water-Kerr Hollow Quarry	30/14	Spill/breached cylinder	Engineering judgment
Freon 11	Air-fugitive	30,170/13,714	Refrigeration systems	Material balance
Freon 113	Air-point	20,931/9,514	Stack emissions	Material balance
	Air-fugitive	5,767/2,621	Cleaning	Material balance
	Water-E. Fork	82/37	leaning	Engineering judgment
	Off-site	60,498/27,499	Disposal/K-25	Monitoring
	Off-site	15/7	Sanitary Sewer	Monitoring
Hydrochloric acid	Air-point	4,725/2,148	Stack/tank emissions	Engineering judgment
	Air-fugitive	458/208	Neutralization	Engineering judgment
Methanol	Air-fugitive	13,949/6,340	Cleaning/cooling	Material balance
	Air-fugitive	2,303/1,047	Spill	Engineering judgment
	Off-site	3/1	Disposal/Rollins	Monitoring
Nitric acid	Air-point (emitted as NO_x)	16,515/7,507	Processing aid/ cleaning	Material balance
	Air-fugitive	3/1	Spill/metal processing	Material balance
	Off-site	16/7	Disposal/Rollins	Monitoring
Perchloroethylene	Air-point	29,700/13,500	Solvent/degreasing	Material balance
	Water-E. Fork	82/37	Solvent/degreasing	Monitoring
	Off-site	203,256/92,389	Disposal/K-25	Monitoring
	Off-site	27/12	Disposal/Rollins	Monitoring
	Off-site	26/12	Sanitary Sewer	Monitoring
Sulfuric acid	Air-point	9/4	Plating	Engineering judgment
	Air-fugitive	4/2	Film processing	Engineering judgment
	Off-site	1,003/456	Disposal/Rollins	Monitoring
		Other large inventory chemicals		
Freon 12	Air-fugitive	935/425	Refrigeration systems	Material balance
Mercury	Water-E. Fork	33/15	Stormwater runoff	Monitoring
	Off-site	6/3	Sanitary Sewer	Monitoring
Acetic acid	Air-point	2/1	Tank emissions	Engineering calculations

Table A.1 (continued)

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		Steam plant emissions		
Sulfur dioxide	Air-point	7,804,730/354,760	Stack emissions	Emission factors
Nitrogen oxygen	Air-point	1,545,511/702,505	Stack emissions	Emission factors
Carbon monoxide	Air-point	91,141/41,428	Stack emissions	Emission factors
Particulates	Air-point	4,097/1,862	Stack emissions	Emission factors

Table A.2. ORNL Plant chemical release information, 1991

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313 chemicals		
Nitric acid	Air: fugitive	145/66	Tank emissions	Engineering calculations
	Off-site disposal	503/228		Disposal record
Sulfuric acid	Air: fugitive	0/0	Tank emissions	Engineering calculations
	Water: White Oak Creek	0/0 (pH adjusted)	Process water	NPDES records Best engineering judgment
	Off-site disposal	245/111		Disposal records
Ethylene glycol	Land	465/211	Leak/spills	Engineering calculations, Spill records
	Water: White Oak Creek	910/413	Leak/spills	Spill records
		2,015/914	Permitted release	Engineering calculations, Operating records
	Off-site disposal	99/45		Disposal records
		Other large inventory chemicals		
Freon 11	Air: fugitive	7,400/3,357	Refrigeration system	Best engineering judgment
Freon 12	Air: fugitive	3,120/1,415	Refrigeration system	Operating records
Freon 22	Air: fugitive	3,268/1,482	Refrigeration system	Operating records
Freon 113	Air: fugitive	5,400/2,449	Refrigeration system Laboratory uses	Inventory records
		Steam plant emissions (all calculated emissions)		
Particulates	Air: point source	24,892/11,314	Stack emission	Engineering calculations based on emission factors
SO_x	Air: point source	2,243,388/1,019,722	Stack emission	Engineering calculations based on emission factors
Carbon monoxide	Air: point source	130,462/59,301	Stack emission	Engineering calculations based on emission factors
Non-methane VOC	Air: point source	1,940/882	Stack emission	Engineering calculations based on emission factors
Methane	Air: point source	791/360	Stack emission	Engineering calculations based on emission factors
NO_x	Air: point source	424,614/193,006	Stack emission	Engineering calculations based on emission factors
		Steam plant emissions (ESR calculated emissions)		
Particulates	Air: point source	24,892/11,314	Stack emission	Engineering calculations based on emission factors
SO_x	Air: point source	2,243,388/1,019,722	Stack emission	Engineering calculations based on emission factors
Carbon monoxide	Air: point source	130,462/59,301	Stack emission	Engineering calculations based on emission factors
NO_x	Air: point source	424,614/193,006	Stack emission	Engineering calculations based on emission factors

Table A.3. K-25 Site chemical release information, 1991

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313		
Chlorine	Air: fugitive emission	5,258/2,390	Water treatment/ Cooling towers	Other
	Water: Poplar Creek	76/35	Sanitary Sewer	Monitoring
	Water: Mitchell Branch	116/53	Cooling tower	Monitoring
	Water: Nameless tributary of Clinch River	400/200	Water treatment	Monitoring
Sulfuric acid	Air: stack emissions	152/69	TSCA incineration by-product	Other[a]
Hydrochloric acid	Air: stack emissions	129/59	TSCA incineration by-product/ tank losses	Other[a]
	Land	68/31	Spills	Other[a]
Ethylene glycol	Land	65/30	Spills	Other[a]
Polycrlorinated biphenyls	Land	10/5	Spills	Other[a]
		Other large inventory chemicals		
Freon 11	Air: fugitive emissions	180/82	Refrigeration/ systems cooling	Other[a]
Freon 12	Air: fugitive emissions	2,160/980	Refrigeration/ systems cooling	Other[a]
Freon 22	Air: fugitive emissions	3,350/1,520	Refrigeration/ systems cooling	Other[a]
Freon 113	Air: fugitive emissions	1,000/454	Other[a]	Other[a]
Freon 114	Air: fugitive emission	22,000/9,979	Refrigeration/ systems cooling	Other[a]
		Steam plant emissions		
Particulates	Air: stack emissions	2,338/1,063	Fossil fuels combustion	Emission factors[b]
Sulfur dioxide	Air: stack emissions	1,154/525	Fossil fuels combustion	Emission factors[b]
Nitrogen oxide	Air: stack emissions	65,027/29,558	Fossil fuels combustion	Emission factors[b]
Carbon monoxide	Air: stack emissions	16,258/7389	Fossil fuels combustion	Emission factors[b]
Organics	Air: stack emission	2,687/1,221	Fossil fuels combustion	Emission factors[b]

[a]Based on best engineering judgment.
[b]AP-42, "Compilation of Air Pollutant Emission Factors."

Appendix B

ERRATA FOR OAK RIDGE RESERVATION ENVIRONMENTAL REPORT FOR 1990

This appendix contains errata reported for the *Oak Ridge Reservation Environmental Report for 1990* (Martin Marietta Energy Systems, Inc., ES/ESH-18, Vols. 1 and 2, Sept. 1991). Corrected values are indicated by a dagger (†), and explanatory footnotes are included when necessary, for example, when entire tables, etc., have been updated because of inaccurate measurements or techniques.

Vol. 1, page 29, Figs. 2.7 and 2.8

As noted in the text for airborne emissions, the noble gas signature is accumulated as a gross measurement. Typically the gross signature was converted into a nominal krypton and xenon signature using the ratios in the cited reference. In preparing the 1990 Environmental Report, using the noble gas ratio was determined to be an acceptable approach for Stack 7911, but the signature for Stack 3039 was due to the packaging of krypton, not reactor core dynamics. Consequently, the dose estimates for 1990 were based upon the noble gas signature of Stack 3039 being 100% ^{85}Kr. The revised bar charts for 1990 (Figs. 2.7 and 2.8 below) are consistent with this dose modeling assumption.

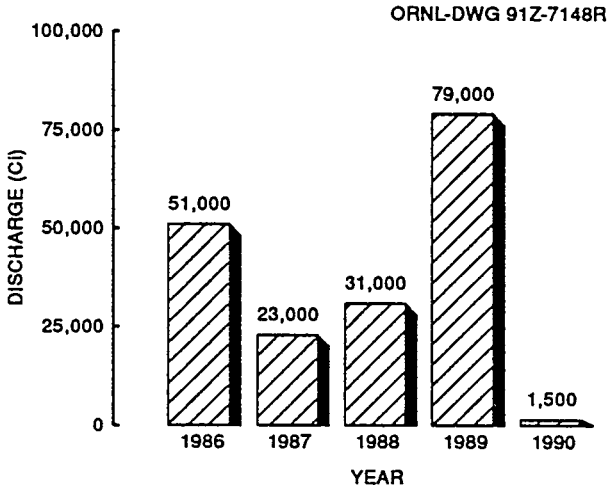

Fig. 2.7. Total discharges of ^{133}Xe from ORNL to the atmosphere, 1986–1990.

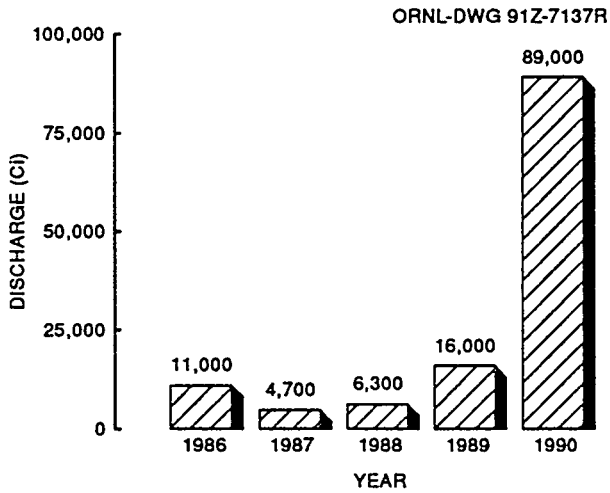

Fig. 2.8. Total discharges of ^{85}Kr from ORNL to the atmosphere, 1986–1990.

Vol. 1, page 37, paragraph 1

The text, "The highest observed concentrations (7-d average) at any monitored site have been 2% of the NESHAP criterion (1.0 $\mu g/m^3$) and <1% of the workplace standard of 50 $\mu g/m^3$," should have read, "With only one exception, the highest observed concentrations (7-d average) at any monitored site have been <50% of the NESHAP criterion (1.0 $\mu g/m^3$) and <1% of the industrial hygiene standard of 50 $\mu g/m^3$.

Vol. 1, page 114, Figs. 3.14 and 3.15

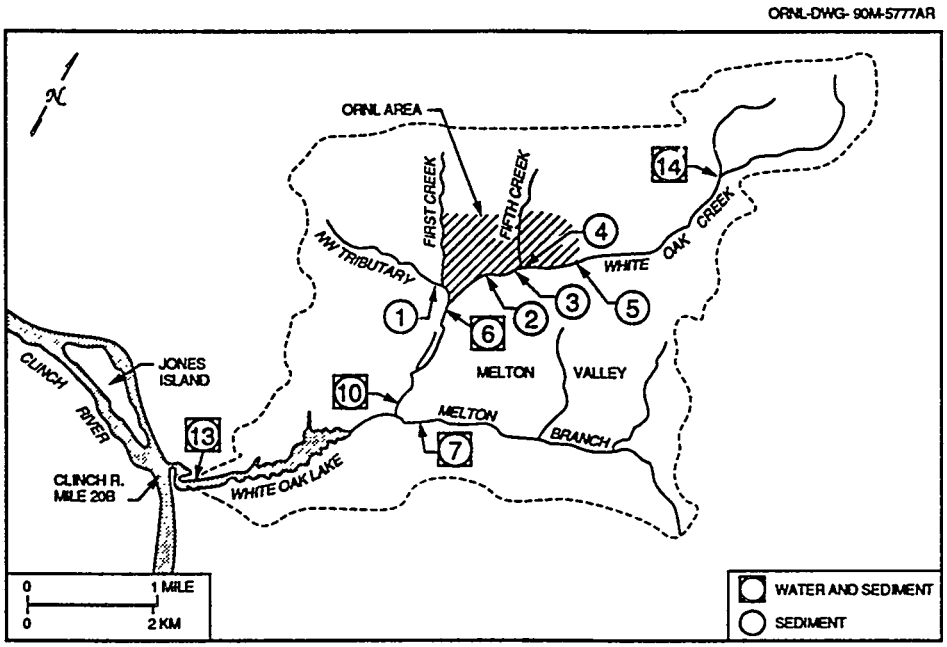

Fig. 3.14. Sample locations for PCB and TOC (sediment only) analyses in the ORNL area.

†The label "sediment" should have read "water."

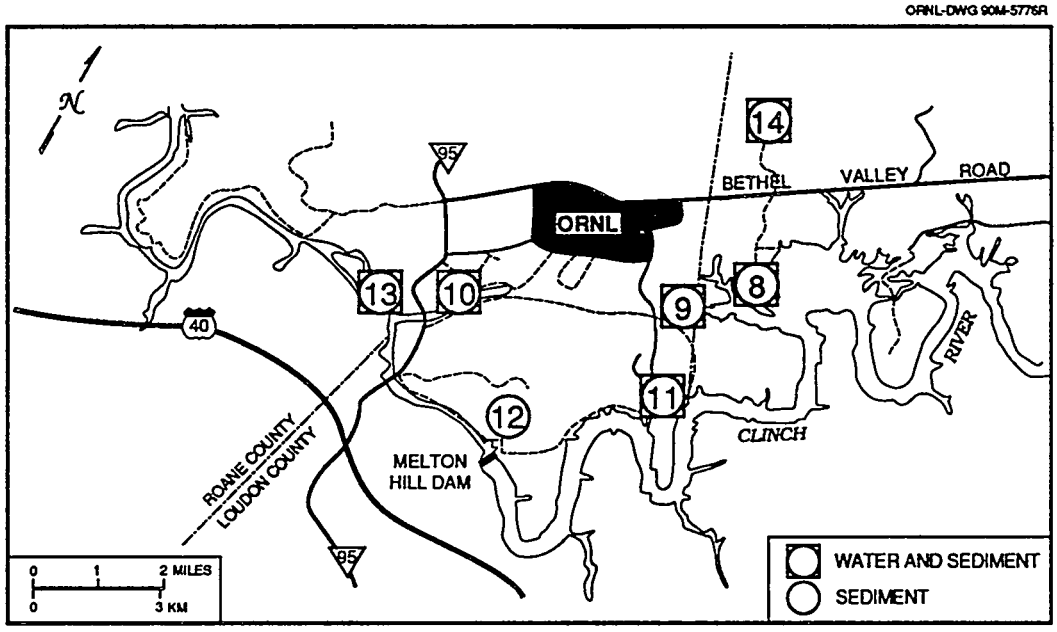

Fig. 3.15. Sample locations for PCB and TOC (sediment only) analyses in the greater ORNL area.

†Location II should have been labeled "sediment."

Vol. 2, Table 2.10. 1990 continuous air monitoring data[a†]

Analysis	Concentration[b] (10^{-15} μCi/mL)					
	Station 34	Percentage DCG[c]	Station 40	Percentage DCG[c]	Station 41	Percentage DCG[c]
^{60}Co	0.067*	<0.010	0.019	<0.010	0.021	<0.010
^{137}Cs	0.0023	<0.010	0.023*	<0.010	0.024*	<0.010
^{238}Pu	0.0014*	<0.010	0.00042	<0.010	0.0012	<0.010
^{239}Pu	–0.0014	<0.010	–0.00094	<0.010	–0.0017	<0.010
^{228}Th	0.023*	0.058	0.020*	0.051	0.016*	0.039
^{230}Th	0.0040*	0.010	0.0053*	0.013	0.0057*	0.014
^{232}Th	0.0034*	0.048	0.0030*	0.042	0.0044*	0.063
Total Sr	0.071*	<0.010	0.057*	<0.010	0.026	<0.010
^{234}U	0.024*	0.026	0.28*	0.31	0.094*	0.10
^{235}U	0.0019*	<0.010	0.014*	<0.014	0.0027*	<0.010
^{238}U	0.0077*	<0.010	0.028*	0.028	0.015*	0.015

Analysis	Station 45	Percentage DCG[c]	Station 46	Percentage DCG[c]	ORNL network	Percentage DCG[c]
^{60}Co	0.012	<0.010	–0.0065	<0.010	0.012	<0.010
^{137}Cs	–0.0052	<0.010	0.028*	<0.010	0.030*	<0.010
^{238}Pu	0.00032	<0.010	0.0023	<0.010	0.00049*	<0.010
^{239}Pu	0.00018	<0.010	–0.0013	<0.010	–0.00027	<0.010
^{228}Th	0.017*	0.043	0.025*	0.062	0.0069*	0.017
^{230}Th	0.0049*	0.012	0.0055*	0.014	0.0042*	0.010
^{232}Th	0.0035*	0.049	0.0052*	0.075	0.0033*	0.048
Total Sr	–0.014	<0.010	0.0036	<0.010	–0.0015	<0.010
^{234}U	0.18*	0.20	0.21*	0.23	0.032*	0.036
^{235}U	0.016*	0.016	0.027*	0.027	0.0032*	<0.010
^{238}U	0.035*	0.035	0.031*	0.031	0.0096*	<0.010

Analysis	ORR network	Percentage DCG[c]	Remote network	Percentage DCG[c]
^{60}Co	–0.0015	<0.010	0.020	<0.010
^{137}Cs	–0.00060	<0.010	0.0011	<0.010
^{238}Pu	0.00009	<0.010	0.0017*	<0.010
^{239}Pu	–0.00022	<0.010	0.00017	<0.010
^{228}Th	0.0076*	0.019	0.018*	0.045
^{230}Th	0.0038*	<0.010	0.0052*	0.013
^{232}Th	0.0046*	0.066	0.0061*	0.087
Total-Sr	0.016*	<0.010	0.043*	<0.010
^{234}U	0.045*	0.050	0.017*	0.019
^{235}U	0.0072*	<0.010	0.0018*	<0.010
^{238}U	0.015*	0.015	0.010*	0.010

[a]See Figs. 2.19 and 2.20 in Vol. 1 for monitoring locations.

[b]Concentrations identified by an asterisk (*) are significantly greater than zero. Multiply μCi/Ml by 37×10^3 to convert to Bq/mL.

[c]Percentage of DCG = average/derived concentration guide (DCG) × 100. The DCG for ^{60}Co is 8×10^{-11} μCi/mL; ^{137}Cs is 4×10^{-10} μCi/mL; ^{238}Pu is 3×10^{-14} μCi/mL; ^{239}Pu is 2×10^{-14} μCi/mL; ^{228}Th is 4×10^{-14} μCi/mL; ^{230}Th is 4×10^{-14} μCi/mL; ^{232}Th is 7×10^{-15} μCi/mL; total Sr is 9×10^{-12} μCi/mL; ^{234}U is 9×10^{-14} μCi/mL; ^{235}U is 1×10^{-13} μCi/mL; ^{238}U is 1×10^{-13} μCi/mL. Source for DCG is DOE Order 5400.5, "Radiation Protection of the Public and the Environment," Chapter III.

†This table is included in this appendix because some of its data were reported incorrectly and most of its asterisks (*'s) indicating a value's significant difference from zero were not provided in the *Oak Ridge Reservation Environmental Report for 1990*, Vol.1, ES/ESH-18/V1, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 1, Table 2.12. 1990 radionuclide concentrations in air†

Areab	Determination	Number of samples	Concentration (10^{-15} μCi/mL)[a]				
			Max	Min	Av[c]	Standard error	DCG (%)
ORNL PAMs	Gross alpha	117	16	0.11	1.6*	0.17	
	Gross beta	117	71	4.7	22*	1.1	
	^{3}H	13	180,000	2,600	33,000*	14,000	0.033
	^{131}I	118	13	–13	0.30	0.29	<0.01
	^{60}Co	1			0.012		<0.01
	^{137}Cs	1			0.030*		<0.01
	^{238}Pu	1			0.00049*		<0.01
	^{239}Pu	1			–0.00027		<0.01
	^{228}Th	1			0.0069*		0.017
	^{230}Th	1			0.0042*		0.010
	^{232}Th	1			0.0033*		0.048
	Total Sr	1			–0.0015		<0.01
	^{234}U	1			0.032*		0.036
	^{235}U	1			0.0032*		<0.01
	^{238}U	1			0.0096*		<0.01
ORR PAMs	Gross alpha	226	14	–0.11	1.7*	0.11	
	Gross beta	226	55	4.4	23*	0.67	
	^{3}H	11	26,000	260	13,000*	2.8	0.013
	^{131}I	157	8.7	–14	0.19	0.24	<0.01
	^{60}Co	6	0.067	–0.0065	0.019	0.011	<0.01
	^{137}Cs	6	0.028	–0.0052	0.012	0.0060	<0.01
	^{238}Pu	6	0.0023	0.00009	0.00096*	0.00035	<0.01
	^{239}Pu	6	0.00018	–0.0017	–0.00089	0.00030	<0.01
	^{228}Th	6	0.025	0.0076	0.018*	0.0025	0.044
	^{230}Th	6	0.0057	0.0038	0.0049*	0.00032	0.012
	^{232}Th	6	0.0052	0.0030	0.0040*	0.00035	0.057
	Total Sr	6	0.071	–0.014	0.027*	0.013	<0.01
	^{234}U	6	0.28	0.024	0.14*	0.040	0.16
	^{235}U	6	0.027	0.0019	0.011*	0.0039	0.011
	^{238}U	6	0.035	0.0077	0.022*	0.0044	0.022
RAMs	Gross alpha	35	12	–0.14	2.1*	0.45	
	Gross beta	36	74	0.47	26*	2.7	
	^{60}Co	1			0.020		<0.01
	^{137}Cs	1			0.0011		<0.01
	^{238}Pu	1			0.0017*		<0.01
	^{239}Pu	1			0.00017		<0.01
	^{228}Th	1			0.018*		0.045
	^{230}Th	1			0.0052*		0.013
	^{232}Th	1			0.0061*		0.087
	Total Sr	1			0.043*		<0.01
	^{234}U	1			0.017*		0.019
	^{235}U	1			0.0018*		<0.01
	^{238}U	1			0.010*		0.010

[a]Multiply μCi/mL by 37×10^3 to convert to Bq/mL.

[b]See Figs. 2.19 and 2.20.

[c]Averages marked with an asterisk (*) are statistically greater than zero at the 95% level of confidence.

†This table is included in this appendix because some of its data were reported incorrectly and most of its asterisks (*'s) indicating a value's significant difference from zero were not provided in the *Oak Ridge Reservation Environmental Report for 1990*, Vol. 1, ES/ESH-18/V1, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 2, Table 3.2. Radionuclide concentrations in water around the K-25 Site in 1990[a]

Parameter	Number of samples	Concentration (pCi/L)			Percentage of DCG[b]
		Max	Min	Av	
		West Fork Poplar Creek			
^{237}Np	4	0	-8.00×10^{-1}	-2.20×10^{-1}	<0.01
$^{239/240}Pu$	2	0	-1.10×10^{-1}	-5.50×10^{-2}	<0.01
^{99}Tc	4	1.59×10^{2}	1.66×10^{1}	1.05×10^{2}	0.11[†]
^{137}Cs	4	2.09	-2.59×10^{1}	−5.95	<0.01
U[c]	4	<0.7	<0.7	<0.7	0.11
U (mg/L)	4	<0.001	<0.001	<0.001	*d*[†]
^{238}Pu	2	-1.3×10^{-1}	-4.6×10^{-1}	-2.95×10^{-1}	<0.01
^{239}Pu	2	4.00×10^{-1}	-1.3×10^{-1}	1.35×10^{-1}	0.45[†]
		K-1710			
^{237}Np	12	1.62	-2.6×10^{-1}	2.74×10^{-1}	0.92[†]
$^{239/240}Pu$	5	9.87×10^{-1}	-4.8×10^{-1}	-4.08×10^{-2}	<0.01
^{99}Tc	12	9.14×10^{2}	-2.44×10^{-2}	8.17×10^{-1}	0.08
^{137}Cs	12	1.16×10^{1}	-9.60×10^{-1}	1.39	0.05[†]
U[c]	12	7.38	<0.7	2.80	0.47
U (mg/L)	12	1.10×10^{-2}	<0.001	4.17×10^{-3}	*d*[†]
^{238}Pu	7	6.70×10^{-1}	-6.00×10^{-1}	-4.86×10^{-2}	<0.01
^{239}Pu	7	6.00×10^{-1}	-9.00×10^{-2}	1.35×10^{-1}	0.45[†]
		K-716			
^{237}Np	12	5.19×10^{-1}	-4.30×10^{-1}	7.55×10^{-2}	0.25
$^{239/240}Pu$	5	1.90	-6.50×10^{-1}	4.20×10^{-1}	1.40
^{99}Tc	12	7.27×10^{2}	-4.20×10^{2}	$6.10 \times 10^{+1}$	0.06
^{137}Cs	12	7.71	−2.36	4.05×10^{-1}	0.01
U[c]	12	2.01	<0.7	1.06	0.18
U (mg/L)	12	0.003	<0.001	1.58×10^{-3}	*d*[†]
^{238}Pu	7	4.20×10^{-1}	-7.70×10^{-1}	-2.23×10^{-1}	<0.01
^{239}Pu	7	5.60×10^{-1}	-9.0×10^{-2}	1.43×10^{-1}	0.48
		K-1513			
^{237}Np	12	3.50×10^{-1}[†]	-4.70×10^{-1}	5.66×10^{-2}[†]	0.19[†]
$^{239/240}Pu$	5	4.23×10^{-1}	-3.20×10^{-1}	-1.54×10^{-2}	<0.01
^{99}Tc	12	7.30×10^{2}	-3.76×10^{2}	6.73×10^{1}	0.07
^{137}Cs	12	4.13	−4.65	6.09×10^{-1}	0.02
U[c]	12	<0.7	<0.7	<0.7	0.11
U (mg/L)	12	<0.001	<0.001	<0.001	*d*[†]
^{238}Pu	7	2.00×10^{-1}	−1.50	-3.60×10^{-1}	<0.01
^{239}Pu	7	5.60×10^{-1}	-3.00×10^{-1}	8.43×10^{-3}	0.03

Vol. 2, Table 3.2 (continued)

Parameter	Number of samples	Concentration (pCi/L)			Percentage of DCG[b]
		Max	Min	Av	
		K-1770			
^{237}Np	12	3.6×10^{-1}	-4.4×10^{-1}	1.53×10^{-2}	0.05
$^{239/240}Pu$	5	1.67	-6.6×10^{-1}	3.06×10^{-1}	1.02
^{99}Tc	12	3.99×10^{2}	-2.44×10^{2}	-1.12×101	<0.01
^{137}Cs	12	8.01	−1.64	8.27×10^{-1}	0.03
U[c]	12	<0.7	<0.7	<0.7	0.11
U (mg/L)	12	<0.001	<0.001	<0.001	*d*[†]
^{238}Pu	7	4.50×10^{-1}	-6.6×10^{-1}	-1.06×10^{-1}	<0.01
^{239}Pu	7	5.70×10^{-1}	-3.0×10^{-1}	8.43×10^{-2}	0.28[†]
		Clinch			
^{237}Np	4	9.00×10^{-2}	-9.00×10^{-2}	4.00×10^{-2}	0.13
$^{239/240}Pu$	2	8.00×10^{-2}	-3.50×10^{-1}	-1.35×10^{-1}	<0.01
^{99}Tc	4	$1.89 \times 10^{+2}$	-1.45×10^{2}	-3.02×10^{1}	<0.01
^{137}Cs	4	1.97	0	7.50×10^{-1}	0.03
U[c]	4	<0.7	<0.7	<0.7	0.11
U (mg/L)	4	<0.001	<0.001	<0.001	*d*[†]
^{238}Pu	2	9.00×10^{-2}	0	4.5×10^{-2}	0.11[†]
^{239}Pu	2	7.0×10^{-2}	-9.00×10^{-2}	-1.00×10^{-2}	<0.01
		Mitchell Branch			
Gross alpha	4	5.83	−1.00	1.25	*d*
Gross beta	4	5.14	−1.20	1.59	*d*
Gross gamma	4	0	0	0	*d*
^{137}Cs	2	3.56	-8.21×10^{-1}	1.37	0.05

[a]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

[b]Average concentration as a percentage of the derived concentration guide (DCG) from DOE Order 5400.5.

[c]The specific activity for natural uranium of 1.49×1^{6} g/Ci was used to determine pCi/L.

[d]Not applicable.

[a]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

[†]This item represents a correction to the value reported in the referenced table in the *Oak Ridge Reservation Environmental Report for 1990*, Vol. 2, ES/ESH-18/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 2, Table 3.12. 1990 K-25 Site radiological effluent at K-1203

Radionuclide	Emission source (Ci)	DCG (pCi/L)	Average concentration (pCi/L)	Percentage of DCG
^{99}Tc	-6.41×10^{-3a}	100,000	-6.10×10^{1a}	<0.01
^{234}U	3.46×10^{-3}	500	3.29×10^{1}	6.59†
^{235}U	1.11×10^{-4}	600	1.06	0.18†
^{236}U	1.88×10^{-3}	500	1.79×10^{1}	3.57
^{238}U	1.85×10^{-3}	600	1.76×10^{1}	2.94

[a]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

†This item represents a correction to the value reported in the referenced table in the *Oak Ridge Reservation Environmental Report for 1990,* Vol. 2, ES/ESH-18/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 2, Table 3.13. 1990 K-25 Site radiological effluent at K-1700†

Radionuclide	Emission source (Ci)	DCG (pCi/L)	Average concentration (pCi/L)	Percentage of DCG
^{237}Np	8.27	30	7.04×10^{-2}	0.24
^{239}Pu	4.29×10^{-4}	30	3.65×10^{-2}	0.12
^{99}Tc	-4.21×10^{-3a}	100,000	-3.58×10^{-1a}	N/A
^{137}C	2.94×10^{-4}	3,000	2.50×10^{-2}	<0.01
^{234}U	5.86×10^{-2}	500	4.99×10^{0}	1.00
^{235}U	2.26×10^{-3}	600	1.92×10^{-1}	<0.01
^{236}U	5.84×10^{-4}	500	4.98×10^{-2}	0.01
^{238}U	3.13×10^{-2}	600	2.66×10^{0}	0.44

[a]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

†The data in this table were corrected from the values reported in the referenced table in the *Oak Ridge Reservation Environmental Report for 1990,* Vol. 2, ES/ESH-18/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 2, Table 3.14. 1990 K-25 Site radiological effluent at K-1007-B

Radionuclide	Emission source (Ci)	DCG (pCi/L)	Average concentration (pCi/L)	Percentage of DCG
^{237}Np	-3.50×10^{-3}[a]	30	−4.35[a]	<0.01
^{239}Pu	5.50×10^{-5}	30	6.84×10^{-2}	0.23[†]
^{99}Tc	1.19×10^{-1}	100,000	1.48×10^{2}	0.15[†]
^{137}Cs	-2.55×10^{-3}[a]	3,000	−3.17[a]	<0.01
^{234}U	1.70×10^{-3}	500	7.04×10^{-1}	0.14[†]
^{235}U	5.71×10^{-5}	600	2.37×10^{-2}	<0.01
^{236}U	1.01×10^{-5}	500	4.18×10^{-3}	<0.01
^{238}U	9.07×10^{-4}	600	3.76×10^{-1}	0.06

[a]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

[†]This item represents a correction to the value reported in the referenced table in the *Oak Ridge Reservation Environmental Report for 1990*, Vol. 2, ES/ESH-18/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 2, Table 3.15. 1990 K-25 Site radiological effluent at K-901A

Radionuclide	Emission source (Ci)	DCG (pCi/L)	Average concentration (pCi/L)	Percentage of DCG
^{237}Np	-1.74×10^{-5}[a]	30	-8.00×10^{-2}[a]	<0.01
^{239}Pu	-2.88×10^{-4}[a]	30	−1.32[a]	<0.01
^{99}Tc	1.24×10^{-1}	100,000	5.69×10^{2}	0.57
^{137}Cs	1.56×10^{-4}	3,000	7.16×10^{-1}	0.02
^{234}U	5.14×10^{-4}	500	2.36	0.47
^{235}U	1.56×10^{-5}	600	7.14×10^{-2}	0.01
^{236}U	3.78×10^{-6}	500	1.73×10^{-2}	<0.01[†]
^{238}U	2.75×10^{-4}	600	1.26	0.21

[a]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

[†]This item represents a correction to the value reported in the referenced table in the *Oak Ridge Reservation Environmental Report for 1990*, Vol. 2, ES/ESH-18/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 2, Table 3.16. 1990 K-25 Site radiological effluent at K-1407-J[†]

Radionuclide	Emission source (Ci)	DCG (pCi/L)	Average concentration (pCi/L)	Percentage of DCG
^{237}Np	3.03×10^{-4}	30	3.33×10^{-1}	1.11
^{239}Pu	-2.48×10^{-5}[a]	30	-2.72×10^{-2}[a]	<0.01
^{99}Tc	2.30×10^{-1}	100,000	2.53×10^{2}	0.25
^{137}Cs	1.43×10^{-3}	3,000	1.57	0.05
^{234}U	1.40×10^{-1}	500	1.54×10^{2}	0.31
^{235}U	5.42×10^{-3}	600	5.95	0.99
^{236}U	1.19×10^{-3}	500	1.30	0.26
^{238}U	7.03×10^{-2}	600	77.2	12.9

[a]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

[†]The data in this table are corrected from the values reported in the referenced table in the *Oak Ridge Reservation Environmental Report for 1990*, Vol. 2, ES/ESH-18/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Vol. 2, Table 3.17. 1990 K-25 Site radiological effluent at K-1407-E/F[a]

Radionuclide	Emission source (Ci)	DCG (pCi/L)	Average concentration (pCi/L)	Percentage of DCG
^{237}Np	-2.21×10^{-6}[b]	30	-1.80×10^{-1}[b]	<0.01
^{239}Pu	-1.83×10^{-5}[b]	30	-1.49[b]	<0.01
^{99}Tc	-2.04×10^{-3}[b]	100,000	-1.66×10^{2}[b]	<0.01
^{137}Cs	2.94×10^{-4}	3,000	2.39×10^{1}	0.80[†]
^{234}U	7.65×10^{-6}	500	6.22×10^{-1}	0.12[†]
^{235}U	2.46×10^{-7}	600	2.00×10^{-2}	<0.01
^{236}U	8.69×10^{-8}	500	7.07×10^{-3}	<0.01
^{238}U	4.10×10^{-6}	600	3.33×10^{-1}	0.06

[a]Data are for December 1990 only.

[b]Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and obtain a negative number. Statistical summaries previously used detection limits to represent sample results even when samples were less than detection limits, which resulted in high biases. To remove these biases and to enable statistical summaries to be equally representative of all component values, recent changes in reporting methods include accepting all results at face value.

[†]This item represents a correction to the value reported in the referenced table in the *Oak Ridge Reservation Environmental Report for 1990*, Vol. 2, ES/ESH-18/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Sept. 1991.

Appendix C

STATISTICAL TREATMENT OF RANDOM UNCERTAINTIES

Random uncertainties are those that can be treated by statistical methods and are derived from an analysis of replicate observations of a random or stochastic process. The information in this appendix has been taken directly from *Upgrading Environmental Radiation Data,* EPA 520/1-80-012, prepared by the Health Physics Society Committee, 1980. Only a small amount of background information is presented here.

Before proceeding, definition of some terminology is necessary. The term variate (or random variable) is used to denote the quantity that may take on any of the observed values. The aggregate of these observations is termed a sample of some parent population and may be described by a frequency distribution. This distribution of the population is a specification of the way in which the number of observations (frequencies) are distributed according to the values of the variates. The parameters of a population are the descriptive measures of the distribution. The mean (μ), a measure of the center or location of the distribution, and the standard deviation (σ), a measure of the spread or scatter of the distribution, are examples of parameters. The mean (μ) is also termed the first moment of the distribution, and the square of the standard deviation (σ^2), called the variance, is the second central moment. In the absence of an infinite population, one must make estimates of the parameters from finite populations (the sample of observations). A sample statistic is this estimator of the population parameter. The values of sample statistics are computed entirely from the sample and are the basic measures of the central tendency (location) and dispersion (variation). The mean ($\bar{x}$) and standard deviation (s) are widely known examples of statistics. Unfortunately, the distinction between population parameters and sample statistics is frequently ignored, and the two are often confused and incorrectly referred to interchangeably. The following diagram is an attempt to clarify the distinction.

Statistics	→	Parameters
Calculated from sample (e.g., $\bar{x}$ and s^2)	used to estimate	for the population (e.g., μ and σ^2)

In practice, the parameters of the population are denoted by Greek alphabetic characters, and the corresponding estimators of these parameters (the statistics) by Roman alphabetic characters. Table B.1 lists a number of commonly used parameters and statistics.

The population distribution must be known before one can proceed with the treatment of random uncertainties. A rigorous analysis would require confirmation that the sample of observations is a normal or some other known distribution. Numerous statistical tests, such as the χ^{2}, t-, and F-tests, are available for this use. Standard statistical sources may be consulted for details. These tests are not always practical, particularly because they are not very applicable with samples of less than about 30 observations. With fewer observations, a normal (or Gaussian) distribution, which is completely characterized by the mean and variance, is assumed. For some other distributions, further parameters, such as skewness (third central moment) or peakedness (fourth central moment), may be necessary. The justification for this assumption of normality is based on precedent. The normal distribution can be viewed as a mathematical result empirically shown to be valid for a large number of different experimental situations. It is still only an assumption, and it is well worthwhile to make a visual

Table C.1. Commonly used population parameters and sample statistics

Population parameters	Sample statistics (Estimators of parameters)
μ_x (mean—first moment)	$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} x_i$
σ_x^2 (variance—second central moment)	$s_x^2 = \frac{1}{n-1}\sum_{i=1}^{n} (x_i - \bar{x})^2$
σ_x (standard deviation of x about μ_x)	$s_x = \sqrt{s_x^2}$
$\sigma_{\bar{x}}$ (standard error of the mean, or standard deviation of the average)	$s_{\bar{x}} = \frac{1}{\sqrt{n}} s_x$
$\sigma_{xy} = \sigma_{yx}$ (covariance)	$s_{xy} = s_{yx} = \frac{1}{n-1}\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})$
$\frac{\sigma}{\mu}(100)$ (coefficient of variation, or relative standard deviation, expressed in percent)	$v_x = \frac{s_x}{\bar{x}}(100)$

examination of the data for any marked departures from normality. There are some simple procedures to do this. They include construction of a histogram or graphical test using probability paper. The discussion of random uncertainties that follows assumes that a normal distribution is justifiable. It can be shown that this subsequent treatment is not absolutely dependent on a normal population distribution. The Central Limit Theorem states this, provided the departures are not too great, and further predicts that the convolution or folding together of nonnormal distributions tends to form normal distributions. The probabilities for some typical intervals in the normal distribution are provided in Table B.2. As stated before, an analysis of the observed values will be used to estimate μ and σ^2.

Table C.2. Probabilities for same typical intervals in normal distribution

Interval $(\mu - \zeta\sigma_x)$ to $(\mu + \zeta\sigma_x)$ (ζ)	Percentage of the population within this interval (%)
0.6745	50
1.000	68.269
1.960	95
2.000	95.450
2.576	99
3.000	99.73

Sample Mean and Standard Deviation

For n measurements of x, the best estimate of the parameter μ is obtained from the mean ($\bar{x}$) of the sample, and the best estimate of σ^2 from the variance (s_x^2), where

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \rightarrow \mu \ . \tag{1}$$

and

$$s_x^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2 \rightarrow \sigma_x^2 \ . \tag{2}$$

The sample standard deviation is the square root of the variance, or the quantity s_x. It refers to the standard deviation computed from a sample of measurements.

Standard Error of the Mean

Any mean $\bar{x}$ is determined from a finite number of measurements. If the determination is repeated, one can obtain a series of slightly different $\bar{x}$ values. According to the Central Limit Theorem, for large n, the distribution of these $\bar{x}$ values will be close to normal for any distribution of x that has at least two finite moments. Thus, a standard deviation of this distribution could be obtained from repeated determinations of $\bar{x}$. It may, however, also be estimated from just the measurements used in a single determination of $\bar{x}$. This estimate of the precision on the mean is termed the standard error of the mean ($s_{\bar{x}}^2$), which is given by

$$s_{\bar{x}}^2 = \frac{s_x^2}{n} = \frac{1}{n(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2 \ . \tag{3}$$

The quantity $s_{\bar{x}}^2$ is termed the variance of the mean. The standard error of the mean ($s_{\bar{x}}$) must not be confused with the sample standard deviation (s_x). The standard deviation s_x is only dependent on the measurement precision, whereas $s_{\bar{x}}$ depends on both the precision and the number of observations.

Statistical Treatment of Data Below the Detection Limit

Results obtained in the laboratory are often reported as "less than" or "below detection." In these situations the detection limit is reported along with the "less than" designation. The sample mean and standard error of the mean are affected by these values; they become "biased"—biased high for the mean and low for the standard error of the mean. That is, the sample standard error of the mean is estimating something smaller than the true standard error.

A further consequence of the bias is an increased likelihood that a population mean will be declared greater than zero in a statistical test using the biased sample mean and standard error. A statistically significant result may be a consequence of the number of values below the detection limit. If, however, there were a number of values above the detection limit, the conclusion that the true mean is greater than zero may be valid even though the estimate of true mean is biased.

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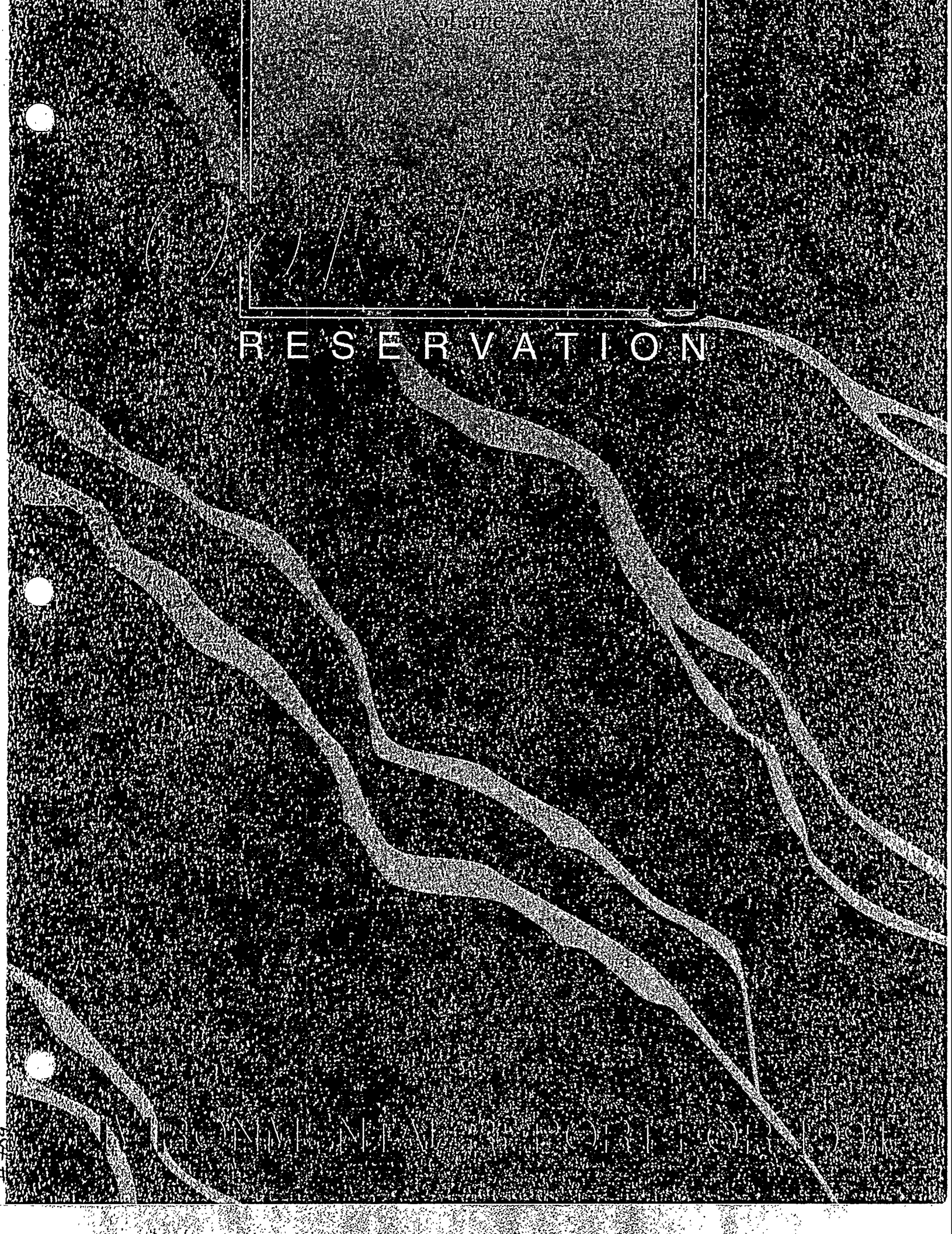
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ACRONYMS AND ABBREVIATIONS

AA	atomic absorption
ACD	Analytical Chemistry Division
ACL	alternate concentration limit
ACN	acetonitrile
ADB	Ash Disposal Basin
ADI	acceptable daily intake
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AESG	Analytical Environmental Support Group
AGM	average geometric mean
ALARA	as low as reasonably achievable
Am	americium
AMAD	activity median aerodynamic diameter
ANAP	Abandoned Nitric Acid Pipeline
ARAR	applicable and appropriate requirements
As	arsenic
ASTM	American Society for Testing and Materials
ATDL	Atmospheric Turbulence and Diffusion Laboratory
ATLC	Atomic Trades and Labor Council
AVLIS	atomic vapor laser isotopic separation
BAT	best available technology
BC	Beaver Creek
BCBG	Bear Creek Burial Grounds
BCHR	Beaver Creek Hydrogeologic Regime
BCK	Bear Creek kilometer
BCV	Bear Creek Valley
BCVWDA	Bear Creek Valley Waste Disposal Area
BF	Brushy Fork
BMAP	Biological Monitoring and Abatement Programs
BMP	best management practices
BOD	biochemical oxygen demand
BRC	below regulatory concern
BTM	breakthrough monitors
CAA	Clean Air Act
CAPCA	Closure and Post Closure Activities
CARL	Comparative Animal Research Laboratory
CAS	Chemical Abstracts Service
CC	Copper Creek
CDI	calculated daily intake
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CH	contact-handled
Ci	curie

CLP	Contract Laboratory Program
Cm	curium
CNF	Central Neutralization Facility
Co	cobalt
COD	chemical oxygen demand
CPCF	Central Pollution Control Facility
CRDL	contract-required detection limit
CRHR	Chestnut Ridge Hydrogeologic Regime
CRK	Clinch River kilometer
CRM	Clinch River mile
CRRI	Clinch River Remedial Investigation
CRSDP	Chestnut Ridge Sediment Disposal Basin
CRSP	Chestnut Ridge Security Pits
Cs	cesium
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
CYRTF	coal yard runoff treatment facility
DAC	derived air concentration
DCF	dose conversion factor
DCG	derived concentration guide
diam	diameter
DMR	discharge monitoring report
DNA	deoxyribonucleic acid
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DWL	drinking water limits
EA	Environmental Assessment
EAP	Environmental Assessment Plan
ECRWP	East Chestnut Ridge Waste Pile
EDE	effective dose equivalent
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EIS	Environmental Impact Statement
EMD	Environmental Management Department
EML	Environmental Measurements Laboratory
EMSL-LV	Environmental Monitoring System Laboratory at Las Vegas
ENE	east–northeast
Energy Systems	Martin Marietta Energy Systems, Inc.
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
ERDS	Environmental Review and Documentation Section
ERP	Environmental Restoration Program
E&SA	Environmental and Safety Activities
ESD	Environmental Sciences Division
ESP	Environmental Surveillance and Protection
ET&I	Equipment Testing and Inspection Division
FAC	free available chlorine
FDA	Food and Drug Administration

FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	feasibility study
FWPCA	Federal Water Pollution Control Act
FY	fiscal year
GQM	groundwater quality monitoring
GUT	garage underground tank
GW	groundwater
GWPP	Groundwater Protection Program
GWPS	Groundwater Protection Standard
GWQAP	groundwater quality assessment plans
GWQAR	groundwater quality assessment reports
H	hydrogen
HAP	hazardous air pollutants
HAZWDDD	Hazardous Waste Development, Demonstration, and Disposal
HAZWRAP	Hazardous Waste Remedial Actions Program
HCK	Hinds Creek kilometer
HEPA	high-efficiency particulate air
HFIR	High Flux Isotope Reactor
Hg	mercury
HRE	Homogenous Reactor Experiment
HSWA	Hazardous and Solid Waste Amendments
HWDU	hazardous waste disposal unit
I	iodine
IAG	interagency agreement
IBI	Index of Biotic Integrity
ICP	inductively coupled plasma
ICRP	International Commission on Radiological Protection
IRIS	Integrated Risk Information System
ISV	in situ vitrification
IWC	instream waste concentration
IWMF	Interim Waste Management Facility
K-25 Site	Oak Ridge K-25 Site
K	Kingston
KHQ	Kerr Hollow Quarry
Kr	krypton
LCR	lowest concentration reported
LDR	land disposal restricted
LLLW	liquid low-level waste
LLW	low-level waste
LLWDDD	low-level waste disposal development and demonstration
LLWDF	Low-Level Waste Disposal Facilities
LSF	Liquid Storage Facility
MAA	material access area
MACT	Maximum Achievable Control Technology
MB	Melton Branch

MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limits
MHD	Melton Hill Dam
MSRE	Molten Salt Reactor Experiment
MT	meteorological tower
NAS	National Academy of Sciences
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
ND	not detected
NDB	Numeric Data Base
NE	northeast
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHP	New Hope Pond
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NNE	north–northeast
NOAA	National Oceanic and Atmospheric Administration
NOEC	no-observed-effect concentration
NOV	Notice of Violation
Np	neptunium
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
NRWTF	Nonradiological Wastewater Treatment Facility
NWT	Northwest Tributary
O&G	oil and grease
OLF	Oil Landfarm Area
OR	Oak Ridge Field Office
ORAU	Oak Ridge Associated Universities
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRER	Oak Ridge Reservation Environmental Report
ORS	Occurrence Reporting System
Pa	protactinium
PA	preliminary assessment
PAM	perimeter air monitoring
Pb	lead
PC	Pond Closure
PCB	polychlorinated biphenyl
PCK	Poplar Creek kilometer
PCP	pentachlorophenol
PET	Proficiency Environmental Testing
PGDP	Paducah Gaseous Diffusion Plant
PIDAS	Perimeter Intrusion Detection and Alarm System
PM10	particulate matter less than 10 microns in diameter
PRTF	Plating Rinsewater Treatment Facility
Pu	plutonium
pvc	polyvinyl chloride

PWA	Process Waste Assessment
PWTF	Process Waste Treatment Facility
PWTP	process waste treatment plant
QA	quality assurance
QC	quality control
Ra	radium
RAM	remote air monitoring
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
R&D	research and development
REDC	Radiochemical Engineering Development Center
RFA	RCRA Facility Assessment
RfD	reference dose
RFI	RCRA facility investigation
RH	remote-handled
RMA	Rocky Mountain Arsenal
RMP	radiological monitoring plan
RMPE	Reduction of Mercury in Plant Effluent
ROD	Record of Decision
RWMD	Reservation Waste Management Division
S-3	S-3 Site
S&A	sampling and analysis
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Se	selenium
SE	standard error of the mean
SERAM	Stack Emission Reduction and Monitoring Project
SF	slope factor
SIE	specific ion electrode
SLF	sanitary landfill
SMCL	secondary maximum contaminant level
SO	sulfur dioxide
SOP	standard operating procedure
SPAD	Steam Plant Ash Disposal
SPCC	Spill Prevention, Control, and Countermeasures
SPWTF	Steam Plant Wastewater Treatment Facility
Sr	strontium
STP	sewage treatment plant
SW	southwest
SWDF	solid waste disposal facility
SWMU	solid waste management unit
SWSA	solid waste storage areas
Tc	technetium
TCLP	toxicity characteristic leaching procedure
TCMP	toxicity control and monitoring program
TDC	Tennessee Department of Conservation
TDEC	Tennessee Department of Environment and Conservation (formerly TDC)
TDS	total dissolved solids
Th	thorium

TOC	total organic carbon
TOX	total organic halogens
TRC	total residual chlorine
TRE	Toxicity Reduction Evaluation
TRK	Tennessee River kilometer
TRM	Tennessee River mile
TRU	transuranic
TRV	thermal relief valve
TSCA	Toxic Substances Control Act
TSF	Tower Shielding Facility
TSP	total suspended particulates
TSS	total suspended solids
TSWMA	Tennessee Solid Waste Management Act
TURF	Thorium-Uranium Process Facility
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
U	uranium
UEFPC	Upper East Fork Poplar Creek
UEFPCHR	Upper East Fork Poplar Creek Hydrogeologic Regime
UF	uranium hexafluoride
UNC	United Nuclear Corporation
USGS	United States Geological Survey
UST	underground storage tank
VC7002	Vehicle Cleaning Facility
VOA	volatile organic aromatics
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area grouping
WCK	White Oak Creek kilometer
WCPA	Waste Coolant Processing Area
WCPF	Waste Coolant Processing Facility
WETF	West End Treatment Facility
WIPP	Waste Isolation Pilot Plant
WMA	Waste Management Area
WMCBF	Waste Machine Coolant Biodegradation Facility
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
WOD	White Oak Dam
WOL	White Oak Lake
WOM	White Oak Mountain
WSW	west–southwest
WTF	Waste Treatment Facility
Xe	xenon
Y-12 Plant	Oak Ridge Y-12 Plant

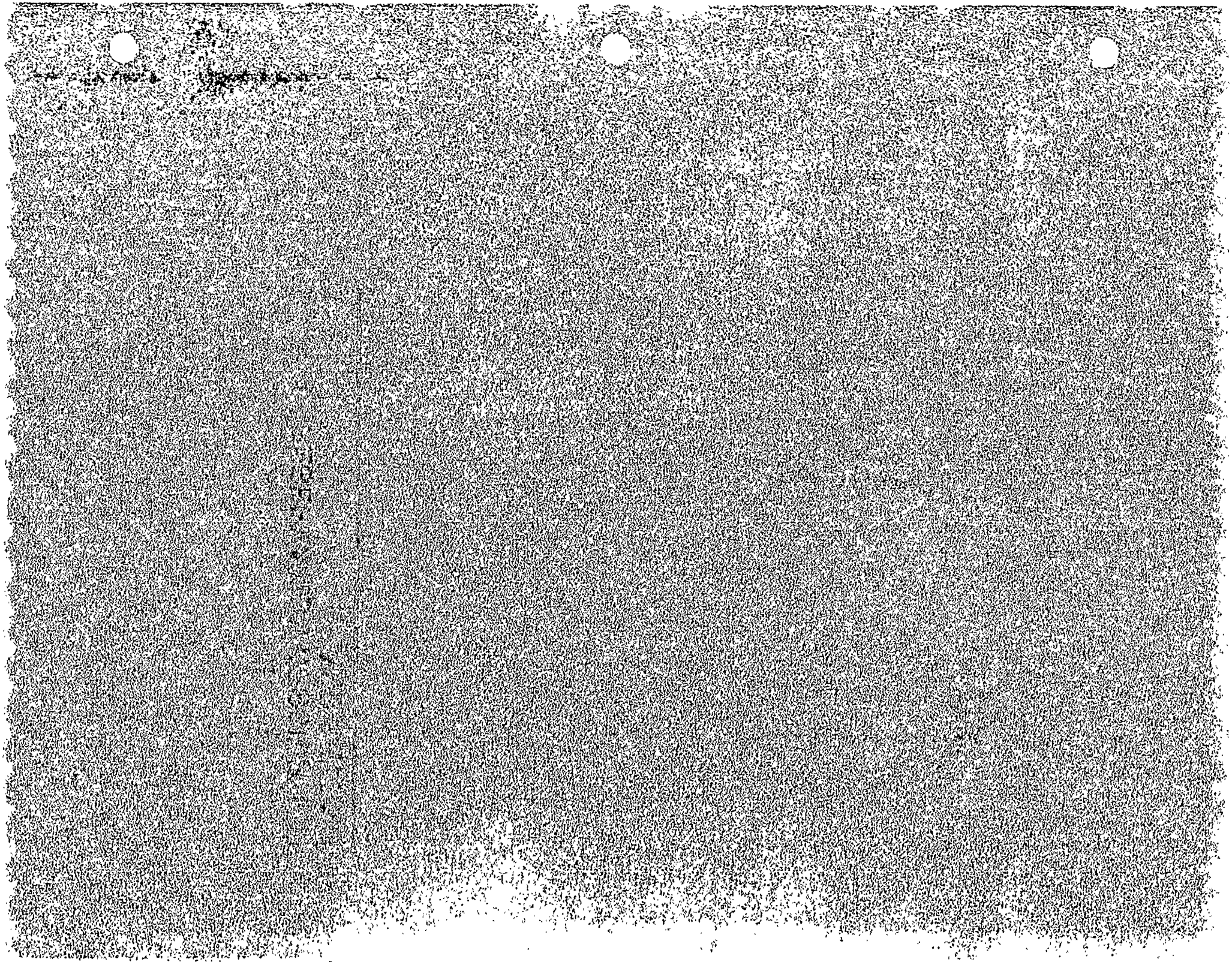
UNITS

µCi	microcurie
µg	microgram
Bq	Becquerel
Btu	British thermal unit
cfm	cubic feet per minute
Ci	curie
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
CY	calendar year
d	day
ft	foot
ft^2	square foot
ft^3	cubic foot
FY	fiscal year
g	gram
gal	gallon
gpd	gallons per day
gpm	gallons per minute
h	hour
ha	hectare
in.	inch
kg	kilogram
km	kilometer
km^2	square kilometer
L	liter
lb	pound
m	meter
M	million
m^2	square meter
m^3	cubic meter
mCi	millicurie
mg	milligram
Mgd	million gallons per day
mil	1/1000 in.
$mile^2$	square mile
min	minute
mL	milliliter
mm	millimeter
mrad	millirad
mrem	millirem
NTU	nephelometric turbidity unit
pCi	picocurie
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
psi	pounds per square inch
R	roentgen
s	second
SU	standard unit
°C	degrees celsius
°F	degrees Fahrenheit
yd^3	cubic yard

CONVERSION TABLE

Multiply	By	To obtain	Multiply	By	To obtain
acre	0.405	ha	ha	2.47	acres
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mile	1.61	km	km	0.621	mile
lb	0.4536	kg	kg	2.205	lb
liq qt-U.S.	0.946	L	L	1.057	liq qt-U.S.
ft^2	0.093	m^2	m^2	10.764	ft^2
$mile^2$	2.59	km^2	km^2	0.386	$mile^2$
ft^3	0.028	m^3	m^3	35.31	ft^3
Bq	27	pCi	pCi	0.037	Bq
nCi	1×10^3	pCi	pCi	1×10^{-3}	nCi
dpm/L	0.45×10^{-9}	$\mu Ci/cm^3$	$\mu Ci/cm^3$	2.22×10^9	dpm/L
pCi/L (water)	10^{-9}	µCi/mL (water)	µCi/mL (water)	10^9	pCi/L (water)
pCi/m^3 (air)	10^{-12}	$\mu Ci/cm^3$ (air)	$\mu Ci/cm^3$	10^{12}	pCi/m^3 (air)
mCi/km^2	1	nCi/m^2	nCi/m^2	1	mCi/km^2
sievert (Sv)	100	rem	rem	0.01	sievert (Sv)

1. RESERVATION DESCRIPTION AND SETTING



1. RESERVATION DESCRIPTION AND SETTING

The first two volumes of this report present data and supporting narratives regarding the impact of the U.S. Department of Energy's (DOE's) Oak Ridge Reservation (ORR) on its surrounding environs and the public during 1991. Volume 1 includes all narrative descriptions, summaries, and conclusions and is intended to be a "stand-alone" report for the reader who does not want to review in detail all of the 1991 data for the ORR. Volume 2 includes the detailed data in formats that ensure all the environmental data are represented. Narratives are not included in Vol. 2. The information in Vol. 2 is addressed and analyzed in Vol. 1. For this reason, Vol. 2 cannot be considered a stand-alone report but is intended to be used in conjunction with Vol. 1.

Table 1.1. Administrative[a] units on the ORR in 1991

Description	Area	
	Hectares	Acres
Oak Ridge Reservation[b]	12,684	31,343
Oak Ridge Y-12 Plant	328	811
Oak Ridge National Laboratory	445	1,100
Oak Ridge K-25 Site	688	1,700
Oak Ridge Associated Universities[c]	121	298
Total	14,266	35,252

[a]Administrative units are those units that are managed by a major installation or by central Energy Systems.

[b]The Oak Ridge Reservation actually encompasses all of the contiguous land owned by DOE in the Oak Ridge area; however, as an "administrative unit," it is all of the land area not controlled by the other units. Each unit includes some land outside the designated fenced area. The total combined fenced area of the three major facilities is 810 ha (2000 acres).

[c]Oak Ridge Associated Universities manages the Scarboro Facility as well as other facilities within the Oak Ridge area.

Table 1.2. Populations of central East Tennessee towns[a]

Town/city	Population
Anderson County	
Clinton	8,972
Lake City	2,166
Norris	1,303
Oak Ridge	27,310
Oliver Springs	3,433
Blount County	
Friendsville	792
Alcoa	6,400
Maryville	19,208
Knox County	
Knoxville	165,121
Loudon County	
Greenback	611
Lenoir City	6,147
Loudon	4,026
Morgan County	
Wartburg	932
Roane County	
Harriman	7,119
Kingston	4,552
Rockwood	5,348
Sevier County	
Sevierville	7,178
Union County	
Luttrell	812
Maynardville	1,298
Campbell County	
Caryville	1,751
Jellico	2,447
Jacksboro	1,568
LaFollette	7,192

[a]*Source: 1990 Census of Population and Housing Public Law 94–171 Data*, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., April 1991.

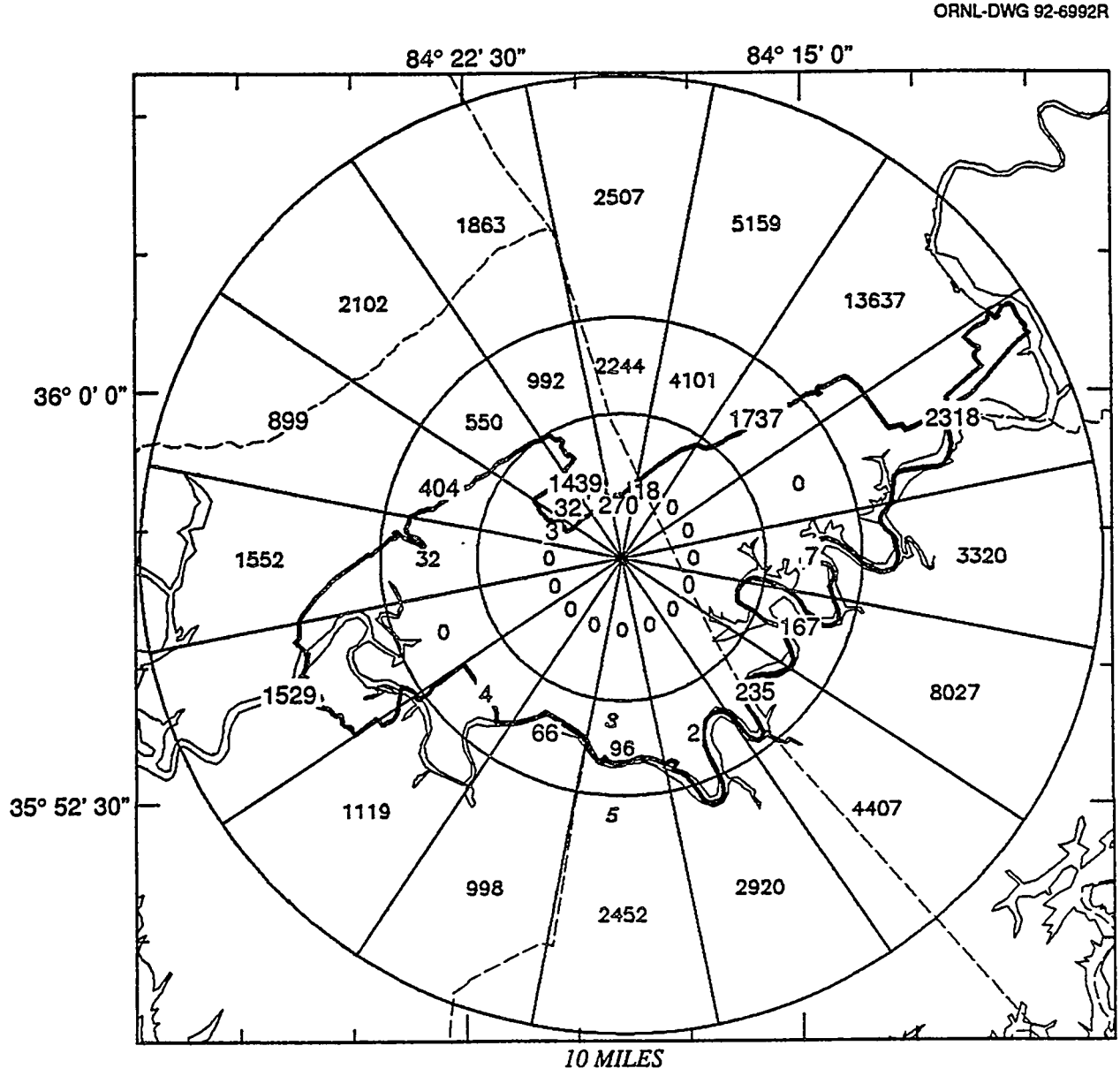


Fig. 1.1. Projected 1991 population levels within 16 km (10 miles) of the center of the Oak Ridge Reservation, by sector and based on 1990 census data (U.S. Department of Commerce 1991, Vol. 1).

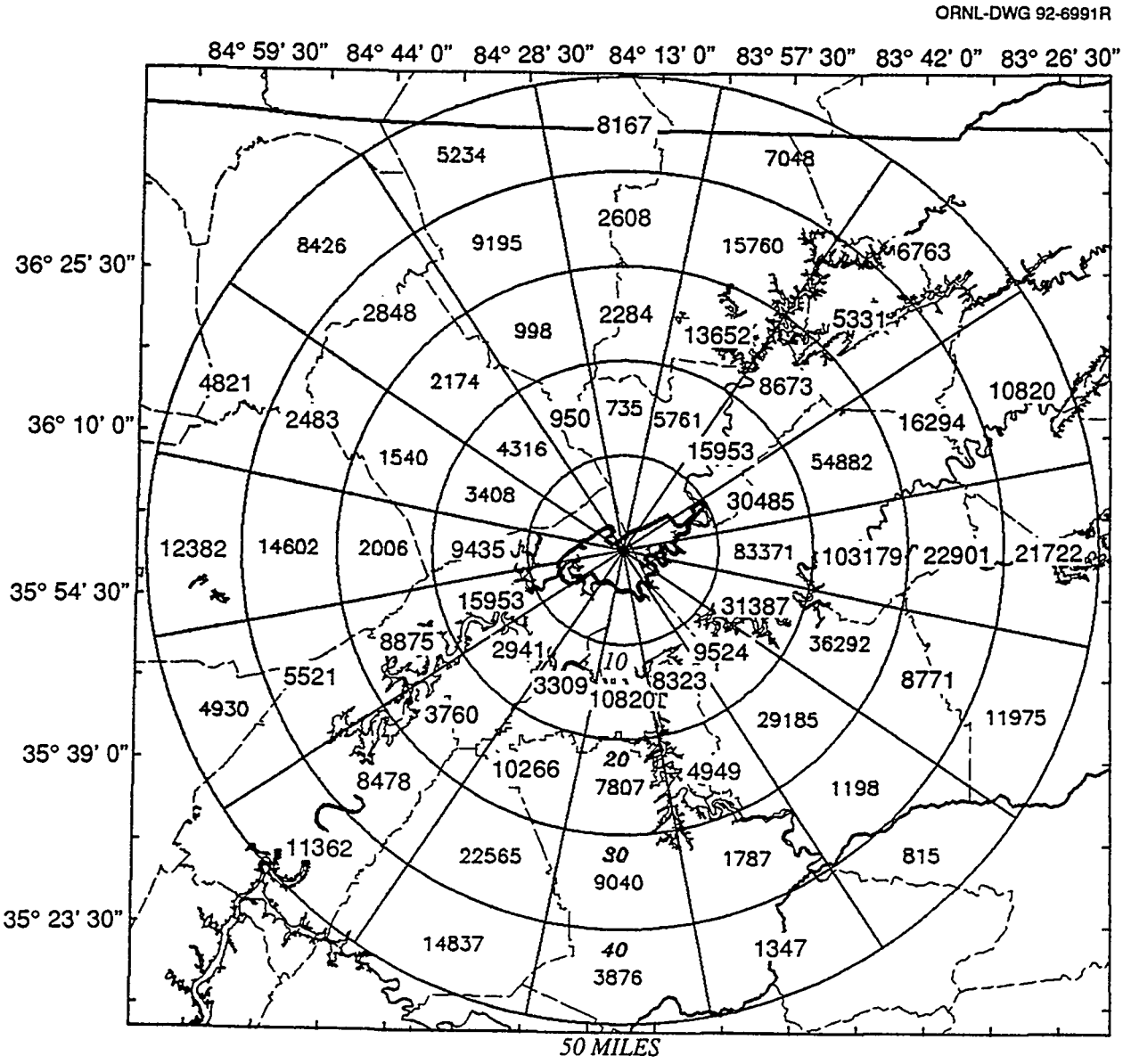


Fig. 1.2. Projected 1991 population levels within 80 km (50 miles) of the center of the Oak Ridge Reservation, by sector and based on 1990 census data (U.S. Department of Commerce 1991, Vol. 1).

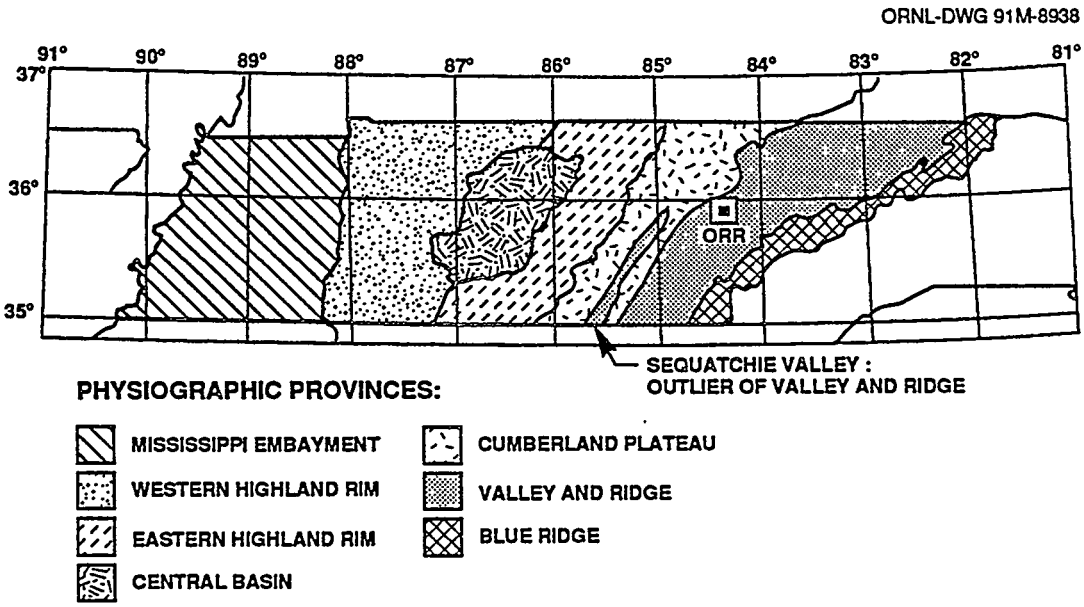


Fig. 1.3. Physiographic map of Tennessee.

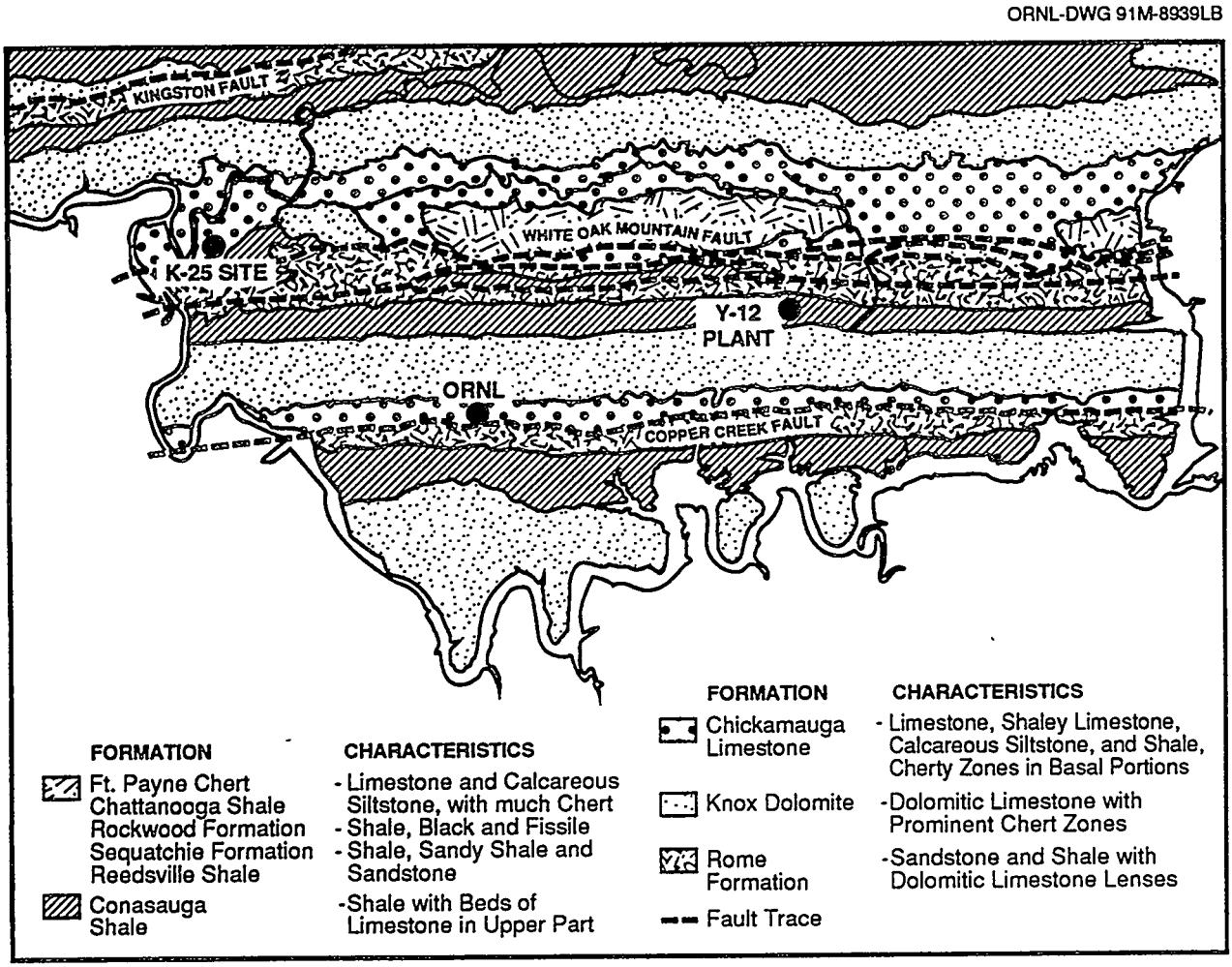


Fig. 1.4. Geologic map of the Department of Energy's Oak Ridge Reservation.

Table 1.3. Use classifications for the Clinch River and its tributaries on the ORR[a]

Stream	Description	DOM[b]	IND[c]	FISH[d]	REC[e]	IRR[f]	LW&W[g]	NAV[h]
Clinch River	km 7.0–19.2 (Poplar Creek)	✓	✓	✓	✓	✓	✓	✓
Poplar Creek	km 0.0–0.8		✓	✓	✓	✓	✓	
Poplar Creek	km 0.8–2.1			✓		✓	✓	
Poplar Creek	km 2.1–8.8			✓	✓	✓	✓	
East Fork Poplar Creek	km 0.0–7.7			✓	✓	✓	✓	
Bear Creek	km 0.0–origin			✓	✓	✓	✓	
East Fork Poplar Creek	km 7.7–13.3			✓		✓	✓	
East Fork Poplar Creek	km 13.3–dam at Y-12 Plant			✓	✓	✓	✓	
Poplar Creek	km 8.8–19.8			✓	✓	✓	✓	
Poplar Creek	km 19.8–23.0			✓		✓	✓	
Indian Creek	At Poplar Creek (km 22.9); km 0.0–origin			✓	✓	✓	✓	
Poplar Creek	km 23.0–origin			✓	✓	✓	✓	
Clinch River	km 19.2–32.0	✓	✓	✓	✓	✓	✓	
White Oak Creek	km 0.0–origin			✓	✓		✓	
Melton Branch	km 0.0–origin			✓			✓	
Clinch River	km 32.0–63.4	✓	✓	✓	✓	✓	✓	✓
Clinch River	km 63.4–65.8	✓	✓	✓	✓	✓	✓	✓
Scarboro Creek	km 0.0–1.6			✓	✓	✓	✓	
Scarboro Creek	km 1.6–2.1			✓		✓	✓	
Scarboro Creek	km 2.1–origin			✓	✓	✓	✓	
Clinch River	km 65.8–74.7	✓	✓	✓	✓	✓	✓	✓
All other tributaries in the Clinch River basin, named and unnamed, that have not been specifically treated shall be classified				✓	✓	✓	✓	

[a]*Source:* "Use Classifications for Surface Waters," Chapter 1200-4-4 in *State of Tennessee Water Quality Standards*, Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, December 1991.

[b]DOM = Domestic water supply.

[c]IND = Industrial water supply.

[d]FISH = Fish and aquatic life.

[e]REC = Recreation.

[f]IRR = Irrigation.

[g]LW&W = Livestock watering and wildlife.

[h]NAV = Navigation.

2. POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

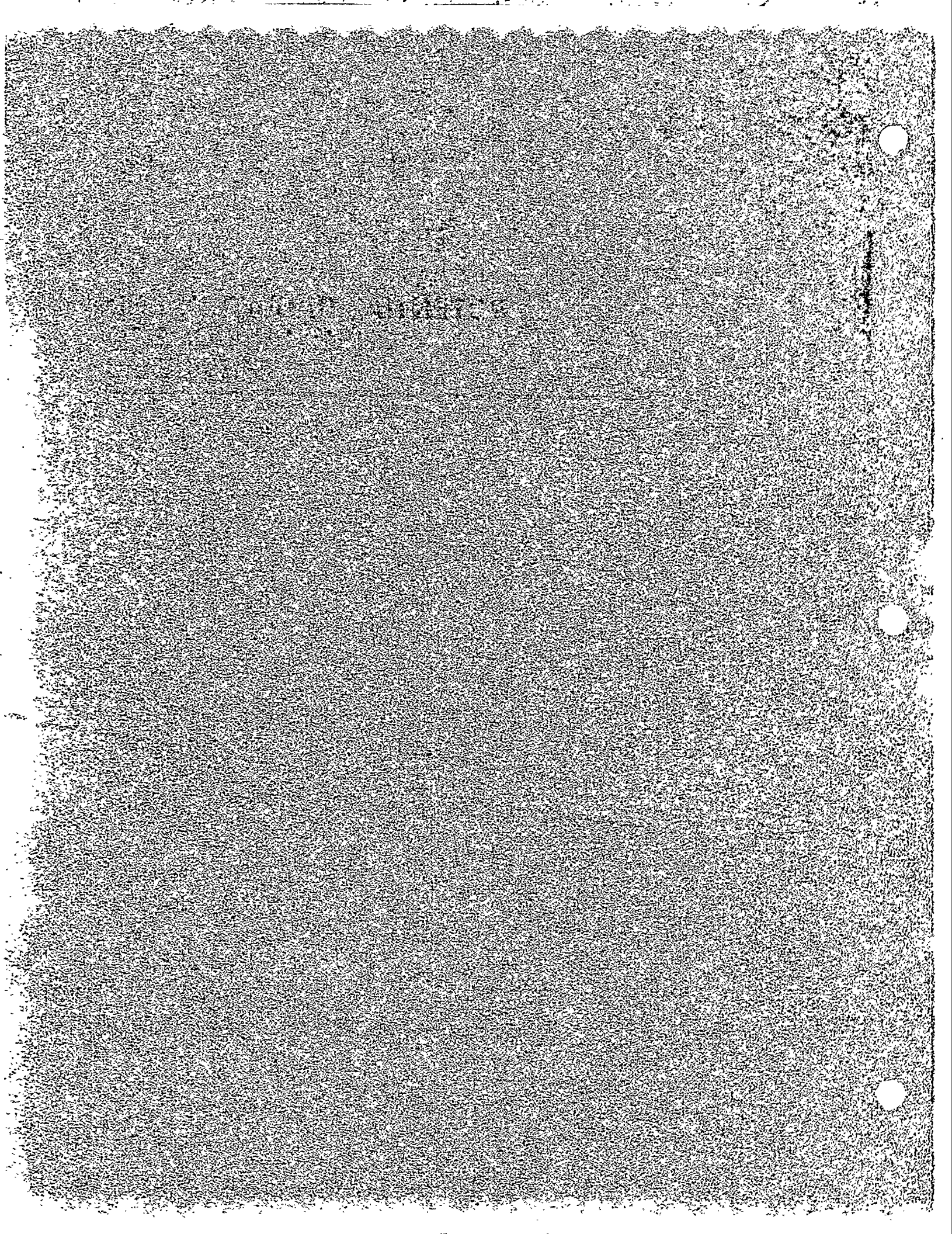


Table 2.1. Internal effective dose equivalent conversion factors (rem/μCi)[a]

Radionuclide (solubility)[b]		Inhalation[c]	Ingestion
^{3}H	(G)	1.26E–4	8.99E–5
^{60}Co	(Y)	2.18E–1	9.86E–3
^{85}Kr	(G)	6.72E–7	0
^{90}Sr	(D)	2.22E–1	1.30E–1
^{99}Tc	(D)	1.03E–3	1.45E–3
	(W)	8.39E–3	1.45E–3
^{106}Ru	(Y)	4.78E–1	2.70E–2
^{132}Te	(W)	8.08E–3	9.44E–3
^{129}I	(D)	1.74E–1	2.61E–1
^{131}I	(D)	3.30E–2	5.06E–2
^{133}I	(D)	5.92E–3	9.99E–3
^{135}I	(D)	1.37E–3	2.34E–3
^{133}Xe	(G)	6.69E–7	0.00E+0
^{134}Cs	(D)	4.51E–2	6.74E–2
^{137}Cs	(D)	3.10E–2	4.61E–2
^{140}La	(W)	5.46E–3	8.40E–3
^{154}Eu	(W)	2.88E–1	9.56E–3
^{155}Eu	(W)	4.18E–2	1.53E–3
^{191}Os	(Y)	4.34E–3	2.30E–3
^{212}Pb	(D)	1.70E–1	4.47E–2
^{228}Th	(Y)	2.55E+2	1.89E–1
^{230}Th	(Y)	2.52E+2	5.25E–1
^{232}Th	(Y)	3.63E+2	4.78E–1
^{234}Th	(Y)	3.60E–2	1.37E–2
^{234m}Pa	(W)	3.77E–6	5.90E–6
^{234}U	(D)	2.67E+0	2.74E–1
	(W)	7.94E+0	2.74E–1
	(Y)	1.32E+2	2.58E–2
^{235}U	(D)	2.54E+0	2.64E–1
	(W)	7.37E+0	2.64E–1
	(Y)	1.22E+2	2.66E–2
^{236}U	(D)	2.53E+0	2.60E–1
	(W)	7.51E+0	2.60E–1
	(Y)	1.25E+2	2.44E–2
^{238}U	(D)	2.40E+0	2.47E–1
	(W)	7.05E+0	2.47E–1
	(Y)	1.18E+2	2.35E–2
^{237}Np	(W)	4.91E+2	4.01E+0
^{238}Pu	(Y)	3.18E+2	3.85E+0
^{239}Pu	(Y)	3.42E+2	4.46E–1

[a]Factors taken from the ALLRAD88 data file provided with CAP-88. See Beres (1990), Sect. 2, Vol. 1.

[b]D = soluble; W = moderately soluble; Y = insoluble; and G = gas.

[c]For AMAD of 1.0 μm.

Table 2.2. External dose equivalent rate conversion factors[a]

Radionuclide	Immersion[b]	Ground surface[c]
^{3}H	0.00E+0	0.00E+0
^{60}Co	1.29E+10	2.26E+6
^{85}Kr	1.11E+7	2.28E+3
^{90}Sr	0.00E+0	0.00E+0
^{99}Tc	2.55E+3	6.03E-1
^{106}Ru	0.00E+0	0.00E+0
^{132}Te	1.07E+9	2.43E+5
^{129}I	4.06E+7	2.14E+4
^{131}I	1.89E+9	3.99E+5
^{133}I	3.05E+9	6.11E+5
^{135}I	8.29E+9	1.44E+6
^{133}Xe	1.69E+8	4.91E+4
^{134}Cs	8.01E+9	1.58E+2
^{137}Cs	0.00E+0	0.00E+0
^{140}La	1.23E+4	2.13E+2
^{154}Eu	6.45E+9	1.20E+6
^{155}Eu	2.76E+8	6.89E+4
^{191}Os	3.35E+8	8.20E+4
^{212}Pb	7.23E+8	1.61E+5
^{228}Th	9.59E+6	2.70E+3
^{230}Th	1.90E+6	8.88E+2
^{232}Th	9.05E+5	6.57E+2
^{234}Th	3.73E+7	9.71E+3
^{234m}Pa	5.93E+7	1.12E+4
^{234}U	7.46E+5	8.00E+2
^{235}U	7.51E+8	1.67E+5
^{236}U	5.90E+5	7.27E+2
^{238}U	5.06E+5	6.41E+2
^{237}Np	1.11E+8	3.14E+4
^{238}Pu	4.34E+5	8.53E+2
^{239}Pu	4.00E+5	3.75E+2

[a]Factors taken from the ALLRAD88 data file provided with CAP-88. See Beres (1990), Sect. 2, Vol. 1.

[b]Units for immersion in air are mrem/year per $\mu Ci/cm^3$.

[c]Units for contaminated ground surface are mrem/year per $\mu Ci/cm^2$.

Table 2.3. Activities (Ci), solubilities, and particle sizes (AMAD, μm) of radionuclides released from ORNL during 1991

Nuclide	Sol. class	AMAD	2026	3020	3039	7025	7512	7911	7830	Total
^{3}H	G	0			1.58E+4	1.50E+2		1.64E+1		1.60E+4
^{7}Be	Y	1.0			6.46E–6				2.21E–7	6.68E–6
^{60}Co	Y	1.0	6.44E–6		1.89E–4					1.95E–4
^{82}Br	D	1.0	8.84E–4							8.84E–4
^{83m}Kr	G	0						7.53E+1		7.53E+1
^{85}Kr	G	0			4.80E+3					4.80E+3
^{85m}Kr	G	0						1.78E+2		1.78E+2
^{87}Kr	G	0						3.60E+2		3.60E+2
^{88}Kr	G	0						5.09E+2		5.09E+2
^{89}Kr	G	0						6.46E+2		6.46E+2
^{90}Sr	D	1.0	1.00E–6	7.76E–7	3.12E–5			6.73E–7	1.12E–8	3.37E–5
^{129}I	D	1.0							4.20E–6	4.20E–6
^{131}I	D	1.0					2.07E–6	4.62E–2		4.62E–2
^{132}I	D	1.0						5.15E–5		5.15E–5
^{133}I	D	1.0						6.16E–2		6.16E–2
^{134}I	D	1.0						5.15E–5		5.15E–5
^{135}I	D	1.0						3.30E–2		3.30E–2
^{133}Xe	G	0						9.08E+2		9.08E+2
^{133m}Xe	G	0						2.82E+1		2.82E+1
^{135}Xe	G	0						2.92E+1		2.92E+1
^{135m}Xe	G	0						1.60E+2		1.60E+2
^{138}Xe	G	0						8.76E+2		8.76E+2
^{137}Cs	D	1.0	9.77E–6	2.70E–6	5.62E–5			2.95E–6	1.14E–7	7.17E–5
^{138}Cs	D	1.0						2.88E–4		2.88E–4
^{137m}Ba	D	1.0	9.77E–6	2.70E–6	5.62E–5			2.93E–6	1.14E–7	7.17E–5
^{191}Os	Y	1.0	1.01E–5	2.12E–6	3.98		2.97E–5	1.25E–5	1.56E–6	3.98
^{194}Au	E	0			3.36E–3					3.36E–6
^{212}Pb	D	1.0	3.80E–2	3.82E–2	1.47E–1		4.13E–4	1.65E–2	8.03E–4	2.41E–1
^{228}Th	Y	1.0	3.24E–8	4.99E–9	4.36E–9				1.31E–10	4.19E–8
^{230}Th	Y	1.0	3.41E–9	5.17E–9	3.85E–9			1.68E–9	1.18E–10	1.41E–8
^{232}Th	Y	1.0	1.70E–9	2.93E–9	4.86E–9			1.76E–9	1.06E–10	1.14E–8
$^{234}U^{a}$	Y	1.0	1.92E–8	1.19E–8	8.15E–9			2.17E–8	1.33E–8	7.43E–8
^{238}Pu	Y	1.0	4.72E–8	2.54E–8						7.26E–8
^{239}Pu	Y	1.0	1.59E–7	2.00E–7						3.59E–7

[a]All uranium emissions were assumed to be Y-class ^{234}U.

Table 2.4. Activities (Ci), solubilities, and AMADs (μm) of radionuclides emitted from the K-25 Site during 1991

Nuclide	Sol. class	AMAD (μm)	Total curies released			
			K-1435	K-1420	K-1015	Total
^{57}Co	Y	1.0	4.15E–7			4.15E–7
^{95}Nb	Y	1.0	1.46E–6			1.46E–6
^{137}Cs	D	1.0	5.52E–4		4.73E–8	5.52E–4
^{137m}Ba	D	1.0	5.52E–4		4.73E–8	5.52E–4
^{237}Np	W	1.0	8.13E–4			8.14E–4
^{234m}Pa	Y	1.0	1.73E–1			1.73E–1
^{238}Pu	Y	1.0			4.26E–8	4.26E–8
^{239}Pu	Y	1.0	5.38E–5			5.38E–5
^{99}Tc	W	1.0	3.95E–2			3.95E–2
^{228}Th	Y	0.3	2.66E–3			2.66E–3
^{230}Th	Y	0.3	8.41E–5			8.41E–5
^{232}Th	Y	0.3	1.52E–5			1.52E–5
^{234}Th	Y	0.3	4.73E–2			4.73E–2
^{234}U	Y	0.3	1.05E–2	1.78E–8	2.34E–7[a]	1.05E–2
^{235}U	Y	1.0	4.61E–4	6.49E–10		4.61E–4
^{236}U	Y	1.0		3.99E–11		3.99E–11
^{238}U	Y	0.3	1.33E–2	3.26E–9		1.33E–2

[a]All emissions of uranium from K-1015 were assumed to be Y-class ^{234}U.

Table 2.5. Activities (Ci), solubilities, and AMADs (μm) of radionuclides emitted from the Y-12 Plant during 1991[a]

Nuclide	AMAD (μm)	Solubility class			
		D	W	Y	All
^{234}U	1.0	1.15E–2	1.74E–2	2.42E–2	5.32E–2
^{235}U	1.0	3.57E–4	5.41E–4	7.58E–4	1.66E–3
^{236}U	1.0	4.80E–5	7.24E–5	9.88E–5	2.19E–4
^{238}U	1.0	6.66E–5	4.88E–6	7.28E–3	7.35E–3
Total		1.20E–2	1.80E–2	3.24E–2	6.24E–2

[a]Does not include 1.6 Ci of ^{85}Kr emitted from building 9735.

Table 2.6. Radionuclide discharges from White Oak Dam during 1991

Radionuclide	Discharge (Ci)
^{3}H	2500
^{60}Co	0.17
Total Sr[a]	3.2
^{137}Cs	1.8

[a]Taken to be ^{90}Sr.

Table 2.7. Estimated radionuclide concentrations (pCi/L) in water

Location	Upper CR[a] (Gallaher[b])	Lower CR[a] (Kingston[c])	Watts Bar (Rockwood[d])	Chickamauga (Dayton[e], Soddy-Daisy/ Falling Water[f])
		Method 1		
^{3}H	2100[g]	0[h]	0[i]	0[i]
^{60}Co	0[g]	0[h]	0[i]	0[i]
Total Sr[j]	0.78[g]	0.54[h]	0.078[i]	0.071[i]
^{137}Cs	0[g]	0[h]	0[i]	0[i]
Total U[k]	0[g]	0.19[h]	0.027[i]	0.025[i]
		Method 2		
^{3}H	420[l]	420[l]	100[i]	94[i]
^{60}Co	0.029[l]	0.029[l]	0.0070[i]	0.0064[i]
Total Sr[j]	0.54[l]	0.54[l]	0.13[i]	0.12[i]
^{137}Cs	0.30[l]	0.30[l]	0.074[i]	0.068[i]
Total U[k]	*m*	*m*	0[i]	0[i]

[a]CR = Clinch River.
[b]DOE drinking water plant serving 4000 persons.
[c]Public water supply serving 6841 persons.
[d]Public water supply serving 7387 persons.
[e]Public water supply serving 9605 persons.
[f]Public water supply serving 9742 persons.
[g]From Table 4.56 in Vol. 2.
[h]From Table 4.57 in Vol. 2.
[i]Calculated by diluting lower CR values with the Tennessee River flow.
[j]Taken to be ^{90}Sr.
[k]Taken to be ^{234}U.
[l]Calculated by dividing White Oak Dam discharge (Table 2.6 in Vol. 2) by the Clinch River flow (5.9×10^{12} L).
[m]No value reported.

Table 2.8. Estimated radionuclide concentrations (pCi/g) in fish

Location	Upper CR[a]	Lower CR[a]	Watts Bar	Chickamauga
		Method 1		
^{3}H	*b*	*b*	*b*	*b*
^{60}Co	0.0022[c]	0[c]	0[d]	0[d]
Total Sr[e]	0.026[c]	0.0051[c]	0.00074[d]	0.00067[d]
^{137}Cs	0.17[c]	0.074[c]	0.011[d]	0.0097[d]
		Method 2[f]		
^{3}H	0.42	0.42	0.10	0.094
^{60}Co	0.0086	0.0085	0.0021	0.0019
Total Sr[e]	0.032	0.032	0.0079	0.0072
^{137}Cs	0.61	0.60	0.15	0.14

[a]CR = Clinch River.
[b]No value reported.
[c]From Table 6.5 in Vol. 2.
[d]Calculated using lower CR values and Tennessee River flow.
[e]Taken to be ^{90}Sr.
[f]Calculated using LADTAP-XL methodology. See Hamby (1991), Sect. 2, Vol. 1.

Table 2.9. Radionuclide concentrations in the leopard frog and the bullfrog near Basin 3524 (Bq/kg dry weight)[a]

Frog sample number	^{241}Am	^{244}Cm	^{60}Co	^{137}Cs	^{238}Pu	^{239}Pu	^{90}Sr	^{152}Eu	^{154}Eu	^{155}Eu
1-C	8.4 ± 7.8	−4.5 ± 5.1	83.0 ± 34.0	5,400.0 ± 2,000.0	3.9 ± 6.6	−2.7 ± 3.9	30,000.0 ± 1,000.0	*b*	*b*	*b*
2-C	8.3 ± 5.1	1.9 ± 3.7	290.0 ± 80.0	21,000.0 ± 1,000.0	23.0 ± 9.0	60.0 ± 12.0	20,000.0 ± 1,000.0	430.0 ± 280.0	*b*	*b*
3-C	6.6 ± 4.0	1.5 ± 2.9	390.0 ± 160.0	8,000.0 ± 400.0	*b*	*b*	8,500.0 ± 300.0	*b*	*b*	*b*
4-C	12.0 ± 3	10.0 ± 3	73.0 ± 5	8,700.0 ± 100	4.0 ± 1	8.0 ± 1	32,000.0 ± 1,000	190.0 ± 30	67.0 ± 20	*b*
5-C	23.0 ± 4	10.0 ± 3	87.0 ± 6	5,500.0 ± 100	10.0 ± 1	33.0 ± 3	9,600.0 ± 100	450.0 ± 40	160.0 ± 20	45.0 ± 14
6-C	22.0 ± 3	8.0 ± 2 (and ^{241}Cm)	38.0 ± 4	5,100.0 ± 100	5.0 ± 1	18.0 ± 2	8,700.0 ± 100	160.0 ± 20	68.0 ± 20	16.0 ± 11

[a]Multiply by 0.027 to convert from Bq/kg to pCi/g.
[b]Not detected.

3. AIRBORNE DISCHARGES, AMBIENT AIR MONITORING, METEOROLOGICAL MONITORING, AND EXTERNAL GAMMA RADIATION

Table 3.1. Air permits at the Y-12 Plant

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
FUGITIVE EMISSION SOURCE	01-1020-89	029891P	Fugitive air emission at the Y-12 Plant	O
Y-9201-1-A(01)	01-0020-15	730303P	Wleding booths	O
Y-9201-1-A(02)	01-0020-15	730303P	Welding Shop	O
Y-9201-1-A(04)	01-0020-15	730303P	Metal fabrication shop	O
Y-9201-1-A(05)	01-0020-15	730303P	Welding shop	O
Y-9201-1-A(15)	01-0020-15	730303P	Metal fabrication shop	O
Y-9201-1-A(19)	01-0020-15	730303P	Welding hood exhaust	O
Y-9201-1-B(16)	01-0020-59	730310P	Tool grinding machines	O
Y-9201-1-B(18)	01-0020-59	730310P	Snadblaster exhaust	O
Y-9201-1-C(3)	01-0020-17	730304P	Graphitic carbon machining	O
Y-9201-1-C(4)	01-0020-17	730304P	Graphitic carbon machining	O
Y-9201-1-D(09)	01-0020-61	730310P	Fabrication shop	O
Y-9201-1-D(10)	01-0020-61	730310P	Fabrication shop	O
Y-9201-1-D(11)	01-0020-61	730310P	Fabrication shop	O
Y-9201-1-D(13)	01-0020-61	730310P	Metal grinders and milling machines	O
Y-9201-1-[E]-(00)	01-1020-92	031880P	Lead machining operations	O
Y-9201-2-B(02)	01-0020-43	012887P	Acid wash station	O
Y-9201-2-C(01)	01-0020-67	015146P	Weld booth	O
Y-9201-2-C(02)	01-0020-67	015146P	Weld booth	O
Y-9201-2-C(03)	01-0020-67	015146P	Weld booth	O
Y-9201-3-A(01)	01-0020-55	013002F	Diesel generator	O
Y-9201-5-B(01)	01-0020-21	730305P	Machining operations L5N hood exhaust	O
Y-9201-5-B(02)	01-0020-21	730305P	Vacuum inlets L5E machining shop	O
Y-9201-5-B(03)	01-0020-21	730305P	Rubber-gel potting hoot exhaust	O
Y-9201-5-B(04)	01-0020-21	730305P	Palarite shop—machine exhaust	O
Y-9201-5-B(05)	01-0020-21	730305P	Tool grinding machines hood exhaust	O
Y-9201-5-B(06)	01-0020-21	730305P	Cleaning hood—equipment service	O
Y-9201-5-B(07)	01-0020-21	730305P	Electrochemical machine-stainless steel	O
Y-9201-5-C(01)	01-1020-43	025949P	Grinding/sanding and welding operations	O
Y-9201-5-D(01)	01-1020-44	025902P	Hood	O
Y-9201-5-D(02)	01-1020-44	025902P	Film dryer exhaust fume hood	O
Y-9201-5-E(01)	01-1020-70	025983P	BeO hot press	O
Y-9201-5-E(02)	01-1020-70	025983P	A53 hot press house vacuum	O
Y-9201-5-E(08)	01-1020-70	025983P	Room exaust	O
Y-9201-5-F(01)	01-0020-36	025973P	Carbon foam saw room	O
Y-9201-5-F(02)	01-0020-36	025973P	Carbon foam urethane mixing vat	O
Y-9201-5-F(03)	01-0020-36	025973P	Carbon foam mixing and pour room	O
Y-9201-5-F(04)	01-0020-36	025973P	Oven	O
Y-9201-5-F(05)	01-0020-36	025973P	Oven	O
Y-9201-5-G(01)	01-0020-44	730308P	Arc melt	O
Y-9201-5-G(02)	01-0020-44	730308P	DeVilbiss hood	O
Y-9201-5-G(03)	01-0020-44	730308P	Nitric acid dip tanks	O
Y-9201-5-G(04)	01-0020-44	730308P	Acid pickling tanks	O
Y-9201-5-G(05)	01-0020-44	730308P	Abrasive saws	O
Y-9201-5-G(06)	01-0020-44	730308P	Scrap metal recycle	O
Y-9201-5-G(07)	01-0020-44	730308P	Vapor Degreaser	O
Y-9201-5-H(01)	01-0020-16	026019P	Mixing process material	O
Y-9201-5-H(02)	01-0020-16	026019P	Setup and sample area	O
Y-9201-5-H(03)	01-0020-16	026019P	Vapor blaster	O
Y-9201-5-H(04)	01-0020-16	026019P	Nickel plating tank exhaust	O
Y-9201-5-H(05)	01-0020-16	026019P	Material handling	O
Y-9201-5-H(06)	01-0020-16	026019P	Material handling	O
Y-9201-5-H(07)	01-0020-16	026019P	Glove box & blending station	O
Y-9201-5-H(08)	01-0020-16	026019P	Inspection house vacuum	O
Y-9201-5N-A(01)	01-1020-18	730314P	Machine shop exhaust	O

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9201-5N-[B]-(239)	01-0020-30	030484P	Plating tanks and hoods	O
Y-9201-5N-[B]-(240)	01-0020-30	030484P	Plating tanks and hoods	O
Y-9201-5N-[B]-(241)	01-0020-30	030484P	Plating tanks and hoods	O
Y-9201-5N-[B]-(242)	01-0020-30	030484P	Incinerator	O
Y-9201-5N-[B]-(243)	01-0020-30	030484P	Grit blaster	O
Y-9201-5N-[B]-(244)	01-0020-30	030484P	Grit blaster and area exhaust	O
Y-9202-A-(20)	01-0020-06	031696P	Laboratory beryllium	O
Y-9202-A-(21)	01-0020-06	031696P	Laboratory	O
Y-9204-2-A(01)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(02)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(03)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(04)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(05)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(06)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(07)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(08)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(09)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(10)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(11)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(12)	01-0020-46	026107P	Storage tank	O
Y-9204-2-A(13)	01-0020-46	026107P	Storage tank	O
Y-9204-2-B	01-0020-45	012889P	Storage tank	O
Y-9204-2-B(14)	01-0020-71	025954P	Reduction cell	O
Y-9204-2-B(15)	01-0020-71	025954P	Reduction cell	O
Y-9204-2-B(16)	01-0020-71	025954P	Reduction cell	O
Y-9204-2-B(17)	01-0020-71	025954P	Reduction cell	O
Y-9204-2-B(18)	01-0020-71	025954P	Caustic scrubber exhaust	O
Y-9204-2-B(19)	01-0020-71	025954P	Caustic scrubber exhaust	O
Y-9204-2-B(20)	01-0020-71	025954P	Storage area	O
Y-9204-2-B(21)	01-0020-71	025954P	Reduction cell	O
Y-9204-2-B(22)	01-0020-71	025954P	Reduction cell	O
Y-9204-2-B(23)	01-0020-71	025954P	Caustic scrubber exhaust	O
Y-9204-2-B(24)	01-0020-71	025954P	Caustic scrubber exhaust	O
Y-9204-2-B(25)	01-0020-71	025954P	Lithium metal wash station	O
Y-9204-2-B(26)	01-0020-71	025954P	Cleaning Station	O
Y-9204-2-B(27)	01-0020-71	025954P	Lithium remelt oven	O
Y-9204-2-B(28)	01-0020-71	025954P	Reduction cell	O
Y-9204-2-C(29)	01-1020-19	025900P	Classified	O
Y-9204-2-C(30)	01-1020-19	025900P	Classified	O
Y-9204-2-C(31)	01-1020-19	025900P	Classified	O
Y-9204-2-C(32)	01-1020-19	025900P	Classified	O
Y-9204-2-C(33)	01-1020-19	025900P	Classified	O
Y-9204-2-C(34)	01-1020-19	025900P	Classified	O
Y-9204-2-C(35)	01-1020-19	025900P	Classified	O
Y-9204-2-C(36)	01-1020-19	025900P	Classified	O
Y-9204-2-C(37)	01-1020-19	025900P	Classified	O
Y-9204-2-C(38)	01-1020-19	025900P	Classified	O
Y-9204-2-C(39)	01-1020-19	025900P	Classified	O
Y-9204-2-C(40)	01-1020-19	025900P	Classified	O
Y-9204-2-C(41)	01-1020-19	025900P	Classified	O
Y-9204-2-C(42)	01-1020-19	025900P	Classified	O
Y-9204-2-C(43)	01-1020-19	025900P	Classified	O
Y-9204-2-C(44)	01-1020-19	025900P	Classified	O
Y-9204-2-C(45)	01-1020-19	025900P	Classified	O
Y-9204-2-C(46)	01-1020-19	025900P	Classified	O

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9204-2-C(47)	01-1020-19	025900P	Classified	O
Y-9204-2-C(48)	01-1020-19	025900P	Classified	O
Y-9204-2-C(49)	01-1020-19	025900P	Classified	O
Y-9204-2-C(50)	01-1020-19	025900P	Classified	O
Y-9204-2-C(51)	01-1020-19	025900P	Classified	O
Y-9204-2-D(52)	01-1020-57	025967P	Storage tanks	O
Y-9204-2-D(53)	01-1020-57	025967P	Station	O
Y-9204-2-D(54)	01-1020-57	025967P	Salvage vats	O
Y-9204-2-D(55)	01-1020-57	025967P	Storage tank	O
Y-9204-2-D(56)	01-1020-57	025967P	Lithium chloride crystallizer	O
Y-9204-2-D(57)	01-1020-57	025967P	Lithium chloride crystallizer	O
Y-9204-2-D(58)	01-1020-57	025967P	Neutralizer	O
Y-9204-2-D(59)	01-1020-57	025967P	3 lab hoods	O
Y-9204-2-D(60)	01-1020-57	025967P	Process tank	O
Y-9204-2-D(61)	01-1020-57	025967P	Lithium chloride crystallizer	O
Y-9204-2-D(62)	01-1020-57	025967P	Lithium hydroxide neutralizer	O
Y-9204-2-D(63)	01-1020-57	025967P	HCL head tanks	O
Y-9204-2-D(64)	01-1020-57	025967P	Process tanks	O
Y-9204-2-D(65)	01-1020-57	025967P	Process tank	O
Y-9204-2-D(66)	01-1020-57	025967P	Neutralizer	O
Y-9204-2-D(67)	01-1020-57	025967P	Neutralizer	O
Y-9204-2-E(68)	01-1020-55	730328P	Oven	O
Y-9204-2-E(69)	01-1020-55	730328P	Oven	O
Y-9204-2-E(70)	01-1020-55	730328P	Tungsten screener	O
Y-9204-2-E(71)	01-1020-55	730328P	Dry box vent	O
Y-9204-2-E(72)	01-1020-55	730328P	Glove boxes	O
Y-9204-2-E(73)	01-1020-55	730328P	Material handling	O
Y-9204-2-E(74)	01-1020-55	730328P	Glove boxes	O
Y-9204-2-E(75)	01-1020-55	730328P	Outgassing/annealing ovens	O
Y-9204-2-E(76)	01-1020-55	730328P	Material handling	O
Y-9204-2-E(77)	01-1020-55	730328P	Glove boxes	O
Y-9204-2-E(78)	01-1020-55	730328P	Reactor unloading station	O
Y-9204-2-E(79)	01-1020-55	730328P	Reactor unloading station	O
Y-9204-2-E(80)	01-1020-55	730328P	Glove boxes	O
Y-9204-2-E(81)	01-1020-55	730328P	Vacuum pump	O
Y-9204-2-F	01-0020-32	012874P	Storage tank	O
Y-9204-2-F(082)	01-0020-51	025897P	Classified	O
Y-9204-2-F(083)	01-0020-51	025897P	Classified	O
Y-9204-2-F(084)	01-0020-51	025897P	Classified	O
Y-9204-2-F(085)	01-0020-51	025897P	Classified	O
Y-9204-2-F(086)	01-0020-51	025897P	Classified	O
Y-9204-2-F(087)	01-0020-51	025897P	Classified	O
Y-9204-2-G(088)	01-1020-79	028350P	Inspection operation	O
Y-9204-2-G(089)	01-1020-79	028350P	Metal working machine shop hood—B-2	O
Y-9204-2-G(090)	01-1020-79	028350P	Metal working machine shop hood—B-2	O
Y-9204-2-H(492)	01-1020-42	025952P	Etching vats	O
Y-9204-2-H(493)	01-1020-42	025952P	Glue mixing	O
Y-9204-2E-A(436)	01-0020-68	730312P	Oven	O
Y-9204-2E-A(439)	01-0020-68	730312P	Hood exhaust	O
Y-9204-2E-A(441)	01-0020-68	730312P	Hood	O

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9204-2E-A(442)	01-0020-68	730312P	Hood	O
Y-9204-2E-A(443)	01-0020-68	730312P	Degreaser	O
Y-9204-2E-A(444)	01-0020-68	730312P	Electropolishers	O
Y-9204-2E-A(445)	01-0020-68	730312P	Surface coating	O
Y-9204-2E-A(448)	01-0020-68	730312P	Glovebox	O
Y-9204-2E-A(449)	01-0020-68	730312P	Storage tank	O
Y-9204-2E-B(12)	01-1020-41	025953P	X-ray testing	O
Y-9204-2E-B(14)	01-1020-41	025953P	Hoods	O
Y-9204-2E-B(15)	01-1020-41	025953P	Hoods	O
Y-9204-2E-C(12)	01-1020-68	730328P	Machine shop hood exhaust—B2E	O
Y-9204-2E-C(13)	01-1020-68	730328P	Machine shop hood exhaust—spec. shop	O
Y-9204-2E-[A]-(202)	01-1020-91	730938P	Positive ion accelerator	O
Y-9204-3-AJ-106	01-0020-89	018208P	Roof exhaust stack	O
Y-9204-4-A(02)	01-1020-56	032416P	Wash tank	O
Y-9204-4-A(03)	01-1020-56	032416P	Quench tanks	O
Y-9204-4-A(04)	01-1020-56	032416P	1000 ton press	O
Y-9204-4-A(05)	01-1020-56	032416P	7500 ton press	O
Y-9204-4-A(06)	01-1020-56	032416P	Exhaust from press pit area	O
Y-9204-4-A(07)	01-1020-56	032416P	Plasma torch cutting machine	O
Y-9204-4-A(08)	01-1020-56	032416P	Vacuum quench furnace	O
Y-9204-4-A(09)	01-1020-56	032416P	Ingot cooler	O
Y-9204-4-A(10)	01-1020-56	032416P	Exhaust from lathe	O
Y-9204-4-A(11)	01-1020-56	032416P	Grinding facility	O
Y-9204-4-A(12)	01-1020-56	032416P	Dye penetrant	O
Y-9204-4-A(13)	01-1020-56	032416P	Salt baths	O
Y-9204-4-A(14)	01-1020-56	032416P	Quench tanks	O
Y-9204-4-A(15)	01-1020-56	032416P	Preheat furnace exhaust	O
Y-9204-4-A(17)	01-1020-56	032416P	Oven exhaust	O
Y-9204-4-A(18)	01-1020-56	032416P	Vacuum furnace quench chamber	O
Y-9204-4-A(19)	01-1020-56	032416P	7500 ton press & 1500 ton press	O
Y-9204-4-B(481)	01-0020-72	730313P	Exhaust from machining operation	O
Y-9204-4-B(482)	01-0020-72	730313P	Exhaust from hood—reclamation area	O
Y-9204-4-B(484)	01-0020-72	730313P	Rooling mill—1st floor assembly	O
Y-9204-4-B(485)	01-0020-72	730313P	Exhaust from paint hood	O
Y-9204-4-B(486)	01-0020-72	730313P	Filtering exhaust from paing booths	O
Y-9204-4-B(488)	01-0020-72	730313P	Laboratory hoods—1st floor	O
Y-9204-4-B(489)	01-0020-72	730313P	Laboratory hoods—reclamation area	O
Y-9204-4-B(490)	01-0020-72	730313P	Assembly process—first floor	O
Y-9204-4-B(491)	01-0020-72	730313P	Assembly process—1st floor	O
Y-9204-4-C(01)	01-1020-36	025968P	Degreaser and welding booth	O
Y-9204-4-D(01)	01-1020-35	730317P	Exhaust hood	O
Y-9204-4-E(01)	01-0020-33	030819P	Plating equipment	O
Y-9204-4-E(02)	01-0020-33	025002P	Plating equipment	O
Y-9204-4-E(03)	01-0020-33	025002P	Plating equipment	O
Y-9204-4-E(04)	01-0020-33	025002P	Plating equipment	O
Y-9204-4-[A]-(88)	01-1020-56	032416P	Grit blast system	O
Y-9206-A(01)	01-0020-48	012892P	Storage tank—tank farm—8500 gal	O
Y-9206-A(02)	01-0020-48	012892P	Storage tank—tank farm—12,800 gal	O
Y-9206-A(03)	01-0020-48	012892P	Storage tank—tank farm—10,000 gal	O
Y-9206-C(01)	01-1020-24	730316P	Classified	O
Y-9206-C(02)	01-1020-24	730316P	Classified	O
Y-9206-D(13)	01-1020-38	025901P	Maintenance shop weld booth	O
Y-9206-E (NEW)	01-1020-24	730316P	Classified	O
Y-9206-[B]-(013)	01-0020-03	731689P	South stack, incinerator	O
Y-9206-[B]-(015)	01-0020-03	731689P	West stack	O

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9206-[B]-(016)	01-0020-03	731689P	Dissolving hood	O
Y-9206-[B]-(017)	01-0020-03	731689P	Steam cleaning hoods	O
Y-9206-[B]-(115)	01-0020-03	731689P	Reduction fluid bed	O
Y-9206-[B]-(135)	01-0020-03	731689P	AEC scrubber stack	O
Y-9206-[B]-(136)	01-0020-03	731689P	AED consolidated stack	O
Y-9206-[B]-(208)	01-0020-03	731689P	Conversion fluid bed	O
Y-9206-[B]-(209)	01-0020-03	731689P	HF purge vent	O
Y-9206-[B]-(210)	01-0020-03	731689P	Chemical make-up area	O
Y-9206-[B]-(211)	01-0020-03	731689P	Hood 29 and 30	O
Y-9206-[B]-(212)	01-0020-03	731689P	Dry vacuum system	O
Y-9212-B(01)	01-0020-02	730301P	U metal drying and briquetting process	O
Y-9212-B(02)	01-0020-02	730301P	Exhaust from chip wasing and drying	O
Y-9212-B(03)	01-0020-02	730301P	E-wing machine shop	O
Y-9212-B(04)	01-0020-02	730301P	U metal and U metal alloy casting	O
Y-9212-C(01)	01-0020-05	025984P	Drum receiving/sampling hood and glovebox	O
Y-9212-C(02)	01-0020-05	025984P	Tube furnace/gas purge vents	O
Y-9212-C(03)	01-0020-05	025984P	Sampling hoods and safe bottles/rm 1022	O
Y-9212-C(04)	01-0020-05	025984P	Dry hood/rm1021	O
Y-9212-C(05)	01-0020-05	025984P	Dissolver tray hoods/rm 1021	O
Y-9212-C(06)	01-0020-05	025984P	Dissolver hood	O
Y-9212-C(07)	01-0020-05	025984P	Dissolver trays/scrubber	O
Y-9212-C(08)	01-0020-05	025984P	Shear and saw hood/rm 1021	O
Y-9212-C(09)	01-0020-05	025984P	Precipitation process	O
Y-9212-D(01)	01-1020-46	025904P	Weld booths	O
Y-9212-F(01)	01-1020-49	730321P	Two deburr benches—hood exh.—A-wing	O
Y-9212-F(02)	01-1020-49	730321P	Two deburr benches—hood exh.—A-wing	O
Y-9212-F(03)	01-1020-49	730321P	Machining—hood exhaust—A-wing	O
Y-9212-F(04)	01-1020-49	730321P	Machining—hood exhaust—A-wing	O
Y-9212-F(05)	01-1020-49	730321P	Machining—hood exhaust—A-wing	O
Y-9212-G(01)	01-1020-47	028435P	Seal-peel pot	O
Y-9212-[A](027)	01-1020-72	997756P	D-wing, room 1010 hoods, rms 26 & 29	O
Y-9212-[A](028)	01-1020-72	997756P	Reduction, shear, and room 1010, EUCF	O
Y-9212-[A](033)	01-1020-72	997756P	Headhous equipment & incinerator	O
Y-9212-[A](040)	01-1020-72	997756P	B-1 sampling lab hoods	O
Y-9212-[A](042)	01-1020-72	997756P	Chloride removal sys./C-1 wing process ex.	O
Y-9212-[A](050)	01-1020-72	997756P	C-1 chip burner, enclosures, load hoods	O
Y-9212-[A](111)	01-1020-72	997756P	Reduction fluid beds	O
Y-9212-[A](112)	01-1020-72	997756P	Conversion fluids beds	O
Y-9212-[A](132)	01-1020-72	997756P	Decontamination facility	O
Y-9212-[A](430)	01-1020-72	997756P	HF dock cylinder/vaporizer purge vent	O
Y-9212-[A](431)	01-1020-72	997756P	N204 cylinder purge vent	O
Y-9215-A(01)	01-0020-37	731839P	Machine shop hood exhaust—M-wing	O
Y-9215-B(02)	01-0020-38	012880P	Turco pretreat spray hood	O
Y-9215-C(02)	01-1020-52	025948P	Hydroform exhaust	O
Y-9215-C(03)	01-1020-52	730323P	Vapor blaster/metal cleaner	O
Y-9215-C(10)	01-1020-52	730323P	Nickel plating—metal working exhaust	O
Y-9215-C(11)	01-1020-52	730323P	Exhaust	O
Y-9215-C(17)	01-1020-52	730323P	Rolling mill	O
Y-9215-C(19)	01-1020-52	730323P	Electric annealing oven	O
Y-9215-D(12)	01-1020-53	025966P	Rolling mill exhaust	O
Y-9215-D(13)	01-1020-53	025966P	Hood exhaust	O
Y-9215-D(14)	01-1020-53	025966P	Exhaust from rolling mill	O
Y-9215-D(15)	01-1020-53	025966P	Turret lathe & shear exhaust	O
Y-9215-E(6)	01-1020-54	025972P	Lab hood	O
Y-9215-E(7)	01-1020-54	025972P	Lab hoods	O

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9215-E(8)	01-1020-54	025972P	Lab hoods	O
Y-9215-[B]-(1)	01-1020-51	732125P	O-wing metal working operations	O
Y-9215-[B]-(2)	01-1020-51	732125P	O-wing metal working operations	O
Y-9215-[B]-(4)	01-1020-51	732125P	O-wing metal working operations	O
Y-9215-[B]-(6)	01-1020-51	732125P	O-wing metal working operations	O
Y-9401-2-[A]-(205)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(220)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(221)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(222)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(223)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(224)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(225)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(226)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(227)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(228)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(229)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(230)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(231)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(232)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(233)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(234)	01-0020-88	730286P	Plating equipment	O
Y-9401-2-[A]-(235)	01-0020-88	730286P	Plating equipment	O
Y-9401-3-A	01-1020-31	029322F	Coal fired boiler	O
Y-9401-3-B(1)	01-1020-32	029322F	Coal fired boiler	O
Y-9401-3-C	01-1020-33	029322F	Coal fired boiler	O
Y-9401-3-D(2)	01-1020-34	029322F	Coal fired boiler	O
Y-9401-3-G(01)	01-1020-61	026472P	Oil storage tank	O
Y-9401-3-G(02)	01-1020-61	026472P	Vent from lime silo	O
Y-9401-3-H(01) [9616-10]	01-1020-62	029280P	Sulfuric acid storage tank/20,000 gal	O
Y-9401-5-A(01)	01-0020-92	026108P	Uranium chip oxidizer	O
Y-9404-11-A(1)	01-1020-81	028426P	Purification plant	O
Y-9404-11-A(2)	01-1020-81	028426P	Purification plant	O
Y-9404-11-A(3)	01-1020-81	028426P	Purification plant	O
Y-9404-11-A(4)	01-1020-81	028426P	Purification plant	O
Y-9404-5-B(02)	01-0020-25	012866P	Spray room exhaust	O
Y-9404-5-B(03)	01-0020-25	012866P	Spray booth	O
Y-9404-7-FUG-A-(00)			PCB storage shed	
Y-9404-9-C(03)	01-0020-40	012882P	PVC curing ovens	O
Y-9404-9-D(04)	01-0020-40	012882P	PVC curing ovens	O
Y-9404-9-E(05)	01-0020-40	012882P	PVC curing ovens	O
Y-9616-6-FUG-A-(00)			Chemical storage	
Y-9616-7-A(01)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(02)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(03)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(04)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(05)	01-1020-74	026502P	West end treatment vent, reactor vessel	O
Y-9616-7-A(06)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(07)	01-1020-74	026502P	West end treatment vent, degassifer unit	O
Y-9616-7-A(08)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(09)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(10)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-A(11)	01-1020-74	026502P	West end treatment vent, lime silo	O
Y-9616-7-A(12)	01-1020-74	026502P	West end treatment storage tank	O
Y-9616-7-WST-[A]-(1)	01-1020-80	031254P	Vent from air stripper	O
Y-9620-2A	01-0020-50	012894P	Storage tank	O
Y-9623-A(01)	01-1020-25	025970P	Vent from reactor vessel	O
Y-9623-A(02)	01-1020-25	025970P	Vent from eight tanks	O

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9623-A(03)	01-1020-25	025970P	Lab hood	O
Y-9623-A(04)	01-1020-25	025970P	Lime silo	O
Y-9623-A(05)	01-1020-25	025970P	Storage tank	O
Y-9623-A(06)	01-1020-25	025970P	Storage tank	O
Y-9720-19-A(01)	01-0020-41	012885P	Curing oven	O
Y-9720-19-C(01)	01-0020-23	012864P	Teflon sintering oven	O
Y-9720-19-D(03)	01-0020-27	012869P	Plastics spray booth	O
Y-9720-20-A(01)	01-1020-39	025971P	Small maintenance shop—fabric filter	O
Y-9720-31-FUG-A-(00)	01-1020-89	029891P	Storage area	
Y-9720-32-SAS-[A]-201	01-0020-42	032547P	Classified waste shredder	O
Y-9720-5-ASM-[A]-(130)	01-1020-75	031958P	Hood @ 9720-5 east end	O
Y-9720-5-FAB-[B]-247	01-1020-85	031741P	Cleaning and packaging of uranium parts	O
Y-9720-58-FUG-A-(00)	01-1020-89	029891P	PCB storage shed	
Y-9720-6-A(1)	01-0020-26	012867P	Paint spray booth	O
Y-9720-6-A(2)	01-0020-26	012867P	Paint spray booth	O
Y-9720-6-B(01)	01-0020-75	015154P	Woodworking operation	O
Y-9720-6-B(03)	01-0020-26	012867P	Drying oven	O
Y-9720-6-C(01)	01-0020-76	015155P	2 welding booths	O
Y-9720-6-C(02)	01-0020-76	015155P	Welding booth	O
Y-9720-6-E(01)	01-0020-83	016548P	Clean room laboratory	O
Y-9720-9-FUG-A-(00)	01-1020-89	029891P	PCB & RCRA storage	
Y-9737-A(01)	01-0020-22	012863P	Oven	O
Y-9737-B(02)	01-0020-78	015157P	Plating tank catalog cat	O
Y-9737-C(02)	01-0020-78	015157P	PC board etcher	O
Y-9737-D(02)	01-0020-78	015157P	Solder centrifuge	O
Y-9737-E(02)	01-0020-78	015157P	Wave solder machine	O
Y-9737-F(02)	01-0020-78	015157P	Oil bath	O
Y-9737-G(03)	01-0020-79	015160P	Fume hood	O
Y-9737-H(04)	01-0020-79	015160P	Varnish room exhaust	O
Y-9737-I(05)	01-0020-79	015160P	Cleaning hood	O
Y-9738-A(01)	01-0020-14	025975P	Sandblaster untitled cat	O
Y-9738-A(02)	01-0020-14	025975P	Hood with fan	O
Y-9738-A(03)	01-0020-14	025975P	Sand blaster	O
Y-9738-A(04)	01-0020-14	025975P	Hood with fan	O
Y-9738-A(05)	01-0020-14	025975P	Hood with fan	O
Y-9739-A(01)	01-1020-78	028105P	Printfold Diazo blueprint copier/rm 160	O
Y-9739-B(02)	01-1020-78	028105P	Printfold Diazo blueprint copier/rm 174	O
Y-9754-3-[A]-(00)			Fuel service station	
Y-9767-4-A(01)	01-0020-35	012877P	Chilled water circulating system	O
Y-9808-A	01-0020-80	015156P	Carpenter shop	O
Y-9808-A(01)	01-1020-22	026109P	Spray booth	O
Y-9809-A(01)	01-0020-93	025899P	Oxide storge vaults	O
Y-9811-1-[A]-(1)	01-1020-95	731997P	Waste oil/storage bulk storage facility	O
Y-9811-1-[A]-(2)	01-1020-95	731997P	Waste oil/storage bulk storage facility	O
Y-9811-1-[A]-(3)	01-1020-95	731997P	Waste oil/storage bulk storage facility	O
Y-9811-1-[A]-(4)	01-1020-95	731997P	Waste oil/storage bulk storage facility	O
Y-9811-1-[A]-(5)	01-1020-95	731997P	Waste oil/storage bulk storage facility	O
Y-9811-1-[A]-(6)	01-1020-95	731997P	Waste oil/storage bulk storage facility	O
Y-9811-1-[A]-(7)	01-1020-95	731997P	Waste oil/storage bulk storage facility	O
Y-9811-6-PMU-A(1)	01-1020-82	029415P	Dry ash handling system	O
Y-9811-8-[A]-(01)	01-1020-63	032988P	Waste oil solvent tanks	O
Y-9811-8-[A]-(02)	01-1020-63	032988P	Waste oil solvent tanks	O
Y-9811-8-[A]-(03)	01-1020-63	032988P	Waste oil solvent tanks	O
Y-9811-8-[A]-(04)	01-1020-63	032988P	Waste oil solvent tanks	O
Y-9811-8-[A]-(05)	01-1020-63	032988P	Waste oil solvent tanks	O
Y-9811-B(02)	01-1020-45	025903P	Incinerator	O
Y-9812-[A]-(287)	01-1020-29	022474P	Storage tank/12,115 gal	O
Y-9812-[A]-(288)	01-1020-29	022474P	Storage tank/12,133 gal	O

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9812-[A]-(289)	01-1020-29	022474P	Storage tank/4,876 gal	O
Y-9815-A(03)	01-0020-11	025895P	Vent from reactors	O
Y-9815-A(04)	01-0020-11	025895P	Storage tank/12,000 gal	O
Y-9815-A(05)	01-0020-11	025895P	Storage tank/4,500 gal	O
Y-9815-A(06)	01-0020-11	025895P	Storage tank/4,400 gal	O
Y-9815-A(07)	01-0020-11	025895P	Storage tank/1,800 gal	O
Y-9815-A(08)	01-0020-11	025895P	2 storage tank/2,200 gal each	O
Y-9818-A(01)	01-0020-12	025965P	Hot well seal tank	O
Y-9818-A(02)	01-0020-12	025965P	11 storage tanks—nitric acid recovery	O
Y-9818-A(03)	01-0020-12	025965P	Bioreactor tanks/ozonation tanks (2)	O
Y-9818-A(04)	01-0020-12	025965P	Basement exhaust	O
Y-9818-A(05)	01-0020-12	025965P	Nitric acid supply line vent	O
Y-9818-A(06)	01-0020-12	025965P	Ozone generator/area exhaust	O
Y-9818-A(07)	01-0020-12	025965P	Storage tank/10,000 gal	O
Y-9818-A(08)	01-0020-12	025965P	Denitrification feed tank/10,000 gal	O
Y-9818-A(09)	01-0020-12	025965P	Nitrate receiving tank/4,000 gal	O
Y-9818-A(10)	01-0020-12	025965P	Nitric acid waste tank/10,000 gal	O
Y-9818-A(11)	01-0020-12	025965P	Nitric acid waste tank/10,000 gal	O
Y-9818-A(12)	01-0020-12	025965P	Nitric acid waste tank/10,000 gal	O
Y-9828-6-FUG-A-(00)	01-1020-89	029891P	Trash monitoring station	
Y-9929-F(01)	01-0020-39	012881P	Open yard coal storage	O
Y-9983-74-FUG-A-(00	01-1020-89	029891P	Old salvage	
Y-9998-A(01)	01-0020-13	025957P	Swagging machines	O
Y-9998-A(02)	01-0020-13	025957P	Swagging machines	O
Y-9998-A(03)	01-0020-13	025957P	Furnaces	O
Y-9998-A(04)	01-0020-13	025957P	Nitric acid pickling tanks	O
Y-9998-A(05)	01-0020-13	025957P	Hood	O
Y-9998-A(06)	01-0020-13	025957P	Foundry operations	O
Y-9998-B(1)	01-1020-40	026110P	Machine shop	O
Y-BCB-FUG-A-(00)	01-1020-89	029891P	Bear Creek Burial Grounds	
Y-BCBG-NAK	01-00020-00	0100020	Open burn for NaK (send letter to Knox)	O
Y-IDY-FUG-A-(00)	01-1020-89	029891P	Interim drum area	
Y-IWF-FUG-A-(00)	01-1020-89	029891P	Industrial waste facility	
Y-SLF-FUG-A-(00)	01-1020-89	029891P	Sanitary landfill	
Y-9201-1-A(01)	01-0020-15	730303P	Welding booths	C
Y-9201-1-A(02)	01-0020-15	730303P	Welding shop	C
Y-9201-1-A(04)	01-0020-15	730303P	Metal fabrication shop	C
Y-9201-1-A(05)	01-0020-15	730303P	Welding shop	C
Y-9201-1-A(15)	01-0020-15	730303P	Metal fabrication shop	C
Y-9201-1-A(19)	01-0020-15	730303P	Welding hood exhaust	C
Y-9201-1-B(16)	01-0020-59	730310P	Tool grinding machines	C
Y-9201-1-B(18)	01-0020-59	730310P	Sandblaster exhaust	C
Y-9201-1-C(3)	01-0020-17	730304P	Graphic carbon machining	C
Y-9201-1-C(4)	01-0020-17	730304P	Graphic carbon machining	C
Y-9201-1-D(09)	01-0020-61	730310P	Fabrication shop	C
Y-9201-1-D(10)	01-0020-61	730310P	Fabrication shop	C
Y-9201-1-D(11)	01-0020-61	730310P	Fabrication shop	C
Y-9201-1-D(13)	01-0020-61	730310P	Metal grinders and milling machines	C
Y-9201-5-B(01)	01-0020-21	730305P	Machining operations L5N hood exhaust	C
Y-9201-5-B(02)	01-0020-21	730305P	Vacuum inlets L5E machining shop	C
Y-9201-5-B(03)	01-0020-21	730305P	Rubber-gel potting hood exhaust	C
Y-9201-5-B(04)	01-0020-21	730305P	Palarite shop—machine exhaust	C
Y-9201-5-B(05)	01-0020-21	730305P	Tool grinding machines hood exhaust	C
Y-9201-5-B(06)	01-0020-21	730305P	Cleaning hood—equipment service	C
Y-9201-5-B(07)	01-0020-21	730305P	Electrochemical machine-stainless steel	C
Y-9201-5-G(01)	01-0020-44	921689P	Arc melt	C
Y-9201-5-G(02)	01-0020-44	921689P	DeVilbiss hood	C
Y-9201-5-G(03)	01-0020-44	921689P	Nitric acid dip tanks	C
Y-9201-5-G(04)	01-0020-44	921689P	Acid pickling tanks	C
Y-9201-5-G(05)	01-0020-44	921689P	Scrap metal recycle	C

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9201-5-G(06)	01-0020-44	921689P	Scrap metal recycle	C
Y-9201-5-G(07)	01-0020-44	921689P	Vapor degreaser	C
Y-9201-5N-A(01)	01-1020-18	730314P	Machine shop exhaust	C
Y-9204-2-E(68)	01-1020-55	730328P	Oven	C
Y-9204-2-E(69)	01-1020-55	730328P	Oven	C
Y-9204-2-E(70)	01-1020-55	730328P	Tungsten screener	C
Y-9204-2-E(71)	01-1020-55	730328P	Dry box vent	C
Y-9204-2-E(72)	01-1020-55	730328P	Glove boxes	C
Y-9204-2-E(73)	01-1020-55	730328P	Material handling	C
Y-9204-2-E(74)	01-1020-55	730328P	Glove boxes	C
Y-9204-2-E(75)	01-1020-55	730328P	Outgassing/annealing ovens	C
Y-9204-2-E(76)	01-1020-55	730328P	Material handling	C
Y-9204-2-E(77)	01-1020-55	730328P	Glove boxes	C
Y-9204-2-E(78)	01-1020-55	730328P	Reactor unloading station	C
Y-9204-2-E(79)	01-1020-55	730328P	Reactor unloading station	C
Y-9204-2-E(80)	01-1020-55	730328P	Glove boxes	C
Y-9204-2-E(81)	01-1020-55	730328P	Vacuum pump	C
Y-9204-2E-A(436)	01-0020-68	730312P	Oven	C
Y-9204-2E-A(439)	01-0020-68	730312P	Hood exhaust	C
Y-9204-2E-A(441)	01-0020-68	730312P	Hood	C
Y-9204-2E-A(442)	01-0020-68	730312P	Hood	C
Y-9204-2E-A(443)	01-0020-68	730312P	Degreaser	C
Y-9204-2E-A(444)	01-0020-68	730312P	Electropolishers	C
Y-9204-2E-A(445)	01-0020-68	730312P	Surface coating	C
Y-9204-2E-A(448)	01-0020-68	730312P	Glovebox	C
Y-9204-2E-A(449)	01-0020-68	730312P	Storage tank	C
Y-9204-2E-C(12)	01-1020-68	730328P	Machine shop hood exhaust—B2E	C
Y-9204-2E-C(13)	01-1020-68	730328P	Machine shop hood exhaust—spec. shop	C
Y-9204-2E-[A]-(202)	01-1020-91	730938P	Positive ion accelerator	C
Y-9204-4-A(02)	01-1020-56	931629P	Wash tank	C
Y-9204-4-A(03)	01-1020-56	931629P	Quench tanks	C
Y-9204-4-A(04)	01-1020-56	931629P	1000 ton press	C
Y-9204-4-A(05)	01-1020-56	931629P	7500 ton press	C
Y-9204-4-A(06)	01-1020-56	931629P	Exhaust from press pit area	C
Y-9204-4-A(07)	01-1020-56	931629P	Plasma torch cutting machine	C
Y-9204-4-A(08)	01-1020-56	931629P	Vacuum quench furnace	C
Y-9204-4-A(09)	01-1020-56	931629P	Ingot cooler	C
Y-9204-4-A(10)	01-1020-56	931629P	Exhaust from lathe	C
Y-9204-4-A(11)	01-1020-56	931629P	Grinding facility	C
Y-9204-4-A(12)	01-1020-56	931629P	Dye penetrant	C
Y-9204-4-A(13)	01-1020-56	931629P	Salt baths	C
Y-9204-4-A(14)	01-1020-56	931629P	Quench tanks	C
Y-9204-4-A(15)	01-1020-56	931629P	Preheat furnace exhaust	C
Y-9204-4-A(17)	01-1020-56	931629P	Oven exhaust	C
Y-9204-4-A(18)	01-1020-56	931629P	Vacuum furnace quench chamber	C
Y-9204-4-A(19)	01-1020-56	931629P	7500 ton press & 1500 ton press	C
Y-9204-4-B(481)	01-0020-72	730313P	Exhaust from machining operation	C
Y-9204-4-B(482)	01-0020-72	730313P	Exhaust from hood—reclamation area	C
Y-9204-4-B(484)	01-0020-72	730313P	Rolling mill—1st floor assembly	C
Y-9204-4-B(485)	01-0020-72	730313P	Exhaust from paint hood	C
Y-9204-4-B(486)	01-0020-72	730313P	Filtering exhaust from paint booths	C
Y-9204-4-B(488)	01-0020-72	730313P	Laboratory hoods—1st floor	C
Y-9204-4-B(489)	01-0020-72	730313P	Laboratory hoods—reclamation area	C
Y-9204-4-B(490)	01-0020-72	730313P	Assembly process—first floor	C
Y-9204-4-B(491)	01-0020-72	730313P	Assembly process—1st floor	C

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9204-4-D(01)	01-1020-35	730317P	Exhaust hood	C
Y-9204-4-[A]-(88)	01-1020-56	931629P	Grit blast system	C
Y-9206-C(01)	01-1020-24	730316P	Classified	C
Y-9206-C(02)	01-1020-24	730316P	Classified	C
Y-9206-E (NEW)	01-1020-24	730316P	Classified	C
Y-9206-[B]-(013)	01-0020-03	731689P	South stack, incinerator	C
Y-9206-[B]-(015)	01-0020-03	731689P	West stack	C
Y-9206-[B]-(016)	01-0020-03	731689P	Dissolving hood	C
Y-9206-[B]-(017)	01-0020-03	731689P	Steam cleaning hoods	C
Y-9206-[B]-(115)	01-0020-03	731689P	Reduction fluid bed	C
Y-9206-[B]-(135)	01-0020-03	731689P	AEC scrubber stack	C
Y-9206-[B]-(136)	01-0020-03	731689P	AEC consolidated stack	C
Y-9206-[B]-(208)	01-0020-03	731689P	Conversion fluid bed	C
Y-9206-[B]-(209)	01-0020-03	731689P	HF purge vent	C
Y-9206-[B]-(210)	01-0020-03	731689P	Chemical make-up area	C
Y-9206-[B]-(211)	01-0020-03	731689P	Hood 29 and 30	C
Y-9206-[B]-(212)	01-0020-03	731689P	Dry vacuum system	C
Y-9212-B(01)	01-0020-02	730301P	U metal drying and briquetting process	C
Y-9212-B(02)	01-0020-02	730301P	Exhaust from chip washing and drying	C
Y-9212-B(03)	01-0020-02	730301P	E-wing machine shop	C
Y-9212-B(04)	01-0020-02	730301P	U metal and U metal alloy casting	C
Y-9212-F(01)	01-1020-49	730321P	Two Deburr benches—hood exh.—A-wing	C
Y-9212-F(02)	01-1020-49	730321P	Two Deburr benches—hood exh.—A-wing	C
Y-9212-F(03)	01-1020-49	730321P	Machining—Hood exhaust—A-wing	C
Y-9212-F(04)	01-1020-49	730321P	Machining—Hood exhaust—A-wing	C
Y-9212-F(05)	01-1020-49	730321P	Machining—Hood exhaust—A-wing	C
Y-9212-[A](027)	01-1020-72	997756P	D-wing, room 1010 hoods, rms 26 & 29	C
Y-9212-[A](028)	01-1020-72	997756P	Reduction, shear, and room 1010, EUCF	C
Y-9212-[A](033)	01-1020-72	997756P	Headhous equipment & incinerator	C
Y-9212-[A](040)	01-1020-72	997756P	B-1 sampling lab hoods	C
Y-9212-[A](042)	01-1020-72	997756P	Chloride removal sys./C-1 wing process ex.	C
Y-9212-[A](050)	01-1020-72	997756P	C-1 chip burner, enclosures, load hoods	C
Y-9212-[A](111)	01-1020-72	997756P	Reduction fluids beds	C
Y-9212-[A](112)	01-1020-72	997756P	Conversion fluid beds	C
Y-9212-[A](132)	01-1020-72	997756P	Decontamination facility	C
Y-9212-[A](430)	01-1020-72	997756P	HF dock cylinder/vaporizer purge vent	C
Y-9212-[A](431)	01-1020-72	997756P	N204 cylinder purge vent	C
Y-9215-A(01)	01-0020-37	731839P	Machine shop hood exhaust—M-wing	C
Y-9215-C(03)	01-1020-52	730323P	Vapor blaster/metal cleaner	C
Y-9215-C(10)	01-1020-52	730323P	Nickel plating—metal working exhaust	C
Y-9215-C(11)	01-1020-52	730323P	Exhaust	C
Y-9215-C(17)	01-1020-52	730323P	Rolling mill	C
Y-9215-C(19)	01-1020-52	730323P	Electric annealing oven	C
Y-9215-[B]-(1)	01-1020-51	732125P	O-wing metal working operations	C
Y-9215-[B]-(2)	01-1020-51	732125P	O-wing metal working operations	C
Y-9215-[B]-(4)	01-1020-51	732125P	O-wing metal working operations	C
Y-9215-[B]-(6)	01-1020-51	732125P	O-wing metal working operations	C
Y-9401-2-[A]-(205)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(220)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(221)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(222)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(223)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(224)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(225)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(226)	01-0020-88	730286P	Plating equipment	C

Table 3.1 (continued)

Y-12 Plant source number	Emission source reference number	Permit number	Source	Permit type[a]
Y-9401-2-[A]-(227)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(228)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(229)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(230)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(231)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(232)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(233)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(234)	01-0020-88	730286P	Plating equipment	C
Y-9401-2-[A]-(235)	01-0020-88	730286P	Plating equipment	C
Y-9811-1-[A]-(1)	01-1020-95	731997P	Waste oil/storage bulk storage facility	C
Y-9811-1-[A]-(2)	01-1020-95	731997P	Waste oil/storage bulk storage facility	C
Y-9811-1-[A]-(3)	01-1020-95	731997P	Waste oil/storage bulk storage facility	C
Y-9811-1-[A]-(4)	01-1020-95	731997P	Waste oil/storage bulk storage facility	C
Y-9811-1-[A]-(5)	01-1020-95	731997P	Waste oil/storage bulk storage facility	C
Y-9811-1-[A]-(6)	01-1020-95	731997P	Waste oil/storage bulk storage facility	C
Y-9811-1-[A]-(7)	01-1020-95	731997P	Waste oil/storage bulk storage facility	C

[a]O = operating; C = construction.

Table 3.2. 1991 Air permits at ORNL

ORNL source number	Emission source reference number	Permit number	Source	Permit type[a]
X-2000-SV2	73-0112-75	024473P	Furnace, ovens, hoods, pumps	O
X-2000-SV9	73-0112-32	024135P	Laser with wet scrubber	O
X-2013-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-2013-SV4	73-0112-52	024913P	Vapor blaster	O
X-2018-02	73-0112-13	024250P	Parts washer (degreaser)	O
X-2018-03	73-0112-44	024117P	Oven	O
X-2026-06	73-0112-77	024759P	Rad laboratory	O
X-2510-T1	73-0112-63	024402P	Tank, propane	O
X-2519-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-2519-1/5	73-0112-03	030284P	5 boilers and ash system	O
X-2519-T1	73-0112-57	031280P	Tank, sulfuric acid	O
X-2522-T1A	73-0112-10	024114P	Tank, fuel oil	O
X-2525-01	73-0112-14	030835P	Degreaser (perchloroethylene)	O
X-2525-02	73-0112-65	730837P	Parts washer (degreaser)	O
X-2525-03	73-0112-65	730837P	Parts washer (degreaser)	O
X-2525-14	73-0112-65		Degreaser, graymills	A
X-2525-6	73-0112-95	027257P	Machine shop	O
X-2525-S13	73-0112-54	027392P	Vapor blaster and buffers	O
X-2525-SV11	73-0112-49	024151P	Electroplating shop	O
X-2525-SV4	73-0112-38	031062P	6 wet and 3 dry grinders	O
X-2525-SV8	73-0112-62	024949P	Spray booth and oven	O
X-2525-T1	73-0112-72	024475P	Tank, waste oil	O
X-2525-T2	73-0112-72	024475P	Tank, waste oil	O
X-2547-01	73-0112-27	028439P	Spray booth	O
X-2547-02	73-0112-65	730837P	Parts washer (degreaser)	O
X-3003-SV6	73-0112-29	023760P	Tank, sulfur hexafluoride	O
X-3003-SV8	73-0112-29	023760P	Tank, sulfur hexafluoride	O
X-3004-T1	73-0112-46	024136P	Tank, nitric acid	O
X-3004-T2	73-0112-46	024136P	Tank, nitric acid	O
X-3004-T3	73-0112-46	024136P	Tank, nitric acid	O
X-3005-02	73-0112-18	880787P/027214P	Parts washer (degreaser)	O
X-3012-SV1	73-0112-74	024449P	Furnace	O
X-3012-SV2	73-0112-50	024252P	Degreaser	O
X-3019-01	73-0112-23	023194P	Thermal denitration	O
X-3025-01	73-0112-65	730837P	Parts washer/degreaser	O
X-3039-01	73-0112-93	026525P	Off gas and hot cell ventilation	O
X-3044-01			Special materials machine shop	A
X-3074-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-3103-T1	73-0112-42	024113P	Tank, sulfuric acid	O
X-3104-03	73-0112-81	024511P	Carpenter shop	O
X-3117-T1	73-0112-42	024115P	Tank, sulfuric acid	O
X-3500-02	73-0112-65	730837P	Parts washer (degreaser)	O
X-3500-SV12	73-0112-73	024450P	Furnace	O
X-3502-01	73-0112-05	030881P	Spray booth	O
X-3502-09	73-0112-94	027194P	Hood-gluing	O
X-3502-SV1	73-0112-39	023808P	Oven, curing	O
X-3502-SV2	73-0112-40	023807P	Oven, tempering	O
X-3502-SV4	73-0112-30	930343P	Cyclone and carpentry shop	O
X-3504-SV1	73-0112-80	024451P	Oven	O
X-3544-SV1	73-0112-70	730468P	PWTP	O
X-3587-SV1	73-0112-56	029830P	Printed circuit board facility	O
X-3608-01	73-0112-37	730489P	NRWTP air stripper column	O
X-4500N1-SV93	73-0112-65	730837P	Parts washer (degreaser)	O
X-4500S1-01	73-0112-87	029920P	Parts washer (degreaser)	O
X-4500S3-50	73-0112-31	024088P	Mercury purification system	O

Table 3.2 (continued)

ORNL source number	Emission source reference number	Permit number	Source	Permit type[a]
X-4500S54-1	73-0112-01	016577P	Furnaces (2)	O
X-4508-S16	73-0112-51	024909P	Spray booth	O
X-4508-SV8	73-0112-61	732645P	Acid etching process	O
X-4508-SV9	73-0112-55	024306P	Sand blaster	O
X-4508-T1	73-0112-64	024403P	Tank, freon	O
X-4515-00	73-0112-68	025239P	HTML	O
X-5500	73-0112-29	023760P	Tank	O
X-6000-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-6000-SV2	73-0112-59	024308P	Vapor blaster	O
X-6005-00	73-0112-29	023760P	Tank, sulfur hexafluoride	O
X-6010-00	73-0112-85	025282P	ORELA	O
X-6010-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-7002-01	73-0112-19	024251P	Parts washer (degreaser)	O
X-7002-01	73-0112-19	024251P	Parts washer (degreaser)	A
X-7002-03	73-0112-65	730837P	Parts washer (degreaser)	O
X-7002-04	73-0112-65	730837P	Parts washer (degreaser)	O
X-7002-05	73-0112-08	030980P	Spray booth	O
X-7002-T1	73-0112-88	025659P	Tank, used oil	O
X-7003-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-7003-01	73-0112-65		Degreaser, graymills	A
X-7003-SV1	73-0112-79	024452P	Furnace	O
X-7005-00	73-0112-45	024118P	Machining tools	O
X-7005-3-7	73-0112-26	028438P	Lead shop furnaces (5)	O
X-7007-1/2	73-0112-09	030824P	Spray booth and cleaning booth	O
X-7012-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-7021-00	73-0112-58	024307P	Grinding shop	O
X-7021-T1	73-0112-89	025660P	Tank, waste oil	O
X-7025-00	73-0112-92	026070P	TTFF	O
X-7057-SV1	73-0112-76	030101P	Sand blaster	O
X-7069-T1	73-0112-60	730836P	Gasoline tank (X-7069-T1)	O
X-7075-T1	73-0112-90	025661P	Tank, waste oil	O
X-7075-T2	73-0112-90	025661P	Tank, photographic waste	O
X-7075-T3	73-0112-90	025661P	Tank, photographic waste	O
X-7503-00	73-0112-83	025254P	Molten salt reactor	O
X-7600-01	73-0112-20	017930P	Nuclear fuel reprocessing	O
X-7601-T1	73-0112-47	024137P	Tank, nitric acid	O
X-7602-01	73-0112-24	027090P	Boiler, hot water	O
X-7603-01	73-0112-25	022743F	Boiler, steam (standby unit)	O
X-7606-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-7667-0	73-00111 0067	73-00111 0067 4	Chemical detonation facility	O
X-7822-00	73-0112-86	025340P	Solid waste shredder	O
X-7830-SV1	73-0112-71	731010P	LWSP (see comments)	O
X-7831-00	73-0112-84	025281P	Baler and box compactor	O
X-7900-T1	73-0112-43	024116P	Tank, nitric acid	O
X-7900-T2	73-0112-43	024116P	Tank, nitric acid	O
X-7900-T3	73-0112-66	025162P	Tank, nitric acid	O
X-7900-T4	73-0112-66	025162P	Tank, corrosion inhibitor	O
X-7903-T1	73-0112-48	024138P	Tank, sulfuric acid	O
X-7910-01	73-0112-65	730837P	Parts washer (degreaser)	O
X-7911-00	73-0112-82	025249P	HFIR, TRU, and TURF	O
X-7934-SV2	73-0112-53	024912P	Silver recovery system	O
X-7935-SV1	73-0112-78	027393P	Equipment cleaning facility	O
X-FE	73-0112-97	029660P	Fugitive emission sources	O

[a]O = operating permit; A = application.

Table 3.3. Air Permits at the K-25 Site

K-25 source number	Emission source reference number (73-XXXX-XX)	Permit number	Source	Permit type[a]
K-1004-L	0106-35	012503P	Main vent of development facility	O
K-1004-L oven	0106-95	024299P	Sintering oven	O
K-1004-T hood	1106-04	024498P	Resin and hardener mixer with hoods	O
K-1004-T center b hood	1106-04	024756P	Resin and hardener mixer with hoods	O
K-1004-T hood meth	1106-15	025493P	Ultrasonic cleaner	O
K-1004-T south oven	1106-01	024304P	Matrix composites curing oven	O
K-1004-T west n oven	0106-96	024301P	Matrix composites curing oven	O
K-1004-T wind 1	1106-28	029901P	Fiber winding spools with epoxy dip	O
K-1004-T wind 2	1106-28	029901P	Fiber winding spools with epoxy dip	O
K-1004-T wind 3	1106-28	029901P	Fiber winding spools with epoxy dip	O
K-1004-T wind 4	1106-28	029901P	Fiber winding spools with epoxy dip	O
K-1024 FT1	0106-18	025655P	Filter test facility	O
K-1037 AVLIS EX LAB	0106-68	031404P	Vacuum system vents	O
K-1037 AVLIS EX LAB	0106-68	031404P	Materials Test Unit (MTU)	O
K-1037 AVLIS EX LAB	0106-68	031404P	Materials handling development	O
K-1037 AVLIS EX LAB	0106-68	031404P	Electron Beam One (EB-1)	O
K-1037 AVLIS furnace	0106-81	023119P	Huppert furnace	O
K-1037 AVLIS grieve oven	0106-80	023118P	Grieve oven TB-500 electric	O
K-1037 AVLIS LAB	1106-35	930506P	AVLIS Lab	PTC
K-1037 AVLIS LCDEV	0106-69	029897P	Expansion Lab C	O
K-1037 AVLIS LGB	0106-77	032345P	Grit blast facility with baghouse	O
K-1037 AVLIS O OVEN	0106-73	029900P	Electric oxidation oven	O
K-1037 AVLIS PRODCON	1106-36	930871P	Products conversion demonstration	PTC
K-1037 AVLIS Q OVEN	0106-79	023120P	Quincy oven	O
K-1037 AVLIS SSB	0106-85	023663P	Small sand blaster	O
K-1037 MLBH	0106-84	023662P	Mechanical lab	O
K-1095 PS123	0106-14	015830P	Paint spray operation	O
K-1098-FSB1	0106-13	015098P	Sand blast facility with baghouse	O
K-1131 MS	0106-29	015099P	Fluorine plant	O
K-1200 center bay	0106-87	732346P	Mixing epoxy resins	O
K-1200 A123	0106-56	019608P	Purge evacuation	O
K-1200 CVTF	0106-62	017339P	Centrifuge	O
K-1200 FAE1	0106-86	029192P	Isotope separating process	O
K-1200 SITF	0106-61	017338P	System interface	O
K-1200 north bay oven	0106-92	024272P	Matrix composites curing	O
K-1202 ST1	1106-20	024911P	Tanks	O
K-1220 B	0106-48	015101P	Machine repair stands	O
K-1231 AP216	0106-53	015704P	HF transfer line vent scrubber	O
K-1232 lime storage silo	1106-26	024456P	Lime storage silo	O
K-1233 1	0106-51	015702P	Classified material process	O
K-1401 121659	0106-09	016306P	1,1,1-trichloroethane degreaser	O
K-1401 275029PL	0106-38	012506P	Plastic shop curing oven	O
K-1401 composite machine	0106-88	025514P	Composite machining process	O

Table 3.3 (continued)

K-25 source number	Emission source reference number (73-XXXX-XX)	Permit number	Source	Permit type[a]
K-1401 foam pack	1106-12	025490P	Foam packing operation	O
K-1401 JIGANDFIXT	0106-71	029898P	Parts fabrication	O
K-1401 HCLE	0106-28	024500P	Hydrochloric acid tank	O
K-1401 MB01	0106-45	017336P	Reclaiming service oven	O
K-1401 MSMC1	0106-32	017337P	Motor curing oven	O
K-1401 MSMC3	0106-66	018526P	Electric bake oven in motor shop	O
K-1401 slope	1106-29	026164P	Uranium hexaflouride converters	O
K-1401 T-104	1106-32	025658P	T-104 acid cleaning tank	O
K-1401 TRICH	1106-10	024947P	1,1,1-trichloroethane storage tank	O
K-1401 LH blove box 1,2,3	1106-03	026679P	LH glove boxes	O
K-1401 machine shop	1106-09	025585P	Machine shop exhaust system	O
K-1401 OOO oven, NE-2	0106-89	028424P	Electric oven for metal parts	O
K-1401 PLS1,4,6	0106-72	029899P	Ovens for curing plastic parts	O
K-1407 H-F-210 lime bin	1106-18	025443P	Lime storage silo	O
K-1407-A lime silo	1106-25	024455P	Lime storage silo	O
K-1413 MS	0106-52	015703P	Development facility vent	O
K-1413 propane lab	0106-28	024500P	Propane storage tank	O
K-1414 gasoline tank	0106-28	016312P	Gasoline storage tank	O
K-1414 UG methanol, unleaded gas	0106-28	024500P	Methanol, unleaded gasoline tank	O
K-1414 unleaded gasoline tank	1106-39	932727P	Unleaded gasoline storage tank	PTC
K-1419 20	0106-83	025250P	Scrubber and cylinder cleaning	O
K-1420 237306 vapor degreaser	0106-49	023797P	Detrex vapor degreaser	O
K-1420 disassembly	0106-74	032344P	Dismantling parts	O
K-1420 CPL	0106-54	017055P	Ultrasonic cleaner	O
K-1420 CPL1	0106-58	017051P	Vent for ultrasonic cleaner	O
K-1420 A	0106-55	017846P	A-area ventilation	O
K-1420 A1	0106-82	024396P	Flammable materials storage tank	O
K-1420 WODF	0106-67	018527P	Waste oil	O
K-1420 phillips vapor	0106-70	023798P	Phillips vapor degreaser	O
K-1425 WOS A	0106-11	029895P	Waste oil and solvent storage tanks	O
K-1425 WOS B	0106-11	029895P	Waste oil and solvent storage tanks	O
K-1425 WOS C	0106-11	029895P	Waste oil and solvent storage tanks	O
K-1425 WOS D	0106-11	029895P	Waste oil and solvent storage tanks	O
K-1435-C tank farm	0106-75	024105P	Storage tanks	O
K-1435 TSCAINCIN	0106-78	032449I	TSCA incinerator	O
K-1501 A1A2C3	0106-04	029902F	Steam plant with 3 stacks	O
K-1501 Boiler 8	0106-12	930870F	Natural gas/#2 oil boiler	PTC
K-1501 sulfuric acid tank	0106-28	024500P	Sulfuric acid storage tank	O
K-1515 north alum tank	0106-28	024500P	North alum tank	O
K-1515 south alum tank	0106-28	024500P	South alum tank	O
K-1600 TTFL	0106-59	017053P	Development lab	O
K-25 A-E	0106-33	012478P	Drying tracks	O
K-25 VAO	0106-15	012488P	Vacuum systems	O
K-25 B-1	0106-19	016309P	Heat exchange medium	O

Table 3.3 (continued)

K-25 source number	Emission source reference number (73-XXXX-XX)	Permit number	Source	Permit type[a]
K291	0106-63	015097P	Wet air evacuation system	O
K-402-8 16990 cool	0106-28	024500P	Coolant tank	O
K-402-9 16989 cool	0106-28	024500P	Coolant tank	O
K-402-9 PC	0106-42	012660P	Gaseous diffusion purge cascade	O
K-502-2 327298	0106-28	024500P	Freon storage tank	O
K-502-2 327300	0106-28	024500P	Freon storage tank	O
K-602 WAP	0106-93	024297P	Evacuation of cascade cells	O
K-602-1 2543 LO	0106-23	016310P	Lube oil tank	O
K-602-2 2540 LO	0106-23	016310P	Lube oil tank	O
K-602-2 325172	0106-28	024500P	Freon storage tank	O
K-602-3 2542 LO	0106-23	016310P	Lube oil tank	O
K-602-4 2541 LO	0106-23	016310P	Lube oil tank	O
K-602-4 325285	0106-28	024500P	Freon storage tank	O
K-602-5 2545 LO	0106-23	016310P	Lube oil tank	O
K-602-6 2544 LO	0106-23	016310P	Lube oil tank	O
K-704 316MO	0106-24	016311P	Mineral oil tank	O
K-732 2135MO	0106-24	016311P	Mineral oil tank	O
K-732 2140MO	0106-24	016311P	Mineral oil tank	O
K-762 2427MO	0106-24	016311P	Mineral oil tank	O
K-762 2428MO	0106-24	016311P	Mineral oil tank	O
K-762 2423MO	0106-24	016311P	Mineral oil tank	O
K-762 2431MO	0106-24	016311P	Mineral oil tank	O
K-832 chromate tank	1106-10	024947P	Chromate storage tank	O
K-892 chromate tank	1106-10	024947P	Chromate storage tank	O
K-892 sulfuric acid tank, N	0106-28	024500P	North sulfuric acid tank	O
K-893 sulfuric acid tank, S	0106-28	024500P	South sulfuric acid tank	O
K-892 lime silo	1106-08	025120P	Lime silo	O
K-894 sulfuric acid tank	0106-28	024500P	Sulfuric acid storage tank	O
K-896 soda silo	1106-24	024758P	Soda silo	O
K-902 jet	0106-93	024298P	Exhaust jet	O
K-902 WAP	0106-93	024298P	Evacuation of cascade cells	O
K-902-1 2310 LO	0106-23	016310P	Lube oil tank	O
K-902-1 2318 LO	0106-23	016310P	Lube oil tank	O
K-902-2 2311 LO	0106-23	016310P	Lube oil tank	O
K-902-2 2319 LO	0106-23	016310P	Lube oil tank	O
K-902-2 2320 LO	0106-23	016310P	Lube oil tank	O
K-902-2 2321 LO	0106-23	016310P	Lube oil tank	O
K-902-3 2312 LO	0106-23	016310P	Lube oil tank	O
K-902-3 2322 LO	0106-23	016310P	Lube oil tank	O
K-902-3 2323 LO	0106-23	016310P	Lube oil tank	O
K-902-3 324383	0106-28	024500P	Freon storage tank	O
K-902-3 324469 Freon	0106-28	024500P	Freon R-114 storage tank	O
K-902-3 324470 Freon	0106-28	024500P	Freon R-114 storage tank	O
K-902-4 2313 LO	0106-23	016310P	Lube oil tank	O

Table 3.3 (continued)

K-25 source number	Emission source reference number (73-XXXX-XX)	Permit number	Source	Permit type[a]
K-902-4 2324 LO	0106-23	016310P	Lube oil tank	O
K-902-4 2325 LO	0106-23	016310P	Lube oil tank	O
K-902-5 2314 LO	0106-23	016310P	Lube oil tank	O
K-902-5 2378 LO	0106-23	016310P	Lube oil tank	O
K-902-5 2379 LO	0106-23	016310P	Lube oil tank	O
K-902-5 PCB 1	1106-10	024947P	PCB oil storage tank	O
K-902-5 PCB 2	1106-10	024947P	PCB oil storage tank	O
K-902-5 PCB 3	1106-10	024947P	PCB oil storage tank	O
K-902-5 PCB 4	1106-10	024947P	PCB oil storage tank	O
K-902-6 2315 LO	0106-23	016310P	Lube oil tank	O
K-902-6 2380 LO	0106-23	016310P	Lube oil tank	O
K-902-6 2381 LO	0106-23	016310P	Lube oil tank	O
K-902-6 PCB 1	1106-10	024947P	PCB oil storage tank	O
K-902-6 PCB 2	1106-10	024947P	PCB oil storage tank	O
K-902-6 PCB 3	1106-10	024947P	PCB oil storage tank	O
K-902-7 2316 LO	0106-23	016310P	Lube oil tank	O
K-902-7 2382 LO	0106-23	016310P	Lube oil tank	O
K-902-7 2383 LO	0106-23	016310P	Lube oil tank	O
K-902-8 2317 LO	0106-23	016310P	Lube oil tank	O
K-902-8 2384 LO	0106-23	016310P	Lube oil tank	O
K-902-8 2385 LO	0106-23	016310P	Lube oil tank	O
K-902-8 PCB	1106-10	024947P	PCB oil storage tank	O

[a]O = operating; PTC = permit to construct.

Table 3.4. 1991 monthly fluoride averages in ambient air at the Y-12 Plant[a]

Station	Average concentrations ($\mu g/m^3$)					
	Jan	Feb	Mar	Apr	May	Jun
1	<0.0120	0.0175	<0.0115	<0.0105	<0.0081	<0.0088
2	0.0153	0.0176	<0.0112	<0.0112	<0.0091	0.0091
3	0.0146	0.0193	<0.0116	<0.0163	<0.0091	<0.0089
4	0.0128	<0.0174	*b*	*b*	<0.0105	<0.0086
5	0.0125	0.0159	<0.0106	*b*	*b*	<0.0568
6	<0.0116	0.0167	0.0127	0.0130	<0.0085	<0.0084
7	0.0115	0.0152	<0.0111	<0.0092	<0.0082	<0.0125
8	0.0141	0.0154	<0.0115	*b*	*b*	*b*
9	0.0142	0.0170	*b*	*b*	<0.0081	<0.0087
10	0.0134	0.0131	<0.0106	<0.0091	<0.0081	<0.0082
11	<0.0118	0.0179	<0.0100	<0.0095	<0.0084	<0.0087
	Jul	Aug	Sep	Oct	Nov	Dec
1	<0.0083	<0.0098	<0.0103	<0.0092	0.0093	<0.0073
2	0.0083	<0.0117	<0.0098	<0.0099	0.0335	<0.0142
3	<0.0186	<0.0101	<0.0088	<0.0100	0.0445	<0.0173
4	0.0096	<0.0117	<0.0100	<0.0102	0.0825	<0.0185
5	<0.0898	<0.0480	<0.0094	<0.0099	0.4104	<0.0385
6	0.0255	<0.0117	<0.0094	<0.0075	0.0178	<0.0101
7	<0.0093	<0.0098	<0.0082	<0.0088	0.0424	<0.0071
8	*b*	*b*	*b*	*b*	0.0153	<0.0096
9	0.0120	<0.0092	<0.0086	<0.0096	0.0137	<0.0089
10	<0.0107	<0.0091	<0.0084	<0.0096	<0.0093	<0.0091
11	<0.0082	<0.0087	<0.0100	<0.0099	<0.0085	<0.0088

[a]Tennessee standard for 30-d average = 1.2 $\mu g/m^3$.
[b]Indicates no sample or downtime.

Table 3.5. 1991 ^{234}U, ^{235}U, ^{236}U, and ^{238}U in ambient air at the Y-12 Plant[a]

Station number	Concentration (10^{-15} µCi/cm^3)			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
		^{234}U		
1	0.138 ± 0.021	0.872 ± 0.057	0.133 ± 0.045	0.064 ± 0.025
2	0.284 ± 0.029	0.253 ± 0.030	0.096 ± 0.037	0.166 ± 0.046
3	0.620 ± 0.040	0.069 ± 0.015	0.333 ± 0.076	0.472 ± 0.094
4	0.722 ± 0.064	0.981 ± 0.086	0.214 ± 0.071	0.413 ± 0.097
5	0.681 ± 0.049	1.371 ± 0.070	0.853 ± 0.145	1.151 ± 0.218
6	0.342 ± 0.034	0.472 ± 0.044	0.340 ± 0.079	0.375 ± 0.085
7	0.477 ± 0.037	0.486 ± 0.060	0.235 ± 0.061	0.328 ± 0.083
8	0.272 ± 0.029	0.664 ± 0.050	0.159 ± 0.049	0.185 ± 0.053
9	0.244 ± 0.065	0.205 ± 0.036	0.103 ± 0.034	0.243 ± 0.065
10	0.144 ± 0.021	0.167 ± 0.022	0.106 ± 0.037	0.082 ± 0.033
11	0.256 ± 0.030	0.130 ± 0.019	0.120 ± 0.039	0.084 ± 0.030
12	0.243 ± 0.029	0.149 ± 0.025	0.066 ± 0.029	0.080 ± 0.029
		^{235}U		
1	0.0060 ± 0.0042	0.0113 ± 0.0100	0.0075 ± 0.0106	0.0076 ± 0.0089
2	0.0030 ± 0.0030	0.0071 ± 0.0050	*b*	0.0025 ± 0.0054
3	0.0208 ± 0.0074	*b*	0.0194 ± 0.0161	0.0081 ± 0.0095
4	0.0222 ± 0.0111	0.0300 ± 0.0150	0.0060 ± 0.0121	0.0038 ± 0.0077
5	0.0275 ± 0.0097	0.0469 ± 0.0149	0.0212 ± 0.0152	0.0397 ± 0.0238
6	0.0134 ± 0.0067	0.0041 ± 0.0041	0.0139 ± 0.0140	0.0168 ± 0.0153
7	0.0116 ± 0.0058	0.0218 ± 0.0126	0.0071 ± 0.0101	0.0070 ± 0.0109
8	0.0153 ± 0.0068	0.0264 ± 0.0100	0.0070 ± 0.0100	0.0032 ± 0.0065
9	0.0079 ± 0.0079	–0.006 ± –0.010	0.0089 ± 0.0103	0.0136 ± 0.0139
10	0.0031 ± 0.0031	0.0089 ± 0.0052	0.0098 ± 0.0114	0.0033 ± 0.0068
11	0.0068 ± 0.0048	0.0051 ± 0.0036	0.0160 ± 0.0145	–0.000 ± 0.0003
12	0.0065 ± 0.0046	0.0118 ± 0.0068	0.0136 ± 0.0138	0.0027 ± 0.0054
		^{236}U		
1	*b*	0.0151 ± 0.0076	0.0029 ± 0.0061	0.0041 ± 0.0059
2	*b*	0.0036 ± 0.0062	*b*	0.0021 ± 0.0044
3	0.0052 ± 0.0037	*b*	*b*	*b*
4	0.0056 ± 0.0056	0.0225 ± 0.0130	0.0049 ± 0.0097	0.0030 ± 0.0062
5	0.0034 ± 0.0060	0.0072 ± 0.0051	0.0107 ± 0.0097	0.0105 ± 0.0109
6	0.0067 ± 0.0047	*b*	*b*	0.0136 ± 0.0124
7	0.0087 ± 0.0050	*b*	0.0057 ± 0.0081	0.0062 ± 0.0088
8	0.0031 ± 0.0031	0.0113 ± 0.0065	–0.0001 ± 0.0002	–0.0001 ± 0.0002
9	*b*	0.0062 ± 0.0062	*b*	0.0028 ± 0.0056
10	0.0031 ± 0.0031	*b*	0.0026 ± 0.0053	0.0081 ± 0.0096
11	0.0034 ± 0.0034	0.0026 ± 0.0026	0.0051 ± 0.0074	–0.000 ± 0.0003
12	*b*	0.0039 ± 0.0039	0.0055 ± 0.0078	–0.0001± 0.0002

Table 3.5 (continued)

Station number	Concentration (10^{-15} μCi/cm^3)			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
		^{238}U		
1	0.0198 ± 0.0073	0.0453 ± 0.0131	0.0120 ± 0.0122	0.0206 ± 0.0134
2	0.0299 ± 0.0095	0.0250 ± 0.0094	0.0175 ± 0.0145	0.0131 ± 0.0108
3	0.0182 ± 0.0069	0.0219 ± 0.0083	0.0157 ± 0.0130	0.0372 ± 0.0189
4	0.0223 ± 0.0136	0.0449 ± 0.0183	0.0389 ± 0.0280	0.0093 ± 0.0108
5	0.0378 ± 0.0124	0.0397 ± 0.0120	0.0214 ± 0.0139	0.0374 ± 0.0210
6	0.0168 ± 0.0075	0.0538 ± 0.0149	0.0252 ± 0.0172	0.0164 ± 0.0136
7	0.0289 ± 0.0091	0.0508 ± 0.0192	0.0172 ± 0.0142	0.0335 ± 0.0212
8	0.1375 ± 0.0209	0.0566 ± 0.0146	0.0396 ± 0.0220	0.0388 ± 0.0211
9	0.0079 ± 0.0136	0.0498 ± 0.0176	0.0311 ± 0.0178	0.0501 ± 0.0249
10	0.0947 ± 0.0170	0.0417 ± 0.0112	0.0290 ± 0.0180	0.0188 ± 0.0148
11	0.0615 ± 0.0145	0.0281 ± 0.0085	0.0129 ± 0.0118	0.0154 ± 0.0121
12	0.0032 ± 0.0056	0.0589 ± 0.0152	0.0386 ± 0.0213	0.0108 ± 0.0098

[a]Minimum detectable activity (MDA) is in the order of 1E–11 μCi/cm^3.
[b]No data available.

Table 3.6. 1991 total suspended particulates in ambient air at the Y-12 Plant[a]

Sample date	Concentration[b,c] (μg/m³)		Sample date	Concentration[b,c] (μg/m³)	
	East	West		East	West
1/6/91	*d*	25.6	7/5/91	40.4	38.8
1/12/91	11.7	*d*	7/11/91	36.0	11.6
1/18/91	17.9	21.6	7/17/91	50.9	45.6
1/24/91	35.6	39.8	7/23/91	43.9	53.2
1/30/91	19.6	21.3	7/29/91	74.0	65.8
2/5/91	43.5	63.9	8/4/91	61.1	50.6
2/11/91	19.3	23.0	8/10/91	31.3	31.1
2/17/91	8.1	10.7	8/16/91	7.2	23.6
2/23/91	22.3	21.8	8/22/91	53.4	41.6
3/1/91	42.5	53.8	8/28/91	41.5	39.3
3/7/91	19.5	18.9	9/3/91	42.1	45.4
3/13/91	54.3	67.5	9/9/91	35.7	46.3
3/19/91	24.0	22.9	9/15/91	80.2	*d*
3/25/91	35.6	29.0	9/21/91	45.4	34.4
3/31/91	19.1	17.1	9/27/91	*d*	*d*
4/6/91	*d*	46.2	10/3/91	45.0	22.6
4/12/91	67.3	75.0	10/9/91	37.0	24.3
4/18/91	108.7	73.2	10/15/91	24.8	28.9
4/24/91	44.1	47.1	10/21/91	56.8	*d*
4/30/91	24.7	21.0	10/27/91	15.7	32.9
5/6/91	38.9	37.7	11/2/91	*d*	*d*
5/12/91	14.8	24.4	11/8/91	17.0	11.6
5/18/91	46.0	49.7	11/14/91	71.8	43.8
5/24/91	30.3	36.4	11/20/91	19.9	21.1
5/30/91	38.0	38.1	11/26/91	36.9	*d*
6/5/91	47.9	51.3	12/2/91	11.2	10.9
6/11/91	65.2	61.7	12/8/91	24.4	22.5
6/17/91	31.1	33.8	12/14/91	9.8	10.2
6/23/91	36.5	56.7	12/20/91	38.8	31.2
6/30/91	31.6	31.7	12/26/91	37.0	30.1
			12/31/91	66.3	53.0

[a]See Fig. 3.17 in Vol.1 for station locations.

[b]Tennessee primary air quality standard = 260 μg/(m³·24h).

[c]Tennessee secondary air quality standard = 150 μg/(m³·24h).

[d]Invalid sample or no sample (downtime).

Table 3.7. 1991 gross alpha and beta in ambient air at the Y-12 Plant

Station number	Concentration (10^{-15} μCi/cm^3)			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
		Gross alpha[a]		
1	0.683 ± 0.158	−0.02 ± −0.12	0.495 ± 0.143	0.566 ± 0.141
2	0.586 ± 0.153	0.220 ± 0.131	0.801 ± 0.155	0.664 ± 0.134
3	0.944 ± 0.171	0.385 ± 0.154	0.788 ± 0.157	0.889 ± 0.155
4	0.740 ± 0.237	0.533 ± 0.319	0.659 ± 0.275	0.760 ± 0.168
5	0.960 ± 0.171	0.857 ± 0.171	0.887 ± 0.149	0.790 ± 0.144
6	0.615 ± 0.176	0.213 ± 0.191	0.641 ± 0.150	0.515 ± 0.152
7	0.765 + 0.162	0.297 ± 0.336	0.536 ± 0.167	0.428 ± 0.144
8	0.635 ± 0.155	0.520 ± 0.161	0.691 ± 0.149	0.337 ± 0.128
9	0.458 ± 0.284	0.509 ± 0.270	0.499 ± 0.141	0.603 ± 0.145
10	0.781 ± 0.163	0.277 ± 0.147	0.707 ± 0.154	0.529 ± 0.143
11	0.602 ± 0.154	0.437 ± 0.157	0.503 ± 0.141	0.253 ± 0.121
12	0.618 ± 0.154	0.206 ± 0.142	0.692 ± 0.156	0.455 ± 0.134
		Gross beta[a]		
1	4.719 ± 0.298	1.741 ± 0.238	7.105 ± 0.315	6.799 ± 0.293
2	7.834 ± 0.347	5.326 ± 0.297	7.765 ± 0.321	6.609 ± 0.270
3	7.280 ± 0.339	5.577 ± 0.324	7.250 ± 0.318	7.914 ± 0.307
4	6.062 ± 0.456	5.874 ± 0.593	4.695 ± 0.486	5.914 ± 0.310
5	6.755 ± 0.331	5.711 ± 0.313	7.392 ± 0.296	6.654 ± 0.279
6	6.542 ± 0.368	6.032 ± 0.413	6.840 ± 0.311	5.844 ± 0.302
7	6.755 ± 0.331	6.643 ± 0.662	5.677 ± 0.332	4.804 ± 0.279
8	7.098 ± 0.336	5.180 ± 0.316	7.122 ± 0.309	6.636 ± 0.288
9	5.308 ± 0.557	7.091 ± 0.537	7.108 ± 0.311	7.818 ± 0.311
10	7.159 ± 0.337	5.164 ± 0.315	7.228 ± 0.319	7.963 ± 0.315
11	6.997 ± 0.334	5.680 ± 0.326	6.925 ± 0.310	5.942 ± 0.273
12	7.693 ± 0.345	5.669 ± 0.322	7.373 ± 0.326	6.620 ± 0.288

[a]Minimum detectable activity (MDA) is approximately 1.0E–09 μCi/cm^3.

Table 3.8. Long-lived gross alpha activity in ambient air on the ORR during 1991

Station	Number of samples	Concentration (10^{-15} μCi/mL)			
		Max	Min	Mean[a]	Standard error of mean
		ORNL PAM stations[b]			
3	22	8.7	0.53	2.3*	0.50
7	26	9.0	0.54	2.7*	0.54
9	25	10	0.57	2.5*	0.49
20	26	9.5	0.45	2.8*	0.50
21	18	8.2	0.99	2.9*	0.55
22	19	3.4	0.46	1.4*	0.21
Summary	136	10	0.45	2.4*	0.20
		ORR PAM stations[b]			
23	23	10	0.52	3.0*	0.58
33	24	18	0.48	2.9*	0.75
34	21	7.3	0.94	2.3*	0.43
40	24	9.4	0.68	2.5*	0.45
41	23	8.0	0.36	2.5*	0.47
42	25	9.2	0.51	2.4*	0.45
43	24	7.2	0.77	2.0*	0.30
44	23	13	0.76	2.3*	0.53
45	25	8.7	0.55	2.2*	0.39
46	21	9.8	0.62	2.3*	0.55
Summary	233	18	0.36	2.5*	0.16
		RAM stations[c]			
52	24	5.3	0.41	1.9*	0.31
58	16	5.9	0.71	1.6*	0.33
Summary	40	5.9	0.41	1.8*	0.23
Overall summary	409	18	0.36	2.4*	0.11

[a]Means marked with an asterisk (*) are statistically determined to be significantly different from zero.
[b]Locations of ORNL and ORR perimeter stations are shown in Fig. 3.19, Vol. 1.
[c]Locations of remote stations are shown in Fig. 3.20, Vol. 1.

Table 3.9. Long-lived gross beta activity in ambient air on the ORR during 1991

Station	Number of samples	Concentration (10^{-15} μCi/mL)			
		Max	Min	Mean[a]	Standard error of mean
		ORNL PAM stations[b]			
3	22	31	7.9	19*	1.2
7	26	31	13	21*	0.95
9	25	31	10	19*	1.1
20	26	38	12	20*	1.2
21	18	29	9.8	20*	1.1
22	19	28	10	19*	1.1
Summary	136	38	7.9	20*	0.45
		ORR PAM stations[b]			
23	23	32	16	23*	0.95
33	24	40	11	21*	1.4
34	21	33	12	20*	1.1
40	24	28	4.8	19*	0.99
41	23	32	11	20*	1.0
42	25	30	12	21*	0.95
43	24	31	7.8	21*	1.2
44	23	37	13	22*	1.3
45	25	37	12	21*	1.2
46	21	31	1.8	19*	1.3
Summary	233	40	1.8	21*	0.37
		RAM stations[c]			
52	24	31	12	18*	1.0
58	16	35	11	20*	1.7
Summary	40	35	11	19*	0.90
Overall summary	409	40	1.8	20*	0.27

[a]Means marked with an asterisk (*) are statistically determined to be significantly different from zero.
[b]Locations of ORNL and ORR perimeter stations are shown in Fig. 3.19, Vol. 1.
[c]Locations of remote stations are shown in Fig. 3.20, Vol. 1.

Table 3.10. ^{131}I concentration in ambient air on the ORR during 1991

Station	Number of samples	Concentration (10^{-15} μCi/mL)				
		Max	Min	Mean[a]	Standard error of mean	Percent of DCG[b]
			ORNL PAM stations[c]			
3	22	5.0	–6.1	0.060	0.53	<0.01
7	26	6.9	–9.9	–0.68	0.86	<0.01
9	25	15	–9.4	0.70	0.84	<0.01
20	26	7.8	–12	–0.13	0.69	<0.01
21	18	4.6	–5.3	0.13	0.56	<0.01
22	19	7.2	–3.9	0.021	0.67	<0.01
Summary	136	15	–12	0.0025	0.30	<0.01
			ORR PAM stations[c]			
23	23	11	–7.1	0.65	0.77	<0.01
34	21	23	–4.3	2.9*	1.4	<0.01
40	24	6.6	–7.0	–0.53	0.78	<0.01
41	23	7.9	–9.7	0.98	0.85	<0.01
44	23	4.2	–6.1	0.97*	0.50	<0.01
45	25	3.8	–14	–0.73	0.74	<0.01
46	21	8.4	–4.8	0.39	0.64	<0.01
Summary	160	23	–14	0.62*	0.32	<0.01
Overall summary	296	23	–14	0.33	0.22	<0.01

[a]Means marked with an asterisk (*) are statistically determined to be significantly different from zero.
[b]Percent of DCG = Mean/DCG × 100. The derived concentration guide (DCG) for ^{131}I is 400,000 × 10^{-15} μCi/mL.
[c]Locations of ORNL and ORR perimeter stations are shown in Fig. 3.19, Vol. 1.

Table 3.11. Tritium concentration in ambient air on the ORR during 1991

Station[a]	Number of samples	Concentration (10^{-6} pCi/mL)				
		Max	Min	Mean[b]	Standard error of mean	Percent of DCG[c]
3	13	1400	14	170	110	*d*
8	13	920	27	200*	76	0.02
Overall summary	26	1400	14	190*	64	0.19

[a]Station locations are shown in Fig. 3.19, Vol. 1.

[b]Means marked with an asterisk (*) are statistically determined to be significantly different from zero.

[c]Percent of DCG = Mean/DCG × 100. The derived concentration guide (DCG) for tritium is 0.1 pCi/mL. The concentration guide assumes that 50% of the tritium is absorbed through the skin.

[d]Not applicable.

Table 3.12. 1991 continuous ambient air monitoring data[a]

Analysis	Concentration (10^{-15} μCi/mL)					
	Station 34	Percentage DCG[b]	Station 40	Percentage DCG[b]	Station 41	Percentage DCG[b]
^{60}Co	0.018	<0.01	–0.006	<0.01	0.057	<0.01
^{137}Cs	0.023	<0.01	0.022	<0.01	0.052	<0.01
^{238}Pu	0.001	<0.01	0.0014	<0.01	–0.0008	<0.01
^{239}Pu	–0.00022	<0.01	–0.0009	<0.01	–0.0027	<0.01
^{228}Th	0.0023*	<0.01	0.002*	<0.01	0.0018	<0.01
^{230}Th	0.0019*	<0.01	0.0062*	0.016	0.0042*	0.011
^{232}Th	0.0021*	0.03	0.004*	0.057	0.0031*	0.044
Total-Sr	0.12*	<0.01	0.071*	<0.01	0.11*	<0.01
^{234}U	–0.0095*	0.011	0.15*	0.17	0.08*	0.089
^{235}U	0.0028*	<0.01	0.01*	0.01	0.0055*	<0.01
^{238}U	0.0042*	<0.01	0.018*	0.018	0.022*	0.022

Analysis	Station 45	Percentage DCG[b]	Station 46	Percentage DCG[b]	ORNL network	Percentage DCG[b]
^{60}Co	–0.019	<0.01	0.02	<0.01	0.014	<0.01
^{137}Cs	0.019	<0.01	0.068*	<0.01	0.007	<0.01
^{238}Pu	0.001	<0.01	–0.0014	<0.01	0.00021	<0.01
^{239}Pu	–0.0023	<0.01	–0.0005	<0.01	0.00012	<0.01
^{228}Th	0.0038*	<0.01	0.0029*	<0.01	0.0019*	<0.01
^{230}Th	0.0035*	<0.01	0.004*	0.01	0.0016*	<0.01
^{232}Th	0.0027*	0.039	0.0035*	0.05	0.0021*	0.03
Total-Sr	0.0094	<0.01	0.02	<0.01	0.019*	<0.01
^{234}U	0.16*	0.18	0.16*	0.18	0.024*	0.027
^{235}U	0.0039*	<0.01	0.01*	0.01	0.003*	<0.01
^{238}U	0.033*	0.033	0.029*	0.029	0.014*	0.014

Analysis	ORR network	Percentage DCG[b]	Remote network	Percentage DCG[b]
^{60}Co	–0.002	<0.01	0.031	<0.01
^{137}Cs	0.0082	<0.01	0.0034	<0.01
^{238}Pu	–0.0002	<0.01	0.0018	<0.01
^{239}Pu	–0.00057	<0.01	–0.0011	<0.01
^{228}Th	0.0033*	<0.01	0.0037*	<0.01
^{230}Th	0.0024*	<0.01	0.003*	<0.01
^{232}Th	0.0031*	0.044	0.0037*	0.053
Total-Sr	0.0084	<0.01	0.037*	<0.01
^{234}U	0.039*	0.043	0.0079*	<0.01
^{235}U	0.0061*	<0.01	0.00028	<0.01
^{238}U	0.02*	0.02	0.0053*	<0.01

[a]See Figs. 3.19 and 3.20 in Vol. 1 for monitoring locations.

[b]Percentage of DCG = average/derived concentration guide (DCG) × 100. The DCG for ^{60}Co is 8×10^{-11} μCi/mL; 137Cs is 4 × 10–10 μCi/mL; ^{238}Pu is 3×10^{-14} μCi/mL; 239Pu is 2 × 10–14 μC/mL; ^{228}Th is 4 × $^{10-14}$ μCi/mL; ^{230}Th is 4×10^{-14} μCi/mL; ^{232}Th is 7×10^{-15} μCi/mL; Total Sr is 9×10^{-12} μCi/mL; ^{234}U is 9×10^{-14} μCi/mL; ^{235}U is 1×10^{-13} μCi/mL; ^{238}U is 1 × 10–13 μCi/mL. Source for DCG is DOE Order 5400.5, "Radiation Protection of the Public and the Environment," Chapter III.

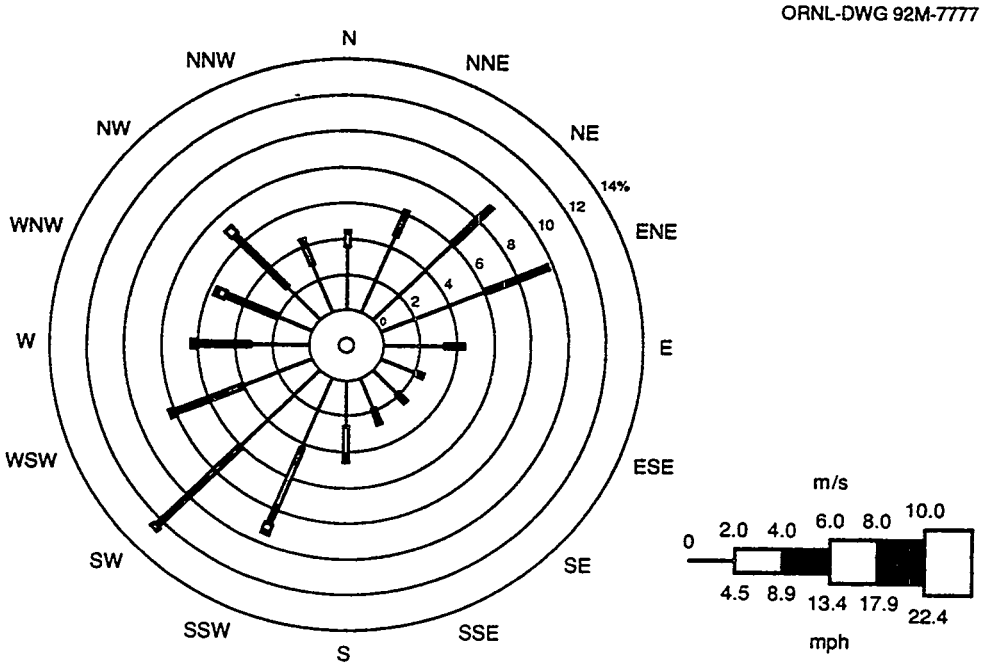


Fig. 3.1. 1991 wind rose for K-25 tower MT1 (10-m level), with 91.4% of possible data.

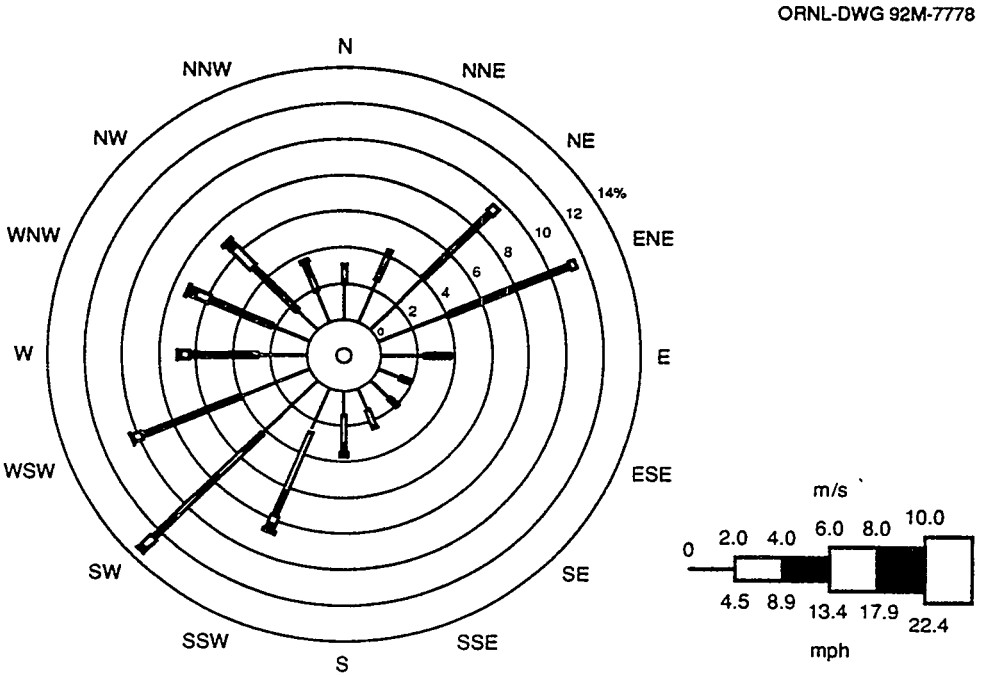


Fig. 3.2. 1991 wind rose for K-25 tower MT1 (60-m level), with 87.5% of possible data.

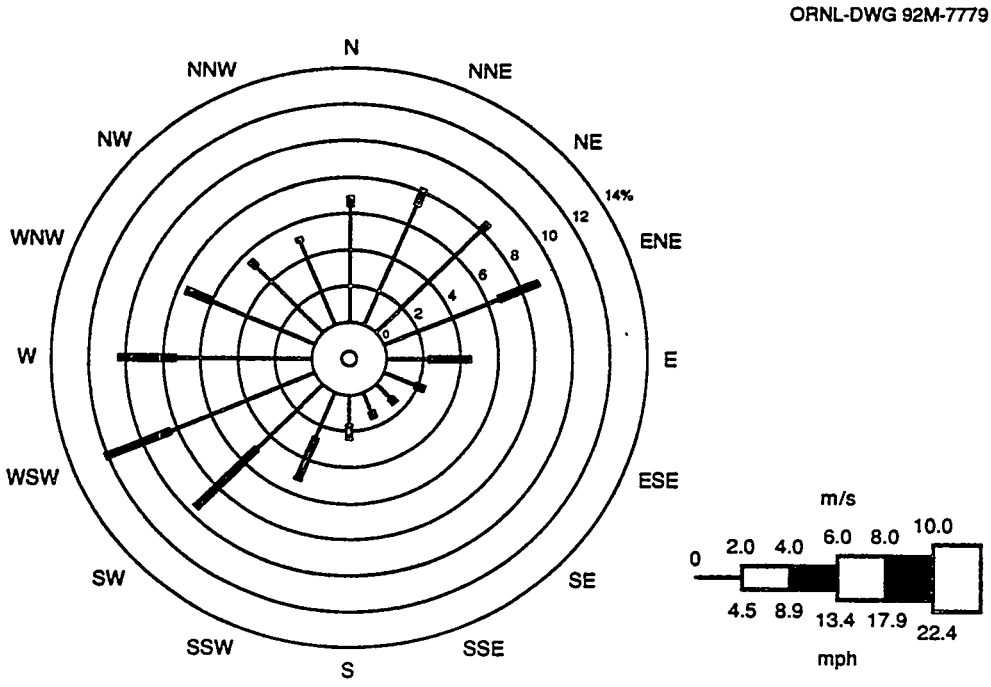


Fig. 3.3. 1991 wind rose for ORNL tower MT2 (10-m level), with 81.8% of possible data.

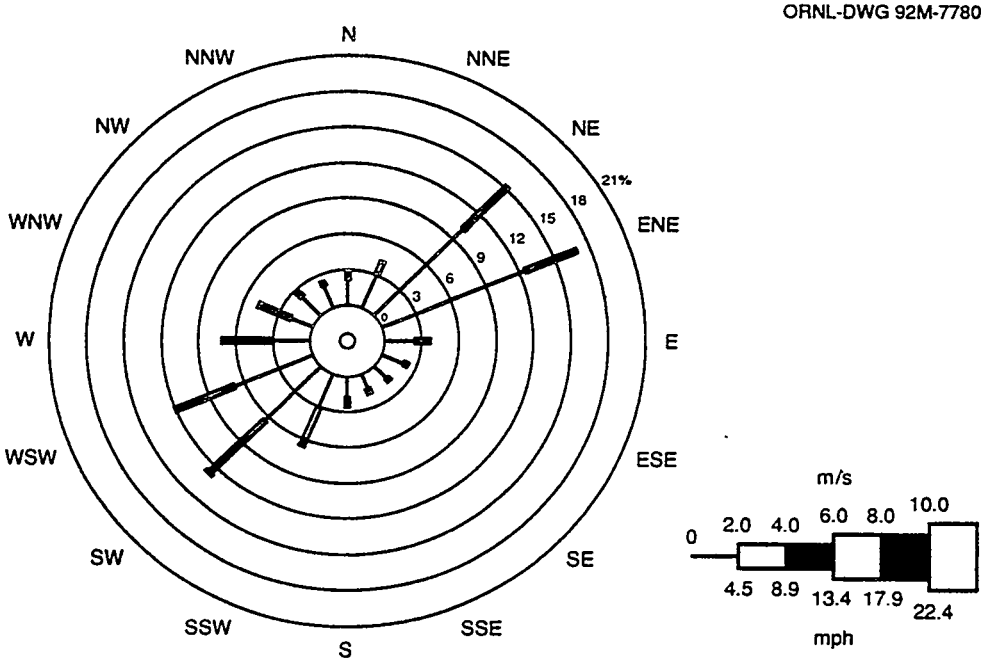


Fig. 3.4. 1991 wind rose for ORNL tower MT2 (30-m level), with 82.2% of possible data.

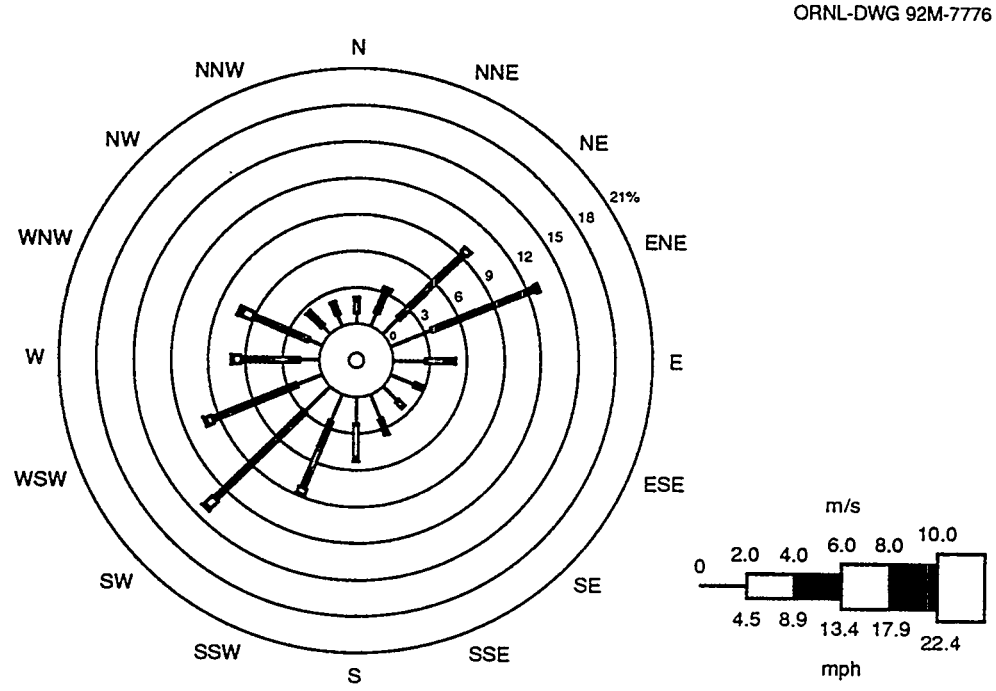


Fig. 3.5. 1991 wind rose for ORNL tower MT2 (100-m level), with 80.4% of possible data.

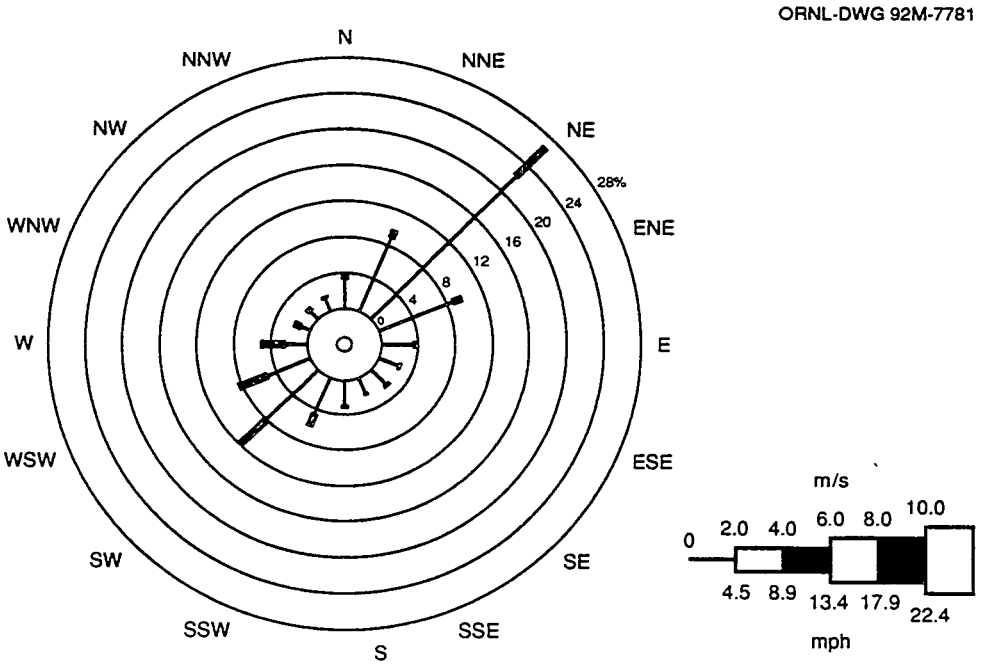


Fig. 3.6. 1991 wind rose for ORNL tower MT3 (10-m level), with 84.0% of possible data.

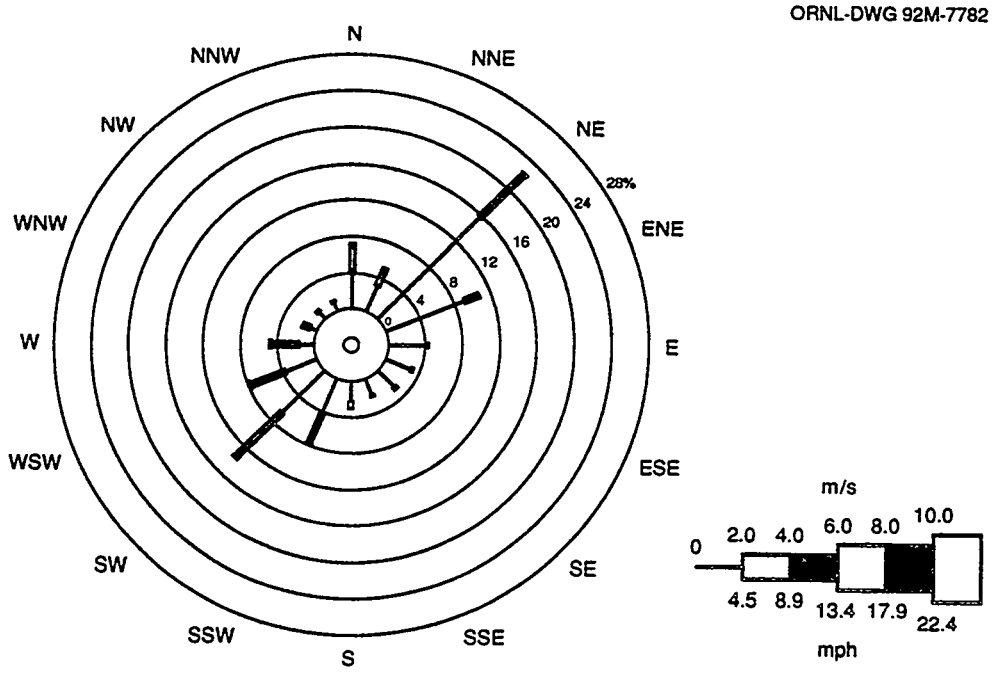


Fig. 3.7. 1991 wind rose for ORNL tower MT3 (30-m level), with 83.0% of possible data.

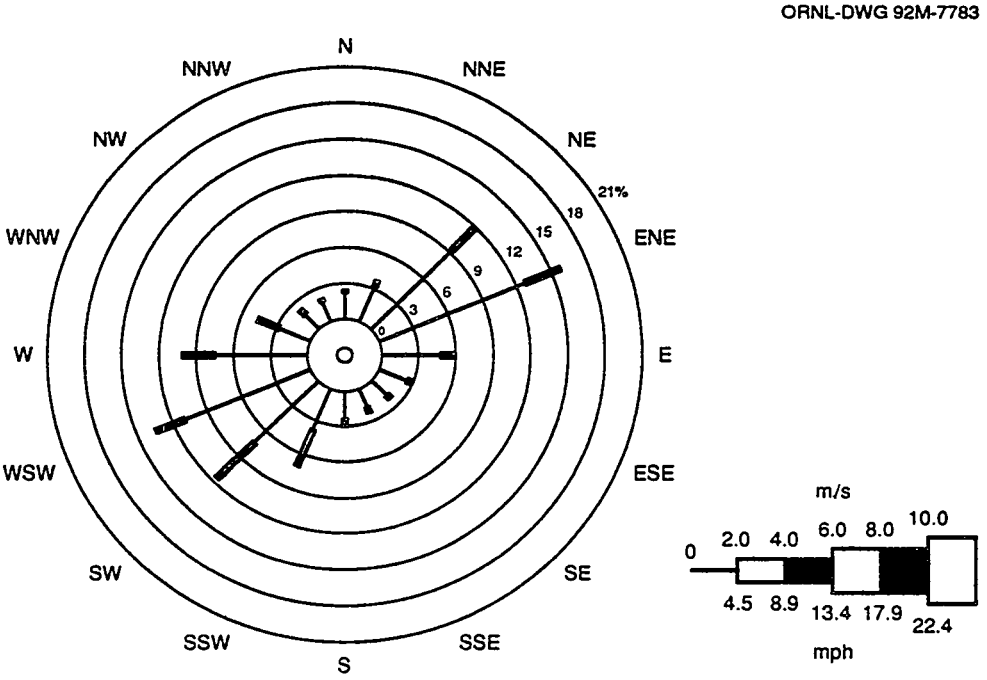


Fig. 3.8. 1991 wind rose for ORNL tower MT4 (10-m level), with 82.3% of possible data.

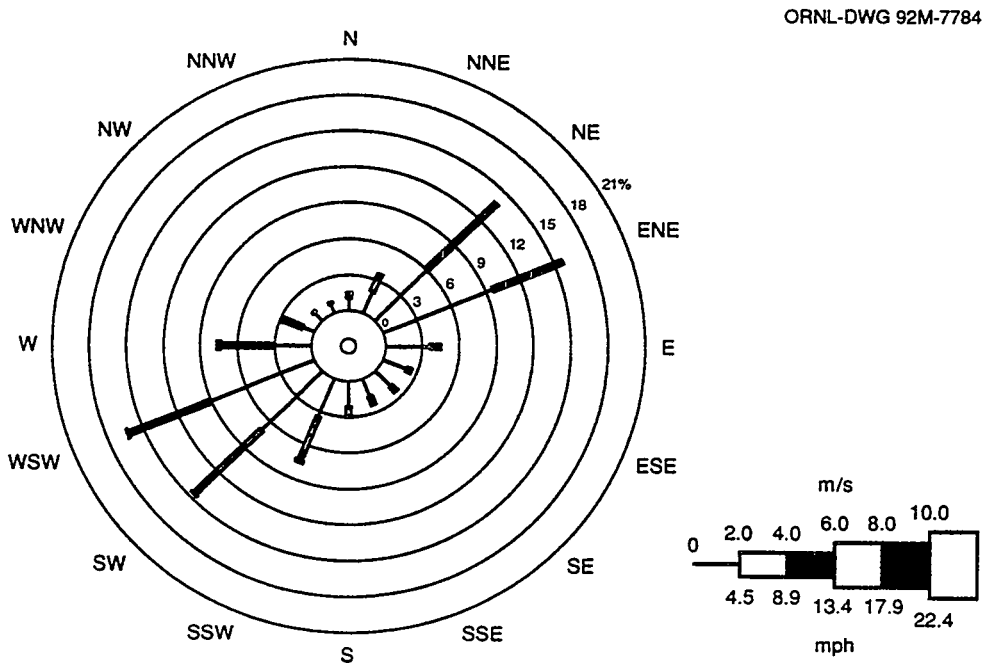


Fig. 3.9. 1991 wind rose for ORNL tower MT4 (30-m level), with 82.5% of possible data.

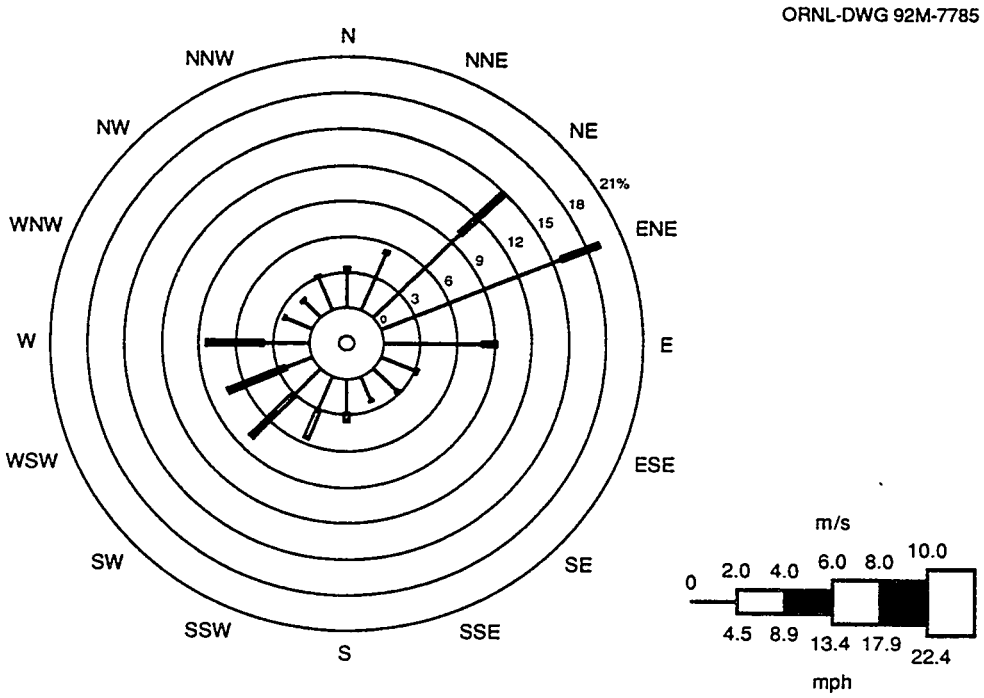


Fig. 3.10. 1991 wind rose for Y-12 Plant tower MTE (east) (10-m level), with 99.3% of possible data.

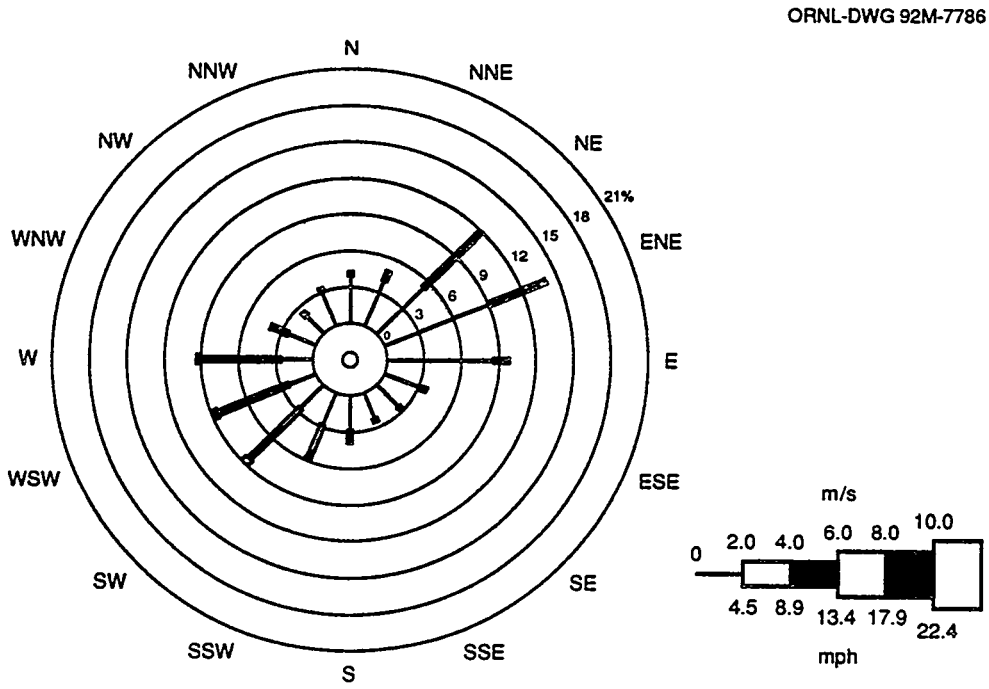


Fig. 3.11. 1991 wind rose for Y-12 Plant tower MTE (east) (30-m level), with 97.2% of possible data.

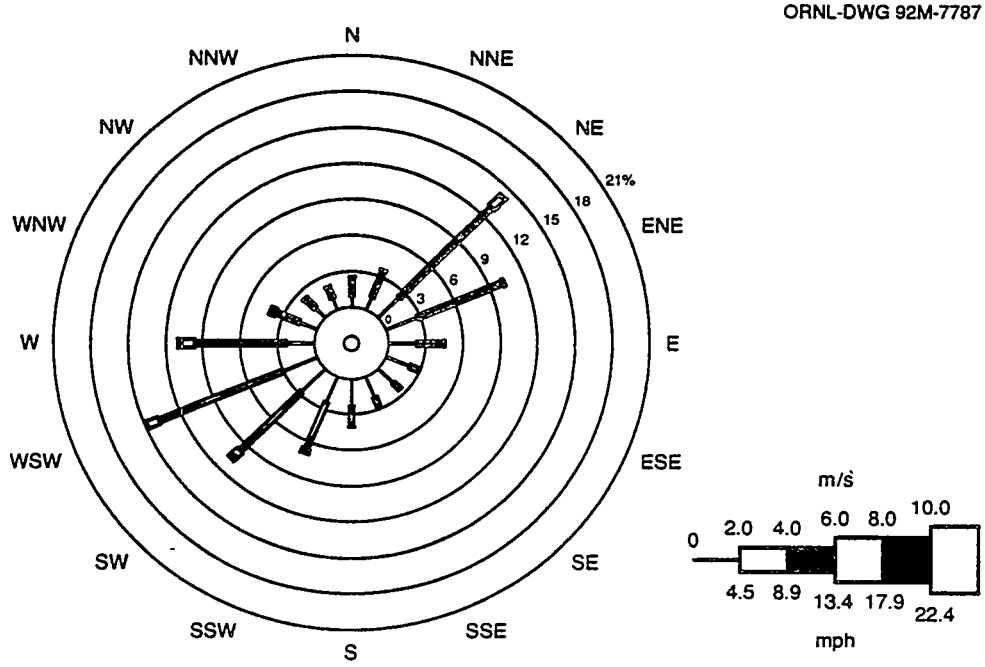


Fig. 3.12. 1991 wind rose for Y-12 Plant tower MTE (east) (100-m level), with 98.7% of possible data.

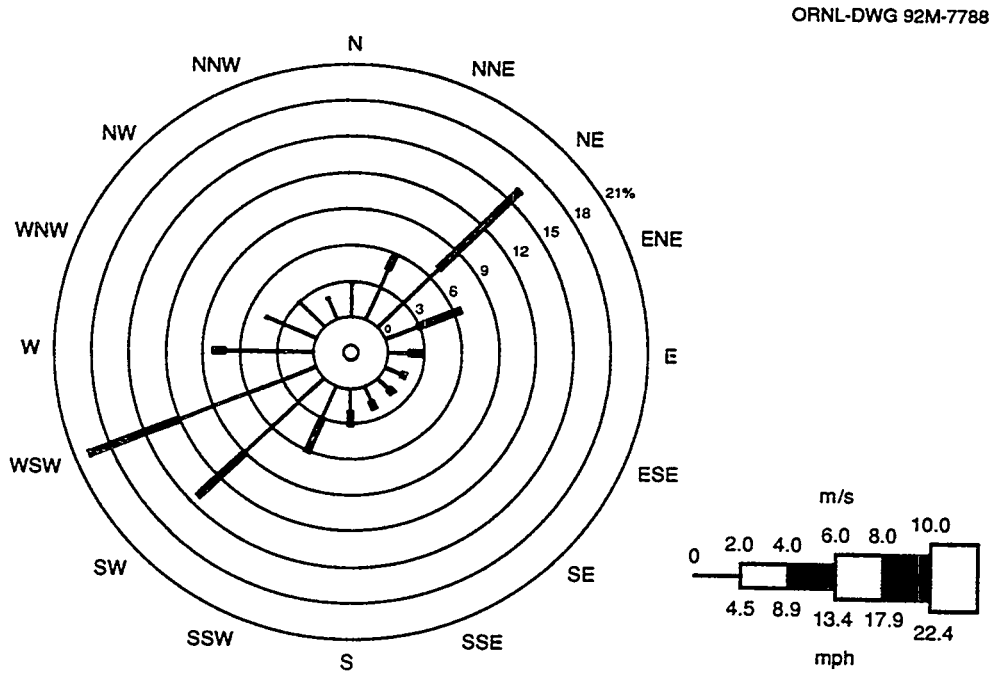


Fig. 3.13. 1991 wind rose for Y-12 Plant tower MTW (west) (10-m level), with 99.3% of possible data.

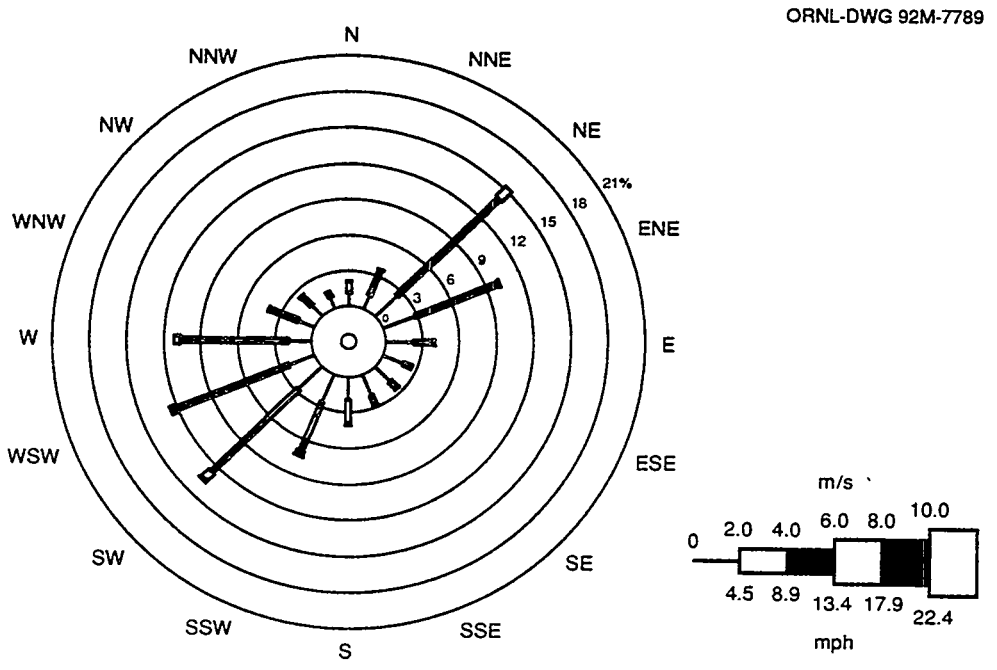


Fig. 3.14. 1991 wind rose for Y-12 Plant tower MTW (west) (60-m level), with 98.0% of possible data.

Table 3.13 1991 external gamma radiation measurements

Location	Number of samples[a]	Exposure rate (μ R/h)			
		Max	Min	Av[b]	Standard error[c]
		ORNL PAM stations[d]			
03	592	9.1	7.3	7.6*	0.0074
07	4,560	260	0.00067	3.3*	0.074
20	6,729	71	6.2	8.9*	0.011
Network summary	11,881	260	0.00067	6.7*	0.038
		Oak Ridge Reservation PAM stations[d]			
08	5,449	16,000	5.9	10*	3.0
31	58	8.2	7.9	8.0*	0.011
33	5,211	190	0.19	5.8*	0.065
34	4,238	89	1.2	8.2*	0.022
40	4,697	490	7.4	34*	1.1
41	5,102	6.3	3.1	5.1*	0.0031
42	6,896	38	4.4	7.1*	0.0084
43	4,918	56	0.00033	3.1*	0.046
44	6,827	300	0.13	7.3*	0.063
45	5,128	28	0.0080	3.4*	0.048
46	5,852	120	7.2	9.2*	0.034
Network summary	54,376	16,000	0.00033	9.1*	0.32

[a]Real-time readings were collected at all stations at 10-minute intervals. The number of samples indicate the total number of valid hourly averages during the year.

[b]Averages marked with an asterisk (*) are statistically greater than zero at the 95% level of confidence.

[c]Standard deviation of the mean.

[d]See Fig. 3.19.

4. SURFACE WATER

Table 4.1. 1991 Y-12 Plant annual summary for upper Bear Creek radiological and nonradiological data km 11.97[a]

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Cadmium	48	0.062	0.0005	0.0083	0.0014	*b*
Chromium	48	0.005	0.001	0.002	0.000	*b*
Cyanide	48	0.003	<0.002	<0.002	0.000	*b*
Lead	48	<0.005	<0.001	<0.001	0.000	*b*
Mercury	48	0.0056	<0.0002	<0.0004	0.0001	*b*
Nitrate (as N)	48	600	38	159	18	*b*
Dissolved oxygen	48	12.2	6.8	9.1	0.2	*b*
Phenols	48	0.006	<0.001	<0.002	0.000	*b*
Total dissolved solids	48	2,300	270	1,305	78	*b*
Total suspended solids	48	36	<5	<6	1	*b*
Selenium	48	<0.002	<0.002	<0.002	0.000	*b*
Thallium	48	<0.005	<0.001	<0.001	0.000	*b*
pH, standard units	48	8.8	6.7	*b*	0.05358	*b*
Aluminum	48	0.89	<0.04	<0.22	0.02	*b*
Barium	48	1.16	0.17	0.49	0.03	*b*
Beryllium	48	<0.002	<0.0004	<0.0004	0.0000	*b*
Boron	48	0.289	0.036	0.094	0.008	*b*
Calcium	48	420	96.6	238.9	12.3	*b*
Cerium	48	<0.08	<0.02	<0.02	0.00	*b*
Cobalt	48	0.01	<0.002	<0.003	0.000	*b*
Copper	48	0.03	0.006	0.007	0.000	*b*
Gallium	48	<0.09	<0.02	<0.02	0.00	*b*
Iron	48	0.66	<0.06	<0.13	0.02	*b*
Lithium	48	<0.08	<0.02	<0.02	0.00	*b*
Magnesium	48	59.8	13.0	32.6	1.8	*b*
Manganese	48	3.78	0.101	1.453	0.119	*b*
Molybdenum	48	<0.03	<0.006	<0.006	0.000	*b*
Nickel	48	0.10	0.009	0.038	0.003	*b*
Niobium	48	<0.05	<0.01	<0.01	0.00	*b*
Phosphorus	48	0.2	<0.05	<0.06	0.00	*b*
Potassium	48	7.4	2.9	4.9	0.2	*b*
Scandium	48	<0.002	<0.000	<0.000	0.000	*b*
Silver	48	<0.03	<0.006	<0.006	0.000	*b*
Sodium	48	67.8	20.5	41.4	1.9	*b*
Strontium	48	1.26	0.29	0.70	0.04	*b*
Thorium	48	0.05	<0.01	<0.01	0.00	*b*
Titanium	48	<0.06	<0.01	<0.01	0.00	*b*
Vanadium	48	<0.02	<0.004	<0.004	0.000	*b*
Zinc	48	0.05	0.007	0.011	0.001	*b*
Zirconium	48	<0.02	<0.004	<0.005	0.000	*b*
PCB, total	48	<0.0005	<0.0005	<0.0005	0.0000	*b*
Volatile organics, total	48	<0.01	<0.01	<0.01	0.00	*b*
^{241}Am[c]	48	9.1	–0.56	0.46	0.26	1.53
^{237}Np[c]	48	6.3	–0.48	1.47	0.16	4.91
^{238}Pu[c]	46	0.42	–0.58	0.00	0.03	0.0
^{99}Tc[c]	48	3.27	0.003	0.562	0.071	0.001
Uranium, total	48	0.848	0.098	0.224	0.017	*b*
^{235}U[c]	48	0.73	0.20	0.36	0.01	*b*
Alpha activity[c]	48	520	28	143	17	*b*

[a]See Fig. 4.2 in Vol. 1.
[b]Not applicable.
[c]pCi/L.

Table 4.2. 1991 Y-12 Plant annual summary for upper Bear Creek radiological and nonradiological data for km 12.4[a]

Parameter	Number of samples	Concentration (mg/L)			Standard error	Percentage of DCG
		Max	Min	Av		
Arsenic	47	<0.005	<0.001	<0.005	0.000	*b*
Cadmium	48	0.022	<0.0005	<0.0015	0.0006	*b*
Chromium	48	0.021	<0.001	<0.002	0.000	*b*
Cyanide	47	0.003	<0.002	<0.002	0.000	*b*
Lead	47	0.058	<0.001	<0.003	0.001	*b*
Nitrate, as N	48	530	6.8	45.6	10.8	*b*
Dissolved oxygen	48	11.2	5.3	7.5	0.2	*b*
Phenols	48	0.007	0.0001	0.0021	0.0002	*b*
Total dissolved solids	48	1100	260	860	25	*b*
Total suspended solids	48	380	0.5	15.9	7.8	*b*
Selium	47	<0.002	<0.002	<0.002	0.000	*b*
Thallium	47	<0.005	<0.001	<0.001	0.000	*b*
pH, standard units	48	7.8	7.3	*b*	0.0	*b*
Aluminum	48	21.8	<0.04	<0.69	0.45	*b*
Barium	48	0.928	0.0499	0.109	0.01761	*b*
Beryllium	48	<0.002	<0.0004	<0.0005	0.0000	*b*
Boron	48	0.291	0.05	0.092	0.006	*b*
Calcium	48	230	57.2	172.9	4.9	*b*
Cerium	48	<0.08	<0.02	<0.02	0.00	*b*
Cobalt	48	0.014	<0.002	<0.003	0.000	*b*
Copper	48	0.052	<0.006	<0.009	0.001	*b*
Gallium	47	<0.09	<0.02	<0.02	0.00	*b*
Iron	48	42.6	<0.06	<1.08	0.88	*b*
Lithium	48	<0.08	<0.02	<0.02	0.00	*b*
Magnesium	48	37.4	8.12	24.63	0.84	*b*
Manganese	48	0.571	0.009	0.058	0.012	*b*
Molybdenum	47	<0.03	<0.006	<0.007	0.001	*b*
Nickel	48	0.04	<0.008	<0.010	0.001	*b*
Niobium	47	<0.05	<0.01	<0.01	0.00	*b*
Phosphorus	48	0.4	<0.05	<0.08	0.01	*b*
Potassium	48	7.5	3.8	5.4	0.1	*b*
Scandium	48	0.0115	<0.0004	<0.0007	0.0002	*b*
Silver	47	<0.03	<0.006	<0.007	0.001	*b*
Sodium	48	179	18.6	61.0	3.5	*b*
Strontium	48	0.578	0.155	0.440	0.0012	*b*
Thorium	48	0.05	<0.01	<0.01	0.00	*b*
Titanium	48	0.19	<0.01	<0.02	0.00	*b*
Vanadium	48	0.09	<0.004	<0.006	0.002	*b*
Zinc	48	0.2	0.007	0.018	0.004	*b*
Zirconium	48	0.05	<0.004	<0.006	0.001	*b*
PCB, total	47	<0.0005	<0.0005	<0.0005	0.0000	*b*
Volatile organics, total	47	<0.01	<0.01	<0.01	0.00	*b*
^{241}Am[c]	48	0.93	–0.34	0.12	0.04	0.40
^{237}Np[c]	48	5.7	–0.37	0.86	0.12	2.86
^{238}Pu[c]	45	0.41	–0.44	–0.01	0.02	–0.03
^{239}Pu[c]	45	0.2	–0.13	0.01	0.01	0.03
^{240}Pu[c]	45	0.2	–0.13	0.01	0.01	0.03
^{99}Tc[c]	48	0.67	0.01	0.14	0.02	0.00
U, total (mg/L)	48	1.04	0.129	0.64	0.03	*b*
^{235}U (%)	48	0.42	0.14	0.30	0.01	*b*

[a]See Fig. 4.2 in Vol. 1.
[b]Not applicable.
[c]pCi/L.

Table 4.3. 1991 annual radiological summary Y-12 Plant diversion ditch[a]

Parameter	Number of samples	Concentration[b]				Percentage of DCG
		Max	Min	Av	Standard error	
U, total	52	0.074	<0.001	<0.038	0.002	*c*
^{235}U (%)	51	0.630	0.180	0.422	0.013	*c*
Th, total	52	<0.011	<0.003	<0.003	0.000	*c*

[a]See Fig. 4.2 in Vol. 1.
[b]Units are in mg/L unless otherwise noted.
[c]Not applicable.

Table 4.4. 1991 Y-12 Plant annual radiological and nonradiological data summary for Station 17[a]

Parameter	Number of samples	Concentration (mg/L)[b]			Standard error	Percentage of DCG
		Max	Min	Av		
Mercury	729	0.0076	0.0004	0.0014	0.0000	*c*
Nitrate	249	130.00	0.55	5.61	0.54	*c*
Total phosphorus	249	0.47	0.12	0.27	0.00	*c*
Copper	250	0.030	<0.006	<0.007	0.000	*c*
Zinc	249	0.170	0.017	0.044	0.001	*c*
Chromium	250	0.030	<0.006	<0.006	0.000	*c*
Molybdenum	249	0.110	<0.006	<0.007	0.000	*c*
Lithium	248	0.41	<0.02	<0.03	0.00	*c*
Selenium	225	<0.007	<0.002	<0.002	0.000	*c*
Cadmium	244	<0.004	<0.004	<0.004	0	*c*
Lead	246	0.020	<0.001	<0.002	0.000	*c*
Nickel	246	<0.050	<0.001	<0.037	0.001	*c*
Calcium	249	73.60	26.80	54.37	0.46	*c*
Magnesium	249	14.40	4.99	10.86	0.10	*c*
Sodium	249	43.0	2.8	17.6	0.5	*c*
Potassium	249	3.3	1.5	2.3	0.0	*c*
Sulfate	249	220	20	68	2	*c*
Chloride	249	150	1	19	1	*c*
Fluoride	249	5.8	0.1	1.0	0.0	*c*
Total suspended solids	243	62	<5	<11	1	*c*
Total dissolved solids	249	520	94	278	4	*c*
Alkalinity	249	140	68	108	1	*c*
Total organic carbons	249	27.0	1.7	14.9	0.4	*c*
Residual chlorine, total	232	<0.1	<0.1	<0.1	0	*c*
Cadmium (AA)	243	0.0041	<0.0001	<0.0006	0.0000	*c*
Temperature, °F	330	82	52	68	0	*c*
pH, standard units	323	8.8	5.5	*b*	0.0	*c*
Dissolved oxygen	318	10.2	2.7	7.6	0.1	*c*
Conductivity, mhos/cm	330	334	3	80	5	*c*
Alpha activity (pCi/L)	42	40.0	6.4	17.6	1.2	*c*
Beta activity (pCi/L)	43	27	8	17	1	*c*
^{237}Np (pCi/L)	43	0.75	–0.63	0.04	0.04	0.13
^{226}Ra (pCi/L)	27	4.30	0.27	2.02	0.23	2.02
^{228}Ra (pCi/L)	28	570	–240	108	34	108
^{90}Sr, (pCi/L)	43	7.1	–2.3	0.6	0.3	0.6
Th, total	43	0.015	–0.003	0.003	0.000	*c*
U, total	43	0.068	0.010	0.031	0.002	*c*
^{235}U (%)	43	0.95	0.22	0.46	0.03	*c*
^{238}Pu (pCi/L)	33	0.36	–0.53	0.00	0.03	0.01
$^{239/240}$Pu (pCi/L)	33	0.23	–0.14	0.03	0.01	0.10
^{99}Tc (pCi/mL)	44	0.140	–0.022	0.013	0.005	0.013
^{234}Th (pCi/L)	42	23.0	–2.7	2.0	0.8	0.02
^{228}Th (pCi/L)	43	3.8	0.01	0.83	0.11	0.21
^{230}Th (pCi/L)	43	2.1	0	0.37	0.05	0.12
^{232}Th (pCi/L)	43	0.46	–0.95	0.06	0.03	0.12
^{234}U (pCi/L)	43	150	3.4	9.7	3.3	*c*
^{235}U (pCi/L)	43	8.8	0.02	0.56	0.20	0.092
^{238}U (pCi/L)	43	35	3	11	1	2

[a]Flow during operations and/or discharging.
[b]Units are in mg/L unless otherwise noted.
[c]Not applicable.

Table 4.5. 1991 annual radiological and nonradiological data summary for West End Sewer, Y-12 Plant

Parameter	Number of samples	Concentration[a]			Standard error	Percentage of DCG
		Max	Min	Av		
Mercury	12	0.012	0.000	0.003	0.001	*b*
Oil and grease	12	10.0	<2.0	<4.3	0.7	*b*
Total suspended solids	12	73	<5	<42	1	*b*
Cyanide	12	0.020	<0.002	<0.005	0.002	*b*
Ammonia	12	14.00	0.25	9.04	1.37	*b*
Kjeldahl nitrogen	12	21.0	0.7	13.5	1.9	*b*
Selenium	12	<0.002	<0.002	<0.002	0.000	*b*
Biochemical oxygen demand	11	86.00	9.98	48.38	7.91	*b*
Chemical oxygen demand	12	160	23	104	13	*b*
Chromium +6	12	<0.01	<0.01	<0.01	0.00	*b*
pH, standard units	12	7.8	7.0	*b*	0.1	*b*
Aluminum	12	0.53	0.11	0.22	0.03	*b*
Arsenic	12	<0.04	<0.04	<0.04	0.00	*b*
Barium	12	0.0975	0.0264	0.0525	0.0060	*b*
Beryllium	12	<0.0004	<0.0004	<0.0004	0.0000	*b*
Boron	12	0.04	0.02	0.03	0.00	*b*
Cadmium	12	<0.004	<0.004	<0.004	0.000	*b*
Calcium	12	52.6	32.2	41.8	2.0	*b*
Cerium	12	<0.02	<0.02	<0.02	0.00	*b*
Chromium	12	<0.006	<0.006	<0.006	0.000	*b*
Cobalt	12	<0.002	<0.002	<0.002	0.000	*b*
Copper	12	0.039	0.007	0.014	0.002	*b*
Gallium	12	<0.02	<0.02	<0.02	0.00	*b*
Iron	12	1.27	<0.06	<0.44	0.09	*b*
Lanthanum	*b*	*b*	*b*	*b*	*b*	*b*
Lead	12	<0.02	<0.02	<0.02	0.00	*b*
Lithium	12	<0.02	<0.02	<0.02	0.00	*b*
Magnesium	12	12.20	8.73	10.11	0.26	*b*
Mangenese	12	0.223	0.009	0.112	0.021	*b*
Molybdenum	12	<0.006	<0.006	<0.006	0.000	*b*
Nickel	12	<0.009	<0.008	<0.008	0.000	*b*
Niobium	12	<0.01	<0.01	<0.01	0.00	*b*
Phosphorus	12	4.25	1.30	2.64	0.21	*b*
Potassium	12	8.8	1.7	6.4	0.7	*b*
Scandium	12	<0.0004	<0.0004	<0.0004	0.0000	*b*
Silver	12	0.012	<0.006	<0.007	0.001	*b*
Sodium	12	19.6	8.6	14.5	0.8	*b*
Strontium	12	0.138	0.074	0.105	0.006	*b*
Thorium	12	<0.01	<0.01	<0.01	0.00	*b*
Titanium	12	<0.01	<0.01	<0.01	0.00	*b*
Vanadium	12	<0.004	<0.004	<0.004	0.000	*b*
Zinc	12	0.36	0.11	0.18	0.02	*b*
Zirconium	12	<0.004	<0.004	<0.004	0.000	*b*
Alpha activity (pCi/L)	12	29.0	−1.4	14.7	2.3	*b*
Beta activity (pCi/L)	12	41.0	7.9	26.4	3.0	*b*
^{235}U (%)	10	2.67	0.97	1.70	0.17	*b*
U, total	12	0.0180	0.0008	0.0067	0.0016	*b*
Gamma, total (pCi/L)	12	200.0	1.2	51.3	16.2	*b*

[a]All units are in mg/L unless noted otherwise.
[b]Not applicable.

Table 4.6. 1991 annual radiological and nonradiological data summary for East End Sewer, Y-12 Plant

Parameter	Number of samples	Concentration[a]			Standard error	Percentage of DCG
		Max	Min	Av		
Mercury	10	0.0045	<0.0002	<0.0026	0.106	*b*
Oil and grease	12	24.0	<2.0	<6.1	1.7	*b*
Total suspended solids	12	44.0	16.0	27.3	2.8	*b*
Cyanide	12	0.0070	<0.0020	<0.0020	0.0004	*b*
Ammonia	12	9.0	2.1	6.9	0.6	*b*
Kjeldahl nitrogen	12	16.0	7.8	11.7	0.6	*b*
Selenium	12	0.0030	<0.0020	<0.0021	0.0001	*b*
Biochemical oxygen demand	11	10	16	29	4	*b*
Chemical oxygen demand	12	150	23	68	9	*b*
Chromium +6	12	<0.01	<0.01	<0.01	0.00	*b*
pH, standard units	10	7.9	6.9	*b*	1.7	*b*
Aluminum	12	0.41	0.11	0.19	0.03	*b*
Arsenic	12	<0.04	<0.04	<0.04	0.00	*b*
Barium	12	0.06	0.03	0.04	0.00	*b*
Beryllium	12	<0.0004	<0.0004	<0.0004	0.0000	*b*
Boron	12	0.047	0.021	0.030	0.002	*b*
Cadmium	12	<0.004	<0.004	<0.004	0.000	*b*
Calcium	12	39.6	34.4	36.8	0.5	*b*
Cerium	12	<0.02	<0.02	<0.02	0.00	*b*
Chromium	12	<0.006	<0.006	<0.006	0.000	*b*
Cobalt	12	<0.002	<0.002	<0.002	0.000	*b*
Copper	12	0.037	0.008	0.015	0.002	*b*
Gallium	12	<0.02	<0.02	<0.02	0.00	*b*
Iron	12	0.51	0.11	0.25	0.03	*b*
Lanthanum	0	0.0000	0.0000	0.0000	0.0000	*b*
Lead	12	<0.02	<0.02	<0.02	0.00	*b*
Lithium	12	<0.02	<0.02	<0.02	0.00	*b*
Magnesium	12	10.50	8.15	9.19	0.20	*b*
Mangenese	12	0.047	0.027	0.037	0.002	*b*
Molybdenum	12	<0.006	<0.006	<0.006	0.000	*b*
Nickel	12	<0.008	<0.008	<0.008	0.106	*b*
Niobium	12	<0.01	<0.01	<0.01	0.11	*b*
Phosphorus	12	3.66	1.45	2.37	0.11	*b*
Potassium	12	6.9	4.5	5.7	0.2	*b*
Scandium	12	<0.0004	<0.0004	<0.0004	0.0000	*b*
Silver	12	0.017	<0.006	<0.008	0.001	*b*
Sodium	12	16.7	8.9	12.5	0.6	*b*
Strontium	12	0.128	0.086	0.098	0.003	*b*
Thorium	12	<0.01	<0.01	<0.01	0.00	*b*
Titanium	12	<0.01	<0.01	<0.01	0.00	*b*
Vanadium	12	<0.004	<0.004	<0.004	0.000	*b*
Zinc	12	0.27	0.07	0.14	0.01	*b*
Zirconium	12	<0.004	<0.004	<0.004	0.000	*b*
Alpha activity (pCi/L)	12	5.8	−2.4	1.6	0.8	*b*
Beta activity (pCi/L)	12	13.0	7.0	9.7	0.5	*b*
^{235}U (%)	9	0.83	0.40	0.61	0.04	*b*
U, total	12	0.003	<0.001	<0.001	0.000	*b*
Gamma, total (pCi/L)	12	190.0	3.5	62.0	15.2	*b*

[a]All units are in mg/L unless noted otherwise.
[b]Not applicable.

Table 4.7. 1991 annual radiological and nonradiological data summary for the Biology Sewer, Y-12 Plant

Parameter	Number of samples	Concentration[a]				
		Max	Min	Av	Standard error	Percentage of DCG
Mercury	12	0.0009	<0.0002	<0.0003	0.0001	*b*
Oil and grease	12	9	<2	<3.0000	0.6155	*b*
Total suspended solids	12	23	<5	<7.1667	1.5267	*b*
Cyanide	12	3	<0.002	<0.2764	0.2482	*b*
Ammonia	12	1.7	<0.2	<0.7525	0.1298	*b*
Kjeldahl nitrogen	12	4.3	0.7	1.6617	0.2937	*b*
Selenium	12	<0.002	<0.002	<0.0020	0.0000	*b*
Biochemical oxygen demand	12	29	6.66	15.3742	2.2759	*b*
Chemical oxygen demand	12	86	15	35.1667	5.1696	*b*
Chromium +6	12	0.01	<0.01	<0.0100	0.0000	*b*
pH, standard units	12	9	7.2	*b*	0.1474	*b*
Aluminum	12	0.64	0.05	0.1858	0.0472	*b*
Arsenic	12	<0.04	<0.04	<0.0400	0.0000	*b*
Barium	12	0.0517	0.0246	0.0302	0.0022	*b*
Beryllium	12	<0.0004	<0.0004	<0.0004	0.0000	*b*
Boron	12	0.311	0.009	0.0629	0.0234	*b*
Cadmium	12	<0.004	<0.004	<0.0040	0.0000	*b*
Calcium	12	40.5	28.3	31.4917	0.9551	*b*
Cerium	12	<0.02	<0.02	<0.0200	0.0000	*b*
Chromium	12	0.01	<0.006	<0.0063	0.0003	*b*
Cobalt	12	0.003	<0.002	<0.0021	0.0001	*b*
Copper	12	0.024	<0.006	<0.0108	0.0014	*b*
Gallium	12	<0.02	<0.02	<0.0200	0.0000	*b*
Iron	12	0.57	<0.06	<0.1033	0.0424	*b*
Lead	12	0.02	<0.02	<0.0200	0.0000	*b*
Lithium	12	0.12	<0.02	<0.0283	0.0083	*b*
Magnesium	12	14	7.56	9.1408	0.5344	*b*
Manganese	12	0.066	0.003	0.0178	0.0049	*b*
Molybdenum	12	<0.007	<0.006	<0.0061	0.0001	*b*
Nickel	12	<0.008	<0.008	<0.0080	0.0000	*b*
Niobium	12	<0.01	<0.01	<0.0100	0.0000	*b*
Phosphorus	12	7.34	<0.05	<3.1790	0.5212	*b*
Potassium	12	3.2	1.2	1.9417	0.1681	*b*
Scandium	12	<0.0004	<0.0004	<0.0004	0.0000	*b*
Silver	12	0.259	<0.006	<0.0448	0.0256	*b*
Sodium	12	22.6	0.66	13.0142	1.5874	*b*
Strontium	12	0.109	0.038	0.0764	0.0052	*b*
Thorium	12	<0.01	<0.01	<0.0100	0.0000	*b*
Titanium	12	<0.01	<0.01	<0.0100	0.0000	*b*
Vanadium	12	<12	<0.004	<0.0040	0.0000	*b*
Zinc	12	0.22	0.01	0.1200	0.0134	*b*
Zirconium	12	<0.004	<0.004	<0.0040	0.0000	*b*
Alpha activity (pCi/L)	12	6.6	–4	0.5358	1.0635	*b*
Beta activity (pCi/L)	12	98	2.3	28.9250	9.1971	*b*
^{235}U (%)	2	0.42	0.35	0.3850	0.0350	*b*
U, total	12	<0.001	<0.001	<0.0010	0.0000	*b*
Gamma, total (pCi/L)	12	120	9.7	60.8920	12.1498	*b*

[a]All units are in mg/L unless noted otherwise.
[b]Not applicable.

Table 4.8. Y-12 Plant release of uranium to the off-site environment as a liquid effluent

Year	Uranium (Ci)	Uranium (kg)
	Station 17	
1988	0.164	220
1989	0.20	316
1990	0.135	197
1991	0.162	235
	Outfall 304	
1988	0.052	94
1989	0.138	244
1990	0.131	204
1991	0.082	159
	Total off-site release	
1988	0.22	314
1989	0.34	560
1990	0.27	401
1991	0.24	394

Table 4.9. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 304, Bear Creek

Parameter	Number of samples	Concentration (mg/L)			Standard error	Percentage of DCG
		Max	Min	Av		
Oil and grease	51	14	<2	<3	0.3	*a*
Biochemical oxygen demand	51	31	4.94	<6.14	0.53	*a*
Chemical oxygen demand	52	46	<5	<9	1	*a*
Total dissolved solids	52	300	6	176	9	*a*
Total suspended solids	52	180	<5	<12	4	*a*
Nitrate as N	52	500	0.4	25.2	13	*a*
Conductivity, μmhos/cm	52	350	104	256	9	*a*
Dissolved oxygen	52	12.4	7.3	9.2	0.2	*a*
Turbidity, NTU	51	25	0.69	5.6	0.75	*a*
pH, standard units	51	8.4	7.1	*b*	0.04	*a*
Flow, Mgd[b]	365	31.45	0.38	4.44	0.29	*a*
Alpha activity (pCi/L)	47	26	2.2	12.7	0.9	*a*
Beta activity (pCi/L)	47	84	1.7	21.5	2.3	*a*
^{90}Sr (pCi/L)	46	5.9	–3.9	0.3	0.3	0.0
^{237}Np (pCi/L)	46	1.1	–0.13	0.11	0.03	0.38
^{226}Ra (pCi/L)	25	9.19	0.59	2.63	0.45	2.63
^{228}Ra (pCi/L)	29	380	–135	93	23	93

[a]Not applicable.
[b]Flow during operations and/or discharging.

Table 4.10. Surface water analytical results of polychlorinated biphenyls monitoring plan for the Oak Ridge Y-12 Plant, CY 1991

Site number	Location	Date sampled	PCB concentration (mg/L)
PCB-1	Outfall 301, Kerr Hollow Quarry	1/10/91	<0.0005
		6/10/91	<0.0005
		9/12/91	<0.0005
		12/12/91	<0.0005
PCB-2	Outfall 302, Rogers Quarry	1/10/91	<0.0005
		6/10/91	<0.0005
		9/12/91	<0.0005
		12/12/91	<0.0005
PCB-3	Outfall 303, New Hope Pond	*a*	
PCB-5	New Hope Pond Inlet	*b*	
PCB-6	Upstream of Outfall 135	1/10/91	<0.0005
		6/10/91	<0.0005
		9/12/91	<0.0005
		12/12/91	<0.0005
PCB-7	Outfall 304, Bear Creek	1/10/91	<0.0005
		6/10/91	<0.0005
		9/12/91	<0.0005
		12/12/91	<0.0005

[a]This outlet was closed in April 1989.
[b]This inlet was closed in November 1988.

Table 4.11. Y-12 Plant NPDES-permitted outfalls, 1991

Quarry—outfall 301
Rogers Quarry—outfall 302
Bear Creek—outfall 304
Category I outfalls—Uncontaminated precipitation runoff and/or groundwater
Category II outfalls—Cooling water, condensate, building area, and foundation drains
Category III outfalls—Outfalls which consisted of Category I or II type wastewaters along with untreated process wastewaters. The untreated process wastewater portion has been removed from these outfalls and has either been eliminated or undergoes treatment prior to discharge
Category IV outfalls—402 – Steam Condensate from the Lithium Process
405 – Sanitary Landfill #2 Sediment Pond
408 – 9202 Catch Basin
Steam Plant fly ash sluice water—outfall 623
Central Pollution Control Facility—outfall 501
West End Treatment Facility—outfall 502
Steam Plant Wastewater Treatment Facility—outfall 503
Plating Rinsewater Treatment Facility—outfall 504
Building 9204-3 Sump Pump Oil Separator—outfall 506
Groundwater Treatment Facility—outfall 512
Miscellaneous discharges (cooling towers, undergo treatment at 503, vapor blasters)

Table 4.12. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 301, Kerr Hollow Quarry

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error
Flow[a], GPM	15	300	2	147	32
pH, standard units	16	8.2	6.6	*b*	0.1
Temperature, °C	16	15.4	9.6	11.9	0.5
Mercury	15	0.0035	<0.0002	<0.0005	0.0002
Total suspended solids	15	5	<5	<5	0
Sellenium	15	0.002	<0.002	<0.002	0
Arsenic	15	<0.2	<0.04	<0.05	0.01
Cadmium	15	<0.004	<0.004	<0.004	0
Chromium	15	<0.006	<0.006	<0.006	0
Copper	15	<0.006	<0.006	<0.006	0
Iron	15	0.2	<0.06	<0.10	0.01
Lead	15	0.09	<0.02	<0.03	0.01
Lithium	15	1.2	<0.02	<0.26	0.10
Nickel	15	0.6	<0.008	<0.087	0.054
Potassium	15	1.5	<0.008	<1.081	0.118
Sodium	15	1.13	<0.02	<0.66	0.08
Zinc	15	0.03	<0.005	<0.015	0.002
Zirconium	15	<0.01	<0.004	<0.005	0.001

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.13. CY 1991 NPDES Permit Number TN 002968

Discharge Point 302, Y-12 Plant, Roger's Quarry

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error
Total suspended solids	52	10	5	5	0
Chemical oxygen demand (COD)	53	11	2.3	5.7	0.2
Sulfate	53	38	15	22	1
Oil and grease	53	12	<2	<3	0
Settleable solids, ml/L	53	0.5	<0.1	<0.1	0.0
Selenium	53	0.005	<0.0002	<0.002	0.000
Mercury	53	0.0006	<0.0002	<0.000	0.000
Arsenic	53	<0.2	<0.04	<0.04	0.00
Cadmium	53	0.005	<0.004	0.004	0.000
Chromium	53	<0.006	<0.006	<0.006	0.000
Copper	53	<0.006	<0.006	<0.006	0.000
Iron	53	0.32	<0.06	<0.08	0.01
Nickel	53	<0.008	<0.008	<0.008	0.000
Zinc	53	<0.01	0.004	<0.009	0.000
Lead	53	<0.02	<0.02	<0.02	0.00
pH, standard units	53	9.2	7.0	*a*	0.1
Temperature, °C	53	31.2	9.5	19.4	1.0
Turbidity, NTU	53	7.6	0.34	1.60	0.21
Flow, Mgd[b]	365	12.76	0.07	0.89	0.08

[a]Not applicable.
[b]Flow during operations and/or discharging.

Table 4.14. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 307, West Borrow Area

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error
Flow,[a] GPD	4	152,381	15,235	62,688	30,542
pH, standard units	4	8.5	7.6	*b*	0.2
Temperature, °C	4	22.5	6.8	14.8	4.1
Conductivity, umho	1	60	60	60	*b*
Ammonia	4	0.4	<0.2	<0.3	0.1
Biochemical oxygen demand	4	<5	<5	<5	0
Chemical oxygen demand	4	14	<5	<9	2
Color, ACU	4	250	10	109	53
Oil and grease	4	2	<2	<2	0
Total organic carbon	4	10.0	1.9	6.5	1.7
Total suspended solids	4	200	<5	<78	46

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.15. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 308, East Borrow Area

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error
Flow,[a] GPD	4	152,381	763	39,620	37,592
pH, standard units	4	8.0	7.8	*b*	0.0
Temperature, °C	4	26.8	7.2	14.8	4.5
Ammonia	4	0.4	<0.2	<0.2	0.0
Biochemical oxygen demand	4	5.5	<5.0	<5.1	0.1
Chemical oxygen demand	4	24	6	15	4
Color, ACU	4	143	50	97	22
Oil and grease	4	16	<2	<6	4
Total organic carbon	4	9.3	3.4	5.9	1.2
Total suspended solids	4	38	16	25	5

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.16. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 309, Sanitary Landfill IV Sedimentation Basin

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error
Flow,[a] GPD	3	7987	1143	4057	2040
pH, standard units	3	8.8	7.3	*b*	0.4
Ammonia	1	<0.2	<0.2	<0.2	*b*
Total suspended solids	3	29	<5	<15	7
Total organic carbon	1	8.5	8.5	8.5	*b*
Chemical oxygen demand	2	<5	<5	<5	0
Biochemical oxygen demand	2	<5	<5	<5	0
Oil and grease	1	<2	<2	<2	*b*
Temperature, °C	3	26	7	15	6
Conductivity, umho	1	110	110	110	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.17. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 501, Central Pollution Control Facility

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Flow,[a] GPD	28	15,616	8,040	12,927	391	*b*
pH, standard units	28	8.7	6.4	*b*	0.1	*b*
Temperature, °C	28	30.5	13.5	23.1	0.8	*b*
Cyanide	28	0.015	<0.002	<0.003	0.0005	*b*
Oil and grease	28	10	<2	<3	0.4	*b*
Phenols	28	0.008	<0.001	<0.003	0.0004	*b*
Total toxic organics	28	0.083	<0.010	<0.021	0.004	*b*
Chloride	28	620	33	314	31	*b*
Color, ACU	28	83	<5	<10	3	*b*
Fluoride	28	5.5	<0.4	<1.6	0.3	*b*
Mercury	28	0.0005	<0.0002	<0.0002	0.00001	*b*
Nitrate	28	540.0	<0.1	<42.0	25.3	*b*
Total suspended solids	28	14.0	<5.0	<6.6	0.5	*b*
Sulfate	28	2,200	1,200	1,700	42	*b*
Sufactants, (MBAS)	28	0.13	<0.05	<0.06	0.00	*b*
Uranium	28	0.098	<0.001	<0.018	0.005	*b*
^{235}U, %	24	1.20	0.04	0.48	0.07	*b*
Aluminum	28	0.90	<0.20	<0.29	0.03	*b*
Beryllium	28	<0.002	<0.002	<0.002	0.000	*b*
Cadmium	28	0.020	<0.001	<0.018	0.001	*b*
Chromium	28	<0.030	<0.030	<0.030	0.000	*b*
Copper	28	0.030	<0.030	<0.030	0.000	*b*
Iron	28	8.5	<0.3	<1.4	0.3	*b*
Lead	28	<0.10	<0.10	<0.10	0.00	*b*
Nickel	28	1.53	0.04	0.61	0.07	*b*
Phosphorus	28	1.40	0.30	0.83	0.05	*b*
Silver	28	0.300	<0.030	<0.040	0.010	*b*
Sodium	28	474.0	68.6	249.3	20.0	*b*
Zinc	28	0.490	<0.020	<0.132	0.024	*b*
Alpha activity, pCi/L	27	190	–170	22	15	*b*
^{241}Am, pCi/L	27	1.5	–0.32	0.19	0.09	0.63
Beta activity, pCi/L	27	1,080	–34	189	42	*b*
^{237}Np, pCi/L	27	0.43	–13	–0.48	0.48	–1.59
^{226}Ra, pCi/L	21	3.5	–12.97	0.66	0.78	0.66
^{228}Ra, pCi/L	24	300	–0.81	89.38	18.18	89.38
^{90}Sr, pCi/L	27	2,500	–290	89	93	9
^{99}Tc, pCi/ml	27	0.45	0	0.11	0.02	0.11
^{234}Th, pCi/L	25	0.52	–0.25	0.14	0.03	0.001
Total thorium, mg/L	27	0.007	<0.003	<0.003	0.000	*b*
^{228}Th, pCi/L	27	4.6	–0.36	0.96	0.24	0.24
^{230}Th, pCi/L	27	0.8	–0.86	0.18	0.06	0.06
^{232}Th, pCi/L	27	3.2	–3	0.02	0.17	0.044
Tritium, pCi/L	27	490	–160	128	31	0.01
^{234}U, pCi/L	27	75	0.23	7.14	3.49	1.43
^{235}U, pCi/L	27	2.7	–0.06	0.34	0.13	0.06
^{238}U, pCi/L	27	41	–0.03	6.58	1.96	1.10
Total gamma, pCi/L	27	460	2.3	91.4	17.5	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.18. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 502, West End Treatment Facility

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Flow,[a] GPD	73	39,100	2,660	21,121	1,244	*b*
pH, standard units	64	8.8	6.4	*b*	0.1	*b*
Temperature, °C	64	28.4	11.9	20.2	0.6	*b*
Residual chlorine	64	0.07	0.02	0.03	0.001	*b*
Cyanide	64	0.009	<0.002	<0.003	0.0003	*b*
Oil and grease	64	38	<2	<4	1	*b*
Total toxic organics	24	0.167	<0.01	<0.026	0.009	*b*
Chloride	63	1,200	650	973	14	*b*
Fluoride	63	38	0.7	19.8	1.1	*b*
Mercury	63	0.002	<0.0002	<0.0002	0.0000	*b*
Nitrate	63	560	<0.02	<28.26	12.03	*b*
Total suspended solids	63	54	<5	<20	2	*b*
Sulfate	63	14,000	3,100	9,562	317	*b*
Uranium	63	0.086	0.002	0.015	0.002	*b*
^{235}Uranium, %	62	1.0	0.16	0.36	0.02	*b*
Aluminum	63	1.1	<0.2	<0.4	0.03	*b*
Arsenic	63	<0.2	<0.2	<0.2	0.0	*b*
Barium	63	0.07	<0.002	<0.017	0.002	*b*
Beryllium	63	0.06	<0.002	<0.015	0.002	*b*
Calcium	63	37.4	6.4	14.6	0.8	*b*
Cadmium	63	0.02	<0.0005	<0.0160	0.0009	*b*
Chromium	63	<0.03	<0.03	<0.03	0.00	*b*
Cobalt	63	0.13	<0.01	<0.05	0.003	*b*
Copper	63	0.08	<0.03	<0.03	0.002	*b*
Iron	63	0.8	<0.3	<0.3	0.01	*b*
Lead	63	<0.1	<0.1	<0.1	0.0	*b*
Magnesium	63	39.3	24.4	30.5	0.4	*b*
Manganese	63	0.153	<0.009	<0.051	0.005	*b*
Molybdenum	63	0.71	<0.03	<0.22	0.02	*b*
Nickel	63	3.02	0.07	0.73	0.08	*b*
Phosphorus	63	78.1	2.2	8.7	1.5	*b*
Potassium	63	296	152	220	4	*b*
Silver	63	<0.03	<0.03	<0.03	0.00	*b*
Sodium	63	7,100	3,440	5,225	106	*b*
Zinc	63	0.84	<0.05	<0.13	0.02	*b*
Alpha activity, pCi/L	24	690	–330	72	43	*b*
^{241}Am, pCi/L	24	0.73	–0.34	0.12	0.05	0.40
Beta activity, pCi/L	24	990	–34	442	50	*b*
^{237}Np, pCi/L	24	0.36	–0.12	0.10	0.02	0.34
^{226}Ra, pCi/L	19	4.3	0.51	2.13	0.24	2.13
^{228}Ra, pCi/L	18	324	–190	110	30	110
^{90}Sr, pCi/L	24	320	–73	18	15	2
^{99}Tc, pCi/ml	24	2.32	0.02	0.24	0.09	0.24
^{234}Th, pCi/L	22	1.7	–0.11	0.26	0.08	0.00
Total thorium, mg/L	24	0.007	<0.003	<0.003	0.0002	*b*
^{228}Th, pCi/L	24	3.8	–0.08	0.80	0.17	0.20
^{230}Th, pCi/L	24	2.1	0.01	0.41	0.09	0.14
^{232}Th, pCi/L	24	0.78	–2.2	–0.01	0.10	–0.03
Tritium, pCi/L	24	5,960	290	1,881	320	0
^{234}U, pCi/L	24	8.6	0.04	3.62	0.54	0.72
^{235}U, pCi/L	24	1.7	–0.08	0.27	0.07	0.05
^{238}U, pCi/L	24	22	–0.25	7.37	1.23	1.23
Total gamma, pCi/L	24	320	34	151	17	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.19. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 503, Steam Plant Wastewater Treatment Facility

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Flow,[a] GPD	359	378,700	700	98,965	2,916	*b*
pH, standard units	159	10.5	5.8	*b*	0.0	*b*
Temperature, °C	159	31.7	12.6	22.6	0.4	*b*
Oil and grease	158	281	<2	<5	2	*b*
Phenols	158	0.016	<0.001	<0.003	0.0002	*b*
Chloride	157	1,100	2.5	344.3	17.9	*b*
Fluoride	158	25	<0.9	<3.2	0.2	*b*
Mercury	158	0.0014	<0.0002	<0.0002	0.00001	*b*
Total suspended solids	157	14	<5	<6	0	*b*
Selenium	158	0.017	<0.002	<0.002	0.0001	*b*
Sulfate	158	3,800	380	1,391	42	*b*
Sulfide	157	<1	<1	<1	0	*b*
Uranium	158	0.023	<0.001	<0.001	0.0001	*b*
^{235}U, %	33	26.7	0.09	<2.21	0.80	*b*
Aluminum	158	4.1	<0.2	<0.3	0.0	*b*
Arsenic	158	<0.2	<0.2	<0.2	0.0	*b*
Barium	158	0.202	0.017	0.103	0.003	*b*
Beryllium	158	<0.002	<0.002	<0.002	0	*b*
Boron	158	0.11	<0.03	<0.04	0.001	*b*
Cadmium	158	<0.02	<0.005	<0.020	0.0002	*b*
Calcium	158	1,050	107	506	13	*b*
Cerium	158	<0.08	<0.08	<0.08	0	*b*
Chromium	158	<0.03	<0.03	<0.03	0	*b*
Cobalt	158	<0.01	<0.01	<0.01	0	*b*
Copper	158	<0.03	<0.03	<0.03	0	*b*
Gallium	158	<0.09	<0.09	<0.09	0	*b*
Iron	158	0.8	<0.3	<0.3	0.01	*b*
Lead	158	0.3	<0.1	<0.1	0.001	*b*
Lithium	158	0.69	<0.08	<0.09	0.004	*b*
Magnesium	158	32.8	0.3	7.0	0.6	*b*
Manganese	158	0.032	<0.009	<0.010	0.0003	*b*
Molybdenum	158	<0.03	<0.03	<0.03	0	*b*
Nickel	158	<0.04	<0.04	<0.04	0	*b*
Niobium	158	0.05	<0.05	<0.05	0	*b*
Phosphorus	158	1.5	<0.2	<0.7	0.02	*b*
Potassium	158	14	<2.5	<7.8	0.2	*b*
Scandium	158	<0.002	<0.002	<0.002	0	*b*
Silver	158	<0.03	<0.03	<0.03	0	*b*
Sodium	158	666	58.3	280.5	9.0	*b*
Strontium	158	1.01	0.104	0.537	0.014	*b*
Thorium	158	<0.05	<0.05	<0.05	0	*b*
Titanium	158	<0.06	<0.06	<0.06	0	*b*
Vanadium	158	<0.02	<0.02	<0.02	0	*b*
Zinc	158	0.16	<0.032	<0.051	0.0008	*b*
Zirconium	158	<0.05	<0.02	<0.02	0.0005	*b*
Alpha activity, pCi/L	49	230	–201	9	10	*b*
^{241}Am, pCi/L	49	0.69	–0.76	0.07	0.04	0.24
Beta activity, pCi/L	49	260	–190	39	11	*b*
^{237}Np, pCi/L	49	2.3	–0.29	0.12	0.05	0.39
^{226}Ra, pCi/L	27	7	0.03	2.00	0.32	2.00
^{228}Ra, pCi/L	27	430	–135	80	23	80
^{90}Sr, pCi/L	49	360	–47	9	8	1
^{99}Tc, pCi/mL	49	0.123	–0.044	0.016	0.005	0.016
^{234}Th, pCi/L	47	0.53	–0.02	0.20	0.02	0.00

Table 4.19 (continued)

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Total thorium, mg/L	49	0.009	<0.003	<0.003	0.0001	*b*
^{228}Th, pCi/L	49	2.9	–0.08	0.84	0.09	0.21
^{230}Th, pCi/L	49	0.87	–0.04	0.28	0.03	0.09
^{232}Th, pCi/L	49	1.2	–0.25	0.10	0.03	0.19
Tritium, pCi/L	48	940	–94	252	36	0.01
^{234}U, pCi/L	49	11	–0.17	0.61	0.28	0.12
^{235}U, pCi/L	49	0.49	–0.17	0.02	0.01	0.00
^{238}U, pCi/L	48	23	–0.08	1.22	0.62	0.20
Total gamma, pCi/L	49	620	–14	80	15	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.20. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 504, Plating Rinsewater Treatment Facilities

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Flow,[a] GPD	7	20,286	16,196	18,305	542	*b*
pH, standard units	7	8.3	6.9	*b*	0.2	*b*
Temperature, °C	7	27.6	17.3	25.1	1.3	*b*
Cyanide	7	0.008	<0.002	<0.003	0.0008	*b*
Oil and grease	7	6	<2	<3	1	*b*
Total toxic organics	7	0.092	<0.01	<0.022	0.012	*b*
Chloride	7	1,900	8.2	320.7	263.7	*b*
Fluoride	7	2	0.61	1.26	0.18	*b*
Mercury	7	0.0013	<0.0002	<0.0004	0.0002	*b*
Nitrate	7	38	<0.1	<10.0	6	*b*
Total suspended solids	7	18	<5	<7	2	*b*
Sulfate	7	800	42	256	95	*b*
Uranium	7	0.05	<0.001	<0.014	0.007	*b*
^{235}U, %	6	1.81	0.23	0.772	0.252	*b*
Aluminum	7	1.2	<0.2	<0.6	0.2	*b*
Beryllium	7	<0.002	<0.0004	<0.0017	0.0002	*b*
Cadmium	7	0.02	<0.014	<0.019	0.0009	*b*
Chromium	7	<0.03	<0.006	<0.027	0.003	*b*
Copper	7	0.03	<0.027	<0.030	0.0004	*b*
Iron	7	4.7	<0.3	<1.6	0.6	*b*
Lead	7	<0.1	<0.02	<0.09	0.01	*b*
Nickel	7	1.27	0.19	0.65	0.15	*b*
Phosphorus	7	0.92	<0.2	<0.3	0.1	*b*
Potassium	7	26	<2.5	<13.8	3.1	*b*
Silver	7	<0.03	<0.006	<0.027	0.003	*b*
Sodium	7	259	12.1	88.5	34.7	*b*
Zinc	7	0.28	<0.05	<0.09	0.03	*b*
Alpha activity, pCi/L	7	26	–5.8	5.4	4.1	*b*
^{241}Am, pCi/L	7	0.18	0.001	0.109	0.023	0.362
Beta activity, pCi/L	7	44	–50	15	12	*b*
^{237}Np, pCi/L	7	0.2	–0.06	0.07	0.03	0.22
^{226}Ra, pCi/L	3	4.9	3.5	4.3	0.4	4.3
^{228}Ra, pCi/L	4	97	1.7	38.9	22.9	38.9
^{90}Sr, pCi/L	7	14	–3	3	2	0
^{99}Tc, pCi/mL	7	0.086	–0.018	0.025	0.013	0.025
^{234}Th, pCi/L	6	0.27	0.1	0.20	0.03	0.002
Total thorium, mg/L	7	<0.003	<0.003	<0.003	0.000	*b*
^{228}Th, pCi/L	7	1.3	0.36	0.66	0.13	0.16
^{230}Th, pCi/L	7	0.7	0	0.2	0.1	0.1
^{232}Th, pCi/L	7	0.14	–0.02	0.06	0.02	0.13
Tritium, pCi/L	7	500	–280	57	93	0.003
^{235}U, pCi/L	7	3.1	–0.02	0.56	0.43	0.09
^{238}U, pCi/L	7	9.6	0.36	2.35	1.25	0.39
Total gamma, pCi/L	7	250	33	104	28	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.21. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 501/504, Central Pollution Control Facility/Plating Rinsewater Treatment Facility[a]

Parameter	Number of samples	Concentration[a]				
		Max	Min	Av	Standard error	Percentage of DCG
Flow[b], GPD	5	35,760	25,416	31,590	2,155	*c*
pH, standard units	5	8.2	7.1	*c*	0.2	*c*
Temperature, °C	5	28.1	19.1	23.9	1.9	*c*
Cyanide	5	<0.002	<0.002	<0.002	0	*c*
Oil and grease	5	4	<2	<3	0.4	*c*
Phenols	5	0.003	<0.001	<0.002	0.0004	*c*
Total toxic organics	5	0.097	<0.01	<0.030	0.017	*c*
Chloride	5	220	24	92	37	*c*
Color, ACU	5	17	<5	<7	2	*c*
Fluoride	5	4	0.9	2.8	0.7	*c*
Mercury	5	0.0005	<0.0002	<0.0003	0.0001	*c*
Nitrate	5	0.49	<0.1	<0.25	0.09	*c*
Total suspended solids	5	<5	<5	<5	0	*c*
Sulfates	5	1,000	620	832	70	*c*
Surfactants as MBAS	5	<0.05	<0.05	<0.05	0	*c*
Uranium	5	0.009	<0.001	<0.003	0.002	*c*
^{235}U, %	4	1.3	0.23	0.67	0.25	*c*
Aluminum	5	0.3	<0.2	<0.3	0.0	*c*
Beryllium	5	<0.002	<0.002	<0.002	0	*c*
Cadmium	5	<0.02	<0.02	<0.02	0	*c*
Chromium	5	<0.03	<0.03	<0.03	0	*c*
Coppper	5	<0.03	<0.03	<0.03	0	*c*
Iron	5	0.7	<0.3	<0.4	0.1	*c*
Lead	5	<0.1	<0.1	<0.1	0	*c*
Nickel	5	1.08	0.16	0.64	0.18	*c*
Phosphorus	5	0.8	0.3	0.6	0.1	*c*
Potassium	5	247	19	146	48	*c*
Silver	5	<0.03	<0.03	<0.03	0	*c*
Sodium	5	95.2	27.6	62.1	13.8	*c*
Zinc	5	<0.05	<0.05	<0.05	0	*c*
Alpha activity, pCi/L	4	37	–13	11	12	*c*
^{241}Am, pCi/L	4	0.2	–0.22	0.05	0.09	0.15
Beta activity, pCi/L	4	360	13	183	94	*c*
^{237}Np, pCi/L	4	0.11	0.04	0.09	0.02	0.28
^{226}Ra, pCi/L	1	7.03	7.03	7.03	*c*	7.03
^{228}Ra, pCi/L	1	5.14	5.14	5.14	*c*	5.14
^{90}Sr, pCi/L	4	0.84	–60	–30.54	12.51	–3.05
^{99}Tc, pci/mL	4	0.98	0.007	0.299	0.231	0.299
^{234}Th, pCi/L	4	2.7	0.08	0.79	0.64	0.01
Total thorium	4	<0.003	<0.003	<0.003	0	*c*
^{228}Th, pCi/L	4	1.7	0.33	0.85	0.30	0.21
^{230}Th, pCi/L	4	0.34	0.13	0.22	0.05	0.07
^{232}Th, pCi/L	4	0.17	–0.01	0.07	0.04	0.13
Tritium, pCi/L	4	240	–46	53	64	0.003
^{234}U, pCi/L	3	1.9	0.29	1.13	0.47	0.23
^{235}U, pCi/L	3	0.11	0.03	0.07	0.02	0.01
^{238}U, pCi/L	3	2.7	0.23	1.15	0.78	0.19
Total gamma, pCi/L	4	190	5.7	80.7	40.7	*c*

[a]Combined discharge.

[b]Flow during operations and/or discharging.

[c]Not applicable.

Table 4.22. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point 506, Building 9204-3 Sump Pump Oil Separator

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Flow,[a] GPM	52	50	50	50	0	*b*
pH, standard units	52	8.8	6.9	*b*	0.1	*b*
Temperature, °C	52	35	20	26	0	*b*
Oil and grease	52	7	<2	<2.4	0.1	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.23. CY 1991 NPDES Permit Number TN 002968

Discharge Point 512, Y-12 Plant, Groundwater Treatment Facility

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
Flow,[a] GPD	29	18170	2550	9524	669	*b*
pH, standard units	25	9	6.56	*b*	0.09	*b*
Temperature, °C	21	88	15.3	37.3	5.6	*b*
Oil and grease	21	3	<2	<2	0.1	*b*
Aluminium	21	0.29	<0.04	<0.08	0.01	*b*
Arsenic	21	0.2	<0.04	<0.06	0.01	*b*
Barium	21	0.271	<0.081	<0.184	0.010	*b*
Beryllium	21	<0.004	<0.0004	<0.0006	0.0002	*b*
Boron	21	10.6	1.28	5.58	0.49	*b*
Cadmium	21	<0.02	<0.004	<0.005	0.001	*b*
Calcium	21	98	34.6	76.3	3.5	*b*
Cerium	21	<0.08	<0.02	<0.02	0.003	*b*
Chromium	21	<0.03	<0.006	<0.007	0.001	*b*
Cobalt	21	0.01	<0.002	<0.003	0.0004	*b*
Copper	21	0.033	<0.006	<0.010	0.002	*b*
Gallium	21	<0.09	<0.02	<0.02	0.003	*b*
Iron	21	0.43	<0.06	<0.14	0.02	*b*
Lead	21	0.13	<0.02	<0.03	0.01	*b*
Lithium	21	0.44	0.023	0.284	0.021	*b*
Magnesium	21	18.1	8.76	12.78	0.71	*b*
Manganese	21	16	0.106	2.945	0.934	*b*
Molybdenum	21	<0.03	<0.006	<0.007	0.001	*b*
Nickel	21	0.054	<0.009	<0.021	0.003	*b*
Niobium	21	<0.05	<0.01	<0.01	0.002	*b*
Phosphorus	21	0.2	<0.05	<0.06	0.01	*b*
Potassium	21	14	8.3	10.7	0.4	*b*
Scandium	21	0.002	<0.0004	<0.0005	0.0001	*b*
Silver	21	<0.03	<0.006	<0.007	0.001	*b*
Sodium	21	46.4	18.8	30.7	2.0	*b*
Strontium	21	0.37	0.147	0.218	0.014	*b*
Thorium	21	<0.05	<0.01	<0.01	0.002	*b*
Titanium	21	<0.06	<0.01	<0.01	0.002	*b*
Vanadium	21	0.02	<0.004	<0.005	0.001	*b*
Zinc	21	0.05	<0.01	<0.01	0.002	*b*
Zirconium	21	<0.02	<0.004	<0.005	0.001	*b*
PCB	21	<0.0005	<0.0005	<0.0005	0	*b*
Methylene chloride	21	<0.010	<0.010	<0.010	0	*b*
Tetrachloroethylene	21	<0.010	<0.010	<0.010	0	*b*
Trichloroethylene	21	<0.010	<0.010	<0.010	0	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 4.24. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant cooling towers

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		602				
Temperature, °C	4		26.7	21.3	24.7	1.3
pH, standard units	4		8.5	7.7	*a*	0.2
Free chlorine	4		0.02	0.01	0.015	0.003
Chromium	4		<0.01	<0.01	<0.01	0
Copper	4		0.019	0.012	0.015	0.001
Zinc	4		0.06	0.03	0.04	0.01
Flow, gal/d[b]	4		9,936	3,512	6,873	1,322
		604				
Temperature, °C	4		27.2	15.5	21.4	2.4
pH, standard units	4		8.4	8.1	*a*	0.1
Free chlorine	4		0.02	<0.01	0.015	0.003
Chromium	4		0.01	<0.01	<0.001	0
Copper	4		0.016	0.006	<0.011	0.002
Zinc	4		0.37	0.18	0.29	0.04
Flow, gal/d[b]	4		17,986	9,803	14,146	2,184
		606				
Temperature, °C	0					
pH, standard units	0					
Free chlorine	0					
Chromium	0					
Copper	0					
Zinc	0					
Flow, gal/d[b]	0					
		610				
Temperature, °C	4		31.5	24.8	28.3	1.4
pH, standard units	4		8.5	8.2	*a*	0.1
Free chlorine	4		0.006	0.01	0.036	0.014
Chromium	4		<0.07	<0.01	<0.01	0.01
Copper	4		0.04	0.011	0.021	0.007
Zinc	4		0.19	0.04	0.09	0.04
Flow, gal/d[b]	4		13,416	7,762	10,310.	1,367
		612				
Temperature, °C	3		24.9	23.5	24	0.5
pH, standard units	3		8.3	7.9	*a*	0.1
Free chlorine	3		0.15	0.02	0.067	0.042
Chromium	3		0.01	<0.01	<0.01	0
Copper	3		<0.022	0.013	0.019	0.003
Zinc	3		0.16	0.1	0.13	0.02
Flow, gal/d[b]	3		30,272	8,072	18,014	6,512

Table 4.24 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		613				
Temperature, °C	4		29.3	25.6	27.3	0.8
pH, standard units	4		8.5	8.2	*a*	0.1
Free chlorine	4		0.05	0.02	0.035	0.006
Chromium	4		<0.05	<0.02	<0.04	0.01
Copper	4		0.014	0.012	0.013	0
Zinc	4		0.07	0.02	0.05	0.01
Flow, gal/d[b]	4		41,835	14,275	29,001	6,055
		615				
Temperature, °C	4		24.2	12.8	20.6	2.6
pH, standard units	4		8.5	7.8	*a*	0.2
Free chlorine	4		0.02	0.01	0.015	0.003
Chromium	4		<0.01	<0.01	<0.01	0
Copper	4		0.315	0.058	0.142	0.06
Zinc	4		2.52	0.1	0.9	0.55
Flow, gal/d[b]	4		3,696	1,031	1,949	602
		616				
Temperature, °C	0					
pH, standard units	0					
Free chlorine	0					
Chromium	0					
Copper	0					
Zinc	0					
Flow, gal/d[b]	0					
		617				
Temperature, °C	4		28.8	18.9	23.7	2
pH, standard units	4		8.5	8.1	*a*	0.1
Free chlorine	4		0.05	0.01	0.03	0.009
Chromium	4		0.01	<0.01	<0.01	0
Copper	4		0.038	0.017	0.025	0.005
Zinc	4		0.08	0.04	0.06	0.01
Flow, gal/d[b]	4		7,762	3,213	5,395	1,081
		618				
Temperature, °C	4		24.7	24.7	24.7	0.3
pH, standard units	4		8.2	8.2	*a*	0.1
Free chlorine	4		0.02	<0.01	<0.018	0.003
Chromium	4		<0.01	<0.01	<0.01	0
Copper	4		0.032	0.032	0.032	0.01
Zinc	4		0.05	0.05	0.05	0
Flow, gal/d[b]	4		10,030	10,031	10,031	2,849

Table 4.24 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		619				
Temperature, °C	4		29.2	24	25.9	1.2
pH, standard units	4		8.4	7.4	*a*	0.2
Free chlorine	4		0.04	0.01	0.028	0.008
Chromium	4		<0.03	<0.01	<0.01	0.01
Copper	4		0.118	0.008	0.05	0.024
Zinc	4		0.59	0.02	0.19	0.13
Flow, gal/d[b]	4		11,798	6,900	8,274	1,178
		620				
Temperature, °C	4		27.3	17.6	24.5	2.3
pH, standard units	4		8.3	7.8	*a*	0.1
Free chlorine	4		0.07	0.01	0.03	0.014
Chromium	4		<0.01	<0.01	<0.01	0
Copper	4		0.135	0.038	0.087	0.022
Zinc	4		0.88	0.37	0.59	0.11
Flow, gal/d[b]	4		6,323	790	3,375	1,142
		622				
Temperature, °C	4		31.8	26.8	29	1.1
pH, standard units	4		8.5	8.2	*a*	0.1
Free chlorine	4		0.2	<0.01	<0.08	0.043
Chromium	4		<0.01	<0.01	<0.01	0
Copper	4		0.01	0.006	0.008	0.001
Zinc	4		0.04	0.02	0.03	0
Flow, gal/d[b]	4		14,950	9,810	12,803	1,287
		624				
Temperature, °C	0					
pH, standard units	0					
Free chlorine	0					
Chromium	0					
Copper	0					
Zinc	0					
Flow, gal/d[b]	0					
		626				
Temperature, °C	5		21.4	9.9	13.9	2.1
pH, standard units	5		8.4	7.8	*a*	0.1
Free chlorine	5		0.98	<0.01	<0.214	0.192
Chromium	5		<0.08	<0.01	<0.02	0.01
Copper	5		0.059	0.009	0.035	0.009
Zinc	5		0.13	0.02	0.08	0.02
Flow, gal/d[b]	5		26,000	923	7,449	4,696

Table 4.24 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		628				
Temperature, °C	4		30.3	24.8	27.6	1.3
pH, standard units	4		8.5	7.8	*a*	0.2
Free chlorine	4		0.1	0.02	0.04	0.02
Chromium	3		0.07	0.01	0.03	0.02
Copper	3		0.054	0.012	0.027	0.013
Zinc	3		0.31	0.08	0.16	0.08
Flow, gal/d[b]	4		24,150	10,278	16,308	3,142
		630				
Temperature, °C	4		28.3	20.7	24.8	1.6
pH, standard units	4		8.5	8.1	*a*	0.1
Free chlorine	4		0.1	0.02	0	0.019
Chromium	4		0.01	<0.01	<0.01	0
Copper	4		0.072	0.014	0.034	0.013
Zinc	4		0.1	0.02	0.07	0.02
Flow, gal/d[b]	4		4,761	3,450	3,815	317
		632				
Temperature, °C	3		28.1	18.9	23	2.7
pH, standard units	3		8.3	8.3	*a*	0
Free chlorine	3		0.05	0.015	0.028	0.011
Chromium	3		<0.01	<0.01	<0.01	0
Copper	3		0.066	0.041	0.057	0.008
Zinc	3		0.1	0.07	0.09	0.01
Flow, gal/d[b]	3		6,037	3,080	4,066	986
		633				
Temperature, °C	0					
pH, standard units	0					
Free chlorine	0					
Chromium	0					
Copper	0					
Zinc	0					
Flow, gal/d[b]	0					
		634				
Temperature, °C	4		27.4	19.9	22.8	1.6
pH, standard units	4		8.5	8.2	*a*	0.1
Free chlorine	4		0.06	0.01	0.035	0.01
Chromium	4		<0.01	<0.01	<0.01	0
Copper	4		0.021	0.01	0.017	0.003
Zinc	4		0.11	0.09	0.1	0
Flow, gal/d[b]	4		71,760	9,711	31,965	13,833

[a]Not applicable.

[b]Flow during operation and/or discharging.

Table 4.25. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Discharge Point = 623, Flyash Sluice

Parameter	Number of samples	Concentration (mg/L)				Percentage of DCG
		Max	Min	Av	Standard error	
pH, standard units	50	9.5	7.3	*a*	0.1	*a*
Flow[b], gpd	132	1,587,000	23,000	240,716	24,258	*a*

[a]Not applicable.
[b]Flow during operations and/or discharging.

Table 4.26. CY 1991 Permit Number TN 0002968

Y-12 Plant Category I Outfalls[a]

Outfall	Number of samples	pH (standard units)				Number of Samples	Flow[a] (GPD)			
		Max	Min	Av	Standard error		Max	Min	Av	Standard error
001	2	7.8	7.7	*b*	0.05	2	79,070	7,600	43,335	35,735
003	2	7.8	7.6	*b*	0.1	2	116,110	2,282	59,196	56,194
006	2	8.0	7.4	*b*	0.3	2	62,300	17,120	39,710	22,590
007	2	7.9	7.4	*b*	0.3	2	32,100	13,316	22,708	9,392
009	1	6.9	6.9	*b*	*b*	1	45,654	45,654	45,654	*b*
011	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
012	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
015	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
017	1	7.5	7.5	*b*	*b*	1	7,609	7,609	7,609	*b*
018	1	7.5	7.5	*b*	*b*	1	2,282	2,282	2,282	*b*
019	1	7.6	7.6	*b*	*b*	1	32,338	32,338	32,338	*b*
031	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
032	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
041	1	7.3	7.3	*b*	*b*	1	4,504	4504	4,504	*b*
044	2	7.8	7.8	*b*	0	2	11,413	380	5,986	5,516
045	2	8.1	7.8	*b*	0.15	2	22,827	761	11,794	11,033
057	2	7.9	7.9	*b*	0	2	11,413	5,407	8,410	3,003
062	1	7.7	7.7	*b*	*b*	1	1,522	1,522	1,522	*b*
086	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
101	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
102	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
108	1	7.6	7.6	*b*	*b*	0	*e*	*e*	*e*	*b*
127	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
134	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
136	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
138	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
140	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
145	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
146	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
149	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
151	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
152	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
153	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
155	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
156	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
159	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
161	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
164	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
170	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
177	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
178	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
179	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
180	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
182	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
183	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
184	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
186	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
193	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
194	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
195	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
196	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
197	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
198	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
199	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*

Table 4.26 (continued)

Outfall	Number of samples	pH (standard units)				Number of samples	Flow[a] (GPD)			
		Max	Min	Av	Standard error		Max	Min	Av	Standard error
200	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
202	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
205	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
206	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
207	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
208	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
209	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
215	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
221	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
223	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
224	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
228	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
229	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
230	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
231	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
232	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
233	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
234	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
235	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
236	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
237	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
247	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
248	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*

[a]Flow during operations and/or discharging.
[b]Not applicable.
[c]No flow.

Table 4.27. CY 1991 NPDES Permit Number TN 0002968

Y-12 Plant Category II Outfalls

Outfall	Number of samples	pH (standard units)				Number of samples	Temperature (°C)				Number of samples	Flow[a] (gal/d)			
		Max	Min	Av	Standard error		Max	Min	Av	Standard error		Max	Min	Av	Standard error
013	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
016	3	8.2	7.4	*b*	0.2	3	23.5	10.7	16.9	3.7	3	72,280	570	25,805	23,666
020	4	7.9	7.1	*b*	0.2	4	22.6	16.3	19.2	1.6	4	45,600	24	14,259	10,561
023	2	7.4	7.0	*b*	0.2	2	32.6	30.0	31.3	1.3	2	761	95	428	333
024	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
025	2	8.3	7.2	*b*	0.6	2	30.0	14.4	22.2	7.8	2	95	95	95	0
026	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
027	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
028	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
029	1	7.9	7.9	*b*	*b*	1	15.8	15.8	15.8	*b*	1	127	127	127	*b*
030	1	7.9	7.9	*b*	*b*	1	16.0	16.0	16.0	*b*	1	761	761	761	*b*
035	2	7.9	7.8	*b*	0.1	2	22.5	18.0	20.2	*b*	2	7,609	3,044	5,326	2,283
040	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
043	2	7.8	7.6	*b*	0.1	2	34.6	16.4	25.5	9.1	2	1,902	190	1,046	856
046	2	7.8	7.4	*b*	0.2	2	31.3	30.0	30.6	1.0	2	761	761	761	0
053	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
054	3	8.4	7.4	*b*	0.3	3	20.1	13.2	16.8	2.0	3	1,141	570	760	190
058	3	7.6	7.3	7.4	0.1	3	18.0	11.1	15.0	2.0	3	11,413	570	4,248	3,583
059	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
060	1	7.9	7.9	*b*	*b*	1	14.5	14.5	14.5	*b*	1	380	380	380	*b*
066	2	8.0	7.8	*b*	0.1	2	28.3	21.1	24.7	3.6	2	150	127	138	12
068	3	7.9	7.0	*b*	0.3	3	32.2	24.9	28.4	2.1	3	761	190	380	190
069	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
073	4	7.9	7.6	*b*	0.1	4	26.3	21.2	22.8	1.2	4	11,413	127	4,026	2,533
074	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
075	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
076	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
077	1	7.4	7.4	*c*	*c*	1	20.5	20.5	20.5	*b*	1	34,110	34,110	34,110	*b*

Table 4.27 (continued)

Outfall	pH (standard units)					Temperature (°C)					Flow[a] (gal/d)				
	Number of samples	Max	Min	Av	Standard error	Number of samples	Max	Min	Av	Standard error	Number of samples	Max	Min	Av	Standard error
078	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
079	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
080	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
081	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
084	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
087	2	7.8	7.4	*b*	0.2	2	17.2	11.3	14.2	3.0	2	11,413	1,141	6,277	5,136
092	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
093	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
094	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
095	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
096	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
098	1	7.9	7.9	*b*	*b*	1	18.0	18.0	18.0	*b*	1	761	761	761	*b*
100	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
111	1	7.9	7.9	*b*	*b*	1	15.1	15.1	15.1	*b*	1	1,902	1,902	1,902	*b*
111	1	7.7	7.7	*b*	*b*	1	17.6	17.6	17.6	*b*	1	190	190	190	*b*
115	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
117	3	8.3	7.1	*b*	0.4	3	30.4	28.7	29.3	0.6	3	761	380	507	127
118	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
119	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
120	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
123	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
124	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
131	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
133	3	8.2	7.1	*b*	0.3	3	23.4	11.8	18.0	3.4	3	1,522	761	1,141	220
137	0	*c*	*c*	*b*	b	0	c	c	*c*	*b*	0	*c*	*c*	*c*	*b*
144	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
171	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
172	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
173	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*

Table 4.27 (continued)

Outfall	Number of samples	pH (standard units)				Number of samples	Temperature (°C)				Number of samples	Flow[a] (gal/d)			
		Max	Min	Av	Standard error		Max	Min	Av	Standard error		Max	Min	Av	Standard error
174	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
175	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
185	1	7.5	7.5	b	b	1	25.5	25.5	25.5	b	1	190	190	190	b
188	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
201	2	7.8	7.2	b	0.3	2	20.8	17.1	19.0	2.0	2	5,707	761	3,234	2,473
203	1	7.4	7.4	b	b	1	12.4	12.4	12.4	b	1	761	761	761	b
204	1	7.5	7.5	b	b	1	11.4	11.4	11.4	b	1	380	380	380	b
210	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
212	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
213	2	7.9	7.3	b	0.3	2	21.2	15.0	18.1	3.1	2	1,141	380	760	381
214	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
216	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
217	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
218	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
219	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
220	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
226	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
238	3	8.4	8.1	b	0.1	3	24.8	9.4	16.6	4.5	3	2,663	380	1,395	671
239	3	8.4	8.1	b	0.1	3	24.8	9.4	16.6	4.5	3	2,663	380	1,395	671
240	3	8.4	8.1	b	0.1	3	24.8	9.4	16.6	4.5	3	2,663	380	1,395	671
241	3	8.4	8.1	b	0.1	3	24.8	9.4	16.6	4.5	3	2,663	380	1,395	671
243	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
244	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
245	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b
246	0	c	c	b	b	0	c	c	c	b	0	c	c	c	b

[a]Flow during operations and/or discharging.
[b]Not applicable.
[c]No flow.

Table 4.28. CY 1990 NPDES Permit Number TN 0002968

Y-12 Plant Category III Outfalls

Outfall	Number of samples	pH (standard units)				Number of samples	Temperature (°C)				Number of samples	Flow[a] (gal/d)			
		Max	Min	Av	Standard error		Max	Min	Av	Standard error		Max	Min	Av	Standard error
002	4	7.8	7.2	*b*	0.1	4	24.2	14.1	17.5	2.3	4	138,600	11,413	66,037	29,937
071	4	8.0	7.3	*b*	0.2	4	20.5	17.1	18.8	0.7	4	76,099	22,827	46,319	13,264
135	4	8.0	7.2	*b*	0.2	4	29.8	22.1	26.4	1.8	4	758,100	416,100	549,775	76,783
147	4	8.1	7.2	*b*	0.2	4	25.3	11.4	18.8	3.0	4	9,211	190	4,443	2,144
150	4	8.2	6.7	*b*	0.3	4	31.5	15.1	24.6	3.4	4	6,483,800	533,900	2,327,550	1,394,717
157	4	7.7	7.3	*b*	0.1	4	23.1	9.6	17.7	2.9	4	3,804	761	1,902	677
160	4	8.1	7.2	*b*	0.2	4	32.6	22.1	27.0	2.2	4	110,700	20,900	64,947	18,337
162	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
163	4	7.7	7.2	*b*	0.1	4	29.3	19.3	24.8		4	363,700	218,200	299,472	33,184
166	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
168	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
169	4	8.1	7.1	*b*	0.2	4	25.6	16.6	21.0	1.8	4	530,900	380,426	475,582	33,144
181	2	7.6	7.3	*b*	0.2	2	21.0	15.7	18.4	2.7	2	761,700	433,700	597,700	164,000
191	0	*c*	*c*	*b*	*b*	0	*c*	*c*	*c*	*b*	0	*c*	*c*	*c*	*b*
192	4	7.8	6.5	*b*	0.3	4	25.2	15.2	19.5	2.1	4	6,110	402	3,150	1,322

[a]Flow during operations and/or discharging.
[b]Not applicable.
[c]No flow.

Table 4.29. CY 1991 NPDES Permit Number TN 002968

Y-12 Plant Category IV Outfalls

Outfall	Number of samples	pH (standard units)				Number of flows	Flow[a] (gal/d)			
		Max	Min	Av	Standard error		Max	Min	Av	Standard error
401	*b*					*b*				
402	15	8.7	7	*c*	0.1	*b*				
403	15	8.8	7.5	*c*	0.1	*b*				
404	*b*					*b*				
405	28	10.2	7.6	*c*	0.1	*b*				
406	*b*			c		*b*				
407	*b*					*b*				
408	48	8.4	7.2	*c*	0.0	*b*				
409	*b*					*b*				
410	*b*					*b*				
411	*b*					*b*				
412	*b*					*b*				
413	*b*					*b*				
414	*b*					*b*				
415	*b*					*b*				
416	*b*					*b*				
417	*b*					*b*				
418	*b*					*b*				
419	*b*					*b*				
420	*b*					*b*				
421	*b*					*b*				
422	*b*					*b*				

[a]Flow during operations and/or discharging.
[b]No discharge.
[c]Not applicable.

Table 4.30. CY 1990 NPDES Permit Number TN 002968

Y-12 Plant Non-permitted Outfalls[a]

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		4				
Flow[c], GPD	3		26,621	570	9,317	8,652
pH, standard units	3		8	7.2	*b*	0.3
Temperature, °C	3		22.7	12.4	17.2	3
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		9.9	5.6	7.5	1.3
Total organic carbon	3		26	2	13	7
Total suspended solids	3		<5	<5	<5	0
		8				
Flow[c], GPD	3		9,131	1,141	5,494	2,334
pH, standard units	3		7.5	6.8	*b*	0.2
Temperature, °C	3		23	16.1	19.7	2
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		10	<5	<7	2
Total organic carbon	3		16	9	12	2
Total suspended solids	3		<5	<5	<5	0
		10				
Flow[c], GPD	3		30,400	1,141	11,274	9,569
pH, standard units	3		7.8	6.9	*b*	0.3
Temperature,°C	3		25.6	21.7	23.6	1.1
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		5.6	<5	<5	0.2
Chemical oxygen demand	3		19	<5	<10	5
Total organic carbon	3		21	17	19	1
Total suspended solids	3		<5	<5	<5	0
		14				
Flow[c], GPD	3		114,250	3,044	49,277	33,442
pH, standard units	3		7.9	7.2	*b*	0.2
Temperature, °C	3		25.4	18	20.6	2.4
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		15	7.3	10.1	2.5
Total organic carbon	3		22	8.6	14.5	3.9
Total suspended solids	3		<5	<5	<5	0
		21				
Flow[c], GPD	3		628,300	239,000	438,700	11,2495
pH, standard units	3		7.7	7.4	*b*	0.1
Temperature,°C	3		26.3	18.5	22.7	2.3
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		12	<5	<8	2
Chemical oxygen demand	3		20	8.7	13.9	3.3
Total organic carbon	3		18	7.4	14.5	3.5
Total suspended solids	3		<5	<5	<5	0

Table 4.30 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		33				
Flow[c], GPD	3		7,609	1,141	3,424	2,095
pH, standard units	3		7.7	7.1	*b*	0.2
Temperature, °C	3		23.1	17.1	20.5	1.8
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		5.99	<5	<5.33	0.33
Chemical oxygen demand	3		12	<5	<7	2
Total organic carbon	3		18	11	15	2
Total suspended solids	3		6	<5	<5	0
		34				
Flow[c], GPD	3		95,110	45,600	72,267	14,420
pH, standard units	3		7.8	6.7	*b*	0.3
Temperature, °C	3		32.7	24.7	27.5	2.6
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		8.5	<5	<6.3	1.1
Total organic carbon	3		34	6.5	16.5	8.8
Total suspended solids	3		<5	<5	<5	0
		36				
Flow[c], GPD	2		2,282	1,522	1,902	380
pH, standard units	2		8	7.4	*b*	0.3
Temperature, °C	2		21.1	17.1	19.1	2
Ammonia	2		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	2		<5	<5	<5	0
Chemical oxygen demand	2		21	19	20	1
Total organic carbon	2		12	8.5	10.3	1.8
Total suspended solids	2		19	<5	<12	7
		39				
Flow[c], GPD	2		761	60	411	351
pH, standard units	2		7.8	7.3	*b*	0.3
Temperature, °C	2		21.5	16.3	18.9	2.6
Ammonia	2		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	2		<5	<5	<5	0
Chemical oxygen demand	2		10	7.3	8.7	1.4
Total organic carbon	2		13	3.3	8.2	4.9
Total suspended solids	2		<5	<5	<5	0
		42				
Flow[c], GPD	3		45,820	11,413	26,687	10,118
pH, standard units	3		7.6	7.2	*b*	0.1
Temperature, °C	3		31.7	24.3	27.8	2.1
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		8.2	<5	<6.1	1.1
Total organic carbon	3		16	14	15	1
Total suspended solids	3		<5	<5	<5	0

Table 4.30 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		47				
Flow[c], GPD	3		77,540	41,100	58,569	10,546
pH, standard units	3		7.9	7.1	*b*	0.2
Temperature, °C	3		26.3	22.3	24.3	1.2
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		6.8	<5	<5.6	0.6
Total organic carbon	3		16	9.2	11.7	2.1
Total suspended solids	3		<5	<5	<5	0
		48				
Flow[c], GPD	3		22,827	5,707	15,218	5,033
pH, standard units	3		7.9	7.2	*b*	0.2
Temperature, °C	3		25.8	22.9	24	0.9
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		5.3	<5	<5.1	0.1
Chemical oxygen demand	3		8.4	<5	<6.1	1.1
Total organic carbon	3		21	10	15	3
Total suspended solids	3		16	<5	<9	4
		49				
Flow[c], GPD	3		91,600	41,840	59,680	15,997
pH, standard units	3		7.6	7.3	*b*	0.1
Temperature, °C	3		22.5	15.9	19.9	2
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		5.1	<5	<5	0.03
Chemical oxygen demand	3		6.4	<5	<5.5	0.5
Total organic carbon	3		18	9.1	14.7	2.8
Total suspended solids	3		6	<5	<5	0.3
		51				
Flow[c], GPD	3		95,100	26,101	63,453	20,122
pH, standard units	3		7.2	6.9	*b*	0.1
Temperature, °C	3		17.4	17.1	17.3	0.1
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		5	5	5	0
Total organic carbon	3		43	30	37	4
Total suspended solids	3		<5	<5	<5	0
		55				
Flow[c], GPD	3		114,130	76,088	94,073	11,031
pH, standard units	3		7.4	7.3	*b*	0.03
Temperature, °C	3		31.4	18.6	25.9	3.8
Ammonia	3		0.21	<0.2	<0.2	0.003
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		<5	<5	<5	0
Total organic carbon	3		16	7.2	13.1	2.9
Total suspended solids	3		<5	<5	<5	0

Table 4.30 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		63				
Flow[c], GPD	3		22,827	6,087	15,008	4,864
pH, standard units	3		7.8	7.0	*b*	0.2
Temperature, °C	3		23.7	16.2	19.2	2.3
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	2		110	<5	<58	53
Chemical oxygen demand	3		97	<5	<41	28
Total organic carbon	3		48	13	25	11
Total suspended solids	3		22	<5	<11	6
		64				
Flow[c], GPD	2		11,413	1,522	6,468	4,946
pH, standard units	2		8.0	7.3	*b*	0.3
Temperature, °C	2		21	16.5	18.8	2.3
Ammonia	2		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	2		<5	<5	<5	0
Chemical oxygen demand	2		7.9	<5	<6.5	1.5
Total organic carbon	2		8	5.5	6.8	1.3
Total suspended solids	2		23	<5	<14	9
		67				
Flow[c], GPD	3		69,124	6,848	35,471	18,153
pH, standard units	3		7.9	7.5	*b*	0.1
Temperature, °C	3		26.2	16.2	21.6	2.9
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		5.8	<5	<5.3	0.3
Total organic carbon	3		21	9.5	16.5	3.5
Total suspended solids	3		<5	<5	<5	0
		71				
Flow[c], GPD	3		76,099	25,109	54,150	15,141
pH, standard units	3		8	7.3	*b*	0.2
Temperature, °C	3		20.5	18.4	19.4	0.6
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		6.2	<5	<5.4	0.4
Total organic carbon	3		19	6.9	13.6	3.6
Total suspended solids	3		<5	<5	<5	0
		83				
Flow[c], GPD	3		57,066	380	19,275	18,895
pH, standard units	3		7.8	7.3	*b*	0.1
Temperature, °C	3		19	15.1	17.5	1.2
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		16	<5	<10	3
Total organic carbon	3		11	2.5	5.8	2.6
Total suspended solids	3		<5	<5	<5	0

Table 4.30 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		88				
Flow[c], GPD	3		13,316	761	5,073	4,123
pH, standard units	3		7.6	7.2	*b*	0.1
Temperature, °C	3		23.9	19.5	21.5	1.3
Ammonia	3		0.45	<0.2	<0.28	0.08
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		10	<5	<7	2
Total organic carbon	3		10	3.7	7.6	2
Total suspended solids	3		<5	<5	<5	0
		99				
Flow[c], GPD	3		11,413	4,565	7,363	2,074
pH, standard units	3		7.8	7.4	*b*	0.1
Temperature, °C	3		21.7	17.1	19.2	1.3
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		6.3	<5	<5.4	0.4
Total organic carbon	3		19	8.8	14.3	3
Total suspended solids	3		<5	<5	<5	0
		109				
Flow[c], GPD	3		1,263,400	286,700	681,567	297,043
pH, standard units	3		8.1	7.4	*b*	0.2
Temperature, °C	3		21.6	13.3	18.7	2.7
Ammonia	3		<2	<0.2	<0.8	0.6
Biochemical oxygen demand	3		6.4	<5	<5.5	0.5
Chemical oxygen demand	3		9.8	<5	<7.3	1.4
Total organic carbon	3		21	3	14	5
Total suspended solids	3		8	<5	<6	1
		110				
Flow[c], GPD	2		254	95	175	80
pH, standard units	2		7.9	7.6	*b*	0.2
Temperature, °C	2		22	15.4	18.7	3.3
Ammonia	2		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	2		<5	<5	<5	0
Chemical oxygen demand	2		6.3	<5	<5.7	0.6
Total organic carbon	2		6.9	4.7	5.8	1.1
Total suspended solids	2		<5	<5	<5	0
		113				
Flow[c], GPD	3		13,680	380	8,491	4,108
pH, standard units	3		7.8	7.4	*b*	0.1
Temperature, °C	3		32.3	19.5	26	3.7
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		6.5	<5	<5.5	0.5
Total organic carbon	3		15	7.2	12.1	2.5
Total suspended solids	3		<5	<5	<5	0

Table 4.30 (continued)

Parameter	Number of samples	Discharge point	Concentration (mg/L)			
			Max	Min	Av	Standard error
		114				
Flow[c], GPD	2		2,282	1,141	1,712	571
pH, standard units	2		7.6	7.3	*b*	0.2
Temperature, °C	2		25.9	21.7	23.8	2.1
Ammonia	2		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	2		<5	<5	<5	0
Chemical oxygen demand	2		12	<5	<9	4
Total organic carbon	2		26	15	21	6
Total suspended solids	2		14	<5	<10	5
		122				
Flow[c], GPD	3		11,413	380	4,185	3,616
pH, standard units	3		7.6	7.0	*b*	0.2
Temperature, °C	3		28.8	21.2	26.2	2.5
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		11	<5	<7	2
Total organic carbon	3		20	8.2	14.4	3.4
Total suspended solids	3		19	<5	<10	5
		125				
Flow[c], GPD	3		146,160	28,533	106,654	39,062
pH, standard units	3		7.5	7.1	*b*	0.1
Temperature, °C	3		25.8	22.1	24.3	1.1
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		<5	<5	<5	0
Total organic carbon	3		17	9.8	14.3	2.3
Total suspended solids	3		<5	<5	<5	0
		135				
Flow[c], GPD	3		758,100	342,200	488,467	134,979
pH, standard units	3		7.7	7.5	*b*	0.1
Temperature, °C	3		29.8	26.7	28.5	0.9
Ammonia	3		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	3		<5	<5	<5	0
Chemical oxygen demand	3		9.6	<5	<7.4	1.3
Total organic carbon	3		20	14	16	2
Total suspended solids	3		<5	<5	<5	0
		142				
Flow[c], GPD	2		7,010	3,044	5,027	1,983
pH, standard units	2		7.5	7.4	*b*	0.05
Temperature, °C	2		32.9	27	30	3
Ammonia	2		<0.2	<0.2	<0.2	0
Biochemical oxygen demand	2		7.8	<5	<6.4	1.4
Chemical oxygen demand	2		6.5	<5	<5.8	0.8
Total organic carbon	2		17	16	17	0.5
Total suspended solids	2		<5	<5	<5	0

[a]Outfalls not included on the NPDES permit.
[b]Not applicable.
[c]Flow during operations and/or discharging.

Table 4.31. Y-12 Plant toxicity control monitoring program summary information for 1991[a]

Site/Building	Test date	Species	NOEC	IWC[b]
Evaporator Process Condensate (Outfall 402)	1/10–17/91	*Ceriodaphnia*	1%	*c*
Evaporator Process Condensate (Outfall 402)	1/10–17/91	FHM	25%	c
Steam Plant Wastewater Treatment Facility (SPWTF) (Outfall 503) Normal Flow	1/17–24/91	*Ceriodaphnia*	12%	11.0%
SPWTF (Outfall 503) Normal Flow	1/17–24/91	FHM	100%	11.0%
SPWTF (Outfall 503) High Flow	1/17–24/91	*Ceriodaphnia*	12%	11.3%
Evaporator Process Condensate (Outfall 402)	5/2–9/91	*Ceriodaphnia*	50%	*c*
Evaporator Process Condensate (Outfall 402)	5/2–9/91	FHM	6%	c
Plating Rinsewater Treatment Facility (PRTF) (Outfall 504)	9/5–12/91	FHM	100%	1.4%
PRTF (Outfall 504)	9/5–12/91	*Ceriodaphnia*	30%	1.4%
Evaporator Process Condensate (Outfall 402)	9/19–25/91	*Ceriodaphnia*	<50%	*c*
Cooling Tower (Outfall 622)	10/10–17/91	FHM	100%	0.3%
Cooling Tower (Outfall 622)	10/10–17/91	*Ceriodaphnia*	100%	0.3%
Central Pollution Control Facility (CPCF) (Outfall 501)[d]	10/24–31/91	FHM	1%	1.2%
CPCF (Outfall 501)[d]	10/24–31/91	*Ceriodaphnia*	6%	1.2%

[a]This table is a summary of the effluents and their corresponding no-observed-effect concentration (NOEC). The tests performed were 7-day toxicity tests using *Ceriodaphnia* and fathead minnows (FHM). Where only one NOEC value is given, it is based on both species.

[b]Based on 4.7 cfs at East Fork Poplar Creek, Station 8. (Annual average flow rate).

[c]NOEC is greater than the IWC. Some information, including flow rate for this effluent, is considered classified and available only to those with a "Q" security clearance. This effluent is scheduled to be converted to total recycle in 1993.

[d]Samples taken at startup, displacing old water.

Table 4.32. Sampling and analysis plan for White Oak Creek headwaters

Parameter	Collection frequency	Sample type	Analysis frequency
Anions			
Fluoride	Monthly	Grab	Monthly
Nitrate (as N)	Monthly	Grab	Monthly
Sulfate (as SO_4)	Monthly	Grab	Monthly
Field Measurements			
Conductivity	Monthly	Grab	Monthly
Dissolved oxygen	Monthly	Grab	Monthly
pH	Monthly	Grab	Monthly
Temperature	Monthly	Grab	Monthly
Turbidity	Monthly	Grab	Monthly
Metals			
Silver	Monthly	Grab	Monthly
Aluminum	Monthly	Grab	Monthly
Arsenic	Monthly	Grab	Monthly
Boron	Monthly	Grab	Monthly
Barium	Monthly	Grab	Monthly
Beryllium	Monthly	Grab	Monthly
Calcium	Monthly	Grab	Monthly
Cadmium	Monthly	Grab	Monthly
Cobalt	Monthly	Grab	Monthly
Chromium	Monthly	Grab	Monthly
Copper	Monthly	Grab	Monthly
Iron	Monthly	Grab	Monthly
Lithium	Monthly	Grab	Monthly
Magnesium	Monthly	Grab	Monthly
Manganese	Monthly	Grab	Monthly
Molybdenum	Monthly	Grab	Monthly
Sodium	Monthly	Grab	Monthly
Nickel	Monthly	Grab	Monthly
Lead	Monthly	Grab	Monthly
Antimony	Monthly	Grab	Monthly
Selenium	Monthly	Grab	Monthly
Silicon	Monthly	Grab	Monthly
Tin	Monthly	Grab	Monthly
Strontium	Monthly	Grab	Monthly
Titanium	Monthly	Grab	Monthly
Vanadium	Monthly	Grab	Monthly
Zinc	Monthly	Grab	Monthly
Zirconium	Monthly	Grab	Monthly
Others			
Oil and grease	Monthly	Grab	Monthly
Phosphorus	Monthly	Grab	Monthly
Solids, total dissolved	Monthly	Grab	Monthly
Carbon, total organic	Monthly	Grab	Monthly
Solids, total suspended	Monthly	Grab	Monthly
Radionuclides			
^{60}Co	Weekly	Flow proportional	Monthly
^{137}Cs	Weekly	Flow proportional	Monthly
Gross alpha	Weekly	Flow proportional	Monthly
Gross beta	Weekly	Flow proportional	Monthly

Table 4.33. Sampling and analysis plan for Melton Hill Dam

Parameter	Collection frequency	Sample type	Analysis frequency
Anions			
Fluoride	Monthly	Grab	Monthly
Nitrate (as N)	Monthly	Grab	Monthly
Sulfate (as SO_4)	Monthly	Grab	Monthly
Field Measurements			
Conductivity	Monthly	Grab	Monthly
Dissolved oxygen	Monthly	Grab	Monthly
pH	Monthly	Grab	Monthly
Temperature	Monthly	Grab	Monthly
Turbidity	Monthly	Grab	Monthly
Metals			
Silver	Monthly	Grab	Monthly
Aluminum	Monthly	Grab	Monthly
Arsenic	Monthly	Grab	Monthly
Boron	Monthly	Grab	Monthly
Barium	Monthly	Grab	Monthly
Beryllium	Monthly	Grab	Monthly
Calcium	Monthly	Grab	Monthly
Cadmium	Monthly	Grab	Monthly
Cobalt	Monthly	Grab	Monthly
Chromium	Monthly	Grab	Monthly
Copper	Monthly	Grab	Monthly
Iron	Monthly	Grab	Monthly
Lithium	Monthly	Grab	Monthly
Magnesium	Monthly	Grab	Monthly
Manganese	Monthly	Grab	Monthly
Molybdenum	Monthly	Grab	Monthly
Sodium	Monthly	Grab	Monthly
Nickel	Monthly	Grab	Monthly
Lead	Monthly	Grab	Monthly
Antimony	Monthly	Grab	Monthly
Selenium	Monthly	Grab	Monthly
Silicon	Monthly	Grab	Monthly
Tin	Monthly	Grab	Monthly
Strontium	Monthly	Grab	Monthly
Titanium	Monthly	Grab	Monthly
Vanadium	Monthly	Grab	Monthly
Zinc	Monthly	Grab	Monthly
Zirconium	Monthly	Grab	Monthly
Others			
Oil and grease	Monthly	Grab	Monthly
Phosphorus	Monthly	Grab	Monthly
Solids, total dissolved	Monthly	Grab	Monthly
Carbon, total organic	Monthly	Grab	Monthly
Solids, total suspended	Monthly	Grab	Monthly
Radionuclides			
^{60}Co	Weekly	Flow proportional	Monthly
^{137}Cs	Weekly	Flow proportional	Monthly
Gross alpha	Weekly	Flow proportional	Monthly
Gross beta	Weekly	Flow proportional	Monthly

Table 4.34. 1991 surface water analyses at White Oak Creek headwaters[a]

Parameter	Number detected/ number of samples	Concentration (mg/L)				Percentage of ref. value[d]
		Max	Min	Av[b]	Standard error[c]	
Anions						
Fluoride	1/12	<1.0	<0.10	<0.43*	0.13	<11
Nitrate, as N	1/12	<5.0	0.10	<1.5*	0.48	<15
Sulfate, as SO_4	10/12	<5.0	1.5	<2.9*	0.38	<1.2
Field measurements						
Conductivity, mS/cm	12/12	1.2	0.030	0.42*	0.12	*e*
Dissolved oxygen	12/12	13	3.1	9.7*	0.84	*e*
Temperature, °C	12/12	19	8.9	13*	0.98	*e*
Turbidity, JTU	12/12	240	15	85*	20	*e*
pH, standard units	12/12	8.7	7.4	7.9*	0.10	*e*
Metals						
Aluminum, total	12/12	1.8	0.075	0.50*	0.16	250
Antimony, total	0/12	<0.050	<0.050	<0.050	0	*e*
Arsenic, total	0/12	<0.010	<0.010	<0.010	0	*e*
Barium, total	11/12	0.10	<0.0010	<0.064*	0.0085	<3.2
Beryllium, total	1/12	<0.0010	<0.00030	<0.00055*	0.000097	*e*
Boron, total	0/12	<0.080	<0.080	<0.080	0	*e*
Cadmium, total	0/12	<0.0050	<0.0050	<0.0050	0	*e*
Calcium, total	12/12	34	18	26*	1.7	*e*
Chromium, total	10/12	0.0093	<0.0040	<0.0068*	0.00058	<14
Cobalt, total	1/12	0.0043	<0.0040	<0.0040*	0.000025	*e*
Copper, total	0/12	<0.0070	<0.0070	<0.0070	0	*e*
Iron, total	11/12	1.9	<0.050	<0.59*	0.17	<200
Lead, total	0/12	<0.050	<0.050	<0.050	0	*e*
Lithium, total	0/12	<15	<15	<15	0	*e*
Magnesium, total	12/12	17	6.2	12*	1.1	*e*
Manganese, total	9/12	0.32	<0.0050	<0.093*	0.028	<190
Molybdenum, total	0/12	<0.040	<0.040	<0.040	0	*e*
Nickel, total	3/12	0.0075	<0.0040	<0.0044*	0.00029	<4.4
Selenium, total	0/12	<0.0050	<0.0050	<0.0050	0	*e*
Silicon, total	12/12	5.8	2.9	4.0*	0.21	*e*
Silver, total	0/12	<0.0050	<0.0050	<0.0050	0	*e*
Sodium, total	0/12	<5.0	<5.0	<5.0	0	*e*
Strontium, total	12/12	0.040	0.020	0.029*	0.0019	*e*
Tin, total	0/12	<0.050	<0.050	<0.050	0	*e*
Titanium, total	1/12	0.030	<0.020	<0.021*	0.00083	*e*
Vanadium, total	1/12	0.0025	<0.0020	<0.0020*	0.000042	*e*
Zinc, total	3/12	0.026	<0.0050	<0.0075*	0.0018	<0.15
Zirconium, total	0/12	<0.020	<0.020	<0.020	0	*e*
Others						
Carbon, total organic	11/12	2.1	<0.50	<0.96*	0.12	*e*
Oil and grease	0/12	<2.0	<2.0	<2.0	0	*e*
Phosphorus	0/12	<0.30	<0.30	<0.30	0	*e*
Solids, total dissolved	12/12	160	53	110*	12	22
Solids, total suspended	9/12	130	<5.0	<36*	10	*e*

Table 4.34 (continued)

Parameter	Number detected/ number of samples	Concentration (mg/L)				Percentage of ref. value[d]
		Max	Min	Av[b]	Standard error[c]	
Radionuclides[f]						
^{60}Co, pCi/L	3/12	62*	–30	14	8.5	*e*
^{137}Cs, pCi/L	2/12	51*	–35	0.86	7.4	*e*
Gross alpha, pCi/L	8/12	6.2*	–1.6	1.6*	0.53	10
Gross beta, pCi/L	9/12	27*	0.81	10*	2.4	20

[a]See Figure 4.6, Vol. 1.

[b]Mean concentrations significantly greater than zero are followed by an asterisk (*).

[c]Standard error of the mean.

[d]Mean concentration as a percentage of the National Primary or Secondary Water Regulation Level, or 4% of the DCG for ingestion of water (from DOE Order 5400.5), when a reference exists, the parameter is a contaminant, and mean concentration is significantly greater than zero.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 4.35. 1991 surface water analyses at Melton Hill Dam[a]

Parameter	Number detected/ number of samples	Concentration (mg/L)				Percentage of ref. value[d]
		Max	Min	Av[b]	Standard error[c]	
Anions						
Fluoride	4/12	1.1	<0.10	<0.47*	0.13	<12
Nitrate, as N	3/12	<5.0	0.60	<1.7*	0.46	<17
Sulfate, as SO_4	12/12	23	16	19*	0.59	7.6
Field measurements						
Conductivity, mS/cm	12/12	1.4	0.020	0.45*	0.13	*e*
Dissolved oxygen	12/12	12	2.8	9.0*	0.83	*e*
Temperature, °C	12/12	23	7.5	15*	1.5	*e*
Turbidity, JTU	12/12	270	4.2	90*	21	*e*
pH, standard units	12/12	8.2	7.1	7.7*	0.094	*e*
Metals						
Aluminum, total	10/12	2.4	<0.050	<0.65*	0.22	<330
Antimony, total	0/12	<0.050	<0.050	<0.050	0	*e*
Arsenic, total	0/12	<0.010	<0.010	<0.010	0	*e*
Barium, total	11/12	0.056	<0.0010	<0.032*	0.0042	<1.6
Beryllium, total	2/12	<0.0010	<0.00030	<0.00056*	0.000096	*e*
Boron, total	0/12	<0.080	<0.080	<0.080	0	*e*
Cadmium, total	0/12	<0.0050	<0.0050	<0.0050	0	*e*
Calcium, total	12/12	41	31	35*	0.91	*e*
Chromium, total	9/12	0.0083	<0.0040	<0.0063*	0.00043	<13
Cobalt, total	0/12	<0.0040	<0.0040	<0.0040	0	*e*
Copper, total	2/12	0.016	<0.0070	<0.0083*	0.00086	<0.83
Iron, total	12/12	3.1	0.15	0.79*	0.25	260
Lead, total	0/12	<0.050	<0.050	<0.050	0	*e*
Lithium, total	0/12	<15	<15	<15	0	*e*
Magnesium, total	12/12	11	8.5	9.5*	0.24	*e*
Manganese, total	11/12	0.70	<0.0050	<0.13*	0.058	<260
Molybdenum, total	0/12	<0.040	<0.040	<0.040	0	*e*
Nickel, total	5/12	0.013	<0.0040	<0.0058*	0.00085	<5.8
Selenium, total	0/12	<0.0050	<0.0050	<0.0050	0	*e*
Silicon, total	12/12	5.7	1.3	3.0*	0.42	*e*
Silver, total	0/12	<0.0050	<0.0050	<0.0050	0	*e*
Sodium, total	0/12	<5.0	<5.0	<5.0	0	*e*
Strontium, total	12/12	0.097	0.075	0.085*	0.0019	*e*
Tin, total	0/12	<0.050	<0.050	<0.050	0	*e*
Titanium, total	0/12	<0.020	<0.020	<0.020	0	*e*
Vanadium, total	3/12	0.0039	<0.0020	<0.0023*	0.00021	*e*
Zinc, total	2/12	0.012	<0.0050	<0.0058*	0.00060	<0.12
Zirconium, total	0/12	<0.020	<0.020	<0.020	0	*e*
Others						
Carbon, total organic	11/12	3.8	<0.50	<1.9*	0.23	*e*
Oil and grease	4/12	35	<2.0	<7.7*	3.7	*e*
Phosphorus	0/12	<0.30	<0.30	<0.30	0	*e*
Solids, total dissolved	12/12	180	110	150*	5.0	29
Solids, total suspended	11/12	62	<5.0	<22*	5.6	*e*

Table 4.35 (continued)

Parameter	Number detected/ number of samples	Concentration (mg/L)				Percentage of ref. value[d]
		Max	Min	Av[b]	Standard error[c]	
Radionuclides[f]						
^{60}Co, pCi/L	1/12	38*	–24	–3.7	5.1	*e*
^{137}Cs, pCi/L	1/12	24	–32	2.3	4.8	*e*
Gross alpha, pCi/L	4/12	3.5*	–3.5	0.41	0.60	*e*
Gross beta, pCi/L	10/12	9.2*	–19	2.8	2.4	*e*

[a]See Figure 4.1, Vol. 1.

[b]Mean concentrations significantly greater than zero are followed by an asterisk (*).

[c]Standard error of the mean.

[d]Mean concentration as a percentage of the National Primary or Secondary Water Regulation Level, or 4% of the DCG for ingestion of water (from DOE Order 5400.5), when a reference exists, the parameter is a contaminant, and mean concentration is significantly greater than zero.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 4.36. ORNL Melton Branch (X13), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Daily	Continuous	Daily
TSS	Monthly	24-h composite	Monthly
Ammonia	Monthly	24-h composite	Monthly
BOD	Monthly	24-h composite	Monthly
TOC	Monthly	Grab	Monthly
pH	Monthly	Grab	Monthly
Fluoride	Monthly	24-h composite	Monthly
Nitrate	Monthly	24-h composite	Monthly
Phosphorus	Monthly	24-h composite	Monthly
Sulfate	Monthly	24-h composite	Monthly
Temperature	Monthly	Grab	Monthly
Conductivity	Monthly	Grab	Monthly
Turbidity	Monthly	Grab	Monthly
Phenols, total	Monthly	Grab	Monthly
DO	Weekly	Grab	Weekly
TDS	Monthly	Grab	Monthly
Oil and grease	Weekly	Grab	Weekly
Residual chlorine	Weekly	Grab	Weekly
Chloroform	Monthly	Grab	Monthly
Trichloroethylene	Monthly	Grab	Monthly
PCB	Monthly	24-h composite	Monthly
Aluminum, total	Monthly	24-h composite	Monthly
Arsenic, total	Monthly	24-h composite	Monthly
Cadmium, total	Monthly	24-h composite	Monthly
Chromium, total	Monthly	24-h composite	Monthly
Copper, total	Monthly	24-h composite	Monthly
Iron, total	Monthly	24-h composite	Monthly
Lead, total	Monthly	24-h composite	Monthly
Manganese, total	Monthly	24-h composite	Monthly
Mercury, total	Monthly	24-h composite	Monthly
Nickel, total	Monthly	24-h composite	Monthly
Silver, total	Monthly	24-h composite	Monthly
Zinc, total	Monthly	24-h composite	Monthly
^{3}H	Weekly	Flow proportional	Monthly
Total Sr[a]	Weekly	Flow proportional	Monthly
Gamma scan	Weekly	Flow proportional	Monthly

[a]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).

Table 4.37. ORNL White Oak Creek (X14), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Daily	Continuous	Daily
TSS	Monthly	24-h composite	Monthly
Ammonia	Monthly	24-h composite	Monthly
BOD	Monthly	24-h composite	Monthly
TOC	Monthly	Grab	Monthly
pH	Monthly	Grab	Monthly
Fluoride	Monthly	24-h composite	Monthly
Nitrate	Monthly	24-h composite	Monthly
Phosphorus	Monthly	24-h composite	Monthly
Sulfate	Monthly	24-h composite	Monthly
Temperature	Monthly	Grab	Monthly
Conductivity	Monthly	Grab	Monthly
Turbidity	Monthly	Grab	Monthly
Phenols, total	Monthly	Grab	Monthly
DO	Weekly	Grab	Weekly
TDS	Monthly	Grab	Monthly
Oil and grease	Weekly	Grab	Weekly
Residual chlorine	Weekly	Grab	Weekly
Chloroform	Monthly	Grab	Monthly
Trichloroethylene	Monthly	Grab	Monthly
PCB	Monthly	24-h composite	Monthly
Aluminum, total	Monthly	24-h composite	Monthly
Arsenic, total	Monthly	24-h composite	Monthly
Cadmium, total	Monthly	24-h composite	Monthly
Chromium, total	Monthly	24-h composite	Monthly
Copper, total	Monthly	24-h composite	Monthly
Iron, total	Monthly	24-h composite	Monthly
Lead, total	Monthly	24-h composite	Monthly
Manganese, total	Monthly	24-h composite	Monthly
Mercury, total	Monthly	24-h composite	Monthly
Nickel, total	Monthly	24-h composite	Monthly
Silver, total	Monthly	24-h composite	Monthly
Zinc, total	Monthly	24-h composite	Monthly
^{3}H	Weekly	Flow proportional	Monthly
Total Sr[a]	Weekly	Flow proportional	Monthly
Gamma scan	Weekly	Flow proportional	Monthly

[a]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).

Table 4.38. ORNL White Oak Dam (X15), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Daily	Continuous	Daily
TSS	Monthly	24-h composite	Monthly
Ammonia	Monthly	24-h composite	Monthly
BOD	Monthly	24-h composite	Monthly
TOC	Monthly	Grab	Monthly
pH	Monthly	Grab	Monthly
Fluoride	Monthly	24-h composite	Monthly
Nitrate	Monthly	24-h composite	Monthly
Phosphorus	Monthly	24-h composite	Monthly
Sulfate	Monthly	24-h composite	Monthly
Temperature	Monthly	Grab	Monthly
Conductivity	Monthly	Grab	Monthly
Turbidity	Monthly	Grab	Monthly
Phenols, total	Monthly	Grab	Monthly
DO	Weekly	Grab	Weekly
TDS	Monthly	Grab	Monthly
Oil and grease	Weekly	Grab	Weekly
Residual chlorine	Weekly	Grab	Weekly
Chloroform	Monthly	Grab	Monthly
Trichloroethylene	Monthly	Grab	Monthly
PCB	Monthly	24-h composite	Monthly
Aluminum, total	Monthly	24-h composite	Monthly
Arsenic, total	Monthly	24-h composite	Monthly
Cadmium, total	Monthly	24-h composite	Monthly
Chromium, total	Monthly	24-h composite	Monthly
Copper, total	Monthly	24-h composite	Monthly
Iron, total	Monthly	24-h composite	Monthly
Lead, total	Monthly	24-h composite	Monthly
Manganese, total	Monthly	24-h composite	Monthly
Mercury, total	Monthly	24-h composite	Monthly
Nickel, total	Monthly	24-h composite	Monthly
Silver, total	Monthly	24-h composite	Monthly
Zinc, total	Monthly	24-h composite	Monthly
^{3}H	Weekly	Flow proportional	Monthly
Total Sr[a]	Weekly	Flow proportional	Monthly
Gamma scan	Weekly	Flow proportional	Weekly
Gross alpha	Weekly	Flow proportional	Weekly
Gross beta	Weekly	Flow proportional	Weekly

[a]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).

Table 4.39. Summary of collection and analysis frequencies of ORNL surface water samples, 1991

Station	Parameter	Collection frequency	Sample type	Analysis frequency
7500 Bridge, MB2	Gamma scan, total Sr[a], ^{3}H	Weekly	Flow proportional	Monthly
First Creek, Fifth Creek, Raccoon Creek	Gamma scan, total Sr[a]	Weekly	Grab	Monthly
NWT	Gamma scan, total Sr[a]	Weekly	Flow proportional	Monthly

[a]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).

Table 4.40. 1991 ORNL radionuclide concentrations in First Creek[a]

Radionuclide	Number detected	Number of samples	Concentrations (pCi/L)[b]			
			Max	Min	Av[c]	Standard error[d]
^{60}Co	0	12	38	–59	1.4	9.1
^{137}Cs	0	12	32	–46	–1.6	8.4
$^{89}Sr + {}^{90}Sr$	12	12	540*	120*	290*	42

[a]See Fig. 4.6, Vol. 1.
[b]Multiply pCi/L by 0.037 to convert to Bq/L.
[c]Mean concentrations significantly greater than zero are identified by an asterisk (*).
[d]Standard error of the mean.

Table 4.41. 1991 ORNL radionuclide concentrations in Fifth Creek[a]

Radionuclide	Number detected	Number of samples	Concentrations (pCi/L)[b]			
			Max	Min	Av[c]	Standard error[d]
^{60}Co	1	12	35*	–57	–9.5	7.9
^{137}Cs	0	12	46	–38	–1.8	6.9
$^{89}Sr + {}^{90}Sr$	12	12	140*	18*	39*	9.3

[a]See Fig. 4.6, Vol. 1.
[b]Multiply pCi/L by 0.037 to convert to Bq/L.
[c]Mean concentrations significantly greater than zero are identified by an asterisk (*).
[d]Standard error of the mean.

Table 4.42. 1991 ORNL radionuclide concentrations at 7500 Bridge[a]

Radionuclide	Number detected	Number of samples	Concentrations (pCi/L)[b]			
			Max	Min	Av[c]	Standard error[d]
^{60}Co	2	12	38*	–46	11	6.2
^{137}Cs	10	12	760*	11	140*	60
^{3}H	12	12	4,900*	1,500*	3,100*	330
$^{89}Sr + {}^{90}Sr$	12	12	180*	38*	81*	12

[a]See Fig. 4.6, Vol. 1.
[b]Multiply pCi/L by 0.037 to convert to Bq/L.
[c]Mean concentrations significantly greater than zero are identified by an asterisk (*).
[d]Standard error of the mean.

Table 4.43. 1991 ORNL radionuclide concentrations in Melton Branch 2[a]

Radionuclide	Number detected	Number of samples	Concentrations (pCi/L)[b]			
			Max	Min	Av[c]	Standard error[d]
^{60}Co	4	12	54*	–27	15*	7.7
^{137}Cs	1	12	97*	–35	6.1	9.7
^{3}H	11	12	11,000*	–220	4,200*	820
$^{89}Sr + ^{90}Sr$	6	12	5.4*	–0.054	2.7*	0.58

[a]See Fig. 4.6, Vol. 1.
[b]Multiply pCi/L by 0.037 to convert to Bq/L.
[c]Mean concentrations significantly greater than zero are identified by an asterisk (*).
[d]Standard error of the mean.

Table 4.44. 1991 ORNL radionuclide concentrations in Northwest Tributary[a]

Radionuclide	Number detected	Number of samples	Concentrations (pCi/L)[b]			
			Max	Min	Av[c]	Standard error[d]
^{60}Co	1	12	43*	–49	5.2	7.6
^{137}Cs	1	12	3000*	–43	240	250
$^{89}Sr + ^{90}Sr$	12	12	62*	2.4*	39*	5.7

[a]See Fig. 4.6, Vol. 1.
[b]Multiply pCi/L by 0.037 to convert to Bq/L.
[c]Mean concentrations significantly greater than zero are identified by an asterisk (*).
[d]Standard error of the mean.

Table 4.45. 1991 ORNL radionuclide concentrations in Raccoon Creek[a]

Radionuclide	Number detected	Number of samples	Concentrations (pCi/L)[b]			
			Max	Min	Av[c]	Standard error[d]
^{60}Co	0	12	30	–43	–3.4	7.1
^{137}Cs	0	12	32	–32	3.7	6.7
$^{89}Sr + ^{90}Sr$	11	12	65*	5.1	28*	6.7

[a]See Fig. 4.6, Vol, Vol. 1.
[b]Multiply pCi/L by 0.037 to convert to Bq/L.
[c]Mean concentrations significantly greater than zero are identified by an asterisk (*).
[d]Standard error of the mean.

Table 4.46. 1991 mercury concentrations in ORNL area surface water[a]

Station	Number of samples	Concentration (μg/L)				Percentage TWQ[c]
		Max	Min	Av	Standard error[b]	
			First Creek			
141	6	0.070	<0.050	<0.053	0.0033	2.9
142	6	<0.050	<0.050	<0.050	0	<2.1
143	6	<0.050	<0.050	<0.050	0	<2.1
241	6	<0.050	<0.050	<0.050	0	<2.1
243	6	<0.050	<0.050	<0.050	0	<2.1
244	6	<0.050	<0.050	<0.050	0	<2.1
246	6	0.050	0.050	0.050	0	2.1
247	6	<0.050	<0.050	<0.050	0	<2.1
248	6	<0.050	<0.050	<0.050	0	<2.1
341	6	0.10	0.060	<0.080	0.0089	4.2
342	6	<0.050	<0.050	<0.050	0	<2.1
343	6	<0.050	<0.050	<0.050	0	<2.1
344	6	<0.050	<0.050	<0.050	0	<2.1
X12	6	<0.050	<0.050	<0.050	0	<2.1
Stream summary	84	0.10	<0.050	<0.052	0.0011	4.2
			Fifth Creek			
161	6	<0.050	<0.050	<0.050	0	<2.1
162	6	<0.050	<0.050	<0.060	0	<2.1
163	6	0.11	<0.050	<0.075	0.012	4.6
164	6	<0.050	<0.050	<0.050	0	<2.1
261	6	<0.050	<0.050	<0.050	0	<2.1
262	6	<0.050	<0.050	<0.050	0	<2.1
265	6	<0.050	<0.050	<0.050	0	<2.1
268	6	<0.050	<0.050	<0.050	0	<2.1
361	6	<0.050	<0.050	<0.050	0	<2.1
362	6	<0.050	<0.050	<0.050	0	<2.1
363	6	<0.050	<0.050	<0.050	0	<2.1
364	6	<0.050	<0.050	<0.050	0	<2.1
365	6	<0.050	<0.050	<0.050	0	<2.1
366	6	<0.050	<0.050	<0.050	0	<2.1
367	6	0.24	<0.050	<0.083	0.031	10
368	6	<0.050	<0.050	<0.050	0	<2.1
Stream summary	96	0.24	<0.050	<0.054	0.0022	10
			Melton Branch			
181	6	<0.050	<0.050	<0.050	0	<2.1
281	6	<0.050	<0.050	<0.050	0	<2.1
283	6	<0.050	<0.050	<0.050	0	<2.1
381	6	<0.050	<0.050	<0.050	0	<2.1
382	6	<0.050	<0.050	<0.050	0	<2.1
383	6	<0.050	<0.050	<0.050	0	<2.1
384	6	<0.050	<0.050	<0.050	0	<2.1
385	6	<0.050	<0.050	<0.050	0	<2.1
386	6	<0.050	<0.050	<0.050	0	<2.1
HDWTR	6	<0.050	<0.050	<0.050	0	<2.1
MBS	6	<0.050	<0.050	<0.050	0	<2.1
MHD	6	<0.050	<0.050	<0.050	0	<2.1
Stream summary	72	<0.050	<0.050	<0.050	0	<2.1

Table 4.46 (continued)

Station	Number of samples	Concentration (μg/L)				Percentage TWQ[c]
		Max	Min	Av	Standard error[b]	
			White Oak Creek			
101	6	0.17	<0.050	<0.11	0.027	7.1
103	6	0.19	<0.050	<0.12	0.031	7.9
106	6	0.18	<0.050	<0.11	0.028	7.5
109	6	<0.050	<0.050	<0.050	0	<2.1
116	6	<0.050	<0.050	<0.050	0	<2.1
202	6	0.10	<0.050	<0.067	0.0084	4.2
204	6	0.090	<0.050	<0.067	0.0076	3.8
206	6	0.12	<0.050	<0.080	0.014	5.0
207	6	0.26	<0.050	<0.15	0.044	11
208	6	0.20	<0.050	<0.12	0.033	8.3
209	6	0.25	<0.050	<0.13	0.037	10
210	6	0.20	<0.050	<0.13	0.034	8.3
216	6	<0.050	<0.050	<0.050	0	<2.1
217	6	<0.050	<0.050	<0.050	0	<2.1
218	6	<0.050	<0.050	<0.050	0	<2.1
222	6	<0.050	<0.050	<0.050	0	<2.1
223	6	<0.050	<0.050	<0.050	0	<2.1
230	6	<0.050	<0.050	<0.050	0	<2.1
232	6	<0.050	<0.050	<0.050	0	<2.1
233	6	<0.050	<0.050	<0.050	0	<2.1
234	6	<0.050	<0.050	<0.050	0	<2.1
301	6	0.12	0.050	0.087	0.014	5.0
302	6	0.13	0.050	0.085	0.016	5.4
304	6	0.15	<0.050	<0.098	0.022	6.3
310	6	0.15	<0.050	<0.097	0.021	6.3
311	6	0.31	<0.050	<0.16	0.051	13
312	6	<0.050	<0.050	<0.050	0	<2.1
313	6	<0.050	<0.050	<0.050	0	<2.1
314	6	<0.050	<0.050	<0.050	0	<2.1
7500	6	<0.050	<0.050	<0.050	0	<2.1
FLUME	6	0.17	<0.050	<0.11	0.026	7.1
HDW	6	<0.050	<0.050	<0.050	0	<2.1
LSC	6	<0.050	<0.050	<0.050	0	<2.1
WOD	6	<0.050	<0.050	<0.050	0	<2.1
X01	6	<0.050	<0.050	<0.050	0	<2.1
X02	6	0.09	<0.050	<0.065	0.0072	3.8
X03	6	<0.050	<0.050	<0.050	0	<2.1
X12	6	0.070	0.050	0.060	0.0045	2.9
Stream summary	228	0.31	<0.050	<0.075	0.0035	13
Overall summary	480	0.31	<0.050	<0.063	0.0018	13

[a]See Figs. 4.6–4.8 in Vol. 1.
[b]Standard error of the mean.
[c]Maximum value percentage of proposed Tennessee Water Quality Standard, 2.4 μg/L, for the protection of fish and aquatic life.

Table 4.47. ORNL Sewage Treatment Plant (X01), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Daily	Continuous	Daily
pH	Weekly	Grab	Weekly
Downstream pH	Weekly	Grab	Weekly
BOD	3/week	24-h composite	3/week
TSS	3/week	24-h composite	3/week
Ammonia	3/week	24-h composite	3/week
Oil and grease	3/week	Grab	3/week
DO	5/week	Grab	5/week
Residual chlorine	3/week	Grab	3/week
Fecal coliform bacteria, geometric mean	3/week	Grab	3/week
Cyanide, total	Monthly	Grab	Monthly
Copper, total	Monthly	24-h composite	Monthly
Mercury, total	Monthly	24-h composite	Monthly
Silver, total	Monthly	24-h composite	Monthly
Zinc, total	Monthly	24-h composite	Monthly
Trichlorethylene	Monthly	Grab	Monthly
Dichlorobromomethane	Monthly	Grab	Monthly
Phenols, total	Monthly	Grab	Monthly
Gamma scan	Weekly	Flow proportional	Monthly
Gross beta	Weekly	Flow proportional	Monthly
Total Sr[a]	Weekly	Flow proportional	Monthly

[a]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).

Table 4.48. ORNL Coal Yard Runoff Treatment Facility (X02), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Daily	Continuous	Daily
pH	Weekly	Grab	Weekly
Temperature	Weekly	Grab	Weekly
Downstream pH	Weekly	Grab	Weekly
TSS	Weekly	24-h composite	Weekly
Oil and grease	Weekly	Grab	Weekly
Chromium, total	Weekly	24-h composite	Weekly
Copper, total	Weekly	24-h composite	Weekly
Iron	Weekly	24-h composite	Weekly
Zinc, total	Weekly	24-h composite	Weekly
Sulfate	Monthly	24-h composite	Monthly
Arsenic, total	Weekly	24-h composite	Weekly
Cadmium, total	Weekly	24-h composite	Weekly
Lead, total	Weekly	24-h composite	Weekly
Manganese, total	Weekly	24-h composite	Weekly
Nickel, total	Weekly	24-h composite	Weekly
Selenium, total	Weekly	24-h composite	Weekly
Silver, total	Weekly	24-h composite	Weekly

Table 4.49. ORNL Nonradiological Wastewater Treatment Facility (X12), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Daily	Continuous	Daily
pH	Continuous	Continuous	Continuous
Downstream pH	Daily	Grab	Daily
Temperature	Weekly	Grab	Weekly
TSS	Weekly	24-h composite	Weekly
Oil and grease	Weekly	Grab	Weekly
TTO	Weekly	Grab	Weekly
Cyanide, total	Weekly	Grab	Weekly
Cadmium, total	Weekly	24-h composite	Weekly
Chromium, total	Weekly	24-h composite	Weekly
Copper, total	Weekly	24-h composite	Weekly
Lead, total	Weekly	24-h composite	Weekly
Nickel, total	Weekly	24-h composite	Weekly
Silver, total	Weekly	24-h composite	Weekly
Zinc, total	Weekly	24-h composite	Weekly
BOD	Weekly	24-h composite	Weekly
Nitrate	Weekly	24-h composite	Weekly
Sulfate	Weekly	24-h composite	Weekly
Phosphorus, total	Weekly	24-h composite	Weekly
Phenol, total	Weekly	Grab	Weekly
Fluoride	Weekly	24-h composite	Weekly
Arsenic, total	Weekly	24-h composite	Weekly
Iron, total	Weekly	24-h composite	Weekly
Mercury, total	Weekly	24-h composite	Weekly
Selenium, total	Weekly	24-h composite	Weekly
Benzene	Weekly	Grab	Weekly
Chlorobenzene	Weekly	Grab	Weekly
Chloroform	Weekly	Grab	Weekly
Dichlorobromomethane	Weekly	Grab	Weekly
Methylene chloride	Weekly	Grab	Weekly
Tetrachloroethylene	Weekly	Grab	Weekly
Trichloroethylene	Weekly	Grab	Weekly
1,1-Dichloroethane	Weekly	Grab	Weekly
^{3}H	Weekly	Flow proportional	Monthly
Gamma scan	Weekly	Flow proportional	Monthly
Gross alpha	Weekly	Flow proportional	Monthly
Gross beta	Weekly	Flow proportional	Monthly
Total Sr[a]	Weekly	Flow proportional	Monthly

[a]Total radioactive Sr($^{89}Sr + ^{90}Sr$).

Table 4.50. NPDES Permit Number TN 0002941, 1991
ORNL discharge point X01 (Sewage Treatment Plant)

Flow rates (1×10^6 L/d)—Max: 2.5, Min: 0.000038, Av: 0.83

X01: Clinch River flow ratios—Max: 0.00089, Min: 0.00000068, Av: 0.00010

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Field measurements							
Chlorine, total residual	154/159	1.9	<0.010	<0.21*	0.012	*d*	*d*
Downstream pH, standard units	53/53	8.1	7.0	7.7*	0.033	*d*	*d*
Downstream temperature, °C	53/53	27	12	20*	0.62	*d*	*d*
Oxygen, dissolved	250/250	19	6.3	10*	0.11	*d*	*d*
Temperature, °C	303/303	29	12	21*	0.30	*d*	*d*
pH, standard units	53/53	8.0	7.0	7.5*	0.033	*d*	*d*
Metals							
Copper, total	2/12	0.011	<0.0070	<0.0074*	0.00034	<0.0001	0.00016
Mercury, total	1/12	0.000080	<0.000050	<0.000053*	0.0000025	0.0025	0.0059
Silver, total	0/12	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Zinc, total	12/12	0.099	0.024	0.050*	0.0060	0.00012	0.00047
Others							
Ammonia (as N)	158/158	6.0	0.010	0.33*	0.059	*d*	*d*
Biochemical oxygen demand	1/158	14	<5.0	<5.1*	0.057	*d*	*d*
Cyanide, total	1/12	0.0040	<0.0020	<0.0022*	0.00017	0.00010	0.00024
Fecal coliform, col/100 mL	57/158	3300	0	1.8	1.1	<0.0001	0.021
Oil and grease	23/158	190	<2.0	<3.6*	1.2	*d*	*d*
Phenolics, total recoverable	0/12	<0.0010	<0.0010	<0.0010	0	*d*	*d*
Suspended solids, total	18/158	86	<2.0	<6.0*	0.55	*d*	*d*
Radionuclides							
^{137}Cs, pCi/L	0/12	19	–46	–1.7	5.3	*d*	*d*
^{60}Co, pCi/L	1/12	43*	–49	2.3	7.3	*d*	*d*
Gross beta, pCi/L	11/11	760*	1.4*	420*	70	0.0033	0.0093
Total Sr, pCi/L	12/12	510*	97*	250*	36	0.011	0.026
Volatile organics							
Bromodichloromethane	1/12	<0.0050	J 0.0010	J 0.0047*	0.00033	0.00047	0.0012
Trichloroethylene	1/12	<0.0050	J 0.0010	J 0.0047*	0.00033	0.0096	0.024

[a] < = undetected; J = below detection limit, but estimated. Mean concentrations significantly greater than zero are followed by an asterisk (*).

[b] Standard error of the mean.

[c] Calculated Clinch River concentration as a percentage of a drinking water limit (DWL) or 4% of the derived concentration guide, when a reference exists and the parameter is a contaminant.

[d] Not applicable.

Table 4.51. NPDES Permit Number TN 0002941, 1991
ORNL discharge point X02 (Coal Yard Runoff Treatment Facility)

Flow rates (1×10^6 L/d)—Max: 0.57, Min: 0, Av: 0.043

X02: Clinch River flow ratios—Max: 0.00060, Min: 0, Av: 0.0000081

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Anions							
Sulfate, as SO_4	12/12	2000	730	1500*	120	0.0049	0.028
Field measurements							
Downstream pH, standard units	250/250	8.5	6.8	7.8*	0.016	*d*	*d*
Downstream temperature, °C	250/250	27	5.1	17*	0.35	*d*	*d*
Temperature, °C	250/250	30	2.6	18*	0.51	*d*	*d*
pH, standard units	250/250	11	6.4	7.6*	0.029	*d*	*d*
Metals							
Arsenic, total	9/41	0.54	<0.050	<0.069*	0.012	0.00073	0.0059
Cadmium, total	0/41	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Chromium, total	37/41	0.020	<0.0040	<0.011*	0.00078	0.00014	0.0016
Copper, total	13/41	0.084	<0.0070	<0.0098*	0.0019	<0.0001	<0.0001
Iron, total	37/41	3.5	<0.050	<0.38*	0.088	0.00088	0.020
Lead, total	1/41	0.075	<0.050	<0.051*	0.00061	0.00062	0.0059
Manganese, total	40/41	0.12	<0.0010	<0.039*	0.0047	0.00037	0.0014
Nickel, total	16/41	0.017	<0.0040	<0.0060*	0.00056	<0.0001	0.00050
Selenium, total	41/41	0.23	0.0080	0.078*	0.010	0.0066	0.088
Silver, total	3/41	0.0091	<0.0050	<0.0051*	0.00011	<0.0001	0.00059
Zinc, total	24/41	0.091	<0.0050	<0.014*	0.0030	<0.0001	<0.0001
Others							
Oil and grease	9/42	150	<2.0	<7.5*	3.5	*d*	*d*
Suspended solids, total	11/41	19	<5.0	<6.0*	0.46	*d*	*d*

[a] < = undetected. Mean concentrations significantly greater than zero are marked with an asterisk (*).
[b] Standard error of the mean.
[c] Calculated Clinch River concentration as a percentage of a drinking water limit (DWL) or 4% of the derived concentration guide, when a reference exists and the parameter is a contaminant.
[d] Not applicable.

Table 4.52. NPDES Permit Number TN 0002941, 1991
ORNL discharge point X12 (Nonradiological Wastewater Treatment Facility)

Flow rates (1×10^6 L/d)—Max: 3.5, Min: 1.2, Av: 1.8
X12: Clinch River flow ratios—Max: 0.0018, Min: 0.000032, Av: 0.00024

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Anions							
Fluoride, total	51/53	4.4	0.80	1.3*	0.068	0.0075	0.036
Nitrate	49/53	15	0.50	3.3*	0.36	0.0064	0.044
Sulfate, as SO_4	53/53	430	30	220*	10	0.021	0.087
Field measurements							
Downstream pH, standard units	250/250	8.7	6.6	7.9*	0.021	*d*	*d*
Downstream temperature, °C	250/250	27	8.4	17*	0.28	*d*	*d*
Temperature, °C	250/250	28	11	20*	0.30	*d*	*d*
pH, standard units	250/250	8.2	6.9	7.4*	0.0094	*d*	*d*
Metals							
Arsenic, total	0/53	<0.050	<0.050	<0.050	0	*d*	*d*
Cadmium, total	0/53	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Chromium, total	26/53	0.028	<0.00040	<0.0059*	0.00054	0.0031	0.050
Copper, total	7/53	0.012	<0.0070	<0.0073*	0.00015	0.00017	0.00062
Iron, total	4/53	4.7	<0.050	<0.14	0.088	*d*	*d*
Lead, total	2/53	0.068	<0.050	<0.051*	0.00042	0.023	0.089
Mercury, total	0/53	<0.000050	<0.000050	<0.000050	0	*d*	*d*
Nickel, total	11/53	0.011	<0.0040	<0.0047*	0.00024	0.0011	0.0061
Selenium, total	0/53	<0.050	<0.050	<0.050	0	0.12	0.44
Silver, total	2/53	0.0057	<0.0050	<0.0050*	0.000013	0.0023	0.0089
Zinc, total	51/53	0.081	<0.0050	<0.020*	0.0018	0.00010	0.00050
Others							
Biochemical oxygen demand	0/53	<5.0	<5.0	<5.0	0	*d*	*d*
Cyanide, total	3/53	0.0050	<0.0020	<0.0021*	0.000079	0.00024	0.00089
Oil and grease	3/53	3.0	<2.0	<2.0*	0.019	*d*	*d*
Phenolics, total recoverable	0/53	<0.0010	<0.0010	<0.0010	0	*d*	*d*
Phosphorus, total	36/53	0.55	0.10	0.28*	0.014	*d*	*d*
Suspended solids, total	0/53	<5.0	<5.0	<5.0	0	*d*	*d*
Total toxic organics	0/53	<0.010	<0.010	<0.010	0	*d*	*d*
Radionuclides							
^{137}Cs, pCi/L	12/12	1,400*	380*	900*	83	0.0066	0.018
^{3}H, pCi/L	12/12	54,000*	21,000*	32,000*	2,900	0.0014	0.0032
^{60}Co, pCi/L	1/12	68*	–27	12	6.9	*d*	*d*
Gross alpha, pCi/L	11/12	27*	6.2*	16*	2.0	0.00078	0.0020
Gross beta, pCi/L	12/12	2,400*	460*	870*	140	0.013	0.031
Total Sr, pCi/L	12/12	840*	19*	130*	68	0.0080	0.036
Volatile Organics							
1,1-Dichloroethane	0/53	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Benzene	0/53	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Bromodichloromethane	0/53	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Chlorobenzene	0/53	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Chloroform	3/53	<0.0050	J 0.0010	J 0.0048	0.00011	0.0011	0.0044
Methylene chloride	11/53	<0.0050	JB 0.0010	JB 0.0044	0.00018	*d*	*d*
Tetrachloroethene	0/53	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Trichloroethene	1/53	<0.0050	J 0.0020	J 0.0049	0.000057	0.023	0.089

[a] < = undetected; J = below detection limit, but estimated; B = found in the blank. Mean concentrations significantly greater than zero are followed by an asterisk (*).

[b] Standard error of the mean.

[c] Calculated Clinch River concentration as a percentage of a drinking water limit (DWL) or 4% of the derived concentration guide, when a reference exists and the parameter is a contaminant.

[d] Not applicable.

Table 4.53. NPDES Permit Number TN 0002941, 1991
ORNL discharge point X13 (Melton Branch 1)

Flow rates (1×10^6 L/d)—Max: 320, Min: 0.87, Av: 10
X13: Clinch River flow ratios—Max: 0.033, Min: 0.000074, Av: 0.0011

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Anions							
Fluoride, total	8/12	1.8	<0.10	<1.1*	0.16	0.022	0.065
Nitrate	5/12	<5.0	0.10	<1.2*	0.36	0.011	0.041
Sulfate, as SO_4	12/12	250	21	85*	21	0.030	0.082
Field Measurements							
Chlorine, total residual	1/53	0.010	<0.010	<0.010	0	*d*	*d*
Conductivity, mS/cm	12/12	2.0	0.10	0.84*	0.21	*d*	*d*
Oxygen, dissolved	53/53	14	7.0	11*	0.23	*d*	*d*
Temperature, °C	65/65	30	4.2	16*	0.85	*d*	*d*
Turbidity, JTU	12/12	34	4.0	15*	2.8	*d*	*d*
pH, standard units	12/12	8.0	7.4	7.7*	0.051	*d*	*d*
Metals							
Aluminum, total	10/12	16	<0.050	<2.1	1.3	*d*	*d*
Arsenic, total	0/12	<0.050	<0.050	<0.050	0	*d*	*d*
Cadmium, total	0/12	<0.0020	<0.0020	<0.0020	0	*d*	*d*
Chromium, total	11/12	0.052	<0.0040	<0.011*	0.0038	0.024	0.091
Copper, total	1/12	0.030	<0.0070	<0.0089*	0.0019	0.0010	0.0029
Iron, total	12/12	22	0.080	2.6	1.8	*d*	*d*
Lead, total	1/12	0.0080	<0.0040	<0.0043*	0.00033	0.010	0.033
Manganese, total	12/12	2.5	0.042	0.31	0.20	*d*	*d*
Mercury, total	1/12	0.000060	<0.000050	<0.000051*	0.00000083	0.030	0.10
Nickel, total	4/12	0.019	<0.0040	<0.0059*	0.0013	0.0062	0.017
Silver, total	0/12	<0.0050	<0.00050	<0.0046*	0.00038	0.0099	0.041
Zinc, total	8/12	0.16	<0.0050	<0.030*	0.013	0.00060	0.0028
Others							
Ammonia, as N	12/12	0.070	0.020	0.039*	0.0042	*d*	*d*
Biochemical oxygen demand	0/12	<5.0	<5.0	<5.0	0	*d*	*d*
Dissolved solids, total	12/12	580	150	300*	39	0.064	0.17
Oil and grease	14/53	53	<2.0	<5.3*	1.3	*d*	*d*
Organic carbon, total	12/12	4.3	1.7	2.7*	0.21	*d*	*d*
Phenolics, total recoverable	0/12	<0.0010	<0.0010	<0.0010	0	*d*	*d*
Phosphorus, total	5/12	1.1	<0.10	<0.39*	0.094	*d*	*d*
Suspended solids, total	7/12	910	5.0	97	75	*d*	*d*
PCBs							
PCB, total	0/12	<0.0050	<0.0020	<0.0023*	0.00025	*d*	*d*

Table 4.53 (continued)

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Radionuclides							
^{137}Cs, pCi/L	3/12	68*	–35	12	9.5	*d*	*d*
^{3}H, pCi/L	12/12	890,000	220,000*	540,000*	61,000	0.12	0.33
^{60}Co, pCi/L	2/12	38*	–59	9.8	9.0	*d*	*d*
Total Sr, pCi/L	12/12	510*	210*	400*	28	0.21	0.73
Volatile organics							
Chloroform	1/12	<0.0050	J 0.0010	J 0.0047*	0.00033	0.0058	0.021
Trichloroethylene	1/12	<0.0050	J 0.0010	J 0.0047*	0.00033	0.11	0.41

[a]< = undetected; J = below detection limit,, but estimated. Mean concentrations significantly greater than zero are followed by an asterisk (*).

[b]Standard error of the mean.

[c]Calculated Clinch River concentration as a percentage of a drinking water limit (DWL) or 4% of the derived concentration guide, when a reference exists and the parameter is a contaminant.

[d]Not applicable.

Table 4.54. NPDES Permit Number TN 0002941, 1991
ORNL discharge point X14 (White Oak Creek)
Flow rates (1×10^6 L/d)—Max: 510, Min: 1.9, Av: 29
X14: Clinch River flow ratios—Max: 0.040, Min: 0.00039, Av: 0.0031

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Anions							
Fluoride, total	9/12	<1.0	0.10	<0.76*	0.075	0.054	0.11
Nitrate	9/12	<5.0	0.40	<1.4*	0.35	0.039	0.094
Sulfate, as SO_4	12/12	52	21	36*	3.2	0.044	0.094
Field measurements							
Chlorine, total residual	1/53	0.020	<0.010	<0.010*	0.00019	*d*	*d*
Conductivity, mS/cm	12/12	1.9	0.20	0.80*	0.19	*d*	*d*
Oxygen, dissolved	53/53	14	6.8	11*	0.23	*d*	*d*
Temperature, °C	65/65	27	8.0	17*	0.70	*d*	*d*
Turbidity, JTU	12/12	18	6.0	12*	1.1	*d*	*d*
pH, standard units	12/12	8.2	7.6	7.9*	0.048	*d*	*d*
Metals							
Aluminum, total	9/12	2.0	<0.050	<0.41*	0.19	0.77	3.7
Arsenic, total	0/12	<0.050	<0.050	<0.050	0	*d*	*d*
Cadmium, total	0/12	<0.0050	<0.0020	<0.0023*	0.00025	0.066	0.13
Chromium, total	8/12	0.012	<0.0040	<0.0060*	0.00073	0.040	0.10
Copper, total	1/12	0.0094	<0.0070	<0.0072*	0.00020	0.0023	0.0046
Iron, total	11/12	2.1	<0.050	<0.43*	0.18	0.54	2.6
Lead, total	2/12	0.0060	<0.0040	<0.0043*	0.00018	0.026	0.053
Manganese, total	12/12	0.17	0.0042	0.046*	0.013	0.34	1.2
Mercury, total	1/12	0.000080	<0.000050	<0.000053*	0.0000025	0.087	0.26
Nickel, total	3/12	0.0057	<0.0040	<0.0043*	0.00017	0.013	0.026
Silver, total	0/12	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Zinc, total	11/12	0.062	<0.0050	<0.027*	0.0050	0.0017	0.0043
Others							
Ammonia, as N	12/12	0.10	0.030	0.049*	0.0066	*d*	*d*
Biochemical oxygen demand	0/12	<5.0	<5.0	<5.0	0	*d*	*d*
Dissolved solids, total	12/12	240	150	180*	8.9	0.11	0.21
Oil and grease	10/53	35	<2.0	<3.6*	0.81	*d*	*d*
Organic carbon, total	12/12	2.8	1.4	1.8*	0.14	*d*	*d*
Phenolics, total recoverable	0/12	<0.0010	<0.0010	<0.0010	0	*d*	*d*
Phosphorus, total	9/12	0.50	0.10	0.28*	0.037	*d*	*d*
Suspended solids, total	5/12	97	<5.0	<17*	8.0	*d*	*d*
PCBs							
PCB, total	0/12	<0.0050	<0.0020	<0.0023*	0.00025	*d*	*d*

Table 4.54 (continued)

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Radionuclides							
^{137}Cs, pCi/L	10/12	350*	23*	100*	31	0.0084	0.036
^{3}H, pCi/L	12/12	97,000*	3,200*	45,000*	8,800	0.027	0.071
^{60}Co, pCi/L	0/12	49	–19	5.2	5.7	*d*	*d*
Total Sr, pCi/L	12/12	230*	49*	130*	19	0.21	0.64
Volatile Organics							
Chloroform	10/12	<0.0050	J 0.0010	J 0.0024*	0.00036	0.0071	0.018
Trichloroethylene	1/12	<0.0050	J 0.0010	J 0.0047*	0.00033	0.30	0.66

[a]< = undetected; J = below detection limit, but estimated. Mean concentrations significantly greater than zero are followed by an asterisk (*).

[b]Standard error of the mean.

[c]Calculated Clinch River concentration as a percentage of a drinking water limit (DWL) or 4% of the derived concentration guide, when a reference exists and the parameter is a contaminant.

[d]Not applicable.

Table 4.55. NPDES Permit Number TN 0002941, 1991
ORNL discharge point X15 (White Oak Dam)
Flow rates (1×10^6 L/d)—Max: 760, Min: 10, Av: 39
X15: Clinch River flow ratios—Max: 0.046, Min: 0.00055, Av: 0.0041

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Anions							
Fluoride, total	9/12	<1.0	0.20	<0.75*	0.074	0.069	0.16
Nitrate	4/12	<5.0	0.10	<1.1*	0.37	0.040	0.081
Sulfate, as SO_4	12/12	50	22	34*	3.2	0.053	0.098
Field measurements							
Chlorine, total residual	0/53	<0.010	<0.010	<0.010	0	*d*	*d*
Conductivity, mS/cm	12/12	1.8	0.20	0.81*	0.17	*d*	*d*
Oxygen, dissolved	53/53	15	6.8	10*	0.27	*d*	*d*
Temperature, °C	65/65	30	4.9	17*	0.94	*d*	*d*
Turbidity, JTU	12/12	120	6.0	30*	9.0	*d*	*d*
pH, standard units	12/12	8.4	7.5	7.8*	0.094	*d*	*d*
Metals							
Aluminum, total	12/12	3.5	0.25	1.2*	0.33	2.3	8.0
Arsenic, total	0/12	<0.010	<0.010	<0.010	0	*d*	*d*
Cadmium, total	0/12	<0.0020	<0.0020	<0.0020	0	*d*	*d*
Chromium, total	12/12	0.043	0.0094	0.019*	0.0031	0.14	0.27
Copper, total	5/12	0.012	<0.0070	<0.0078*	0.00042	0.0031	0.0058
Iron, total	12/12	3.7	0.33	1.4*	0.30	1.8	4.7
Lead, total	4/12	0.0060	0.0030	0.0041	0.00019	0.034	0.065
Manganese, total	12/12	0.28	0.037	0.16*	0.023	1.3	2.7
Mercury, total	4/12	0.00020	<0.000050	<0.000079*	0.000017	0.17	0.81
Nickel, total	5/12	0.0087	<0.0040	<0.0050*	0.00048	0.020	0.036
Silver, total	1/12	<0.0050	<0.0050	<0.0050	0	*d*	*d*
Zinc, total	11/12	0.056	<0.0050	<0.027*	0.0049	0.0021	0.0043
Others							
Ammonia, as N	12/12	0.19	0.040	0.090*	0.015	*d*	*d*
Biochemical oxygen demand	0/12	<5.0	<5.0	<5.0	0	*d*	*d*
Dissolved solids, total	12/12	260	140	190*	11	0.15	0.28
Oil and grease	32/53	180	<2.0	<12*	3.5	*d*	*d*
Organic carbon, total	12/12	12	1.6	3.9*	0.81	*d*	*d*
Phosphorus, total	7/12	5.1	<0.10	<0.71	0.40	*d*	*d*
Suspended solids, total	12/12	87	8.0	39*	7.6	*d*	*d*
PCBs							
PCB, total	0/12	<0.0050	<0.0020	<0.0023*	0.00025	*d*	*d*

Table 4.55 (continued)

Parameter	Number detected/ number of samples	Concentration (mg/L)				CR av as % DWL[c]	CR max as % DWL[c]
		Max[a]	Min[a]	Av[a]	Standard error[b]		
Radionuclides							
^{137}Cs, pCi/L	52/53	680*	4.6	120*	21	0.017	0.17
^{3}H, pCi/L	12/12	250,000*	54,000*	150,000*	20,000	0.12	0.34
^{60}Co, pCi/L	32/53	62*	-3.0	8.1*	1.6	0.0010	0.022
Gross alpha, pCi/L	53/53	140*	2.2*	11*	2.6	0.018	0.51
Gross beta, pCi/L	53/53	1,100*	73*	450*	25	0.14	0.63
Total Sr, pCi/L	12/12	270*	110*	190*	13	0.36	0.76
Volatile Organics							
Chloroform	0/12	<0.0050	<0	<0.0046*	0.00042	0.018	0.041
Trichloroethylene	0/12	<0.0050	<0	<0.0046*	0.00042	0.37	0.81

[a]< = undetected. Mean concentrations significantly greater than zero are followed by an asterisk (*).

[b]Standard error of the mean.

[c]Calculated Clinch River concentration as a percentage of a drinking water limit (DWL) or 4% of the derived concentration guide, when a reference exists and the parameter is a contaminant.

[d]Not applicable.

Table 4.56. 1991 surface water analyses at Gallaher

Parameter	Number detected/ number of samples	Concentration				Percentage of ref. value[c]
		Max	Min	Av[a]	Standard errorb	
Metals (mg/L)						
Uranium, total	4/4	0.0060	0.000080	0.0018	0.0014	*d*
Radionuclides, pCi/L[e]						
^{60}Co	1/4	1.3*	–1.9	–0.21	0.68	*d*
^{137}Cs	1/4	6.2	–0.27	2.8	1.3	*d*
Gross alpha	4/4	3.2*	0.84*	2.0*	0.49	13
Gross beta	4/4	11*	3.2*	6.6*	1.8	13
^{3}H	4/4	4,600*	1,000*	2,100*	850	10
^{238}Pu	1/4	0.035	–0.081	–0.0082	0.025	*d*
^{239}Pu	0/4	0.0062	–0.027	–0.0041	0.0077	*d*
$^{89}Sr + ^{90}Sr$	3/4	1.1*	0.27	0.78*	0.20	9.8
U,[f] total	4/4	4.0	0.053	1.2	0.93	*d*

[a]Mean concentrations significantly greater than zero are followed by an asterisk (*).
[b]Standard error of the mean.
[c]Mean concentration as a percentage of the National Primary Drinking Water Limit, or 4% of the DCG for ingestion of water (from DOE Order 5400.5), when a reference exists, mean concentration is significantly greater than zero.
[d]Not applicable.
[e]Multiply pCi/L by 0.037 to convert to Bq/L.
[f]Calculated activity, assuming natural abundance.

Table 4.57. 1991 surface water analyses at Kingston

Parameter	Number detected/ number of samples	Concentration				Percentage of ref. value[c]
		Max	Min	Av[a]	Standard error[b]	
Metals (mg/L)						
Uranium, total	4/4	0.00055	0.000040	0.00028*	0.00012	*d*
Radionuclides, pCi/L[e]						
^{60}Co	0/4	1.4	–0.11	0.57	0.30	*d*
^{137}Cs	0/4	0.81	–0.35	0.18	0.25	*d*
Gross alpha	2/4	1.5*	0.19	0.66	0.29	*d*
Gross beta	4/4	7.0*	2.6*	5.2*	0.92	10
^{3}H	2/4	3,000*	–54	890	700	*d*
^{238}Pu	0/4	–0.00076	–0.081	–0.022	0.020	*d*
^{239}Pu	0/4	0.00059	–0.054	–0.017	0.013	*d*
$^{89}Sr + ^{90}Sr$	3/4	0.89*	0.062	0.54*	0.20	6.7
U,[f] total	4/4	0.36	0.026	0.19*	0.077	*d*

[a]Mean concentrations significantly greater than zero are followed by an asterisk (*).
[b]Standard error of the mean.
[c]Mean concentration as a percentage of the National Primary Drinking Water Limit, or 4% of the DCG for ingestion of water (from DOE Order 5400.5), when a reference exists and mean concentration is significantly greater than zero.
[d]Not applicable.
[e]Multiply pCi/L by 0.037 to convert to Bq/L.
[f]Calculated activity, assuming natural abundance.

Table 4.58. Summary of collection and analysis frequencies of Gallaher and Kingston surface water samples, 1991

Station	Parameter	Collection frequency	Sample type	Analysis frequency
Gallaher	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr^{a}, ^{238}Pu, ^{239}Pu	Weekly	Time proportional	Quarterly
Kingston	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr^{a}, ^{238}Pu, ^{239}Pu	Weekly	Grab	Quarterly

[a]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).

Table 4.59. ORNL category I outfalls (storm drains), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Yearly	Instantaneous	Yearly
pH	Yearly	Grab	Yearly
Downstream pH	Yearly	Grab	Yearly
Temperature	Yearly	Grab	Yearly
Oil and grease	Yearly	Grab	Yearly
TSS	Yearly	Grab	Yearly
Gross beta	Yearly	Grab	Yearly

Table 4.60. ORNL category II outfalls (parking lot drains, storage area drains, once-through water, condensate), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Quarterly	Instantaneous	Quarterly
pH	Quarterly	Grab	Quarterly
Downstream pH	Quarterly	Grab	Quarterly
Temperature	Quarterly	Grab	Quarterly
Oil and grease	Quarterly	Grab	Quarterly
TSS	Quarterly	Grab	Quarterly
Gross beta	Quarterly	Grab	Quarterly

Table 4.61. ORNL category III outfalls (process and/or lab drains), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Quarterly	Instantaneous	Quarterly
pH	Quarterly	Instantaneous	Quarterly

Table 4.62. ORNL steam plant (SP2519), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Quarterly	*a*	Quarterly
Temperature	Quarterly	Grab	Quarterly
pH	Quarterly	Grab	Quarterly

[a]Not applicable.

Table 4.63. ORNL cooling systems (cooling tower blowdown), 1991

Parameter	Collection frequency	Type	Analysis frequency
Flow	Quarterly	*a*	Quarterly
pH	Quarterly	Grab	Quarterly
Downstream pH	Quarterly	Grab	Quarterly
Chromium, total	Quarterly	Grab	Quarterly
Zinc, total	Quarterly	Grab	Quarterly
Copper, total	Quarterly	Grab	Quarterly
Temperature	Quarterly	Grab	Quarterly
Residual chlorine	During addition	Grab	During addition

[a]Not applicable.

Table 4.64. NPDES Permit Number TN 0002941, 1991

ORNL discharge point SP2519 (Steam Plant)

Flow (L/d): Max 440; Min 170; Av 320

Parameter	Number of samples	Max	Min	Av	Standard error
pH, standard units	3	11	8.6	*a*	*a*
Temperature, °C	3	50	14	30	11

[a]Not applicable.

Table 4.65. NPDES Permit Number TN 0002941, 1991

Cooling systems at ORNL

Flow (L/d): Max 710,000; Min 3,800; Av 100,000

Parameter	Number of samples	Concentration (mg/L)[a]			
		Max	Min	Av	Standard error
Chlorine, total residual	53	0.20	<0.010	<0.059	0.0097
Chromium, total	56	2.5	<0.0040	<0.067	0.044
Copper, total	56	3.5	<0.0070	<0.16	0.065
Downstream pH, standard units	53	8.5	7.5	*b*	*b*
pH, standard units	53	9.0	7.2	*b*	*b*
Temperature, °C	53	38	13	26	0.71
Zinc, total	56	3.0	0.017	0.31	0.064

[a]< = undetected.
[b]Not applicable.

Table 4.66. NPDES Permit Number TN 0002941, 1991

Category I outfalls at ORNL

Flow (L/d): Max 330,000; Min 1,400; Av 58,000

Parameter	Number of samples	Concentration (mg/L)[a]			
		Max	Min	Av	Standard error
Downstream pH, standard units	21	8.2	7.0	*b*	*b*
Gross beta, pCi/L	21	54	1.6	14	2.9
Oil and grease	21	54	<2.0	<6.7	2.6
pH, standard units	21	8.5	7.0	*b*	*b*
Suspended solids, total	21	250	<5.0	<54	15
Temperature, °C	21	24	15	19	0.47

[a] < = undetected.
[a]Not applicable.

Table 4.67. NPDES Permit Number TN 0002941, 1991

Category II outfalls at ORNL

Flow (L/d): Max 760,000; Min 550; Av 96,000

Parameter	Number of samples	Concentration (mg/L)[a]			
		Max	Min	Av	Standard error
Downstream pH, standard units	189	8.7	7.0	*b*	*b*
Gross beta, pCi/L	206	5,700	–3	68	29
Oil and grease	209	110	<2.0	<5.3	0.70
pH, standard units	188	8.5	6.8	*b*	*b*
Suspended solids, total	206	1,500	<5.0	<32	8.2
Total Sr[c]	1	3.7	3.7	3.7	*b*
Temperature, °C	188	63	10	20	0.55

[a]< = undetected.
[b]Not applicable.
[c]Total radioactive Sr($^{89}Sr + ^{90}Sr$).

Table 4.68. NPDES Permit Number TN 0002941, 1991

Category III outfalls at ORNL

Flow (L): Max 1,600,000; Min 550; Av 130,000

Parameter	Number of samples	Max	Min	Av	Standard error
pH, standard units	59	9.2	7.3	*a*	*a*

[a]Not applicable.

Table 4.69. 1991 Toxicity test results of ORNL wastewaters and ambient waters

Outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)	In-stream waste concentration[b] (%)
Coal Yard Runoff Treatment Facility (X02)	April	100	6	0.0–4.0
Sewage Treatment Plant (X01)	Jan.	12	12	18.0
	March	NT[c]	<6	NC[d]
	June	100	25	18.0
	Aug.	100	100	21.3
	Aug.	100	25	21.3
	Sep.	100	50	14.0
Nonradiological wastewater treatment plant (X12)	June	100	100	NC[d]
	Dec.	NT[c]	<6	NC[d]
Melton Branch (X13)	Jan.	100	100	
	April	<100[e]	100	
	June	100	100	
	Aug.	<100	100	
	Sep.	100	100	
	Oct.	100	100	
	Dec.	<100[e]	100	
White Oak Creek (X14)	Jan.	100	100	
	April	100	100	
	June	100	100	
	Aug.	<100	100	
	Sep.	100	100	
	Oct.	100	100	
	Dec.	100	100	

[a]NOEC = no-observed-effect concentration.
[b]Based on critical low flow of White Oak Creek.
[c]Not tested.
[d]Not calculated.
[e]Based on survival.

Table 4.70. 1991 Average water quality parameters measured during toxicity tests of ORNL wastewaters and ambient waters

Values are averages of full-strength wastewater 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)	April	7.3	1693	15	1037
Sewage Treatment Plant (X01)	Jan.	7.9	441	110	156
	March	7.9	435	112	159
	June	7.8	401	99	152
	Aug.	7.7	351	98	135
	Aug.	7.8	360	98	145
	Sep.	7.6	351	102	150
Nonradiological wastewater treatment plant (X12)	June	7.7	616	85	127
	Dec.	7.6	679	86	193
Melton Branch (X13)	Jan.	8.1	341	131	172
	April	7.7	341	123	160
	June	7.7	469	117	231
	Aug.	7.8	392	96	193
	Sep.	7.7	429	91	212
	Oct.	7.8	513	98	259
	Dec.	8.0	303	92	157
White Oak Creek (X14)	Jan.	8.1	357	122	158
	April	7.8	313	110	133
	June	7.7	324	113	153
	Aug.	7.8	311	108	128
	Sep.	7.8	322	110	146
	Oct.	7.9	348	118	149
	Dec.	8.1	268	130	128

Table 4.71. Radionuclide concentrations in surface waters around the K-25 Site in 1991

Radionuclide	Number of samples[a]	Concentrations (pCi/L)[b]					Percentage of DCG[e]
		Max	Min	Av	Standard error[c]	DCG[d]	
		West Fork Poplar Creek (upstream of K-25 Site)					
Total U (mg/L)	4	0.001	0.001	0.001	*f*	*f*	*f*
^{237}Np	4	0.24	–0.417	–0.044	0.236	30	<0.001
^{238}Pu	4	0.12	–4.59	–1.12	2.01	40	<0.001
^{239}Pu	4	0.12	–1.67	–0.39	0.74	30	<0.001
^{137}Cs	4	23.1	–3.33	5.03	10.54	3,000	0.168
^{99}Tc	4	400	–299	–64.03	278.40	100,000	<0.001
Gross alpha	2	1.8	0.75	1.28	0.53	*f*	*f*
Gross beta	2	3.23	2.9	3.07	0.17	*f*	*f*
		K-1710 (Poplar Creek upstream of K-25 Site)					
Total U (mg/L)	12	0.012	0.001	0.003	0.003	*f*	*f*
^{237}Np	12	0.89	–0.811	0.086	0.373	30	0.286
^{238}Pu	12	0.41	–35.3	–3.28	9.758	40	<0.001
^{239}Pu	12	0.41	–1.62	–0.081	0.478	30	<0.001
^{137}Cs	12	53.5	–32.6	13.63	24.24	3,000	0.454
^{99}Tc	12	384	–469	–105	254	100,000	<0.001
Gross alpha	7	6.05	0.012	3.18	1.99	*f*	*f*
Gross beta	7	11.7	2.71	7.99	3.37	*f*	*f*
		K-716 (Poplar Creek downstream of K-25 Site)					
Total U (mg/L)	12	0.008	0.001	0.003	0.002	*f*	*f*
^{237}Np	12	11.6	–0.821	1.011	3.22	30	3.37
^{238}Pu	12	0.80	–17.4	–1.79	4.91	40	<0.001
^{239}Pu	12	5.79	–1.64	–0.343	1.704	30	<0.001
^{137}Cs	12	32.7	–12.4	6.04	11.15	3,000	0.201
^{99}Tc	12	407	–474	40.24	267.43	100,000	0.040
Gross alpha	7	33.4	1.68	7.72	10.58	*f*	*f*
Gross beta	7	24	2.07	9.22	6.79	*f*	*f*
		K-1513 (Clinch River upstream of K-25 Site)					
Total U (mg/L)	12	0.001	0.001	0.001	*f*	*f*	*f*
^{237}Np	12	10.4	–0.220	0.900	2.868	30	3.000
^{238}Pu	12	0.72	–5.23	–0.392	1.473	40	<0.001
^{239}Pu	12	5.19	–1.74	0.318	1.553	30	1.060
^{137}Cs	12	799	–22.4	69.468	220.988	3,000	2.316
^{99}Tc	12	492,407	–646	–45.675	304.512	100,000	–0.046
Gross alpha	7	8.45	–1.19	1.383	3.016	*f*	*f*
Gross beta	7	8.88	1.15	4.889	2.769	*f*	*f*
		K-1770 (Clinch River downstream of K-25 Site)					
Total U (mg/L)	12	0.001	0.001	0.001	0.002	*f*	*f*
^{237}Np	12	0.47	–0.843	–0.0378	0.278	30	<0.001
^{238}Pu	12	0.26	–10.2	–1.23	2.989	40	<0.001
^{239}Pu	12	0.63	–1.67	–0.026	10.548	30	<0.001
^{137}Cs	12	75	–37.5	7.63	29.24	3,000	0.254
^{99}Tc	12	287	–696	–258.16	328.68	100,000	<0.001
Gross alpha	7	3.45	–1.2	0.416	1.521	*f*	*f*
Gross beta	7	7.62	–3.97	0.563	3.96	*f*	*f*

Table 4.71 (continued)

Radionuclide	Number of samples[a]	Concentrations (pCi/L)[b]					Percentage of DCG[e]
		Max	Min	Av	Standard error[c]	DCG[d]	
		Clinch River at Brashear Island (downstream of K-25 Site)					
Total U (mg/L)	4	0.001	0.001	0.001	*f*	*f*	*f*
^{237}Np	4	0	–0.811	–0.227	–0.227	30	<0.001
^{238}Pu	4	0.15	–4.46	–1.05	1.971	40	<0.001
^{239}Pu	4	0.15	–1.62	–0.343	0.739	30	<0.001
^{137}Cs	4	18.3	–21.6	0.037	14.214	3,000	0.001
^{99}Tc	4	268	–294	–64.78	240.635	100,000	<0.001
Gross alpha	2	1.82	0.87	1.345	0.475	*f*	*f*
Gross beta	2	5.06	4.13	4.595	0.465	*f*	*f*
		Mitchell Branch (within facility)					
Total U (mg/L)	4	0.001	0.001	0.001	*f*	*f*	*f*
^{237}Np	4	0.140	0.000	0.070	*f*	30	<0.001
^{238}Pu	4	1.010	0.000	0.505	0.505	40	1.263
^{239}Pu	4	0.000	0.000	0.000	0.739	30	<0.001
^{137}Cs	4	36.3	0.920	18.298	16.971	3,000	0.610
^{99}Tc	4	139	–397	–129	268	100,000	<0.001
Gross alpha	4	2.52	–0.79	0.638	1.305	*f*	*f*
Gross beta	4	3.14	0.340	1.293	1.139	*f*	*f*

[a]Grab samples were taken quarterly at West Fork Poplar Creek, the Clinch River, and Mitchell Branch. At the other locations a 24-hour composite sample was taken monthly.

[b]Multiply pCi/L by 0.037 to convert to Bq/L.

[c]Standard deviation of the mean.

[d]Derived concentration guide (DCG) for ingestion of water (from DOE Order 5400.5).

[e]Mean concentration as a percentage of the DCG.

[f]Not applicable.

Table 4.72. 1991 K-25 Site concentrations at West Fork Poplar Creek

Parameter	Concentration			
	Max	Min	Av	Standard deviation
1,1,1-Trichloroethane, µg/L	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethene, µg/L	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichloroethane, µg/L	<5	<5	<5	0
1,2-Dichloropropane, µg/L	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	<10	<10	<10	0
1,4-Dichlorobenzene, µg/L	<10	<10	<10	0
2,4,6-Trichlorophenol, µg/L	<10	<10	<10	0
2,4-Dichlorophenol, µg/L	<10	<10	<10	0
2,4-Dimethylphenol, µg/L	<10	<10	<10	0
2,4-Dinitrophenol, µg/L	<10	<10	<10	0
2,4-Dinitrotoluene, µg/L	<10	<10	<10	0
2,6-Dinitrotoluene, µg/L	<10	<10	<10	0
2-Chloroethylvinyl ether, µg/L	<10	<10	<10	0
2-Chloronaphthalene, µg/L	<10	<10	<10	0
2-Chlorophenol, µg/L	<10	<10	<10	0
2-Nitrophenol, µg/L	<10	<10	<10	0
3,3-Dichlorobenzidine, µg/L	<20	<20	<20	0
4,6-Dinitro-2-methylphenol, µg/L	<50	<50	<50	0
4-Bromophenyl-phenylether, µg/L	<10	<10	<10	0
4-Chloro-3-methylphenol, µg/L	<10	<10	<10	0
4-Chlorophenyl-phenylether, µg/L	<10	<10	<10	0
4-Nitrophenol, µg/L	<50	<50	<50	0
Acenaphthene, µg/L	<10	<10	<10	0
Acenaphthylene, µg/L	<10	<10	<10	0
Ammonia nitrogen, mg/L	<200	<200	<200	0
Anthracene, µg/L	<10	<10	<10	0
Arsenic, µg/L	<5	<5	<5	0
Benzene, µg/L	<5	<5	<5	0
Benzidine, µg/L	<10	<10	<10	0
Benzo(a)anthracene, µg/L	<10	<10	<10	0
Benzo(a)pyrene, µg/L	<10	<10	<10	0
Benzo(b)fluoranthene, µg/L	<10	<10	<10	0
Benzo(g,h,i)perylene, µg/L	<10	<10	<10	0
Benzo(k)fluoranthene, µg/L	<10	<10	<10	0
bis(2-Chloroethoxy)methane, µg/L	<10	<10	<10	0
bis(2-Chloroethyl)ether, µg/L	<10	<10	<10	0
bis(2-Chloroisopropyl)ether, µg/L	<10	<10	<10	0
bis(2-Ethylhexyl)phthalate, µg/L	<10	<10	<10	0
Bromodichloromethane, µg/L	<5	<5	<5	0
Bromoform, µg/L	<5	<5	<5	0
Bromomethane, µg/L	<10	<10	<10	0
Butylbenzylphthalate, µg/L	<10	<10	<10	0
Cadmium, mg/L	<2	<2	<2	0
Carbon tetrachloride, µg/L	<5	<5	<5	0
Chemical oxygen demand (COD), mg/L	21,000	7,000	13,000	5,571
Chlorobenzene, µg/L	<5	<5	<5	0
Chloroethane, µg/L	<10	<10	<10	0

Table 4.72 (continued)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
Chloroform, µg/L	<5	<5	<5	0
Chloromethane, µg/L	<10	<10	<10	0
Chromium, mg/L	<10	<10	<10	0
Chrysene, µg/L	<10	<10	<10	0
cis-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Copper, mg/L	8.6	8.6	8.6	0.0
Cyanide colorimetric, mg/L	<100	<100	<100	0
Di-n-butylphthalate, µg/L	<10	<10	<10	0
Di-n-octylphthalate, µg/L	<10	<10	<10	0
Dibenz(a,h)anthracene, µg/L	<10	<10	<10	0
Dibromochloromethane, µg/L	<5	<5	<5	0
Diethylphthalate, µg/L	<10	<10	<10	0
Dimethylphthalate, µg/L	<10	<10	<10	0
Dissolved solids, mg/L	214,000	80,000	155,500	49,406
Ethylbenzene, µg/L	<5	<5	<5	0
Fluoranthane, µg/L	<10	<10	<10	0
Fluorene, µg/L	<10	<10	<10	0
Flouride, mg/L	IC	100	100	0
Hexachlorobenzene, µg/L	<10	<10	<10	0
Hexachlorobutadiene, µg/L	<10	<10	<10	0
Hexachlorocyclopentadiene, µg/L	<10	<10	<10	0
Hexachloroethane, µg/L	<10	<10	<10	0
Ideno(1,2,3-cd)pyrene, µg/L	<10	<10	<10	0
Isophorone, µg/L	<10	<10	<10	0
Lead, mg/L	8.1	8.1	8.1	0.0
Manganese, mg/L	300.0	89.3	162.3	91.4
Mercury, µg/L	<0.2	<0.2	<0.2	0.0
Methylene chloride, µg/L	<5	<5	<5	0
N-nitroso-di-n-propylamine, µg/L	<10	<10	<10	0
N-nitrpsodimethylamine, µg/L	<10	<10	<10	0
N-nitrodiphenylamine, µg/L	<10	<10	<10	0
Naphthalene, µg/L	<10	<10	<10	0
Nickel, mg/L	<10	<10	<10	0
Nitrate nitrogen, mg/L	390	200	313	82
Nitrobenzene, µg/L	<10	<10	<10	0
Pentachlorophenol, µg/L	<50	<50	<50	0
pH, standard units	7.95	7.60	7.79	0.13
Phenanthrene, µg/L	<10	<10	<10	0
Phenol, µg/L	<10	<10	<10	0
Pyrene, µg/L	<10	<10	<10	0
Sodium, mg/L	6,100	2,000	4,330	1,677
Sulfate, mg/L	51,000	27,000	38,000	7,720
Suspended solids, mg/L	28000	8000	18000	0
Tetrachloroethene, µg/L	<5	<5	<5	0
Toluene, µg/L	<5	<5	<5	0
trans-1,2-Dichloroethene, µg/L	<5	<5	<5	0
trans-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Trichloroethene, µg/L	<5	<5	<5	0
Trichlorofluoromethane, µg/L				0
Uranium fluorometric, µg/L	<1	<1	<1	0
Vinyl chloride, µg/L	<10	<10	<10	0
Zinc, mg/L	12	6.5	8.8	2.3

Table 4.73. 1991 K-25 Site concentrations at Clinch River (Brashear Island)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
1,1,1-Trichloroethane, µg/L	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethene, µg/L	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichloroethane, µg/L	<5	<5	<5	0
1,2-Dichloropropane, µg/L	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	<10	<10	<10	0
1,4-Dichlorobenzene, µg/L	<10	<10	<10	0
2,4,6-Trichlorophenol, µg/L	<10	<10	<10	0
2,4-Dichlorophenol, µg/L	<10	<10	<10	0
2,4-Dimethylphenol, µg/L	<10	<10	<10	0
2,4-Dinitrophenol, µg/L	<10	<10	<10	0
2,4-Dinitrotoluene, µg/L	<10	<10	<10	0
2,6-Dinitrotoluene, µg/L	<10	<10	<10	0
2-Chloroethylvinyl ether, µg/L	<10	<10	<10	0
2-Chloronaphthalene, µg/L	<10	<10	<10	0
2-Chlorophenol, µg/L	<10	<10	<10	0
2-Nitrophenol, µg/L	<10	<10	<10	0
3,3-Dichlorobenzidine, µg/L	<20	<20	<20	0
4,6-Dinitro-2-methylphenol, µg/L	<50	<50	<50	0
4-Bromophenyl-phenylether, µg/L	<10	<10	<10	0
4-Chloro-3-methylphenol, µg/L	<10	<10	<10	0
4-Chlorophenyl-phenylether, µg/L	<10	<10	<10	0
4-Nitrophenol, µg/L	<50	<50	<50	0
Acenaphthene, µg/L	<10	<10	<10	0
Acenaphthylene, µg/L	<10	<10	<10	0
Ammonia nitrogen, mg/L	<200	<200	<200	0
Anthracene, µg/L	<10	<10	<10	0
Arsenic, mg/L	<5	<5	<5	0
Benzene, µg/L	<5	<5	<5	0
Benzidine, µg/L	<10	<10	<10	0
Benzo(a)anthracene, µg/L	<10	<10	<10	0
Benzo(a)pyrene, µg/L	<10	<10	<10	0
Benzo(b)fluoranthene, µg/L	<10	<10	<10	0
Benzo(g,h,i)perylene, µg/L	<10	<10	<10	0
Benzo(k)fluoranthene, µg/L	<10	<10	<10	0
bis(2-Chloroethoxy)methane, µg/L	<10	<10	<10	0
bis(2-Chloroethyl)ether, µg/L	<10	<10	<10	0
bis(2-Chloroisopropyl)ether, µg/L	<10	<10	<10	0
bis(2-Ethylhexyl)phthalate, µg/L	<10	<10	<10	0
Bromodichloromethane, µg/L	<5	<5	<5	0
Bromoform, µg/L	<5	<5	<5	0
Bromomethane, µg/L	<10	<10	<10	0
Butylbenzylphthalate, µg/L	<10	<10	<10	0
Cadmium, mg/L	<2	<2	<2	0
Carbon tetrachloride, µg/L	<5	<5	<5	0
Chemical oxygen demand (COD), µg/L	16,000	15,000	15,500	500
Chlorobenzene, µg/L	<5	<5	<5	0
Chloroethane, µg/L	<10	<10	<10	0

Table 4.73 (continued)

Parameter	Concentration			Standard deviation
	Max	Min	Av	
Chloroform, µg/L	<5	<5	<5	0
Chloromethane, µg/L	<10	<10	<10	0
Chromium, mg/L	<10	<10	<10	0
Chrysene, µg/L	<10	<10	<10	0
cis-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Copper, mg/L	<4.0	<4.0	<4.0	0
Cyanide colorimetric, mg/L	<100	<100	<100	0
Di-n-butylphthalate, µg/L	<10	<10	<10	0
Di-n-octylphthalate, µg/L	<10	<10	<10	0
Dibenz(a,h)anthracene, µg/L	<10	<10	<10	0
Dibromochloromethane, µg/L	<5	<5	<5	0
Diethylphthalate, µg/L	<10	<10	<10	0
Dimethylphthalate, µg/L	<10	<10	<10	0
Dissolved solids, mg/L	158,000	134,000	142,000	9,381
Ethylbenzene, µg/L	<5	<5	<5	0
Fluoranthane, µg/L	<10	<10	<10	0
Fluorene, µg/L	<10	<10	<10	0
Flouride IC, mg/L	<100	<100	<100	0
Hexachlorobenzene, µg/L	<10	<10	<10	0
Hexachlorobutadiene, µg/L	<10	<10	<10	0
Hexachlorocyclopentadiene, µg/L	<10	<10	<10	0
Hexachloroethane, µg/L	<10	<10	<10	0
Ideno(1,2,3-cd)pyrene, µg/L	<10	<10	<10	0
Isophorone, µg/L	<10	<10	<10	0
Lead, mg/L	<4	<4	<4	0
Manganese, mg/L	150	30.6	74.4	45.4
Mercury, mg/L	<0.2	<0.2	<0.2	0.0
Methylene chloride, µg/L	<5	<5	<5	0
N-nitroso-di-n-propylamine, µg/L	<10	<10	<10	0
N-nitrpsodimethylamine, µg/L	<10	<10	<10	0
N-nitrodiphenylamine, µg/L	<10	<10	<10	0
Naphthalene, µg/L	<10	<10	<10	0
Nickel, mg/L	<10	<10	<10	0
Nitrate nitrogen, mg/L	480	180	320	123
Nitrobenzene, µg/L	<10	<10	<10	0
Pentachlorophenol, µg/L	<50	<50	<50	0
pH, standard units	8.50	7.75	8.24	0.31
Phenanthrene, µg/L	<10	<10	<10	0
Phenol, µg/L	<10	<10	<10	0
Pyrene, µg/L	<10	<10	<10	0
Sodium, mg/L	4,600	3,240	4,035	525
Sulfate, mg/L	21,000	18,000	19,250	0
Suspended solids, mg/L	76,000	8,000	26,500	1,090
Tetrachloroethene, µg/L	<5	<5	<5	28,684
Toluene, µg/L	<5	<5	<5	0
trans-1,2-Dichloroethene, µg/L	<5	<5	<5	0
trans-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Trichloroethene, µg/L	<5	<5	<5	0
Trichlorofluoromethane				0
Uranium fluorometric, µg/L	1	1	1	0
Vinyl chloride, µg/L	<10	<10	<10	0
Zinc, mg/L	22.00	3.44	10.16	7.11

Table 4.74. 1991 K-25 Site concentrations at K-716 (Poplar Creek)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
1,1,1-Trichloroethane, µg/L	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethene, µg/L	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichloroethane, µg/L	<5	<5	<5	0
1,2-Dichloropropane, µg/L	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	<10	<10	<10	0
1,4-Dichlorobenzene, µg/L	<10	<10	<10	0
2,4,6-Trichlorophenol, µg/L	<10	<10	<10	0
2,4-Dichlorophenol, µg/L	<10	<10	<10	0
2,4-Dimethylphenol, µg/L	<10	<10	<10	0
2,4-Dinitrophenol, µg/L	<50	<50	<50	0
2,4-Dinitrotoluene, µg/L	<10	<10	<10	0
2,6-Dinitrotoluene, µg/L	<10	<10	<10	0
2-Chloroethylvinyl ether, µg/L	<10	<10	<10	0
2-Chloronaphthalene, µg/L	<10	<10	<10	0
2-Chlorophenol, µg/L	<10	<10	<10	0
2-Nitrophenol, µg/L	<10	<10	<10	0
3,3-Dichlorobenzidine, µg/L	<20	<20	<20	0
4,6-Dinitro-2-methylphenol, µg/L	<50	<50	<50	0
4-Bromophenyl-phenylether, µg/L	<10	<10	<10	0
4-Chloro-3-methylphenol, µg/L	<10	<10	<10	0
4-Chlorophenyl-phenylether, µg/L	<10	<10	<10	0
4-Nitrophenol, µg/L	<50	<50	<50	0
Acenaphthene, µg/L	<10	<10	<10	0
Acenaphthylene, µg/L	<10	<10	<10	0
Ammonia nitrogen, mg/L	<200	<200	<200	0
Anthracene, µg/L	<10	<10	<10	0
Arsenic, mg/L	<5	<5	<5	0
Benzene, µg/L	<5	<5	<5	0
Benzidine, µg/L	<50	<50	<50	0
Benzo(a)anthracene, µg/L	<10	<10	<10	0
Benzo(a)pyrene, µg/L	<10	<10	<10	0
Benzo(b)fluoranthene, µg/L	<10	<10	<10	0
Benzo(g,h,i)perylene, µg/L	<10	<10	<10	0
Benzo(k)fluoranthene, µg/L	<10	<10	<10	0
bis(2-Chloroethoxy)methane, µg/L	<10	<10	<10	0
bis(2-Chloroethyl)ether, µg/L	<10	<10	<10	0
bis(2-Chloroisopropyl)ether, µg/L	<10	<10	<10	0
bis(2-Ethylhexyl)phthalate, µg/L	<10	<10	<10	0
Bromodichloromethane, µg/L	<5	<5	<5	0
Bromoform, µg/L	<5	<5	<5	0
Bromomethane, µg/L	<10	<10	<10	0
Butylbenzylphthalate, µg/L	<10	<10	<10	0
Cadmium, µg/L	<2	<2	<2	0
Carbon tetrachloride, µg/L	<5	<5	<5	0
Chemical oxygen demand (COD), mg/L	41,000	7,000	20,250	11,214
Chlorobenzene, µg/L	<5	<5	<5	0
Chloroethane, µg/L	<10	<10	<10	0

Table 4.74 (continued)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
Chloroform, µg/L	<5	<5	<5	0
Chloromethane, µg/L	<10	<10	<10	0
Chromium, mg/L	13	13	13	0
Chrysene, µg/L	<10	<10	<10	0
cis-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Copper, mg/L	14.00	4.60	8.37	3.01
Cyanide colorimetric, mg/L	<100	<100	<100	0
Di-n-butylphthalate, µg/L	<10	<10	<10	0
Di-n-octylphthalate, µg/L	<10	<10	<10	0
Dibenz(a,h)anthracene, µg/L	<10	<10	<10	0
Dibromochloromethane, µg/L	<5	<5	<5	0
Diethylphthalate, µg/L	<10	<10	<10	0
Dimethylphthalate, µg/L	<10	<10	<10	0
Dissolved solids, mg/L	180,000	82,000	138,333	29,715
Ethylbenzene, µg/L	<5	<5	<5	0
Fluoranthane, µg/L	<10	<10	<10	0
Fluorene, µg/L	<10	<10	<10	0
Flouride IC, mg/L	200	100	178	39
Hexachlorobenzene, µg/L	<10	<10	<10	0
Hexachlorobutadiene, µg/L	<10	<10	<10	0
Hexachlorocyclopentadiene, µg/L	<10	<10	<10	0
Hexachloroethane, µg/L	<10	<10	<10	0
Ideno(1,2,3-cd)pyrene, µg/L	<10	<10	<10	0
Isophorone, µg/L	<10	<10	<10	0
Lead, mg/L	14.0	4.6	7.8	3.2
Manganese, mg/L	500.0	84.1	208.8	146.4
Mercury, mg/L	3.60	0.23	1.10	1.07
Methylene chloride, µg/L	<5	<5	<5	0
N-nitroso-di-n-propylamine, µg/L	<10	<10	<10	0
N-nitrpsodimethylamine, µg/L	<10	<10	<10	0
N-nitrodiphenylamine, µg/L	<10	<10	<10	0
Naphthalene, µg/L	<10	<10	<10	0
Nickel, mg/L	17	12	15	3
Nitrate nitrogen, mg/L	700	110	476	146
Nitrobenzene, µg/L	<10	<10	<10	0
Pentachlorophenol, µg/L	<50	<50	<50	0
pH, standard units	8.70	7.25	7.90	0.44
Phenanthrene, µg/L	<10	<10	<10	0
Phenol, µg/L	<10	<10	<10	0
Pyrene, µg/L	<10	<10	<10	0
Sodium, mg/L	6,300	2,800	4,218	1,165
Sulfate, mg/L	33,000	19,000	24,667	5,019
Suspended solids, mg/L	243,000	9,000	91,750	81,618
Tetrachloroethene, µg/L	<5	<5	<5	0
Toluene, µg/L	<5	<5	<5	0
trans-1,2-Dichloroethene, µg/L	<5	<5	<5	0
trans-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Trichloroethene, µg/L	<5	<5	<5	0
Trichlorofluoromethane, µg/L	<5	<5	<5	0
Uranium fluorometric, µg/L	8	1	3	0
Vinyl chloride, µg/L	10	8	9	0
Zinc, mg/L	60.0	15.3	26.6	13.0

Table 4.75. 1991 K-25 Site concentrations at K-1513 (Clinch River)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
1,1,1-Trichloroethane, µg/L	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethene, µg/L	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichloroethane, µg/L	<5	<5	<5	0
1,2-Dichloropropane, µg/L	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	<10	<10	<10	0
1,4-Dichlorobenzene, µg/L	<10	<10	<10	0
2,4,6-Trichlorophenol, µg/L	<10	<10	<10	0
2,4-Dichlorophenol, µg/L	<10	<10	<10	0
2,4-Dimethylphenol, µg/L	<10	<10	<10	0
2,4-Dinitrophenol, µg/L	<50	<50	<50	0
2,4-Dinitrotoluene, µg/L	<10	<10	<10	0
2,6-Dinitrotoluene, µg/L	<10	<10	<10	0
2-Chloroethylvinyl ether, µg/L	<10	<10	<10	0
2-Chloronaphthalene, µg/L	<10	<10	<10	0
2-Chlorophenol, µg/L	<10	<10	<10	0
2-Nitrophenol, µg/L	<10	<10	<10	0
3,3-Dichlorobenzidine, µg/L	<20	<20	<20	0
4,6-Dinitro-2-methylphenol, µg/L	<50	<50	<50	0
4-Bromophenyl-phenylether, µg/L	<10	<10	<10	0
4-Chloro-3-methylphenol, µg/L	<10	<10	<10	0
4-Chlorophenyl-phenylether, µg/L	<10	<10	<10	0
4-Nitrophenol, µg/L	<50	<50	<50	0
Acenaphthene, µg/L	<10	<10	<10	0
Acenaphthylene, µg/L	<10	<10	<10	0
Ammonia nitrogen, mg/L	<200	<200	<200	0
Anthracene, µg/L	<10	<10	<10	0
Arsenic, mg/L	<5	<5	<5	0
Benzene, µg/L	<5	<5	<5	0
Benzidine, µg/L	<50	<50	<50	0
Benzo(a)anthracene, µg/L	<10	<10	<10	0
Benzo(a)pyrene, µg/L	<10	<10	<10	0
Benzo(b)fluoranthene, µg/L	<10	<10	<10	0
Benzo(g,h,i)perylene, µg/L	<10	<10	<10	0
Benzo(k)fluoranthene, µg/L	<10	<10	<10	0
bis(2-Chloroethoxy)methane, µg/L	<10	<10	<10	0
bis(2-Chloroethyl)ether, µg/L	<10	<10	<10	0
bis(2-Chloroisopropyl)ether, µg/L	<10	<10	<10	0
bis(2-Ethylhexyl)phthalate, µg/L	<10	<10	<10	0
Bromodichloromethane, µg/L	<5	<5	<5	0
Bromoform, µg/L	<5	<5	<5	0
Bromomethane, µg/L	<10	<10	<10	0
Butylbenzylphthalate, µg/L	<10	<10	<10	0
Cadmium, mg/L	<2	<2	<2	0
Carbon tetrachloride, µg/L	<5	<5	<5	0
Chemical oxygen demand (COD), mg/L	11,000	7,000	8,200	1,600
Chlorobenzene, µg/L	<5	<5	<5	0
Chloroethane, µg/L	<10	<10	<10	0

Table 4.75 (continued)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
Chloroform, µg/L	<5	<5	<5	0
Chloromethane, µg/L	<10	<10	<10	0
Chromium, mg/L	<10	<10	<10	0
Chrysene, µg/L	<10	<10	<10	0
cis-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Copper, mg/L	<4	<4	<4	0
Cyanide colorimetric, mg/L	236	236	236	0
Di-n-butylphthalate, µg/L	<10	<10	<10	0
Di-n-octylphthalate, µg/L	<10	<10	<10	0
Dibenz(a,h)anthracene, µg/L	<10	<10	<10	0
Dibromochloromethane, µg/L	<5	<5	<5	0
Diethylphthalate, µg/L	<10	<10	<10	0
Dimethylphthalate, µg/L	<10	<10	<10	0
Dissolved solids, mg/L	166,000	78,000	142,666	23,028
Ethylbenzene, µg/L	<5	<5	<5	0
Fluoranthane, µg/L	<10	<10	<10	0
Fluorene, µg/L	<10	<10	<10	0
Flouride IC, mg/L	200	200	200	0
Hexachlorobenzene, µg/L	<10	<10	<10	0
Hexachlorobutadiene, µg/L	<10	<10	<10	0
Hexachlorocyclopentadiene, µg/L	<10	<10	<10	0
Hexachloroethane, µg/L	<10	<10	<10	0
Ideno(1,2,3-cd)pyrene, µg/L	<10	<10	<10	0
Isophorone, µg/L	<10	<10	<10	0
Lead, mg/L	8.6	8.6	8.6	0.0
Manganese, mg/L	54	21	38	11
Mercury, mg/L	<0.2	<0.2	<0.2	0.0
Methylene chloride, µg/L	<5	<5	<5	0
N-nitroso-di-n-propylamine, µg/L	<10	<10	<10	0
N-nitrpsodimethylamine, µg/L	<10	<10	<10	0
N-nitrodiphenylamine, µg/L	<10	<10	<10	0
Naphthalene, µg/L	<10	<10	<10	0
Nickel, mg/L	130	130	130	0
Nitrate nitrogen, mg/L	720	140	421	175
Nitrobenzene, µg/L	<10	<10	<10	0
Pentachlorophenol, µg/L	<50	<50	<50	0
pH, standard units	8.60	7.50	8.03	0.33
Phenanthrene, µg/L	<10	<10	<10	0
Phenol, µg/L	<10	<10	<10	0
Pyrene, µg/L	<10	<10	<10	0
Sodium, mg/L	5,600	3,210	4,209	804
Sulfate, mg/L	28,000	16,500	20,792	3,652
Suspended solids, mg/L	22,000	4,000	9,167	5,359
Tetrachloroethene, µg/L	<5	<5	<5	0
Toluene, µg/L	<5	<5	<5	0
trans-1,2-Dichloroethene, µg/L	<5	<5	<5	0
trans-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Trichloroethene, µg/L	<5	<5	<5	0
Trichlorofluoromethane, µg/L	<5	<5	<5	0
Uranium fluorometric, µg/L	<1	<1	<1	0
Vinyl chloride, µg/L	<10	<10	<10	0
Zinc, mg/L	74.0	4.6	18.8	22.9

Table 4.76. 1991 K-25 Site concentrations at K-1710 (Poplar Creek)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
1,1,1-Trichloroethane, µg/L	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethene, µg/L	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichloroethane, µg/L	<5	<5	<5	0
1,2-Dichloropropane, µg/L	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	<10	<10	<10	0
1,4-Dichlorobenzene, µg/L	<10	<10	<10	0
2,4,6-Trichlorophenol, µg/L	<10	<10	<10	0
2,4-Dichlorophenol, µg/L	<10	<10	<10	0
2,4-Dimethylphenol, µg/L	<10	<10	<10	0
2,4-Dinitrophenol, µg/L	<50	<50	<50	0
2,4-Dinitrotoluene, µg/L	<10	<10	<10	0
2,6-Dinitrotoluene, µg/L	<10	<10	<10	0
2-Chloroethylvinyl ether, µg/L	<10	<10	<10	0
2-Chloronaphthalene, µg/L	<10	<10	<10	0
2-Chlorophenol, µg/L	<10	<10	<10	0
2-Nitrophenol, µg/L	<10	<10	<10	0
3,3-Dichlorobenzidine, µg/L	<20	<20	<20	0
4,6-Dinitro-2-methylphenol, µg/L	<50	<50	<50	0
4-Bromophenyl-phenylether, µg/L	<10	<10	<10	0
4-Chloro-3-methylphenol, µg/L	<10	<10	<10	0
4-Chlorophenyl-phenylether, µg/L	<10	<10	<10	0
4-Nitrophenol, µg/L	<50	<50	<50	0
Acenaphthene, µg/L	<10	<10	<10	0
Acenaphthylene, µg/L	<10	<10	<10	0
Ammonia nitrogen, mg/L	250	250	250	0
Anthracene, µg/L	<10	<10	<10	0
Arsenic, µg/L	7.2	7.2	7.2	0.0
Benzene, µg/L	<5	<5	<5	0
Benzidine, µg/L	<50	<50	<50	0
Benzo(a)anthracene, µg/L	<10	<10	<10	0
Benzo(a)pyrene, µg/L	<10	<10	<10	0
Benzo(b)fluoranthene, µg/L	<10	<10	<10	0
Benzo(g,h,i)perylene, µg/L	<10	<10	<10	0
Benzo(k)fluoranthene, µg/L	<10	<10	<10	0
bis(2-Chloroethoxy)methane, µg/L	<10	<10	<10	0
bis(2-Chloroethyl)ether, µg/L	<10	<10	<10	0
bis(2-Chloroisopropyl)ether, µg/L	<10	<10	<10	0
bis(2-Ethylhexyl)phthalate, µg/L	<10	<10	<10	0
Bromodichloromethane, µg/L	<5	<5	<5	0
Bromoform, µg/L	<5	<5	<5	0
Bromomethane, µg/L	<10	<10	<10	0
Butylbenzylphthalate, µg/L	<10	<10	<10	0
Cadmium, mg/L	2.4	2.4	2.4	0.0
Carbon tetrachloride, µg/L	<5	<5	<5	0
Chemical oxygen demand (COD), mg/L	23,000	7,000	14,071	5,571
Chlorobenzene, µg/L	<5	<5	<5	0
Chloroethane, µg/L	<10	<10	<10	0

Table 4.76 (continued)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
Chloroform, µg/L	<5	<5	<5	0
Chloromethane, µg/L	<10	<10	<10	0
Chromium, mg/L	12	12	12	0
Chrysene, µg/L	<10	<10	<10	0
cis-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Copper, mg/L	29.00	4.40	9.68	8.18
Cyanide colorimetric, mg/L	<100	<100	<100	0
Di-n-butylphthalate, µg/L	<10	<10	<10	0
Di-n-octylphthalate, µg/L	<10	<10	<10	0
Dibenz(a,h)anthracene, µg/L	<10	<10	<10	0
Dibromochloromethane, µg/L	<5	<5	<5	0
Diethylphthalate, µg/L	<10	<10	<10	0
Dimethylphthalate, µg/L	<10	<10	<10	0
Dissolved solids, mg/L	244,000	70,000	151,666	61,538
Ethylbenzene, µg/L	<5	<5	<5	0
Fluoranthane, µg/L	<10	<10	<10	0
Fluorene, µg/L	<10	<10	<10	0
Flouride IC, mg/L	400	200	310	90
Hexachlorobenzene, µg/L	<10	<10	<10	0
Hexachlorobutadiene, µg/L	<10	<10	<10	0
Hexachlorocyclopentadiene, µg/L	<10	<10	<10	0
Hexachloroethane, µg/L	<10	<10	<10	0
Ideno(1,2,3-cd)pyrene, µg/L	<10	<10	<10	0
Isophorone, µg/L	<10	<10	<10	0
Lead, mg/L	49.0	4.1	16.6	18.8
Manganese, mg/L	2,000	97	378	662
Mercury, mg/L	16.00	0.22	2.77	5.42
Methylene chloride, µg/L	<5	<5	<5	0
N-nitroso-di-n-propylamine, µg/L	<10	<10	<10	0
N-nitrpsodimethylamine, µg/L	<10	<10	<10	0
N-nitrodiphenylamine, µg/L	<10	<10	<10	0
Naphthalene, µg/L	<10	<10	<10	0
Nickel, mg/L	24.0	11.3	15.8	5.8
Nitrate nitrogen, mg/L	4500	300	1223	1,552
Nitrobenzene, µg/L	<10	<10	<10	0
Pentachlorophenol, µg/L	<50	<50	<50	0
pH, standard units	8.0	7.5	7.8	0.2
Phenanthrene, µg/L	<10	<10	<10	0
Phenol, µg/L	<10	<10	<10	0
Pyrene, µg/L	<10	<10	<10	0
Sodium, mg/L	15,000	2,500	6,769	4,502
Sulfate, mg/L	45,000	6,000	31,417	10,574
Suspended solids, mg/L	1,230,000	1,000	194,917	425,945
Tetrachloroethene, µg/L	<5	<5	<5	0
Toluene, µg/L	<5	<5	<5	0
trans-1,2-Dichloroethene, µg/L	<5	<5	<5	0
trans-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Trichloroethene, µg/L	<5	<5	<5	0
Trichlorofluoromethane, µg/L	<5	<5	<5	0
Uranium fluorometric, µg/L	12	1	4	0
Vinyl chloride, µg/L	<10	<10	<10	0
Zinc, mg/L	120.0	4.3	29.9	31.2

Table 4.77. 1991 K-25 Site concentrations at K-1770 (Clinch River)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
1,1,1-Trichloroethane, µg/L	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethene, µg/L	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichloroethane, µg/L	<5	<5	<5	0
1,2-Dichloropropane, µg/L	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	<10	<10	<10	0
1,4-Dichlorobenzene, µg/L	<10	<10	<10	0
2,4,6-Trichlorophenol, µg/L	<10	<10	<10	0
2,4-Dichlorophenol, µg/L	<10	<10	<10	0
2,4-Dimethylphenol, µg/L	<10	<10	<10	0
2,4-Dinitrophenol, µg/L	<50	<50	<50	0
2,4-Dinitrotoluene, µg/L	<10	<10	<10	0
2,6-Dinitrotoluene, µg/L	<10	<10	<10	0
2-Chloroethylvinyl ether, µg/L	<10	<10	<10	0
2-Chloronaphthalene, µg/L	<10	<10	<10	0
2-Chlorophenol, µg/L	<10	<10	<10	0
2-Nitrophenol, µg/L	<10	<10	<10	0
3,3-Dichlorobenzidine, µg/L	<20	<20	<20	0
4,6-Dinitro-2-methylphenol, µg/L	<50	<50	<50	0
4-Bromophenyl-phenylether, µg/L	<10	<10	<10	0
4-Chloro-3-methylphenol, µg/L	<10	<10	<10	0
4-Chlorophenyl-phenylether, µg/L	<10	<10	<10	0
4-Nitrophenol, µg/L	<50	<50	<50	0
Acenaphthene, µg/L	<10	<10	<10	0
Acenaphthylene, µg/L	<10	<10	<10	0
Ammonia nitrogen, mg/L	<200	<200	<200	0
Anthracene, µg/L	<10	<10	<10	0
Arsenic, mg/L	<5	<5	<5	0
Benzene, µg/L	<5	<5	<5	0
Benzidine, µg/L	<50	<50	<50	0
Benzo(a)anthracene, µg/L	<10	<10	<10	0
Benzo(a)pyrene, µg/L	<10	<10	<10	0
Benzo(b)fluoranthene, µg/L	<10	<10	<10	0
Benzo(g,h,i)perylene, µg/L	<10	<10	<10	0
Benzo(k)fluoranthene, µg/L	<10	<10	<10	0
bis(2-Chloroethoxy)methane, µg/L	<10	<10	<10	0
bis(2-Chloroethyl)ether, µg/L	<10	<10	<10	0
bis(2-Chloroisopropyl)ether, µg/L	<10	<10	<10	0
bis(2-Ethylhexyl)phthalate, µg/L	<10	<10	<10	0
Bromodichloromethane, µg/L	<5	<5	<5	0
Bromoform, µg/L	<5	<5	<5	0
Bromomethane, µg/L	<10	<10	<10	0
Butylbenzylphthalate, µg/L	<10	<10	<10	0
Cadmium, mg/L	<2	<2	<2	0
Carbon tetrachloride, µg/L	<5	<5	<5	0
Chemical oxygen demand (COD), mg/L	27,500	5,000	11,071	7,174
Chlorobenzene, µg/L	<5	<5	<5	0
Chloroethane, µg/L	<10	<10	<10	0

Table 4.77 (continued)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
Chloroform, µg/L	<5	<5	<5	0
Chloromethane, µg/L	<10	<10	<10	0
Chromium, µg/L	<10	<10	<10	0
Chrysene, µg/L	<10	<10	<10	0
cis-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Copper, mg/L	5.5	4.9	5.2	0.3
Cyanide colorimetric, mg/L	<100	<100	<100	0
Di-n-butylphthalate, µg/L	<10	<10	<10	0
Di-n-octylphthalate, µg/L	<10	<10	<10	0
Dibenz(a,h)anthracene, µg/L	<10	<10	<10	0
Dibromochloromethane, µg/L	<5	<5	<5	0
Diethylphthalate, µg/L	<10	<10	<10	0
Dimethylphthalate, µg/L	<10	<10	<10	0
Dissolved solids, mg/L	174,000	64,000	140,000	27,092
Ethylbenzene, µg/L	<5	<5	<5	0
Fluoranthane, µg/L	<10	<10	<10	0
Fluorene, µg/L	<10	<10	<10	0
Flouride IC, mg/L	100	100	100	0
Hexachlorobenzene, µg/L	<10	<10	<10	0
Hexachlorobutadiene, µg/L	<10	<10	<10	0
Hexachlorocyclopentadiene, µg/L	<10	<10	<10	0
Hexachloroethane, µg/L	<10	<10	<10	0
Ideno(1,2,3-cd)pyrene, µg/L	<10	<10	<10	0
Isophorone, µg/L	<10	<10	<10	0
Lead, mg/L	<4	<4	<4	0
Manganese, mg/L	88.3	26.0	49.3	19.8
Mercury, mg/L	0.24	0.24	0.24	0.00
Methylene chloride, µg/L	<5	<5	<5	0
N-nitroso-di-n-propylamine, µg/L	<10	<10	<10	0
N-nitrosodimethylamine, µg/L	<10	<10	<10	0
N-nitrodiphenylamine, µg/L	<10	<10	<10	0
Naphthalene, µg/L	<10	<10	<10	0
Nickel, mg/L	<10	<10	<10	0
Nitrate nitrogen, µg/L	600	130	373	137
Nitrobenzene, µg/L	<10	<10	<10	0
Pentachlorophenol, µg/L	<50	<50	<50	0
ph, standard units	8.40	7.65	8.04	0.22
Phenanthrene, µg/L	<10	<10	<10	0
Phenol, µg/L	<10	<10	<10	0
Pyrene, µg/L	<10	<10	<10	0
Sodium, mg/L	6,390	3,500	4,393	836
Sulfate, mg/L	28,000	17,000	21,333	2,953
Suspended solids, mg/L	63,000	4,000	17,917	17,100
Tetrachloroethene, µg/L	<5	<5	<5	0
Toluene, µg/L	<5	<5	<5	0
trans-1,2-Dichloroethene, µg/L	<5	<5	<5	0
trans-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Trichloroethene, µg/L	<5	<5	<5	0
Trichlorofluoromethane, µg/L	<5	<5	<5	0
Uranium fluorometric, µg/L	1	1	1	0
Vinyl chloride, µg/L	<10	<10	<10	0
Zinc, mg/L	14.00	4.24	8.05	3.38

Table 4.78. 1991 K-25 Site concentrations at Mitchell Branch

Parameter	Concentration			
	Max	Min	Av	Standard deviation
1,1,1-Trichloroethane, µg/L	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethane, µg/L	<5	<5	<5	0
1,1-Dichloroethene, µg/L	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichlorobenzene, µg/L	<10	<10	<10	0
1,2-Dichloroethane, µg/L	<5	<5	<5	0
1,2-Dichloropropane, µg/L	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	<10	<10	<10	0
1,4-Dichlorobenzene, µg/L	<10	<10	<10	0
2,4,6-Trichlorophenol, µg/L	<10	<10	<10	0
2,4-Dichlorophenol, µg/L	<10	<10	<10	0
2,4-Dimethylphenol, µg/L	<10	<10	<10	0
2,4-Dinitrophenol, µg/L	<10	<10	<10	0
2,4-Dinitrotoluene, µg/L	<10	<10	<10	0
2,6-Dinitrotoluene, µg/L	<10	<10	<10	0
2-Chloroethylvinyl ether, µg/L	<10	<10	<10	0
2-Chloronaphthalene, µg/L	<10	<10	<10	0
2-Chlorophenol, µg/L	<10	<10	<10	0
2-Nitrophenol, µg/L	<10	<10	<10	0
3,3-Dichlorobenzidine, µg/L	<20	<20	<20	0
4,6-Dinitro-2-methylphenol, µg/L	<50	<50	<50	0
4-Bromophenyl-phenylether, µg/L	<10	<10	<10	0
4-Chloro-3-methylphenol, µg/L	<10	<10	<10	0
4-Chlorophenyl-phenylether, µg/L	<10	<10	<10	0
4-Nitrophenol, µg/L	<50	<50	<50	0
Acenaphthene, µg/L	<10	<10	<10	0
Acenaphthylene, µg/L	<10	<10	<10	0
Ammonia nitrogen, mg/L	<200	<200	<200	0
Anthracene, µg/L	<10	<10	<10	0
Arsenic, mg/L	<5	<5	<5	0
Benzene, µg/L	<5	<5	<5	0
Benzidine, µg/L	<10	<10	<10	0
Benzo(a)anthracene, µg/L	<10	<10	<10	0
Benzo(a)pyrene, µg/L	<10	<10	<10	0
Benzo(b)fluoranthene, µg/L	<10	<10	<10	0
Benzo(g,h,i)perylene, µg/L	<10	<10	<10	0
Benzo(k)fluoranthene, µg/L	<10	<10	<10	0
bis(2-Chloroethoxy)methane, µg/L	<10	<10	<10	0
bis(2-Chloroethyl)ether, µg/L	<10	<10	<10	0
bis(2-Chloroisopropyl)ether, µg/L	<10	<10	<10	0
bis(2-Ethylhexyl)phthalate, µg/L	<10	<10	<10	0
Bromodichloromethane, µg/L	<5	<5	<5	0
Bromoform, µg/L	<5	<5	<5	0
Bromomethane, µg/L	<10	<10	<10	0
Butylbenzylphthalate, µg/L	<10	<10	<10	0
Cadmium, mg/L	<2	<2	<2	0
Carbon tetrachloride, µg/L	<5	<5	<5	0
Chemical oxygen demand (COD), mg/L	21,000	7,000	14,000	7,000
Chlorobenzene, µg/L	<5	<5	<5	0
Chloroethane, µg/L	<10	<10	<10	0

Table 4.78 (continued)

Parameter	Concentration			
	Max	Min	Av	Standard deviation
Chloroform, µg/L	<5	<5	<5	0
Chloromethane, µg/L	<10	<10	<10	0
Chromium, mg/L	<10	<10	<10	0
Chrysene, µg/L	<10	<10	<10	0
cis-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Copper, mg/L	8.6	8.6	8.6	0.0
Cyanide colorimetric, mg/L	<100	<100	<100	0
Di-n-butylphthalate, µg/L	<10	<10	<10	0
Di-n-octylphthalate, µg/L	<10	<10	<10	0
Dibenz(a,h)anthracene, µg/L	<10	<10	<10	0
Dibromochloromethane, µg/L	<5	<5	<5	0
Diethylphthalate, µg/L	<10	<10	<10	0
Dimethylphthalate, µg/L	<10	<10	<10	0
Dissolved solids, mg/L	132,000	68,000	108,000	24,351
Ethylbenzene, µg/L	<5	<5	<5	0
Fluoranthane, µg/L	<10	<10	<10	0
Fluorene, µg/L	<10	<10	<10	0
Flouride IC, mg/L	<100	<100	<100	0
Hexachlorobenzene, µg/L	<10	<10	<10	0
Hexachlorobutadiene, µg/L	<10	<10	<10	0
Hexachlorocyclopentadiene, µg/L	<10	<10	<10	0
Hexachloroethane, µg/L	<10	<10	<10	0
Ideno(1,2,3-cd)pyrene, µg/L	<10	<10	<10	0
Isophorone, µg/L	<10	<10	<10	0
Lead, mg/L	8.1	8.1	8.1	0.0
Manganese, mg/L	620	13	210	270
Mercury, mg/L	<0.2	<0.2	<0.2	0.0
Methylene chloride, µg/L	<5	<5	<5	0
N-nitroso-di-n-propylamine, µg/L	<10	<10	<10	0
N-nitrpsodimethylamine, µg/L	<10	<10	<10	0
N-nitrodiphenylamine, µg/L	<10	<10	<10	0
Naphthalene, µg/L	<10	<10	<10	0
Nickel, mg/L	14	14	14	0
Nitrate nitrogen, mg/L	<20	<20	<20	0
Nitrobenzene, µg/L	<10	<10	<10	0
Pentachlorophenol, µg/L	<50	<50	<50	0
ph, standard units	8.10	7.15	7.76	0.35
Phenanthrene, µg/L	<10	<10	<10	0
Phenol, µg/L	<10	<10	<10	0
Pyrene, µg/L	<10	<10	<10	0
Sodium, mg/L	830	461	640	145
Sulfate, mg/L	4,000	2,000	2,667	943
Suspended solids, mg/L	177,000	9,000	65,333	78,961
Tetrachloroethene, µg/L	<5	<5	<5	0
Toluene, µg/L	<5	<5	<5	0
trans-1,2-Dichloroethene, µg/L	<5	<5	<5	0
trans-1,3-Dichloropropene, µg/L	<5	<5	<5	0
Trichloroethene, µg/L	<5	<5	<5	0
Trichlorofluoromethane				0
Uranium fluorometric, µg/L	<1	<1	<1	0
Vinyl chloride, µg/L	<10	<10	<10	0
Zinc, mg/L	13.0	3.8	8.1	3.8

Table 4.79. K-25 Site water monitoring locations

Location	Agency	Type	NPDES ID if applicable
Clinch River (Brashaer Island)	DOE	Perimeter	
West Fork Poplar Creek	DOE	Perimeter	
K-710A (inactive)	TDC	NPDES	008
K-716	DOE	Perimeter	
K-901-A	TDC	NPDES	007
K-1007-B	TDC	NPDES	006
K-1203	TDC	NPDES	005
K-1407-E and K-1407-F	TDC	NPDES	010
K-1407-J	TDC	NPDES	011
K-1513	DOE	Perimeter	
K-1515-C	TDC	NPDES	009
K-1700	TDC	NPDES	001
K-1710	DOE	Perimeter	
K-1770	DOE	Perimeter	

Table 4.80. K-25 Site NPDES sampling frequency

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1700 (001)	Grab	Daily		pH
K-1700 (001)	*b*	Daily		Flow
K-1700 (001)	24 h/comp.	2/week		Aluminum
K-1700 (001)	24 h/comp.	4/week		Chemical oxygen demand
K-1700 (001)	24 h/comp.	2/week		Chromium
K-1700 (001)	24 h/comp.	2/week		Dissolved solids
K-1700 (001)	24 h/comp.	2/week		Fluoride
K-1700 (001)	24 h/comp.	2/week		Nitrate
K-1700 (001)	Grab	2/week		Oil and grease
K-1700 (001)	24 h/comp.	4/week		Total suspended solids
K-1700 (001)	Grab	4/week		Temperature
K-1700 (001)	Grab	4/week		Turbidity
K-1700 (001)	24 h/comp.	2/week		Lead
K-1700 (001)	24 h/comp.	2/week		Zinc
K-1700 (001)	24 h/comp.	1/week		Uranium[c]
K-1700 (001)	24 h/comp.	1/week	1/month	Cesium
K-1700 (001)	24 h/comp.	1/week	1/month	Neptunium
K-1700 (001)	24 h/comp.	1/week	1/month	Plutonium
K-1700 (001)	24 h/comp.	1/week	1/month	Technetium
K-1203 (005)	Grab	Daily		pH
K-1203 (005)	Grab	Daily		Chlorine, residual
K-1203 (005)	Grab	Daily		Dissolved oxygen
K-1203 (005)	Grab	Daily		Settleable solids
K-1203 (005)	*b*	Daily		Flow
K-1203 (005)	24 h/comp.	3/week		Ammonia nitrogen
K-1203 (005)	24 h/comp.	3/week		Biochemical oxygen demand
K-1203 (005)	Grab	3/week		Fecal coliform
K-1203 (005)	24 h/comp.	3/week		Total suspended solids
K-1203 (005)	24 h/comp.	1/week		Uranium[c]
K-1203 (005)	24 h/comp.	1/week	1/month	Technetium
K-1007-B (006)	Grab	Daily		pH
K-1007-B (006)	Grab	1/week		Dissolved oxygen
K-1007-B (006)	*b*	Daily		Flow
K-1007-B (006)	24 h/comp.	1/week		Chemical oxygen demand
K-1007-B (006)	24 h/comp.	1/week		Chromium
K-1007-B (006)	24 h/comp.	1/week		Fluoride
K-1007-B (006)	Grab	1/week		Oil and grease
K-1007-B (006)	24 h/comp.	1/week		Total suspended solids
K-1007-B (006)	24 h/comp.	1/week		Uranium[c]
K-1007-B (006)	24 h/comp.	1/week	1/month	Cesium
K-1007-B (006)	24 h/comp.	1/week	1/month	Plutonium
K-1007-B (006)	24 h/comp.	1/week	1/month	Neptunium
K-1007-B (006)	24 h/comp.	1/week	1/month	Technetium
K-901-A (007)	Grab	Daily		pH
K-901-A (007)	Grab	Daily		Dissolved oxygen
K-901-A (007)	*b*	Daily		Flow
K-901-A (007)	24 h/comp.	2/week		Chemical oxygen demand
K-901-A (007)	24 h/comp.	1/week		Chromium
K-901-A (007)	24 h/comp.	1/week		Fluoride
K-901-A (007)	Grab	1/week		Oil and grease
K-901-A (007)	24 h/comp.	2/week		Total suspended solids
K-901-A (007)	Grab	2/week		Turbidity

Table 4.80 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-901-A (007)	24 h/comp.	1/week		Uranium[c]
K-901-A (007)	24 h/comp.	1/week	1/month	Cesium
K-901-A (007)	24 h/comp.	1/week	1/month	Neptunium
K-901-A (007)	24 h/comp.	1/week	1/month	Plutonium
K-901-A (007)	24 h/comp.	1/week	1/month	Technetium
K-1515-C (009)	Grab	1/week		pH
K-1515-C (009)	*b*	Daily		Flow
K-1515-C (009)	Grab	1/week		Total suspended solids
K-1515-C (009)	Grab	1/week		Aluminum
K-1515-C (009)	Grab	1/week		Sulfate
K-1515-C (009)	Grab	1/week		Chemical oxygen demand
K-1407-J (011)	Continuous	Daily		pH
K-1407-J (011)	Continuous	Daily		Flow
K-1407-J (011)	Grab	Daily		Temperature
K-1407-J (011)	24 h/comp.	2/week		Cadmium
K-1407-J (011)	24 h/comp.	2/week		Chromium
K-1407-J (011)	24 h/comp.	2/week		Copper
K-1407-J (011)	24 h/comp.	2/week		Lead
K-1407-J (011)	24 h/comp.	2/week		Nickel
K-1407-J (011)	24 h/comp.	2/week		Silver
K-1407-J (011)	24 h/comp.	2/week		Zinc
K-1407-J (011)	Grab	1/week		Cyanide
K-1407-J (011)	Grab	1/week		Total toxic organics
K-1407-J (011)	Grab	2/week		Oil and grease
K-1407-J (011)	24 h/comp.	4/week		Total suspended solids
K-1407-J (011)	24 h/comp.	1/week		Polychlorinated biphenyls
K-1407-J (011)	24 h/comp.	4/week		Chemical oxygen demand
K-1407-J (011)	24 h/comp.	4/week		Total dissolved solids
K-1407-J (011)	24 h/comp.	2/week		Total organic carbon
K-1407-J (011)	24 h/comp.	1/week		Ammonia
K-1407-J (011)	24 h/comp.	1/week		Bromide
K-1407-J (011)	24 h/comp.	1/week		Chlorine, total residual
K-1407-J (011)	24 h/comp.	1/week		Chloride
K-1407-J (011)	24 h/comp.	4/week		Fluoride
K-1407-J (011)	24 h/comp.	2/week		Nitrate-Nitrite
K-1407-J (011)	24 h/comp.	1/week		Nitrogen
K-1407-J (011)	24 h/comp.	1/week		Phosphorus
K-1407-J (011)	24 h/comp.	1/week		Sulfate
K-1407-J (011)	24 h/comp.	1/week		Sulfide
K-1407-J (011)	24 h/comp.	1/week		Sulfite
K-1407-J (011)	24 h/comp.	1/week		Surfactants
K-1407-J (011)	24 h/comp.	2/week		Aluminum
K-1407-J (011)	24 h/comp.	1/week		Barium
K-1407-J (011)	24 h/comp.	2/week		Boron
K-1407-J (011)	24 h/comp.	2/week		Cobalt
K-1407-J (011)	24 h/comp.	2/week		Iron
K-1407-J (011)	24 h/comp.	2/week		Magnesium
K-1407-J (011)	24 h/comp.	2/week		Molybdenum
K-1407-J (011)	24 h/comp.	2/week		Manganese
K-1407-J (011)	24 h/comp.	1/week		Tin
K-1407-J (011)	24 h/comp.	2/week		Titanium
K-1407-J (011)	24 h/comp.	2/week		Antimony

Table 4.80 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1407-J (011)	24 h/comp.	1/week		Arsenic
K-1407-J (011)	24 h/comp.	2/week		Beryllium
K-1407-J (011)	24 h/comp.	2/week		Mercury
K-1407-J (011)	24 h/comp.	2/week		Selenium
K-1407-J (011)	24 h/comp.	1/week		Thallium
K-1407-J (011)	24 h/comp.	1/week		Uranium[c]
K-1407-J (011)	Grab	1/week		Phenols
K-1407-J (011)	Grab	5/week		GC/MS[d] fraction volatile compounds
K-1407-J (011)	72 h/comp.	1/month		GC/MS acid compounds
K-1407-J (011)	72 h/comp.	1/month		GC/MS base/neutral compounds
K-1407-J (011)	24 h/comp.	1/week	1/month	Cesium
K-1407-J (011)	24 h/comp.	1/week	1/month	Plutonium
K-1407-J (011)	24 h/comp.	1/week	1/month	Neptunium
K-1407-J (011)	24 h/comp.	1/week	1/month	Technetium
K-1407-E/F (010)	Grab	Continuous		Flow
K-1407-E/F (010)	Grab	1/week		Temperature
K-1407-E/F (010)	24 h/comp.	1/week		Total suspended solids
K-1407-E/F (010)	Grab	1/week		Oil and grease
K-1407-E/F (010)	24 h/comp.	1/week		Chromium
K-1407-E/F (010)	24 h/comp.	1/week		Copper
K-1407-E/F (010)	24 h/comp.	1/week		Iron
K-1407-E/F (010)	24 h/comp.	1/week		Zinc
K-1407-E/F (010)	24 h/comp.	1/week		Arsenic
K-1407-E/F (010)	24 h/comp.	1/week		Cadmium
K-1407-E/F (010)	24 h/comp.	1/week		Lead
K-1407-E/F (010)	24 h/comp.	1/week		Manganese
K-1407-E/F (010)	24 h/comp.	1/week		Nickel
K-1407-E/F (010)	24 h/comp.	1/week		Selenium
K-1407-E/F (010)	24 h/comp.	1/week		Silver
K-1407-E/F (010)	24 h/comp.	1/month		Sulfate
K-1407-E/F (010)	Grab	Continuous		pH
K-1407-E/F (010)	24 h/comp.	1/week		Polychlorinated biphenyls
K-1407-E/F (010)	24 h/comp.	1/week		Uranium[c]
K-1407-E/F (010)	24 h/comp.	1/week		Cesium
K-1407-E/F (010)	24 h/comp.	1/week		Neptunium
K-1407-E/F (010)	24 h/comp.	1/week		Plutonium
K-1407-E/F (010)	24 h/comp.	1/week		Technetium

[a]Analysis frequency–identical to sample frequency unless otherwise noted.
[b]Not applicable.
[c]An isotopic analysis is conducted on uranium if any week is above 0.02 mg/L.
[d]Gas chromatograph/mass spectrometer.

Table 4.81. K-25 Site NPDES permit discharges

Serial discharges	Effluent discharges	Average flow (gal × 10^6/d)	Receiving stream
K-1700 (001)	K-1407-E/F effluent surface runoff once-through cooling	0.81	Poplar Creek
K-1407-J (011)	Metals cleaning facility Uranium recovery Chemical Process Development Facility TSCA Incinerator	0.006	Poplar Creek
K-1407-E/F (010)	Steam plant and coal yard effluents Surface runoff	0.105	Mitchell Branch
K-901-A (007)	Lime-softening sludges from fire water makeup treatment Surface runoff	1.87	Clinch River
K-1203 (005)	Sanitary wastewaters Organic industrial wastewaters	0.47	Poplar Creek
K-1007-B (006)	Potable water from once-through cooling systems Fire water from once-through systems Surface runoff	1.76	Poplar Creek
K-1515-C (009)	Water from sludge and backwash systems associated with the potable water plant Surface runoff	0.48	Clinch River

Table 4.82. Radionuclide concentrations at K-25 Site NPDES locations in 1991

Radionuclide	Number of samples[a]	Concentrations (pCi/L)[b]					Percentage of DCG[e]
		Max	Min	Av	Standard error[c]	DCG[d]	
			K-1203 Sewage Treatment Plant (005)				
^{234}U	12	6.17	0.62	2.42	1.54	500	0.48
^{235}U	12	0.20	0.02	0.08	0.05	600	0.01
^{236}U	12	0.06	0.006	0.02	0.02	500	0.005
^{238}U	12	3.3	0.33	1.29	0.83	600	0.22
^{137}Cs	12	0.63	–0.36	11.8	23.7	3,000	0.39
^{99}Tc	12	66.4	–868	–140	248	100,000	<0.001
Gross alpha	12	81.8	7.32	23.2	19.1	*f*	*f*
Gross beta	12	47.2	3.7	16.1	10.4	*f*	*f*
			K-1700 Coal Pile Runoff, and Once-Through Cooling Water (001)				
^{234}U	12	14.87	3.09	5.81	3.05	500	1.16
^{235}U	12	0.28	0.11	0.20	0.06	600	0.03
^{236}U	12	0.20	0.03	0.06	0.04	500	0.01
^{238}U	12	4.29	1.65	2.66	0.74	600	0.44
^{137}Cs	12	51.8	–0.38	6.33	0.25	3,000	0.21
^{99}Tc	12	1,530	–359	96.9	461	100,000	0.10
^{237}Np	12	0.66	–0.10	0.16	0.25	30	0.53
^{238}Pu	12	0.91	–0.44	0.03	0.32	40	0.08
^{239}Pu	12	0.75	–0.20	0.05	0.22	30	0.17
Gross alpha	12	38.2	3.23	9.50	8.95	*f*	*f*
Gross beta	12	59.5	12.1	23.9	12.2	*f*	*f*
			K-1007-B Settling Basin for Laboratory and Surface Water Runoff (006)				
^{234}U	12	6.17	0.62	1.08	1.54	500	0.22
^{235}U	12	0.25	0.03	0.04	0.06	600	0.007
^{236}U	12	0.06	0.006	0.01	0.002	500	0.002
^{238}U	12	3.30	0.33	0.58	0.08	600	0.09
^{137}Cs	12	51.8	–0.38	6.33	0.25	3,000	0.21
Gross alpha	12	14.6	–1.31	2.24	3.97	*f*	*f*
Gross beta	12	28.0	3.04	10.0	5.92	*f*	*f*
			K-901-A Settling Basin for Surface Runoff and Lime-Softening Sludges (007)				
^{234}U	12	6.17	0.62	1.95	1.38	500	0.39
^{235}U	12	0.15	0.02	0.05	0.03	600	0.008
^{236}U	12	0.06	0.006	0.02	0.01	500	0.004
^{238}U	12	3.31	0.33	1.05	0.74	600	0.18
^{137}Cs	12	49.2	–18.3	2.65	0.18	3,000	0.09
Gross alpha	12	15.9	–1.43	3.36	4.13	*f*	*f*
Gross beta	12	33.3	0.52	19.6	10.5	*f*	*f*
			K-1407-J Treated Effluents from CNF and TSCA (011)				
^{234}U	12	679	25.9	374	186	500	74.9
^{235}U	12	84.3	3.22	20.8	23.2	600	3.47
^{236}U	12	13.0	0.27	5.07	3.72	500	1.01
^{238}U	12	363	13.9	201	99.9	600	33.4
^{137}Cs	12	20.8	–16.9	0.75	13	3,000	0.02
^{99}Tc	12	2,760	–460	754	1,040	100,000	0.75
^{237}Np	12	20.7	0	4.60	5.7	30	15.3
^{238}Pu	12	0.24	–0.24	–0.01	0.13	40	<0.001
^{239}Pu	12	0.47	–0.12	0.05	0.01	30	0.17
Gross alpha	12	962	7.76	290	259	*f*	*f*
Gross beta	12	1,690	–0.13	545	454	*f*	*f*

Table 4.82 (continued)

Radionuclide	Number of samples[a]	Concentrations (pCi/L)[b]					Percentage of DCG[e]
		Max	Min	Av	Standard error[c]	DCG[d]	
		K-1407-E/F Steam Plant, Coal Pile Runoff, and Surface Runoff (010)[g]					
^{234}U	12	2.47	0.62	1.54	0.69	500	0.31
^{235}U	12	0.08	0.02	0.05	0.02	600	0.008
^{236}U	12	0.03	0.006	0.02	0.007	500	0.003
^{238}U	12	1.32	0.33	0.83	0.37	600	0.14
^{137}Cs	12	0.44	–3.41	–0.85	1.81	3,000	<0.001
^{99}Tc	12	110	–115	22.3	98.3	100,000	0.02
^{237}Np	12	–0.05	–0.14	–0.06	0.06	30	<0.001
^{238}Pu	12	0.18	–0.05	–0.29	0.33	40	<0.001
^{239}Pu	12	0.22	–0.20	0.07	0.17	30	0.23
Gross alpha	12	9.10	–0.15	0.59	9.35	*f*	*f*
Gross beta	12	11.8	–3.41	5.05	5.45	*f*	*f*

[a]The outfalls are sampled weekly, combined for a monthly composite, and then analyzed.
[b]Multiply pCi/L by 0.037 to convert to Bq/L.
[c]Standard deviation of the mean.
[d]Derived concentration guide (DCG) for ingestion of water (from DOE Order 5400.5).
[e]Mean concentration as a percentage of the DCG.
[f]Not applicable.
[g]Data are for January, February, March, and December only.

Table 4.83. 1991 NPDES Permit Number TN 0002950

Discharge Point K-1700, Mitchell Branch, K-25 Site

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
1,1,1-Trichloroethane, µg/L	89	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	89	<5	<5	<5	0
1,1-Dichloroethane, µg/L	188	<5	<5	<5	0
1,2-Dichloroethane, µg/L	85	<5	<5	<5	0
1,2-Dichlorobenzene, µg/L	14	<5	<5	<5	0
1,2,-Dichloropropene, µg/L	89	<5	<5	<5	0
2-Chlorovinyl ether, µg/L	89	<10	<10	<10	0
Aluminum, mg/L	108	3.5	0.031	0.287	0.42
Benzene, µg/L	89	<5	<5	<5	0
Beryllium, mg/L	89	0.003	0.0003	0.0011	0
Bromodichloromethane, µg/L	89	<5	<5	<5	0
Bromoform, µg/L	89	<5	<5	<5	0
Bromomethane, µg/L	89	<10	<10	<10	0
Cadmium, µg/L	89	0.049	0.002	0.0026	0.0049
Carbon tetrachloride, µg/L	89	<5	<5	<5	0
Chemical oxygen demand (COD), mg/L	224	36	<5	6.46	4.44
Chlorobenzene, µg/L	97	<5	<5	<5	0
Chloroethane, µg/L	89	<10	<10	<10	0
Chloroform, µg/L	89	<5	<5	<5	0
Chloromethane, µg/L	89	<10	<10	<10	0
Chromium, mg/L	111	0.055	0.01	0.011	0.0046
Cis-1,3-dichloropropene, µg/L	89	<5	<5	<5	0
Dibromochloromethane, µg/L	89	<5	<5	<5	0
Dissolved solids, mg/L	114	1,080	74	218.9	108.49
Ethyl benzene, µg/L	89	<5	<5	<5	0
Flow, MGD	365	7.4246	0.0632	0.7183	2.589
Fluoride, mg/L	113	0.9	0.1	0.1863	0.0924
Lead, mg/L	112	0.026	0.004	0.00487	0.0029
Mercury, mg/L	90	0.00051	0.0002	0.00021	0.00004
Methylene chloride, µg/L	90	<17	<5	5.4	2.14
Nitrate nitrogen, mg/L	111	1.13	0.04	0.3515	0.145
Oil and grease, mg/L	113	10.98	2	2.16	1.05
pH, standard units	365	8.5	6.95	*a*	*a*
Selenium, mg/L	94	0.013	0.005	0.0051	0.0008
Silver, mg/L	94	0.077	0.01	0.011	0.0068
Tetrachloroethene, µg/L	89	<5	<5	<5	0
Toluene, µg/L	89	<5	<5	<5	0
Total suspended solids, mg/L	220	1,080	1	6.4	9.572
Trans-1,2-dichloroethane, µg/L	89	50	<5	25.08	14.816
Trans-1,3-dichloroethane, µg/L	85	<5	<5	<5	0
Trichloroethelene, µg/L	87	69	<5	41,773	15.64
Trichlorofluoromethane, µg/L	8	<5	<5	<5	0
Turbidity, NTU	222	72	0.85	6.91	7.41
Vinyl chloride, µg/L	89	<10	<10	<10	0

[a]Not applicable.

Table 4.84. 1991 NPDES Permit Number TN 0002950

Discharge Point K-1203 Sewage Treatment Plant, K-25 Site

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
Ammonia nitrogen, mg/L	174	1.61	0.2	0.215	0.1148
Antimony, mg/L	1	<0.05	<0.05	<0.05	0
Arsenic, mg/L	2	<0.05	<0.05	<0.05	0
Beryllium, mg/L	1	<0.001	<0.001	<0.001	0
Biological oxygen demand (BOD), mg/L	175	12	2.7	5.291	1.08
Boron, mg/L	1	0.027	0.027	0.027	0
Cadmium, mg/L	1	0.003	0.003	0.003	0
Calcium, mg/L	1	35	35	35	0
Chemical oxygen demand (COD), mg/L	220	159	5	12,109	12.23
Chromium, mg/L	1	0.01	0.01	0.01	0
Cobalt, mg/L	1	<0.1	<0.1	<0.1	0
Copper, mg/L	1	0.0081	0.0081	0.0081	0
Fecal coliform, col/100 mL	174	>5,000	0	125.469	598.4935
Flow, MGD	365	2.787	0.1915	0.4479	0.83919
Iron, mg/L	1	0.41	0.41	0.41	0
Lead, mg/L	2	0.05	<0.004	0.027	0.023
Magnesium, mg/L	1	9.9	9.9	9.9	0
Manganese, mg/L	1	0.15	0.15	0.15	0
Mercury, mg/L	1	0.00022	0.00022	0.00022	0
Molybdenum, mg/L	1	<0.01	<0.01	<0.01	0
Nickel, mg/L	1	<0.05	<0.05	<0.05	0
Nitrate nitrogen, mg/L	125	226	0.65	8.083	19.7543
pH, standard units	365	8.9	6.8	*a*	*a*
Potassium, mg/L	1	3.3	3.3	3.3	0
Selenium, mg/L	2	0.05	<0.005	0.0275	0.0225
Settleable solids, mg/L	307	4	0.1	0.119	0.2241
Silicon, mg/L	1	1.9	1.9	1.9	0
Silver, mg/L	1	<0.01	<0.01	<0.01	0
Sodium, mg/L	1	13	13	13	0
Suspended solids, mg/L	173	230	2	9.546	17.242
Total organic carbon, mg/L	43	9	1	3.725	1.896
Total residual chlorine, mg/L	455	13	0.003	0.066	0.03195
Vanadium, mg/L	1	<0.5	<0.5	<0.5	0
Zinc, mg/L	1	0.049	0.049	0.049	0

[a]Not applicable.

Table 4.85. 1991 NPDES Permit Number TN 0002950

Discharge Point K-1007-B Holding Pond, K-25 Site

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
Chemical oxygen demand (COD), mg/L	98	21	<5	8.939	4.686
Chromium, mg/L	52	0.04	0.01	0.0106	0.00409
Flow, MGD	365	46.521	0.343	1.9718	14.745
Fluoride, mg/L	52	1	<0.01	0.1217	0.1238
Oil and grease, mg/L	48	3.5	<2	2.03	0.2121
pH, standard units	365	9.5	7	*a*	*a*
Suspended solids, mg/L	103	24	1	10.144	4.1889

[a]Not applicable.

Table 4.86. 1991 NPDES Permit Number TN 0002950

Discharge Point K-901-A Holding Pond, K-25 Site

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
Chemical oxygen demand (COD), mg/L	114	43	<5	7.579	5.567
Chromium, mg/L	57	0.12	<0.01	0.0136	0.01477
Flow, MGD	365	5.689	0.00338	0.3753	1.64331
Fluoride, mg/L	57	1	<0.1	0.1334	0.1283
Oil and grease, mg/L	57	2.4	<2	2.007	0.0521
pH, standard units	365	8.6	7.1	*a*	*a*
Suspended solids, mg/L	123	395	2	24.235	50.288
Turbidity, mg/L	87	72	2.7	15.9552	11.19

[a]Not applicable.

Table 4.87. 1991 NPDES Permit Number TN 0002950

Discharge Point K-1515-C Holding Pond, K-25 Site

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
Aluminum, mg/L	69	0.86	0.21	0.4715	0.153
Chemical oxygen demand (COD), mg/L	69	15	<5	5.884	2.393
Flow, MGD	365	8.942	0.0296	0.371	2.643
pH, standard units	365	8.5	6.3	*a*	*a*
Sulfate, mg/L	69	34	8	18.2	4.216
Suspended solids, mg/L	67	13	0	5.971	2.637

[a]Not applicable.

Table 4.88. 1991 NPDES Permit Number TN 0002950

Discharge Point K-1407-J Treatment Pond at K-25 Site

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
1,1,1-Trichloroethane, µg/L	230	<5	<5	<5	0
1,1,2,2-Tetrachloroethane, µg/L	230	<5	<5	<5	0
1,1,2-Trichloroethane, µg/L	230	<5	<5	<5	0
1,1-Dichloroethane, µg/L	230	<5	<5	<5	0
1,1-Dichloroethene, µg/L	230	<5	<5	<5	0
1,2,4-Trichlorobenzene, µg/L	66	<40	<10	10.45	3.66
1,2-Dichlorobenzene, µg/L	99	<40	<10	<10.3	3.0
1,2-Dichloroethane, µg/L	229	<5	<5	<5	0
1,2-Dichloropropane, µg/L	229	<5	<5	<5	0
1,3-Dichlorobenzene, µg/L	100	<40	<10	<10.3	3.5
1,4-Dichlorobenzene, µg/L	103	<40	<10	<10.3	3.5
2,4,6-Trichlorophenol, µg/L	67	<40	<10	<10.5	3.6
2,4-Dichlorophenol, µg/L	67	<40	<10	<10.5	3.6
2,4-Dimethylphenol, µg/L	67	<40	<10	<10.5	3.6
2,4-Dinitrophenol, µg/L	67	<40	<10	<10.5	3.6
2,4-Dinitrotoluene, µg/L	67	<40	<10	<10.5	3.6
2,6-Dinitrotoluene, µg/L	67	<40	<10	<10.5	3.6
2-Chloroethylvinyl ether, µg/L	228	<10	<10	<10	0
2-Chloronaphthalene, µg/L	70	<40	<10	<10.5	3.6
2-Chlorophenol, µg/L	70	<40	<10	<10.4	3.6
2-Nitrophenol, µg/L	70	<40	<10	<10.4	3.6
3,3'-Dichlorobenzidine, µg/L	70	<80	<20	<28.9	7.17
4,6-Dinitro-2-methylphenol, µg/L	70	<200	<50	<52.17	17.93
4-Bromophenyl-phenylether, µg/L	70	<40	<10	<10.4	3.6
4-Chloro-3-methylphenol, µg/L	70	<40	<10	<10.4	3.6
4-Chlorophenyl-phenylether, µg/L	70	<40	<10	<10.4	3.6
4-Nitrophenol, µg/L	70	200	50	52.17	17.9
Acenaphthene, µg/L	70	<40	<10	<10.4	3.6
Acenaphthylene, µg/L	70	<40	<10	<10.4	3.6
Aluminum, mg/L	96	1.9	0.095	0.205	0.23
Ammonia nitrogen, mg/L	47	0.25	<0.2	0.201	0.007
Anthracene, µg/L	55	<40	<10	<10.5	3.9
Antimony, mg/L	103	<0.05	<0.05	<0.05	0
Arsenic, mg/L	129	<0.005	<0.005	<0.005	0
Barium, mg/L	160	0.33	0.022	0.098	0.0297
Benzene, µg/L	231	<5	<5	5	0
Benzidine, µg/L	69	40	<10	10.43	3.6
Benzo(a)anthracene, µg/L	69	<40	10.43	3.6	3.6
Benzo(a)pyrene, µg/L	69	40	<10	10.43	3.6
Benzo(b)fluoranthene, µg/L	69	40	<10	10.43	3.6
Benzo(g,h,i)perylene, µg/L	69	40	<10	10.43	3.6
Benzo(k)fluoranthene, µg/L	69	40	<10	10.43	3.6
Beryllium, mg/L	99	<0.003	<0.0003	<0.00097	0.0003
Bis(2-chloroethoxy)methane, µg/L	68	<40	<10	10.4	3.6
Bis(2-chloroethyl)ether, µg/L	68	<40	<10	10.4	3.6
Bis(2-chloroisopropyl)ether, µg/L	67	<40	<10	10.4	3.6
Bis(2-ethylhexyl)phthalate, µg/L	68	<40	<10	<10.4	3.6
Boron, mg/L	95	1.6	0.019	0.367	0.4

Table 4.88 (continued)

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
Bromide, mg/L	44	10	1	2.39	1.7
Bromodichloromethane, µg/L	230	7	<2	4.996	0.238
Bromoform, µg/L	230	<5	<5	<5	0
Bromomethane, µg/L	230	<10	<10	<10	0
Butylbenzylphthalte, µg/L	69	<40	<10	<10.4	3.6
Cadmium, mg/L	126	0.0057	<0.002	<0.0021	0.0004
Carbon tetrachloride, µg/L	231	<5	<5	<5	0
Chemical oxygen demand, mg/L	167	343	<5	<15.5	28.04
Chloride, mg/L	34	3090	<20	626.21	638.988
Chlorobenzene, µg/L	231	<5	<5	<5	0
Chloroethane, µg/L	231	<10	<10	<10	0
Chloroform, µg/L	214	52	<1	<5.86	6.76
Chloromethane, µg/L	230	<10	<10	<10	0
Chromium, mg/L	123	0.1	<10	0.014	0.012
Chrysene, µg/L	69	<40	<10	<10.4	3.6
Cis-1,3-dichloropropene, µg/L	230	<5	<5	<5	0
Cobalt, mg/L	103	<0.1	<0.1	<0.1	0
Copper, mg/L	120	0.081	<0.004	<0.014	0.013
Cyanide, mg/L	59	0.33	<0.1	<0.11	0.032
Di-n-butylphthalate, µg/L	69	<40	<10	<10.4	3.6
Di-n-octylphthalate, µg/L	69	<40	<10	<10.4	3.6
Dibenz(a.h)anthracene, µg/L	69	<40	<10	<10.4	3.6
Dibromochloromethane, µg/L	231	<5	<5	<5	0
Diethylphthalate, µg/L	68	<40	<10	<10.4	3.6
Dimethylphthalate, µg/L	68	<40	<1.0	<10.4	3.6
Dissolved solids, µg/L	177	7322	260	2077.2	1374.6
Ethyl benzene, µg/L	229	<5	<5	<5	0
Fluoranthene, µg/L	69	<40	<10	<10.4	3.6
Fluorene, µg/L	69	<40	<10	<10.4	3.6
Fluoride, mg/L	164	71	0.2	13.2	17.3
Hexachlorobenzene, µg/L	69	<40	<10	<10.4	3.6
Hexachlorobutadiene, µg/L	69	<40	<10	<10.4	3.6
Hexacylopentadiene, µg/L	69	<40	<10	<10.4	3.6
Hexachloroethane, µg/L	69	<40	<10	<10.4	3.6
Indeno(1,2,3-cd)pyrene, µg/L	69	<40	<10	<10.4	3.6
Iron, mg/L	119	3.3	0.099	0.68	0.73
Isophorone, µg/L	70	<40	<10	<10.4	3.6
Kjeldahl nitrogen, mg/L	45	2.74	0.84	1.08	0.3
Lead, mg/L	125	0.016	<0.004	<0.0046	0.002
Magnesium, mg/L	95	0.47	8.9	17.36	13.73
Manganese, mg/L	118	0.342	<0.01	0.034	0.036
MBAS, mg/L	57	0.3	<0.2	<0.203	0.015
Methylene chloride, µg/L	102	19	<2	5.66	2.36
Molybdenum, mg/L	99	<0.1	<0.01	<0.016	0.018
N-nitroso-di-N-propylamine, µg/L	69	<40	<10	<10.4	3.6
N-nitrosodimethylamine, µg/L	69	<40	<10	<10.4	3.6
N-nitrosodiphenylamine, µg/L	69	<40	<10	<10.4	3.6
Naphthalene, µg/L	69	<40	<10	<10.4	3.6
Nickel, mg/L	125	0.5	<0.01	<0.06	0.06
Nitrate nitrogen, mg/L	98	23	<0.2	<2.02	2.5
Nitrobenzene, µg/L	70	<40	<10	<10.4	3.6
Oil and grease, mg/L	109	14.5	<2	<2.3	1.8

Table 4.88 (continued)

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
PCB					
Aroclor-1016, µg/L	63	<0.5	<0.5	<0.5	0
Aroclor-1221, µg/L	63	<0.5	<0.5	<0.5	0
Aroclor-1232, µg/L	63	<0.5	<0.5	<0.5	0
Aroclor-1242, µg/L	63	<0.5	<0.5	<0.5	0
Aroclor-1248, µg/L	63	<0.5	<0.5	<0.5	0
Aroclor-1250, µg/L	63	1.4	<1	1.01	0.05
Aroclor-1260, µg/L	63	<1	<1	<1	0
Pentachlorophenol, µg/L	70	<200	<50	<52.14	17.8
pH, standard units	365	8.9	6.7	*a*	*a*
Phenanthrene, µg/L	70	<40	<10	<10.4	3.6
Phenol, µg/L	70	<40	<10	<10.4	3.6
Phenols, µg/L	46	1.5	0.03	<0.07	0.21
Phosphorus, mg/L	95	3.7	<0.2	<3.06	6.12
Pyrene, µg/L	69	<40	<10	<10.4	3.6
Selenium, mg/L	130	<0.025	<0.005	<0.00538	0.0025
Silver, mg/L	129	0.06	<0.01	<0.011	0.0078
Sulfate, mg/L	61	1500	135	553.23	284.4
Sulfide, mg/L	43	2	<1	<1.02	0.151
Sulfite, mg/L	41	2	<0.1	<1.38	0.73
Suspended solids, mg/L	218	36	0.1	7.18	5.68
Tetrachloroethene, µg/L	230	<5	<5	<5	0
Thallium, mg/L	104	<0.01	<0.01	<0.01	0
Tin, mg/L	101	0.05	<0.01	<0.02	0.017
Titanium, mg/L	101	0.03	<0.003	<0.0053	0.0056
Toluene, µg/L	229	11	<5	<5.03	0.396
Total organic carbon, mg/L	83	19	<1	<4.05	2.52
Phosphate, mg/L	40	92	0.6	9.32	15.2
Total residual chlorine, mg/L	39	0.22	<0.02	<0.072	0.04
Trans-1,2-dichloroethene, µg/L	219	8	<5	<5.04	0.3
Trans-1,3-dichloropropene, µg/L	231	<5	<5	<5	0
Trichloroethene, µg/L	231	<5	<5	<5	0
Vinyl chloride, µg/L	231	<10	<10	<10	0
Zinc, mg/L	122	0.29	<0.002	<0.028	0.03
Trichlorofluoromethane, µg/L	51	<5	<5	<5	0

[a]Not applicable.

Table 4.89. 1991 NPDES Permit Number TN 0002950

Discharge Point K-1407-E/F Treatment Ponds, K-25 Site

Parameter	Number of samples	Concentration			Standard error
		Max	Min	Av	
Arsenic, mg/L	15	<0.005	<0.005	<0.005	0
Cadmium, mg/L	15	<0.002	<0.002	<0.002	0
Chromium, mg/L	15	<0.01	<0.01	<0.01	0
Copper, mg/L	15	0.037	0.00733	0.0242	0.009
Flow, MGD	365	0.6554	0	0.13947	0.241998
Iron, mg/L	15	2.4	0.2	0.745	0.552
Lead, mg/L	15	0.008	0.004	0.0044	0.0011
Manganese, mg/L	15	0.54	0.06	0.181	0.1096
Nickel, mg/L	15	0.239	<0.05	0.085746	0.0483
Oil and grease, mg/L	17	<2	<2	<2	0
PCB					
Aroclor 1016, µg/L	15	<0.5	<0.5	<0.5	0
Aroclor 1221, µg/L	15	<0.5	<0.5	<0.5	0
Aroclor 1232, µg/L	15	<0.5	<0.5	<0.5	0
Aroclor 1242, µg/L	15	<0.5	<0.5	<0.5	0
Aroclor 1248, µg/L	15	<0.5	<0.5	<0.5	0
Aroclor 1254, µg/L	15	2.6	<1	1.10667	3.99
Aroclor 1260, µg/L	15	<1	<1	<1	0
pH, standard units	365	9	6.4	*a*	*a*
Selenium, mg/L	15	0.02	0.005	0.006	0.0037
Silver, mg/L	15	<0.01	<0.01	<0.01	0
Sulfate, mg/L	4	1660	76	1007.25	637.62
Suspended solids, mg/L	14	14	4	8.286	3.37
Zinc, mg/L	13	0.047	0.02	0.025	0.0078

[a]Not applicable.

Table 4.90. 1991 toxicity test results of the K-25 Site wastewater

K-25 Site outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)
K-1407-E/F (010)	Feb.	100	50
K-1407-J (011)	Feb.	100	50
	April	100	50
	June	100	50
	Aug.	100	100
	Oct.	100	50
	Dec.	100	100

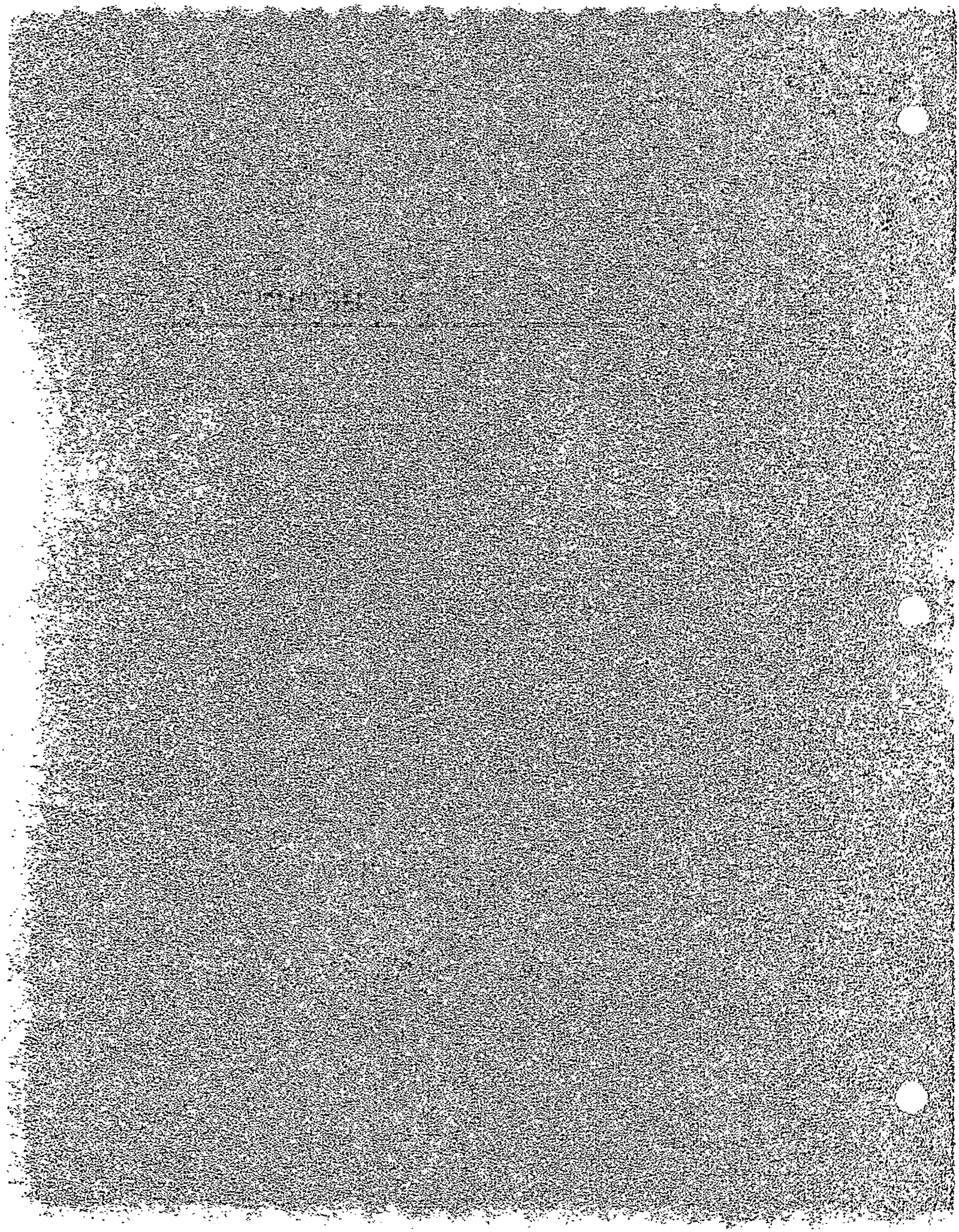
[a]No-observed-effect concentration.

Table 4.91. 1991 average water quality parameters measured during toxicity tests of the K-25 Site wastewaters

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

K-25 Site outfall	Test date	pH (standard units)	Conductivity (µs/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1407-E/F	Feb.	7.7	2287	58	631
K-1407-J	Feb.	7.7	2979	61	596
	April	7.8	8663	122	359
	June	7.9	1601	163	443
	Aug.	8.1	2187	224	456
	Oct.	7.9	3114	143	555
	Dec.	7.8	2327	136	589

5. GROUNDWATER



REFERENCES

The following references are referred to in Tables 5.1–5.11.

1. RCRA 40 CFR Pt. 265 Appendix 3.
2. Safe Drinking Water Act—National Primary Drinking Water Regulations, 40 CFR Pt. 141, as amended.
3. Safe Drinking Water Act National Secondary Drinking Water Regulations, 40 CFR Pt. 143, as amended.
4. State of Tennessee Hazardous Waste Regulations TN 1200-1-11-5, Appendix 05/B.
5. DOE Order 5400.5. Derived Concentration Guides (DCGs) for Air and Water.
6. National Primary Drinking Water Regulations; Synthetic Organic Chemicals, US EPA, Federal Register, July 8, 1987, pp. 25690–25717.

Table 5.1. Primary drinking water parameters monitored in groundwater during 1991

Parameter	Reference[a]	Applicable standards[b] (mg/L)
As	1, 2, 4	0.05
Ba	1, 2, 4	2.0
Cd	1, 2, 4	0.010
Cr	1, 2, 4	0.05
F	1, 2, 3, 4	4.0, 2.0[c], 1.4–2.4[d]
Pb	1, 2, 4	0.05
Nitrate	1, 2, 4	10
Hg	1, 2, 4	0.002
Se	1, 2, 4	0.01
Ag	1, 2, 4	0.05
Endrin	1, 2, 4	0.0002
Lindane	1, 2, 4	0.004
Methoxychlor	1, 2, 4	0.1
Toxaphene	1, 2, 4	0.005
2,4-D	1, 2, 4	0.1
2,4,5-TP Silvex	1, 2, 4	0.01
^{226}Ra and ^{228}Ra (pCi/L)	1, 2, 4	5
Gross alpha (pCi/L)	1, 2, 4	15
Gross beta (mrem/year)	1, 2, 4	4
Coliform bacteria (col./100 mL)	1, 2, 4	1[b]

[a]References for applicable standards precede this table.
[b]Maximum contaminant level.
[c]Secondary maximum contaminant level.
[d]RCRA 40 CFR Pt. 265 Appendix B and State of Tennessee Hazardous Waste Regulations.

Table 5.2. Parameters establishing groundwater quality monitored during 1991

Parameter	Reference	Applicable[a] standards (mg/L)
Chloride	3	250
Fe	3	0.3
Mn	3	0.05
Phenols		None
Na		None
Sulfate	3	250

[a]Secondary maximum contaminant level.

Table 5.3. Indicator parameters monitored in groundwater semiannually in 1991

Parameter	Reference	Applicable standards
Total organic carbon (mg/L)		None
Total organic halogen (mg/L)		None
Specific conductance (mS/cm)		None
pH (standard units)	3	6.5–8.5[a]

[a]Secondary maximum contaminant level.

Table 5.4. Typical inductively coupled argon plasma (ICAP) metals scan of groundwater (results used for metals analysis and site characterization studies)

Parameter	Reference	Applicable standards (mg/L)
Al		None
Sb		None
Ba	1, 2, 4	2.0[a]
Be		None
B		None
Cd	1, 2, 4	0.01[a]
Ca		None
Cr	1, 2, 4	0.05[a]
Co		None
Cu	3	1.0[b]
Li		None
Mg		None
Mn	3	0.05[b]
Mo		None
Ni		None
Nb		None
P		None
K		None
Si		None
Ag	1, 2, 4	0.05[a]
Na		None
Sr		None
Th		None
Ti		None
V		None
Zn	3	5.0[b]
Zr		None

[a]Maximum contaminant level.
[b]Secondary maximum contaminant level.

Table 5.5. Typical metals sought in groundwater by atomic absorption (AA) spectroscopy (results used to fulfill required monitoring and in characterization studies)

Parameter	Reference	Applicable[a] standards (mg/L)
Sb		None
As	1, 2, 4	0.05
Ba	1, 2, 4	2.0
Be		None
Cd	1, 2, 4	0.010
Cr	1, 2, 4	0.05
Cu	3	1
Pb	1, 2, 4	0.05
Hg	1, 2, 4	0.002
Ni		None
Se	1, 2, 4	0.01
Ag	1, 2, 4	0.05
Tl		None
Zn	3	5.0[b]

[a]Maximum contaminant level.
[b]Secondary maximum contaminant level.

Table 5.6. Typical anions sought in groundwater

Results used for required monitoring characterization studies

Parameter	Reference	Applicable standards (mg/L)
Chloride	3	250[a]
Fluoride	2, 3	4.0[a], 2.0[b], 1.4–2.4[c]
Nitrate	1, 2, 4	10[b]
Nitrite		1[d]
Phosphate		None
Sulfate	3	250[b]

[a]Maximum contaminant level.
[b]Secondary maximum contaminant level.
[c]State of Tennessee Hazardous Waste Regulations, TN 1200-1-11.05, Appendix 0.05/B.

Table 5.7. Volatile organics (hazardous substance list) sought in groundwater

Parameter	Reference	Chemical Abstracts Service No.	Applicable[a] standards (mg/L)
Chloromethane		74-87-3	None
Bromomethane		74-83-9	None
Vinyl chloride	6	75-01-4	0.002
Chloroethane		75-00-3	None
Methylene chloride		75-09-2	None
Acetone		67-64-1	None
Carbon disulfide		75-15-0	None
1,1-dichloroethene	6	75-35-4	0.007
1,1-dichloroethane		75-35-3	None
1,2-dichloroethene (total)		540-59-0	None
Chloroform		67-66-3	None
1,2-dichloroethane	6	107-06-2	0.005
2-butanone		78-93-3	None
1,1,1-trichloroethane	6	71-55-6	0.20
Carbon tetrachloride	6	56-23-5	0.005
Vinyl acetate		108-05-4	None
Bromodichloromethane		75-27-4	None
1,1,2,2-tetrachloroethane		79-34-5	None
1,2-dichloropropane		78-87-5	None
Cis-1,3,-dichloropropene		10061-01-5	None
Trichloroethene	6	79-01-6	0.005
Dibromochloromethane		124-48-1	None
1,1,2-trichloroethane		79-00-5	None
Benzene	6	71-43-2	0.005
trans-1,3-dichloropropene		10061-02-6	None
Bromoform		75-25-2	None
2-hexanone		591-78-6	None
4-methyl-2-pentanone		108-10-1	None
Tetrachloroethene		127-18-4	None
Toluene		108-88-3	None
Chlorobenzene		108-90-7	None
Ethyl benzene		100-41-4	None
Styrene		100-42-5	None
Xylenes (total)		133-02-7	None

[a]Maximum contaminant level effective 7/8/87.

Table 5.8. Pesticides and polychlorinated biphenyls (hazardous substance list) sought in groundwater

Parameter	Reference	Chemical Abstracts Service No.	Applicable standards (mg/L)
Alpha-BHC		319-84-6	None
Beta-BHC		319-85-7	None
Delta-BHC		319-86-8	None
Gamma-BHC (Lindane)		58-89-9	None
Heptachlor		76-44-8	None
Aldrin		309-00-2	None
Heptachlor epoxide		1024-57-3	None
Endrin		72-20-8	None
Dieldrin		60-57-1	None
4,4'-DDE		72-55-9	None
Endosulfan I		959-98-8	0.0002
Endosulfan II		33213-65-9	None
4,4'-DDD		72-54-8	None
Endosulfan sulfate		1031-07-8	None
4,4'-DDT		50-29-3	None
Endrin ketone		53494-70-5	None
Methoxychlor		72-43-5	0.1
Alpha-chlordane		5103-71-9	None
Gamma-chlordane		5103-74-2	None
Toxaphene		8001-35-2	0.005
Aroclor-1016		12674-11-2	None
Aroclor-1221		11104-28-2	None
Aroclor-1232		11141-16-5	None
Aroclor-1242		53469-21-9	None
Aroclor-1248		12672-29-6	None
Aroclor-1254		11097-69-1	None
Aroclor-1260		11096-82-5	None

Table 5.9. Base/neutral/acid extractable organics (hazardous substance list) sought in groundwater

Parameter	Reference	Chemical Abstracts Service No.	Applicable[a] standards (mg/L)
Phenol		108-95-2	None
bis(2-chloroethyl) ether		111-44-4	None
2-chlorophenol		95-57-8	None
1,3-dichlorobenzene		541-73-1	None
1,4-dichlorobenzene	6	106-46-7	0.075
Benzyl alcohol		100-51-6	None
1,2-dichlorobenzene		95-50-1	None
2-methylphenol		95-48-7	None
bis(2-chloroisopropyl)ether		39638-32-9	None
4-methylphenol		106-44-5	None
N-Nitroso-di-n-propylamine		621-64-7	None
Hexachloroethane		67-72-1	None
Nitrobenzene		98-95-3	None
Isophorone		78-59-1	None
2-nitrophenol		88-75-5	None
2,4-dimethylphenol		105-67-9	None
Benzoic acid		65-85-0	None
bis(2-chloroethoxy) methane		111-91-1	None
2,4-dichlorophenol		120-83-2	None
1,2,4-trichlorobenzene		120-82-1	None
Naphthalene		91-20-3	None
4-chloroaniline		106-47-8	None
Hexachlorobutadiene		87-68-3	None
4-chloro-3-methylphenol (para-chloro-meta-cresol)		59-50-7	None
2-methylnaphthalene		91-57-6	None
Hexachlorocyclopentadiene		77-47-4	None
2,4,6-trichlorophenol		88-06-2	None
2,4,5-trichlorophenol		95-95-4	None
2-chloronaphthalene		91-58-7	None
2-nitroaniline		88-74-4	None
Dimethyl phthalate		131-11-3	None
Acenaphthylene		208-96-8	None
2,6-dinitrotoluene		606-20-2	None
3-nitroaniline		99-09-2	None
Acenaphthene		83-32-9	None
2,4-dinitrophenol		51-28-5	None
4-nitrophenol		100-02-7	None
Dibenzofuran		132-64-9	None
2,4-dinitrotoluene		121-14-2	None
Diethylphthalate		84-66-2	None
4-chlorophenyl phenyl ether		7005-72-3	None
Fluorene		86-73-7	None
4-nitroaniline		100-01-6	None
4,6-dinitro-2-methylphenol		534-52-1	None
N-nitrosodiphenylamine		86-30-6	None
4-bromophenyl phenyl ether		101-55-3	None
Hexachlorobenzene		118-74-1	None
Pentachlorophenol		87-86-5	None
Phenanthrene		85-01-8	None
Anthracene		120-12-7	None
Di-*n*-butylphthalate		84-74-2	None
Fluoranthene		206-44-0	None
Pyrene		129-00-0	None

Table 5.9 (continued)

Parameter	Reference	Chemical Abstracts Service No.	Applicable[a] standards (mg/L)
Butyl benzyl phthalate		85-68-7	None
3,3'-dichlorobenzidine		91-94-1	None
Benzo[*a*]anthracene		56-55-3	None
Chrysene		218-01-9	None
bis(2-ethylhexyl)phthalate		117-81-7	None
Di-n-octyl phthalate		117-84-0	None
Benzo[*b*]fluoranthene		205-99-2	None
Benzo[*k*]fluoranthene		207-08-9	None
Benzo[*a*]pyrene		50-32-8	None
Indeno(1,2,3-cd)pyrene		193-39-5	None
Dibenz[*a,h*]anthracene		53-70-3	None
Benzo[*g,h,i*]perylene		191-24-2	None

[a]Maximum contaminant level effective 7/8/87.

Table 5.10. Radionuclides and radioactive metals sought in groundwater

Parameter	Reference	Applicable standards[a] (pCi/L)
Gross alpha radiation	1, 2, 4	15
Gross beta radiation (mrem/yr)	1, 2, 4	4[b]
Gross gamma radiation		None
^{226}Ra and ^{228}Ra	1, 2, 4	5
^{137}Cs	5	3,000
^{90}Sr	5, 2	1,000; 8.0
^{60}Co	5	10,000
Tritium	5, 2	2,000,000; 20,000
^{99}Tc	5	100,000
^{239}Pu	5	30
^{235}U	5	600
Total uranium (mg/L)	5	0.89[c]

[a]Maximum contaminant level.
[b]Maximum contaminant level in the absence of ^{90}Sr and alpha emitters = 1,000 pCi/L.
[c]Converted from DOE 5400.5 values.

Table 5.11. Other typical parameters that may be included in groundwater studies

Parameter	Reference	Applicable standards (mg/L)
Alkalinity (CO_3)		None
Alkalinity (HCO_3)		None
Total phosphorus		None
Solids:		
Total		None
Suspended		None
Dissolved	3	500
Turbidity (JTU)	2	1.0
Total Kjeldahl nitrogen		None
Ammonia (as N)		None
Chemical oxygen demand		None
MBAS		None

Table 5.12. Constituents in groundwater at the Y-12 Plant site Upper East Fork Poplar Creek Hydrogeologic Regime (UEFPCHR), 1991

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Beta-4 Security Pit							
Iron, total (mg/L)	12	12	48	0.11	8	0.3	11
Manganese, total (mg/L)	12	12	15	0.016	2.6	0.05	11
Selenium, total (mg/L)	1	12	0.16	<0.050	0.16	0.01	1
Turbidity (NTU)	*a*	12	130	3.7	52	5	10
1,2-Dichloroethene, total (µg/L)	4	12	36	<5	25	*b*	*a*
Methylene chloride (µg/L)	4	12	17	<5	16	*b*	*a*
Tetrachloroethene (µg/L)	1	12	5	<5	5	*b*	*a*
New Hope Pond							
Arsenic, total (mg/L)	2	58	0.10	<0.050	0.076	0.05	2
Chromium, total (mg/L)	12	58	1.1	<0.010	0.16	0.05	5
Iron, total (mg/L)	56	58	19	<0.0050	1.6	0.3	36
Lead, total (mg/L)	15	58	0.063	<0.0080	0.017	0.05	1
Manganese, total (mg/L)	54	58	1.5	<0.0010	0.23	0.05	29
Selenium, total (mg/L)	1	58	0.096	<0.050	0.096	0.01	1
Silver, total (mg/L)	2	58	0.078	<0.0060	0.043	0.05	1
Chloride (mg/L)	58	58	750	2	44	250	2
Dissolved solids (mg/L)	58	58	710	180	360	500	3
pH	*a*	58	9.4	6.3	7.3	6.5/8.5	7
Sulfate (mg/L)	57	58	830	<10	34	250	1
Turbidity (NTU)	*a*	58	1.7 E3	0.20	65	5	32
1,2-Dichloroethene, total (µg/L)	11	58	97	<5	38	*b*	*a*
Acetone (µg/L)	4	58	170	<10	63	*b*	*a*
Carbon tetrachloride (µg/L)	31	58	7.1 E3	<5	1.8 E3	5	31
Chloroform (µg/L)	23	58	830	<5	220	*b*	*a*
Methylene chloride (µg/L)	4	58	42	<5	30	*b*	*a*
Tetrachloroethene (µg/L)	24	58	390	<5	110	*b*	*a*
Toluene (µg/L)	3	58	70	<5	54	*b*	*a*
Trichloroethene (µg/L)	9	58	150	<5	67	5	9
^{234}U (pCi/L)	*a*	17	450	0.00	35	*b*	*a*
^{238}U (pCi/L)	*a*	17	280	0.00	22	*b*	*a*
Gross alpha (pCi/L)	*a*	58	550	–0.50	20	15	6
Gross beta (pCi/L)	*a*	58	340	0.76	17	50	3
Strontium (pCi/L)	*a*	2	17	2.7	9.6	8	1
Rust Garage Area							
Chromium, total (mg/L)	4	5	0.21	<0.010	0.10	0.05	2
Iron, total (mg/L)	5	5	5.9	0.11	2.8	0.3	3
Manganese, total (mg/L)	5	5	3.6	0.086	1.2	0.05	5
pH	*a*	5	6.5	4.5	5.8	6.5/8.5	3
Turbidity (NTU)	*a*	5	360	4.7	130	5	4
Acetone (µg/L)	1	5	23	<10	23	*b*	*a*
Benzene (µg/L)	1	5	1.8 E4	<5	1.8 E4	5	1
Ethylbenzene (µg/L)	1	5	6.6 E3	<5	6.6 E3	*b*	*a*
Toluene (µg/L)	1	5	4.5 E4	<5	4.5 E4	*b*	*a*
Xylenes (µg/L)	1	5	4.4 E4	<5	4.4 E4	*b*	*a*
Gross alpha (pCi/L)	*a*	5	21	1.5	10	15	1

Table 5.12 (UEFPCHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
			S2 Site				
Arsenic, total (mg/L)	1	14	0.071	<0.050	0.071	0.05	1
Cadmium, total (mg/L)	6	14	5	<0.010	1.7	0.01	6
Copper, total (mg/L)	13	14	130	<0.0040	18	1	2
Iron, total (mg/L)	12	14	2.7	<0.0050	0.72	0.3	7
Lead, total (mg/L)	8	14	0.055	<0.0040	0.018	0.05	1
Manganese, total (mg/L)	14	14	40	0.0050	7	0.05	8
Mercury, total (mg/L)	3	14	0.0090	<0.00020	0.0052	0.002	2
Selenium, total (mg/L)	1	14	0.053	<0.050	0.053	0.01	1
Zinc, total (mg/L)	14	14	7.1	0.0060	1	5	2
Chloride (mg/L)	13	14	360	<10	41	250	1
Dissolved solids (mg/L)	14	14	3.3 E3	22	740	500	6
Nitrate-N (mg/L)	14	14	1.0 E3	0.2	100	10	6
pH	*a*	14	7.6	5.2	6.9	6.5/8.5	2
Sulfate (mg/L)	14	14	650	2	61	250	1
Turbidity (NTU)	*a*	14	85	0.70	29	5	12
1,2-Dichloroethene, total (μg/L)	4	14	88	<5	48	*b*	*a*
4-Methyl-2-pentanone (μg/L)	1	14	16	<10	16	*b*	*a*
Carbon tetrachloride (μg/L)	6	14	20	<5	14	5	6
Chloroform (μg/L)	6	14	35	<5	16	*b*	*a*
Methylene chloride (μg/L)	2	14	16	<5	16	*b*	*a*
Tetrachloroethene (μg/L)	6	14	660	<5	380	*b*	*a*
Trichloroethene (μg/L)	6	14	360	<5	180	5	6
^{234}U (pCi/L)	*a*	4	0.43	0.00	0.32	*b*	*a*
^{238}U (pCi/L)	*a*	4	0.81	0.00	0.20	*b*	*a*
Gross alpha (pCi/L)	*a*	14	230	0.16	29	15	4
Gross beta (pCi/L)	*a*	14	93	1.9	21	50	2
			S3 ponds				
Cadmium, total (mg/L)	4	16	0.027	<0.010	0.020	0.01	4
Chromium, total (mg/L)	2	16	0.054	<0.010	0.036	0.05	1
Iron, total (mg/L)	16	16	3.2	0.0080	0.68	0.3	9
Manganese, total (mg/L)	15	16	2	<0.0010	0.77	0.05	8
Dissolved solids (mg/L)	16	16	2.0 E4	10	1.4 E3	500	1
pH	*a*	16	10	5.7	7.4	6.5/8.5	6
Turbidity (NTU)	*a*	16	70	0.48	16	5	9
1,2-Dichloroethane (μg/L)	1	16	1.1 E3	<5	1.1 E3	5	1
1,2-Dichloroethene, total (μg/L)	14	16	1.2 E3	<5	350	*b*	*a*
4-Methyl-2-pentanone (μg/L)	1	16	26	<10	26	*b*	*a*
Methylene chloride (μg/L)	2	16	160	<5	120	*b*	*a*
Tetrachloroethene (μg/L)	12	16	960	<5	370	*b*	*a*
Toluene (μg/L)	1	16	13	<5	13	*b*	*a*
Trichloroethene (μg/L)	11	16	330	<5	140	5	11

Table 5.12 (UEFPCHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Underground Storage Tank Pgm.							
Barium, total (mg/L)	76	76	39	0.038	1.8	1	4
Cadmium, total (mg/L)	13	76	0.040	<0.0020	0.0099	0.01	4
Chromium, total (mg/L)	34	76	7.2	<0.050	0.82	0.05	17
Iron, total (mg/L)	76	76	110	0.087	8.2	0.3	70
Lead, total (mg/L)	29	76	0.10	<0.0040	0.022	0.05	3
Manganese, total (mg/L)	76	76	14	0.021	2.8	0.05	75
Mercury, total (mg/L)	10	76	0.0048	<0.00020	0.0011	0.002	1
Selenium, total (mg/L)	1	76	0.091	<5	0.091	0.01	1
Chloride (mg/L)	71	76	330	<100	41	250	3
Dissolved solids (mg/L)	76	76	3.4 E4	38	1.8 E3	500	19
Nitrate-N (mg/L)	28	76	1.5 E4	<2	1.0 E3	10	7
pH	*a*	76	8	5	7	6.5/8.5	21
Turbidity (NTU)	*a*	76	2.9 E3	0.3	230	5	62
1,1,2,2-Tetrachloroethane (µg/L)	1	76	29	<5	29	*b*	*a*
1,1-Dichloroethane (µg/L)	2	76	71	<5	43	*b*	*a*
1,1-Dichloroethene (µg/L)	4	76	2.4 E3	<5	2.1 E3	7	4
1,2-Dichloroethane (µg/L)	2	76	940	<5	520	5	2
1,2-Dichloroethene, total (µg/L)	7	76	1.1 E3	<5	390	*b*	*a*
2-Hexanone (µg/L)	1	76	220	<10	220	*b*	*a*
4-Methyl-2-pentanone (µg/L)	5	76	1.4 E3	<10	420	*b*	*a*
Acetone (µg/L)	1	76	17	<10	17	*b*	*a*
Benzene (µg/L)	33	76	1.0 E4	<5	2.7 E3	5	33
Chloroform (µg/L)	8	76	37	<5	26	*b*	*a*
Chloromethane (µg/L)	5	76	530	<10	230	*b*	*a*
Ethylbenzene (µg/L)	28	76	1.6 E3	<5	440	*b*	*a*
Methylene chloride (µg/L)	21	76	1.7 E3	<5	330	*b*	*a*
Tetrachloroethene (µg/L)	13	76	170	<5	54	*b*	*a*
Toluene (µg/L)	32	76	5.5 E3	<5	1.2 E3	*b*	*a*
Trichloroethene (µg/L)	15	76	1.7 E4	<5	3.9 E3	5	14
Vinyl acetate (µg/L)	2	76	2.6 E3	<10	1.3 E3	*b*	*a*
Vinyl chloride (µg/L)	1	76	38	<10	38	2	1
Xylenes (µg/L)	34	76	8.7 E3	<5	2.1 E3	*b*	*a*
^{234}U (pCi/L)	*a*	7	250	–17	33	*b*	*a*
^{237}Np (pCi/L)	*a*	5	4.6	–2.9	0.83	*b*	*a*
^{238}U (pCi/L)	*a*	7	290	–2.4	41	*b*	*a*
^{241}Am (pCi/L)	*a*	5	0.86	–0.38	0.23	*b*	*a*
Gross alpha (pCi/L)	*a*	76	290	–2	10	15	8
Gross beta (pCi/L)	*a*	76	850	–3.9	38	50	4
Strontium (pCi/L)	*a*	5	370	–3.7	97	8	2
Tritium (pCi/L)	*a*	2	2.0 E5	4.9 E3	1.0 E5	20,000	1

Table 5.12 (UEFPCHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
U.S. Geological Survey sites							
Iron, total (mg/L)	35	35	49	0.040	6.2	0.3	27
Lead, total (mg/L)	13	35	0.30	<0.0080	0.052	0.05	4
Manganese, total (mg/L)	31	35	4	<0.0010	0.52	0.05	13
Chloride (mg/L)	33	35	520	<1	54	250	4
Dissolved solids (mg/L)	35	35	1.2 E3	230	450	500	7
pH	*a*	35	9.2	6.2	7.3	6.5/8.5	8
Turbidity (NTU)	*a*	35	3.0 E3	0.40	280	5	24
Acetone (μg/L)	3	35	45	<10	23	*b*	*a*
Carbon tetrachloride (μg/L)	4	35	100	<5	74	5	4
Chloroform (μg/L)	4	35	28	<5	13	*b*	*a*
Tetrachloroethene (μg/L)	3	35	10	<5	8	*b*	*a*
Toluene (μg/L)	1	35	7	<5	7	*b*	*a*
Trichloroethene (μg/L)	2	35	6	<5	6	5	1
^{234}U (pCi/L)	*a*	18	4.9	0.00	0.92	*b*	*a*
^{238}U (pCi/L)	*a*	18	4.3	–0.46	0.52	*b*	*a*
Gross alpha (pCi/L)	*a*	35	46	–0.42	4.3	15	2
Gross beta (pCi/L)	*a*	35	71	–0.45	8.7	50	1
Waste coolant facilities							
Chromium, total (mg/L)	6	20	0.57	<0.010	0.13	0.05	2
Iron, total (mg/L)	20	20	6.6	0.011	0.84	0.3	13
Manganese, total (mg/L)	20	20	0.91	0.0030	0.17	0.05	16
pH	*a*	20	7.7	6	6.9	6.5/8.5	3
Turbidity (NTU)	*a*	20	130	0.17	36	5	12
1,1,1-Trichloroethane (μg/L)	10	20	500	<5	220	200	4
1,1-Dichloroethane (μg/L)	8	20	210	<5	110	*b*	*a*
1,1-Dichloroethene (μg/L)	10	20	300	<5	200	7	9
1,2-Dichloroethene, total (μg/L)	14	20	1.3 E4	<5	5.4 E3	*b*	*a*
Acetone (μg/L)	1	20	1.5 E3	<10	1.5 E3	*b*	*a*
Chloroform (μg/L)	1	20	5	<5	5	*b*	*a*
Methylene chloride (μg/L)	7	20	1.6 E3	<5	520	*b*	*a*
Tetrachloroethene (μg/L)	14	20	2.2 E3	<5	820	*b*	*a*
Toluene (μg/L)	1	20	72	<5	72	*b*	*a*
Trichloroethene (μg/L)	14	20	1.4 E3	<5	690	5	14
Vinyl chloride (μg/L)	6	20	450	<10	250	2	6
Y-12 Salvage Yard							
Chromium, total (mg/L)	3	16	0.40	<0.010	0.28	0.05	3
Iron, total (mg/L)	16	16	2.4	0.048	0.77	0.3	11
Manganese, total (mg/L)	16	16	0.062	0.0020	0.032	0.05	2
Dissolved solids (mg/L)	16	16	680	190	350	500	4
Turbidity (NTU)	*a*	16	70	2.4	13	5	11
1,2-Dichloroethene, total (μg/L)	1	16	46	<5	46	*b*	*a*
Methylene chloride (μg/L)	2	16	15	<5	15	*b*	*a*
^{234}U (pCi/L)	*a*	8	0.88	–0.44	0.11	*b*	*a*
^{238}U (pCi/L)	*a*	8	0.46	0.00	0.22	*b*	*a*

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

Table 5.13. Constituents in groundwater at the Y-12 Plant site Bear Creek Hydrogeologic Regime (BCHR), 1991

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Bear Creek Springs							
Iron, total (mg/L)	19	20	1.5	<0.0050	0.22	0.3	2
Manganese, total (mg/L)	20	20	0.57	0.0020	0.057	0.05	5
Dissolved solids (mg/L)	20	20	950	81	330	500	4
Nitrate-N (mg/L)	14	20	57	<10	21	10	7
Turbidity (NTU)	NA	20	28	0.060	4.8	5	4
Trichloroethene (µg/L)	2	19	13	<5	10	5	2
^{234}U (pCi/L)	NA	20	17	–0.43	3.9	NR	NA
^{238}U (pCi/L)	NA	20	21	–0.43	5.6	NR	NA
Gross alpha (pCi/L)	NA	20	32	–0.44	12	15	8
Gross beta (pCi/L)	NA	20	120	–5.3	40	50	6
Bear Creek Surface Water							
Arsenic, total (mg/L)	3	20	0.060	<0.050	0.055	0.05	2
Iron, total (mg/L)	20	20	30	0.013	1.8	0.3	6
Manganese, total (mg/L)	20	20	5.7	0.0080	0.62	0.05	11
Selenium, total (mg/L)	1	20	0.066	<0.050	0.066	0.01	1
Dissolved solids (mg/L)	20	20	960	36	310	500	4
Nitrate-N (mg/L)	16	20	74	<0.2	23	10	7
pH	*a*	20	8.1	6.4	7.3	6.5/8.5	1
Turbidity (NTU)	*a*	20	100	0.75	11	5	8
1,2-Dichloroethene, total (µg/L)	3	20	11	<5	8	*b*	*a*
^{234}U (pCi/L)	*a*	20	33	0.00	7.1	*b*	*a*
^{238}U (pCi/L)	*a*	20	83	–0.44	16	*b*	*a*
Gross alpha (pCi/L)	*a*	20	77	–1	28	15	12
Gross beta (pCi/L)	*a*	20	270	–5	73	50	8
Exit Pathway- Traverse A							
Iron, total (mg/L)	9	9	3.3	0.021	0.71	0.3	2
Manganese, total (mg/L)	9	9	0.46	0.0010	0.079	0.05	3
Nitrate-N (mg/L)	8	9	20	<0.2	8.4	10	2
pH	*a*	9	7.9	6.2	7	6.5/8.5	2
Turbidity (NTU)	*a*	9	41	0.25	8.5	5	4
Methylene chloride (µg/L)	1	9	16	<5	16	*b*	*a*
Gross alpha (pCi/L)	*a*	9	28	1.4	11	15	2
Gross beta (pCi/L)	*a*	9	93	–2.4	28	50	1
Exit Pathway- Traverse B							
Iron, total (mg/L)	18	18	230	0.37	16	0.3	18
Lead, total (mg/L)	3	18	0.25	<0.0040	0.091	0.05	1
Manganese, total (mg/L)	18	18	3.5	0.0070	0.32	0.05	9
Selenium, total (mg/L)	1	18	0.67	<0.050	0.67	0.01	1
Dissolved solids (mg/L)	18	18	960	210	430	500	6
Nitrate-N (mg/L)	17	18	84	<1	16	10	6
pH	*a*	18	9	7	8	6.5/8.5	4
Turbidity (NTU)	*a*	18	450	1.4	58	5	15
1,2-Dichloroethene, total (µg/L)	2	18	38	<5	25	*b*	*a*
Acetone (µg/L)	4	18	180	<10	80	*b*	*a*
Methylene chloride (µg/L)	5	18	17	<5	16	*b*	*a*
Trichloroethene (µg/L)	8	18	79	<5	42	5	8
Gross alpha (pCi/L)	*a*	18	58	–0.62	14	15	5
Gross beta (pCi/L)	*a*	18	200	0.86	38	50	4

Table 5.13 (BCHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Exit Pathway—Traverse W							
Iron, total (mg/L)	3	3	15	5.4	11	0.3	3
Manganese, total (mg/L)	3	3	0.14	0.065	0.11	0.05	3
Chloride (mg/L)	3	3	1.6 E3	45	740	250	2
Dissolved solids (mg/L)	3	3	6.0 E3	900	3.8 E3	500	3
Sulfate (mg/L)	3	3	2.2 E3	46	890	250	2
Turbidity (NTU)	*a*	3	95	54	72	5	3
Gross alpha (pCi/L)	*a*	3	32	1.8	19	15	2
Lysimeter Demo							
Arsenic, total (mg/L)	1	20	0.061	<0.50	0.061	0.05	1
Barium, total (mg/L)	19	20	2.1	<0.0010	0.61	1	3
Iron, total (mg/L)	20	20	32	0.0060	3.5	0.3	12
Lead, total (mg/L)	4	20	0.066	<0.0040	0.032	0.05	1
Manganese, total (mg/L)	18	20	2.5	<0.010	0.36	0.05	15
Selenium, total (mg/L)	2	20	0.086	<0.50	0.075	0.01	2
Dissolved solids (mg/L)	20	20	4.4 E3	100	1.0 E3	500	4
Nitrate-N (mg/L)	4	20	3.3 E3	<0.2	1.3 E3	10	4
pH	*a*	20	8.2	5.9	7.2	6.5/8.5	2
Turbidity (NTU)	*a*	20	340	0.65	42	5	10
Acetone (μg/L)	2	20	49	<10	36	*b*	*a*
Methylene chloride (μg/L)	4	20	17	<5	16	*b*	*a*
Gross beta (pCi/L)	*a*	20	400	1	50	50	4
Oil Landfarm							
Arsenic, total (mg/L)	4	112	0.071	<0.050	0.066	0.05	4
Chromium, total (mg/L)	18	112	0.44	<0.011	0.053	0.05	2
Iron, total (mg/L)	111	112	82	<0.0040	3	0.3	59
Lead, total (mg/L)	28	112	0.16	<0.0060	0.022	0.05	3
Manganese, total (mg/L)	105	112	16	<0.0010	0.42	0.05	33
Mercury, total (mg/L)	4	112	0.0097	<0.00020	0.0026	0.002	1
Selenium, total (mg/L)	3	112	0.17	<0.050	0.096	0.01	3
Silver, total (mg/L)	5	112	0.13	<0.0060	0.031	0.05	1
Dissolved solids (mg/L)	111	111	1.0 E3	100	400	500	27
Fluoride (mg/L)	69	112	270	<0.1	4.5	4	5
Nitrate-N (mg/L)	40	112	170	<10	33	10	17
pH	*a*	112	11.1	3.9	7.1	6.5/8.5	32
Sulfate (mg/L)	107	112	470	<10	47	250	7
Turbidity (NTU)	*a*	112	800	0.20	42	5	56
1,1-Dichloroethane (μg/L)	6	112	5	<5	5	*b*	*a*
1,1-Dichloroethene (μg/L)	9	112	16	<5	9	7	4
1,2-Dichloroethene, total (μg/L)	14	112	52	<5	24	*b*	*a*
Acetone (μg/L)	4	112	21	<10	17	*b*	*a*
Carbon tetrachloride (μg/L)	4	112	8	<5	7	5	3
Chlorobenzene (μg/L)	2	112	8	<5	7	*b*	*a*
Methylene chloride (μg/L)	5	112	32	<5	19	*b*	*a*
Tetrachloroethene (μg/L)	3	112	6	<5	5	*b*	*a*
Toluene (μg/L)	1	111	6	<5	6	*b*	*a*
Trichloroethene (μg/L)	33	112	400	<5	88	5	33
^{234}U (pCi/L)	*a*	8	3.3	0	0.62	*b*	*a*
^{237}Np (pCi/L)	*a*	1	2	2	2	*b*	*a*
^{238}U (pCi/L)	*a*	8	0.87	0	0.32	*b*	*a*
Gross alpha (pCi/L)	*a*	112	48	–0.82	3.7	15	6
Gross beta (pCi/L)	*a*	112	89	–2.5	13	50	6

Table 5.13 (BCHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
			Rust Spoil Area				
Arsenic, total (mg/L)	1	20	0.068	<0.050	0.068	0.05	1
Iron, total (mg/L)	19	20	8.1	<0.0050	0.88	0.3	5
Manganese, total (mg/L)	19	20	3.6	<0.0010	0.69	0.05	7
Dissolved solids (mg/L)	20	20	670	150	430	500	8
Nitrate-N (mg/L)	16	20	18	<0.2	9	10	9
pH	*a*	20	12.5	6.3	7.4	6.5/8.5	4
Turbidity (NTU)	*a*	20	75	0.20	8.2	5	5
1,2-Dichloroethene, total (μg/L)	10	20	34	<	13	*b*	*a*
Chloroform (μg/L)	2	20	5	<	5	*b*	*a*
Trichloroethene (μg/L)	16	20	80	<	41	5	16
$^{125}I + ^{129}I$ (Bq/L)	*a*	16	0.10	0.010	0.061	*b*	*a*
Gross beta (pCi/L)	*a*	20	57	–0.78	21	50	1
			S3 ponds				
Arsenic, total (mg/L)	2	51	0.095	<	0.073	0.05	1
Barium, total (mg/L)	51	51	390	0.0010	31	1	13
Cadmium, total (mg/L)	10	51	4	<0.0020	0.81	0.01	6
Chromium, total (mg/L)	6	51	0.31	<0.010	0.17	0.05	4
Copper, total (mg/L)	23	51	1.6	<4	0.26	1	3
Iron, total (mg/L)	47	51	25	<	2.7	0.3	27
Lead, total (mg/L)	17	51	1.3	<0.0040	0.082	0.05	1
Manganese, total (mg/L)	47	51	210	<0.010	15	0.05	25
Mercury, total (mg/L)	7	51	0.11	<0.00020	0.027	0.002	3
Selenium, total (mg/L)	1	51	0.079	<	0.079	0.01	1
Zinc, total (mg/L)	44	51	20	<0.20	0.71	5	1
Chloride (mg/L)	42	51	440	<100	64	250	3
Dissolved solids (mg/L)	50	51	6.2 E4	<1	7.1 E3	500	27
Fluoride (mg/L)	24	51	110	<0.1	7	4	8
Nitrate-N (mg/L)	28	51	1.1 E4	<0.2	2.1 E3	10	23
pH	*a*	51	9.9	3.7	7.4	6.5/8.5	21
Sulfate (mg/L)	45	51	1.8 E3	<5.0 E3	95	250	3
Turbidity (NTU)	*a*	51	85	0.40	10	5	30
Acetone (μg/L)	10	51	1.3 E3	<10	250	*b*	*a*
Chloroform (μg/L)	2	51	38	<	36	*b*	*a*
Methylene chloride (μg/L)	5	51	310	<	160	*b*	*a*
Tetrachloroethene (μg/L)	3	51	7.1 E3	<	6.1 E3	*b*	*a*
Toluene (μg/L)	1	51	35	<	35	*b*	*a*
Trichloroethene (μg/L)	1	51	6	<	6	5	1
$^{125}I + ^{129}I$ (Bq/L)	*a*	2	0.10	0.10	0.10	*b*	*a*
^{234}U (pCi/L)	*a*	18	4.7 E3	–0.43	690	*b*	*a*
^{237}Np (pCi/L)	*a*	8	1.1 E3	0.00	300	*b*	*a*
^{238}U (pCi/L)	*a*	18	1.4 E4	0.00	1.7 E3	*b*	*a*
^{239}Pu (pCi/L)	*a*	2	41	0.00	21	30	1
^{241}Am (pCi/L)	*a*	4	28	0.86	15	*b*	*a*
Gross alpha (pCi/L)	*a*	52	1.5 E4	–11	820	15	9
Gross beta (pCi/L)	*a*	52	7.5 E4	–25	3.5 E3	50	9
Strontium (pCi/L)	*a*	8	240	–9.9	93	8	4
Tritium (pCi/L)	*a*	8	8.4 E4	27	1.3 E4	20,000	1

Table 5.13 (BCHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
			Spoil Area I				
Arsenic, total (mg/L)	1	24	0.052	<0.050	0.052	0.05	1
Dissolved solids (mg/L)	24	24	520	180	280	500	1
Nitrate-N (mg/L)	18	24	34	<0.2	6	10	3
1,2-Dichloroethene, total (μg/L)	9	24	140	<	40	*b*	*a*
Acetone (μg/L)	1	24	22	<10	22	*b*	*a*
Methylene chloride (μg/L)	2	24	17	<	16	*b*	*a*
Tetrachloroethene (μg/L)	12	24	38	<	17	*b*	*a*
Trichloroethene (μg/L)	8	24	15	<	8	5	8
^{234}U (pCi/L)	*a*	2	0.48	0.00	0.24	*b*	*a*
^{238}U (pCi/L)	*a*	2	0.48	0.00	0.24	*b*	*a*
Gross beta (pCi/L)	*a*	24	160	–1.4	19	50	3
			U.S. Geological Survey sites				
Iron, total (mg/L)	6	6	13	0.062	3.7	0.3	3
Manganese, total (mg/L)	6	6	0.13	0.0040	0.041	0.05	1
Zinc, total (mg/L)	6	6	5.1	0.0050	1.2	5	1
Dissolved solids (mg/L)	6	6	1.4 E3	46	530	500	2
pH	*a*	6	7.2	3	5.6	6.5/8.5	4
Sulfate (mg/L)	6	6	1.2 E3	1	360	250	2
Turbidity (NTU)	*a*	6	550	4	130	5	4
			Y-12 Burial grounds				
Arsenic, total (mg/L)	4	186	0.077	<	0.061	0.05	4
Barium, total (mg/L)	184	186	1.6	<0.10	0.15	1	1
Cadmium, total (mg/L)	16	186	0.058	<0.0020	0.011	0.01	4
Chromium, total (mg/L)	34	186	0.71	<0.010	0.087	0.05	8
Iron, total (mg/L)	184	186	110	<0.0050	3.1	0.3	126
Lead, total (mg/L)	59	186	0.56	<0.0040	0.027	0.05	5
Manganese, total (mg/L)	183	186	1.5	<0.10	0.19	0.05	116
Selenium, total (mg/L)	2	186	0.066	<	0.062	0.01	2
Chloride (mg/L)	146	186	3.5 E3	<	130	250	11
Dissolved solids (mg/L)	186	186	5.2 E3	48	460	500	28
Fluoride (mg/L)	123	186	14	<0.1	1	4	10
Nitrate-N (mg/L)	23	186	20	<	5	10	3
pH	*a*	186	10.8	3	7.3	6.5/8.5	81
Turbidity (NTU)	*a*	186	1.0 E3	0.15	42	5	119
1,1,1-Trichloroethane (μg/L)	10	186	610	<	170	200	4
1,1-Dichloroethane (μg/L)	26	186	3.2 E3	<	290	*b*	*a*
1,1-Dichloroethene (μg/L)	9	186	660	<	140	7	7
1,2-Dichloroethane (μg/L)	1	186	8	<	8	5	1
1,2-Dichloroethene, total (μg/L)	21	186	800	<	120	*b*	*a*
Acetone (μg/L)	7	186	130	<10	41	*b*	*a*
Benzene (μg/L)	3	186	420	<	190	5	3
Carbon tetrachloride (μg/L)	1	186	50	<	50	5	1
Chloroethane (μg/L)	5	186	33	<10	17	*b*	*a*
Chloroform (μg/L)	3	186	38	<	16	*b*	*a*
Ethylbenzene (μg/L)	2	186	33	<	23	*b*	*a*
Methylene chloride (μg/L)	24	186	61	<	18	*b*	*a*

Table 5.13 (BCHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Y-12 Burial grounds (continued)							
Tetrachloroethene (µg/L)	23	186	2.5 E4	<5	2.0 E3	*b*	*a*
Toluene (µg/L)	2	186	670	<5	340	*b*	*a*
Trichloroethene (µg/L)	16	186	1.5 E4	<5	1.8 E3	5	15
Vinyl chloride (µg/L)	8	186	180	<10	59	2	8
Xylenes (µg/L)	2	186	130	<5	91	*b*	*a*
^{234}U (pCi/L)	*a*	34	3.5	–0.44	0.45	*b*	*a*
^{237}Np (pCi/L)	*a*	1	1.3	1.3	1.3	*b*	*a*
^{238}U (pCi/L)	*a*	34	4.5	–0.88	0.29	*b*	*a*
^{241}Am (pCi/L)	*a*	1	0.40	0.40	0.40	*b*	*a*
Gross alpha (pCi/L)	*a*	186	31	–27	2.3	15	5
Gross beta (pCi/L)	*a*	186	83	–35	4.9	50	2
Strontium (pCi/L)	*a*	1	24	24	24	8	1

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

Table 5.14. Constituents in groundwater at the Y-12 Plant site Chestnut Ridge Hydrogeologic Regime (CRHR), 1991

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
			Ash Disposal Basin				
Iron, total (mg/L)	16	16	0.59	0.015	0.16	0.3	1
Turbidity (NTU)	*a*	16	6.7	0.24	2.7	5	2
Methylene chloride (µg/L)	1	16	17	<5	17	*b*	*a*
			Chestnut Ridge Security Pit				
Iron, total (mg/L)	64	68	8.4	<0.0050	0.50	0.3	16
Lead, total (mg/L)	10	68	0.093	<0.0040	0.022	0.05	1
Manganese, total (mg/L)	48	68	0.26	<0.0010	0.020	0.05	4
pH	*a*	68	8.7	6.2	7.3	6.5/8.5	10
Turbidity (NTU)	*a*	68	1.3 E3	0.20	47	5	19
1,1,1-Trichloroethane (µg/L)	35	68	480	<5	120	200	10
1,1-Dichloroethane (µg/L)	25	68	130	<5	53	*b*	*a*
1,1-Dichloroethene (µg/L)	16	68	130	<5	57	7	16
1,2-Dichloroethene, total (µg/L)	6	68	51	<5	21	*b*	*a*
Chloroform (µg/L)	1	68	5	<5	5	*b*	*a*
Tetrachloroethene (µg/L)	34	68	73	<5	23	*b*	*a*
Toluene (µg/L)	1	68	6	<5	6	*b*	*a*
Trichloroethene (µg/L)	2	68	9	<5	8	5	2
^{234}U (pCi/L)	*a*	2	0.44	0.43	0.44	*b*	*a*
^{238}U (pCi/L)	*a*	2	0.44	0.00	0.22	*b*	*a*
			East CR Waste Pile				
Iron, total (mg/L)	16	16	4.8	0.014	0.68	0.3	4
pH	*a*	16	8.2	6.3	7.2	6.5/8.5	4
Turbidity (NTU)	*a*	16	50	0.28	7	5	4
Acetone (µg/L)	1	16	71	<10	71	*b*	*a*
			Kerr Hollow Quarry				
Iron, total (mg/L)	26	27	140	<0.0050	6.4	0.3	13
Lead, total (mg/L)	5	27	0.13	<0.0040	0.032	0.05	1
Manganese, total (mg/L)	23	27	1	<0.0010	0.086	0.05	5
Selenium, total (mg/L)	1	27	0.89	<0.050	0.89	0.01	1
Turbidity (NTU)	*a*	27	100	0.15	16	5	17
Acetone (µg/L)	1	27	11	<10	11	*b*	*a*
Methylene chloride (µg/L)	2	27	17	<5	17	*b*	*a*
Gross alpha (pCi/L)	*a*	27	16	-0.15	5.5	15	1
			Landfill II				
Chromium, total (mg/L)	4	9	0.056	<0.010	0.034	0.05	2
Iron, total (mg/L)	9	9	380	0.019	45	0.3	6
Lead, total (mg/L)	4	9	0.26	<0.0040	0.11	0.05	2
Manganese, total (mg/L)	7	9	13	<0.0010	2.1	0.05	6
Mercury, total (mg/L)	3	9	0.0039	<0.00020	0.0024	0.002	2
Selenium, total (mg/L)	1	9	0.63	<0.050	0.63	0.01	1
Dissolved solids (mg/L)	9	9	590	150	350	500	2
pH	*a*	9	8.8	6.9	7.8	6.5/8.5	2
Turbidity (NTU)	*a*	9	1.3 E4	0.35	2.7 E3	5	6
1,1-Dichloroethane (µg/L)	3	9	35	<5	27	b	*a*
Methylene chloride (µg/L)	1	9	16	<5	16	b	*a*
Tetrachlorocthene (µg/L)	1	9	5	<5	5	*b*	*a*
Gross alpha (pCi/L)	*a*	9	26	0.77	7.7	15	2

Table 5.14 (CRHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
			Landfill II Expansion				
Arsenic, total (mg/L)	1	31	0.34	<0.050	0.34	0.05	1
Iron, total (mg/L)	31	31	6.6	0.0090	0.51	0.3	11
Manganese, total (mg/L)	24	31	0.54	<0.0010	0.035	0.05	2
Selenium, total (mg/L)	1	31	0.16	<0.050	0.16	0.01	1
Silver, total (mg/L)	2	31	0.19	<0.0060	0.15	0.05	2
pH	*a*	32	11.7	6.5	7.8	6.5/8.5	3
Turbidity (NTU)	*a*	32	200	0.15	16	5	13
Acetone (μg/L)	1	32	25	<10	25	*b*	*a*
Gross alpha (pCi/L)	*a*	32	35	–0.62	2.8	15	1
Gross beta (pCi/L)	*a*	32	86	0.37	8.5	50	1
			Landfill III				
Cadmium, total (mg/L)	1	28	0.030	<0.0020	0.030	0.01	1
Chromium, total (mg/L)	7	28	4	<0.010	0.66	0.05	4
Iron, total (mg/L)	26	28	31	<0.0050	3.9	0.3	15
Lead, total (mg/L)	9	28	6.4	<0.0040	0.77	0.05	3
Manganese, total (mg/L)	21	28	7.8	<0.0010	0.46	0.05	9
Dissolved solids (mg/L)	28	28	680	90	210	500	1
pH	*a*	28	8.3	6	7.2	6.5/8.5	6
Turbidity (NTU)	*a*	28	1.6 E4	0.46	640	5	15
Acetone (μg/L)	3	28	18	<10	14	*b*	*a*
Benzene (μg/L)	1	28	7	<5	7	5	1
Methylene chloride (μg/L)	1	28	16	<5	16	*b*	*a*
^{234}U (pCi/L)	*a*	4	2	0.00	0.72	*b*	*a*
^{238}U (pCi/L)	*a*	4	0.82	–0.41	0.21	*b*	*a*
Gross alpha (pCi/L)	*a*	28	83	–0.050	5.9	15	2
Gross beta (pCi/L)	*a*	28	140	–0.040	13	50	2
			Landfill IV				
Arsenic, total (mg/L)	1	20	0.064	<0.050	0.064	0.05	1
Iron, total (mg/L)	18	20	13	<0.0050	1.1	0.3	10
Manganese, total (mg/L)	15	20	0.32	<0.0010	0.039	0.05	2
Turbidity (NTU)	*a*	20	270	0.20	29	5	11
Acetone (μg/L)	3	20	18	<10	17	*b*	*a*
^{234}U (pCi/L)	*a*	10	1.2	–0.46	0.12	*b*	*a*
^{238}U (pCi/L)	*a*	10	1.3	0.00	0.34	*b*	*a*
			Rogers Quarry				
Iron, total (mg/L)	8	8	1.3	0.026	0.45	0.3	3
Manganese, total (mg/L)	8	8	0.16	0.0020	0.055	0.05	3
Dissolved solids (mg/L)	8	8	540	240	370	500	2
Turbidity (NTU)	*a*	8	15	0.50	6.5	5	4

Table 5.14 (CRHR continued)

Parameter	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Sediment Disposal Basin							
Arsenic, total (mg/L)	1	31	0.058	<0.050	0.058	0.05	1
Iron, total (mg/L)	31	31	6	0.033	1	0.3	16
Lead, total (mg/L)	7	31	0.30	<0.0040	0.056	0.05	1
Manganese, total (mg/L)	28	31	0.37	<0.0010	0.058	0.05	9
pH	*a*	124	9.7	5.8	7.5	6.5/8.5	32
Turbidity (NTU)	*a*	31	1.2 E3	1.4	68	5	22
Acetone (μg/L)	4	31	77	<10	37	*b*	*a*
Diethylphthalate (μg/L)	1	28	13	<10	13	*b*	*a*
^{234}U (pCi/L)	*a*	2	0.87	0.48	0.68	*b*	*a*
^{238}U (pCi/L)	*a*	2	0.95	–0.44	0.26	*b*	*a*
United Nuclear Site							
Arsenic, total (mg/L)	1	24	0.070	<0.050	0.070	0.05	1
Iron, total (mg/L)	24	24	6.3	0.0080	0.63	0.3	4
Manganese, total (mg/L)	15	24	0.18	<0.0010	0.026	0.05	3
Turbidity (NTU)	*a*	24	110	0.25	10	5	5
Methylene chloride (μg/L)	2	24	16	<5	16	*b*	*a*
^{234}U (pCi/L)	*a*	14	15	–0.43	1.6	*b*	*a*
^{238}U (pCi/L)	*a*	14	20	–0.48	1.3	*b*	*a*

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

Table 5.15. Constituents in Waste Area Grouping (WAG) 1 groundwater at ORNL, March 7–26, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Chloride	23	23	68	1.5	19*	250	0[3]
Fluoride	20	23	3.4	0.10	0.52*	4.0	0[2]
Nitrate	4	23	8.3	1.6	5.4*	10	0[2]
Phosphate	1	23	2.2	2.2	2.2	*e*	[*e*]
Sulfate as SO_4	22	23	110	2.0	36*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	23	23	0.96	0.15	0.42*	*e*	[*e*]
Dissolved oxygen (ppm)	23	23	5.4	0.010	2.0*	*e*	[*e*]
Redox (mV)	23	23	210	–200	50*	*e*	[*e*]
Temperature (°C)	23	23	18	10	14*	31	0[1]
Turbidity (JTU)	23	23	910	110	430*	1.0	23[2]
pH (standard units)	23	23	9.0	6.6	7.3*	(6.5, 8.5)	1[3]
Metals, filtered (mg/L)							
Aluminum	3	23	0.26	0.071	0.15	0.20	1[3]
Barium	23	23	0.43	0.023	0.14*	2.0	0[2]
Beryllium	9	23	0.00092	0.00042	0.00065*	*e*	[*e*]
Boron	1	1	1.0	1.0	1.0	*e*	[*e*]
Calcium	23	23	170	1.3	89*	*e*	[*e*]
Chromium	16	23	0.019	0.0055	0.013*	0.050	0[1]
Iron	11	23	19	0.067	4.8*	0.30	9[3]
Magnesium	23	23	31	0.47	7*	*e*	[*e*]
Manganese	16	23	7.2	0.0019	1.7*	0.050	10[3]
Nickel	4	23	0.0062	0.0043	0.0049*	0.10	0[1]
Potassium	23	23	7.5	0.35	1.8*	*e*	[*e*]
Silicon	1	1	5.6	5.6	5.6	*e*	[*e*]
Silver	2	23	0.0061	0.0054	0.0058*	0.050	0[1]
Sodium	20	23	260	5.8	41*	*e*	[*e*]
Strontium	1	1	1.3	1.3	1.3	*e*	[*e*]
Vanadium	6	23	0.0032	0.0021	0.0027*	*e*	[*e*]
Zinc	11	23	0.019	0.0052	0.0079*	5.0	0[1]
Metals, unfiltered (mg/L)							
Aluminum	6	23	0.29	0.059	0.18*	0.20	3[3]
Barium	23	23	0.33	0.025	0.12*	2.0	0[2]
Beryllium	9	23	0.00082	0.00052	0.00068*	*e*	[*e*]
Calcium	23	23	170	1.5	88*	*e*	[*e*]
Chromium	17	23	0.019	0.0054	0.013*	0.050	0[1]
Iron	18	23	18	0.054	3.0*	0.30	12[3]
Magnesium	23	23	30	0.55	16*	*e*	[*e*]
Manganese	20	23	6.4	0.0017	1.3*	0.050	10[3]
Nickel	5	23	0.0078	0.0040	0.0053*	0.10	0[1]
Potassium	23	23	7.0	0.40	1.7*	*e*	[*e*]
Silver	3	23	0.0068	0.0056	0.0062*	0.050	0[1]
Sodium	20	23	300	5.2	43*	*e*	[*e*]
Vanadium	7	23	0.0038	0.0023	0.0032*	*e*	[*e*]
Zinc	8	23	0.024	0.0054	0.011*	5.0	0[1]

Table 5.15 (WAG 1 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Others, filtered							
Solids, total dissolved (mg/L)	23	23	720	180	400*	500	6[1]
Others, unfiltered							
Alkalinity (mg/L)	23	23	450	150	300*	*e*	[*e*]
Carbon, total organic (mg/L)	23	23	4.3	0.70	1.9*	*e*	[*e*]
Halides, total organic (μg/L)	12	23	44	5.0	16*	*e*	[*e*]
Nitrogen, total Kjeldahl (mg/L)	13	23	3.1	0.13	0.92*	*e*	[*e*]
Solids, total suspended (mg/L)	12	23	39	5.0	14*	*e*	[*e*]
Sulfide, total (mg/L)	15	23	4.5	0.16	0.68*	*e*	[*e*]
Pesticides and PCBs, unfiltered (μg/L)							
Endosulfan sulfate	2	23	JB 0.040	JB 0.010	0.025	*e*	[*e*]
Heptachlor	2	23	J 0.033	JB 0.010	0.022	*e*	[*e*]
gamma-BHC (Lindane)	1	23	JB 0.030	JB 0.030	0.030	*e*	[*e*]
Radionuclides, filtered (g/L)							
U-Total	1	1	0.000021	0.000021	0.000021	*e*	[*e*]
Radionuclides, unfiltered (g/L)							
U-Total	1	1	0.000031	0.000031	0.000031	*e*	[*e*]
Radionuclides, filtered (pCi/L)							
^{60}Co	2	23	86	46	66	200	0[4]
Gross alpha	9	23	300	1.3	35	15	1[2]
Gross beta	15	23	14,000	3.0	950	50	3[2]
$^{89}Sr + ^{90}Sr$	8	18	6,500	3.2	840	40	5[4]
^{234}U	1	1	300	300	300	20	1[4]
^{235}U	1	1	1.1	1.1	1.1	24	0[4]
^{238}U	1	1	7.0	7.0	7.0	24	0[4]
Radionuclides[f], unfiltered (pCi/L)							
^{60}Co	1	23	57	57	57	200	0[4]
^{137}Cs	1	23	54	54	54	120	0[4]
Gross alpha	11	23	260	1.4	26	15	1[2]
Gross beta	12	23	14,000	3.2	1,200	50	3[2]
^{3}H	14	23	6,500	840	2,400*	80,000	0[4]
$^{89}Sr + ^{99}Sr$	9	17	6,800	3.5	770	40	4[4]
^{234}U	1	1	300	300	300	20	1[4]
^{235}U	1	1	1.6	1.6	1.6	24	0[4]
^{238}U	1	1	10	10	10	24	0[4]
Tentatively identified compounds, unfiltered (μg/L)							
Toluene-solvent in std. solns.-7.07	1	1	JB 470	JB 470	470	*e*	[*e*]
Toluene-solvent in std. solns.-7.08	1	1	JB 490	JB 490	490	*e*	[*e*]
Toluene-solvent in std. solns.-7.09	2	2	JB 230	JB 190	210*	*e*	[*e*]
Toluene-solvent in std. solns.-7.1	2	2	JB 470	JB 270	370	*e*	[*e*]
Toluene-solvent in std. solns.-7.11	1	1	JB 180	JB 180	180	*e*	[*e*]
Unknown-10.3	1	1	J 140	J 140	140	*e*	[*e*]
Unknown-25.16	1	1	J 17	J 17	17	*e*	[*e*]
Unknown-7.95	1	1	J 33	J 33	33	*e*	[*e*]
Unknown-8.16	2	2	J 220	J 13	120	*e*	[*e*]
Unknown-8.17	1	1	J 28	J 28	28	*e*	[*e*]
Unknown-8.9	1	1	J 12	J 12	12	*e*	[*e*]
Unknown-9.1	1	1	J 9.0	J 9.0	9.0	*e*	[*e*]

Table 5.15 (WAG 1 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Volatile organics, unfiltered (µg/L)							
1,2-Dichloroethene	1	23	J 3.0	J 3.0	3.0	*e*	[*e*]
Carbon disulfide	1	23	J 3.0	J 3.0	3.0	*e*	[*e*]
Carbon tetrachloride	1	23	J 2.0	J 2.0	2.0	5.0	0[2]
Chloroform	3	23	8.0	J 3.0	4.7	100	0[2]
Methylene chloride	2	23	JB 1.0	JB 1.0	1.0	*e*	[*e*]
Trichloroethene	4	23	6.0	J 2.0	3.8*	5.0	1[2]
Upgradient wells							
Anions, unfiltered (mg/L)							
Chloride	3	3	11	2.3	5.8	250	0[3]
Fluoride	3	3	0.60	0.10	0.43	4.0	0[2]
Nitrate	1	3	5.5	5.5	5.5	10	0[2]
Sulfate (as SO_4)	3	3	36	20	27*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	3	3	0.41	0.28	0.33*	*e*	[*e*]
Dissolved oxygen (ppm)	3	3	6.7	0.70	2.7	*e*	[*e*]
Redox (mV)	3	3	200	–200	62	*e*	[*e*]
Temperature (°C)	3	3	15	14	15*	31	0[1]
Turbidity (JTU)	3	3	1,000	140	650	1.0	3[2]
pH (standard units)	3	3	7.8	6.9	7.4*	(6.5, 8.5)	0[3]
Metals, filtered (mg/L)							
Barium	3	3	0.30	0.037	0.17	2.0	0[2]
Calcium	3	3	110	49	84*	*e*	[*e*]
Chromium	3	3	0.018	0.0041	0.012	0.050	0[1]
Cobalt	1	3	0.0047	0.0047	0.0047	*e*	[*e*]
Iron	1	3	0.25	0.25	0.25	0.30	0[3]
Magnesium	3	3	31	7.5	21*	*e*	[*e*]
Manganese	2	3	0.0069	0.0034	0.0052	0.050	0[3]
Potassium	3	3	1.1	0.66	0.88*	*e*	[*e*]
Sodium	2	3	18	5.7	12	*e*	[*e*]
Vanadium	2	3	0.0035	0.0021	0.0028	*e*	[*e*]
Zinc	3	3	0.0087	0.0069	0.0075*	5.0	0[1]
Metals, unfiltered (mg/L)							
Barium	3	3	0.24	0.11	0.18*	2.0	0[2]
Calcium	3	3	110	45	86*	*e*	[*e*]
Chromium	3	3	0.015	0.0052	0.012*	0.050	0[1]
Iron	2	3	0.055	0.054	0.055*	0.30	0[3]
Magnesium	3	3	29	8.0	21*	*e*	[*e*]
Manganese	2	3	0.0058	0.0027	0.0042	0.050	0[3]
Nickel	1	3	0.0042	0.0042	0.0042	0.10	0[1]
Potassium	3	3	1.2	0.68	0.96*	*e*	[*e*]
Sodium	2	3	17	7.9	13	*e*	[*e*]
Zinc	2	3	0.013	0.0060	0.0093	5.0	0[1]

Table 5.15 (WAG 1 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Others, filtered							
Solids, total dissolved (mg/L)	3	3	400	300	340*	500	0[1]
Others, unfiltered							
Alkalinity (mg/L)	3	3	350	250	280*	*e*	[*e*]
Carbon, total organic (mg/L)	3	3	1.2	0.80	1.0*	*e*	[*e*]
Nitrogen, total Kjeldahl (mg/L)	1	3	0.45	0.45	0.45	*e*	[*e*]
Sulfide, total (mg/L)	2	3	0.64	0.16	0.40	*e*	[*e*]
Pesticides and PCBs, unfiltered (μg/L)							
beta-BHC	1	3	1.7	1.7	1.7	*e*	[*e*]
delta-BHC	1	3	0.29	0.29	0.29	*e*	[*e*]
Radionuclides[f], filtered (pCi/L)							
Gross alpha	1	3	1.8	1.8	1.8	15	0[2]
Gross beta	2	3	3.8	3.5	3.6*	50	0[2]
Radionuclides[f], unfiltered (pCi/L)							
^{60}Co	2	3	68	46	57	200	0[4]
Gross alpha	1	3	2.4	2.4	2.4	15	0[2]
^{3}H	3	3	3,200	1,300	2,400*	80,000	0[4]
$^{89}Sr + ^{90}Sr$	1	3	3.2	3.2	3.2	40	0[4]
Volatile organics, unfiltered (μg/L)							
Chloroform	1	3	J 1.0	J 1.0	1.0	100	0[2]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is coded as:

1. Rules of Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.16. Constituents in Waste Area Grouping (WAG) 2, groundwater at ORNL, June 7–21, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells							
Anions, unfiltered (mg/L)							
Chloride	7	8	31	0.80	9.1*	250	0[3]
Fluoride	4	8	2.0	0.10	0.65	4.0	0[2]
Nitrate	2	8	13	4.5	8.6	10	1[2]
Sulfate (as SO_4)	7	8	32	1.0	11*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	8	8	0.59	0.21	0.44*	*e*	[*e*]
Dissolved oxygen (ppm)	8	8	9.3	2.8	4.5*	*e*	[*e*]
Redox (mV)	8	8	200	88	150*	*e*	[*e*]
Temperature (°C)	8	8	17	14	15*	30	0[1]
Turbidity (JTU)	8	8	230	55	190*	1.0	8[2]
pH (standard units)	8	8	9.0	6.1	7.2*	(6.5, 8.5)	3[3]
Metals, filtered (mg/L)							
Aluminum	8	8	0.34	0.075	0.13*	0.20	1[3]
Barium	8	8	0.97	0.023	0.29*	2.0	0[2]
Boron	3	8	1.1	0.14	0.46	*e*	[*e*]
Calcium	8	8	160	0.68	68*	*e*	[*e*]
Chromium	4	8	0.014	0.0046	0.010*	0.050	0[1]
Copper	1	8	0.010	0.010	0.010	1.0	0[1]
Iron	7	8	23	0.15	5.7	0.30	3[3]
Magnesium	8	8	24	0.24	9.7*	*e*	[*e*]
Manganese	8	8	1.2	0.0047	0.23	0.050	4[3]
Nickel	2	8	0.18	0.0092	0.095	0.10	1[1]
Potassium	8	8	6.5	1.5	3.0*	*e*	[*e*]
Silicon	8	8	9.9	3.7	7.0*	*e*	[*e*]
Sodium	8	8	210	6.7	56*	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	8	8	10	0.077	2.6	0.20	4[3]
Barium	8	8	0.95	0.042	0.34*	2.0	0[2]
Beryllium	2	8	0.0018	0.0013	0.0015*	*e*	[*e*]
Boron	3	8	0.95	0.15	0.43	*e*	[*e*]
Calcium	8	8	170	1.3	69*	*e*	[*e*]
Chromium	7	8	0.063	0.0050	0.019*	0.050	1[1]
Cobalt	1	8	0.011	0.011	0.011	*e*	[*e*]
Copper	1	8	0.012	0.012	0.012	1.0	0[1]
Iron	8	8	36	0.068	8.2	0.30	6[3]
Magnesium	8	8	23	0.31	9.8*	*e*	[*e*]
Manganese	8	8	1.4	0.0071	0.27	0.050	5[3]

Table 5.16 (WAG 2 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Nickel	5	8	0.18	0.0043	0.045	0.10	1[1]
Potassium	8	8	3,000	0.92	380	*e*	[*e*]
Silicon	8	8	26	3.4	11*	*e*	[*e*]
Sodium	7	8	190	11	59*	*e*	[*e*]
Vanadium	3	8	0.021	0.0021	0.0095	*e*	[*e*]
Zinc	4	8	0.045	0.0080	0.034*	5.0	0[1]
Others, filtered							
Alkalinity (mg/L)	8	8	440	110	290*	*e*	[*e*]
Others, unfiltered (mg/L)							
Alkalinity	8	8	440	110	290*	*e*	[*e*]
Ammonia	8	8	11	0.030	1.5	*e*	[*e*]
Carbon, total organic	8	8	4.7	0.50	1.3*	*e*	[*e*]
Cyanide, total	1	8	0.010	0.010	0.010	*e*	[*e*]
Halides, total organic	4	8	6.8	5.3	6.1*	*e*	[*e*]
Solids, total dissolved	7	8	480	91	300*	500	0[1]
Solids, total suspended	3	8	610	33	250	*e*	[*e*]
Radionuclides,[f] filtered (pCi/L)							
^{60}Co	2	8	59	41	50	200	0[4]
Gross alpha	3	8	3.0	2.5	2.8*	15	0[2]
Gross beta	4	8	1,600	3.2	400	50	1[2]
^{3}H	5	8	180,000	760	71,000	20,000	3[2]
$^{89}Sr + ^{90}Sr$	1	8	760	760	760	8.0	1[2]
Radionuclides,[f] unfiltered (pCi/L)							
Gross alpha	4	8	4.9	1.7	2.8*	15	0[2]
Gross beta	5	8	1,600	3.2	330	50	1[2]
^{3}H	5	8	180,000	780	72,000	20,000	3[2]
$^{89}Sr + ^{90}Sr$	3	8	860	2.1	290	8.0	1[2]
Tentatively identified compounds, unfiltered (µg/L)							
Unknown-6.09	1	1	J 6.0	J 6.0	6.0	*e*	[*e*]
Unknown-6.13	2	2	J 21	J 5.0	13	*e*	[*e*]
Volatile Organics, unfiltered (µg/L)							
Acetone	5	8	J 3.0	JB 2.0	2.6*	*e*	[*e*]
Benzene	1	8	J 1.0	J 1.0	1.0	5.0	0[2]
Carbon disulfide	1	8	J 1.0	J 1.0	1.0	*e*	[*e*]
Vinyl te	1	8	J 1.0	J 1.0	1.0	*e*	[*e*]

Table 5.16 (WAG 2 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Upgradient wells				
Anions, unfiltered (mg/L)							
Chloride	10	10	300	1.0	33	250	1[3]
Fluoride	6	10	0.50	0.10	0.25*	4.0	0[2]
Sulfate (as SO_4)	10	10	68	5.3	27*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	10	10	0.51	0.24	0.37*	*e*	[*e*]
Dissolved oxygen (ppm)	10	10	8.9	3.5	5.5*	*e*	[*e*]
Redox (mV)	10	10	190	160	180*	*e*	[*e*]
Temperature (°C)	10	10	15	13	14*	30	0[1]
Turbidity (JTU)	10	10	230	190	220*	1.0	10[2]
pH (standard units)	10	10	8.8	6.3	7.0*	(6.5, 8.5)	2[3]
Metals, filtered (mg/L)							
Aluminum	10	10	0.29	0.055	0.11*	0.20	1[3]
Antimony	2	10	0.0050	0.0050	0.0050	*e*	[*e*]
Barium	10	10	0.61	0.039	0.21*	2.0	0[2]
Boron	4	10	0.84	0.14	0.34	*e*	[*e*]
Calcium	10	10	130	1.1	65*	*e*	[*e*]
Chromium	7	10	0.012	0.0047	0.0088*	0.050	0[1]
Cobalt	1	10	0.0092	0.0092	0.0092	*e*	[*e*]
Copper	1	10	0.014	0.014	0.014	1.0	0[1]
Iron	6	10	9.1	0.14	1.8	0.30	4[3]
Magnesium	10	10	29	0.37	13*	*e*	[*e*]
Manganese	10	10	14	0.0052	1.6	0.050	6[3]
Nickel	5	10	0.019	0.0057	0.0089*	0.10	0[1]
Potassium	10	10	5.3	1.7	3.1*	*e*	[*e*]
Silicon	10	10	9.6	3.5	6.9*	*e*	[*e*]
Sodium	9	10	190	5.6	47*	*e*	[*e*]
Vanadium	1	10	0.0028	0.0028	0.0028	*e*	[*e*]
Zinc	2	10	0.038	0.0070	0.023	5.0	0[1]
Metals, unfiltered (mg/L)							
Aluminum	10	10	0.94	0.066	0.25*	0.20	4[3]
Arsenic	1	10	0.010	0.010	0.010	0.050	0[2]
Barium	10	10	0.62	0.036	0.22*	2.0	0[2]
Boron	4	10	0.84	0.15	0.34	*e*	[*e*]
Calcium	10	10	120	1.5	63*	*e*	[*e*]
Chromium	8	10	0.013	0.0047	0.0088*	0.050	0[1]
Cobalt	1	10	0.0069	0.0069	0.0069	*e*	[*e*]
Copper	1	10	0.0089	0.0089	0.0089	1.0	0[1]
Iron	10	10	8.5	0.17	1.2	0.30	8[3]

Table 5.16 (WAG 2 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Magnesium	10	10	25	0.55	12*	*e*	[*e*]
Manganese	10	10	12	0.012	1.4	0.050	6[3]
Nickel	9	10	0.017	0.0045	0.0078*	0.10	0[1]
Potassium	10	10	4.2	0.42	2.0*	*e*	[*e*]
Silicon	10	10	9.8	4.0	7.0*	*e*	[*e*]
Sodium	9	10	180	6.3	46*	*e*	[*e*]
Vanadium	1	10	0.0039	0.0039	0.0039	*e*	[*e*]
Zinc	5	10	0.034	0.0052	0.014*	5.0	0[1]
Others, filtered							
Alkalinity (mg/L)	10	10	390	140	270*	*e*	[*e*]
Others, unfiltered (mg/L)							
Alkalinity	10	10	390	140	270*	*e*	[*e*]
Ammonia	10	10	0.74	0.050	0.19*	*e*	[*e*]
Carbon, total organic	8	10	2.0	0.50	0.96*	*e*	[*e*]
Halides, total organic	4	10	12	7.0	9.4*	*e*	[*e*]
Solids, total dissolved	10	10	510	190	340*	500	1[1]
Solids, total suspended	3	10	17	6.0	9.7	*e*	[*e*]
Radionuclides,[f] filtered (pCi/L)							
^{60}Co	1	10	51	51	51	200	0[4]
^{137}Cs	1	10	59	59	59	120	0[4]
Gross alpha	7	10	19	1.5	6.9*	15	1[2]
Gross beta	10	10	17	3.5	8.8*	50	0[2]
^{3}H	5	10	300,000	570	61,000	20,000	1[2]
$^{89}Sr + ^{90}Sr$	6	10	5.1	2.2	3.9*	8.0	0[2]
Radionuclides,[f] unfiltered (pCi/L)							
^{60}Co	2	10	73	65	69*	200	0[4]
Gross alpha	7	10	14	2.1	6.2*	15	0[2]
Gross beta	8	10	30	5.7	12*	50	0[2]
^{3}H	7	10	270,000	680	40,000	20,000	1[2]
$^{89}Sr + ^{90}Sr$	6	10	9.5	2.1	4.2*	8.0	1[2]
Tentatively identified compounds, unfiltered (μg/L)							
Unknown-6.13	1	1	J 7.0	J 7.0	7.0	*e*	[*e*]

Table 5.16 (WAG 2 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Volatile organics, unfiltered (µg/L)							
1,1,2,2-Tetrachloroethane	1	10	J 1.0	J 1.0	1.0	*e*	[*e*]
2-Hexanone	1	10	J 2.0	J 2.0	2.0	*e*	[*e*]
4-Methyl-2-pentanone	1	10	J 1.0	J 1.0	1.0	*e*	[*e*]
Acetone	2	10	JB 5.0	JB 4.0	4.5*	*e*	[*e*]
Benzene	2	10	J 2.0	J 2.0	2.0	5.0	0[2]
Carbon disulfide	3	10	13	J 2.0	7.3	*e*	[*e*]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.17. Constituents in Waste Area Grouping (WAG) 3 groundwater at ORNL, August 5–29, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Chloride	11	11	370	0.65	81*	250	2[3]
Fluoride	10	11	1.3	0.20	0.54*	4.0	0[2]
Nitrate	1	11	5.5	5.5	5.5	10	0[2]
Sulfate (as SO_4)	11	11	150	3.8	43*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	11	11	1.2	0.23	0.60*	*e*	[*e*]
Dissolved oxygen (ppm)	11	11	12	2.9	7.5*	*e*	[*e*]
Redox (mV)	11	11	190	120	160*	*e*	[*e*]
Temperature (°C)	11	11	16	14	15*	30	0[1]
Turbidity (JTU)	11	11	370	59	190*	1.0	11[2]
pH (standard units)	11	11	10	6.6	7.4*	(6.5, 8.5)	1[3]
Metals, filtered (mg/L)							
Aluminum	9	11	0.28	0.056	0.10*	0.20	1[3]
Arsenic	1	11	0.014	0.014	0.014	0.050	0[2]
Barium	11	11	0.77	0.0027	0.18*	2.0	0[2]
Beryllium	1	11	0.0011	0.0011	0.0011	*e*	[*e*]
Boron	8	11	2.7	0.094	0.74*	*e*	[*e*]
Calcium	11	11	180	0.37	110*	*e*	[*e*]
Chromium	9	11	0.022	0.0090	0.013*	0.050	0[1]
Cobalt	1	11	0.0080	0.0080	0.0080	*e*	[*e*]
Copper	5	11	0.032	0.0081	0.016*	1.0	0[1]
Iron	6	11	2.0	0.11	0.72*	0.30	4[3]
Magnesium	11	11	65	0.054	27*	*e*	[*e*]
Manganese	11	11	2.8	0.0014	0.43	0.050	5[3]
Nickel	3	11	0.041	0.0040	0.017	0.10	0[1]
Potassium	11	11	22	2.2	6.9*	*e*	[*e*]
Silicon	11	11	16	5.2	7.4*	*e*	[*e*]
Sodium	11	11	120	7.8	45*	*e*	[*e*]
Vanadium	4	11	0.016	0.0029	0.0092*	*e*	[*e*]
Zinc	1	11	0.036	0.036	0.036	5.0	0[1]
Metals, unfiltered (mg/L)							
Aluminum	9	11	1.3	0.076	0.44*	0.20	4[3]
Arsenic	2	11	0.012	0.010	0.011*	0.050	0[2]
Barium	11	11	0.73	0.013	0.18*	2.0	0[2]
Beryllium	3	11	0.0012	0.0011	0.0011*	*e*	[*e*]
Boron	8	11	2.7	0.091	0.71	*e*	[*e*]
Calcium	11	11	170	1.7	110*	*e*	[*e*]
Chromium	10	11	0.024	0.0059	0.013*	0.050	0[1]
Cobalt	2	11	0.014	0.0041	0.0089	*e*	[*e*]
Copper	4	11	0.028	0.010	0.017*	1.0	0[1]

Table 5.17 (WAG 3 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Iron	10	11	26	0.055	3.2	0.30	7[3]
Magnesium	11	11	61	0.40	26*	*e*	[*e*]
Manganese	11	11	2.9	0.0061	0.45	0.050	5[3]
Nickel	5	11	0.047	0.0071	0.017*	0.10	0[1]
Potassium	11	11	21	1.4	4.6*	*e*	[*e*]
Selenium	1	11	0.0085	0.0085	0.0085	0.010	0[1]
Silicon	11	11	18	4.8	7.4*	*e*	[*e*]
Sodium	10	11	110	12	46*	*e*	[*e*]
Vanadium	2	11	0.017	0.0087	0.013	*e*	[*e*]
Zinc	4	11	0.076	0.0074	0.029	5.0	0[1]
Others, filtered							
Alkalinity (mg/L)	11	11	430	190	310*	*e*	[*e*]
Solids, total dissolved (mg/L)	11	11	970	280	480*	500	5[1]
Others, unfiltered							
Alkalinity (mg/L)	11	11	420	110	300*	*e*	[*e*]
Carbon, total organic (mg/L)	10	11	3.9	0.50	1.4*	*e*	[*e*]
Halides, total organic (μg/L)	6	11	250	5.3	67	*e*	[*e*]
Solids, total suspended (mg/L)	3	11	21	5.0	14*	*e*	[*e*]
Radionuclides[f], filtered (pCi/L)							
^{60}Co	1	11	49	49	49	200	0[4]
Gross alpha	6	11	11	1.7	4.0*	15	0[2]
Gross beta	11	11	1,200	5.4	210*	50	4[2]
^{3}H	8	11	32,000	840	5,200	20,000	1[2]
$^{89}Sr + ^{90}Sr$	7	11	620	2.2	140	8.0	4[2]
Radionuclides[f], unfiltered (pCi/L)							
Gross alpha	6	11	16	1.4	4.5	15	1[2]
Gross beta	10	11	1,300	7.6	230	50	4[2]
^{3}H	8	11	32,000	890	5,200	20,000	1[2]
$^{89}Sr + ^{90}Sr$	7	11	650	2.6	150	8.0	4[2]
Tentatively identified compounds, unfiltered (μg/L)							
Benzenesulfonamide,n-butyl-22	1	1	J 8.0	J 8.0	8.0	*e*	[*e*]
Benzenesulfonamide,n-butyl-22	1	1	J 9.0	J 9.0	9.0	*e*	[*e*]
Propane,2,2′-oxybis-19.51	1	1	J 780	J 780	780	*e*	[*e*]
Propane,2,2′-oxybis-19.54	1	1	J 22	J 22	22	*e*	[*e*]
Propane,2,2′-oxybis-19.52	1	1	J 50	J 50	50	*e*	[*e*]
Propane,2,2′-oxybis-19.58	1	1	J 24	J 24	24	*e*	[*e*]
Unknown-6.12	1	1	J 7.0	J 7.0	7.0	*e*	[*e*]

Table 5.17 (WAG 3 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells (continued)				
Volatile organics, unfiltered (µg/L)							
1,1,1-Trichloroethane	3	11	B 5.0	JB 4.0	4.7*	200	0[2]
1,2-Dichloroethene	2	11	15	J 2.0	8.5	*e*	[*e*]
Carbon disulfide	1	11	J 1.0	J 1.0	1.0	*e*	[*e*]
Chloroform	1	11	J 3.0	J 3.0	3.0	100	0[2]
Trichloroethene	1	11	18	18	18	5.0	1[2]
			Upgradient wells				
Chloride	3	3	6.7	1.4	3.5	250	0[3]
Fluoride	1	3	1.6	1.6	1.6	4.0	0[2]
Sulfate (as SO_4)	3	3	17	6.0	11*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	3	3	0.40	0.14	0.28*	*e*	[*e*]
Dissolved oxygen (ppm)	3	3	5.0	4.4	4.7*	*e*	[*e*]
Redox (mV)	3	3	210	180	190*	*e*	[*e*]
Temperature (°C)	3	3	16	14	14*	30	0[1]
Turbidity (JTU)	3	3	220	32	140	1.0	3[2]
pH (standard units)	3	3	6.9	6.1	6.6*	(6.5, 8.5)	1[3]
Metals, filtered (mg/L)							
Aluminum	3	3	0.099	0.078	0.086*	0.20	0[3]
Barium	3	3	0.061	0.019	0.039*	2.0	0[2]
Calcium	3	3	140	79	110*	*e*	[*e*]
Chromium	1	3	0.0081	0.0081	0.0081	0.050	0[1]
Iron	1	3	0.76	0.76	0.76	0.30	1[3]
Magnesium	3	3	18	4.0	9.0	*e*	[*e*]
Manganese	3	3	0.14	0.0020	0.078	0.050	2[3]
Potassium	3	3	3.8	0.79	2.3	*e*	[*e*]
Silicon	3	3	5.7	2.5	4.6*	*e*	[*e*]
Sodium	1	3	6.7	6.7	6.7	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	3	3	0.64	0.27	0.41*	0.20	3[3]
Barium	3	3	0.058	0.019	0.037*	2.0	0[2]
Calcium	3	3	130	73	100*	*e*	[*e*]
Chromium	1	3	0.0063	0.0063	0.0063	0.050	0[1]
Iron	3	3	1.0	0.28	0.67*	0.30	2[3]
Magnesium	3	3	17	3.6	8.2	*e*	[*e*]
Manganese	3	3	0.14	0.0087	0.078	0.050	2[3]
Potassium	3	3	1.4	0.71	0.99*	*e*	[*e*]
Silicon	3	3	5.6	2.8	4.7*	*e*	[*e*]

Table 5.17 (WAG 3 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Others, filtered							
Alkalinity (mg/L)	3	3	390	190	290*	*e*	[*e*]
Solids, total dissolved (mg/L)	3	3	420	320	370*	500	0[1]
Others, unfiltered							
Alkalinity (mg/L)	3	3	390	190	290*	*e*	[*e*]
Carbon, total organic (mg/L)	3	3	1.6	0.78	1.1*	*e*	[*e*]
Halides, total organic (µg/L)	1	3	15	15	15	*e*	[*e*]
Solids, total suspended (mg/L)	2	3	64	14	39	*e*	[*e*]
Radionuclides[f], filtered (pCi/L)							
Gross alpha	1	3	3.2	3.2	3.2	15	0[2]
Gross beta	2	3	7.0	6.8	6.9*	50	0[2]
^{3}H	3	3	1,300	950	1,100*	20,000	0[2]
$^{89}Sr + ^{90}Sr$	3	3	3.2	1.2	2.3*	8.0	0[2]
Radionuclides[f], unfiltered (pCi/L)							
Gross alpha	1	3	4.3	4.3	4.3	15	0[2]
^{3}H	2	3	920	890	910*	20,000	0[2]
$^{89}Sr + ^{90}Sr$	3	3	2.6	1.8	2.1*	8.0	0[2]
Volatile organics, unfiltered (µg/L)							
Carbon disulfide	2	3	5.0	J 3.0	4.0	*e*	[*e*]
Methylene chloride	1	3	21	21	21	*e*	[*e*]
Tetrachloroethene	1	3	15	15	15	*e*	[*e*]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is coded as:

1. Rules of Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.18. Constituents in Waste Area Grouping (WAG) 4 groundwater at ORNL, March 5–April 8 and November 14–December 19, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Bromide	3	22	1.4	1.0	1.1*	*e*	[*e*]
Chloride	22	22	240	1.5	53*	250	0[3]
Fluoride	18	22	4.4	0.10	1.0*	4.0	1[2]
Nitrate	3	22	3.0	1.0	1.7	10	0[2]
Sulfate as SO_4	20	22	110	14	46*	250	0[3]
Base/neutral/acid extractable organics, unfiltered (µg/L)							
Diethyl phthalate	1	21	J 3.0	J 3.0	3.0	*e*	[*e*]
Field measurements, unfiltered							
Conductivity (mS/cm)	22	22	1.3	0.14	0.64*	*e*	[*e*]
Dissolved oxygen (ppm)	22	22	12	0.20	4.0*	*e*	[*e*]
Redox (mV)	22	22	160	17	97*	*e*	[*e*]
Temperature (°C)	22	22	16	12	14*	30	0[1]
Turbidity (JTU)	22	22	670	0.36	100*	1.0	21[2]
pH (standard units)	22	22	9.6	6.6	7.8*	(6.5, 8.5)	6[3]
Metals, filtered (mg/L)							
Aluminum	12	22	0.25	0.057	0.12*	0.20	1[3]
Antimony	1	22	0.0065	0.0065	0.0065	*e*	[*e*]
Barium	22	22	0.73	0.022	0.16*	2.0	0[2]
Boron	11	22	0.64	0.081	0.34*	*e*	[*e*]
Calcium	22	22	130	1.4	60*	*e*	[*e*]
Chromium	15	22	0.028	0.0045	0.016*	0.050	0[1]
Copper	3	22	0.0096	0.0081	0.0089*	1.0	0[1]
Iron	12	22	24	0.11	4.6*	0.30	9[3]
Magnesium	22	22	32	0.20	15*	*e*	[*e*]
Manganese	20	22	4.0	0.0020	0.57*	0.050	13[3]
Mercury	1	22	0.000050	0.000050	0.000050	0.00020	0[1]
Nickel	18	22	0.17	0.0040	0.064*	0.10	7[1]
Phosphorus	1	11	0.44	0.44	0.44	*e*	[*e*]
Potassium	22	22	8.2	1.7	4.1*	*e*	[*e*]
Selenium	3	22	0.0067	0.0050	0.0061*	0.010	0[1]
Silicon	22	22	15	3.4	8.3*	*e*	[*e*]
Sodium	22	22	370	9.9	110*	*e*	[*e*]
Strontium	11	11	1.5	0.083	0.60*	*e*	[*e*]
Tin	1	11	0.089	0.089	0.089	*e*	[*e*]
Vanadium	6	22	0.0049	0.0024	0.0032*	*e*	[*e*]
Zinc	2	22	0.011	0.0093	0.010*	5.0	0[1]

Table 5.18 (WAG 4 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Metals, unfiltered (mg/L)							
Aluminum	18	22	1.1	0.053	0.27*	0.20	6[3]
Arsenic	3	22	0.020	0.017	0.018*	0.050	0[2]
Barium	22	22	0.78	0.026	0.18*	2.0	0[2]
Boron	10	22	0.56	0.092	0.35*	*e*	[*e*]
Calcium	22	22	140	1.5	63*	*e*	[*e*]
Chromium	20	22	0.073	0.0058	0.019*	0.050	1[1]
Iron	22	22	24	0.072	3.0*	0.30	17[3]
Magnesium	22	22	32	0.31	15*	*e*	[*e*]
Manganese	22	22	5.2	0.0055	0.61*	0.050	13[3]
Nickel	15	22	0.17	0.0064	0.084*	0.10	7[1]
Potassium	22	22	6.2	1.5	3.1*	*e*	[*e*]
Selenium	1	22	0.016	0.016	0.016	0.010	1[1]
Silicon	22	22	15	1.8	8.4*	*e*	[*e*]
Sodium	22	22	390	10	110*	*e*	[*e*]
Strontium	11	11	1.4	0.075	0.57*	*e*	[*e*]
Vanadium	8	22	0.0076	0.0032	0.0052*	*e*	[*e*]
Zinc	12	22	0.060	0.0052	0.016*	5.0	0[1]
Others, filtered (mg/L)							
Alkalinity	22	22	590	110	330*	*e*	[*e*]
Solids, total dissolved	22	22	910	220	500*	500	10[1]
Others, unfiltered (mg/L)							
Alkalinity	22	22	590	110	330*	*e*	[*e*]
Carbon, total organic	14	22	10	0.58	2.4*	*e*	[*e*]
Halides, total organic	12	22	1,500	1.2	340*	*e*	[*e*]
Solids, total suspended	11	22	36	6.0	17*	*e*	[*e*]
Radionuclides,[f] filtered (pCi/L)							
^{60}Co	3	22	46	38	43*	200	0[4]
Gross alpha	10	22	38	2.1	10*	15	1[2]
Gross beta	18	22	1,400	4.1	150*	50	5[2]
^{3}H	16	22	10,000,000	840	2,200,000*	20,000	12[2]
$^{89}Sr + ^{90}Sr$	10	22	590	2.7	120	8.0	5[2]
Radionuclides,[f] unfiltered (pCi/L)							
^{60}Co	2	22	62	54	58*	200	0[4]
^{137}Cs	3	22	62	46	54*	120	0[4]
Gross alpha	16	22	35	2.0	7.7*	15	2[2]
Gross beta	17	22	1,400	5.9	150	50	4[2]
^{3}H	15	22	11,000,000	4,600	2,300,000*	20,000	12[2]
$^{89}Sr + ^{90}Sr$	10	22	540	4.1	110	8.0	4[2]

Table 5.18 (WAG 4 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Tentatively identified compounds, unfiltered (μg/L)							
Ethane,1,1,'-oxybis—12.73	1	1	J 8.0	J 8.0	8.0	*e*	[*e*]
Toluene-solventinstdsolns-7.11	1	1	JB 9.0	JB 9.0	9.0	*e*	[*e*]
Unknown-17.4	1	1	J 49	J 49	49	*e*	[*e*]
Unknown-17.87	1	1	J 73	J 73	73	*e*	[*e*]
Unknown-18.97	1	1	J 8.0	J 8.0	8.0	*e*	[*e*]
Unknown-19.48	1	1	J 12	J 12	12	*e*	[*e*]
Unknown-19.51	1	1	J 4.0	J 4.0	4.0	*e*	[*e*]
Unknown-20.15	1	1	J 400	J 400	400	*e*	[*e*]
Unknown-20.68	1	1	J 970	J 970	970	*e*	[*e*]
Unknown-21.79	1	1	J 5.0	J 5.0	5.0	*e*	[*e*]
Unknown-22.33	1	1	J 1.0	J 1.0	1.0	*e*	[*e*]
Unknown-22.37	1	1	J 1.0	J 1.0	1.0	*e*	[*e*]
Unknown-22.7	1	1	J 0	J 0	0	*e*	[*e*]
Unknown-23.79	1	1	J 5.0	J 5.0	5.0	*e*	[*e*]
Unknown-25.31	1	1	J 6.0	J 6.0	6.0	*e*	[*e*]
Unknown-4.35	1	1	J 6.0	J 6.0	6.0	*e*	[*e*]
Unknown-6.38	1	1	J 13	J 13	13	*e*	[*e*]
Unknown-7.46	1	1	J 16	J 16	16	*e*	[*e*]
Unknown-8.05	1	1	J 10	J 10	10	*e*	[*e*]
Unknown-8.07	1	1	J 9.0	J 9.0	9.0	*e*	[*e*]
Volatile organics unfiltered (μg/L)							
1,1-Dichloroethene	4	22	24	8.0	14*	7.0	4[2]
1,2-Dichloroethane	2	22	J 5.0	J 4.0	4.5*	5.0	0[2]
1,2-Dichloroethene	4	22	E 1,100	36	530*	*e*	[*e*]
Acetone	4	22	JB 7.0	JB 3.0	4.8*	*e*	[*e*]
Benzene	3	22	J 2.0	J 1.0	1.7*	5.0	0[2]
Carbon disulfide	6	22	7.0	JB 1.0	4.5*	*e*	[*e*]
Chlorobenzene	1	22	J 2.0	J 2.0	2.0	*e*	[*e*]
Styrene	3	22	J 1.0	J 1.0	1.0	*e*	[*e*]
Toluene	1	22	J 2.0	J 2.0	2.0	*e*	[*e*]
Trichloroethene	4	22	170	52	120*	5.0	4[2]
Vinyl chloride	5	22	Y 1,400	J 5.0	430	2.0	22[2]
Xylene, total	1	22	J 1.0	J 1.0	1.0	*e*	[*e*]

Table 5.18 (WAG 4 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells							
Anions, unfiltered (mg/L)							
Chloride	8	8	3.3	1.8	2.3*	250	0[3]
Fluoride	6	8	1.2	0.20	0.47*	4.0	0[2]
Sulfate as SO_4	8	8	65	9.5	26*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	8	8	0.34	0.040	0.19*	*e*	[*e*]
Dissolved oxygen (ppm)	8	8	9.6	0.90	5.1*	*e*	[*e*]
Redox (mV)	8	8	190	16	120*	*e*	[*e*]
Temperature (°C)	8	8	16	14	15*	30	0[1]
Turbidity (JTU)	8	8	850	88	330*	1.0	8[2]
pH (standard units)	8	8	7.7	6.2	7.0*	(6.5, 8.5)	3[3]
Metals, filtered (mg/L)							
Aluminum	4	8	0.19	0.067	0.12*	0.20	0[3]
Barium	8	8	0.28	0.032	0.17*	2.0	0[2]
Calcium	8	8	67	13	37*	*e*	[*e*]
Chromium	8	8	0.016	0.0058	0.010*	0.050	0[1]
Copper	1	8	0.012	0.012	0.012	1.0	0[1]
Iron	6	8	10	0.13	6.1*	0.30	5[3]
Magnesium	8	8	15	7.2	11*	*e*	[*e*]
Manganese	8	8	3.8	0.50	1.9*	0.050	8[3]
Nickel	4	8	0.0066	0.0051	0.0057*	0.10	0[1]
Phosphorus	2	4	0.78	0.65	0.72*	*e*	[*e*]
Potassium	8	8	7.2	1.5	3.7*	*e*	[*e*]
Silicon	8	8	19	12	15*	*e*	[*e*]
Sodium	8	8	22	6.8	12*	*e*	[*e*]
Strontium	4	4	0.59	0.027	0.21	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	6	8	6.0	0.14	1.7	0.20	3[3]
Barium	8	8	0.31	0.055	0.20*	2.0	0[2]
Calcium	8	8	69	13	37*	*e*	[*e*]
Chromium	7	8	0.034	0.0046	0.014*	0.050	0[1]
Cobalt	5	8	0.0061	0.0045	0.0051*	*e*	[*e*]
Copper	1	8	0.014	0.014	0.014	1.0	0[1]
Iron	8	8	13	0.41	7.4*	0.30	8[3]
Magnesium	8	8	15	6.2	11*	*e*	[*e*]
Manganese	8	8	4.3	0.48	2.1*	0.050	8[3]
Nickel	2	8	0.0090	0.0083	0.0087*	0.10	0[1]

Table 5.18 (WAG 4 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Phosphorus	3	4	0.70	0.30	0.53*	*e*	[*e*]
Potassium	8	8	5.9	1.2	3.3*	*e*	[*e*]
Silicon	8	8	20	13	16*	*e*	[*e*]
Sodium	8	8	20	6.3	11*	*e*	[*e*]
Strontium	4	4	0.55	0.029	0.20	*e*	[*e*]
Titanium	2	4	0.059	0.025	0.042	*e*	[*e*]
Vanadium	3	8	0.0098	0.0032	0.0054	*e*	[*e*]
Zinc	3	8	0.025	0.0078	0.014	5.0	0[1]
Others, filtered (mg/L)							
Alkalinity	8	8	210	69	140*	*e*	[*e*]
Solids, total dissolved	8	8	310	120	200*	500	0[1]
Others, unfiltered (mg/L)							
Alkalinity	8	8	210	64	140*	*e*	[*e*]
Carbon, total organic	2	8	0.60	0.53	0.56*	*e*	[*e*]
Solids, total suspended	6	8	260	6.0	75	*e*	[*e*]
Radionuclides,[f] filtered (pCi/L)							
^{60}Co	1	8	41	41	41	200	0[4]
^{137}Cs	1	8	3.0	3.0	3.0	120	0[4]
Gross alpha	3	8	8.6	3.2	5.2*	15	0[2]
Gross beta	5	8	46	8.9	18*	50	0[2]
^{3}H	1	8	27,000	27,000	27,000	20,000	1[2]
$^{89}Sr + ^{90}Sr$	2	8	5.4	3.5	4.5	8.0	0[2]
Radionuclides,[f] unfiltered (pCi/L)							
^{137}Cs	2	8	6.2	2.7	4.5	120	0[4]
Gross alpha	7	8	8.1	1.1	3.7*	15	0[2]
Gross beta	6	8	13	5.1	10*	50	0[2]
^{3}H	2	8	25,000	1,400	13,000	20,000	1[2]
$^{89}Sr + ^{90}Sr$	4	8	8.6	3.0	5.7*	8.0	2[2]
Tentatively identified compounds, unfiltered (μg/L)							
Unknown-25.37	1	1	J 9.0	J 9.0	9.0	*e*	[*e*]
Unknown-25.38	1	1	J 6.0	J 6.0	6.0	*e*	[*e*]
Unknown-30.15	1	1	J 7.0	J 7.0	7.0	*e*	[*e*]
Unknown-4.39	1	1	J 11	J 11	11	*e*	[*e*]

Table 5.18 (WAG 4 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Volatile organics, unfiltered (µg/L)							
Acetone	2	8	JB 5.0	JB 4.0	4.5*	*e*	[*e*]
Styrene	1	8	J 1.0	J 1.0	1.0	*e*	[*e*]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.19. Constituents in Waste Area Grouping (WAG) 5 groundwater at ORNL, June 27–July 26, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Chloride	20	20	41	0.95	13*	250	0[3]
Fluoride	13	20	2.4	0.10	0.41*	4.0	0[2]
Nitrate	1	20	1.8	1.8	1.8	10	0[2]
Sulfate (as SO_4)	19	20	390	3.0	53*	250	2[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	20	20	0.63	0.22	0.42*	*e*	[*e*]
Dissolved oxygen (ppm)	20	20	9.0	0.20	3.9*	*e*	[*e*]
Redox (mV)	20	20	190	−16	140*	*e*	[*e*]
Temperature (°C)	20	20	18	14	15*	30	0[1]
Turbidity (JTU)	20	20	480	82	180*	1.0	20[2]
pH (standard units)	20	20	8.5	6.2	6.9*	(6.5, 8.5)	3[3]
Metals, filtered (mg/L)							
Aluminum	20	20	0.17	0.052	0.11*	0.20	0[3]
Barium	20	20	0.95	0.014	0.29*	2.0	0[2]
Beryllium	1	20	0.0011	0.0011	0.0011	*e*	[*e*]
Boron	6	20	1.9	0.091	0.53	*e*	[*e*]
Calcium	20	20	180	3.4	96*	*e*	[*e*]
Chromium	18	20	0.013	0.0046	0.0085*	0.050	0[1]
Cobalt	1	20	0.0052	0.0052	0.0052	*e*	[*e*]
Copper	11	20	0.023	0.0075	0.011*	1.0	0[1]
Iron	11	20	1.5	0.071	0.73*	0.30	7[3]
Magnesium	20	20	45	1.4	20*	*e*	[*e*]
Manganese	19	20	1.3	0.0041	0.28*	0.050	12[3]
Nickel	9	20	0.028	0.0040	0.012*	0.10	0[1]
Potassium	20	20	11	1.7	4.0*	*e*	[*e*]
Silicon	20	20	14	2.3	8.7*	*e*	[*e*]
Sodium	20	20	140	7.0	26*	*e*	[*e*]
Strontium	1	1	0.19	0.19	0.19	*e*	[*e*]
Vanadium	4	20	0.0080	0.0021	0.0043*	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	19	20	2.8	0.054	0.54*	0.20	9[3]
Barium	20	20	0.87	0.017	0.28*	2.0	0[2]
Beryllium	1	20	0.0010	0.0010	0.0010	*e*	[*e*]
Boron	5	20	1.7	0.17	0.57	*e*	[*e*]
Calcium	20	20	190	4.3	98*	*e*	[*e*]
Chrom	14	20	0.0	0.0041	0.0074*	0.050	0[1]
Cobalt	2	20	0.0	0.0053	0.0066	*e*	[*e*]
Copper	2	20	0.018	0.013	0.016	1.0	0[1]

Table 5.19 (WAG 5 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Iron	20	20	2.7	0.058	0.91*	0.30	13[3]
Magnesium	20	20	45	1.9	19*	*e*	[*e*]
Manganese	20	20	1.3	0.0045	0.26*	0.050	13[3]
Nickel	12	20	0.030	0.0043	0.013*	0.10	0[1]
Potassium	20	20	9.1	0.86	2.8*	*e*	[*e*]
Silicon	20	20	13	2.3	8.7*	*e*	[*e*]
Sodium	19	20	130	7.0	24*	*e*	[*e*]
Strontium	1	1	0.20	0.20	0.20	*e*	[*e*]
Vanadium	2	20	0.0064	0.0033	0.0048	*e*	[*e*]
Zinc	2	20	0.014	0.0088	0.011	5.0	0[1]
Others, filtered (mg/L)							
Alkalinity	20	20	550	110	300*	*e*	[*e*]
Solids, total dissolved	20	20	760	210	420*	500	6[1]
Others, unfiltered (mg/L)							
Alkalinity	20	20	560	110	310*	*e*	[*e*]
Carbon, total organic	17	20	4.2	0.39	1.4*	*e*	[*e*]
Halides, total organic	10	20	120	3.8	31*	*e*	[*e*]
Phenolics, total recoverable	1	20	0.011	0.011	0.011	*e*	[*e*]
Solids, total suspended	9	20	53	11	29*	*e*	[*e*]
Radionuclides,[f] filtered (pCi/L)							
^{60}Co	6	20	78	24	45*	200	0[4]
^{137}Cs	2	20	54	43	49*	120	0[4]
Gross alpha	7	20	150	2.1	32	15	3[2]
Gross beta	14	20	1,200	4.3	140	50	5[2]
^{3}H	16	20	260,000,000	1,100	24,000,000	20,000	12[2]
$^{89}Sr + ^{90}Sr$	12	20	540	2.1	73	8.0	6[2]
Radionuclides,[f] unfiltered (pCi/L)							
^{60}Co	3	20	70	38	50*	200	0[4]
Gross alpha	8	20	150	2.0	28	15	2[2]
Gross beta	16	20	1,000	3.0	130*	50	5[2]
^{3}H	16	20	260,000,000	1,200	23,000,000	20,000	12[2]
$^{89}Sr + ^{90}Sr$	9	20	510	2.7	110*	8.0	7[2]
Tentatively identified compounds, unfiltered (μg/L)							
Methane,dichlorofluoro-6.89	1	1	J 8.0	J 8.0	8.0	*e*	[*e*]
Propane,2,2'-oxybis-19.46	1	1	J 7.0	J 7.0	7.0	*e*	[*e*]
Unknown-11.1	1	1	J 10	J 10	10	*e*	[*e*]

Table 5.19 (WAG 5 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Volatile organics, unfiltered (µg/L)							
1,1-Dichloroethane	5	20	J 5.0	J 1.0	2.6*	*e*	[*e*]
1,1-Dichloroethene	1	20	6.0	6.0	6.0	7.0	0[2]
1,2-Dichloroethane	1	20	J 1.0	J 1.0	1.0	5.0	0[2]
1,2-Dichloroethene	7	20	Y 2,600	J 2.0	390	*e*	[*e*]
Acetone	11	20	13	JB 5.0	7.0*	*e*	[*e*]
Benzene	1	20	29	29	29	5.0	1[2]
Carbon disulfide	14	20	75	JB 1.0	17*	*e*	[*e*]
Tetrachloroethene	1	20	J 2.0	J 2.0	2.0	*e*	[*e*]
Trichloroethene	4	20	40	J 3.0	20	5.0	2[2]
Vinyl chloride	4	20	Y 4,700	J 8.0	1,200	2.0	20[2]
Upgradient wells							
Anions, unfiltered (mg/L)							
Chloride	2	2	2.7	1.6	2.2	250	0[3]
Fluoride	2	2	0.40	0.10	0.25	4.0	0[2]
Sulfate (as SO_4)	2	2	19	7.2	13	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	2	2	0.29	0.24	0.27*	*e*	[*e*]
Dissolved oxygen (ppm)	2	2	5.5	4.8	5.2*	*e*	[*e*]
Redox (mV)	2	2	170	150	160*	*e*	[*e*]
Temperature (°C)	2	2	14	14	14*	30	0[1]
Turbidity (JTU)	2	2	230	210	220*	1.0	2[2]
pH (standard units)	2	2	7.0	6.5	6.8*	(6.5, 8.5)	0[3]
Metals, filtered (mg/L)							
Aluminum	2	2	0.14	0.14	0.14	0.20	0[3]
Barium	2	2	0.14	0.11	0.12*	2.0	0[2]
Calcium	2	2	69	68	68*	*e*	[*e*]
Chromium	1	2	0.0053	0.0053	0.0053	0.050	0[1]
Copper	1	2	0.011	0.011	0.011	1.0	0[1]
Magnesium	2	2	12	2.8	7.4	*e*	[*e*]
Manganese	2	2	0.018	0.0033	0.010	0.050	0[3]
Potassium	2	2	3.2	0.47	1.8	*e*	[*e*]
Silicon	2	2	12	7.1	9.8	*e*	[*e*]
Sodium	2	2	13	5.9	9.2	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	2	2	2.3	0.11	1.2	0.20	1[3]
Barium	2	2	0.1[illegible]	0.13	0.13*	2.0	0[2]
Calcium	2	2	75	68	72*	*e*	[*e*]

Table 5.19 (WAG 5 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Chromium	1	2	0.0076	0.0076	0.0076	0.050	0[1]
Cobalt	1	2	0.0044	0.0044	0.0044	*e*	[*e*]
Iron	1	2	1.6	1.6	1.6	0.30	1[3]
Magnesium	2	2	12	2.7	7.5	*e*	[*e*]
Manganese	2	2	0.066	0.0031	0.035	0.050	1[3]
Potassium	2	2	1.6	0.84	1.2	*e*	[*e*]
Silicon	2	2	11	11	11*	*e*	[*e*]
Sodium	2	2	9.7	6.4	8.1	*e*	[*e*]
Others, filtered (mg/L)							
Alkalinity	2	2	220	180	200*	*e*	[*e*]
Solids, total dissolved	2	2	1,100	240	650	500	1[1]
Others, unfiltered (mg/L)							
Alkalinity (mg/L)	2	2	220	180	200*	*e*	[*e*]
Carbon, total organic (mg/L)	1	2	0.60	0.60	0.60	*e*	[*e*]
Solids, total suspended (mg/L)	1	2	45	45	45	*e*	[*e*]
Radionuclides,[f] filtered (pCi/L)							
^{60}Co	1	2	46	46	46	200	0[4]
^{3}H	2	2	1,500	1,400	1,500*	20,000	0[2]
Radionuclides,[f] unfiltered (pCi/L)							
Gross alpha	2	2	2.2	1.9	2.0*	15	0[2]
^{3}H	2	2	1,900	1,300	1,600	20,000	0[2]
Volatile organics, unfiltered (μg/L)							
Acetone	2	2	JB 5.0	JB 4.0	4.5*	*e*	[*e*]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.20. Constituents in Solid Waste Storage Area (SWSA) 6 groundwater at ORNL semi-annual assessment wells, February 14–March 1, September 4–October 14, and December 9–18, 1991

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Field measurements, unfiltered							
Conductivity (mS/cm)	18	18	0.42	0.013	0.20*	*d*	[*d*]
Dissolved oxygen (ppm)	18	18	9.5	0.20	4.4*	*d*	[*d*]
Redox (mV)	18	18	280	160	210*	*d*	[*d*]
Temperature (°C)	18	18	21	12	16*	30	0[1]
Turbidity (JTU)	18	18	420	40	130*	1.0	18[2]
pH (standard units)	18	18	7.7	4.8	6.2*	(6.5, 8.5)	9[3]
Others, unfiltered							
Alkalinity (mg/L)	9	9	250	5.0	120*	*d*	[*d*]
Carbon, total organic (mg/L)	5	9	3.4	0.55	1.2*	*d*	[*d*]
Radionuclides, filtered (pCi/L)[e]							
^{60}Co	2	9	5.4	3.2	4.3	200	0[4]
Gross alpha	3	18	3.5	2.5	2.9*	15	0[2]
Gross beta	6	9	7.3	3.8	5.0*	50	0[2]
^{3}H	12	18	30,000	860	12,000*	20,000	0[2]
$^{89}Sr + ^{90}Sr$	3	9	9.7	5.9	8.4*	8	0[2]
Volatile organics, unfiltered (µg/L)							
Carbon disulfide	1	9	8.0	8.0	8.0	*d*	[*d*]
Chloroform	1	9	J 2.0	J 2.0	2.0	100	0[2]
Methylene chloride	1	9	J 2.0	J 2.0	2.0	*d*	[*d*]
Tentatively identified compounds, unfiltered (µg/L)							
Ethane,1,1'-oxybis–12.82	1	1	J 300	J 300	300	*d*	[*d*]
			Upgradient wells				
Field measurements, unfiltered							
Conductivity (mS/cm)	14	14	0.84	0.023	0.33*	*d*	[*d*]
Dissolved oxygen (ppm)	13	13	11	3.0	6.0*	*d*	[*d*]
Redox (mV)	14	14	280	17	190*	*d*	[*d*]
Temperature (°C)	14	14	16	12	14*	30	0[1]
Turbidity (JTU)	13	13	930	53	180*	1.0	13[2]
pH (standard units)	14	14	8.5	4.9	7.3*	(6.5, 8.5)	3[3]

Table 5.20 (SWSA 6 continued)

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Others, unfiltered							
Alkalinity (mg/L)	7	7	430	7.5	210*	*d*	[*d*]
Carbon, total organic (mg/L)	3	7	1.1	U 0.73	0.90*	*d*	[*d*]
Halides, total organic (μg/L)	1	7	U 5.9	U 5.9	5.9	*d*	[*d*]
Radionuclides				filtered (pCi/L)[e]			
^{137}Cs	1	7	4.3	4.3	4.3	120	0[4]
Gross alpha	5	14	2.6	2.0	2.3*	15	0[2]
Gross beta	4	7	13	5.7	8.4*	50	0[2]
^{3}H	2	14	1,000	810	910*	20,000	0[2]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR (7-1-1990 edition) Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR (7-1-1990 edition) Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]Not applicable.

[e]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.21. Constituents in Solid Waste Area (SWSA) 6 groundwater at ORNL quarterly assessment wells, February 14–March 1, September 4–October 14, and December 9–18, 1991

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Field measurements, unfiltered							
Conductivity (mS/cm)	30	30	0.83	0.10	0.48*	*d*	[*d*]
Dissolved oxygen (ppm)	30	30	12	0.010	4.8*	*d*	[*d*]
Redox (mV)	30	30	660	150	210*	*d*	[*d*]
Temperature (°C)	30	30	16	11	14*	30	0[1]
Turbidity (JTU)	30	30	760	6.3	150*	1.0	30[2]
pH (standard units)	30	30	8.3	5.9	7.3*	(6.5, 8.5)	1[3]
Others, unfiltered							
Alkalinity (mg/L)	30	30	480	30	290*	*d*	[*d*]
Radionuclides, filtered (pCi/L)[e]							
^{60}Co	12	30	970	4.3	340*	200	6[4]
^{137}Cs	1	30	3.2	3.2	3.2	120	0[4]
Gross alpha	12	30	26	1.4	4.8*	15	1[2]
^{3}H	28	30	2,100,000	490	360,000*	20,000	15[2]
$^{89}Sr + ^{90}Sr$	14	30	54	1.9	13*	8	1[2]
Volatile organics, unfiltered (µg/L)							
1,1,1-Trichloroethane	1	30	J 1.0	J 1.0	1.0	200	0[2]
1,1-Dichloroethane	1	30	J 2.0	J 2.0	2.0	*d*	[*d*]
1,2-Dichloroethane	3	30	19	11	15*	5.0	3[2]
1,2-Dichloroethene	6	30	10	J 4.0	6.7*	*d*	[*d*]
4-Methyl-2-pentanone	1	30	J 5.0	J 5.0	5.0	*d*	[*d*]
Acetone	4	30	JB 5.0	JB 3.0	3.8*	*d*	[*d*]
Benzene	1	30	J 3.0	J 3.0	3.0	5.0	0[2]
Carbon disulfide	2	30	160	B 33	97	*d*	[*d*]
Carbon tetrachloride	3	30	65	40	52*	5.0	3[2]
Chloroform	4	30	60	J 2.0	40*	100	0[2]
Methylene chloride	1	30	J 2.0	J 2.0	2.0	*d*	[*d*]
Styrene	1	30	J 1.0	J 1.0	1.0	*d*	[*d*]
Trichloroethene	6	30	E 330	J 1.0	140*	5.0	4[2]

Table 5.21 (SWSA 6 continued)

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Tentatively identified compounds, unfiltered (µg/L)							
1,2,2-Trifluoro-chloro-7.83	1	1	J 12	J 12	12	*d*	[*d*]
1-Hexanol,2-ethyl-28.66	2	2	J 5.0	J 5.0	5.0	*d*	[*d*]
Ethane,1,1,2-trichloro-7.85	1	1	J 8.0	J 8.0	8.0	*d*	[*d*]
Methane,trichlorofluoro-6.9	1	1	J 7.0	J 7.0	7.0	*d*	[*d*]
Methane,trichlorofluoro-6.91	1	1	J 8.0	J 8.0	8.0	*d*	[*d*]
Methane,trichlorofluoro-6.94	1	1	J 8.0	J 8.0	8.0	*d*	[*d*]
Unknown-18.78	1	1	J 23	J 23	23	*d*	[*d*]
Unknown-22.87	1	1	J 160	J 160	160	*d*	[*d*]
Unknown-25.36	1	1	J 9.0	J 9.0	9.0	*d*	[*d*]
Unknown-25.37	2	2	J 8.0	J 7.0	7.5*	*d*	[*d*]
Unknown-26.64	1	1	J 200	J 200	200	*d*	[*d*]
Unknown-30.12	1	1	J 6.0	J 6.0	6.0	*d*	[*d*]
Unknown-30.13	2	2	J 8.0	J 6.0	7.0*	*d*	[*d*]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR (7-1-1990) Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR (7-1-1990) Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]Not applicable.

[e]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.22. Summary of constituents detected in Waste Area Grouping (WAG) 7 groundwater at ORNL, April 22–May 15, 1991

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Chloride	12	14	25	1.0	7.3*	250	0[3]
Fluoride	8	14	7.0	0.10	1.5	4.0	1[2]
Nitrate	2	14	1,100	46	560	10	2[2]
Sulfate, as SO_4	14	14	570	8.8	140*	250	3[3]
Base neutral/acid extractable organics, unfiltered (μg/L)							
Phenol	5	14	B 38	B 13	26*	*d*	[*d*]
Unknown-39.78	1	1	J 13	J 13	13	*d*	[*d*]
Unknown-5.5	1	1	J 80	J 80	80	*d*	[*d*]
Unknown-5.51	1	1	B 51	B 51	51	*d*	[*d*]
Unknown-5.52	1	1	B 38	B 38	38	*d*	[*d*]
Unknown-5.54	1	1	B 39	B 39	39	*d*	[*d*]
Unknown-5.58	1	1	B 5.0	B 5.0	5.0	*d*	[*d*]
Unknownhydrocarbon-28.16	1	1	J 23	J 23	23	*d*	[*d*]
Field measurements, unfiltered							
Conductivity (mS/cm)	14	14	2.0	0.29	0.65*	*d*	[*d*]
Dissolved oxygen (ppm)	14	14	4.5	0.10	1.7*	*d*	[*d*]
Redox (mV)	14	14	920	11	220*	*d*	[*d*]
Temperature (°C)	14	14	15	13	14*	30	0[1]
Turbidity (JTU)	14	14	120	46	96*	1.0	14[2]
pH (standard units)	14	14	9.0	7.0	7.7*	(6.5, 8.5)	2[3]
Metals, filtered (mg/L)							
Aluminum	10	14	0.14	0.061	0.079*	0.20	0[3]
Antimony	2	14	0.012	0.0060	0.0090	*d*	[*d*]
Barium	14	14	0.22	0.0097	0.090*	2.0	0[2]
Boron	4	14	0.39	0.15	0.29*	*d*	[*d*]
Calcium	14	14	190	3.0	78*	*d*	[*d*]
Chromium	10	14	0.011	0.0042	0.0078*	0.050	0[1]
Cobalt	2	14	0.050	0.034	0.042	*d*	[*d*]
Iron	4	14	7.0	0.091	2.0	0.30	3[3]
Magnesium	14	14	83	0.74	19*	*d*	[*d*]
Manganese	14	14	1.3	0.0010	0.18*	0.050	4[3]
Nickel	10	14	0.38	0.0053	0.064	0.10	2[1]
Potassium	14	14	7.8	0.76	3.2*	*d*	[*d*]
Silicon	14	14	12	4.3	6.9*	*d*	[*d*]
Sodium	12	14	580	6.4	130*	*d*	[*d*]
Strontium	5	5	1.3	0.22	0.51*	*d*	[*d*]
Vanadi	4	14	0.00	0.0032	0.0050*	*d*	[*d*]

Table 5.22 (WAC ontinued)

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Metals, unfiltered (mg/L)							
Aluminum	14	14	3.9	0.052	0.85*	0.20	8[3]
Barium	14	14	0.22	0.012	0.095*	2.0	0[2]
Beryllium	5	14	0.0012	0.00043	0.00072*	*d*	[*d*]
Boron	4	14	0.39	0.15	0.29*	*d*	[*d*]
Calcium	14	14	190	3.3	77*	*d*	[*d*]
Chromium	9	14	0.019	0.0040	0.0092*	0.050	0[1]
Cobalt	2	14	0.048	0.035	0.041*	*d*	[*d*]
Iron	14	14	8.3	0.076	1.4*	0.30	7[3]
Magnesium	14	14	78	0.75	19*	*d*	[*d*]
Manganese	14	14	1.3	0.0034	0.19*	0.050	6[3]
Nickel	8	14	0.37	0.0070	0.083	0.10	2[1]
Potassium	14	14	7.6	0.68	2.8*	*d*	[*d*]
Silicon	14	14	14	4.2	8.0*	*d*	[*d*]
Sodium	12	14	550	7.2	130*	*d*	[*d*]
Strontium	8	8	2.4	0.031	0.63*	*d*	[*d*]
Titanium	1	8	0.034	0.034	0.034	*d*	[*d*]
Vanadium	6	14	0.0079	0.0029	0.0051*	*d*	[*d*]
Zinc	3	14	0.026	0.0054	0.013	5.0	0[1]
Others, filtered (mg/L)							
Alkalinity	14	14	590	15	290*	*d*	[*d*]
Solids, total dissolved	14	14	2,200	260	650*	500	6[1]
Others, unfiltered (mg/L)							
Alkalinity	14	14	590	15	280*	*d*	[*d*]
Carbon, total organic	13	14	2.4	0.50	1.0*	*d*	[*d*]
Halides, total organic	13	14	41	3.3	22*	*d*	[*d*]
Solids, total suspended	7	14	210	11	62*	*d*	[*d*]
Radionuclides, filtered (pCi/L)[e]							
^{60}Co	5	14	680	46	200	200	1[4]
Gross alpha	6	14	43	1.6	10	15	1[2]
Gross beta	11	14	4,100	5.4	450	50	4[2]
^{3}H	10	14	1,100,000	1,300	180,000	20,000	4[2]
$^{89}Sr + ^{90}Sr$	5	14	5.1	2.7	3.8*	8.0	0[2]

Table 5.22 (WAG 7 continued)

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Radionuclides, unfiltered (pCi/L)[e]							
^{60}Co	3	14	760	43	320	200	1[4]
Gross alpha	7	14	41	3.2	10*	15	1[2]
Gross beta	13	14	3,800	3.2	360	50	5[2]
^{3}H	10	14	1,000,000	1,500	170,000	20,000	4[2]
$^{89}Sr + ^{90}Sr$	4	14	7.0	3.2	4.9*	8.0	0[2]
Upgradient wells							
Anions, unfiltered (mg/L)							
Chloride	2	2	3.6	0.92	2.3	250	0[3]
Fluoride	1	2	0.20	0.20	0.20	4.0	0[2]
Sulfate, as SO_4	2	2	100	8.5	55	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	2	2	0.37	0.090	0.23	*d*	[*d*]
Dissolved oxygen (ppm)	2	2	6.1	2.4	4.3	*d*	[*d*]
Redox (mV)	2	2	200	170	190*	*d*	[*d*]
Temperature (°C)	2	2	14	14	14*	30	0[1]
Turbidity (JTU)	2	2	120	69	96	1.0	2[2]
pH (standard units)	2	2	7.8	5.8	6.8*	(6.5, 8.5)	1[3]
Metals, filtered (mg/L)							
Aluminum	1	2	0.052	0.052	0.052	0.20	0[3]
Antimony	1	2	0.028	0.028	0.028	*d*	[*d*]
Barium	2	2	0.059	0.030	0.045	2.0	0[2]
Calcium	2	2	29	2.0	15	*d*	[*d*]
Magnesium	2	2	6.5	3.0	4.8	*d*	[*d*]
Manganese	2	2	0.33	0.066	0.20	0.050	2[3]
Nickel	1	2	0.014	0.014	0.014	0.10	0[1]
Potassium	2	2	6.6	0.87	3.7	*d*	[*d*]
Silicon	2	2	11	11	11*	*d*	[*d*]
Sodium	1	2	110	110	110	*d*	[*d*]
Strontium	2	2	0.71	0.015	0.36	*d*	[*d*]
Tin	1	2	0.050	0.050	0.050	*d*	[*d*]
Metals, unfiltered (mg/L)							
Aluminum	2	2	2.1	0.14	1.1	0.20	1[3]
Barium	2	2	0.085	0.030	0.058	2.0	0[2]
Beryllium	2	2	0.00042	0.00038	0.00040*	*d*	[*d*]
Boron	1	2	0.097	0.097	0.097	*d*	[*d*]
Calciu-	2	2	27	2.1	15	*d*	[*d*]

Table 5.22 (WAG ontinued)

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Chromium	1	2	0.0053	0.0053	0.0053	0.050	0[1]
Cobalt	1	2	0.0078	0.0078	0.0078	*d*	[*d*]
Iron	2	2	2.3	0.088	1.2	0.30	1[3]
Magnesium	2	2	6.5	3.2	4.9	*d*	[*d*]
Manganese	2	2	0.32	0.083	0.20	0.050	2[3]
Nickel	1	2	0.014	0.014	0.014	0.10	0[1]
Potassium	2	2	4.8	1.4	3.1	*d*	[*d*]
Silicon	2	2	12	11	11*	*d*	[*d*]
Sodium	1	2	110	110	110	*d*	[*d*]
Strontium	2	2	0.68	0.017	0.35	*d*	[*d*]
Titanium	1	2	0.023	0.023	0.023	*d*	[*d*]
Vanadium	2	2	0.0044	0.0034	0.0039*	*d*	[*d*]
Others, filtered (mg/L)							
Alkalinity	2	2	210	13	110	*d*	[*d*]
Solids, total dissolved	2	2	370	55	210	500	0[1]
Others, unfiltered (mg/L)							
Alkalinity	2	2	210	11	110	*d*	[*d*]
Halides, total organic	2	2	25	16	20	*d*	[*d*]
Solids, total suspended	1	2	120	120	120	*d*	[*d*]
Radionuclides, filtered (pCi/L)[e]							
^{60}Co	1	2	38	38	38	200	0[4]
Gross alpha	1	2	2.1	2.1	2.1	15	0[2]
Gross beta	2	2	8.9	5.1	7.0	50	0[2]
^{3}H	1	2	1,000	1,000	1,000	20,000	0[2]
Radionuclides, unfiltered (pCi/L)[e]							
^{60}Co	1	2	41	41	41	200	0[4]
Gross alpha	1	2	3.2	3.2	3.2	15	0[2]
Gross beta	2	2	8.4	5.7	7.0	50	0[2]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR (7-1-1990) Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR (7-1-1990) Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]Not applicable.

[e]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.23. Constituents in Waste Area Groupings (WAGs) 8 and 9 groundwater at ORNL, May 22–June 3, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Bromide	1	9	4.6	4.6	4.6	*e*	[*e*]
Chloride	9	9	12	3.5	6.2*	250	0[3]
Fluoride	8	9	1.4	0.20	0.40*	4.0	0[2]
Nitrate	2	9	4.6	1.5	3.1	10	0[2]
Sulfate (as SO_4)	9	9	270	9.1	59*	250	1[3]
Base neutral/acid extractable organics, unfiltered (μg/L)							
Phenol	9	9	B 13	JB 9.0	11*	*e*	[*e*]
Field Measurements, unfiltered							
Conductivity (mS/cm)	9	9	0.62	0.16	0.35*	*e*	[*e*]
Dissolved oxygen (ppm)	9	9	12	2.9	5.8*	*e*	[*e*]
Redox (mV)	9	9	190	90	160*	*e*	[*e*]
Temperature (°C)	9	9	17	14	15*	31	0[1]
Turbidity (JTU)	9	9	220	130	200*	1.0	9[2]
pH (standard units)	9	9	8.9	6.0	7.0*	(6.5, 8.5)	3[3]
Metals, filtered (mg/L)							
Aluminum	8	9	0.27	0.053	0.094*	0.20	1[3]
Barium	9	9	0.20	0.028	0.10*	2.0	0[2]
Boron	3	9	0.57	0.12	0.30	*e*	[*e*]
Calcium	9	9	120	1.3	51*	*e*	[*e*]
Chromium	6	9	0.010	0.0041	0.0073*	0.050	0[1]
Cobalt	1	9	0.018	0.018	0.018	*e*	[*e*]
Iron	8	9	26	0.056	3.9	0.30	3[3]
Magnesium	9	9	25	0.17	14*	*e*	[*e*]
Manganese	9	9	3.4	0.0010	0.76*	0.050	6[3]
Nickel	8	9	0.013	0.0043	0.0080*	0.10	0[1]
Potassium	9	9	4.5	1.7	2.7*	*e*	[*e*]
Silicon	9	9	16	2.4	7.5*	*e*	[*e*]
Sodium	8	9	160	5.9	48*	*e*	[*e*]
Strontium	1	1	0.16	0.16	0.16	*e*	[*e*]
Vanadium	3	9	0.0038	0.0021	0.0028*	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	8	9	3.5	0.050	0.71	0.20	3[3]
Barium	9	9	0.19	0.026	0.11*	2.0	0[2]
Boron	3	9	0.57	0.11	0.29	*e*	[*e*]
Calcium	9	9	110	1.3	48*	*e*	[*e*]
Chromium	5	9	0.014	0.0048	0.0089*	0.050	0[1]
Cobalt	1	9	0.017	0.017	0.017	*e*	[*e*]
Iron	9	9	25	0.054	4.3	0.30	5[3]
Magnesium	9	9	22	0.14	13*	*e*	[*e*]
Manganese	9	9	3.8	0.0074	0.80*	0.050	6[3]
Nickel	3	9	0.0066	0.0043	0.0055*	0.10	0[1]
Potassium	9	9	4.7	1.5	2.7*	*e*	[*e*]
Silicon	9	9	20	2.8	8.1*	*e*	[*e*]
Sodium	8	9	160	5.9	46*	*e*	[*e*]
Vanadium	3	9	0.0052	0.0024	0.0041*	*e*	[*e*]
Zinc	1	9	0.0059	0.0059	0.0059	5.0	0[1]

Table 5.23 (WAGs 8 and 9 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Others, filtered							
Alkalinity (mg/L)	9	9	340	100	190*	*e*	[*e*]
Solids, total dissolved (mg/L)	8	9	610	140	330*	500	2[1]
Others, unfiltered							
Alkalinity (mg/L)	9	9	340	100	190*	*e*	[*e*]
Carbon, total organic (mg/L)	6	9	1.8	0.50	0.87*	*e*	[*e*]
Halides, total organic (µg/L)	3	9	12	2.7	6.2	*e*	[*e*]
Solids, total suspended (mg/L)	4	9	62	12	38*	*e*	[*e*]
Radionuclides[f], filtered (pCi/L)							
^{60}Co	1	9	41	41	41	200	0[4]
Gross alpha	4	9	7.0	1.4	4.1*	15	0[2]
Gross beta	8	9	1,300	4.1	440*	50	3[2]
^{3}H	4	9	68,000	650	18,000	20,000	1[2]
$^{89}Sr + ^{90}Sr$	5	9	810	7.8	420*	8.0	4[2]
Radionuclides[f], unfiltered (pCi/L)							
^{137}Cs	1	9	59	59	59	120	0[4]
Gross alpha	5	9	9.5	2.2	4.1*	15	0[2]
Gross beta	8	9	1,300	3.8	440*	50	3[2]
^{3}H	4	9	68,000	680	18,000	20,000	1[2]
$^{89}Sr + ^{90}Sr$	4	9	700	6.2	510*	8.0	3[2]
Tentatively identified compounds, unfiltered (µg/L)							
Ethanethiol-8.02	1	1	J 11	J 11	11	*e*	[*e*]
Ethanethiol-8.04	1	1	J 6.0	J 6.0	6.0	*e*	[*e*]
Methanethiol-3.56	1	1	J 18	J 18	18	*e*	[*e*]
Methanethiol-3.58	1	1	J 26	J 26	26	*e*	[*e*]
Sulfur dioxide-2.81	1	1	J 190	J 190	190	*e*	[*e*]
Unknown-5.55	1	1	J 46	J 46	46	*e*	[*e*]
Unknown-5.58	1	1	J 65	J 65	65	*e*	[*e*]
Volatile organics, unfiltered (µg/L)							
1,2-Dichloroethene	1	9	5.0	5.0	5.0	*e*	[*e*]
Carbon disulfide	5	9	18	J 3.0	12*	*e*	[*e*]
Trichloroethene	1	9	6.0	6.0	6.0	5.0	1[2]
Upgradient wells							
Anions, unfiltered (mg/L)							
Chloride	2	2	5.1	3.2	4.2	250	0[3]
Fluoride	1	2	0.20	0.20	0.20	4.0	0[2]
Sulfate as SO_4	2	2	110	26	69	250	0[3]
Base neutral/acid extractable organics, unfiltered (µg/L)							
Phenol	2	2	B 16	B 11	14	*e*	[*e*]
Field measurements, unfiltered							
Conductivity (mS/cm)	2	2	0.34	0.31	0.33*	*e*	[*e*]
Dissolved oxygen (ppm)	2	2	5.1	4.0	4.6*	*e*	[*e*]
Redox (mV)	2	2	170	120	140*	*e*	[*e*]
Temperature (°C)	2	2	14	13	14*	31	0[1]
Turbidity (JTU)	2	2	210	190	200*	1.0	2[2]
pH (standard units)	2	2	8.1	6.4	7.3*	(6.5, 8.5)	1[3]

Table 5.23 (WAGs 8 and 9 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Metals, filtered (mg/L)							
Aluminum	1	2	0.075	0.075	0.075	0.20	0[3]
Barium	2	2	0.10	0.032	0.067	2.0	0[2]
Boron	1	2	0.32	0.32	0.32	*e*	[*e*]
Calcium	2	2	52	19	36	*e*	[*e*]
Chromium	1	2	0.012	0.012	0.012	0.050	0[1]
Cobalt	1	2	0.0045	0.0045	0.0045	*e*	[*e*]
Iron	1	2	3.0	3.0	3.0	0.30	1[3]
Magnesium	2	2	23	4.3	13	*e*	[*e*]
Manganese	2	2	4.4	0.049	2.2	0.050	1[3]
Nickel	2	2	0.013	0.0068	0.0099	0.10	0[1]
Potassium	2	2	3.9	2.9	3.4*	*e*	[*e*]
Silicon	2	2	13	6.1	9.6	*e*	[*e*]
Sodium	2	2	67	10	39	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	1	2	0.97	0.97	0.97	0.20	1[3]
Barium	2	2	0.093	0.051	0.072	2.0	0[2]
Boron	1	2	0.31	0.31	0.31	*e*	[*e*]
Calcium	2	2	51	17	34	*e*	[*e*]
Chromium	1	2	0.011	0.011	0.011	0.050	0[1]
Iron	1	2	6.1	6.1	6.1	0.30	1[3]
Magnesium	2	2	22	4.0	13	*e*	[*e*]
Manganese	2	2	4.8	0.047	2.4	0.050	1[3]
Nickel	1	2	0.0082	0.0082	0.0082	0.10	0[1]
Potassium	2	2	3.7	3.0	3.4*	*e*	[*e*]
Silicon	2	2	14	6.0	10	*e*	[*e*]
Sodium	2	2	65	10	37	*e*	[*e*]
Others, filtered							
Alkalinity (mg/L)	2	2	170	110	140	*e*	[*e*]
Solids, total dissolved (mg/L)	2	2	330	240	280*	500	0[1]
Others, unfiltered							
Alkalinity (mg/L)	2	2	170	110	140	*e*	[*e*]
Halides, total organic (μg/L)	2	2	5.8	3.6	4.7	*e*	[*e*]
Solids, total suspended (mg/L)	1	2	33	33	33	*e*	[*e*]
Radionuclides[f], filtered (pCi/L)							
Gross alpha	2	2	3.2	1.9	2.6	15	0[2]
$^{89}Sr + {}^{90}Sr$	2	2	9.5	7.8	8.6*	8.0	1[2]

Table 5.23 (WAGs 8 and 9 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Radionuclides[f], unfiltered (pCi/L)							
^{60}Co	1	2	51	51	51	200	0[4]
Gross alpha	2	2	3.0	2.0	2.5	15	0[2]
Gross beta	1	2	4.3	4.3	4.3	50	0[2]
$^{89}Sr + ^{90}Sr$	2	2	9.2	3.2	6.2	8.0	1[2]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is coded as:

1. Rules of Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.24. Constituents in Waste Area Grouping (WAG) 11 groundwater at ORNL, October 24–November 8, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Chloride	4	5	2.1	0.60	1.3*	250	0[3]
Fluoride	2	5	0.90	0.20	0.55	4.0	0[2]
Nitrate	3	5	1.7	1.0	1.5*	10	0[2]
Sulfate (as SO_4)	5	5	15	2.3	5.8*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	5	5	0.25	0.20	0.22*	*e*	[*e*]
Dissolved oxygen (ppm)	5	5	9.9	4.9	7.6*	*e*	[*e*]
Redox (mV)	5	5	210	180	200*	*e*	[*e*]
Temperature (°C)	5	5	13	12	12*	30	0[1]
Turbidity (JTU)	5	5	620	280	440*	1.0	5[2]
pH (standard units)	5	5	9.0	7.5	8.0*	(6.5, 8.5)	1[3]
Metals, filtered (mg/L)							
Aluminum	5	5	0.092	0.058	0.074*	0.20	0[3]
Barium	5	5	0.12	0.019	0.059*	2.0	0[2]
Calcium	5	5	66	13	42*	*e*	[*e*]
Chromium	3	5	0.014	0.0073	0.0096*	0.050	0[1]
Copper	4	5	0.012	0.0075	0.0092*	1.0	0[1]
Magnesium	5	5	20	1.8	12*	*e*	[*e*]
Manganese	4	5	0.0065	0.0010	0.0026	0.050	0[3]
Potassium	5	5	9.1	0.86	4.2*	*e*	[*e*]
Silicon	5	5	9.2	2.5	5.5*	*e*	[*e*]
Sodium	1	5	13	13	13	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	5	5	55	0.091	11	0.20	3[3]
Barium	5	5	0.26	0.024	0.12*	2.0	0[2]
Beryllium	1	5	0.0061	0.0061	0.0061	*e*	[*e*]
Cadmium	1	5	0.011	0.011	0.011	0.010	1[1]
Calcium	5	5	71	14	45*	*e*	[*e*]
Chromium	4	5	0.078	0.0084	0.030	0.050	1[1]
Cobalt	1	5	0.026	0.026	0.026	*e*	[*e*]
Copper	1	5	0.056	0.056	0.056	1.0	0[1]
Iron	5	5	89	0.090	18	0.30	2[3]
Magnesium	5	5	20	4.2	14*	*e*	[*e*]
Manganese	5	5	1.8	0.0019	0.39	0.050	2[3]
Mercury	1	5	0.00030	0.00030	0.00030	0.00020	1[1]
Nickel	2	5	0.092	0.0041	0.048	0.10	0[1]
Potassium	5	5	.3	1.6	5.3*	*e*	[*e*]

Table 5.24 (WAG ... continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Silicon	5	5	57	5.2	17	*e*	[*e*]
Sodium	1	5	9.4	9.4	9.4	*e*	[*e*]
Vanadium	2	5	0.082	0.0027	0.042	*e*	[*e*]
Zinc	5	5	0.24	0.0053	0.054	5.0	0[1]
Others, filtered (mg/L)							
Alkalinity	5	5	200	55	140*	*e*	[*e*]
Solids, total dissolved	5	5	220	100	170*	500	0[1]
Others, unfiltered (mg/L)							
Alkalinity	5	5	200	55	140*	*e*	[*e*]
Halides, total organic	3	5	99	54	69*	*e*	[*e*]
Solids, total suspended	3	5	1,400	13	490	*e*	[*e*]
Radionuclides,[f] filtered (pCi/L)							
Gross alpha	5	5	11	3.8	6.9*	15	0[2]
Gross beta	5	5	27	6.8	14*	50	0[2]
^{3}H	1	5	59,000	59,000	59,000	20,000	1[2]
$^{89}Sr + ^{90}Sr$	1	5	5.1	5.1	5.1	8.0	0[2]
Radionuclides[f] unfiltered (pCi/L)							
Gross alpha	4	5	21	4.1	9.9*	15	1[2]
Gross beta	5	5	41	7.8	19*	50	0[2]
^{3}H	2	5	43,000	2,400	23,000	20,000	1[2]
Tentatively identified compounds, unfiltered (µg/L)							
1,1,2-Trichloro-1,2,2-trifluoro-ethane-7.81	1	1	J 11	J 11	11	*e*	[*e*]
Benzene,1,2,4-trimethyl--28.27	1	1	J 8.0	J 8.0	8.0	*e*	[*e*]
Unknown-25.36	1	1	J 14	J 14	14	*e*	[*e*]
Unknown-30.13	1	1	J 16	J 16	16	*e*	[*e*]
Volatile organics, unfiltered (µg/L)							
2-Butanone	1	5	JB 7.0	JB 7.0	7.0	*e*	[*e*]
2-Hexanone	1	5	J 3.0	J 3.0	3.0	*e*	[*e*]
4-Methyl-2-pentanone	2	5	J 2.0	J 1.0	1.5	*e*	[*e*]
Acetone	2	5	JB 9.0	JB 5.0	7.0	*e*	[*e*]
Trichloroethene	2	5	32	15	24	5.0	2[2]

Table 5.24 (WAG 11 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells							
Anions, unfiltered (mg/L)							
Chloride	6	6	1.6	0.80	1.1*	250	0[3]
Fluoride	4	6	0.60	0.10	0.35*	4.0	0[2]
Nitrate	3	6	4.6	1.0	2.2	10	0[2]
Phosphate	1	6	1.5	1.5	1.5	*e*	[*e*]
Sulfate (as SO_4)	6	6	3.6	2.0	2.9*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	6	6	0.36	0.26	0.30*	*e*	[*e*]
Dissolved oxygen (ppm)	6	6	10	4.3	6.3*	*e*	[*e*]
Redox (mV)	6	6	190	170	180*	*e*	[*e*]
Temperature (°C)	6	6	16	13	14*	30	0[1]
Turbidity (JTU)	6	6	500	320	400*	1.0	6[2]
pH (standard units)	6	6	7.9	7.3	7.6*	(6.5, 8.5)	0[3]
Metals, filtered (mg/L)							
Aluminum	5	6	0.11	0.057	0.093*	0.20	0[3]
Barium	6	6	0.21	0.020	0.092*	2.0	0[2]
Calcium	6	6	76	25	56*	*e*	[*e*]
Chromium	3	6	0.014	0.0064	0.0094*	0.050	0[1]
Copper	3	6	0.040	0.014	0.025*	1.0	0[1]
Iron	2	6	0.38	0.26	0.32	0.30	1[3]
Magnesium	6	6	18	2.2	11*	*e*	[*e*]
Manganese	5	6	0.42	0.0010	0.16	0.050	2[3]
Potassium	6	6	6.4	2.8	4.8*	*e*	[*e*]
Silicon	6	6	10	6.7	7.7*	*e*	[*e*]
Sodium	2	6	8.9	5.0	6.9	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	6	6	0.57	0.052	0.21*	0.20	2[3]
Barium	6	6	0.20	0.023	0.091*	2.0	0[2]
Calcium	6	6	76	28	56*	*e*	[*e*]
Chromium	5	6	0.0098	0.0043	0.0062*	0.050	0[1]
Iron	5	6	0.60	0.079	0.33*	0.30	3[3]
Magnesium	6	6	17	2.2	11*	*e*	[*e*]
Manganese	6	6	0.37	0.0011	0.12	0.050	2[3]
Potassium	6	6	3.7	1.9	2.8*	*e*	[*e*]
Silicon	6	6	10	6.4	7.6*	*e*	[*e*]
Zinc	5	6	0.016	0.0059	0.010*	5.0	0[1]

Table 5.24 (WAG 11 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Others, filtered (mg/L)							
Alkalinity	6	6	260	120	180*	e	[e]
Solids, total dissolved	6	6	270	27	160*	500	0[1]
Others, unfiltered (mg/L)							
Alkalinity	6	6	250	120	180*	e	[e]
Carbon, total organic	2	6	0.83	0.65	0.74*	e	[e]
Phenolics, total recoverable	1	6	0.0060	0.0060	0.0060	e	[e]
Solids, total suspended	2	6	8.0	7.0	7.5*	e	[e]
Radionuclides,[f] filtered (pCi/L)							
^{60}Co	1	6	49	49	49	200	0[4]
Gross alpha	5	6	7.0	2.0	4.2*	15	0[2]
Gross beta	6	6	18	4.6	8.4*	50	0[2]
^{3}H	2	6	1,300	1,200	1,200*	20,000	0[2]
$^{89}Sr + ^{90}Sr$	3	6	11	3.0	6.1	8.0	1[2]
Radionuclides,[f] unfiltered (pCi/L)							
Gross alpha	5	6	13	1.4	4.4	15	0[2]
Gross beta	6	6	5.9	4.1	5.1*	50	0[2]
$^{89}Sr + ^{90}Sr$	1	6	4.1	4.1	4.1	8.0	0[2]
Tentatively identified compounds, unfiltered (µg/L)							
2-Fluorophenol-7.82	1	1	J 34	J 34	34	e	[e]
Unknown-27.9	1	1	J 5.0	J 5.0	5.0	e	[e]
Unknown-4.39	2	2	J 8.0	J 7.0	7.5*	e	[e]
Unknown-7.59	1	1	J 4.0	J 4.0	4.0	e	[e]
Unknown-7.61	3	3	J 5.0	J 4.0	4.7*	e	[e]
Volatile organics, unfiltered (µg/L)							
Methylene chloride	2	6	JB 2.0	JB 2.0	2.0	e	[e]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.25. Constituents in Waste Area Grouping (WAG) 17 groundwater at ORNL, April 11–17, 1991

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Downgradient wells				
Anions, unfiltered (mg/L)							
Chloride	4	4	18	5.9	12*	250	0[3]
Fluoride	4	4	0.70	0.20	0.35*	4.0	0[2]
Nitrate	1	4	3.5	3.5	3.5	10	0[2]
Sulfate (as SO_4)	4	4	51	28	40*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	4	4	0.55	0.22	0.42*	*e*	[*e*]
Dissolved oxygen (ppm)	4	4	2.0	0.50	0.98*	*e*	[*e*]
Redox (mV)	4	4	200	110	160*	*e*	[*e*]
Temperature (°C)	4	4	18	14	15*	31	0[1]
Turbidity (JTU)	4	4	130	120	120*	1.0	4[2]
pH (standard units)	4	4	7.5	6.8	7.1*	(6.5, 8.5)	0[3]
Metals, filtered (mg/L)							
Aluminum	1	4	0.061	0.061	0.061	0.20	0[3]
Antimony	1	4	0.0060	0.0060	0.0060	*e*	[*e*]
Barium	4	4	0.18	0.021	0.096	2.0	0[2]
Calcium	4	4	120	57	100*	*e*	[*e*]
Chromium	3	4	0.011	0.0092	0.010*	0.050	0[1]
Iron	1	4	0.32	0.32	0.32	0.30	1[3]
Magnesium	4	4	39	8.1	25*	*e*	[*e*]
Manganese	4	4	0.16	0.0015	0.060	0.050	2[3]
Nickel	1	4	0.013	0.013	0.013	0.10	0[1]
Potassium	4	4	2.5	0.84	1.8*	*e*	[*e*]
Silicon	4	4	6.6	2.4	4.7*	*e*	[*e*]
Sodium	4	4	12	5.9	9.1*	*e*	[*e*]
Strontium	4	4	1.2	0.14	0.56*	*e*	[*e*]
Vanadium	1	4	0.0024	0.0024	0.0024	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	4	4	0.77	0.28	0.42*	0.20	4[3]
Barium	4	4	0.19	0.024	0.099	2.0	0[2]
Boron	1	4	0.084	0.084	0.084	*e*	[*e*]
Calcium	4	4	130	53	100*	*e*	[*e*]
Chromium	3	4	0.011	0.010	0.011*	0.050	0[1]
Iron	2	4	0.44	0.39	0.41*	0.30	2[3]
Magnesium	4	4	40	7.6	25*	*e*	[*e*]
Manganese	4	4	0.16	0.0057	0.062	0.050	2[3]
Nickel	1	4	0.018	0.018	0.018	0.10	0[1]
Potassium	4	4	2.3	1.2	1.8*	*e*	[*e*]
Silicon	4	4	6.6	2.9	4.8*	*e*	[*e*]
Sodium	3	4	12	6.8	9.8*	*e*	[*e*]
Strontium	4	4	1.3	0.13	0.58	*e*	[*e*]

Table 5.25 (WAG 17 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Downgradient wells (continued)							
Others, filtered							
Alkalinity (mg/L)	4	4	430	130	310*	*e*	[*e*]
Solids, total dissolved (mg/L)	4	4	490	220	400*	500	0[1]
Others, unfiltered							
Alkalinity (mg/L)	4	4	430	130	310*	*e*	[*e*]
Carbon, total organic (mg/L)	4	4	1.5	1.0	1.3*	*e*	[*e*]
Halides, total organic (µg/L)	2	4	210	2.7	100	*e*	[*e*]
Radionuclides[f], filtered (pCi/L)							
Gross alpha	1	4	5.1	5.1	5.1	15	0[2]
Gross beta	2	4	11	9.2	10*	50	0[2]
^3H	2	4	7,300	2,700	5,000	20,000	0[2]
Radionuclides[f], unfiltered (pCi/L)							
Gross alpha	2	4	13	3.8	8.5	15	0[2]
Gross beta	4	4	20	4.9	8.9*	50	0[2]
^3H	2	4	6,800	3,200	5,000	20,000	0[2]
Volatile organics, unfiltered (µg/L)							
1,1-Dichloroethane	1	4	J 2.0	J 2.0	2.0	*e*	[*e*]
1,1-Dichloroethene	1	4	25	25	25	7.0	1[2]
1,2-Dichloroethene	2	4	E 700	J 1.0	350	*e*	[*e*]
2-Butanone	1	4	29	29	29	*e*	[*e*]
Acetone	2	4	E 230	J 9.0	120	*e*	[*e*]
Benzene	1	4	21	21	21	5.0	1[2]
Bromodichloromethane	1	4	J 3.0	J 3.0	3.0	100	0[2]
Chloroform	1	4	17	17	17	100	0[2]
Tetrachloroethene	1	4	32	32	32	*e*	[*e*]
Toluene	1	4	J 1.0	J 1.0	1.0	*e*	[*e*]
Trichloroethene	2	4	E 1,200	13	610	5.0	2[2]
Vinyl chloride	1	4	99	99	99	2.0	4[2]
Upgradient wells							
Anions, unfiltered (mg/L)							
Chloride	4	4	8.8	1.5	4.3*	250	0[3]
Fluoride	2	4	0.30	0.30	0.30	4.0	0[2]
Nitrate	2	4	1.4	1.1	1.3*	10	0[2]
Sulfate (as SO_4)	4	4	67	14	33*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	4	4	0.46	0.28	0.37*	*e*	[*e*]
Dissolved oxygen (ppm)	4	4	2.5	1.4	1.8*	*e*	[*e*]
Redox (mV)	4	4	180	95	150*	*e*	[*e*]
Temperature (°C)	4	4	16	13	15*	31	0[1]
Turbidity (JTU)	4	4	120	25	96*	1.0	4[2]
pH (standard units)	4	4	7.6	6.8	7.3*	(6.5, 8.5)	0[3]

Table 5.25 (WAG 17 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
			Upgradient wells (continued)				
Metals, filtered (mg/L)							
Aluminum	1	4	0.053	0.053	0.053	0.20	0[3]
Antimony	1	4	0.0070	0.0070	0.0070	*e*	[*e*]
Barium	4	4	0.11	0.021	0.058*	2.0	0[2]
Boron	2	4	0.17	0.081	0.13	*e*	[*e*]
Calcium	4	4	120	51	93*	*e*	[*e*]
Chromium	3	4	0.0091	0.0077	0.0083*	0.050	0[1]
Iron	2	4	0.073	0.073	0.073*	0.30	0[3]
Magnesium	4	4	37	4.1	23*	*e*	[*e*]
Manganese	4	4	0.0085	0.0024	0.0059*	0.050	0[3]
Nickel	1	4	0.0083	0.0083	0.0083	0.10	0[1]
Potassium	4	4	3.4	0.52	2.1*	*e*	[*e*]
Silicon	4	4	8.5	3.9	6.0*	*e*	[*e*]
Sodium	3	4	7.6	5.6	6.9*	*e*	[*e*]
Strontium	4	4	1.8	0.15	0.80	*e*	[*e*]
Vanadium	1	4	0.0021	0.0021	0.0021	*e*	[*e*]
Metals, unfiltered (mg/L)							
Aluminum	4	4	2.0	0.23	0.72	0.20	4[3]
Barium	4	4	0.10	0.024	0.060*	2.0	0[2]
Boron	2	4	0.20	0.10	0.15	*e*	[*e*]
Calcium	4	4	120	53	94*	*e*	[*e*]
Chromium	3	4	0.011	0.0068	0.0090*	0.050	0[1]
Iron	3	4	2.0	0.11	0.73	0.30	1[3]
Magnesium	4	4	36	4.3	23*	*e*	[*e*]
Manganese	4	4	0.040	0.0026	0.014	0.050	0[3]
Nickel	1	4	0.0055	0.0055	0.0055	0.10	0[1]
Potassium	4	4	3.4	0.65	2.1*	*e*	[*e*]
Silicon	4	4	7.9	3.9	6.5*	*e*	[*e*]
Sodium	2	4	7.8	6.9	7.3*	*e*	[*e*]
Strontium	4	4	1.8	0.15	0.81	*e*	[*e*]
Zinc	2	4	0.014	0.0077	0.011	5.0	0[1]
Others, filtered							
Alkalinity (mg/L)	4	4	360	250	300*	*e*	[*e*]
Solids, total dissolved (mg/L)	4	4	420	270	360*	500	0[1]
Others, unfiltered							
Alkalinity (mg/L)	4	4	370	250	300*	*e*	[*e*]
Carbon, total organic (mg/L)	4	4	1.0	0.58	0.74*	*e*	[*e*]
Solids, total suspended (mg/L)	1	4	130	130	130	*e*	[*e*]
Radionuclides[f], filtered (pCi/L)							
^{60}Co	1	4	38	38	38	200	0[4]
Gross alpha	4	4	24	2.7	9.3	15	1[2]
Gross beta	3	4	14	5.9	8.9*	50	0[2]
^{3}H	4	4	15,000	1,200	6,800	20,000	0[2]
$^{89}Sr + ^{90}Sr$	2	4	4.9	4.6	4.7*	8.0	0[2]

Table 5.25 (WAG 17 continued)

Analyte	Number detected	Number of samples	Values above the detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Upgradient wells (continued)							
Radionuclides[f], unfiltered (pCi/L)							
^{60}Co	1	4	30	30	30	200	0[4]
Gross alpha	3	4	12	3.2	6.7	15	0[2]
Gross beta	4	4	11	5.4	7.0*	50	0[2]
^{3}H	4	4	15,000	1,400	6,900	20,000	0[2]
$^{89}Sr + ^{90}Sr$	2	4	6.8	3.8	5.3	8.0	0[2]
Tentatively identified compounds, unfiltered (µg/L)							
Unknown-6.16	1	1	J 8.0	J 8.0	8.0	*e*	[*e*]
Unknown-6.17	1	1	J 7.0	J 7.0	7.0	*e*	[*e*]
Volatile organics, unfiltered (µg/L)							
Acetone	2	4	JB 9.0	JB 6.0	7.5	*e*	[*e*]
Carbon disulfide	1	4	J 2.0	J 2.0	2.0	*e*	[*e*]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is coded as:

1. Rules of Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]The source of the reference limit is enclosed within brackets.

[e]Not applicable.

[f]Multiply pCi/L by 0.037 to convert to Bq/L.

Table 5.26. Constituents in the Waste Area Grouping (WAG) 1 groundwater at the K-25 Site, 1991

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
1,1,1-Trichloroethane, µg/L	4	45	120	3	44.75	0.20 mg/L[c]	0
1,1,2-Trichloroethane, µg/L	1	45	1	1	1	*c*	*d*
1,1-Dichloroethane, µg/L	13	45	2,200	1	175.77	*c*	*d*
1,1-Dichloroethene, µg/L	19	45	1,400	1	82.32	0.007 mg/L[c]	6
1,1-Dichloroethene (Total), µg/L	2	45	3,000	2,800	2,900	*c*	*d*
1,2-Dichloroethene (Total), µg/L	26	45	3,700	1	487.65	*c*	*d*
1,2,3-Trimethylbenzene, µg/L	1	45	97	97	97	*c*	*d*
1,2-Dichloroethane, µg/L	1	45	8	8	8	*c*	*d*
1,2-Dichloro-1,1,2-Trifluoro, µg/L	6	45	780	14	223.5	*c*	*d*
1,4-Diethylbenzene, µg/L	1	45	5.1	5.1	5.1	*c*	*d*
1,4-Dimethyl-2-ethylbenzene, µg/L	1	45	8.6	8.6	8.6	*c*	*d*
2-Butanone, µg/L	6	45	91	1	31.67	*c*	*d*
4-Methyl-2-Pentanone, µg/L	1	45	1	1	1	*c*	*d*
7-Oxabicyclo 4.1.0 Heptane, µg/L	1	45	38	38	38	*c*	*d*
Acetone, µg/L	27	45	60	2	17.89	*c*	*d*
Carbon dioxide, µg/L	4	45	450	5.1	118.03	0.005 mg/L[b]	4
Chloroethane, µg/L	2	45	7	5	6	0.20 mg/L[b]	0
Chloroethene, µg/L	1	45	96	96	96	*c*	*d*
Chloroform, µg/L	6	45	24	3	8.33	0.1 mg/L[b]	0
Conductivity, µmhos/cm		189	1,338	132	546.24	*c*	*d*
Freon 113, µg/L	6	45	9,200	21	1,895	*c*	*d*
Furan, Tetrahydro–2,2–Dimeth, µg/L	1	45	54	54	54	*c*	*d*
Gross alpha (Total), pCi/L	36	45	53.2 ± 12.5	−0.59 ± 1.18		15 pCi/L[b]	
Gross alpha (Dis), pCi/L	41	45	49.9 ± 11.4	−1.07 ± 1.52		15 pCi/L[b]	
Gross beta (Total), pCi/L	36	45	675 ± 69	0.1 ± 3.24		50 pCi/L[b]	7
Gross beta (Dis), pCi/L	41	45	197 ± 22	−0.94 ± 3.42		50 pCi/L[b]	
Methylene Chloride, µg/L	24	45	16	1	4.92	*c*	*d*
m-Ethyltoluene, µg/L	1	45	16	16	16	*c, d*	
n-Methyl-Methanamine, µg/L	1	45	5.1	5.1	5.1	*c*	*d*
pH		189	10.04	4.96	6.96	6.5–8.5[e]	66
^{99}Tc (Dis), pCi/L	4	45	228 ± 30	75.9 ± 14.9		4,000 pCi/L[f]	0
^{99}Tc (Total), pCi/L	12	45	265 ± 34	−1.58 ± 0.13		4,000 pCi/L[f]	0
Tetrachloroethene, µg/L	15	45	4,300	1	299.13	*c*	*d*

Table 5.26 (WAG atinued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Toluene, µg/L	1	45	5	5	5	*c*	*d*
Total Xylenes, µg/L	1	45	10	10	10	*c*	*d*
Trichloroethene	30	45	42,000	2	2,230.8	0.0050 mg/L[b]	27
Trichlorofluoromethane, µg/L	2	45	75	75	75	*c*	*d*
Unknown	1	45	22	22	22	*c*	*d*
Unknown C_6H_{10}	2	45	370	16	193	*c*	*d*
^{234}U (Dis), pCi/L	4	45	38.1 ± 4.3	11.7 ± 1.6		20 pCi/L[f]	1
^{234}U (Total), pCi/L	8	45	35.2 ± 4.2	0.54 ± 0.27		20 pCi/L[f]	1
$^{235,236}U$ (Dis), pCi/L	4	45	12.5 ± 1.7	0.56 ± 0.24		20 pCi/L[f]	0
$^{235,236}U$ (Total), pCi/L	8	45	2.11 ± 0.46	0 ± 0.15		20 pCi/L[f]	0
^{238}U (Dis), pCi/L	4	45	17.8 ± 2.2	2.82 ± 0.56		24 pCi/L[f]	0
^{238}U (Total), pCi/L	8	45	7.99 ± 1.19	0.23 ± 0.21		24 pCi/L[f]	0
Vinyl chloride, µg/L	21	45	490	2	144.71	0.002 mg/L[b]	21
			K1407-B and K-1407-C ponds				
1,1,1–Trichloroethane, µg/L	3	43	110	20	76.66	0.20 mg/L[b]	0
1,1-Dichloroethane, µg/L	18	43	1,000	4	314.28	*c*	*d*
1,1-Dichloroethene, µg/L	19	43	560	7	198.63	0.007 mg/L[b]	19
1,2-Dichloroethane, µg/L	1	43	2	2	2	*c*	*d*
1,2-Dichloroethene (Total), µg/L	19	43	3,000	2	1,203.63	*c*	*d*
1-Propanol, µg/L	1	43	11	11	11	*c*	*d*
Acetone, µg/L	3	43	180	26	79.33	*c*	*d*
Aluminum (Dis), µg/L	19	26	160	22	83.09	0.1 mg/L[e]	7
Aluminum (Total), µg/L	21	26	15,100	27	2,347.90	0.1 mg/L[e]	18
Antimony (Dis), µg/L	4	26	50.3	32	41.43	*c*	*d*
Antimony (Total), µg/L	4	26	59	35.2	47.25	*c*	*d*
Arsenic (Dis), µg/L	3	26	10	3	7.43	0.05 mg/L[b]	0
Arsenic (Total), µg/L	8	26	30	3	9.50	0.05 mg/L[b]	0
Barium (Dis), µg/L	22	26	434	16	96.16	2.0 mg/L[b]	0
Barium (Total), µg/L	22	26	444	17	116.29	2.0 mg/L[b]	0
Boron (Dis), µg/L	14	26	1,200	6.2	133.75	*c*	*d*
Boron (Total), µg/L	11	26	1,400	17	160.55	*c*	*d*

Table 5.26 (WAG 1 continued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
K1407-B and K-1407-C ponds (continued)							
Cadmium (Dis), µg/L	9	26	6	2.6	4.22	0.01 mg/L[b]	0
Cadmium (Total), µg/L	13	26	9.2	2.8	5.54	0.01 mg/L[b]	0
Calcium (Dis), µg/L	23	26	230,000	20,000	112,308.70	*c*	*d*
Calcium (Total), µg/L	22	26	230,000	19,000	114,004.55	*c*	*d*
^{137}Cs, pCi/L	2	13	−3.1 ± 30.7	−9.46 ± 31.5		120 pCi/L[f]	0
Chloride IC, µg/L	27	26	476,000	460	109,354.07	250 mg/L[e]	6
Chloroform, µg/L	9	43	10	0.8	2.03	0.1 mg/L[b]	0
Chromium (Dis), µg/L	12	26	53.6	12	30.8	0.05 mg/L[b]	2
Chromium (Total), µg/L	13	26	59.4	10.2	34.75	0.05 mg/L[b]	4
Cobalt (Dis), µg/L	5	26	45.9	5.8	20.32	*c*	*d*
Cobalt (Total), µg/L	8	26	45.9	5.6	24.18	*c*	*d*
Conductivity, µmhos/cm		96	2,121	140	927.61	*c*	*d*
Copper (Dis), µg/L	8	26	15.4	6	11.45	1.0 mg/L[e]	0
Copper (Total), µg/L	8	26	22	13.7	17.11	1.0 mg/L[e]	0
Cyclohexane, µg/L	2	43	550	13	281.5	*c*	*d*
Ethyl Ether, µg/L	4	43	6	5	5.25	*c*	*d*
Fluoride, µg/L	2	26	200	130	165	2 mg/L[e]	1
Freon-113, µg/L	17	43	3,400	20	1,216.47	*c*	*d*
Gross alpha, pCi/L		13	14.55 ± 2.9	−1.14 ± 1.2		15 pCi/L[b]	0
Gross beta, pCi/L		13	431.3 ± 13.2	2.52 ± 3		50 pCi/L[b]	1
Hexane, 3-Methoxy-, µg/L	1	43	87	87	87	*c*	*d*
Iron (Dis), µg/L	21	26	20,000	7.2	2,038.91	0.3 mg/L[e]	10
Iron (Total), µg/L	21	26	70,600	27	10,546.39	0.3 mg/L[e]	17
Lead (Dis), µg/L	3	26	55.6	47.9	50.7	0.05 mg/L[e]	1
Lead (Total), µg/L	6	26	79	46.3	58.05	0.05 mg/L[e]	4
Lead (Dis) AAS, µg/L	6	26	7	2	3.83	0.05 mg/L[e]	0
Lead (Total) AAS, µg/L	8	26	39	2	13.83	0.05 mg/L[e]	0
Lithium (Dis), µg/L	1	26	5.6	5.6	5.6	*c*	*d*
Lithium (Total), µg/L	2	26	6.5	5	5.75	*c*	*d*
Magnesium (Dis), µg/L	22	26	33,000	3,600	1,590.81	*c*	*d*
Magnesium (Total), µg/L	21	26	32,000	3,600	16,210.48	*c*	*d*
Manganese (Dis), µg/L	22	26	20,000	4.3	6,117.91	0.05 mg/L[e]	18
Manganese (Total), µg/L	22	26	20,000	7.1	5,562.53	0.05 mg/L[e]	19
Methylene chloride, µg/L	8	26	1,700	16	399.86	*c*	*d*
Molybdenum (Dis), µg/L	3	26	12	10.2	11.07	*c*	*d*
Molybdenum (Total), µg/L	6	26	20.9	11.4	15.33	*c*	*d*

Table 5.26 (WA _ continued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
K1407-B and K-1407-C Ponds (continued)							
Nickel (Dis), µg/L	4	26	34	12	26.9	0.10 mg/L[f]	4
Nickel (Total), µg/L	9	26	53.4	13	31.31	0.10 mg/L[f]	9
Niobium (Dis), µg/L	1	13	8.2	8.2	8.2	*c*	*d*
Niobium (Total), µg/L	1	13	16	16	16	*c*	*d*
Nitrate, µg/L	2	13	6,130	2,020	4,075	10 mg/L[b]	0
pH		100	7.5	6.04	6.72	6.5–8.5[e]	18
Phenol (Total), µg/L	3	26	40	20	26.67	*c*	*d*
Phosphorous (Total), µg/L	1	26	250	250	250	*c*	*d*
Potassium (Dis), µg/L	23	26	4,400	1,500	2,643.91	*c*	*d*
Potassium (Total), µg/L	23	26	7,080	1,700	2,975.65	*c*	*d*
Propane, 2-Methyl-1-Prop, µg/L	2	43	75	69	72	*c*	*d*
Silicon (Dis), µg/L	13	13	7,200	1,700	4,269.23	*c*	*d*
Silicon (Total), µg/L	13	13	6,900	1,900	43,307.69	*c*	*d*
Silver (Dis), µg/L	12	26	42.6	12.1	20.08	0.05 mg/L[f]	12
Silver (Total), µg/L	13	26	43	7.3	24.09	0.05 mg/L[f]	13
Sodium (Dis), µg/L	21	26	140,000	1,320	53,066.19	*c*	*d*
Sodium (Total), µg/L	22	26	140,000	1,260	45,250	*c*	*d*
Strontium (Dis), µg/L	12	13	490	35	213.58	*c*	*d*
Strontium (Total), µg/L	12	13	490	37	212.67	*c*	*d*
Sulfate, µg/L	14	26	283,000	3,020	87,580	250 mg/L[e]	1
Total dissolved solids, µg/L	12	13	1,400,000	118,000	648,666.67	500 mg/L[e]	7
Total suspended solids, µg/L	11	13	73,000	7,000	25,727.27	*c*	*d*
^{99}Tc, pCi/L	2	13	–5.25 ± 1600	–251 ± .0016		4,000 pCi/L[f]	0
Tetrachloroethene, µg/L	10	43	680	2	411.50	*c*	*d*
Thallium (Dis), µg/L	3	26	3	3	3	*c*	*d*
Thallium (Total), µg/L	3	26	3	3	3	*c*	*d*
Titanium (Dis), µg/L	8	26	6	3.4	4.56	*c*	*d*
Titanium (Total), µg/L	10	26	17	5.4	14.27	*c*	*d*
TOC, µg/L		100	49,500	1,100	5,379.21	*c*	*d*
Toluene, µg/L	1	43	4	4	4	1 mg/L[b]	0
TOX, µg/L		111	12,830	12	1,441.77	*c*	*d*
Trichloroethene, µg/L	21	43	11,000	2	2,931.67	0.005 mg/L[b]	20
Turbidity, NTU		11	95	1.6	21.06	*c*	*d*

Table 5.26 (WAG 1 continued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
K1407-B and K-1407-C Ponds (continued)							
Unknown, µg/L	31		89	9	30.74	*c*	*d*
Unknown Hydrocarbon, µg/L	1	43	72	72	72	*c*	*d*
Uranium fluorometric (Dis), µg/L	1	13	2	2	2	*c*	*d*
Uranium fluorometric (Total), µg/L	2	13	4	2	3	*c*	*d*
^{234}U, pCi/L	1	13	0.91 ± 1.8	0.91 ± 1.8		20 pCi/L[f]	0
^{235}U, pCi/L	2	13	1.68 ± 0.04	0.46 ± 0.9		24 pCi/L[f]	0
^{238}U, pCi/L	1	13	98.32			24 pCi/L[f]	1
Vanadium (Dis), µg/L	10	26	28.8	5.8	16.93	*c*	*d*
Vanadium (Total), µg/L	10	26	40.2	12.8	27	*c*	*d*
Vinyl chloride, µg/L	13	43	440	40	223.08	0.002 mg/L[b]	13
Zinc (Dis), µg/L	22	26	54	5.0	13.4	5 mg/L[e]	0
Zinc (Total), µg/L	20	26	101	3.8	22.46	5 mg/L[e]	0

[a]For radionuclides and metals Total = unfiltered sample (soluable + suspended) and Dis (dissolved) = filtered sample (soluable only). For organics Total = total detected for that particular species.

[b]Federal Primary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 141—National Primary Drinking Water Regulations, Subpart B-Maximum Contaminant Levels.

[c]No reference

[d]Not applicable

[e]Federal Secondary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 143—National Secondary Drinking Water Regulations.

[f]DOE Guidelines for Radionuclides: DOE Order 5400.5, February 8, 1990. Chapter III, Derived Concentration Guides for Air and Water, which is 4% of the DCG (equivalent to 4 mrem).

Table 5.27. Constituents in the Waste Area Grouping (WAG) 2 groundwater at the K-25 Site, 1991

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
1,1,1-Trichloroethane, µg/L	6	44	638	0.5	135.42	0.20 mg/L[b]	1
1,1,2,2-Tetrachloroethane, µg/L	2	44	1	1	1	*c*	*d*
1,1,2,2-Tetrafluoroethane, µg/L	3	40	260	27	114.67	*c*	*d*
1,1,2-Trichloroethane, µg/L	2	44	8.4	5	6.7	*c*	*d*
1,1-Dichloroethane, µg/L	17	44	1,480	1	198.74	*c*	*d*
1,1-Dichloroethene, µg/L	5	44	490	2	118.40	0.007 mg/L[b]	4
1,1-Difluoroethane, µg/L	3	40	480	43	196.67	*c*	*d*
1,2,3-Trimethylbenzene, µg/L	1	40	19	19	19	*c*	*d*
1,2-Dichloroethene (total), µg/L	18	40	340	1	50.83	*c*	*d*
1,2,3-Trimethylbenzene, µg/L	1	40	97	97	97	*c*	*d*
1,2-Dichloroethane, µg/L	4	44	32.2	3	12.8	*c*	*d*
1,2-Dichloro-1,1,2-Trifluoro, µg/L	11	40	3,100	12	435.45	*c*	*d*
1,2-Dimethyl-cis-Cyclopr, µg/L	2	40	110	100	105	*c*	*d*
1,3-Dimethyl-5-Ethylbenzene, µg/L	1	40	7.8	7.8	7.8	*c*	*d*
1,3-Epoxy-4-Methylpentan, µg/L	1	40	14	14	14	*c*	*d*
1-Ethyl-2-Methyl-Benzene, µg/L	1	40	560	560	560	*c*	*d*
1-Methyl-2-Ethylbenzene, µg/L	1	40	23	23	23	*c*	*d*
1-Methyl-4-Ethylbenzene, µg/L	1	40	88	88	88	*c*	*d*
1-Methyl-Cyclopentene, µg/L	1	40	62	62	62	*c*	*d*
2,2,3,4-Tetramethylpentan, µg/L	1	40	13	13	13	*c*	*d*
2,2,3-Trimethylhexane, µg/L	1	40	100	100	100	*c*	*d*
2,2-Dimethyloxetane, µg/L	1	40	70	70	70	*c*	*d*
2,3-Dimethylbutane, µg/L	1	40	40	40	40	*c*	*d*
2-Methylnapthalene, µg/L	1	40	1	1	1	*c*	*d*
2-Azido-2,3,3-Trimethylbut, µg/L	1	40	120	120	120	*c*	*d*
2-Butanone, µg/L	13	40	81	1	10.38	*c*	*d*
2-Butene, µg/L	2	40	160	15	87.5	*c*	*d*
2-Chloro-1,1,1,3,4,4,4-Hept, µg/L	1	40	28	28	28	*c*	*d*
2-Chloro-1,1,1-Trifluoroe, µg/L	4	40	70	9.2	34.8	*c*	*d*
2-Hexanone, µg/L	10	40	140	2	31.53	*c*	*d*
2-Hexene (Z), µg/L	1	40	110	110	110	*c*	*d*
2-Methyl, 2-Butanol, µg/L	1	40	87	87	87	*c*	*d*
2-Methyl, 2-Butene, µg/L	1	40	520	520	520	*c*	*d*
2-Methylnaphthalene, µg/L	3	40	12,000	24	7341.33	*c*	*d*
2-Methylpropane, µg/L	1	40	610	610	610	*c*	*d*

Table 5.27 (WAG 2 continued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
2-Methyl-1-Nitropropane, µg/L	2	40	1,800	95	947.5	*c*	*d*
2-Pentene (E), µg/L	1	40	150	150	150	*c*	*d*
2-Pentene (Z), µg/L	2	40	120	31	75.5	*c*	*d*
2-Propenyl-Benzene, µg/L	1	40	100	100	100	*c*	*d*
3-Furanol, Tetrahydro, µg/L	1	40	6.5	6.5	6.5	*c*	*d*
3-Hexene (Z), µg/L	1	40	450	450	450	*c*	*d*
3-Methylpentane, µg/L	1	40	20	20	20	*c*	*d*
3-Methyl-1-Butene, µg/L	1	40	99	99	99	*c*	*d*
3-Methyl-2-Pentene (Z), µg/L	2	40	110	21	65.5	*c*	*d*
3-Octane, µg/L	1	40	16	16	16	*c*	*d*
3-Octanone, µg/L	1	40	12	12	12	*c*	*d*
4-Methyl-2-Pentanone, µg/L	4	40	62	1	24.75	*c*	*d*
Acenaphthene, µg/L	2	40	460	1	230.5	*c*	*d*
Acetone, µg/L	26	40	200	2	25.54	*c*	*d*
Ammonia Nitrogen, mg/L	10	18	3.25	0.27	0.818	*c*	*d*
Aroclor, µg/L	1	1	9.3	9.3	9.3	0.0005 mg/L[b]	1
Benzene, µg/L	17	58	1,000	0.6	211.95	0.005 mg/L[b]	14
Benzene, Diethyl-Isomer, µg/L	2	40	19,000	29	9514.5	*c*	*d*
Benzene, Dimethyl-Isomer, µg/L	1	40	50	50	50	*c*	*d*
Benzene, Ethyl-Methyl-Isomer, µg/L	2	40	19,000	48	9,524	*c*	*d*
Benzene, Methyl-Propyl-Isomer, µg/L	2	40	16,000	17	8008.5	*c*	*d*
Benzene, Tetramethyl Isomer, µg/L	1	40	15	15	15	*c*	*d*
Bis(1,1-Dimethylethl) Nitro, µg/L	1	40	93	93	93	*c*	*d*
Bis(2-Ethylhexyl) Phthala, µg/L	1	40	2,400	2,400	2,400	*c*	*d*
Bromoform, µg/L	1	44	1	1	1	*c*	*d*
Carbon Dioxide, µg/L	6	40	2,700	12	461.5	0.005 mg/L[b]	6
Chlorine Oxide, µg/L	5	40	140	7.7	41.08	*c*	*d*
Chlorobenzene, µg/L	2	44	2	2	2	*c*	*d*
Chloroethane, µg/L	3	44	280	3	110	0.20 mg/L[b]	1
Chloroform, µg/L	5	44	17	1	6.92	0.1 mg/L[b]	0
Conductivity, µmhos/cm		156	7,280	6.83	960.34	*c*	*d*
Cumene, µg/L	1	40	24	24	24	*c*	*d*
Cyclobutanol, µg/L	1	40	5.9	5.9	5.9	*c*	*d*
Cyclohexane, µg/L	1	40	140	140	140	*c*	*d*
Cyclopentane, µg/L	1	40	120	120	120	*c*	*d*
Decane, Trimethyl-Isomer, µg/L	1	40	17,000	17,000	17,000	*c*	*d*
Dibutyl Carbitol, µg/L	5	40	180	9.1	141.82	*c*	*d*

Table 5.27 (...G 2 continued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Dimethylamine, µg/L	1	40	44	44	44	c	d
Di-N-Octyl Phthalate, µg/L	1	40	10	10	10	c	d
Ethanol, 2-(Phenylmethyl)AM	2	40	28	9.8	18.9	c	d
Ethylbenzene, µg/L	13	58	320	0.5	80.52	c	d
Fluorene, µg/L	3	40	760	1	493.67	c	d
Freon 113, µg/L	11	40	7,700	5.4	1371.31	c	d
Furan, Tetrahydro-2,2-Dimeth, µg/L	1	40	20	20	20	c	d
Gross alpha (total), pCi/L	20	40	9.82 ± 6.35	–0.57 ± 3.41		15 pCi/L[b]	0
Gross alpha (Dis), pCi/L	20	40	9.01 ± 6.37	–0.63 ± 1.27		15 pCi/L[b]	0
Gross beta (total), pCi/L	19	40	36.5 ± 6.3	1.36 ± 3.49		50 pCi/L[b]	0
Gross beta (Dis), pCi/L	19	40	35.5 ± 6.6	0.46 ± 2.9		50 pCi/L[b]	0
Heptane, µg/L	1	40	13	13	13	c	d
Hexanal, µg/L	1	40	5.3	5.3	5.3	c	d
Hexanoic acid, 2-Ethyl, µg/L	1	40	25	25	25	c	d
Isobutane, µg/L	1	40	41	41	41	c	d
Isobutyl chloride, µg/L	1	40	160	160	160	c	d
Methylcyclopentane, µg/L	4	40	240	52	105.75	c	d
Methylene chloride, µg/L	25	44	290	1	23.63	c	d
m-Ethyltoluene, µg/L	1	40	9.5	9.5	9.5	c	d
m & p-Xylenes, mg/L	7	18	2.14	0.0005	0.32	c	d
Napthalene, µg/L	4	40	5,100	10	1999.6	c	d
Napthalene, Dimethyl-Iso, µg/L	1	40	7,800	7,800	7,800	c	d
Napthalene, Methyl, µg/L	3	40	11,000	14	6704.67	c	d
o-Xylene, µg/L	6	18	1,030	1.3	205.92	c	d
o-(2-Methylpropyl)-Hydro, µg/L	1	40	740	740	740	c	d
Pentanal, µg/L	1	40	5.3	5.3	5.3	c	d
Pentane, µg/L	3	40	580	310	430	c	d
pH		166	12.64	5.86	6.96	6.5–8.5[e]	43
Phenanthrene, µg/L	2	40	1,600	1	800.5	c	d
^{90}Sr (total), pCi/L	3	40	0.89 ± 0.88	–0.25 ± 0.73		8 pCi/L[d]	
^{90}Sr (Dis), pCi/L	2	40	0.081 ± 0.72	–0.51 ± 0.68		8 pCi/L[d]	
Srene, µg/L	1	40	1	1	1	c	d
^{99}Tc (Dis), pCi/L	5	40	12.1 ± 14.1	2.5 ± 10.1		4,000 pCi/L[f]	0
^{99}Tc (total), pCi/L	6	40	3.66 ± 0.13	–7.9 ± 7.8		4,000 pCi/L[f]	0
Tert-Butyl Methyl Ether, µg/L	1	40	16	16	16	c	d
Tetrachloroethene, µg/L	8	44	49	0.7	12.81	c	d

Table 5.27 (WAG 2 continued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Tetradecane, µg/L	1	40	8,200	8,200	8,200	*c*	*d*
Toluene, µg/L	20	58	4,200	0.6	450.81	*c*	*d*
Total Xylenes, µg/L	10	40	3,200	30	546.90	*c*	*d*
TPH, High, mg/L	12	18	13	0.1	1.78	*c*	*d*
TPH, Low, mg/L	8	18	8.3	0.1	2.65	*c*	*d*
Trans-1,2-Dichloroethyle, µg/L	1	40	0.0196	0.0196	0.0196	*c*	*d*
Trans-1,3-Dichloropropen, µg/L	2	40	69	10	39.5	*c*	*d*
Trichloroethene, µg/L	17	44	340	1	35.21	0.0050 mg/L[b]	7
Trichlorofluoromethane, µg/L	2	44	1.76	0.177	0.97	*c*	*d*
Tricyclo[3,2,1,02]Oct-6-ene, µg/L	2	40	150	27	88.5	*c*	*d*
Unknown, µg/L	5	40	8,600	20	2118.40	*c*	*d*
Unknown C_6H_{10}, µg/L	1	40	32	32	32	*c*	*d*
Unknown $C_{10}H_{12}$, µg/L	2	40	7,600	27	3813.5	*c*	*d*
Unknown $C_{10}H_{14}$, µg/L	1	40	26	26	26	*c*	*d*
Unknown $C_{16}H_{34}$, µg/L	1	40	8,800	8,800	8,800	*c*	*d*
Unknown $C_{19}H_{40}$, µg/L	1	40	270	270	270	*c*	*d*
Unknown $C_{43}H_{88}$, µg/L	1	40	670	670	670	*c*	*d*
Unknown C_6H_{10}; µg/L	3	40	18	6	13	*c*	*d*
Unknown C_7H_8, µg/L	1	40	94	94	94	*c*	*d*
Unknown C_8H_{10}, µg/L	1	40	150	150	150	*c*	*d*
Unknown C_9H_{12}, µg/L	2	40	28,000	110	14,055	*c*	*d*
Unknown Hexadecane, µg/L	1	40	6,800	6,800	6,800	*c*	*d*
Unknown Hydrocarbon, µg/L	3	40	12,000	1,900	7533.33	*c*	*d*
^{234}U (total), pCi/L	2	40	1.18 ± 0.28	0.52 ± 0.27		20 pCi/L[f]	0
^{234}U (Dis), pCi/L	1	40	0.545 ± 0.19	0.545 ± 0.19		20 pCi/L[f]	0
$^{235/236}U$ (total), pCi/L	1	40	0.31 ± 0.23	0.31 ± 0.23		20 pCi/L[f]	0
^{238}U (Dis), pCi/L	1	40	0.38 ± 0.16	0.38 ± 0.16		24 pCi/L[f]	0
^{238}U (total), pCi/L	2	40	1.33 ± 0.3	0.33 ± 0.23		24 pCi/L[f]	0
Vinyl Acetate, µg/L	3	40	37	6	22.67	*c*	*d*
Vinyl Chloride, µg/L	9	44	255	12	99.94	0.002 mg/L[b]	9
Beta-Methyl-, Benzeneet, µg/L	1	40	5.8	5.8	5.8	*c*	*d*

[a]For radionuclides and metals Total = unfiltered sample (soluable + suspended) and Dis (dissolved) = filtered sample (soluable only). For organics Total = total detected for that particular species.

[b]Federal Primary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 141—National Primary Drinking Water Regulations, Subpart B-Maximum Contaminant Levels.

[c]No reference

[d]Not applicable

[e]Federal Secondary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 143—National Secondary Drinking Water Regulations.

[f]DOE Guidelines for Radionuclides: DOE Order 5400.5, February 8, 1990. Chapter III, Derived Concentration Guides for Air and Water, which is 4% of the DCG (equivalent to 4 mrem).

Table 5.28. Constituents in the Waste Area Grou[illegible]s (WAG) 3 groundwater at the K-25 Site, 1991

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Acetone, µg/L	1	1	4	4	4	*b*	*c*
Conductivity, µmhos/cm		4	690	670	681.75	*b*	*c*
Gross alpha (Total), pCi/L		1	29.1 ± 9.3	29.1 ± 9.3		15 pCi/L[d]	1
Gross alpha (Dis), pCi/L		1	26.8 ± 8.2	26.8 ± 8.2		15 pCi/L[d]	1
Gross beta (Total), pCi/L		1	4.16 ± 3.05	4.16 ± 3.05		50 pCi/L[d]	0
Gross beta (Dis), pCi/L		1	8.87 ± 3.17	8.87 ± 3.17		50 pCi/L[d]	0
Methylene chloride, µg/L	1	1	1	1	1	*b*	*c*
pH		4	7.5	7.5	7.5	6.5–8.5	0
^{234}U (Dis), pCi/L	1	1	16.1 ± 2	16.1 ± 2		20 pCi/L[e]	0
^{234}U (Total), pCi/L	1	1	15.8 ± 1.9	15.8 ± 1.9		20 pCi/L[e]	0
^{235,236}U (Dis), pCi/L	1	1	1.12 ± 0.3	1.12 ± 0.3		20 pCi/L[e]	0
^{235,236}U (Total), pCi/L	1	1	1.03 ± 0.27	1.03 ± 0.27		20 pCi/L[e]	0
^{238}U (Dis), pCi/L	1	1	8.09 ± 1.14	8.09 ± 1.14		24 pCi/L[e]	0
^{238}U (Total), pCi/L	1	1	7.53 ± 1.01	7.53 ± 1.01		24 pCi/L[e]	0

[a]For radionuclides and metals Total = unfiltered sample (soluable + suspended) and Dis (dissolved) = filtered sample (soluable only). For organics Total = total detected for that particular species.

[b]No reference

[c]Not applicable

[d]Federal Primary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 141—National Primary Drinking Water Regulations, Subpart B-Maximum Contaminant Levels.

[e]DOE Guidelines for Radionuclides: DOE Order 5400.5, February 8, 1990. Chapter III, Derived Concentration Guides for Air and Water, which is 4% of the DCG (equivalent to 4 mrem).

Table 5.29. Constituents in the Waste Area Grouping (WAG) 4 groundwater at the K-25 Site, 1991

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
1,1,1-Trichloroethane, µg/L	4	14	21	8	15.25	0.20 mg/L[b]	0
1,1,2-Trichloroethane, µg/L	2	14	4	2	3	*c*	*d*
1,1-Dichloroethane, µg/L	4	14	17	2	6.75	*c*	*d*
1,1-Dichloroethene, µg/L	3	14	4	3	3.33	0.007 mg/L[d]	0
1,2-Dichloroethene (Total), µg/L	2	14	4	4	4	*c*	*d*
2-Butanone, µg/L	5	14	2	1	1.6	*c*	*d*
4-Methyl-2-pentanone, µg/L	2	14	2	1	1.5	*c*	*d*
Acetone, µg/L	11	14	18	4	8.45	*c*	*d*
Benzene, µg/L	1	14	4	4	4	0.005 mg/L[d]	0
Carbon dioxide, µg/L	4	14	25	13	19.75	0.005 mg/L[d]	4
Carbon tetrachloride, µg/L	1	14	4	4	4	0.005 mg/L[d]	0
Chloroform, µg/L	4	14	36	3	19	0.10 mg/L[d]	0
Conductivity, µmhos/cm		56	1,056	388	741.91	*c*	*d*
Gross alpha (Total), pCi/L		14	72.4 ± 16.4	0 ± 0.044		15 pCi/L[d]	6
Gross alpha (Dis), pCi/L		14	52.8 ± 13.5	0 ± 0.0472		15 pCi/L[d]	5
Gross beta (Total), pCi/L		14	49 ± 7.6	4.08 ± 2.82		50 pCi/L[d]	0
Gross beta (Dis), pCi/L		14	47.4 ± 7.3	2.29 ± 2.91		50 pCi/L[d]	0
Methylene chloride, µg/L	6	14	35	1	7.33	*c*	*d*
pH		56	10.1	6.73	7.39	6.5–8.5[e]	5
^{90}Sr (Dis), pCi/L	3	14	0.74 ± 0.87	0.18 ± 0.81		8.0 pCi/L[b]	0
^{90}Sr (Total), pCi/L	3	14	1.29 ± 0.92	1.07 ± 0.97		8.0 pCi/L[b]	0
^{99}Tc (Dis), pCi/L	3	14	47.6 ± 15.2	5 ± 11		4,000 pCi/L[f]	0
^{99}Tc (Total), pCi/L	3	14	60.8 ± 16.3	12.2 ± 12.8		4,000 pCi/L[f]	0
Tetrachloroethene, µg/L	2	14	2	2	2	*c*	*d*
Trichloroethene, µg/L	3	14	11	1	7.33	0.0050 mg/L[d]	2
^{234}U (Dis), pCi/L	4	14	45.3 ± 5.7	2.37 ± 0.28		20 pCi/L[f]	1
^{234}U (Total), pCi/L	7	14	46.6 ± 5.3	8.32 ± 1.08		20 pCi/L[f]	3
^{235,236}U (Dis), pCi/L	4	14	2.64 ± 0.68	0.87 ± 0.26		20 pCi/L[f]	0
^{235,236}U (Total), pCi/L	6	14	2.25 ± 0.44	0.83 ± 0.23		20 pCi/L[f]	0
^{238}U (Dis), pCi/L	4	14	40.2 ± 5.1	10.5 ± 1.4		24 pCi/L[f]	1
^{238}U (Total), pCi/L	6	14	38.9 ± 4.4	4.92 ± 0.71		24 pCi/L[f]	1
Vinyl chloride, µg/L	21	45	490	2	144.71	0.002 mg/L[d]	21

[a]For radionuclides and metals Total = unfiltered sample (soluable + suspended) and Dis (dissolved) = filtered sample (soluable only). For organics Total = total detected for that particular species.

[b]Federal Primary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 141—National Primary Drinking Water Regulations, Subpart B-Maximum Contaminant Levels.

[c]No reference

[d]Not applicable

[e]Federal Secondary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 143—National Secondary Drinking Water Regulations.

[f]DOE Guidelines for Radionuclides: DOE Order 5400.5, February 8, 1990. Chapter III, Derived Concentration Guides for Air and Water, which is 4% of the DCG (equivalent to 4 mrem).

Table 5.30. Constituents in the Waste Area Group (WAG) 10 groundwater at the K-25 Site, 1991

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
1,1,1-Trichloroethane, µg/L	7	21	2,200	6	390.57	0.20 mg/L[b]	2
1,1,2-Trichloroethane, µg/L	4	21	10	1	3.5	*c*	*d*
1,1-Dichloroethane, µg/L	3	21	40	1	15.33	*c*	*d*
1,1-Dichloroethene, µg/L	7	21	1,200	6	213.57	0.007 mg/L[b]	6
1,2-Dichloroethene (Total), µg/L	9	21	22	1	34.44	*c*	*d*
2-Butanone, µg/L	5	21	10	1	3.4	*c*	*d*
2-Hexanone, µg/L	2	21	2	1	1.5	*c*	*d*
7-Oxabicyclo 4.1.0 Heptane, µg/L	1	21	12	12	12	*c*	*d*
Acetone, µg/L	25	21	11	1	5.76	*c*	*d*
Aluminum (Dis), µg/L	6	21	108	60	89.93	0.1 mg/L[e]	2
Aluminum (Total), µg/L	6	21	3,710	92.4	792.4	0.1 mg/L[e]	5
Barium (Dis), µg/L	6	21	82.9	24.1	41.83	2.0 mg/L[b]	0
Barium (Total), µg/L	6	21	82.1	24.2	42.6	2.0 mg/L[b]	0
Cadmium (Dis), µg/L	1	21	3.6	3.6	3.6	0.01 mg/L[b]	0
Cadmium (Total), µg/L	1	21	3.5	3.5	3.5	0.01 mg/L[b]	0
Calcium (Dis), µg/L	6	21	96,600	42,400	73,466.67	*c*	*d*
Calcium (Total), µg/L	6	21	97,000	46,100	74,816.67	*c*	*d*
Carbon tetrachloride, µg/L	6	21	250	6	59.17	0.005 mg/L[b]	6
Chloroethane, µg/L	9	21	17	1	3.78	0.20 mg/L[b]	0
Chloroform, µg/L	8	21	46	4	9.25	0.1 mg/L[b]	0
Chromium (Dis), µg/L	5	21	20.2	11.5	17.8	0.05 mg/L[b]	0
Chromium (Total), µg/L	6	21	23.2	13.1	19.7	0.05 mg/L[b]	0
Copper (Dis), µg/L	1	21	12.6	12.6	12.6	1.0 mg/L[e]	0
Copper (Total), µg/L	2	21	17.2	10.9	14.05	1.0 mg/L[e]	0
Ethane, 1,1,2-Trichloro-1,2	3	21	75	43	55.67	*c*	*d*
Ethanol, 2-(2-Methoxyethoxy)	1	21	28	28	28	*c*	*d*
Fluoride, mg/L	10	21	1.7	0.1	0.41	2 mg/L[e]	0
Gross alpha (Total), pCi/L		21	23.6 ± 8.2	−1.02 ± 2.5		15 pCi/L[f]	5
Gross alpha (Dis), pCi/L		21	21.1 ± 7.4	−1.06 ± 3.35		15 pCi/L[f]	3
Gross beta (Total), pCi/L		21	675 ± 69	0.1 ± 3.24		50 pCi/L[f]	7
Gross beta (Dis), pCi/L		21	429 ± 45	0.1 ± 3.37		50 pCi/L[f]	4
Iron (Dis), µg/L	6	21	598	15.8	130.68	0.30 mg/L[e]	1
Iron (Total), µg/L	6	21	5,550	57.1	1,220.08	0.30 mg/L[e]	2
Lead (Total) µg/L	1	21	8.8	8.8	8.8	0.05 mg/L[b]	0

Table 5.30 (WAG 10 continued)

Analyte[a]	Number detected	Number of samples	Values above detection limit			Reference value	Number of values exceeding reference
			Max	Min	Av		
Magnesium (Dis), µg/L	6	21	22,600	5,110	9,521.67	[c]	[d]
Magnesium (Total), µg/L	6	21	25,000	5,160	10,066.67	[c]	[d]
Manganese (Dis), µg/L	6	21	1,070	33.9	566.82	0.05 mg/L[e]	5
Manganese (Total), µg/L	6	21	1,130	189	639.33	0.05 mg/L[e]	6
Methylene Chloride, µg/L	23	21	27	1	7.09	[c]	[d]
Nickel (Total), µg/L	1	21	38.2	38.2	38.2	0.10 mg/L[g]	0
n-Butylbenzenesulphonamide	1	21	18	18	18	[c]	[d]
pH		88	8.45	6.31	7.25	6.5–8.5[e]	12
Potassium (Dis), µg/L	6	21	3,050	517	1,454.5	[c]	[d]
Potassium (Total), µg/L	6	21	4,720	537	1,932.83	[c]	[d]
Silver (Dis), µg/L	6	21	22.8	10.1	17.92	0.05 mg/L[g]	0
Silver (Total), µg/L	6	21	23	12.4	18.58	0.05 mg/L[g]	0
Sodium (Dis), µg/L	6	21	7,200	466	3,366	[c]	[d]
Sodium (Total), µg/L	6	21	7,130	710	3,498.33	[c]	[d]
Conductivity, µmhos/cm		89	527	190	357.93	[c]	[d]
^{99}Tc (Dis), pCi/L	21	21	708 ± 80	–3.9 ± 10.1		4,000 pCi/L[f]	0
^{99}Tc (Total), pCi/L	20	21	1,100 ± 120	–2.4 ± 11.3		4,000 pCi/L[f]	0
Tetrachloroethene	6	21	34	1	8.5	[c]	[d]
Trichloroethene	12	21	3,100	3	571.58	0.0050 mg/L[b]	10
Unknown	2	21	8.4	8.1	8.25	[c]	[d]
Unknown C_6H_{10}	4	21	920	750	850	[c]	[d]
Total Uranium (Dis), µg/L	21	21	4.68 ± 0.49	0.077 ± 0.01		[c]	[d]
Total Uranium (Total), µg/L	20	21	5.27 ± 0.57	0.098 ± 0.011		[c]	[d]
Vanadium (Dis), µg/L	4	21	12.7	10.9	11.83	[c]	[d]
Vanadium (Total), µg/L	5	21	19.4	10.8	13.34	[c]	[d]
Zinc (Dis), µg/L	4	21	13.8	5.6	8.8	5 mg/L[e]	0
Zinc (Total), µg/L	5	21	79.7	5.3	22.28	5 mg/L[e]	0

[a]For radionuclides and metals Total = unfiltered sample (soluable + suspended) and Dis (dissolved) = filtered sample (soluable only). For organics Total = total detected for that particular species.

[b]Federal Primary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 141—National Primary Drinking Water Regulations, Subpart B-Maximum Contaminant Levels.

[c]No reference

[d]Not applicable

[e]Federal Secondary Drinking Water Standards 40 CFR (7-1-1990 Edition) Part 143—National Secondary Drinking Water Regulations.

[f]DOE Guidelines for Radionuclides: DOE Order 5400.5, February 8, 1990. Chapter III, Derived Concentration Guides for Air and Water, which is 4% of the DCG (equivalent to 4 mrem.

[g]State of Tennessee General Water Quality Criteria: Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.

Table 5.31. Summary of constituents detected in off-site groundwater during 1991

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
Anions (mg/L), unfiltered							
Chloride	38	42	77	1.0	6.2*	250	0[3]
Fluoride	9	42	6.9	0.10	1.6	4.0	2[2]
Nitrate	22	42	14	1.0	4.1*	10	2[2]
Sulfate, as SO_4	41	42	52	1.0	11*	250	0[3]
Field measurements, unfiltered							
Conductivity (mS/cm)	42	42	1.9	0.073	0.77*	*d*	[*d*]
Temperature (°C)	42	42	26	7.9	16*	30	0[1]
pH (standard units)	42	42	8.7	6.9	7.6*	(6.5, 8.5)	2[3]
Metals (mg/L), unfiltered							
Barium	42	42	0.39	0.0010	0.079*	2.0	0[2]
Calcium	42	42	100	0.44	41*	*d*	[*d*]
Chromium	17	42	0.022	0.0044	0.011*	0.050	0[1]
Cobalt	1	42	0.0054	0.0054	0.0054	*d*	[*d*]
Copper	25	42	0.10	0.0044	0.028*	1.0	0[1]
Iron	29	42	30	0.0059	2.7*	0.30	8[3]
Lead	6	42	0.023	0.0050	0.0093*	0.050	0[1]
Magnesium	42	42	28	0.19	14*	*d*	[*d*]
Manganese	23	42	1.4	0.0011	0.13*	0.050	6[3]
Nickel	13	42	0.013	0.0044	0.0078*	0.10	0[1]
Sodium	32	42	420	0.56	44*	*d*	[*d*]
Uranium, total	23	42	0.0025	0.00020	0.00084*	*d*	[*d*]
Vanadium	4	42	0.0036	0.0027	0.0032*	*d*	[*d*]
Zinc	40	42	0.65	0.0046	0.13*	5.0	0[1]
Radionuclides (pCi/L),[e] unfiltered							
^{60}Co	3	42	59	3.0	22	200	0[4]
^{137}Cs	3	42	62	14	46	120	0[4]
Gross alpha	42	42	13	−1.4	1.5*	15	0[2]
Gross beta	42	42	43	−0.81	6.9*	50	0[2]
^{3}H	2	42	1,200	950	1,100*	20,000	0[2]
$^{89}Sr + ^{90}Sr$	42	42	8.6	−2.0	2.1*	8.0	2[2]
^{99}Tc	7	42	22	4.3	11*	4,000	0[4]
Uranium, total (pCi/L)[f]	23	42	1.7	0.13	0.56*	24	0[4]

Table 5.31 (continued)

Analyte	Number detected	Number of samples	Detected values			Reference value[c]	Number of values exceeding reference [ref][c]
			Max[a]	Min[a]	Av[b]		
Tentatively identified compounds (µg/L), unfiltered							
Acetic acid, methyl ester	2	42	J 140	J 30	85	*d*	[*d*]
Cyclohexane	3	42	JB 10	JB 9.0	9.7*	*d*	[*d*]
Freon 113	1	42	J 9.0	J 9.0	9.0	*d*	[*d*]
Furan,tetrahydro—11.68	1	42	J 8.0	J 8.0	8.0	*d*	[*d*]
Unknown (acetic acid ester)	3	42	J 34	J 7.0	17	*d*	[*d*]
Unknown acid ester	1	42	J 9.0	J 9.0	9.0	*d*	[*d*]
		42					
Volatile organics (µg/L), unfiltered							
1,2-Dichloroethane	7	42	J 1.0	J 0.50	0.81*	5.0	0[2]
Acetone	4	42	30	4.0	20*	*d*	[*d*]
Benzene	2	42	J 1.0	J 0.30	0.65	5.0	0[2]
Carbon disulfide	8	42	4.0	J 0.50	1.2*	*d*	[*d*]
Chloroform	3	42	9.0	J 0.50	3.8	100	0[2]
Toluene	1	42	E 56	E 56	56	*d*	[*d*]

[a]Prefixes J, B, and E mean that the value was estimated, found in the laboratory blank, or exceeded the calibration range, respectively.

[b]An asterisk (*) follows each mean that is significantly greater than zero.

[c]If a reference limit exists, the source is enclosed in brackets and coded as:

1. Rules of Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
2. 40 CFR Part 141—National Primary Drinking Water Regulations, Subparts B and G, as amended.
3. 40 CFR Part 143—National Secondary Drinking Water Regulations, as amended.
4. DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water, as amended.

[d]Not applicable.

[e]Multiply pCi/L by 0.037 to convert to Bq/L.

[f]Calculated activity, assuming natural abundance.

6. BIOLOGICAL MONITORING

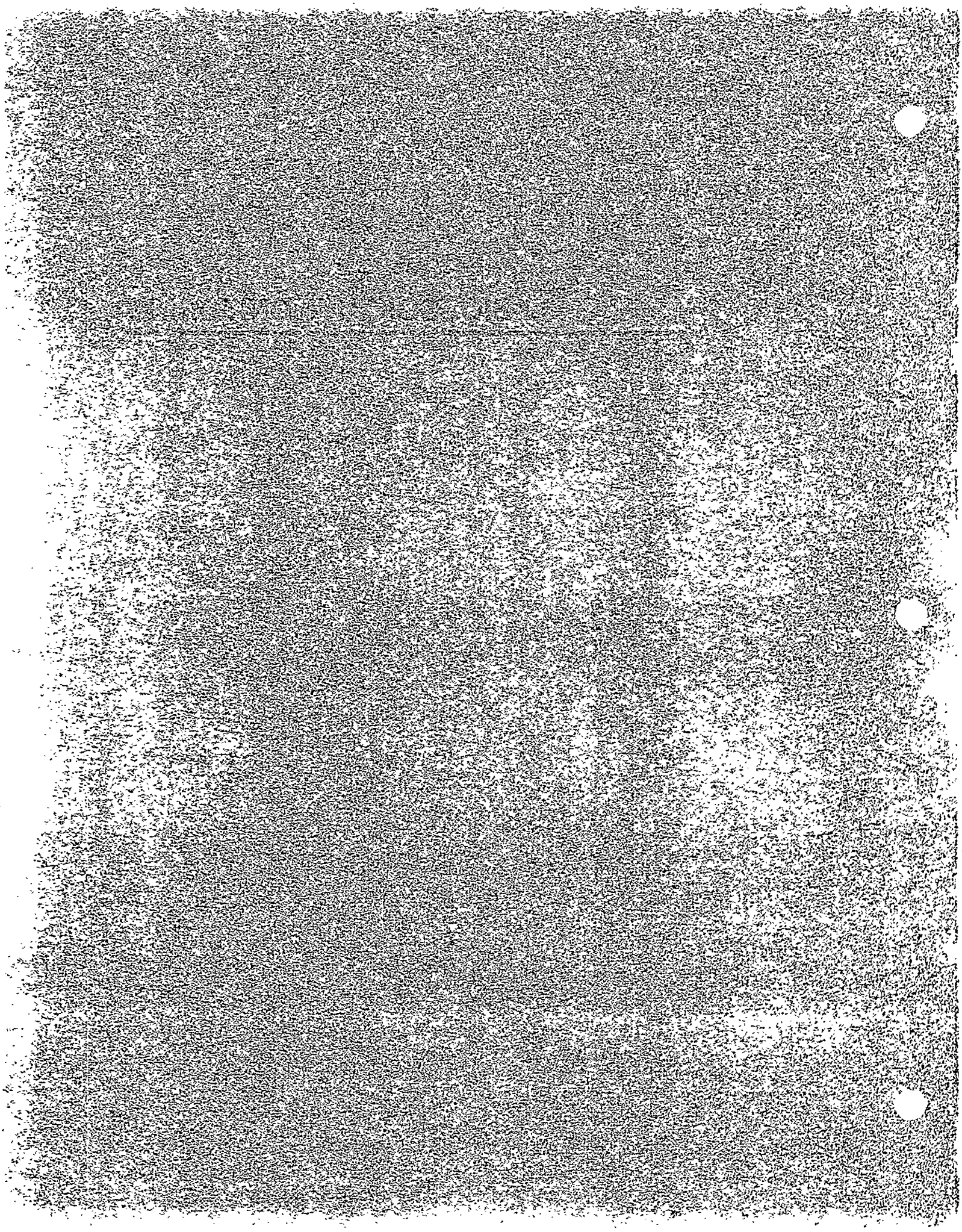


Table 6.1. 1991 ORNL concentrations of ^{131}I in raw milk

Station[a]	Number of samples	Concentration (pCi/L)			
		Max	Min	Av[b]	Standard error[c]
		Immediate environs			
1	10	1.1	–2.2	–0.16	0.35
2	12	1.4	–0.38	0.29*	0.16
3	12	1.3	–0.81	–0.025	0.18
4	12	1.4	–1.1	–0.11	0.20
8	4	0.81	–0.54	0.027	0.32
Network summary	50	1.4	–2.2	0.0065	0.10

[a]See Fig. 6.1 in Vol. 1.
[b]An asterisk (*) indicates that the average is significantly greater than zero at the 95% confidence level.
[c]Standard error of the mean.

Table 6.2. 1991 ORNL concentration of total radioacitve Sr in raw milk

Station[a]	Number of samples	Concentration (pCi/L)			
		Max	Min	Av[b]	Standard error[c]
		Immediate environs			
1	10	6.8	1.3	2.8*	0.57
2	12	7.0	0.81	3.2*	0.51
3	12	11	1.2	4.3*	0.81
4	12	9.2	1.5	4.0*	0.62
8	4	4.9	0.86	3.7*	0.95
Network summary	50	11	0.81	3.6*	0.31

[a]See Fig. 6.1 in Vol. 1.
[b]An asterisk (*) indicates that the average is significantly greater than zero at the 95% confidence level.
[c]Standard error of the mean.

Table 6.3. 1991 mercury concentrations in Clinch River bluegill

Location[a]	Number of fish sampled	Concentration (μg/g wet wt)			
		Max	Min	Av	Standard error[b]
CRK 8.0	12	0.15	0.050	0.11	0.0081
CRK 33.3	12	0.070	0.024	0.039	0.0041
CRK 40.0	12	0.067	0.023	0.043	0.0046

[a]See Fig. 6.2 in Vol. 1.
[b]Standard error of the mean.

Table 6.4. 1991 total PCB concentrations in Clinch River bluegill

Location[a]	Number of fish sampled	Concentration (μg/g wet wt)			
		Max	Min	Av	Standard error[b]
CRK 8.0	12	<1.3	~0.028	<0.50	0.14
CRK 33.3	12	<1.2	~0.012	<0.50	0.14
CRK 40.0	12	<1.5	JB0.015	<0.44	0.14

[a]See Fig. 6.2 in Vol 1.
[b]Standard error of the mean.

Table 6.5. 1991 radionuclide concentrations in Clinch River bluegill

Location[a]	Radionuclide	Number of samples[b]	Max	Min	Av[c]	Standard error[d]
			Concentration (pCi/g ash wt)			
CRK 8.0	^{60}Co	6	0.16	–0.24	–0.022	0.058
CRK 8.0	^{137}Cs	6	6.7	4.8	5.8*	0.30
CRK 8.0	Total Sr[e]	6	0.91	0.029	0.39*	0.15
CRK 33.3	^{60}Co	6	0.35	–0.10	0.18*	0.068
CRK 33.3	^{137}Cs	6	21	6.7	14*	2.2
CRK 33.3	Total Sr[e]	6	5.6	0.24	2.3*	0.89
CRK 40.0	^{60}Co	6	0.10	–0.13	–0.022	0.043
CRK 40.0	^{137}Cs	6	0.91	0.32	0.52*	0.090
CRK 40.0	Total Sr[e]	6	0.29	–0.054	0.11*	0.050
			Concentration (pCi/g wet wt)			
CRK 8.0	^{60}Co	6	0.0019	–0.0031	0.00033	0.00073
CRK 8.0	^{137}Cs	6	0.087	0.060	0.074*	0.0050
CRK 8.0	Total Sr[e]	6	0.012	0.00035	0.0051*	0.0021
CRK 33.3	^{60}Co	6	0.0039	–0.0013	0.0022*	0.00081
CRK 33.3	^{137}Cs	6	0.25	0.077	0.17*	0.025
CRK 33.3	Total Sr[e]	6	0.057	0.0030	0.026*	0.0096
CRK 40.0	^{60}Co	6	0.0014	–0.0016	–0.00026	0.00055
CRK 40.0	^{137}Cs	6	0.011	0.0039	0.0065*	0.0010
CRK 40.0	Total Sr[e]	6	0.0039	–0.00065	0.0015*	0.00066

[a]See Fig. 6.2 in Vol. 1.
[b]A sample is a composite of 6 to 10 fish.
[c]An asterisk (*) indicates that the average is significantly greater than zero at 95% confidence level.
[d]Standard error of the mean.
[e]Total radioactive Sr (^{89}Sr and ^{90}Sr).

7. SOIL AND SEDIMENT MONITORING

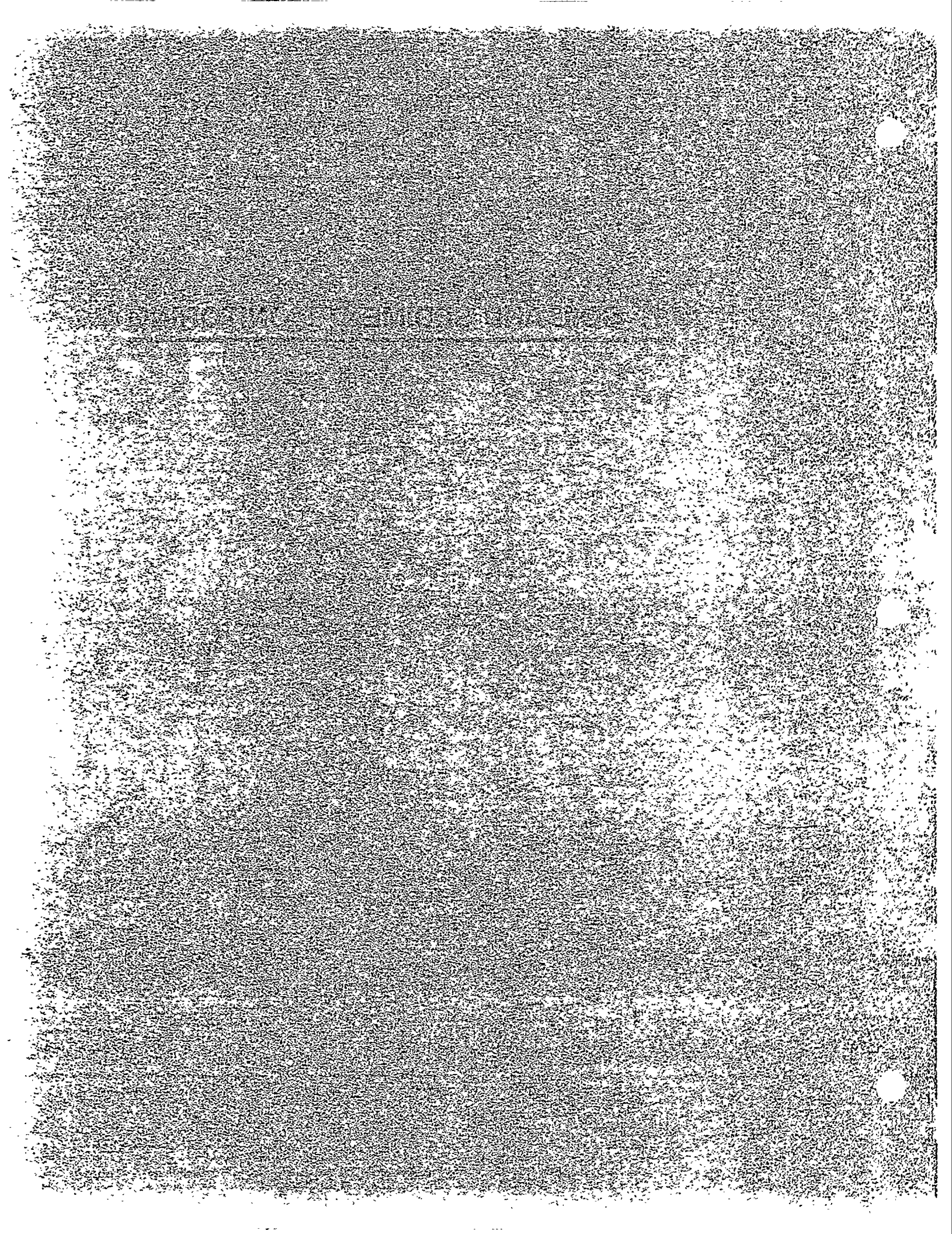


Table 7.1. 1991 summary of inorganic analysis of soil at ORNL air stations[a]

Analyte	Number of samples	Concentration (mg/kg dry wt)			
		Max	Min	Av	Standard error[b]
Ag	15	60	<0.52	<6.3	4.1
Al	15	24,000	7,900	16,000	1,300
As	15	18	<5.2	<8.6	1.2
B	15	<10	<8.3	<9.5	0.13
Ba	15	540	23	150	31
Be	15	1.7	0.59	1.2	0.081
Ca	15	85,000	2,100	19,000	6,200
Cd	15	8.1	1.5	2.8	0.40
Co	15	55	9.0	19	2.9
Cr	15	37	20	27	1.4
Cu	15	54	4.7	24	3.7
Fe	15	37,000	18,000	30,000	1,500
Hg	15	0.27	0.040	0.099	0.016
Li	15	<2,000	<1,600	<1,800	30
Mg	15	36,000	550	5,600	2,200
Mn	15	6,900	500	1,700	440
Mo	15	<5.2	<4.1	<4.8	0.073
Na	15	<650	<520	<600	9.3
Ni	15	47	8.1	26	3.1
P	15	520	120	340	33
Pb	15	85	<5.2	<27	5.8
Sb	15	6.5	<5.2	<6.0	0.099
Se	15	8.3	<5.2	<6.1	0.18
Si	15	1,800	1,000	1,500	53
Sn	15	<6.5	<5.2	<6.0	0.093
Sr	15	61	7.5	22	4.4
Ti	15	210	61	130	14
V	15	59	21	34	2.9
Zn	15	4,000	13	350	260
Zr	15	17	4.3	9.8	0.90

[a]See Fig. 3.19 in Vol. 1.
[b]Standard error of the mean.

Table 7.2. 1991 summary of inorganic analysis of soil at ORR air stations[a]

Analyte	Number of samples	Concentration (mg/kg dry wt)			
		Max	Min	Av	Standard error[b]
Ag	9	19	<0.53	<3.1	2.0
Al	9	23,000	14,000	20,000	1,200
As	9	13	<5.3	<6.7	0.84
B	9	<10	<8.5	<9.1	0.16
Ba	9	160	59	110	12
Be	9	1.3	0.66	1.0	0.068
Ca	9	36,000	820	11,000	4,600
Cd	9	3.1	1.2	1.9	0.21
Co	9	36	12	19	2.3
Cr	9	36	22	27	1.5
Cu	9	31	7.9	20	3.0
Fe	9	35,000	20,000	26,000	1,600
Hg	9	5.1	0.070	1.2	0.66
Li	9	<1,900	<1,600	<1,700	36
Mg	9	7,100	1,000	3,200	850
Mn	9	2,400	570	1,100	180
Mo	9	<5.0	<4.3	<4.6	0.080
Na	9	<620	<530	<570	9.7
Ni	9	36	9.4	21	3.1
P	9	930	100	340	82
Pb	9	62	14	38	6.3
Sb	9	<6.2	<5.3	<5.7	0.095
Se	9	<6.2	<5.3	<5.7	0.095
Si	9	2,400	1,100	1,800	130
Sn	9	<6.2	<5.3	<5.7	0.095
Sr	9	42	5.9	17	4.7
Ti	9	430	120	210	30
V	9	49	25	36	2.7
Zn	9	130	32	66	12
Zr	9	14	4.0	8.1	1.1

[a]See Fig. 3.19 in Vol. 1.
[b]Standard error of the mean.

Table 7.3. Analysis of soil at ORNL air station 3, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	60	<0.65	<22	19
Al	3	12,000	10,000	11,000	580
As	3	14	<6.2	<8.8	2.6
B	3	<10	<9.9	<10	0.033
Ba	3	170	67	110	31
Be	3	1.1	0.79	1.0	0.10
Ca	3	85,000	12,000	49,000	21,000
Cd	3	2.6	2.2	2.4	0.12
Co	3	13	9.3	12	1.2
Cr	3	27	20	23	2.0
Cu	3	31	14	22	4.9
Fe	3	32,000	22,000	28,000	3,000
Hg	3	0.27	0.040	0.16	0.067
Li	3	<2,000	<1,900	<1,900	33
Mg	3	36,000	1,600	15,000	11,000
Mn	3	930	500	730	120
Mo	3	<5.2	<4.9	<5.0	0.088
Na	3	<650	<620	<630	8.8
Ni	3	24	14	19	2.9
P	3	450	160	290	86
Pb	3	34	21	28	3.8
Sb	3	<6.5	<6.2	<6.3	0.088
Se	3	<6.5	<6.2	<6.3	0.088
Si	3	1,800	1,500	1,600	88
Sn	3	<6.5	<6.2	<6.3	0.088
Sr	3	61	15	45	15
Ti	3	86	69	76	5.1
V	3	40	21	28	5.9
Zn	3	170	54	100	35
Zr	3	11	8.1	10	0.97
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.089	–0.0027	0.028	0.031
^{137}Cs	3	4.1	0.92	2.2	0.96
G-Alpha	3	8.9	6.5	8.1*	0.81
G-Beta	3	19	14	17*	1.9
^{40}K	3	13	8.1	9.8*	1.6
^{238}Pu	3	0.046	–0.011	0.010	0.018
^{239}Pu	3	0.084	0.011	0.053	0.022
^{228}Th	3	0.81	0.49	0.67*	0.095
^{230}Th	3	0.65	0.25	0.39*	0.13
^{232}Th	3	0.51	0.30	0.42*	0.065
Total-Sr	3	1.8	0.81	1.2*	0.29
^{234}U	3	0.95	0.30	0.61*	0.19
^{235}U	3	0.059	0.024	0.042*	0.010
^{238}U	3	0.76	0.19	0.42	0.17

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.4. Analysis of soil at ORNL air station 7, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	21	<0.56	<7.6	6.7
Al	3	21,000	19,000	20,000	670
As	3	<6.5	<5.6	<6.0	0.26
B	3	<10	<9.0	<9.5	0.29
Ba	3	170	87	120	25
Be	3	1.7	1.2	1.5	0.15
Ca	3	22,000	5,300	11,000	5,500
Cd	3	2.6	2.0	2.2	0.20
Co	3	19	15	17	1.2
Cr	3	27	24	25	0.88
Cu	3	19	17	18	0.58
Fe	3	32,000	28,000	30,000	1,200
Hg	3	0.070	0.060	0.067	0.0033
Li	3	<2,000	<1,700	<1,800	88
Mg	3	3,700	2,800	3,200	270
Mn	3	1,300	1,200	1,300	33
Mo	3	<5.2	<4.5	<4.8	0.21
Na	3	<650	<560	<600	26
Ni	3	26	21	24	1.5
P	3	510	340	440	51
Pb	3	21	17	19	1.2
Sb	3	<6.5	<5.6	<6.0	0.26
Se	3	<6.5	<5.6	<6.0	0.26
Si	3	1,700	1,500	1,600	58
Sn	3	<6.5	<5.6	<6.0	0.26
Sr	3	24	12	16	4.0
Ti	3	120	98	110	7.0
V	3	30	27	29	1.0
Zn	3	95	58	77	11
Zr	3	12	9.2	11	0.82
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.078	0.014	0.035	0.022
^{137}Cs	3	1.5	0.32	0.80	0.34
G-Alpha	3	8.1	5.1	6.9*	0.91
G-Beta	3	27	14	20*	3.9
^{40}K	3	20	16	18*	1.2
^{238}Pu	3	0.022	−0.016	0.0080	0.012
^{239}Pu	3	0.17	−0.018	0.060	0.056
^{228}Th	3	0.84	0.65	0.77*	0.059
^{230}Th	3	0.41	0.25	0.31*	0.048
^{232}Th	3	0.59	0.35	0.50*	0.077
Total-Sr	3	0.57	0.51	0.53*	0.018
^{234}U	3	0.51	0.35	0.46*	0.054
^{235}U	3	0.032	0.018	0.025*	0.0042
^{238}U	3	0.32	0.30	0.32*	0.0090

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.5. Analysis of soil at ORNL air station 9, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	0.74	<0.59	<0.65	0.046
Al	3	19,000	7,900	13,000	3,200
As	3	<6.2	<5.8	<6.0	0.12
B	3	<9.9	<9.4	<9.6	0.17
Ba	3	180	60	110	36
Be	3	1.4	0.59	0.89	0.25
Ca	3	44,000	2,100	16,000	14,000
Cd	3	3.1	1.5	2.1	0.49
Co	3	25	9.0	18	4.8
Cr	3	32	21	25	3.5
Cu	3	13	4.7	8.8	2.4
Fe	3	37,000	18,000	25,000	5,900
Hg	3	0.11	0.050	0.083	0.018
Li	3	<1,900	<1,800	<1,800	33
Mg	3	6,900	550	2,900	2,000
Mn	3	4,000	760	2,300	940
Mo	3	<4.9	<4.7	<4.8	0.067
Na	3	<620	<580	<600	12
Ni	3	12	8.1	9.8	1.1
P	3	470	120	310	100
Pb	3	37	24	30	3.8
Sb	3	<6.2	<5.8	<6.0	0.12
Se	3	<6.2	<5.8	<6.0	0.12
Si	3	1,500	1,000	1,300	150
Sn	3	<6.2	<5.8	<6.0	0.12
Sr	3	37	7.5	17	9.8
Ti	3	120	61	100	20
V	3	41	27	33	4.2
Zn	3	28	13	21	4.4
Zr	3	17	8.2	12	2.6
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.019	–0.014	–0.0027	0.011
^{137}Cs	3	1.1	0.41	0.77*	0.20
G-Alpha	3	7.8	3.2	6.3*	1.5
G-Beta	3	17	4.3	11*	3.7
^{40}K	3	13	5.1	8.4*	2.4
^{238}Pu	3	0.0054	–0.020	–0.0040	0.0081
^{239}Pu	3	0.046	–0.0073	0.012	0.017
^{228}Th	3	1.0	0.59	0.81*	0.12
^{230}Th	3	0.43	0.30	0.37*	0.039
^{232}Th	3	0.73	0.41	0.56*	0.094
Total-Sr	3	0.57	0.38	0.44*	0.063
^{234}U	3	0.49	0.41	0.45*	0.024
^{235}U	3	0.049	0.0027	0.028	0.013
^{238}U	3	0.35	0.19	0.29*	0.051

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.6. Analysis of soil at ORNL air station 20, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	<0.62	<0.52	<0.57	0.029
Al	3	24,000	20,000	22,000	1,200
As	3	<6.2	<5.2	<5.7	0.29
B	3	<9.9	<8.3	<9.1	0.46
Ba	3	180	160	170	6.7
Be	3	1.3	1.2	1.3	0.033
Ca	3	5,200	2,700	3,800	740
Cd	3	2.5	2.3	2.4	0.058
Co	3	19	18	18	0.33
Cr	3	37	32	35	1.7
Cu	3	26	22	24	1.2
Fe	3	37,000	34,000	36,000	1,000
Hg	3	0.070	0.040	0.053	0.0088
Li	3	<1,900	<1,600	<1,700	88
Mg	3	4,500	4,100	4,300	120
Mn	3	870	550	670	100
Mo	3	<4.9	<4.1	<4.5	0.23
Na	3	<620	<520	<570	29
Ni	3	36	33	34	0.88
P	3	360	190	270	50
Pb	3	8.3	<5.2	<6.6	0.91
Sb	3	<6.2	<5.2	<5.7	0.29
Se	3	<6.2	<5.2	<5.7	0.29
Si	3	1,700	1,200	1,500	150
Sn	3	<6.2	<5.2	<5.7	0.29
Sr	3	14	11	12	0.88
Ti	3	210	200	210	3.3
V	3	30	27	29	1.0
Zn	3	65	62	64	0.88
Zr	3	6.5	4.3	5.4	0.64
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.073	0.024	0.044*	0.015
^{137}Cs	3	0.57	0.14	0.36*	0.12
G-Alpha	3	5.1	4.1	4.7*	0.32
G-Beta	3	15	14	14*	0.45
^{40}K	3	26	18	22*	2.5
^{238}Pu	3	0.0068	−0.0025	0.0029	0.0028
^{239}Pu	3	0.0086	0.00027	0.0036	0.0026
^{228}Th	3	0.51	0.30	0.41*	0.063
^{230}Th	3	0.14	0.092	0.12*	0.015
^{232}Th	3	0.46	0.23	0.35*	0.068
Total-Sr	3	0.38	0.19	0.26*	0.059
^{234}U	3	0.35	0.16	0.24*	0.057
^{235}U	3	0.19	0.022	0.11	0.048
^{238}U	3	0.20	0.097	0.15*	0.030

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.7. Analysis of soil at ORNL air station 21, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	<0.60	<0.57	<0.59	0.0088
Al	3	19,000	12,000	14,000	2,300
As	3	18	13	16	1.7
B	3	<9.6	<9.2	<9.4	0.12
Ba	3	540	23	240	160
Be	3	1.4	1.2	1.3	0.067
Ca	3	23,000	4,300	13,000	5,400
Cd	3	8.1	2.6	4.7	1.7
Co	3	55	10	28	14
Cr	3	25.	25	25	0
Cu	3	54	37	48	5.4
Fe	3	35,000	30,000	33,000	1,500
Hg	3	0.17	0.11	0.13	0.020
Li	3	<1,800	<1,700	<1,800	33
Mg	3	4,300	930	2,400	990
Mn	3	6,900	810	3,300	1,800
Mo	3	<4.8	<4.6	<4.7	0.058
Na	3	<600	<570	<590	8.8
Ni	3	47	31	41	4.9
P	3	520	330	420	55
Pb	3	85	<6.0	<52	24
Sb	3	6.5	<5.7	<6.1	0.23
Se	3	8.3	<5.7	<6.7	0.82
Si	3	1,500	1,400	1,500	33
Sn	3	6.1	<5.7	<5.9	0.12
Sr	3	25	12	18	3.8
Ti	3	210	96	140	35
V	3	59	45	53	4.1
Zn	3	4,000	250	1,500	1,200
Zr	3	15	6.6	11	2.4
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.027	–0.0054	0.012	0.0094
^{137}Cs	3	1.4	–0.011	0.52	0.45
G-Alpha	3	7.0	4.6	5.9*	0.70
G-Beta	3	9.7	7.0	8.0*	0.86
^{40}K	3	5.1	4.1	4.6*	0.31
^{238}Pu	3	0.0038	0.00081	0.0022	0.00087
^{239}Pu	3	0.027	–0.000081	0.012	0.0079
^{228}Th	3	0.46	0.43	0.44*	0.0090
^{230}Th	3	0.76	0.41	0.56*	0.10
^{232}Th	3	0.38	0.32	0.36*	0.018
Total-Sr	3	0.32	0.027	0.17	0.086
^{234}U	3	0.81	0.46	0.60*	0.11
^{235}U	3	0.032	0.022	0.028*	0.0032
^{238}U	3	0.43	0.30	0.35*	0.041

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.8. Analysis of soil at ORR air station 40, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	19	<0.53	<6.7	6.1
Al	3	22,000	15,000	18,000	2,000
As	3	<5.8	<5.3	<5.6	0.17
B	3	<9.4	<8.5	<9.1	0.28
Ba	3	160	140	150	6.7
Be	3	1.3	1.1	1.2	0.067
Ca	3	36,000	4,900	24,000	9,600
Cd	3	3.1	2.2	2.6	0.27
Co	3	19	15	17	1.2
Cr	3	36	28	31	2.4
Cu	3	26	26	26	0
Fe	3	35,000	29,000	31,000	1,900
Hg	3	5.1	0.10	3.1	1.5
Li	3	<1,800	<1,600	<1,700	67
Mg	3	7,100	5,500	6,400	480
Mn	3	1,100	850	940	80
Mo	3	<4.7	<4.3	<4.6	0.13
Na	3	<590	<530	<570	19
Ni	3	36	26	30	3.2
P	3	930	390	580	180
Pb	3	28	18	22	3.2
Sb	3	<5.8	<5.3	<5.6	0.17
Se	3	<5.8	<5.3	<5.6	0.17
Si	3	1,600	1,100	1,400	170
Sn	3	<5.8	<5.3	<5.6	0.17
Sr	3	42	12	31	9.4
Ti	3	430	210	300	67
V	3	33	25	28	2.5
Zn	3	110	59	77	17
Zr	3	14	7.0	10	2.1
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.016	–0.0054	0.0063	0.0063
^{137}Cs	3	0.78	0.11	0.37	0.21
G-Alpha	3	2.2	1.4	1.7*	0.23
G-Beta	3	3.0	1.9	2.5*	0.33
^{40}K	3	21	17	19*	1.1
^{238}Pu	3	0.0081	–0.0089	0.00063	0.0050
^{239}Pu	3	–0.0035	–0.0057	–0.0042	0.00072
^{228}Th	3	0.20	0.092	0.13*	0.036
^{230}Th	3	0.11	0.049	0.068*	0.019
^{232}Th	3	0.15	0.049	0.087	0.030
Total-Sr	3	0.054	0.011	0.034	0.013
^{234}U	3	0.81	0.43	0.59*	0.12
^{235}U	3	0.043	0.020	0.033*	0.0069
^{238}U	3	0.54	0.21	0.34*	0.10

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.9. Analysis of soil at ORR air station 45, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	5.3	<0.59	<2.2	1.6
Al	3	23,000	14,000	18,000	2,600
As	3	13	<5.9	<9.0	2.1
B	3	<10	<9.1	<9.5	0.26
Ba	3	88	59	72	8.5
Be	3	1.2	0.93	1.0	0.084
Ca	3	16,000	1,700	7,500	4,400
Cd	3	2.1	1.9	2.0	0.067
Co	3	36	16	24	6.2
Cr	3	29	22	27	2.3
Cu	3	31	18	26	3.9
Fe	3	28,000	25,000	27,000	880
Hg	3	0.86	0.18	0.44	0.21
Li	3	<1,900	<1,700	<1,800	58
Mg	3	3,100	1,000	1,900	620
Mn	3	1,200	570	870	180
Mo	3	<5.0	<4.5	<4.7	0.15
Na	3	<620	<570	<590	15
Ni	3	26	19	24	2.3
P	3	320	190	270	42
Pb	3	62	37	51	7.4
Sb	3	<6.2	<5.7	<5.9	0.15
Se	3	<6.2	<5.7	<5.9	0.15
Si	3	2,100	1,800	1,900	100
Sn	3	<6.2	<5.7	<5.9	0.15
Sr	3	23	6.9	13	5.1
Ti	3	180	120	150	18
V	3	49	38	44	3.3
Zn	3	130	52	88	23
Zr	3	10	4.0	7.9	1.9
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.0054	–0.051	–0.029	0.017
^{137}Cs	3	0.97	0.13	0.48	0.25
G-Alpha	3	2.0	0.95	1.5*	0.32
G-Beta	3	2.2	1.3	1.6*	0.30
^{40}K	3	11	6.8	8.5*	1.3
^{238}Pu	3	0.0062	–0.012	–0.0026	0.0053
^{239}Pu	3	0.0030	–0.0027	0.00036	0.0017
^{228}Th	3	0.10	0.059	0.081*	0.012
^{230}Th	3	0.073	0.043	0.057*	0.0087
^{232}Th	3	0.065	0.062	0.063*	0.00090
Total-Sr	3	0.049	–0.0027	0.023	0.015
^{234}U	3	0.49	0.15	0.31*	0.096
^{235}U	3	0.035	0.0073	0.019	0.0083
^{238}U	3	0.59	0.12	0.33	0.14

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.10. Analysis of soil at ORR air station 46, 1991[a]

Analyte	Number of samples	Concentration			
		Max	Min	Av[b]	Standard error[c]
		Metals (mg/kg dry wt)			
Ag	3	<0.57	<0.54	<0.55	0.010
Al	3	23,000	20,000	22,000	1,000
As	3	<5.7	<5.4	<5.5	0.10
B	3	<9.1	<8.6	<8.8	0.17
Ba	3	140	93	110	15
Be	3	1.0	0.66	0.80	0.10
Ca	3	1,400	820	1,200	180
Cd	3	1.3	1.2	1.2	0.033
Co	3	20	12	17	2.4
Cr	3	26	22	24	1.2
Cu	3	10	7.9	9.0	0.61
Fe	3	24,000	20,000	21,000	1,300
Hg	3	0.090	0.070	0.080	0.0058
Li	3	<1,700	<1,600	<1,600	33
Mg	3	1,400	1,100	1,300	88
Mn	3	2,400	980	1,600	410
Mo	3	<4.5	<4.3	<4.4	0.067
Na	3	<570	<540	<550	10
Ni	3	11	9.4	10	0.48
P	3	200	100	160	31
Pb	3	59	14	40	13
Sb	3	<5.7	<5.4	<5.5	0.10
Se	3	<5.7	<5.4	<5.5	0.10
Si	3	2,400	2,000	2,200	120
Sn	3	<5.7	<5.4	<5.5	0.10
Sr	3	7.3	5.9	6.6	0.41
Ti	3	200	180	190	6.7
V	3	38	36	37	0.58
Zn	3	37	32	34	1.5
Zr	3	8.5	4.4	6.2	1.2
		Radionuclides (pCi/g dry wt)			
^{60}Co	3	0.062	0.0081	0.034	0.016
^{137}Cs	3	0.49	0.14	0.36*	0.11
G-Alpha	3	1.5	1.1	1.4*	0.11
G-Beta	3	1.8	1.6	1.7*	0.048
^{40}K	3	15	11	13*	1.1
^{238}Pu	3	0.0022	−0.0011	0.0011	0.0011
^{239}Pu	3	0.0022	0.00027	0.00090	0.00063
^{228}Th	3	0.12	0.092	0.11*	0.0087
^{230}Th	3	0.070	0.059	0.064*	0.0032
^{232}Th	3	0.092	0.078	0.084*	0.0041
Total-Sr	3	0.043	0.027	0.036*	0.0048
^{234}U	3	0.26	0.12	0.19*	0.040
^{235}U	3	0.020	0.010	0.014*	0.0031
^{238}U	3	0.16	0.076	0.11*	0.025

[a]See Fig. 3.19 in Vol. 1.
[b]Averages of radionuclides significantly greater than zero are identified by an asterisk (*).
[c]Standard error of the mean.

Table 7.11. 1991 total uranium and fluoride in soil from the K-25 Site perimeter[a]

Analyte	Number of samples	Concentration (μg/g dry wt)			
		Max	Min	Av	Standard error[b]
Total uranium	12	11.4	2.1	4.64	2.78
Fluoride	12	76	<12	29.17	27.95

[a]See Fig. 7.1 in Vol. 1.
[b]Standard error of the mean.

Table 7.12. ORNL 1991 concentration of PCB in sediment

Location[a]	Analysis	Number of samples	Concentration (μg/kg)			
			Max	Min	Av	Standard error[b]
WOC 06	Aroclor-1016	4	<810	<140	<320	160
	Aroclor-1221	4	<810	<140	<320	160
	Aroclor-1232	4	<810	<140	<320	160
	Aroclor-1242	4	<810	<140	<320	160
	Aroclor-1248	4	<810	<140	<320	160
	Aroclor-1254	4	~790	<180	~470	130
	Aroclor-1260	4	~880	~160	~390	170
WOC 10	Aroclor-1016	4	<630	<120	<380	140
	Aroclor-1221	4	<630	<120	<380	140
	Aroclor-1232	4	<630	<120	<380	140
	Aroclor-1242	4	<630	<120	<380	140
	Aroclor-1248	4	<630	<120	<380	140
	Aroclor-1254	4	~780	~42	~400	160
	Aroclor-1260	4	<310	~8.0	~220	71
WOC 14	Aroclor-1016	4	<150	<100	<130	14
	Aroclor-1221	4	<150	<100	<130	14
	Aroclor-1232	4	<150	<100	<130	14
	Aroclor-1242	4	<150	<100	<130	14
	Aroclor-1248	4	<150	<100	<130	14
	Aroclor-1254	4	<310	~4.0	~180	64
	Aroclor-1260	4	<290	~69	~190	46
WOD 13	Aroclor-1016	4	<130	<110	<120	3.4
	Aroclor-1221	4	<130	<110	<120	3.4
	Aroclor-1232	4	<130	<110	<120	3.4
	Aroclor-1242	4	<130	<110	<120	3.4
	Aroclor-1248	4	<130	<110	<120	3.4
	Aroclor-1254	4	<250	~23	~180	54
	Aroclor-1260	4	<250	<220	<230	6.7
MB 07	Aroclor-1016	4	<130	<100	<120	6.5
	Aroclor-1221	4	<130	<100	<120	6.5
	Aroclor-1232	4	<130	<100	<120	6.5
	Aroclor-1242	4	<130	<100	<120	6.5
	Aroclor-1248	4	<130	<100	<120	6.5
	Aroclor-1254	4	<260	<210	<230	13
	Aroclor-1260	4	<260	<210	<230	13
CR 08	Aroclor-1016	4	<120	<110	<110	0.99
	Aroclor-1221	4	<120	<110	<110	0.99
	Aroclor-1232	4	<120	<110	<110	0.99
	Aroclor-1242	4	<120	<110	<110	0.99
	Aroclor-1248	4	<120	<110	<110	0.99
	Aroclor-1254	4	<230	<230	<230	1.8
	Aroclor-1260	4	<230	<230	<230	1.8

Table 7.12 (continued)

Location[a]	Analysis	Number of samples	Concentration (μg/kg)			
			Max	Min	Av	Standard error[b]
CR 09	Aroclor-1016	4	<130	<110	<120	4.9
	Aroclor-1221	4	<130	<110	<120	4.9
	Aroclor-1232	4	<130	<110	<120	4.9
	Aroclor-1242	4	<130	<110	<120	4.9
	Aroclor-1248	4	<130	<110	<120	4.9
	Aroclor-1254	4	<260	<220	<240	9.8
	Aroclor-1260	4	<260	<220	<240	9.8
CR 11	Aroclor-1016	4	<140	<120	<130	3.9
	Aroclor-1221	4	<140	<120	<130	3.9
	Aroclor-1232	4	<140	<120	<130	3.9
	Aroclor-1242	4	<140	<120	<130	3.9
	Aroclor-1248	4	<140	<120	<130	3.9
	Aroclor-1254	4	<270	~25	~200	60
	Aroclor-1260	4	<270	<240	<260	7.5
CR 12	Aroclor-1016	4	<120	<100	<110	3.4
	Aroclor-1221	4	<120	<100	<110	3.4
	Aroclor-1232	4	<120	<100	<110	3.4
	Aroclor-1242	4	<120	<100	<110	3.4
	Aroclor-1248	4	<120	<100	<110	3.4
	Aroclor-1254	4	<240	~8.0	~120	61
	Aroclor-1260	4	<240	<210	<230	6.8

[a]See Fig. 4.10 in Vol. 1.
[b]Standard error of the mean.

8. SPECIAL STUDIES

All data for this section are presented in Vol. 1.

9. SOLID WASTE MANAGEMENT PROGRAM

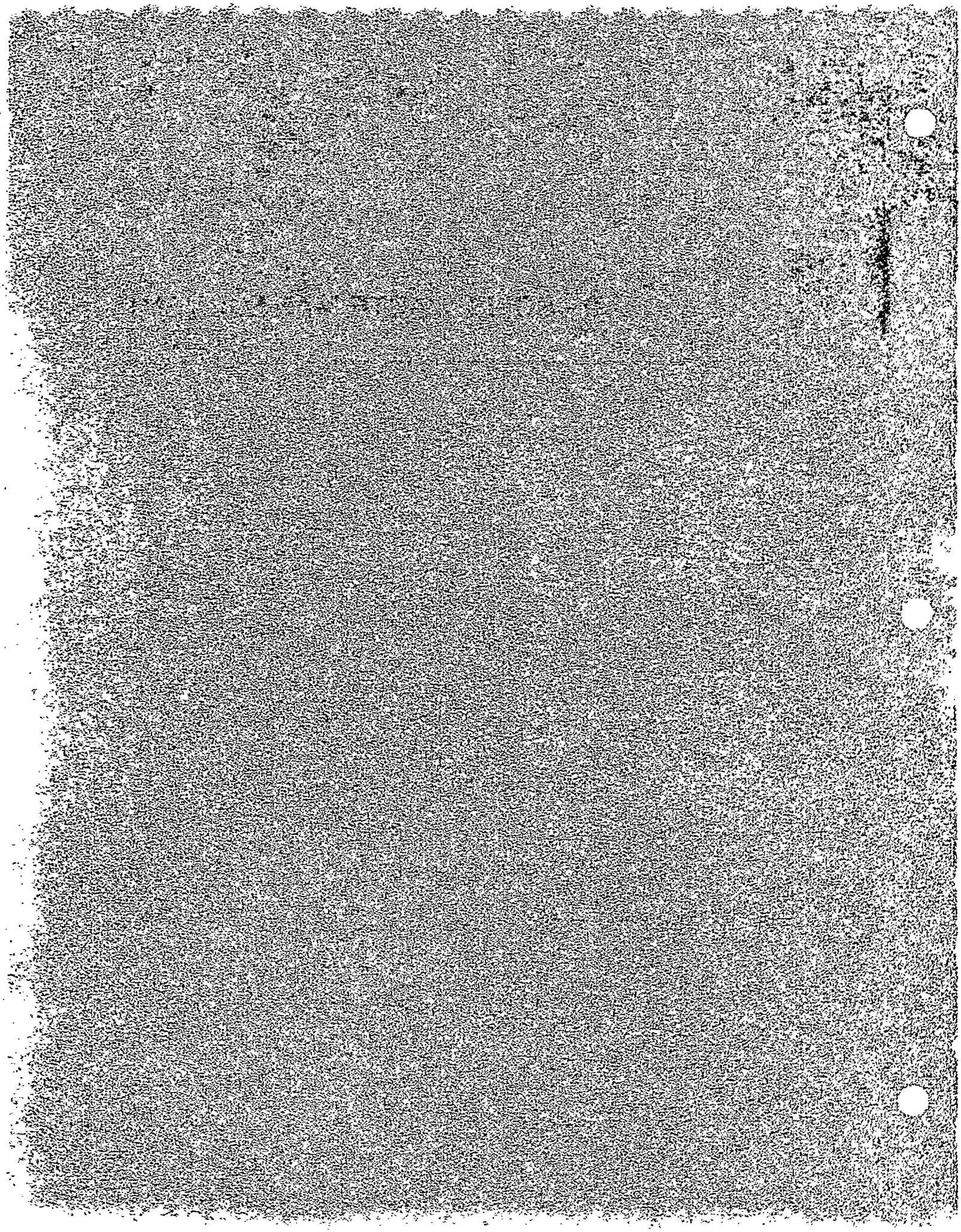


Table 9.1. Y-12 Plant on-site waste treatment data for 1991

Waste	Quantity treated (kg)	Treatment method	Residue
	Liquids		
Nonhazardous	1,293,192[a]	*b*	Sludge
Hazardous	775,790	*c*	Sludge
Low-level aqueous	929,029	*b,d*	Sludge
Mixed	2,915,754	*b*	Sludge
	Solids		
Low-level solids	137,434	Compaction	Solid

[a]Does not include wastewater treated at the Steam Plant Wastewater Treatment Facility.

[b]Batch reactors, settling, filtration, chrome reduction, hydrated lime treatment, dewatering, effluent polishing, biodenitrification, and biological degradation.

[c]Batch reactors, settling, filtration, chrome reduction, hydrated lime treatment, dewatering, effluent polishing, biodenitrification, biological degradation, pH control, and metal precipitation.

[d]Batch reactors, settling, filtration, chrome reduction, hydrated lime treatment, dewatering, effluent polishing, and biodenitrification.

Table 9.2. ORNL waste treatment data for 1991

Waste	Quantity treated (kg)	Treatment method	Residue
Hazardous	0	Detonation	None
Hazardous	1,269.70	Neutralization	None

Table 9.3. Y-12 Plant on-site waste disposal during 1991

Waste	Disposal method	Quantity (kg)
Sanitary/industrial		15,765,451[a,b]
Solid/low-level		1,469,957[a,b]
Classified		23,539

[a]This category includes construction/demolition spoils from the Y-12 Plant.
[b]This category includes disposals from ORNL and the K-25 Site.

Table 9.4. ORNL on-site waste disposal during 1991

Waste	Disposal method	Quantity
Hazardous, kg	Released to air	442.79
Sanitary		
Radiological, m^3	Buried, SWSA 6	17.58
Nonradiological, m^3	Buried, SWSA 6	NA[a]
Asbestos		
Radiological, kg	Buried, SWSA 6	5,014.8
Scrap metal		
Radiological, kg	Buried, SWSA 6	31,012.8

[a] Not available.

Table 9.5. Y-12 Plant off-site waste disposal for 1991

Waste	Disposal method	Quantity (kg)
PCB/RCRA liquid	Incineration	338,346
PCB/RCRA solids	Incineration	23,272
PCB liquid	Incineration	33,348
PCB solid	Landfill burial	18,402
RCRA liquid	Incineration	134,221
Mercury	Landfill burial	342,468
RCRA	Incineration	11,859
Scrap metal (clean)	Public sale	454,725

Table 9.6. ORNL off-site waste disposal for 1991

Waste	Disposal method	Quantity (kg)	Location
Asbestos	Landfilling	19,229	Y-12 Sanitary Landfill, Oak Ridge, Tenn.
Hazardous	Incineration	14,840	Baton Rouge, La.
Hazardous	Incineration	68,933	El Dorado, Ark.
Hazardous	Chemical stabilization/ landfill	417	Emelle, Ala.

Table 9.7. K-25 Site off-site waste disposal activities during 1991

Waste	Quantity	Ultimate disposal
Asbestos (nonrad)	88 m^3	Y-12 landfill
Batteries (solid)	256 batteries	Sold to public (for recycle)
Brass	3,753 kg	Sold to public
Film (solid)	164.25 kg	Sold to public (for recovery)
Hazardous waste	38,045 kg	Commercial disposal facility
Lead	3,105 kg	Sold to public
Nonhazardous	13,136 m^3	Y-12 landfill
Office furniture	20,000 units	Sold to public
PCBs	794.035 kg	Commercial disposal facility
Scrap metal— nonradiological	148 tons	Sold to public
Tires	777 tires	Sold to public

Table 9.8. Waste placed in storage on-site at the Y-12 Plant in 1991

Waste	Quantity (kg)
Low-level	343,286
Mixed	340,643[a]
PCB	131,130
PCB/uranium	28,434
RCRA	109,972
Scrap metal	
Clean	854,882
Uranium-contaminated	950,080

[a]Includes wastes stored at the K-25 Site.

Table 9.9. Total waste in storage at the Y-12 Plant at the end of 1991

Waste	Quantity (kg)
Low-level	884,103
Mixed	7,979,572
Hazardous	176,030
PCB	262,479
PCB/uranium	3,743,087
Noncontaminated oils/ solvents	351,476
Roofing materials	3,109,000
Scrap metal	
Clean	854,882
Uranium-contaminated	3,075,408

Table 9.10. Waste placed in storage at ORNL during 1991

Waste	Quantity
Hazardous, kg	65,898.24
Mixed, kg	19,273.08
PCB, kg	
Radiological	7,193.61
Nonradiological	14,694.00
Transuranic, kg	
Contact handled	3,358.8
Remote handled	1,270.0
Low-level, m^3	3.82 (1,739.9 kg)
Asbestos (kg)	
Nonradiological	0
Radiological	0
Scrap metal, kg	
Nonradiological	Not applicable
Radiological	31,012.8
Miscellaneous	
Radiological, m^3	0

Table 9.11. Total waste in storage at ORNL at the end of 1991

Waste	Quantity
Hazardous, kg	102,035.88
Mixed, kg	101,382.11
PCB, kg	
Radiological	13,130.50
Nonradiological	18,445.83
Transuranic, m^3	
Contact handled	NA[a]
Remote handled	NA[a]
Low level, m^3	
Scrap metal radiological (units)	

[a]Not available.

Table 9.12. K-25 Site waste placed in on-site storage during 1991

Waste	Quantity (kg)	Type storage[a]		Ultimate disposal
		Short-term	Long-term	
Scrap metal (noncompacted) (m^3)	654		X	Under review
CNF centrifuge sludge	93,949		X	Under review
Waste oils and waste oils contaminated with PCBS and/or solvents	104,760	X		TSCA Incinerator
Laboratory acids (BMP)	35,933	X		Under review
Laboratory bases (BMP)	3,971	X		Under review
Laboratory organics (BMP)	11,220	X		Under review
Laboratory sludges (BMP)	598	X		Under review
Photographic solutions	7,628	X		ORNL for silver recovery
Paint waste	11,798	X		TSCA Incinerator
Aerosal cans	1,033	X		To be punctured, segregated, nonhazardous to landfill, off-site.
TSCA ash	7,297		X	Under review
TSCA and IWS sludge	79,034		X	Under review
Gas cylinders	61		X	Under review
Metallic mercury	583	X		Off-site recycle
Solvent-contaminated rags	3,348	X		TSCA Incinerator
Low-level radioactive waste (m^3)	361		X	Under review
Flammable liquids (lab packs)	429	X		Off-site
Flammable liquids (bulk)	9,868	X		Off-site
Flammable solids (lab packs)	20	X		Off -ite
Flammable solids (bulk)	58	X		Off-site
Flammable corrosive liquids	3	X		Off-site
Corrosive liquids (lab packs)	166	X		Off-site
Corrosive liquids (bulk)	6,894	X		Off-site
Corrosive solids (lab packs)	161	X		Off-site
Corrosive solids (bulk)	12,374	X		Off-site
Poisonous solids (lab packs)	4	X		Off-site
Poisonous liquids (lab packs)	5	X		Off-site
Oxidizing acidic liquids	1,422	X		Off-site
Oxidizers, liquid (bulk)	142	X		
Oxidizers, solid (bulk)	45	X		
Combustible liquids	90	X		Off-site
PCB/RCRA liquids	313,448		X	Under review
PCB/RCRA solids	102,292		X	Under review
Hazardous wastes solids	17,825	X		Off-site
Hazardous waste liquids	35,919	X		Off-site
Hazardous wastes (lab packs)	53	X		Off-site

[a]Short-term storage is for periods less than 5 years; long-term storage is for periods greater than 5 years.

Table 9.13. Waste placed in storage at the K-25 Site from other DOE facilities during 1991

Waste	Quantity[a]	Type storage[b]		Ultimate disposal
		Short-term	Long-term	
Metal sludges and activated carbon (kg)	67,576			Under review
LLW (m^3)	112			Under review
Acetonitrile (kg)	4,136	X		Blended, TSCA incinerated
Hazardous waste radioactive materials, mixed (kg)	443,679		X	Under review
Hazardous waste contaminated soils (kg)	3,864		X	Under review

[a]Numbers are liters unless otherwise noted.
[b]Short-term storage is for periods less than 5 years; long-term storage is for periods greater than 5 years.

Table 9.14. Total waste in storage at the K-25 Site at the end of 1991

Waste	Quantity	Ultimate disposal
K-25 low-level waste (m^3)	1,048	Incineration
K-1420 nitric acid (mixed) (kg)	8,850	Under review
K-1420 electroless nickel solution (mixed) (kg)	830	Under review
Spent solvents oils, & PCB liquids (mixed) (L)	556,755	Incineration
Paint waste (kg)	52,667	Incineration
K-1232 spent carbon filter agent (mixed) (kg)	25,284	Under review
Portsmouth PCB contaminated soil (m^3)	1,832	Under review
Incineration ash (kg)	110,903	Under review
Incineration sludge (kg)	181,106	Under review
K-1407B/C pond sludge (mixed) (kg)	35,305,441	To be dewatered or decanted
RMI lead contaminated liquid (mixed) (kg)	23,843	Under review
WMCO hazardous waste liquid (mixed) (kg)	917	Incineration
WMCO hazardous waste solid (mixed) (m^3)	77	Under review
Y-12 LLW (m^3)	3,514	Under review
X-10 LLW (m^3)	835	Under review
Y-12 hazardous liquids (kg)	11,698	Under review
PORTS hazardous solids (kg)	7,845	Under review
PORTS hazardous liquids (kg)	24,149	Under review
RMI spent solvents (mixed) (kg)	1,245	Under review
X-10 hazardous liquids (L)	440	Under review
Lab pack chemicals (kg)	1,347	Incineration
Centrifuge epoxies/resins (kg)	7,691	Under review
CNF centrifuge sludge (kg)	689,444	Under review
Laboratory BMP solutions (kg)	192,224	Under review
Photo wastes (kg)	3,507	Off-site
Metallic mercury (kg)	1,760	Under review
Rags contaminated with solvents (kg)	5,757	Under review
Test burn materials (kg)	32,081	Under review
Metal shavings/lead (kg)	27,881	Under review
Hazardous waste liquids (kg)	76,541	Under review
Asbestos covered lead pipe (kg)	2,318	Under review
Hazardous waste solids (kg)	72,004	Under review
Gases/cylinders (kg)	579	Under review
TSCA + IWS sludge (kg)	181,106	Under review
Laundry sludge (kg)	35,193	Under review
Waste from treatment of WMCO hazardous waste liquid (kg)	5,658	Under review

10. QUALITY ASSURANCE

Table 10.1. Example of inorganic QC results for sampling GW-115

Y-12 Plant, 1991

Parameter	GW-115	Field replicate	Field blank
Concentration (mg/L)			
As	<0.050	<0.0059	[a]
Ba	0.25	0.25	[a]
Cd	<0.002	<0.002	[a]
Cr	<0.01	<0.01	[a]
Pb	<0.004	<0.004	[a]
Se	<0.050	<0.050	[a]
Ag	<0.01	0.01	[a]
Hg	<0.0002	<0.0060	[a]
pH (standard units)	7.4	7.5	[a]
Activity (pCi/L)[b]			
Alpha	1.45 ± 1.1	1.63 ± 1.1	[a]
Beta	6.79 ± 3.3	4.52 ± 3.2	[a]
Suspended solids (mg/L)	1.0	<1.0	[a]
U Fluorometric (mg/L)	<0.001	<0.001	[a]
Conductivity (μmho/cm)	345.0	342.0	[a]
Alkalinity (mg/L)			
CO_3	<1.0	<1.0	[a]
HCO_3	217	216	[a]

[a]Not applicable.

[b]The confidence interval is reported per DOE/EH-0173T, Chapter 7, Section 7.1, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.

Table 10.2. Example of organic QC data at GW-115

Y-12 Plant, 1991

Parameter	GW-115	Field duplicate	Field blank	Field blank duplicate
		Volatile organic compounds (μg/L)		
Chloromethane	10 U	10 U	10 U	10 U
Bromomethane	10 U	10 U	10 U	10 U
Vinyl chloride	10 U	10 U	10 U	10 U
Chloroethane	10 U	10 U	10 U	10 U
Methylene chloride	5 U	5 U	5 U	5 U
Acetone	10 U	10 U	10 U	10 U
Carbon disulfide	5 U	5 U	5 U	5 U
1,1-dichloroethene	5 U	5 U	5 U	5 U
1,1-dichloroethane	5 U	5 U	5 U	5 U
Chloroform	5 U	0.8 JB	5 U	0.8 JB
1,2-dichloroethane	5 U	5 U	5 U	5 U
2-butanone	10 U	10 U	10 U	10 U
1,1,1-trichloroethane	5 U	5 U	5 U	5 U
Carbon tetrachloride	5 U	5 U	5 U	5 U
Vinyl acetate	10 U	10 U	10 U	10 U
Bromodichloromethane	5 U	5 U	5 U	5 U
1,1,2,2-tetrachloroethane	5 U	5 U	5 U	5 U
1,2-dichloropropane	5 U	5 U	5 U	5 U
Trans-1,3-dichloropropene	5 U	5 U	5 U	5 U
Trichloroethene	5 U	5 U	5 U	5 U
1,1,2-trichloroethane	5 U	5 U	5 U	5 U
Benzene	5 U	5 U	5 U	5 U
Cis-1,3-dichloropropene	5 U	5 U	5 U	5 U
Bromoform	5 U	5 U	5 U	5 U
2-hexanone	10 U	10 U	10 U	10 U
4-methyl-2-pentanone	10 U	10 U	10 U	10 U
Tetrachloroethene	5 U	5 U	5 U	5 U
Toluene	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U
Ethylbenzene	5 U	5 U	5 U	5 U
Styrene	5 U	5 U	5 U	5 U
Xylenes	5 U	5 U	5 U	5 U
		Surrogate recovery (%)		
Toluene-D8	101.4	104.9	100.4	102.4
Bromofluorobenzene	101.9	106.3	99.8	104.6
1,2-dichloroethane D-4	104.1	113.1	96.3	104.4

U = compound analyzed for but not detected.
J = indicates an estimated value.
B = Analyte found in blank as well as sample.

Table 10.3. K-25 Site environmental analysis procedures for NPDES

Parameter	Regulatory method	Lowest concentration reported[a]
Alkalinity, $CaCO_3$ (mg/L)	EPA-310.1	1
Gross alpha activity (pCi/L)	EPA-900.0	1.0
Gross beta activity (pCi/L)	EPA-900.0	4.0
^{241}Am and ^{244}Cm (pCi/L)		
^{241}Am	ACD-160066[h]	3.0
^{244}Cm	ACD-160066[h]	3.0
As and Se, gaseous hydride-AA (mg/L)		
As	EPA-206.2	0.005
Se	EPA-270.2	0.005
Asbestos (fibers/L)		0.3×10^6
Biochemical oxygen demand, 5-d (mg/L)	EPA-405.1	5
Bromide, spectrophotometric (mg/L)	EPA-320.1	0.1
Chemical oxygen demand (low level) titration method (mg/L)	EPA-410.4	5
Chloride, titration, $HgNO_3$ (mg/L)	EPA-325.3	2
Anions, ion chromatograph[b] (mg/L)		
Chloride	EPA-300.0	1
Nitrate (N)	EPA-352.1	1
Sulfate	EPA-375.4	1
Phosphate (P)	EPA-365.1	1
$TRCl_2$, amperometric (mg/L)	EPA-330.1	0.05
Cr (VI), colorimetric (mg/L)	307B	0.01
Coliform bacteria, fecal (colonies/100 mL)	9221C Std Mth[d]	1
Coliform bacteria, total (colonies/100 mL)	9221B Std Mth	1
Color (color unit)	EPA-110.2	1
Conductance, specific (μmho/cm)	EPA-120.1	0.5
Cyanide, total (5-cm cell)	EPA-335.2	0.004
Dissolved oxygen, membrane electrode method (mg/L)	EPA-360.1	0.1
Fluoride (mg/L)	EPA-340.2	0.1
Gamma-ray emitters (pCi/L)		2.5
Herbicides (chlorinated phenoxy acid), GC method (μg/L)		
2,4-D	6640B Std Mth	<1.0
Silvex	6640B Std Mth	<0.1
Hg, total (mg/L)	EPA-245.1	0.0002
Methylene-blue-active substances (mg/L)	EPA-425.1	0.05
^{237}Np (pCi/L)	ACD-1665[h]	1.0
N (mg/L)		
Ammonia, SIE	EPA-350.3	0.2
Kjeldahl (total), spectrophotometric	EPA-351.3	0.2
Kjeldahl (total), volumetric	EPA-351.3	0.2
Kjeldahl (total), SIE	EPA-351.4	0.2
Nitrate, brucine method	EPA-352.1	0.1
Nitrate-nitrite, Cd-Redn.	EPA-353.3	0.1
O&G, gravimetric (mg/L)	EPA-413.1	5
Pesticides (organochlorine), GC method (μg/L)		
Lindane	EPA-608[e]	0.01
Endrin	EPA-608	0.05
Toxaphene	EPA-608	1.0
Methoxychlor	6630 B & C Std Mth	0.2
Phenols (mg/L)	EPA-420.1	0.03
pH, electrometric (standard units)	EPA-9040	Nearest 0.1

Table 10.3 (continued)

Parameter	Regulatory method	Lowest concentration reported[a]
P (all forms), spectrophotometric (mg/L)	EPA-365.2	0.1
Pu isotopes (pCi/L)	ACD-1665[h]	1.0
PCBs, each (μg/L)	EPA-608	
Aroclor-1016		0.5
Aroclor-1221		0.5
Aroclor-1232		0.5
Aroclor-1242		0.5
Aroclor-1248		0.5
Aroclor-1254		1.0
Aroclor-1260		1.0
Priority pollutants, organic (base/neutral/acid), each (μg/L)	CLP Methodology	Mostly 10–50[f]
Priority pollutants, organic (volatile, purgeable), each (μg/L)	CLP Methodology	Mostly 10–30[g]
Solids (residue)		
Dissolved (mg/L)	EPA-160.1	10
Settleable [mL/(L·h)]	EPA-160.5	0.1
Total (mg/L)	EPA-160.3	1.0
Undissolved (mg/L)	EPA-160.2	4
Volatile (mg/L)	EPA-160.4	5
^{90}Sr (pCi/L)	ACD-160069[h]	4.0
Sulfate, turbidimetric method (mg/L)	375.4	5
^{99}Tc (pCi/L)	ACD-160069[h]	300
Th isotopes (pCi/L)	ACD-1665[h]	0.4
Th, spectrophotometric (mg/L)		2×10^{-3}
Total organic carbon, combustion or oxidation (mg/L)	EPA-415.1	1
Tritium (pCi/L)	ACD-160059[h]	5000
Turbidity (NTU)	EPA-180.1	0.1
U (total), fluorometric (mg/L)	ACD-183707[h]	1×10^{-3}
U isotopes (pCi/L)	ACD-210026[h]	1
U isotopic abundances (wt %)	ACD-2116[h]	0.001

[a]The lowest concentration reported (LCR) may vary among specific samples, depending on interferences in the sample matrix. However, these LCRs have been assigned to accommodate most minor interferences. Some of the Energy Systems LCRs are higher than the method detection limits (MDLs) listed by EPA. This is consistent with guidance from EPA. However, any data reported below the MDLs must be supported by sound documentation. The LCRs applied by the Energy Systems laboratories meet the needs of the programs they support.

[b]Approved for drinking water only (reagent water).

[c]*Methods for Analysis of Inorganic Substances in Water and Fluvial Sediment*, U.S. Department of the Interior, U.S. Geological Survey, Open-File Report 78-679; or "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," N. W. Skougstad et al., *Techniques of Water-Resources Investigation*, Book 5, Chapter A1, U.S. Geological Survey, 1979.

[d]All references to *Standard Methods* for the 15th Edition, 1980.

[e]*Federal Register* 49 (209), 43, 261, October 26, 1984.

[f]For 81 compounds.

[g]For 31 compounds.

[h]No regulatory method available for use.

Table 10.4. K-25 Site environmental analysis procedures for waste water characterization and groundwater monitoring

Parameter	Regulatory method	Lowest concentration reported[a]
Alkalinity, $CaCO_3$ (mg/L)	EPA-310.1	1
Gross alpha activity (pCi/L)	EPA-900.0	1.0
Gross beta activity (pCi/L)	EPA-900.0	4.0
^{241}Am and ^{244}Cm (pCi/L)		
^{241}Am	ACD-160066[h]	3.0
^{244}Cm	ACD-160066[h]	3.0
As, gaseous hydride-AA (mg/L)	EPA-7060	0.002
Se, gaseous hydride-AA (mg/L)	EPA-7740	0.002
Asbestos (fibers/L)		0.3×10^6
Biochemical oxygen demand, 5-d (mg/L)	EPA-405.1	5
Bromide, spectrophotometric (mg/L)	EPA-320.1	0.1
Chemical oxygen demand (low level) titration method (mg/L)	EPA-410.4	5
Chloride, titration, $HgNO_3$ (mg/L)	EPA-325.3	2
Anions, ion chromatograph[b] (mg/L)		
Chloride	EPA-300.0	1
Nitrate (N)	EPA-352.1	1
Sulfate	EPA-375.4	1
Phosphate (P)	EPA-365.1	1
$TRCl_2$, amperometric (mg/L)	EPA-330.1	0.05
Cr (VI), colorimetric (mg/L)	307B	0.01
Coliform bacteria, fecal (colonies/100 mL)	9221C Std Mth[d]	1
Coliform bacteria, total (colonies/100 mL)	9221B Std Mth	1
Color (color unit)	EPA-110.2	1
Conductance, specific (μmho/cm)	EPA-120.1	0.5
Cyanide, total (5-cm cell)	EPA-335.2	0.004
Dissolved oxygen, membrane electrode method (mg/L)	EPA-360.1	0.1
Fluoride (mg/L)	EPA-340.2	0.1
Gamma-ray emitters (pCi/L)		2.5
Herbicides (chlorinated phenoxy acid), GC method (μg/L)		
2,4-D	6640B Std Mth	<1.0
Silvex	6640B Std Mth	<0.1
Hg, total (mg/L)	245.1	0.0002
Methylene-blue-active substances (mg/L)	425.1	0.05
^{237}Np (pCi/L)	ACD-1665[h]	1.0
N (mg/L)		
Ammonia, SIE	EPA-350.3	0.2
Kjeldahl (total), spectrophotometric	EPA-351.3	0.2
Kjeldahl (total), volumetric	EPA-351.3	0.2
Kjeldahl (total), SIE	EPA-351.4	0.2
Nitrate, brucine method	EPA-352.1	0.1
Nitrate-nitrite, Cd-Redn.	EPA-353.3	0.1
N-nitrosomorpholine, spectrophotometric (mg/L)		0.1
O&G, gravimetric (mg/L)	EPA-413.1	5
Pesticides (organochlorine), GC method (μg/L)		
Lindane	EPA-608[e]	0.01
Endrin	EPA-608	0.05
Toxaphene	EPA-608	1.0
Methoxychlor	6630 B & C Std Mth	0.2
Phenols (mg/L)	EPA-420.1	0.03
pH, electrometric (standard units)	EPA-9040	Nearest 0.1

Table 10.4 (continued)

Parameter	Regulatory method	Lowest concentration reported[a]
P (all forms), spectrophotometric (mg/L)	EPA-365.2	0.1
Pu isotopes (pCi/L)		1.0
PCBs, each (μg/L)	EPA-8080	
Aroclor-1016		0.5
Aroclor-1221		0.5
Aroclor-1232		0.5
Aroclor-1242		0.5
Aroclor-1248		0.5
Aroclor-1254		1.0
Aroclor-1260		1.0
Priority pollutants, organic (base/neutral/acid), each (μg/L)	CLP Methodology	Mostly 10–50[f]
Priority pollutants, organic (volatile, purgeable), each (μg/L)	CLP Methodology	Mostly 10–30[g]
Solids (residue)		
Dissolved (mg/L)	EPA-160.1	10
Settleable [mL/(L·h)]	EPA-160.5	1.0
Total (mg/L)	EPA-160.3	10
Undissolved (mg/L)	EPA-160.2	4
Volatile (mg/L)	EPA-160.4	5
^{90}Sr (pCi/L)		4.0
Sulfate, turbidimetric method (mg/L)	EPA-375.4	5
^{99}Tc (pCi/L)	ACD-160069[h]	300
Th isotopes (pCi/L)	ACD-1665[h]	0.4
Th, spectrophotometric (mg/L)		2×10^{-3}
Total organic carbon, combustion or oxidation (mg/L)	EPA-415.1	1
Tritium (pCi/L)	ACD-160059[h]	5000
Turbidity (NTU)	EPA-180.1	0.05
U (total), fluorometric (mg/L)	ACD-183707[h]	1×10^{-3}
U isotopes (pCi/L)	ACD-210026[h]	1
U isotopic abundances (wt %)	ACD-2116[h]	0.001

[a]The lowest concentration reported (LCR) may vary among specific samples, depending on interferences in the sample matrix. However, these LCRs have been assigned to accommodate most minor interferences. Some of the Energy Systems LCRs are higher than the method detection limits (MDLs) listed by EPA. This is consistent with guidance from EPA. However, any data reported below the MDLs must be supported by sound documentation. The LCRs applied by the Energy Systems laboratories meet the needs of the programs they support.

[b]Approved for drinking water only (reagent water).

[c]*Methods for Analysis of Inorganic Substances in Water and Fluvial Sediment*, U.S. Department of the Interior, U.S. Geological Survey, Open-File Report 78-679; or "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," N. W. Skougstad et al., *Techniques of Water-Resources Investigation*, Book 5, Chapter A1, U.S. Geological Survey, 1979.

[d]All references to *Standard Methods* for the 15th Edition, 1980.

[e]*Federal Register* 49 (209), 43, 261, October 26, 1984.

[f]For 81 compounds.

[g]For 31 compounds.

[h]No regulatory method available for use.

Table 10.5. K-25 Site atomic absorption and ICP environmental analysis procedures for waters

Element	Lowest concentration reported[a] (mg/L)			
	EPA 200 series/7000 series flame AA	EPA 200 series/7000 series graphite furnace AA	EPA -200.7 ICP	EPA-6010 ICP
Ag	0.05	0.01	0.01	0.006
Al	0.10	0.01	0.10	0.02
As	*b*	0.005	0.05	0.05
Ba	0.10	0.01	0.10	0.0010
Ca	0.05	*b*	0.05	5.0
Cd	0.01	0.002	0.003	0.003
Cr	0.05	0.01	0.010	0.010
Cu	0.01	0.004	0.004	0.004
Fe	0.05	*b*	0.05	0.005
K	0.2	*b*	0.60	0.60
Li	*b*	*b*	0.004	0.004
Mg	0.02	*b*	0.02	0.003
Mn	0.02	0.01	0.01	0.001
Mo	*b*	*b*	0.01	0.01
Na	*b*	*b*	0.05	0.02
Ni	0.05	0.01	0.05	0.01
Pb	0.10	0.004	0.05	0.05
Se	*b*	0.005	0.05	0.05
Zn	0.02	*b*	0.02	0.002

[a]The lowest concentration reported (LCR) may vary among specific samples, depending on interferences in the sample matrix. However, these LCRs have been assigned to accommodate most minor interferences. Some of the Energy Systems LCRs are higher than the method detection limits (MDLs) listed by EPA. This is consistent with guidance from EPA. However, any data reported below the MDLs must be supported by sound documentation. The LCRs applied by Energy Systems laboratories meet the needs of the programs they support.

[b]Element not normally determined using this technique.

Table 10.6. K-25 Site environmental analysis procedures for air

Parameter	NIOSH[a] or EPA method	Lowest concentration reported[b]
Gross alpha, beta, air filters, radiochemistry (pCi/m^3)	APHA 601, 602[c]	
Alpha		0.005
Beta		0.025
Fluoride, air, SIE (total μg)	EPA-340.2	0.2
Fluoride, stacks, SIE (mg/L)		0.001
Gamma-ray spec., air filters (pCi/filter)		30
^{131}I, gamma-ray spec., air filter (pCi/filter)		2.5
Metals in air particulates emission spec. (μg/sample)	EC-2440	For 48 metals, mostly 1–10
Air filters, radiochemistry (pCi/filter)		
Pu	EPA-680/4-75-001	0.04
^{90}Sr		2
^{99}Tc		300
Th alpha isotopes, radiochemistry (pCi/filter)		0.04
U, air filters, fluorometric (total μg)		0.2
U isotopes, air filters, radiochemistry (pCi/filter)	EPA-680/4-75-001	0.04
U, stack gases, spec./fluoro. (mg/L)		0.001
Dioctyl phthalate, air, GC method (mg/m^3)	NIOSH S40	2
Formaldehyde, air (mg/m^3)	NIOSH 125	0.1
Isopropanol, air (mg/m^3)	NIOSH S64	180
Oil mist, air, infrared (mg/m^3)		0.5
Organic solvents, air, GC method (mg/sample)	NIOSH 1003	18 cpds; 0.01 to 1.0
Pentachlorophenol, air, HPLC (mg/m^3)	NIOSH S297	0.27
PCBs, air, GC (total μg)	NIOSH 244	0.2

[a] *NIOSH Manual of Analytical Methods*, 2nd ed., U.S. Dept. of Health, Education, and Welfare, 1977.

[b] The lowest concentration reported (LCR) may vary among specific samples, depending on interferences in the sample matrix. However, these LCRs have been assigned to accommodate most minor interferences. Some of the Energy Systems LCRs are higher than the method detection limits (MDLs) listed by EPA. This is consistent with guidance from EPA. However, any data reported below the MDLs must be supported by sound documentation. The LCRs applied by Energy Systems laboratories meet the needs of the programs they support.

[c] *APHA Methods*, American Public Health Assoc., 1977.

Table 10.7. Energy Systems environmental analysis procedures for soil and sediment

Parameter	EPA method	Lowest concentration reported[a]
Fluoride (mg/L)		0.1
Gamma-ray spectrum analysis (pCi/filter)		2.5
Hg (total), cold vapor absorption (mg/kg)	EPA-7471	0.1
Metals, atomic absorption	EPA-7000 Series	*c*
Metals, inductively coupled plasma-optical emission spectrometric (ICP-OES)	EPA-6010	*c*
Np, direct gamma spectrum		*b*
^{237}Np, radiochemical (pCi/kg)		20
Pu, radiochemical (pCi/filter)		1.0
PCBs, gas chromatographic (mg/kg)	EPA-8080	
Aroclor 1016		0.1
Aroclor 1221		0.1
Aroclor 1232		0.1
Aroclor 1242		0.1
Aroclor 1248		0.1
Aroclor 1254		0.2
Aroclor 1260		0.2
^{90}Sr, radiochemical (pCi/filter)	704 Std Mth[d]	4
^{99}Tc, radiochemical (pCi/filter)		300
Th, spectrophotometric (mg/kg)		3
Th (alpha-emitting) isotopes, radiochemical (pCi/filter)		1
U (total), fluorometric (mg/kg)		1
U (total and isotopic), isotope dilution mass spectrometric (ng)		10
U isotopes, radiochemical (pCi/filter)		1.0

[a]The lowest concentration reported (LCR) may vary among specific samples, depending on interferences in the sample matrix. However, these LCRs have been assigned to accommodate most minor interferences. Some of the Energy Systems LCRs are higher than the method detection limits (MDLs) listed by EPA. This is consistent with guidance from EPA. However, any data reported below the MDLs must be supported by sound documentaion. The LCRs applied by Energy Systems laboratories meet the needs of the programs they support.

[b]Procedure in preparation.

[c]See Table 10.5.

[d]References to Standard Methods are from the 14th Edition, 1975.

Table 10.8. Proficiency Analytical Testing Program at the Y-12 Environmental Laboratory for NIOSH Program, 1991

Analysis and sample date	Sample	Values		Performance limits	Performance evaluation
		Reference	Y-12		
Cadmium (mg)					
2/91	1	0.0092	0.0093	0.0083–0.0101	Acceptable
	2	0.0118	0.0122	0.0105–0.0131	Acceptable
	3	0.0149	0.0150	0.0134–0.0163	Acceptable
	4	0.0168	0.0171	0.0151–0.0184	Acceptable
5/91	1	0.0139	0.0140	0.0124–0.0154	Acceptable
	2	0.0070	0.0071	0.0062–0.0077	Acceptable
	3	0.0197	0.0197	0.0178–0.0216	Acceptable
	4	0.0110	0.0107	0.0098–0.0121	Acceptable
8/91	1	0.0123	0.0123	0.0108–0.0138	Acceptable
	2	0.0100	0.0100	0.0087–0.0113	Acceptable
	3	0.0061	0.0059	0.0053–0.0069	Acceptable
	4	0.0166	0.0166	0.0147–0.0186	Acceptable
11/91	1	0.0090	0.0091	0.0080–0.0099	Acceptable
	2	0.0051	0.0051	0.0044–0.0057	Acceptable
	3	0.0129	0.0130	0.0114–0.0143	Acceptable
	4	0.0109	0.0112	0.0097–0.0121	Acceptable
Lead (mg)					
2/91	1	0.0358	0.0355	0.0319–0.0397	Acceptable
	2	0.0779	0.0797	0.0694–0.0863	Acceptable
	3	0.0446	0.0448	0.0405–0.0487	Acceptable
	4	0.0612	0.0612	0.0546–0.0678	Acceptable
5/91	1	0.0464	0.0461	0.0414–0.0514	Acceptable
	2	0.0557	0.0558	0.0495–0.0618	Acceptable
	3	0.0243	0.0245	0.0216–0.0270	Acceptable
	4	0.0348	0.0342	0.0307–0.0389	Acceptable
8/91	1	0.0601	0.0606	0.0541–0.0660	Acceptable
	2	0.0300	0.0304	0.0267–0.0332	Acceptable
	3	0.0849	0.0852	0.0761–0.0937	Acceptable
	4	0.0494	0.0500	0.0449–0.0538	Acceptable
11/91	1	0.0247	0.0255	0.0219–0.0275	Acceptable
	2	0.0493	0.0498	0.0443–0.0543	Acceptable
	3	0.0734	0.0746	0.0664–0.0804	Acceptable
	4	0.0589	0.0608	0.0535–0.0644	Acceptable
Zinc (mg)					
2/91	1	0.1505	0.1500	0.1328–0.1682	Acceptable
	2	0.1115	0.1130	0.0930–0.1300	Acceptable
	3	0.2125	0.2140	0.1916–0.2334	Acceptable
	4	0.1770	0.1770	0.1562–0.1978	Acceptable
5/91	1	0.1356	0.1355	0.1223–0.1489	Acceptable
	2	0.0779	0.0776	0.0678–0.0879	Acceptable
	3	0.2064	0.2060	0.1815–0.2313	Acceptable
	4	0.1627	0.1600	0.1429–0.1826	Acceptable
11/91	1	0.0941	0.0959	0.0836–0.1046	Acceptable
	2	0.0746	0.0754	0.0649–0.0843	Acceptable
	3	0.1194	0.1210	0.1050–0.1339	Acceptable
	4	0.1737	0.1790	0.1564–0.1910	Acceptable
Chromium (mg)					
8/91	1	0.1185	0.1160	0.0909–0.1461	Acceptable
	2	0.0601	0.0591	0.0472–0.0730	Acceptable
	3	0.1979	0.1930	0.1485–0.2474	Acceptable
	4	0.1494	0.1450	0.1146–0.1842	Acceptable

Table 10.8 (continued)

Analysis and sample date	Sample	Values		Performance limits	Performance evaluation
		Reference	Y-12		
Asbestos (F/MM2)					
2/91	1	238	254.2	107.6–419.5	Acceptable
	2	603.5	533.2	320.2–975.8	Acceptable
	3	838.4	712	455.2–1337.7	Acceptable
	4	416.3	303	191.6–727	Acceptable
5/91	1	745.6	908.2	411.7–1177.9	Acceptable
	2	592.6	812.6	289.9–1002.4	Acceptable
	3	224.3	243.4	99.7–398.7	Acceptable
	4	320.2	336.8	153.5–547.5	Acceptable
8/91	1	231.1	182.8	115.8–385.9	Acceptable
	2	408.5	312.6	224.1–647.8	Acceptable
	3	805.6	745.5	422.2–1311.8	Acceptable
	4	657.6	622.4	368.8–1029.2	Acceptable
11/91	1	296.3	310	82.4–642.7	Acceptable
	2	238.7	187.4	69.1–510.2	Acceptable
	3	402.7	265.3	155.9–764.6	Acceptable
	4	668.1	523.8	303.4–1175	Acceptable
1,1,1-Trichloroethane (mg)					
2/91	1	1.0121	0.9975	0.8694–1.1547	Acceptable
	2	0.5112	0.5040	0.4383–0.5839	Acceptable
	3	0.8764	0.8802	0.7646–0.9882	Acceptable
	4	1.2244	1.2260	1.0862–1.3625	Acceptable
Tetrachlorethylene (mg)					
2/91	1	0.5678	0.5650	0.4798–0.6557	Acceptable
	2	0.8797	0.8920	0.7584–1.0010	Acceptable
	3	1.0753	1.1057	0.9336–1.2169	Acceptable
	4	0.4294	0.4221	0.3676–0.4911	Acceptable
Trichloroethylene (mg)					
2/91	1	0.4771	0.4635	0.4189–0.5353	Acceptable
	2	0.7274	0.7242	0.6418–0.8129	Acceptable
	3	0.9451	0.9471	0.8416–1.0485	Acceptable
	4	0.8049	0.7951	0.7130–0.8968	Acceptable
Chloroform (mg)					
5/91	1	0.4937	0.4325	0.4237–0.5637	Acceptable
	2	1.1172	0.9418	0.9775–1.2568	Unacceptable
	3	0.6446	0.5277	0.5636–0.7255	Unacceptable
	4	0.8139	0.6830	0.7215–0.9064	Unacceptable
Carbon tetrachloride (mg)					
5/91	1	0.6094	0.5675	0.5325–0.6863	Acceptable
	2	1.3941	1.2122	1.2547–1.5335	Unacceptable
	3	0.9685	0.8343	0.8549–1.0820	Unacceptable
	4	1.0979	0.9622	0.9732–1.2225	Unacceptable
1,2-Dichloroethane (mg)					
5/91	1	0.9101	0.7969	0.8164–1.0037	Unacceptable
	2	0.8343	0.6879	0.7463–0.9223	Unacceptable
	3	0.4492	0.3660	0.3998–0.4985	Unacceptable
	4	0.7042	0.5889	0.6282–0.7801	Unacceptable
Benzene (mg)					
8/91	1	0.0926	0.0881	0.0746–0.1105	Acceptable
	2	0.1774	0.1708	0.1519–0.2028	Acceptable
	3	0.2265	0.2178	0.1988–0.2541	Acceptable
	4	0.2545	0.2479	0.2191–0.2900	Acceptable
O-xylene (mg)					
8/91	1	1.6014	1.6166	1.3560–1.8468	Acceptable
	2	1.2698	1.2471	1.0834–1.4562	Acceptable
	3	1.0270	1.0389	0.8799–1.1741	Acceptable
	4	0.7036	0.7169	0.6068–0.8005	Acceptable

Table 10.8 (continued)

Analysis and sample date	Sample	Values		Performance limits	Performance evaluation
		Reference	Y-12		
Toluene (mg)					
8/91	1	0.7084	0.6772	0.5854–0.8315	Acceptable
	2	0.9961	0.9725	0.8752–1.1171	Acceptable
	3	1.2135	1.1903	1.0568–1.3702	Acceptable
	4	1.2897	1.2865	1.1471–1.4322	Acceptable
Carbon tetrachloride (mg)					
11/91	1	1.0459	1.0091	0.9069–1.1849	Acceptable
	2	0.7349	0.7370	0.6310–0.8388	Acceptable
	3	0.4216	0.4167	0.3449–0.4983	Acceptable
	4	1.2862	1.3154	1.1219–1.4505	Acceptable
1,2-Dichloroethane (mg)					
11/91	1	0.9289	0.8825	0.8230–1.0347	Acceptable
	2	0.7369	0.7265	0.6450–0.8288	Acceptable
	3	1.1655	1.1405	1.0159–1.3152	Acceptable
	4	0.6918	0.6815	0.6194–0.7641	Acceptable
Trichloroethylene (mg)					
11/91	1	0.9064	0.8750	0.7820–1.0308	Acceptable
	2	0.5177	0.5207	0.4498–0.5857	Acceptable
	3	1.0936	1.0792	0.9415–1.2457	Acceptable
	4	0.7079	0.7140	0.6284–0.7873	Acceptable

Table 10.9. Proficiency Analytical Testing Program at the K-25 Laboratory for NIOSH Program, 1991

Analysis and sample date	Sample	Values		Performance limits	Performance evaluation
		Reference	K-25		
Cd (mg)					
2/91	1	0.0092	0.0090	0.0083–0.0101	Acceptable
	2	0.0118	0.0118	0.0105–0.0131	Acceptable
	3	0.0149	0.0145	0.0134–0.0163	Acceptable
	4	0.0168	0.0168	0.0151–0.0184	Acceptable
5/91	1	0.0139	0.0132	0.0124–0.0154	Acceptable
	2	0.0070	0.0068	0.0062–0.0077	Acceptable
	3	0.0197	0.0185	0.0178–0.0216	Acceptable
	4	0.0110	0.0105	0.0098–0.0121	Acceptable
8/91	1	0.0123	0.0117	0.0108–0.0138	Acceptable
	2	0.0100	0.0094	0.0087–0.0113	Acceptable
	3	0.0061	0.0056	0.0053–0.0069	Acceptable
	4	0.0166	0.0160	0.0147–0.0186	Acceptable
11/91	1	0.0090	0.0077	0.0080–0.0099	Unacceptable
	2	0.0051	0.0048	0.0044–0.0057	Acceptable
	3	0.0129	0.0124	0.0097–0.0121	Acceptable
	4	0.0109	0.0106	0.0097–0.0121	Acceptable
Cr (mg)					
8/91	1	0.1185	0.1003	0.0909–0.1461	Acceptable
	2	0.0601	0.0567	0.0472–0.0730	Acceptable
	3	0.1979	0.1795	0.1485–0.2474	Acceptable
	4	0.1494	0.1411	0.1146–0.1842	Acceptable
Pb (mg)					
2/91	1	0.0358	0.0342	0.0319–0.0397	Acceptable
	2	0.0779	0.0745	0.0694–0.0863	Acceptable
	3	0.0446	0.0418	0.0405–0.0487	Acceptable
	4	0.0612	0.0598	0.0546–0.0678	Acceptable
5/91	1	0.0464	0.0450	0.0414–0.0514	Acceptable
	2	0.0557	0.0525	0.0495–0.0618	Acceptable
	3	0.0243	0.0225	0.0216–0.0270	Acceptable
	4	0.0348	0.0338	0.0307–0.0389	Acceptable
8/91	1	0.0601	0.0588	0.0541–0.0660	Acceptable
	2	0.0300	0.0292	0.0267–0.0332	Acceptable
	3	0.0849	0.0808	0.0761–0.0937	Acceptable
	4	0.0494	0.0489	0.0449–0.0538	Acceptable
11/91	1	0.0247	0.0216	0.0219–0.0275	Unacceptable
	2	0.0493	0.0484	0.0443–0.0543	Acceptable
	3	0.0734	0.0722	0.0664–0.0804	Acceptable
	4	0.0589	0.0593	0.0535–0.0644	Acceptable
Zn (mg)					
2/91	1	0.1505	0.1508	0.1328–0.1682	Acceptable
	2	0.1115	0.1122	0.0930–0.1300	Acceptable
	3	0.2125	0.2188	0.1916–0.2334	Acceptable
	4	0.1770	0.1838	0.1562–0.1978	Acceptable
5/91	1	0.1356	0.1268	0.1223–0.1489	Acceptable
	2	0.0779	0.0705	0.0678–0.0879	Acceptable
	3	0.2064	0.1973	0.1815–0.2313	Acceptable
	4	0.1627	0.1563	0.1429–0.1826	Acceptable
11/91	1	0.0941	0.0810	0.0836–0.1046	Unacceptable
	2	0.0746	0.0704	0.0649–0.0843	Acceptable
	3	0.1194	0.1130	0.1050–0.1339	Acceptable
	4	0.1737	0.1660	0.1564–0.1910	Acceptable

Table 10.9 (continued)

Analysis and sample date	Sample	Values		Performance limits	Performance evaluation
		Reference	K-25		
Asbestos (F/mm^2)					
2/91	1	238	293	107.6–419.5	Acceptable
	2	603.5	585.9	320.2–975.8	Acceptable
	3	838.4	585.9	455.2–1337.7	Acceptable
	4	416.3	343.9	191.6–727	Acceptable
5/91	1	745.6	482	411.7–1177.9	Acceptable
	2	592.6	435	289.9–1002.4	Acceptable
	3	224.3	230	99.7–398.7	Acceptable
	4	320.2	266.2	153.5–547.5	Acceptable
8/91	1	231.1	356.6	115.8–385.9	Acceptable
	2	408.5	509.5	224.1–647.8	Acceptable
	3	805.6	780.2	422.2–1311.8	Acceptable
	4	657.6	710.1	368.8–1029.2	Acceptable
11/91	1	296.3	497.3	82.4–642.7	Acceptable
	2	238.7	227.4	69.1–510.2	Acceptable
	3	402.7	424.6	155.9–764.6	Acceptable
	4	668.1	751.5	303.4–1175	Acceptable
Benzene (mg)					
8/91	1	0.0926	0.0892	0.0746–0.1105	Acceptable
	2	0.1774	0.1708	0.1519–0.2028	Acceptable
	3	0.2265	0.2182	0.1988–0.2541	Acceptable
	4	0.2545	0.2457	0.2191–0.2900	Acceptable
1,1,1-Trichloroethane (mg)					
2/91	1	1.0121	1.0123	0.8694–1.1547	Acceptable
	2	0.5112	0.5095	0.4383–0.5839	Acceptable
	3	0.8764	0.8712	0.7646–0.9882	Acceptable
	4	1.2244	1.1998	1.0862–1.3625	Acceptable
Tetrachloroethylene (mg)					
2/91	1	1.0121	1.0123	0.8694–1.1547	Acceptable
	2	0.5112	0.5095	0.4383–0.5839	Acceptable
	3	0.8764	0.8712	0.7646–0.9882	Acceptable
	4	1.2244	1.1998	1.0862–1.3625	Acceptable
Trichloroethylene (mg)					
2/91	1	0.4771	0.4662	0.4189–0.5353	Acceptable
	2	0.7274	0.6963	0.6418–0.8129	Acceptable
	3	0.9451	0.9052	0.8416–1.0485	Acceptable
	4	0.8049	0.7669	0.7130–0.8968	Acceptable
11/91	1	0.9064	0.8792	0.7820–1.0308	Acceptable
	2	0.5177	0.5000	0.4498–0.5857	Acceptable
	3	1.0936	1.0515	0.9415–1.2457	Acceptable
	4	0.7079	0.6788	0.6284–0.7873	Acceptable
Chloroform (mg)					
5/91	1	0.4937	0.4920	0.4237–0.5637	Acceptable
	2	1.1172	1.0890	0.9775–1.2568	Acceptable
	3	0.6446	0.6263	0.5636–0.7255	Acceptable
	4	0.8139	0.8080	0.7215–0.9064	Acceptable

Table 10.9 (continued)

Analysis and sample date	Sample	Values		Performance limits	Performance evaluation
		Reference	K-25		
Carbon tetrachloride (mg)					
5/91	1	0.6094	0.6330	0.5325–0.6863	Acceptable
	2	1.3941	1.4924	1.2547–1.5335	Acceptable
	3	0.9685	1.0359	0.8549–1.0820	Acceptable
	4	1.0979	1.2041	0.9732–1.2225	Acceptable
11/91	1	1.0459	0.9834	0.9069–1.1849	Acceptable
	2	0.7349	0.6915	0.6310–0.8388	Acceptable
	3	0.4216	0.3959	0.3449–0.4983	Acceptable
	4	1.2862	1.2017	1.1219–1.4505	Acceptable
1,2-Dichloroethane (mg)					
5/91	1	0.9101	0.8970	0.8164–1.0037	Acceptable
	2	0.8343	0.8264	0.7463–0.9223	Acceptable
	3	0.4492	0.4422	0.3998–0.4985	Acceptable
	4	0.7042	0.6966	0.6282–0.7801	Acceptable
11/91	1	0.9289	0.8964	0.8230–1.0347	Acceptable
	2	0.7369	0.7006	0.6450–0.8288	Acceptable
	3	1.1655	1.1102	1.0159–1.3152	Acceptable
	4	0.6918	0.6666	0.6194–0.7641	Acceptable
O-xylene (mg)					
8/91	1	1.6014	1.4934	1.3560–1.8468	Acceptable
	2	1.2698	1.1886	1.0834–1.4562	Acceptable
	3	1.0270	0.9690	0.8799–1.1741	Acceptable
	4	0.7036	0.6435	0.6068–0.8005	Acceptable
Toluene (mg)	1	0.7084	0.6410	0.5854–0.8315	Acceptable
	2	0.9961	0.9011	0.8752–1.1171	Acceptable
	3	1.2135	1.1007	1.0568–1.3702	Acceptable
	4	1.2897	1.1612	1.1471–1.4322	Acceptable

Table 10.10. Water supply performance evaluation study WS-028 for NIOSH Program—K-25 Site, 1991

Parameter	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True[a]		
		Trace metals (μg/L)			
Sb	2	33.6	35.0	27.8–46.6	Acceptable
As	1	109	129	109–144	Acceptable
Ba	1	538	533	472–574	Acceptable
Be	2	0.810	0.800	0.611–0.991	Acceptable
Cd	1	7.40	7.73	6.37–8.90	Acceptable
Cr	1	199	220	179–223	Acceptable
Cu	1	968	950	866–1020	Acceptable
Pb	1	7.54	7.28	5.52–9.41	Acceptable
Hg	1	7.16	7.14	5.54–8.46	Acceptable
Ni	2	227	211	185–231	Acceptable
Se	1	12.2[b]	13.1	9.68–14.6	Acceptable
Ag	1	60.4	60.7	52.7–68.9	Acceptable
Tl	2	1.53	2.00	1.08–2.94	Acceptable
		Nitrate/nitrite/fluoride (mg/L)			
Nitrate as N	1	7.76	8.80	7.40–10.4	Acceptable
Nitrite as N	1	0.74	0.770	0.674–0.879	Acceptable
Fluoride	1	1.57	1.60	1.44–1.76	Acceptable
		Insecticides (μg/L)			
Chlordane[b]	3	5.51	3.77	2.04–4.77	Unacceptable
Endrin	1	0.181	0.163	0.107–0.233	Acceptable
Heptachlor	4	0.132	0.142	0.0398–0.220	Acceptable
Heptachlor epoxide	4	0.119	0.125	0.0721–0.168	Acceptable
Lindane	1	1.15	0.638	0.378–0.861	Unacceptable
Methoxychlor	1	10.7	12.4	8.10–15.9	Acceptable
Toxaphene[b]	2	12.6	12.7	7.47–15.7	Acceptable
		Herbicides (μg/L)			
2,4-D	1	2.17	3.33	0.971–5.26	Acceptable
2,4,5-TP, Silvex	1	1.47	1.75	0.532–2.57	Acceptable
		Trihalomethanes (μg/L)			
Bromodichloromethane	1	15.9	18.7	15.0–22.4	Acceptable
Bromoform	1	26.0	34.6	27.7–41.5	Unacceptable
Chlorodibromomethane	1	21.7	27.1	21.7–32.5	Acceptable
Chloroform	1	15.5	14.2	11.4–17.0	Acceptable
Total trihalomethane	1	79.10	94.6	75.7–114	Acceptable

Table 10.10 (continued)

Parameter	Number of samples	Values		Acceptance limits	Performance evaluation
		Reported	True[a]		
		Volatile organic compounds (μg/L)			
Benzene	1	11.4	11.8	9.44–14.2	Acceptable
Carbon tetrachloride	1	10.7	12.2	9.76–14.6	Acceptable
1,4-Dichlorobenzene	1	10.7	12.5	10.0–15.0	Acceptable
1,2-Dichloroethane	1	7.19	6.95	4.17–9.73	Acceptable
1,1-Dichloroethylene	1	3.99	4.72	2.83–6.61	Acceptable
Cis-1,2-Dichloroethylene	2	12.9	13.0	10.4–15.6	Acceptable
Trans-1,2-Dichloroethylene	2	11.2	11.6	9.28–13.9	Acceptable
Bromobenzene	3	13.2	13.4	10.7–16.1	Acceptable
N-Butylbenzene	3	6.70	7.29	4.37–10.2	Acceptable
4-Chlorotoluene	3	8.06	12.3	9.84–14.8	Unacceptable
4-Isopropyltoluene	3	12.6	13.9	11.1–16.7	Acceptable
1,1,1,2-Tetrachloroethane	3	7.55	8.23	4.94–11.5	Acceptable
1,2,4-Trichlorobenzene	3	8.66	8.62	5.17–12.1	Acceptable
1,2,3-Trichloropropane	3	12.2	11.6	9.28–13.9	Acceptable
1,2,4-Trimethylbenzene	3	8.26	9.46	5.68–13.2	Acceptable
Ethylbenzene	2	11.2	11.6	9.28–13.9	Acceptable
Styrene	2	10.5	10.6	8.48–12.7	Acceptable
Chlorobenzene	2	14.7	14.6	11.7–17.5	Acceptable
Tetrachloroethylene	2	9.02	9.03	5.42–12.6	Acceptable
Toluene	2	13.8	13.8	11.0–16.6	Acceptable
1,2-Dichlorobenzene	2	13.3	15.4	12.3–18.5	Acceptable
1,1,1-Trichloroethane	1	12.8	15.2	12.2–18.2	Acceptable
Trichloroethylene	1	6.84	7.37	4.42–10.3	Acceptable
1.3-Dichloropropane	2	3.94	4.32	2.59–6.05	Acceptable
Vinyl chloride	1	8.07	9.40	5.64–13.2	Acceptable
Total xylenes	2	8.40	8.45	5.07–11.8	Acceptable
		Miscellaneous analytes			
Residual free chlorine (mg/L)[b]	1	1.58	1.70	1.33–1.88	Acceptable
Turbidity (NTUs)[b]	1	5.6	5.60	5.23–6.27	Acceptable
Sulfate (mg/L)	1	42.8	43.0	37.7–47.2	Acceptable
Total cyanide (mg/L)	1	0.50	0.460	0.312–0.567	Acceptable

[a]Based on theoretical calculations, or a reference value when necessary.
[b]Significant general method bias is anticipated for this result.

Table 10.11. EPA EMSL-LV Intercomparison Radionuclide Control Program

Y-12, 1991

Analysis and sample date	Values		Normalized deviation	Performance evaluation
	EPA	Y-12		
		Water (pCi/L)		
Gross alpha				
4-16	54.0 ± 14.0	51.7	0.29	Acceptable
5–17	24.0 ± 6.0	23.3	0.19	Acceptable
10–22	82.0 ± 21.0	150	5.61	Unacceptable
Gross beta				
4–16	115.0 ± 17.0	125	1.05	Acceptable
5–17	46.0 ± 5.0	64.0	6.24	Unacceptable
10–22	65.0 ± 10.0	72	1.21	Acceptable
^{3}H				
6–21	12,480 ± 1,248.0	14,767	3.17	Unacceptable
10–18	2,454.0 ± 352.0	2,730	1.36	Acceptable
^{239}Pu				
1–18	3.3 ± 0.3	3.33	0.19	Acceptable
8–23	19.4 ± 1.9	16.8	2.40	Acceptable
U				
3–15	7.6 ± 3.0	7.97	0.21	Acceptable
4–16	29.8 ± 3.0	30.8	0.60	Acceptable
7–19	14.2 ± 3.0	13.4	0.46	Acceptable
11–15	24.9 ± 3.0	25.0	0.06	Acceptable
^{131}I				
2–15	75.0 ± 8.0	77.0	0.43	Acceptable
^{134}Cs				
4–16	24.0 ± 5.0	22.3	0.58	Acceptable
6–7	15.0 ± 5.0	15.0	0.00	Acceptable
10–4	10.0 ± 5.0	9.67	0.12	Acceptable
^{137}Cs				
4–16	25.0 ± 5.0	25.3	0.12	Acceptable
6–7	14.0 ± 5.0	15.7	0.58	Acceptable
10–4	10.0 ± 5.0	10.3	0.12	Acceptable
^{60}Co				
6–7	10.0 ± 5.0	9.67	0.12	Acceptable
10–4	29.0 ± 5.0	29.0	0.00	Acceptable
^{65}Zn				
6–7	108.0 ± 11.0	112	0.68	Acceptable
10–4	73.0 ± 7.0	78.7	1.40	Acceptable
^{106}Ru				
6–7	149.0 ± 15.0	154	0.54	Acceptable
10–4	199.0 ± 20.0	206	0.64	Acceptable
^{133}Ba				
6–7	62.0 ± 6.0	71.7	2.79	Acceptable
10–4	98.0 ± 10.0	108	1.67	Acceptable

Table 10.11 (continued)

Analysis and sample date	Values		Normalized deviation	Performance evaluation
	EPA	Y-12		
		Air filter (pCi/filter)		
Gross alpha				
3–29	25.0 ± 6.0	30.7	1.64	Acceptable
Gross beta				
3–29	124.0 ± 6.0	130	1.64	Acceptable
^{90}Sr				
3–29	40.0 ± 5.0	40.3	0.12	Acceptable
^{137}Cs				
3–29	40.0 ± 5.0	48.3	2.89	Acceptable

Table 10.12. EPA EMSL-LV Intercomparison Radionuclide Control Program

ORNL Low-Level Radiochemical Laboratory, 1991

Analysis and sample date	Values		Ratio[b] (ORNL/EPA)	Performance evaluation[c]
	EPA[a]	ORNL		
		Water (pCi/L)		
Gross alpha				
2/91	5.0 ± 8.7	4.67	0.93	Acceptable
5/91	24 ± 10.4	13.7	0.57	Acceptable
9/91	10 ± 8.7	5.0	0.50	Acceptable
Gross beta				
2/91	5.0 ± 8.7	6.3	1.26	Acceptable
5/91	46 ± 8.7	36	0.78	Unacceptable
9/91	20 ± 5	18	0.90	Acceptable
^{133}Ba				
2/91	75 ± 13.9	71	0.95	Acceptable
6/91	62 ± 10.4	57.3	0.92	Acceptable
10/91	98 ± 17.3	89.7	0.92	Acceptable
^{134}Cs				
2/91	8 ± 8.7	6.3	0.79	Acceptable
4/91	24 ± 8.7	22.7	0.95	Acceptable
6/91	15 ± 8.7	12.3	0.82	Acceptable
10/91	10 ± 8.7	9.0	0.90	Acceptable
^{137}Cs				
2/91	8 ± 8.7	11	1.38	Acceptable
4/91	25 ± 8.7	25.0	1.00	Acceptable
6/91	14 ± 8.7	15.7	1.12	Acceptable
10/91	10 ± 8.7	10.7	1.07	Acceptable
^{60}Co				
2/91	40 ± 8.7	38.7	0.97	Acceptable
6/91	10 ± 8.7	10.3	1.03	Acceptable
10/91	29 ± 8.7	28.7	0.99	Acceptable
^{3}H				
6/91	12,480 ± 2,165	11,333	0.91	Acceptable
^{131}I				
2/91	75 ± 13.9	78.3	1.04	Acceptable
^{106}Ru				
2/91	186 ± 33	190	1.02	Acceptable
6/91	149 ± 26	142	0.95	Acceptable
10/91	199 ± 34.7	186.7	0.94	Acceptable
^{89}Sr				
1/91	5.0 ± 8.7	5.33	1.07	Acceptable

Table 10.12 (continued)

Analysis and sample date	Values		Ratio[b] (ORNL/EPA)	Performance evaluation[c]
	EPA[a]	ORNL		
		Water (pCi/L)		
^{90}Sr				
1/91	5.0 ± 8.7	5.0	1.00	Acceptable
5/91	39 ± 8.7	30.7	0.79	Acceptable
U				
4/91	29.8 ± 5.2	29.0	0.97	Acceptable
^{65}Zn				
2/91	149 ± 26	150	1.01	Acceptable
6/91	108 ± 19.1	109	1.01	Acceptable
10/91	73 ± 12.1	74	1.01	Acceptable
		Air (pCi/filter)		
Gross alpha				
3/91	25 ± 10.4	20.7	0.83	Acceptable
Gross beta				
3/91	125 ± 10.4	111.7	0.90	Unacceptable
^{137}Cs				
3/91	40 ± 8.7	39	0.98	Acceptable
^{90}Sr				
3/91	40 ± 8.7	44	1.10	Acceptable
		Milk (pCi/L)		
^{137}Cs				
4/91	49 ± 8.7	49	1.00	Acceptable
^{131}I				
4/91	60 ± 10.4	65	1.08	Acceptable

[a]Values and uncertainty were provided by the EPA and are published as provided.

[b]Ratio is given as an indication of performance in comparison to EPA values. Ratio is not used as a measure of acceptability of data and may vary widely in relation to the individual precision associated with a particular radionuclide.

[c]The EPA gives three classes of performance based on the number of standard deviations that a result is from the true value; these are acceptable (< sigma), warning (2 to 3 sigma), and unacceptable (>3 sigma).

Table 10.13. EPA EMSL-LV Intercomparison Radionuclide Control Program—K-25 Site, 1991

Analysis and sample data	Values[a]		Ratio[b] (EPA/K-25)	Performance evaluation
	EPA	K-25		
		Water (pCi/L)		
^{239}Pu				
1/18/91	*c*	*c*	*c*	*c*
8/23/91	19.4 ± 1.9	18.37 ± 0.45	1.1	Acceptable
Gross alpha				
1/25/91	5.0 ± 5.0	4.33 ± 1.53	1.2	Acceptable
4/16/91	54.0 ± 14.0	900.0 ± 26.06	0.060	Outlier[d]
5/17/91	24.0 ± 6.0	20.67 ± 1.15	1.2	Acceptable
9/20/91	10.0 ± 5.0	*c*	*c*	*c*
Gross beta				
1/25/91	5.0 ± 5.0	8.33 ± 1.53	0.60	Acceptable
4/16/91	115.0 ± 17.0	2185.67 ± 75.04	0.05	Outlier[d]
5/17/91	46.0 ± 5.0	43.0 ± 4.58	1.1	Acceptable
9/20/91	20.0 ± 5.0	*c*	*c*	*c*
U				
3/15/91	7.6 ± 3.0	6.50 ± 0.20	1.2	Acceptable
11/15/91	29.4 ± 3.0	22.70 ± 2.13	1.30	Acceptable
^{60}Co				
2/8/91	40.0 ± 5.0	42.00 ± 2.0	0.95	Acceptable
6/7/91	10.0 ± 5.0	8.67 ± 0.58	1.2	Acceptable
10/4/91	29.0 ± 5.0	26.00 ± 1.0	1.1	Acceptable
10/4/91	29.0 ± 5.0	26.0 ± 1.0	1.1	Acceptable
^{65}Zn				
2/8/91	149.0 ± 15.0	157.67 ± 2.08	0.94	Acceptable
6/7/91	108.0 ± 11.0	110.33 ± 2.52	0.98	Acceptable
10/4/91	73.0 ± 7.0	71.0 ± 3.46	1.0	Acceptable
10/4/91	73.0 ± 7.0	71.0 ± 3.46	1.02	Acceptable
^{106}Ru				
2/8/91	186.0 ± 19.0	181.67 ± 20.8	1.0	Acceptable
6/7/91	149.0 ± 15.0	119.33 ± 23.18	1.2	Unacceptable
10/4/91	199.0 ± 20.0	166.0 ± 13.08	1.2	Acceptable
^{134}Ce				
2/8/91	8.0 ± 5.0	5.33 ± 0.58	1.5	Acceptable
4/16/91	24.0 ± 5.0	358.0 ± 28.0	0.07	Outlier[d]
6/7/91	15.0 ± 5.0	12.33 ± 1.15	1.2	Acceptable
10/4/91	10.0 ± 5.0	7.0 ± 1.0	1.4	Acceptable

Table 10.13 (continued)

Analysis and sample data	Values (pCi/unit)[a]		Ratio[b] (EPA/K-25)	Performance evaluation
	EPA	K-25		
		Water (pCi/L)		
^{137}Ce				
2/8/91	8.0 ± 5.0	10.0 ± 0.0	0.8	Acceptable
4/17/91	25.0 ± 5.0	411.0 ± 8.66	0.061	Outlier[d]
6/7/91	14.0 ± 5.0	13.00 ± 2.00	1.2	Acceptable
10/4/91	10.0 ± 5.0	10.0 ± 1.0	1.0	Acceptable
^{133}Ba				
2/8/91	75.0 ± 8.0	78.0 ± 0.0	0.96	Acceptable
6/7/91	62.0 ± 6.0	57.00 ± 2.65	1.2	Acceptable
10/4/91	98.0 ± 10.0	94.33	1.0	Acceptable
10/4/91	98.0 ± 10.0	94.33 ± 6.43	1.03	Acceptable
^{131}I				
2/15/91	75.0 ± 8.0	*c*	*c*	*c*
^{3}H				
2/22/91	4,418.0 ± 442.0	4,558.67 ± 286.7	0.97	Acceptable
5/17/91	12,480 ± 1,248.0	12,427.67 ± 468.29	1.0	Acceptable
10/18/91	2,454 ± 352	2,217 ± 55.0	1.1	Acceptable
^{226}Ra				
4/16/91	8.0 ± 1.2	*c*	*c*	*c*
^{228}Ra				
4/16/91	15.2 ± 3.8	*c*	*c*	*c*
U (Natural)				
4/16/91	29.8 ± 3.0	467.5 ± 13.13	0.060	Outlier[d]
7/19/91	14.2 ± 3.0	15.4 ± 0.85	0.92	Acceptable
^{89}Sr				
4/16/91	28.0 ± 5.0	*c*	*c*	*c*
^{90}Sr				
4/16/91	26.0 ± 5.0	*c*	*c*	*c*
Alpha				
3/29/91	25.0 ± 6.0	20.67 ± 0.58	1.2	Acceptable

Table 10.13 (continued)

Analysis and sample data	Values (pCi/unit)[a]		Ratio[b] (EPA/K-25)	Performance evaluation
	EPA	K-25		
		Air (pCi/filter)		
Beta				
3/29/91	124.0 ± 6.0	156.33 ± 6.81	0.79	Unacceptable
8/30/91	92.0 ± 10.0	101.67 ± 4.16	0.90	Acceptable
^{90}Sr				
3/29/91	40.0 ± 5.0	*c*	*c*	*c*
8/30/91	30.0 ± 5.0	*c*	*c*	*c*
^{137}Ce				
?	40.0 ± 5.0	39.0 ± 1.73	1.02	Acceptable
8/30/91	30.0 ± 5.0	28.0 ± 0.0	1.1	Acceptable
Alpha	25.0 ± 6.0	22.67 ± 0.58	1.1	Acceptable
8/30/91				

[a]Values and uncertainty were provided by the EPA and are published as provided.

[b]Ratio is given as an indication of performance in comparison to EPA values. Ratio is not used as a measure of acceptability of data and may vary widely in relation to the individual precision associated with a particular radionuclide.

[c]No data reported.

[d]A calculation error was made.

Table 10.14. DOE Environmental Measurements Laboratory (EML) Quality Assessment Program (QAP)

Y-12 Radiochemistry Laboratory

Parameter	EML value	Y-12 value	Y-12 percent error[a]	Ratio Y-12/EML	Performance evaluation
		QAP-34, May 1991			
		Air filter			
^{7}Be (Bq/filter)	53.0	66	9	1.25	Acceptable
^{54}Mn (Bq/filter)	4.80	5.6	7	1.17	Acceptable
^{57}Co (Bq/filter)	5.82	6.5	4	1.12	Acceptable
^{60}Co (Bq/filter)	5.14	4.8	3	0.93	Acceptable
^{90}Sr (Bq/filter)	0.0789	0.12	58	1.52	Unacceptable
^{137}Cs (Bq/filter)	4.53	5.7	7	1.26	Acceptable
^{144}Ce (Bq/filter)	52.2	63	3	1.21	Acceptable
^{239}Pu (Bq/filter)	0.154	0.16	25	1.04	Acceptable
^{241}Am (Bq/filter)	0.101	0.093	31	0.92	Acceptable
U (μg/filter)	2.76	0.027		0.01	Unceptable
		Soil			
^{40}K (Bq/kg)	374	396	7	1.06	Acceptable
^{90}Sr (Bq/kg)	9.20	6.6	53	0.72	Acceptable
^{137}Cs (Bq/kg)	150	155	9	1.03	Acceptable
^{238}Pu (Bq/kg)	11.5	8.49	26	0.74	Acceptable
^{239}Pu (Bq/kg)	3.40	3.01	38	0.89	Acceptable
^{241}Am (Bq/kg)	1.76	1.0	209	0.57	Acceptable
U (μg/g)	2.34	1.59		0.68	Acceptable
		Vegetation (Bq/kg)			
^{40}K	1,150	1,310	4	1.14	Acceptable
^{90}Sr	186	170	5	0.91	Acceptable
^{137}Cs	67.6	72	11	1.07	Acceptable
^{238}Pu	4.06	3.84	24	0.95	Acceptable
^{239}Pu	1.40	1.08	36	0.77	Acceptable
^{241}Am	0.829	0.89	68	1.07	Acceptable
		Water			
^{3}H (Bq/L)	361	374	10	1.04	Acceptable
^{54}Mn (Bq/L)	213	229	10	1.08	Acceptable
^{57}Co (Bq/L)	230	238	7	1.03	Acceptable
^{60}Co (Bq/L)	201	184	1	0.92	Acceptable
^{90}Sr (Bq/L)	8.63	10.1	5	1.17	Acceptable
^{137}Cs (Bq/L)	169	171	15	1.01	Acceptable
^{144}Ce (Bq/L)	35.1	38	15	1.08	Acceptable
^{239}Pu (Bq/L)	0.773	0.73	17	0.94	Acceptable
^{241}Am (Bq/L)	1.19	0.94	18	0.79	Acceptable
U (μg/ml)	0.0172	0.021		1.22	Acceptable
		QAP-35, November 1991			
		Air filter			
^{239}Pu (Bq/filter)	0.084	0.08	25	0.95	Acceptable
^{241}Am (Bq/filter)	0.104	0.11	18	1.06	Acceptable
U (μg/filter)	3.08	4.3		1.40	Acceptable

Table 10.14 (continued)

Parameter	EML value	Y-12 value	Y-12 percent error	Ratio Y-12/EML	Performance evaluation
		Soil			
^{239}Pu (Bq/kg)	7.35	8.2	18	1.12	Acceptable
U (μg/g)	2.28	1.7		0.75	Acceptable
		Water			
^{239}Pu (Bq/L)	0.510	0.44	18	0.86	Acceptable
^{241}Am (Bq/L)	0.570	0.58	15	1.02	Acceptable
U (μg/ml)	0.037	0.04		1.08	Acceptable

Table 10.15. 1991 EML intercomparison study

ORNL Low-Level Radiochemical Laboratory, March 1991

Parameter	EML value	ORNL value	ORNL % error[a]	Ratio (ORNL/EML)	Performance evaluation
		Air (pCi/filter)			
^{7}Be	0.530E+02	0.500E+02	6	0.94	Acceptable
^{54}Mn	0.480E+01	0.500E+01	6	1.04	Acceptable
^{57}Co	0.582E+01	0.580E+01	8	1.00	Acceptable
^{60}Co	0.514E+01	0.530E–01	7	1.03	Acceptable
^{90}Sr	0.789E–01	0.600E–01	61	0.76	Acceptable
^{90}Sr	0.789E–01	0.680E–01	98	0.86	Acceptable
^{137}Cs	0.453E+01	0.480E+01	6	1.06	Acceptable
^{144}Ce	0.522E+02	0.550E+02	1	1.05	Acceptable
^{239}Pu	0.154E+00	0.110E+00	9	0.71	Acceptable
^{239}Pu	0.154E+00	0.110E+00	18	0.71	Acceptable
^{241}Am	0.101E+00	0.720E–01	16	0.71	Acceptable
^{241}Am	0.101E+00	0.640E–01	21	0.63	Acceptable
		Soil (pCi/g)			
^{40}K	0.374E+03	0.370E+03	10	0.99	Acceptable
^{40}K	0.374E+03	0.350E+03	11	0.94	Acceptable
^{90}Sr	0.920E+01	0.980E+01	27	1.07	Acceptable
^{137}Cs	0.150E+03	0.150E+03	6	1.00	Acceptable
^{137}Cs	0.150E+03	0.150E+03	6	1.00	Acceptable
^{238}Pu	0.115E+02	0.104E+02	9	0.90	Acceptable
^{239}Pu	0.340E+01	0.350E+01	14	1.03	Acceptable
^{241}Am	0.176E+01	0.170E+01	29	0.97	Acceptable
U, Bq	0.594E+02	0.220E+02	13	0.37	Unacceptable
		Vegetation (pCi/g)			
^{40}K	0.115E+04	0.120E+04	8	1.04	Acceptable
^{90}Sr	0.186E+03	0.169E+03	5	0.91	Acceptable
^{137}Cs	0.676E+02	0.680E+02	7	1.01	Acceptable
^{238}Pu	0.406E+01	0.340E+01	14	0.84	Acceptable
^{239}Pu	0.140E+01	0.880E+00	22	0.63	Acceptable
^{241}Am	0.829E+00	0.790E+00	37	0.95	Acceptable
		Water (pCi/mL)			
^{3}H	0.361E+03	0.350E+03	14	0.97	Acceptable
^{54}Mn	0.213E+03	0.230E+03	4	1.08	Acceptable
^{54}Mn	0.213E+03	0.230E+03	4	1.08	Acceptable
^{57}Co	0.230E+03	0.235E+03	4	1.02	Acceptable
^{60}Co	0.201E+03	0.190E+03	5	0.95	Acceptable
^{60}Co	0.201E+03	0.210E+02	4	1.04	Acceptable
^{90}Sr	0.863E+01	0.100E+02	10	1.16	Acceptable
^{137}Cs	0.169E+03	0.185E+03	5	1.09	Acceptable
^{144}Ce	0.351E+02	0.400+02	7	1.14	Acceptable
^{239}Pu	0.773E+00	0.700E+00	14	0.91	Acceptable
^{241}Am	0.119E+01	0.120E+01	8	1.01	Acceptable
U, Bq	0.437E+00	0.400E+00	25	0.92	Acceptable

[a]Counting error = 2 sigma.

Table 10.16. 1991 EML Intercomparison Study

ORNL Low-Level Radiochemical Laboratory, September 1991

Parameter	EML value	ORNL value	ORNL % error[a]	Ratio (ORNL/EML)	Performance evaluation
		Air (pCi/filter)			
^{7}Be	0.538E+02	0.540E+02	7	1.00	Acceptable
^{54}Mn	0.243E+02	0.250E+02	4	1.03	Acceptable
^{57}Co	0.166E+02	0.180E+02	5	1.08	Acceptable
^{60}Co	0.230E+02	0.230E+02	4	1.00	Acceptable
^{90}Sr	0.663E+00	0.520E+00	23	0.78	Acceptable
^{137}Cs	0.280E+02	0.280E+02	3	1.00	Acceptable
^{144}Ce	0.508E+02	0.490E+02	2	0.96	Acceptable
^{239}Pu	0.840E-01	0.530E-01	18	0.63	Acceptable
^{241}Am	0.104E+00	0.820E-01	20	0.79	Acceptable
U, Bq	0.783E-01	0.780E-01	21	1.00	Acceptable
		Soil (pCi/filter)			
^{40}K	0.430E+03	0.460E+03	13	1.07	Acceptable
^{90}Sr	0.378E+01	0.340E+01	55	0.90	Acceptable
^{137}Cs	0.312E+03	0.350E+03	2	1.12	Acceptable
^{239}Pu	0.735E+01	0.800E+01	11	1.09	Acceptable
^{241}Am	0.158E+01	0.160E+01	37	1.01	Acceptable
U, Bq	0.578E+02	0.200E+02	10	0.35	Unacceptable
		Vegetation (pCi/g)			
^{40}K	0.992E+03	0.110E+04	9	1.11	Acceptable
^{90}Sr	0.439E+03	0.420E+03	4	0.96	Acceptable
^{137}Cs	0.271E+02	0.300E+02	10	1.11	Acceptable
^{239}Pu	0.365E+00	0.240E+00	29	0.66	Acceptable
^{241}Am	0.266E+00	0.320E+00	59	1.20	Acceptable
^{3}H	0.100E+03	0.100E+03	30	1.00	Acceptable
^{54}Mn	0.103E+03	0.100E+03	10	0.97	Acceptable
^{57}Co	0.166E+03	0.170E+03	5	1.02	Acceptable
^{60}Co	0.291E+03	0.300E+03	3	1.03	Acceptable
^{90}Co	0.101E+02	0.110E+02	18	1.09	Acceptable
^{137}Cs	0.460E+02	0.480E+02	2	1.04	Acceptable
^{144}Ce	0.226E+03	0.220E+03	4	0.97	Acceptable
^{239}Pu	0.510E+00	0.460E+00	13	0.90	Acceptable
^{241}Am	0.570E+00	0.630E+00	22	1.11	Acceptable
U, Bq	0.940E+00	0.11E+01	18	1.17	Acceptable

[a]Counting error = 2 sigma.

Table 10.17. EML intercomparison study results for K-25 Site in March 1991

Parameter	EML value	K-25 value	Error, K-25 %	Ratio (K-25/EML)	Performance evaluation[a]
		Water (pCi/mL)			
^{3}H	0.361×10^{3}	0.786×10^{3}	13	2.18 ± 0.31	Unacceptable
^{54}Mn	0.213×10^{3}	0.225×10^{3}	0	1.06 ± 0.05	Acceptable
^{57}Co	0.230×10^{3}	0.234×10^{3}	0	1.02 ± 0.05	Acceptable
^{60}Co	0.201×10^{3}	0.197×10^{3}	0	0.98 ± 0.05	Acceptable
^{90}Sr	0.863×10^{1}	0.853×10^{1}	9	0.99 ± 0.11	Acceptable
^{137}Cs	0.169×10^{3}	0.179×10^{3}	0	1.06 ± 0.05	Acceptable
^{239}Pu	0.773×10^{0}	0.770×10^{0}	5	1.0 ± 0.10	Acceptable
^{241}Am	0.119×10^{1}	0.945×10^{0}	6	0.79 ± 0.08	Acceptable
U, Bq	0.437×10^{0}	0.364×10^{0}	9	0.83 ± 0.09	Acceptable
^{144}Ce	0.351×10^{2}	0.414×10^{2}	4	1.18 ± 0.09	Unacceptable
		Air (pCi/filter)			
^{54}Mn	0.480×10^{1}	0.490×10^{1}	7	1.02 ± 0.08	Acceptable
^{57}Co	0.582×10^{1}	0.553×10^{1}	4	0.95 ± 0.05	Acceptable
^{60}Co	0.514×10^{1}	0.488×10^{1}	6	0.95 ± 0.07	Acceptable
^{137}Cs	0.453×10^{1}	0.496×10^{1}	7	1.09 ± 0.09	Acceptable
^{144}Ce	0.522×10^{2}	0.553×10^{2}	3	1.06 ± 0.06	Acceptable
^{239}Pu	0.154×10^{0}	0.175×10^{0}	9	1.14 ± 0.25	Acceptable
^{241}Am	0.101×10^{0}	0.734×10^{-1}	14	0.73 ± 0.13	Acceptable
U, Bq	0.700×10^{-1}	0.576×10^{-1}	27	0.82 ± 0.25	Acceptable
		Soil (pCi/g)			
^{239}Pu	0.340×10^{1}	0.445×10^{1}	23	1.31 ± 0.32	Acceptable
^{137}Cs	0.150×10^{3}	0.150×10^{3}	8	1.0 ± 0.09	Acceptable
^{238}Pu	0.115×10^{2}	0.114×10^{2}	14	0.99 ± 0.15	Acceptable
^{241}Am	0.176×10^{1}	0.117×10^{1}	31	0.66 ± 0.22	Acceptable
U, Bq	0.549×10^{2}	0.254×10^{2}	6	0.43 ± 0.04	Unacceptable

[a]Acceptable ratio is 0.5 to 1.5.

Table 10.18. EML intercomparison study results for K-25 Site in September 1991

Parameter	EML value	K-25 value	Error, K-25 %	Ratio (K-25/EML)	Performance evaluation[a]
		Water (pCi/mL)			
^{54}Mn	0.103×10^{3}	0.103×10^{3}	1	1.00 ± 0.04	Acceptable
^{57}Co	0.166×10^{3}	0.175×10^{3}	0	1.02 ± 0.05	Acceptable
^{60}Co	0.291×10^{3}	0.292×10^{3}	0	1.00 ± 0.04	Acceptable
^{137}Cs	0.460×10^{2}	0.488×10^{2}	1	1.06 ± 0.05	Acceptable
^{144}Ce	0.226×10^{3}	0.233×10^{3}	1	1.03 ± 0.05	Acceptable
^{239}Pu	0.510×10^{0}	0.598×10^{0}	10	1.17 ± 0.14	Acceptable
^{3}H	0.100×10^{3}	0.453×10^{3}	6	4.53 ± 0.30	Unacceptable
		Air (pCi/filter)			
^{54}Mn	0.243×10^{2}	0.230×10^{2}	2	0.95 ± 0.04	Acceptable
^{57}Co	0.166×10^{2}	0.169×10^{2}	1	1.02 ± 0.05	Acceptable
^{60}Co	0.230×10^{2}	0.209×10^{2}	1	0.91 ± 0.04	Acceptable
^{137}Cs	0.280×10^{2}	0.265×10^{2}	2	0.95 ± 0.05	Acceptable
^{144}Ce	0.508×10^{2}	0.481×10^{2}	2	0.95 ± 0.04	Acceptable
^{239}Pu	0.840×10^{-1}	0.839×10^{-1}	62	1.00 ± 0.63	Acceptable
^{241}Am	0.104×10^{0}	0.858×10^{-1}	41	0.82 ± 0.35	Acceptable
		Soil (pCi/g)			
^{137}Cs	0.312×10^{3}	0.242×10^{3}	7	0.78 ± 0.07	Acceptable
^{239}Pu	0.735×10^{1}	0.703×10^{1}	31	0.96 ± 0.31	Acceptable
U, Bq	0.289×10^{2}	0.662×10^{1}	39	0.23 ± 0.09	Unacceptable

[a]Acceptable ratio is 0.5 to 1.5.

Table 10.19. Proficiency Environmental Testing Control Program at the Y-12 Environmental Laboratory in 1991

Level 1 Concentrations

Parameter	Average recovery[a] (%)	Average number of standard deviations[b]	Performance[c]		
			Acceptable	Warning	Unacceptable
Biochemical oxygen demand	102.8	0.499	11	0	0
Chemical oxygen demand	91.8	0.671	11	1	0
Total organic carbon	104.4	0.566	12	0	0
Ammonia nitrogen	100.5	0.266	12	0	0
Nitrate nitrogen	102.9	0.268	12	0	0
Phosphate-P	102.0	0.155	12	0	0
Kjeldahl nitrogen	119.4	0.299	11	0	0
Total phosphorus	92.9	0.509	12	0	0
Total suspended solids	87.3	0.726	11	1	0
Total dissolved solids	92.3	0.526	12	0	0
Oil and grease	102.3	0.605	12	0	0
Alkalinity	100.1	0.195	12	0	0
Calcium	101.3	0.300	12	0	0
Chloride	98.9	0.335	12	0	0
Conductivity	89.4	0.610	11	0	1
Magnesium	102.4	0.308	12	0	0
Potassium	103.5	0.483	12	0	0
Sodium	100.4	0.402	12	0	0
Sulfate	96.8	0.444	12	0	0
Total hardness	101.6	0.245	12	0	0
pH	96.4	0.923	12	0	0
Aluminum	110.4	0.302	12	0	0
Antimony	95.4	0.346	10	0	0
Arsenic	92.8	0.710	11	1	0
Barium	102.1	0.416	12	0	0
Beryllium	99.8	0.230	12	0	0
Boron	114.1	0.366	11	0	0
Cadmium	104.0	0.518	12	0	0
Chromium	101.3	0.319	12	0	0
Cobalt	100.9	0.228	12	0	0
Copper	106.1	0.497	12	0	0
Iron	100.6	0.468	12	0	0
Lead	103.4	0.858	10	1	1
Manganese	102.8	0.585	12	0	0
Mercury	101.6	0.473	11	0	0
Molybdenum	102.1	0.587	12	0	0
Nickel	105.7	0.568	12	0	0
Selenium	103.0	0.524	12	0	0
Silver	98.4	0.430	12	0	0
Thallium	91.9	0.861	11	1	0
Vanadium	101.3	0.354	12	0	0
Zinc	107.2	0.320	12	0	0
Phenol	111.6	0.871	12	0	0
Cyanide	91.7	0.696	11	1	0
Residual chlorine	98.8	0.449	10	0	0
Fluoride	107.0	1.201	9	1	2
Hexavalent chromium	106.2	1.028	9	1	0
Uranium	97.6	0.384	12	0	0

Table 10.19 (continued)

Parameter	Average recovery[a] (%)	Average number of standard deviations[b]	Performance[c]		
			Acceptable	Warning	Unacceptable
		Organics			
Benzene	113.3	0.860	3	0	0
Chlorobenzene	111.1	1.105	2	1	0
1,2-Dichlorobenzene	130.7	2.003	1	0	1
1,4-Dichlorobenzene	108.5	1.740	1	0	0
Ethylbenzene	114.8	1.287	3	0	0
Toluene	110.8	0.917	3	0	0
Carbon Tetrachloride	96.6	0.315	1	0	0
Chloroform	113.7	0.902	2	1	0
Methylene Chloride	126.4	1.887	1	0	0
Tetrachloroethene	106.1	0.621	1	0	0
1,1,1-Trichloroethane	102.5	0.015	1	0	0
1,1,2-Trichloroethane	107.7	0.628	2	0	0
4-Chloro-3-Methyl Phenol	44.9	1.237	1	0	0
2,4-Dichlorophenol	46.9	1.053	1	0	0
2-Nitrophenol	50.7	0.642	1	0	0
Pentachlorophenol	61.0	0.273	1	0	0
Phenol	49.7	0.141	1	0	0
2,4,6-Trichlorophenol	59.1	0.793	1	0	0
Diethylphthlate	27.8	0.632	1	0	0
2,4-Dinitrotoluene	597	26.8	0	0	1
2,6-Dinitrotoluene	91.4	1.498	1	0	0
Acenaphthene	356	18.1	0	0	1
Chrysene	101.5	1.61	1	0	0
Naphthlene	90.8	1.096	1	0	0
Pyrene	429	18.8	0	0	1
Bis (2-Chloroethyl) Ether	88.7	0.907	1	0	0
Hexachlorobutadiene	71.5	0.832	1	0	0
Hexachlorocyclopentadiene	78.9	1.770	1	0	0
Hexachloroethane	80.8	1.108	1	0	0
1,2,4-Trichlorobenzene	248	9.78	0	0	1

[a]Average of all results for the Y-12 laboratory. All parameters were not measured every month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameter and the month.

[c]The adopted limits place the warning (marginal) level at 1.96 standard deviations and the acceptance level at 2.58 deviations from the mean.

Table 10.20. Proficiency Environmental Testing Control Program at the Y-12 Environmental Laboratory in 1991

Level 2 Concentrations

Parameter	Average recovery[a] (%)	Average number of standard deviations[b]	Performance[c]		
			Acceptable	Warning	Unacceptable
Biochemical oxygen demand	103.8	0.510	11	0	0
Chemical oxygen demand	91.5	0.444	12	0	0
Total organic carbon	107.1	0.462	12	0	0
Ammonia nitrogen	99.7	0.164	12	0	0
Nitrate nitrogen	106.5	0.700	12	0	0
Phosphate-P	103.4	0.293	12	0	0
Kjeldahl nitrogen	107.4	0.180	11	0	0
Total phosphorus	102.1	0.509	12	0	0
Total suspended solids	94.1	0.368	12	0	0
Total dissolved solids	97.8	0.524	12	0	0
Oil and grease	96.8	0.445	12	0	0
Alkalinity	99.3	0.442	12	0	0
Calcium	100.0	0.231	12	0	0
Chloride	98.3	0.391	12	0	0
Conductivity	87.8	0.696	11	0	1
Magnesium	101.9	0.376	12	0	0
Potassium	102.3	0.477	12	0	0
Sodium	98.8	0.378	12	0	0
Sulfate	98.7	0.439	12	0	0
Total hardness	101.2	0.361	12	0	0
pH	95.9	0.652	12	0	0
Aluminum	101.7	0.270	12	0	0
Antimony	100.7	0.427	12	0	0
Arsenic	97.5	0.737	11	1	0
Barium	102.0	0.366	12	0	0
Beryllium	100.1	0.251	12	0	0
Boron	102.4	0.336	12	0	0
Cadmium	102.7	0.429	12	0	0
Chromium	102.8	0.366	12	0	0
Cobalt	101.1	0.254	12	0	0
Copper	102.9	0.384	12	0	0
Iron	100.9	0.329	12	0	0
Lead	103.5	0.554	12	0	0
Manganese	103.3	0.726	12	0	0
Mercury	94.6	0.434	11	0	0
Molybdenum	100.8	0.560	12	0	0
Nickel	100.9	0.257	12	0	0
Selenium	105.9	0.678	10	2	0
Silver	100.1	0.347	12	0	0
Thallium	98.9	0.505	10	0	0
Vanadium	100.7	0.209	12	0	0
Zinc	102.3	0.411	12	0	0
Phenol	107.1	0.863	11	1	0
Cyanide	96.1	0.368	12	0	0
Residual chlorine	96.4	0.316	12	0	0
Fluoride	109.1	1.440	8	2	2
Hexavalent chromium	94.4	1.527	8	1	1
Uranium	97.5	0.358	12	0	0

Table 10.20 (continued)

Parameter	Average recovery[a] (%)	Average number of standard deviations[b]	Performance[c]		
			Acceptable	Warning	Unacceptable
		Organics			
Benzene	111.8	0.907	2	1	0
Chlorobenzene	106.0	0.761	3	0	0
1,2-Dichlorobenzene	114.9	1.135	2	0	0
1,4-Dichlorobenzene	111.5	0.979	1	0	0
Ethylbenzene	108.0	0.990	2	1	0
Toluene	104.1	0.756	2	1	0
Carbon Tetrachloride	105.3	0.638	1	0	0
Chloroform	106.6	0.788	3	0	0
Methylene Chloride	120.6	1.394	1	0	0
Tetrachloroethene	106.1	1.293	1	0	0
1,1,1-Trichloroethane	90.6	0.608	1	0	0
1,1,2-Trichloroethane	104.2	0.574	2	0	0
4-Chloro-3-Methyl Phenol	77.0	0.352	1	0	0
2,4-Dichlorophenol	63.9	0.421	1	0	0
2-Nitrophenol	65.3	0.251	1	0	0
Phenol	56.9	0.042	1	0	0
2,4,6-Trichlorophenol	55.4	0.910	1	0	0
Diethylphthlate	10.9	0.971	1	0	0
2,4-Dinitrotoluene	161.9	3.108	0	0	1
2,6-Dinitrotoluene	87.3	0.859	1	0	0
Acenapthene	225	10.6	0	0	1
Chrysene	86.4	0.426	1	0	0
Naphthalene	94.4	1.343	1	0	0
Pyrene	219	9.127	0	0	1
Bis (2-Chloroethyl) Ether	103.4	1.447	1	0	0
Hexachlorobutadiene	81.9	1.097	1	0	0
Hexachlorocyclopentadiene	66.6	0.560	1	0	0
Hexachloroethane	79.7	1.211	1	0	0
1,2,4-Trichlorobenzene	170	5.502	0	0	1

[a]Average of all results for the Y-12 laboratory. All parameters were not measured every month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameter and the month.

[c]The adopted limits place the warning (marginal) level at 1.96 standard deviations and the acceptance level at 2.58 deviations from the mean.

Table 10.21. Proficiency Environmental Testing Control Program at ORNL in 1991

Level 1 Concentration, Inorganics

Parameter	Average recovery (%)[a]	Average number of standard deviations[b]	Performance		
			Acceptable[c]	Marginal[c]	Unacceptable[c]
BOD	95.9	0.70	12	0	0
TOC	101.7	0.15	8	0	0
Ammonia as N	120.1	0.64	12	0	0
Nitrate as N	97.4	0.31	9	0	0
Orthophosphate as P	82.2	1.64	7	0	2
Total P	85.1	0.67	5	0	0
Suspended solids	90.0	0.86	10	1	0
Dissolved solids	101.5	0.62	11	0	0
Oil and grease	92.9	0.30	11	0	0
Alkalinity	98.2	0.36	12	0	0
Chloride	96.0	0.59	2	0	0
Conductivity	94.3	0.58	12	0	0
Sulfate	99.0	0.58	3	0	0
Total hardness as $CaCO_3$	100.3	0.21	12	0	0
pH	98.9	0.56	12	0	0
Ag	99.1	0.31	11	0	0
Al	100.2	0.21	11	0	0
As	103.9	0.60	11	0	0
Ba	100.4	0.45	11	0	0
Be	100.9	0.31	11	0	0
B	104.8	0.34	11	0	0
Cd	101.3	0.21	11	0	0
Co	96.7	0.58	11	0	0
Cr	98.0	0.24	11	0	0
Cu	99.4	0.37	11	0	0
Fe	99.4	0.29	11	0	0
Hg	102.5	0.28	10	0	0
Mo	99.1	0.28	11	0	0
Mn	95.1	0.45	11	0	0
Ni	98.1	0.20	11	0	0
Pb	100.9	0.39	11	0	0
Sb	96.2	0.43	11	0	0
Se	80.6	1.10	9	1	0
U	93.4	0.64	10	0	0
V	99.4	0.25	11	0	0
Zn	97.1	0.50	11	0	0
Phenol	94.8	0.40	12	0	0
Cyanide	104.5	0.45	12	0	0
Total residual chloride	98.7	0.56	9	0	0
Total organic halides	103.3	0.37	5	0	0

[a]Average of all results at ORNL. All parameters were not analyzed each month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameters and the month.

[c]For EPA, the warning level is 1.96 standard deviations, and the acceptance level is 2.58 standard deviations from the mean.

Table 10.22. Proficiency Environmental Testing Control Program at ORNL in 1991

Level 2 Concentration, Inorganics

Parameter	Average recovery (%)[a]	Average number of standard deviations[b]	Performance		
			Acceptable[c]	Marginal[c]	Unacceptable[c]
BOD	95.0	0.34	12	0	0
TOC	97.5	0.72	7	0	1
Ammonia as N	107.6	0.56	12	0	0
Nitrate as N	100.6	0.25	9	0	0
Orthophosphate as P	91.9	0.95	9	0	0
Total P	96.6	0.77	7	0	0
Suspended solids	96.3	0.80	12	0	0
Dissolved solids	101.7	0.48	11	0	0
Oil and grease	91.5	0.21	11	0	0
Alkalinity	99.0	0.48	12	0	0
Chloride	87.7	2.29	0	1	0
Conductivity	92.3	0.63	12	0	0
Sulfate	99.4	0.31	3	0	0
Total hardness as $CaCO_3$	101.3	0.50	11	0	1
pH	98.7	0.49	12	0	0
Ag	100.5	0.27	11	0	0
Al	99.7	0.25	11	0	0
As	105.6	0.55	11	0	0
Ba	99.7	0.41	11	0	0
Be	101.1	0.36	11	0	0
B	101.4	0.29	11	0	0
Cd	100.6	0.36	11	0	0
Co	96.8	0.61	11	0	0
Cr	98.6	0.35	11	0	0
Cu	101.3	0.37	11	0	0
Fe	100.0	0.45	11	0	0
Hg	101.3	0.26	10	0	0
Mo	99.1	0.31	11	0	0
Mn	98.7	0.35	11	0	0
Ni	99.6	0.32	11	0	0
Pb	100.6	0.32	11	0	0
Sb	101.1	0.45	11	0	0
Se	105.8	0.46	10	0	0
U	96.3	0.80	10	0	0
V	98.8	0.38	11	0	0
Zn	99.2	0.58	10	1	0
Phenol	93.6	0.62	12	0	0
Cyanide	105.6	0.46	12	0	0
Total residual chloride	100.8	0.72	9	0	0
Total organic halides	94.6	0.34	5	0	0

[a]Average of all results at ORNL. All parameters were not analyzed each month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameters and the month.

[c]For EPA, the warning level is 1.96 standard deviations, and the acceptance level is 2.58 standard deviations from the mean.

Table 10.23. Proficiency Environmental Testing Control Program at ORNL in 1991

Level 1 Concentration, Organics

Parameter	Average recovery (%)[a]	Average number of standard deviations[b]	Performance		
			Acceptable[c]	Marginal[c]	Unacceptable[c]
Benzene	178.0	5.00	7	0	1
Chlorobenzene	234.2[d]	21.2[d]	10	0	1
1,2 Dichlorobenzene	87.1	0.46	2	0	0
1,4 Dichlorobenzene	104.1	0.42	2	0	0
Ethyl benzene	127.7	2.53	10	0	1
Toluene	104.1	1.07	9	0	1
Carbon tetrachloride	88.8	0.46	6	0	0
Chloroform	173.0	12.7	8	0	1
Methylene chloride	115.5	1.39	8	0	1
Tetrachloroethene	93.7	0.36	5	0	0
1,1,1-Trichloroethane	110.4	2.05	4	0	1
1,1,2-Trichloroethane	116.9	1.76	8	0	1
Trichloroethene	448.7[e]	39.6[e]	3	0	1
4-Chloro-3-methyl phenol	76.6	0.48	6	0	0
2-Chlorophenol	58.8	0.52	3	0	0
2,4-Dichlorophenol	70.2	0.50	5	0	0
2,4-Dinitrophenol	38.7	0.38	3	0	0
2-Methyl-4,6-dinitrophenol	62.2	0.51	5	0	0
2-Nitrophenol	66.9	0.26	5	0	0
4-Nitrophenol	81.1	0.84	3	0	0
Pentachlorophenol	58.4	0.60	5	0	0
Phenol	72.0	0.84	4	0	0
2,4,6-Trichlorophenol	66.5	0.45	6	0	0
Bis(2-ethylhexyl)phthalate	85.2	1.05	2	0	0
Di-n-butylphthalate	84.0	0.41	2	0	0
Diethylphthalate	85.1	0.69	7	0	0
Dimethylphthalate	74.1	0.46	4	0	0
2,4-Dinitrotoluene	69.9	0.38	6	0	0
2,6-Dinitrotoluene	67.4	0.15	6	0	0
Isophorone	67.9	0.54	5	0	0
Nitrobenzene	68.2	0.23	2	0	0
Acenaphthene	73.8	0.38	6	0	0
Anthracene	72.8	0.77	1	0	0
Chrysene	77.2	0.58	5	0	0
Naphthalene	69.0	0.51	3	0	0
Phenanthrene	82.1	0.51	5	0	0
Pyrene	86.8	0.69	6	0	0
Bis (2-chloroethyl) ether	62.4	0.62	6	0	0
1,2-Dichlorobenzene	51.7	0.61	2	0	0
1,4-Dichlorobenzene	60.0	0.78	6	0	0
Hexachlorobutadiene	50.5	0.63	5	0	0
Hexachlorocyclopentadiene	43.0	0.05	1	0	0
Hexachloroethane	58.0	0.50	6	0	0
1,2,4-Trichlorobenzene	62.8	0.60	7	0	0
Aldrin	62.1	0.92	9	1	0
Gamma-BHC	83.8	0.36	8	0	0
4,4'-DDT	88.4	0.21	7	0	0
Dieldrin	99.4	0.62	9	1	0
Endrin	97.6	0.38	9	0	0
Heptachlor	63.5	0.71	7	0	0

[a]Average of all results at ORNL. All parameters were not analyzed each month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameters and the month.

[c]For EPA, the warning level is 1.96 standard deviations, and the acceptance level is 2.58 standard deviations from the mean.

[d]Would be 98.7% and 0.51 if outlier is removed.

[e]Would be 90.7% and 0.51 if outlier is removed.

Table 10.24. Proficiency Environmental Testing Control Program at ORNL in 1991

Level 2 Concentration, Organics

Parameter	Average recovery (%)[a]	Average number of standard deviations[b]	Performance		
			Acceptable[c]	Marginal[c]	Unacceptable[c]
Benzene	85.3	1.07	7	0	1
Chlorobenzene	86.5	1.65	10	0	1
1,2-Dichlorobenzene	89.5	0.46	2	0	0
1,4-Dichlorobenzene	103.1	0.45	2	0	0
Ethyl benzene	86.7	0.73	10	0	1
Toluene	89.7	0.66	9	0	1
Carbon tetrachloride	90.7	0.65	5	1	0
Chloroform	87.7	1.33	8	0	1
Methylene chloride	93.2	0.57	8	0	1
Tetrachloroethene	91.8	0.40	5	0	0
1,1,1-Trichloroethane	82.9	1.71	4	0	1
1,1,2-Trichloroethane	92.6	0.75	8	0	1
Trichloroethene	69.3	2.18	3	0	1
4-Chloro-3-methyl phenol	71.8	0.53	6	0	0
2-Chlorophenol	61.8	0.58	3	0	0
2,4-Dichlorophenol	70.4	0.37	5	0	0
2,4-Dinitrophenol	61.5	0.34	3	0	0
2-Methyl-4,6-dinitrophenol	74.4	0.41	5	0	0
2-Nitrophenol	67.3	0.54	5	0	0
4-Nitrophenol	82.5	0.75	3	0	0
Pentachlorophenol	66.9	0.61	5	0	0
Phenol	73.6	0.67	4	0	0
2,4,6-Trichorophenol	71.1	0.58	6	0	0
Bis(2-ethylhexyl)phthalate	84.6	0.25	2	0	0
Di-n-butylphthalate	68.6	0.48	2	0	0
Diethylphthalate	73.0	0.61	7	0	0
Dimethylphthalate	73.2	0.48	4	0	0
2,4-Dinitrotoluene	76.8	0.70	6	0	0
2,6-Dinitrotoluene	76.5	0.45	6	0	0
Isophorone	67.5	0.82	5	0	0
Nitrobenzene	58.1	0.77	2	0	0
Acenaphthene	73.1	0.28	6	0	0
Anthracene	66.0	0.85	1	0	0
Chrysene	80.3	0.20	5	0	0
Naphthalene	61.7	0.63	3	0	0
Phenanthrene	73.2	0.74	4	1	0
Pyrene	82.7	0.57	6	0	0
Bis (2-chloroethyl) ether	61.8	0.56	6	0	0
1,2-Dichlorobenzene	44.8	0.91	2	0	0
1,4-Dichlorobenzene	53.1	0.83	6	0	0
Hexachlorobutadiene	48.3	0.77	5	0	0
Hexachlorocyclopentadiene	43.6	0.42	1	0	0
Hexachloroethane	58.8	0.71	6	0	0
1,2,4-Trichlorobenzene	60.3	0.54	7	0	0
Aldrin	59.5	1.26	9	1	0
Gamma-BHC	82.9	0.22	8	0	0
4,4'-DDT	87.6	0.32	7	0	0
Dieldrin	100.0	0.78	10	0	0
Endrin	92.1	0.30	9	0	0
Heptachlor	63.8	0.89	7	0	0

[a]Average of all results at ORNL. All parameters were not analyzed each month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameters and the month.

[c]For EPA, the warning level is 1.96 standard deviations, and the acceptance level is 2.58 standard deviations from the mean.

Table 10.25. Proficiency Environmental Testing Control Program at K-25 in 1991

Level 1 Concentrations

Parameter[a]	Average recovery (%)[a]	Average number of standard deviations[b]	Performance[c]		
			Acceptable	Marginal	Unacceptable
Alkalinity	94.671	–0.75	10	1	0
Aluminum	92.630	–0.44	11	0	0
Ammonia nitrogen	140.241	0.83	9	0	1
Antimony	81.371	–0.66	9	0	2
Arsenic	99.170	0.11	10	0	0
Barium	99.383	0.06	11	0	0
Beryllium	95.720	–0.35	11	0	0
Biochemical oxygen demand	104.087	0.43	11	0	0
Boron	107.621	–0.02	11	0	0
Cadmium	103.783	0.50	11	0	0
Calcium	100.750	0.15	11	0	0
Chemical oxygen demand	91.141	–0.47	11	0	0
Chloride	102.265	0.27	11	0	0
Chromium	104.617	0.24	11	0	0
Chromium+6	91.953	–0.11	10	0	0
Cobalt	103.081	0.49	10	1	0
Conductivity	91.906	0.07	11	0	0
Copper	99.532	–0.23	11	0	0
Cyanide	107.266	0.40	9	1	1
Fluoride	100.231	–0.03	11	0	0
Iron	100.418	–0.11	11	0	0
Lead	100.845	0.17	10	0	0
Magnesium	105.799	0.66	11	0	0
Manganese	102.779	0.60	11	0	0
Mercury	97.320	–0.32	11	0	0
Molybdenum	95.595	–0.14	11	0	0
Nickel	107.210	0.46	11	0	0
Nitrate nitrogen	98.164	–0.01	11	0	0
Oil and grease	111.255	0.64	11	0	0
Orthophosphate as P	93.409	–0.43	11	0	0
pH	96.597	0.14	11	0	0
Phenol	94.101	–0.33	11	0	0
Potassium	104.139	0.48	11	0	0
Selenium	95.642	–0.31	10	0	0
Silver	107.142	0.52	11	0	0
Sodium	103.365	0.47	9	2	0
Sulfate	100.740	0.04	11	0	0
Thallium	95.113	–0.17	10	0	0
Total dissolved solids	104.392	0.12	11	0	0
Total hardness (as $CaCO_3$)	100.616	–0.13	11	0	0
Total Kjeldahl nitrogen	132.424	0.24	10	1	0
Total organic carbon	102.271	0.03	10	1	0
Total organic halides (TO_x)	91.749	–0.40	7	1	0
Total phosphorus as P	118.702	0.55	11	0	0
Total residual chlorine	80.226	–0.95	9	2	0
Total suspended solids	90.785	–0.31	11	0	0
Uranium	100.626	0.25	10	1	0
Vanadium	102.786	0.36	11	0	0
Zinc	106.567	0.16	11	0	0

[a]Average of all results for ORGDP. All parameters were not measured every month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameters and the month.

[c]For the EPA, the warning (marginal) level is 1.96 standard deviations and the acceptance level is 2.58 standard deviations from the mean.

Table 10.26. Proficiency Environmental Testing Control Program at K-25 in 1991

Level 2 Concentrations

Parameter[a]	Average recovery (%)[a]	Average number of standard deviations[b]	Performance[c]		
			Acceptable	Marginal	Unacceptable
Alkalinity	94.533	–0.68	11	0	0
Aluminum	106.746	0.46	10	0	1
Ammonia nitrogen	102.375	0.04	8	0	3
Antimony	95.760	–0.12	11	0	0
Arsenic	99.571	0.02	10	0	0
Barium	100.817	0.24	11	0	0
Beryllium	96.833	–0.29	11	0	0
Biochemical oxygen demand	99.720	0.15	11	0	0
Boron	103.306	0.39	11	0	0
Cadmium	106.531	0.99	10	1	0
Calcium	100.945	0.09	11	0	0
Chemical oxygen demand	85.430	–0.32	11	0	0
Chloride	101.888	0.33	11	0	0
Chromium	108.605	1.06	11	0	0
Chromium +6	105.384	0.95	10	0	1
Cobalt	104.357	0.83	10	1	0
Conductivity	90.320	0.18	11	0	0
Copper	102.624	0.33	11	0	0
Cyanide	107.844	0.36	10	0	1
Fluoride	103.334	0.38	10	1	0
Iron	105.158	0.75	11	0	0
Lead	102.868	0.27	10	0	0
Magnesium	105.407	0.76	11	0	0
Manganese	104.048	0.84	11	0	0
Mercury	96.188	–0.29	10	1	0
Molybdenum	98.722	0.21	11	0	0
Nickel	108.640	0.89	11	0	0
Nitrate nitrogen	91.847	–0.71	11	0	0
Oil and grease	100.231	0.50	11	0	0
Orthophosphate as P	95.928	–0.56	11	0	0
pH	96.540	–0.02	10	1	0
Phenol	99.143	0.06	11	0	0
Potassium	102.004	0.16	11	0	0
Selenium	99.838	0.05	10	0	0
Silver	104.823	0.71	11	0	0
Sodium	101.976	0.30	9	1	1
Sulfate	99.640	0.03	11	0	0
Thallium	94.088	–0.25	10	0	0
Total dissolved solids	103.452	0.27	11	0	0
Total hardness as $CaCO_3$	96.672	–0.29	11	0	0
Total Kjeldahl nitrogen	103.338	–0.11	11	0	0
Total organic carbon	99.429	–0.20	11	0	0
Total organic halides (TO_x)	78.111	–0.83	8	0	0
Total phosphorus as P	101.960	0.28	11	0	0
Total residual chlorine	92.167	–0.15	11	0	0
Total suspended solids	95.649	–0.04	10	1	0
Uranium	97.892	0.24	11	0	0
Vanadium	104.294	0.67	11	0	0
Zinc	105.691	0.74	10	1	0

[a]Average of all results for K-25. All parameters were not measured every month.

[b]The average number of standard deviations from the mean of all participants. The number of participant laboratories varied depending on the parameters and the month.

[c]For the EPA, the warning (marginal) level is 1.96 standard deviations and the acceptance level is 2.58 standard deviations from the mean.

Table 10.27. 1991 performance evaluation report, DMR-QA study number 011—Y-12 Environmental Laboratory

Analytes	Values		Limits		Performance evaluation
	Reported	True	Acceptable	Warning	
			Trace metals (μg/L)		
Aluminum	3,340	3,200	2,730–3,630	2,840–3,510	Acceptable
Arsenic	148	200	158–234	168–225	Unacceptable
Beryllium	143	130	104–159	111–152	Acceptable
Cadmium	194	190	161–218	168–211	Acceptable
Chromium	429	410	334–477	352–459	Acceptable
Cobalt	190	180	154–205	161–198	Acceptable
Copper	772	730	656–817	676–797	Acceptable
Iron	1,080	1,000	887–1,140	918–1,110	Acceptable
Lead	98	47.9	38.3–58.3	40.8–55.8	Unacceptable
Manganese	956	920	850–1,010	869–986	Acceptable
Mercury	3.20	3.40	2.54–4.41	2.78–4.18	Acceptable
Nickel	460	430	383–485	396–472	Acceptable
Selenium	75	86.0	60.7–105	66.1–99.1	Acceptable
Vanadium	4,870	4,600	4,130–5,160	4,260–5,020	Acceptable
Zinc	118	110	88.5–133	94.1–128	Acceptable
			Miscellaneous analytes		
pH, standard units	5.55	5.52	5.42–5.66	5.45–5.64	Acceptable
Total suspended solids, mg/L	18.7	23.9	14.8–26.5	16.3–25.0	Acceptable
Oil and grease, mg/L	15.8	17.0	9.07–22.1	10.7–20.5	Acceptable
			Nutrients (mg/L)		
Ammonia-nitrogen	4.13	4.20	3.30–5.09	3.51–4.88	Acceptable
Nitrate-nitrogen	9.48	10.0	8.09–11.9	8.55–11.4	Acceptable
Kjeldahl-nitrogen	23.8	25.0	18.9–29.9	20.3–28.5	Acceptable
Total phosphorus	1.85	1.80	1.38–2.13	1.47–2.04	Acceptable
Orthophosphate	0.313	0.320	0.251–0.385	0.267–0.369	Acceptable
			Demands (mg/L)		
COD	62.7	65.4	49.3–75.8	52.7–72.5	Acceptable
TOC	27.0	25.9	21.9–29.8	22.9–28.8	Acceptable
5-day BOD	52.7	41.4	22.7–60.2	27.4–55.5	Acceptable
			Additional miscellaneous analytes (mg/L)		
Total cyanide	0.535	0.530	0.365–0.676	0.404–0.637	Acceptable
Total phenolics	0.015	0.0146	0.0025–0.0266	0.0056–0.0236	Acceptable
Total residual chlorine	0.10	0.110	D.L.–0.246	0.0099–0.210	Acceptable

Table 10.28. EPA performance evaluation DMR-QA study number 011—K-25 Site, 1991

Analytes	Values		Limits		Performance evaluation
	Reported	True[a]	Acceptance	Warning	
		Trace metals (μg/L)			
Al	3280	3200	2730–3630	2840–3510	Acceptable
As[a]	202	200	158–234	168–225	Acceptable
Be	131	130	104–159	111–152	Acceptable
Cd	194	190	161–218	168–211	Acceptable
Cr	440	410	334–477	352–459	Acceptable
Co	190	180	154–205	161–198	Acceptable
Cu	756	730	656–817	676–797	Acceptable
Fe	1040	1000	887–1140	918–1110	Acceptable
Pb	49.3	47.9	38.3–58.3	40.8–55.8	Acceptable
Mn[a]	973	920	850–1010	869–986	Acceptable
Hg	1.24	3.40	2.54–4.41	2.78–4.78	Unacceptable
Ni	454	430	383–485	396–472	Acceptable
Se	84.7	86.0	60.7–105	66.1–99.1	Acceptable
V	4900	4600	4130–5160	4260–5020	Acceptable
Zn	118	110	88.5–133	94.1–128	Acceptable
		Miscellaneous analytes (mg/L)			
pH, standard units	5.42	5.52	5.42–5.66	5.45–5.64	Warning
Total suspended solids	21.8	23.9	14.8–26.5	16.3–25.0	Acceptable
O&G	15.6	17.0	9.07–22.1	10.7–20.5	Acceptable
		Nutrients (mg/L)			
Ammonia-nitrogen	5.22	4.20	3.30–5.09	3.51–4.88	Unacceptable
Nitrate-nitrogen	9.08	10.0	8.09–11.9	8.55–11.4	Acceptable
Kjeldahl-nitrogen	22.9	25.0	18.9–29.9	20.3–28.5	Acceptable
Total P	1.96	1.80	1.38–2.13	1.47–2.04	Acceptable
Orthophosphate	0.326	0.320	0.251–0.385	0.267–0.369	Acceptable
		Demands (mg/L)			
COD	69	65.4	49.3–75.8	52.7–72.5	Acceptable
TOC	21.1	25.9	21.9–29.8	22.9–28.8	Unacceptable
5-day BOD	39.4	41.4	22.7–60.2	27.4–55.5	Acceptable
		Additional miscellaneous analytes (mg/L)			
Total cyanide	0.515	0.530	0.365–0.676	0.404–0.637	Acceptable
Total phenolics	0.01	0.0146	0.0025–0.0266	0.0056–0.0236	Acceptable
Total residual chlorine	0.059	0.110	D.L.–0.246	0.099–0.210	Acceptable

[a]Based upon theoretical calculations or a reference value, when necessary.

Table 10.29. 1991 performance evaluation report, water supply study number WS028—Y-12 Environmental Laboratory

Analytes	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True		
		Trace metals (μg/L)			
Antimony	2	38	35.0	27.8–46.6	Acceptable
Arsenic	1	109	129	109–144	Acceptable
Barium	1	535	533	472–574	Acceptable
Beryllium	2	0.81	0.800	0.611–0.991	Acceptable
Cadmium	1	7.88	7.73	6.37–8.90	Acceptable
Chromium	1	204	200	179–223	Acceptable
Copper	1	936	950	866–1020	Acceptable
Lead	1	6.7	7.28	5.52–9.41	Acceptable
Mercury	1	6.49	7.14	5.54–8.46	Acceptable
Nickel	2	216	211	185–231	Acceptable
Selenium	1	12	13.1	9.68–14.6	Acceptable
Silver	1	62.8	60.7	52.7–68.9	Acceptable
Thallium	2	1.9	2.00	1.08–2.94	Acceptable
		Insecticides (μg/L)			
Lindane	1	1.197	0.638	0.378–0.861	Unacceptable
Methoxychlor	1	12.4	12.4	8.10–15.9	Acceptable
Toxaphene	2	8.70	12.7	7.47–15.7	Acceptable
Chlordane	3	2.29	3.77	2.04–4.77	Acceptable
Endrin	1	0.180	0.163	0.107–0.233	Acceptable
Heptachlor	4	0.101	0.142	0.0398–0.220	Acceptable
Heptachlor epoxide	4	0.100	0.125	0.0721–0.168	Acceptable
Hexachlorobenzene	4	0.158	0.167	0.0786–0.236	Acceptable
Hexachlorocyclopentadiene	4	0.075	0.230	D.L.–0.402	Acceptable
		Herbicides (μg/L)			
2,4-D	1	5.8	3.33	0.971–5.26	Unacceptable
2,4,5-TP (Silvex)	1	2.7	1.75	0.532–2.57	Unacceptable
		Trihalomethanes (μg/L)			
Bromodichloromethane	1	17.8	18.7	15.0–22.4	Acceptable
Bromoform	1	35.9	34.6	27.7–41.5	Acceptable
Chlorodibromomethane	1	27.0	27.1	21.7–32.5	Acceptable
Chloroform	1	13.4	14.2	11.4–17.0	Acceptable
Total trihalomethane	1	94.10	94.6	75.7–114	Acceptable
		Volatile organic compounds (μg/L)			
Benzene	1	11.2	11.8	9.44–14.2	Acceptable
Carbon tetrachloride	1	10.8	12.2	9.76–14.6	Acceptable
Chlorobenzene	2	13.8	14.6	11.7–17.5	Acceptable
1,2-Dichlorobenzene	2	15.4	15.4	12.3–18.5	Acceptable
1,4-Dichlorobenzene	1	11.3	12.5	10.0–15.0	Acceptable
1,2-Dichloroethane	1	6.8	6.95	4.17–9.73	Acceptable
1,1-Dichloroethylene	1	4.3	4.72	2.83–6.61	Acceptable
C 1,2-Dichloroethylene	2	12.9	13.0	10.4–15.6	Acceptable
T 1,2-Dichloroethylene	2	9.2	9.81	5.89–13.7	Acceptable
1,2-Dichloropropane	2	6.6	7.37	4.42–10.3	Acceptable

Table 10.29 (continued)

Analytes	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True		
		Volatile organic compounds (μg/L)			
Ethylbenzene	2	10.5	11.6	9.28–13.9	Acceptable
Styrene	2	9.5	10.6	8.48–12.7	Acceptable
Tetrachloroethylene	2	7.7	9.03	5.42–12.6	Acceptable
Toluene	2	12.4	13.8	11.0–16.6	Acceptable
1,1,1-Trichloroethane	1	13.4	15.2	12.2–18.2	Acceptable
Trichloroethylene	1	3.8	4.32	2.59–6.05	Acceptable
Vinyl chloride	1	8.0	9.40	5.64–13.2	Acceptable
Total xylenes	2	8.4	8.45	5.07–11.8	Acceptable
Bromobenzene	3	12.6	13.4	10.7–16.1	Acceptable
N-Butylbenzene	3	6.3	7.29	4.37–10.2	Acceptable
4-Chlorotoluene	3	10.4	12.3	9.84–14.8	Acceptable
4-Isopropyltoluene	3	12.3	13.9	11.1–16.7	Acceptable
1,1,1,2-Tetrachloroethane	3	7.7	8.23	4.94–11.5	Acceptable
1,2,4-Trichlorobenzene	3	7.9	8.62	5.17–12.1	Acceptable
1,2,3-Trichloropropane	3	10.7	11.6	9.28–13.9	Acceptable
1,2,4-Trimethylbenzene	3	8.4	9.46	5.68–13.2	Acceptable
		Miscellaneous analytes			
Sulfate (mg/L)	1	40.6	43.0	37.7–47.2	Acceptable
Total cyanide (mg/L)	1	0.420	0.460	0.312–0.567	Acceptable
Residual free chlorine (mg/L)	1	1.64	1.70	1.33–1.88	Acceptable
Turbidity (NTUs)	1	6.11	5.60	5.23–6.27	Acceptable
Total filterable residue (mg/L)	1	363	261	180–385	Acceptable
Calcium (as $CaCO_3$) (mg/L)	1	129	130	119–139	Acceptable
pH (standard units)	1	8.87	9.17	8.84–9.32	Acceptable
Alkalinity (as $CaCO_3$) (mg/L)	1	38.4	37.0	34.7–41.9	Acceptable
Corrosivity (Langelier ind. at 20°C)	1	+0.59	0.85	0.597–1.18	Unacceptable
Corrosivity (Aggressive ind. at 20°C)	1	12.54	12.8	12.5–13.1	Acceptable
Sodium (mg/L)	1	16.6	17.0	15.2–18.9	Acceptable
		Nitrate/nitrite/fluoride (mg/L)			
Nitrate as N	1	7.39	8.80	7.40–10.4	Unacceptable
Nitrite as N	1	0.804	0.770	0.674–0.879	Acceptable
Fluoride	1	1.52	1.60	1.44–1.76	Acceptable

Table 10.30. Water supply performance evaluation study WP–026–ORNL, 1991

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
			Trace metals (mg/L)			
Al	1	900	870	720–999	755–964	Acceptable
	2	3,290	3,200	2,730–3,630	2,840–3,510	Acceptable
As	1	76.0	69.9	55.5–82.8	58.9–79.4	Acceptable
	2	217	200	158–234	168–225	Acceptable
Be	1	11.1	11.1	7.73–14.7	8.63–13.8	Acceptable
	2	134	130	104–159	111–152	Acceptable
Cd	1	6.10	5.07	3.42–6.82	3.85–6.40	Acceptable
	2	203	190	161–218	168–211	Acceptable
Co	1	804	815	706–915	733–888	Acceptable
	2	179	180	154–205	161–198	Acceptable
Cr	1	74.0	74.0	56.7–90.2	60.8–86.0	Acceptable
	2	410	410	334–477	352–459	Acceptable
Fe	1	346	340	293–391	305–379	Acceptable
	2	1,030	1,000	887–1,140	918–1,110	Acceptable
Hg	1	0.52	0.543	0.246–0.903	0.329–0.820	Acceptable
	2	3.37	3.40	2.54–4.41	2.78–4.18	Acceptable
Mn	1	423	420	385–460	394–451	Acceptable
	2	947	920	850–1,010	869–986	Acceptable
Ni	1	1,610	1,600	1,420–1,770	1,460–1,720	Acceptable
	2	432	430	383–485	396–472	Acceptable
Pb	1	249	320	271–369	283–357	Unacceptable
	2	42.0	47.9	38.3–58.3	40.8–55.8	Acceptable
Se	1	31.7	10.0	5.92–13.1	6.82–12.2	Unacceptable
	2	92.5	86.0	60.7–105	66.1–9.1	Acceptable
V	1	1,930	2,000	1,760–2,240	1,820–2,180	Acceptable
	2	4,510	4,600	4,130–5,160	4,260–5,020	Acceptable
Zn	1	1,860	1,900	1,670–2,110	1,720–2,060	Acceptable
	2	102	110	88.5–133	94.1–128	Acceptable
Sb	3	17.8	17.1	8.31–26.0	10.5–23.8	Acceptable
	4	97.1	97.0	55.9–128	64.9–118	Acceptable
Ag	3	0.760	0.806	0.460–1.16	0.550–1.07	Acceptable
	4	6.56	6.80	5.14–8.34	5.54–7.94	Acceptable
Tl	3	6.60	6.75	4.11–9.43	4.81–8.73	Acceptable
	4	86.5	97.1	76.6–118	81.9–112	Acceptable

Table 10.30 (continued)

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
			Trace metals (μg/L)			
Mo	3	26.6	27.3	17.0–36.6	19.8–33.9	Acceptable
	4	3.01	4.01	1.21–6.99	2.03–6.17	Acceptable
Sr	3	3.18	2.99	2.07–3.95	2.33–3.70	Acceptable
	4	69.1	68.0	52.8–84.3	57.0–80.1	Acceptable
Ti	3	201	190	160–222	168–214	Acceptable
	4	40.2	39.9	30.8–47.5	33.0–45.2	Acceptable
			Minerals (mg/L except as noted)			
pH, standard units	3	8.94	8.80	8.46–9.24	8.55–9.14	Acceptable
	4	5.55	5.52	5.42–5.66	5.45–5.64	Acceptable
Specific conductivity (μmhos/cm)	1	120	119	104–128	107–125	Acceptable
	2	913	901	799–986	822–963	Acceptable
Total hardness (as $CaCO_3$)	1	18.2	18.5	14.7–22.4	15.6–21.5	Acceptable
	2	67.1	71.0	61.8–80.3	64.1–77.9	Acceptable
Ca	1	1.27	1.30	0.909–1.61	0.997–1.52	Acceptable
	2	67.1	71.0	61.8–80.3	64.1–77.9	Acceptable
Mg	1	3.59	3.70	3.16–4.25	3.29–4.11	Acceptable
	2	17.8	18.5	16.0–21.0	16.6–20.4	Acceptable
Na	1	8.80	9.44	8.29–10.8	8.60–10.5	Acceptable
	2	49.2	55.8	49.3–61.8	50.9–60.3	Unacceptable
K	1	8.85	8.95	7.43–10.3	7.80–9.97	Acceptable
	2	28.5	28.9	24.8–33.2	25.9–32.1	Acceptable
Total alkalinity (as $CaCO_3$)	1	18.8	18.2	14.7–23.0	15.7–22.0	Acceptable
	2	108	112	96.7–116	99.1–114	Acceptable
Chloride	1	24.9	18.4	10.6–15.5	11.2–14.9	Unacceptable
	2	356	181	164–201	169–196	Unacceptable
Fluoride	1	1.45	0.750	0.636–0.852	0.664–0.825	Unacceptable
	2	5.95	2.90	2.38–3.27	2.50–3.16	Unacceptable
Sulfate	1	22.1	11.0	8.35–13.4	8.98–12.8	Unacceptable
	2	68.6	35.5	28.0–41.9	29.8–40.1	Unacceptable
			Nutrients (mg/L)			
Ammonia-N	1	18.0	18.0	14.4–21.3	15.2–20.4	Acceptable
	2	3.95	4.20	3.30–5.09	3.51–4.88	Acceptable
Nitrate-N	1	7.84	8.00	6.47–9.52	6.83–9.15	Acceptable
	2	9.93	10.0	8.09–11.9	8.55–11.4	Acceptable

Table 10.30 (continued)

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
			Nutrients (mg/L)			
Orthophosphate	1	1.27	1.40	1.15–1.63	1.20–1.57	Acceptable
	2	0.28	0.320	0.251–0.385	0.267–0.369	Acceptable
Kjeldahl-N	3	2.91	3.10	1.96–4.21	2.23–3.94	Acceptable
	4	22.8	25.0	18.9–29.9	20.3–28.5	Acceptable
Total P	3	3.22	3.60	2.84–4.28	3.02–4.11	Acceptable
	4	1.67	1.80	1.38–2.13	1.47–2.04	Acceptable
			Demand (mg/L)			
TOC	1	18.6	18.4	15.5–21.7	16.3–20.9	Acceptable
	2	26.1	25.9	21.9–29.8	22.9–28.8	Acceptable
5-day BOD	1	25.6	30.0	15.8–44.2	19.3–40.6	Acceptable
	2	33.8	41.4	22.7–60.2	27.4–55.5	Acceptable
			PCB's (μg/L)			
Aroclor-1232	1	3.19	3.77	1.93–5.06	2.33–4.66	Acceptable
Aroclor-1254	2	4.49	8.37	3.86–11.0	4.70–10.1	Acceptable
			PCB's in oil (mg/kg)			
PCB 1016/1242	1	17.1	32.4	5.93–45.6	11.0–40.5	Acceptable
PCB 1260	2	9.61	18.6	2.82–29.5	6.25–26.0	Acceptable
			Pesticides (μg/L)			
Chlordane	3	0.546	1.13	0.543–1.49	0.661–1.37	Check for error
	4	4.39	8.88	4.60–11.5	5.48–10.6	Unacceptable
Aldrin	1	0.116	0.227	0.0496–0.315	0.0828–0.282	Acceptable
	2	0.277	0.606	0.134–0.891	0.229–0.797	Acceptable
Dieldrin	1	0.163	0.208	0.104–0.300	0.129–0.275	Acceptable
	2	0.321	0.467	0.269–0.650	0.317–0.603	Acceptable
DDD	1	0.137	0.157	0.0504–0.272	0.0787–0.244	Acceptable
	2	0.642	0.882	0.436–1.13	0.523–1.04	Acceptable
DDE	1	0.136	0.183	0.0715–0.274	0.0974–0.249	Acceptable
	2	0.254	0.417	0.170–0.626	0.227–0.569	Acceptable
DDT	1	0.219	0.217	0.0782–0.352	0.113–0.317	Acceptable
	2	0.601	0.780	0.383–1.13	0.476–1.04	Acceptable
Heptachlor	1	0.080	0.119	0.0234–0.174	0.0466–0.155	Acceptable
	2	0.336	0.587	0.214–0.796	0.287–0.723	Acceptable

Table 10.30 (continued)

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
		Volatile halocarbons (µg/L)				
1,2 dichloroetane	1	17.6	17.2	10.5–23.1	12.1–21.5	Acceptable
	2	40.2	38.9	26.8–52.3	30.0–49.1	Acceptable
Chloroform	1	13.2	13.3	8.35–17.4	9.49–16.3	Acceptable
	2	63.6	64.4	41.1–82.8	46.4–77.6	Acceptable
1,1,1 trichloroethane	1	12.8	14.3	8.15–18.5	9.44–17.2	Acceptable
	2	32.8	36.6	21.5–48.6	24.9–45.2	Acceptable
Trichloroethene	1	12.6	13.9	8.68–18.6	9.94–17.3	Acceptable
	2	34.1	38.9	25.9–50.2	29.0–47.1	Acceptable
Carbon tetrachloride	1	10.1	11.7	6.46–16.2	7.68–15.0	Acceptable
	2	43.0	46.6	28.6–64.2	33.0–59.7	Acceptable
Tetrachloroethene	1	14.5	15.1	9.27–20.4	10.7–19.0	Acceptable
	2	62.3	63.9	40.5–85.0	46.2–79.3	Acceptable
Bromodichloromethane	1	14.9	16.1	10.5–20.7	11.8–19.4	Acceptable
	2	52.4	53.8	37.0–70.5	41.3–66.2	Acceptable
Dibromochloromethane	1	12.8	15.2	9.76–20.6	11.1–19.2	Acceptable
	2	49.5	52.5	36.0–69.7	40.3–65.4	Acceptable
Bromoform	1	14.5	17.8	9.79–25.1	11.7–23.1	Acceptable
	2	52.2	54.0	32.8–76.2	38.3–70.7	Acceptable
Methylene chloride	1	20.0	17.5	9.11–25.1	11.1–23.1	Acceptable
	2	59.8	54.6	29.0–77.3	35.1–71.2	Acceptable
Chlorobenzene	1	16.4	16.5	11.1–21.6	12.4–20.3	Acceptable
	2	69.2	68.4	45.5–90.2	51.2–84.5	Acceptable
		Volatile aromatics (µg/L)				
Benzene	1	12.1	11.8	7.72–16.1	8.78–15.0	Acceptable
	2	46.7	46.5	31.3–61.0	35.1–57.2	Acceptable
Ethylbenzene	1	15.2	15.3	9.78–20.0	11.1–18.7	Acceptable
	2	66.1	66.2	43.8–86.2	49.2–80.8	Acceptable
Toluene	1	19.0	18.9	12.8–24.6	14.3–23.1	Acceptable
	2	53.1	52.7	39.4–65.9	42.7–62.6	Acceptable

Table 10.30 (continued)

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
		Miscellaneous paramaters (mg/L)				
Total cyanide	1	0.012	0.020	D.L.–0.0352	0.0020–0.0304	Acceptable
	2	0.510	0.530	0.365–0.676	0.404–0.637	Acceptable
Non-filter residue	1	60.5	63.3	46.1–67.2	48.7–64.5	Acceptable
	2	22.0	23.9	14.8–26.5	16.3–25.0	Acceptable
Oil & grease	1	12.2	13.0	6.48–17.7	7.88–16.3	Acceptable
	2	16.2	17.0	9.07–22.1	10.7–20.5	Acceptable
Total phenolic	1	0.439	0.455	0.195–0.714	0.261–0.648	Acceptable
	2	0.012	0.0146	0.0025–0.0266	0.0056–0.0236	Acceptable
Total residual chlorine	1	1.76	2.00	1.27–2.25	1.40–2.12	Acceptable
	2	0.12	0.110	D.L.–0.246	0.0099–0.210	Acceptable

[a]Based upon theoretical calculations or a reference value, when necessary.
D.L. stands for detection limit.

Table 10.31. Water supply performance evaluation study WP–027—ORNL, 1991

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
			Trace metals (mg/L)			
Al	1	90.6	88.0	55.2–138	65.7–128	Acceptable
	2	1,040	1,051	864–1240	911–1,190	Acceptable
As	1	259	242	193–283	204–272	Acceptable
	2	9	9.85	6.89–12.9	7.65–12.2	Acceptable
Be	1	6.49	6.24	3.75–8.99	4.42–8.32	Acceptable
	2	209	210	171–242	180–233	Acceptable
Cd	1	1.96	2.16	1.07–3.44	1.37–3.14	Acceptable
	2	427	432	367–502	384–485	Acceptable
Co	1	120	125	106–142	111–138	Acceptable
	2	32.8	33.2	26.5–40.3	28.3–38.5	Acceptable
Cr	1	32.0	33.7	24.7–40.7	26.7–38.7	Acceptable
	2	559	550	428–645	456–618	Acceptable
Cu	1	11.9	11.8	8.12–15.6	9.06–14.6	Acceptable
	2	151	148	130–164	134–160	Acceptable
Fe	1	140	139	117–163	123–157	Acceptable
	2	19.5	18.7	12.4–26.5	14.1–24.7	Acceptable
Hg	1	0.71	0.74	0.401–1.05	0.483–0.964	Acceptable
	2	16.7	18.0	13.4–22.0	14.5–20.9	Acceptable
Mn	1	265	271	238–297	245–289	Acceptable
	2	49.8	50.4	43.5–56.0	45.1–54.5	Acceptable
Ni	1	506	520	450–577	466–561	Acceptable
	2	21.9	20.4	15.4–25.3	16.7–24.1	Acceptable
Pb	1	70.3	67.8	55.2–79.9	58.3–76.8	Acceptable
	2	358	351	300–401	312–388	Acceptable
Se	1	104	94.7	62.0–114	68.6–108	Acceptable
	2	40.4	41.2	27.3–50.7	30.2–47.7	Acceptable
V	1	719	720	637–806	659–783	Acceptable
	2	90.2	90.0	75.9–105	79.7–101	Acceptable
Zn	1	1,610	1,601	1,370–1,800	1,420–1740	Acceptable
	2	78.3	79.9	66.9–92.7	70.1–89.5	Acceptable
Sb	3	46	51.9	34.1–64.3	37.9–60.4	Acceptable
	4	157	174	121–210	132–199	Acceptable
Ag	3	16.4	17.0	14.1–20.5	14.9–19.7	Acceptable
	4	3	3.09	2.29–3.87	2.49–3.66	Acceptable

Table 10.31 (continued)

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
			Trace metals (mg/L)			
Tl	3	53	52.0	37.0–65.3	40.6–61.7	Acceptable
	4	27	26.9	20.4–33.3	22.1–31.6	Acceptable
Mo	3	16.5	16.0	11.2–21.8	12.6–20.4	Acceptable
	4	67.9	65.0	43.3–84.0	49.1–78.2	Acceptable
Sr	3	40	89.0	30.5–47.9	32.8–45.6	Acceptable
	4	24.1	23.1	17.9–28.5	19.4–27.1	Acceptable
Ti	4	122	120	98.1–135	103–130	Acceptable
			Minerals (mg/L except as noted)			+
pH-units	3	4.98	5.01	4.92–5.10	4.94–5.08	Acceptable
	4	7.17	7.21	7.00–7.40	7.05–7.35	Acceptable
Spec. cond.	1	706	684	608–746	625–729	Acceptable
(umhos/cm 25°C)	2	176	171	152–189	157–185	Acceptable
TDS at 18°C	1	391	406	303–530	331–502	Acceptable
	2	99	107	55.2–126	64.0–117	Acceptable
Total hardness	1	112	113	102–122	105–119	Acceptable
(as $CaCO^3$)	2	50.2	51.1	44.8–55.4	46.1–54.1	Acceptable
Na	1	91.1	88.4	80.5–96.5	82.5–94.5	Acceptable
	2	8.61	7.98	6.65–9.28	6.98–8.95	Acceptable
K	1	14.9	16.0	13.5–18.3	14.1–17.7	Acceptable
	2	3.88	4.00	2.97–4.90	3.21–4.65	Acceptable
Total alkaninity	1	83	79.3	70.7–91.7	73.3–89.1	Acceptable
(as $CaCO^3$)	2	4.5	5.55	3.21–9.91	4.04–9.08	Acceptable
Chloride	1	73.5	31.7	70.7–86.2	72.6–84.2	Acceptable
	2	33.3	36.2	30.6–39.8	31.8–38.7	Acceptable
Fluoride	1	0.31	0.30	0.240–0.382	0.258–0.364	Acceptable
	2	3.49	3.60	3.03–4.11	3.16–3.97	Acceptable
Sulfate	1	143	125	107–142	111–138	Unacceptable[b]
	2	7.41	7.20	4.22–9.71	4.91–9.02	Acceptable
			Nutrients (mg/L)			
Ammonia as N	1	0.56	0.49	0.311–0.712	0.359–0.664	Acceptable
	2	7.10	6.80	5.31–8.17	5.65–7.83	Acceptable
Nitrate as N	1	9.94	9.10	7.34–10.8	7.76–10.4	Acceptable
	2	0.35	0.33	0.212–0.448	0.241–0.420	Acceptable
Orthophosphate	1	0.61	0.73	0.608–0.849	0.637–0.820	Check for error[c]
	2	3.09	3.30	2.80–3.77	2.91–3.66	Acceptable
Total phosphorus	3	9.13	9.90	7.86–11.8	8.33–11.3	Acceptable
	4	1.29	1.40	1.09–1.71	1.16–1.63	Acceptable

Table 10.31 (continued)

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
			Demands (mg/L)			
TOC	1	5.76	5.00	3.77–7.07	4.20–6.63	Acceptable
	2	101	98.0	83.3–110	86.7–106	Acceptable
5-day BOD	1	5.2	8.10	3.22–13.0	4.44–11.8	Acceptable
	2	146	155	93.4–224	110–207	Acceptable
			PCBs (µg/L)			
Aroclor 1016/1242	2	3.74	3.80	0.698–5.25	1.28–4.66	Acceptable
Aroclor 1248	1	6.4	7.53	3.97–9.82	4.71–9.09	Acceptable
			PCBs in oil (mg/L)			
PCB 1016/1242	2	2.67	41.7	8.26–58.0	14.6–51.7	Unacceptable[b]
PCB 1254	1	3.45	19.5	1.65–34.9	5.90–30.6	Check for error[c]
			Pesticides (µg/L)			
Chlordane	3	4.68	5.61	2.95–7.25	3.50–6.70	Acceptable
	4	1.53	1.84	0.945–2.42	1.13–2.23	Acceptable
Aldrin	1	0.46	0.42	0.918–0.572	0.152–0.511	Acceptable
	2	0.11	0.10	0.122–0.144	0.0289–0.128	Acceptable
Dieldrin	1	0.43	0.42	0.209–0.594	0.258–0.545	Acceptable
	2	0.12	0.14	0.550–0.212	0.0749–0.192	Acceptable
DDD	1	0.59	0.58	0.296–0.818	0.362–0.752	Acceptable
	2	0.15	0.15	0.523–0.254	0.0781–0.229	Acceptable
DDE	1	0.35	0.36	0.159–0.518	0.205–0.472	Acceptable
	2	0.14	0.16	0.0607–0.238	0.0834–0.215	Acceptable
DDT	1	0.67	0.65	0.318–0.932	0.396–0.854	Acceptable
	2	0.14	0.15	0.0447–0.255	0.716–0.228	Acceptable
Heptachlor	1	0.55	0.46	0.157–0.636	0.218–0.574	Acceptable
	2	0.15	0.14	0.411–0.208	0.0624–0.186	Acceptable
Heptachlor epoxide	1	0.58	0.55	0.276–0.736	0.334–0.678	Acceptable
	2	0.27	0.22	0.121–0.300	0.143–0.277	Acceptable
			Volatile aromatics (µg/L)			
Benzene	1	64.4	72.3	51.2–97.8	57.0–91.9	Acceptable
	2	9.08	8.98	5.91–12.2	6.71–11.4	Acceptable
Ethylbenzene	1	60.3	58.3	43.4–75.3	47.4–71.3	Acceptable
	2	11.9	11.9	7.35–15.7	8.41–14.6	Acceptable
Toluene	1	64.8	60.4	44.4–76.8	48.4–72.8	Acceptable
	2	11.9	10.6	7.11–14.0	7.99–13.2	Acceptable
1,2-Dichlorobenzene	1	63.1	73.6	46.2–102	53.3–95.3	Acceptable
	2	13.9	14.2	9.01–19.2	10.3–17.9	Acceptable

Table 10.31 (continued)

Analytes	Sample number	Values		Limits		Performance evaluation
		Reported	True[a]	Acceptable	Warning	
			Volatile aromatics (µg/L)			
1,3-Dichlorobenzene	1	43.5	46.4	28.6–63.4	33.0–59.0	Acceptable
	2	11.8	12.7	7.81–17.2	9.00–16.0	Acceptable
1,4-Dichlorobenzene	1	61.2	63.7	37.9–90.0	44.5–83.4	Acceptable
	2	10.5	9.74	5.94–13.5	6.91–12.5	Acceptable
			Miscellaneous parameters (mg/L)			
Total cyanide	1	1.03	0.97	0.683–1.27	0.757–1.20	Acceptable
	2	0.09	0.09	0.529–0.124	0.619–0.115	Acceptable
Non-filterable residue	1	74.1	78.6	58.6–82.7	61.5–79.7	Acceptable
	2	36.1	37.5	26.5–40.2	28.2–38.5	Acceptable
Oil and grease	1	40.6	46.0	27.9–54.0	31.2–50.7	Acceptable
	2	5.3	8.0	3.21–12.2	4.34–11.1	Acceptable
Total phenolics	1	0.13	0.13	0.0482–0.191	0.0661–0.173	Acceptable
	2	2.38	2.40	0.941–3.51	1.26–3.19	Acceptable

[a]Based upon theoretical calculations or a reference value, when necessary.

[b]The reported value was beyond the acceptance limits.

[c]The reported value was within the acceptance limits, but since the value was outside of the warning limits a marginal problem may exist.

Table 10.32. Water supply performance evaluation study WS–027—ORNL, 1991

Analytes	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True[a]		
		Trace metals (μg/L)			
Sb	2	7.5[b]	7.00	5.20–10.5	Acceptable
As	1	29.5	30.0	24.6–34.0	Acceptable
Ba	1	929	953	849–1030	Acceptable
Be	2	4.63	4.67	3.41–5.81	Acceptable
Cd	1	30.2	29.3	25.2–33.1	Acceptable
Cr	1	73.1	75.3	65.8–84.6	Acceptable
Cu	1	122	122	109–133	Acceptable
Pb	1	87.0	91.3	78.6–102	Acceptable
Hg	1	1.18	1.29	0.903–1.73	Acceptable
Ni	2	445	451	393–495	Acceptable
Se	1	60.4[b]	59.9	46.3–66.8	Acceptable
Ag	1	47.3	48.5	39.7–55.6	Acceptable
Tl	2	25.9	26.9	20.7–31.8	Acceptable
		Nitrate/nitrite/fluoride (mg/L)			
Nitrate as N	1	0.590	0.550	0.381–0.778	Acceptable
Nitrite as N	1	0.290	0.250	0.214–0.290	Acceptable
Fluoride	1	4.23	4.35	3.91–4.79	Acceptable
		Insecticides (μg/L)			
Chlordane	3	0.841	1.84	1.04–2.06	Unacceptable
Endrin	1	0.621	0.554	0.371–0.687	Acceptable
Lindane	1	0.137	0.125	0.0653–0.176	Acceptable
Methoxychlor	1	11.8	16.6	12.0–20.8	Unaccpetable
Toxaphene	2	5.14[b]	6.39	3.79–7.80	Acceptable
		PAH's (μg/L)			
Benzo(a)pyrene	1	4.20[b]	22.1	5.18–25.3	Unacceptable
Benzo(k)fluoranthene	1	*c*	11.7	3.23–15.7	Unacceptable
Fluorene	1	3.90	6.43	2.03–9.18	Acceptable
Fluoranthene	1	12.1[b]	16.3	6.84–21.6	Acceptable
Naphthalene	1	13.7[b]	24.3	7.82–30.0	Acceptable
		Adipate/phthalate (μg/L)			
Bis (2-ethylhexyl) adipate	1	*c*	12.4	D.L—22.2	Unacceptable
Bis (2-ethylhexyl) phthalate	1	2.30	17.3	D.L—34.3	Acceptable
Butylbenzyl phthalate	1	5.20[b]	13.7	D.L—20.3	Acceptable
Dimethyl phthalate	1	3.80[b]	10.2	D.L—14.3	Acceptable
		Trihalomethanes (μg/L)			
Bromodichloromethane	1	31.7	32.4	25.9–38.9	Acceptable
Bromoform	1	21.9	22.7	18.2–27.2	Acceptable
Chlorodibromomethane	1	30.0	30.8	24.6–37.0	Acceptable
Chloroform	1	85.6	87.0	69.6–104	Acceptable
Total trihalomethane	1	169.2	172.9	138–207	Acceptable

Table 10.32 (continued)

Analytes	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True[a]		
		Volatile organic compounds (μg/L)			
Benzene	1	7.42	7.09	4.25–9.93	Acceptable
Carbon tetrachloride	1	7.90	8.48	5.09–11.9	Acceptable
1,2-Dichlorethane	1	5.38	4.88	2.93–6.83	Acceptable
1,1-Dichloroethylene	1	10.3	9.45	5.67–13.2	Acceptable
1,1,1-Trichloroethane	1	7.16	7.38	4.43–10.3	Acceptable
Trichloroethylene	1	13.8	14.0	11.2–16.8	Acceptable
Vinyl chloride	1	4.57	3.57	2.14–5.00	Acceptable
		Miscellaneous analytes (mg/L except as noted)			
Residual free chlorine	1	0.460[b]	0.470	0.297–0.551	Acceptable
Turbidity (NTU's)	1	1.0[b]	0.910	0.706–1.29	Acceptable
	2	1.0	0.910	0.432–1.42	Acceptable
Calcium (mg $CaCO_3$/L)	1	128	134	122–144	Acceptable
pH (units)	1	9.06[b]	9.17	8.72–9.36	Acceptable
Alkalinity (mg $CaCO_3$/L)	1	27.8[b]	30.5	28.5–35.7	Unacceptable
Soduim	1	7.07	14.0	13.0–15.6	Unacceptable
Sulfate	1	12.7	13.0	10.6–15.1	Acceptable
Total cyanide	1	0.177	0.180	0.121–0.222	Acceptable

[a]Based upon theoretical calculations or a reference value, when necessary.
[b]Significant general method bias is anticipated for this result.
[c]No value was reported.
D.L. stands for detection limit.

Table 10.33. Water supply performance evaluation study WS–028—ORNL, 1991

Analytes	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True[a]		
		Trace metals (μg/L)			
Sb	2	42.0	35.0	27.8–46.6	Acceptable
As	1	126	129	109–144	Acceptable
Ba	1	536	533	472–574	Acceptable
Be	2	0.772	0.800	0.611–0.991	Acceptable
Cd	1	7.84	7.73	6.37–8.90	Acceptable
Cr	1	201	200	179–223	Acceptable
Cu	1	882	950	866–1020	Acceptable
Pb	1	10.0	7.28	5.52–9.41	Unacceptable
Hg	1	7.00	7.14	5.54–8.46	Acceptable
Ni	2	211	211	185–231	Acceptable
Se	1	12.8[b]	13.1	9.68–14.6	Acceptable
Ag	1	57.7	60.7	52.7–68.9	Acceptable
Tl	2	1.70	2.00	1.08–2.94	Acceptable
		Nitrate/nitrite/fluoride (mg/L)			
Nitrate as N	1	9.21	8.80	7.40–10.4	Acceptable
Nitrite as N	1	0.759	0.770	0.674–0.879	Acceptable
Fluoride	1	1.50	1.60	1.44–1.76	Acceptable
		Insecticides (μg/L)			
Chlordane	3	0.802[b]	3.77	2.04–4.77	Unacceptable
Endrin	1	0.123	0.163	0.107–0.233	Acceptable
Lindane	1	0.461	0.638	0.376–0.861	Acceptable
Methoxychlor	1	9.15	12.4	8.10–15.9	Acceptable
Toxaphene	2	3.02[b]	12.7	7.47–15.7	Unacceptable

Table 10.33 (continued)

Analytes	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True[a]		
		Trihalomethanes (μg/L)			
Bromodichloromethane	1	16.5	18.7	15.0–22.4	Acceptable
Bromoform	1	31.8	34.6	27.7–41.5	Acceptable
Chlorodibromomethane	1	23.4	27.1	21.7–32.5	Acceptable
Chloroform	1	14.1	14.2	11.4–17.0	Acceptable
Total trihalomethane	1	85.80	94.6	75.7–114	Acceptable
		Miscellaneous analytes			
Residual free chlorine (mg/L)	1	1.59[b]	1.70	1.33–1.88	Acceptable
Turbidity (NTU's)	1	5.1[b]	5.60	5.23–6.27	Unacceptable
Total filterable residue (mg/L)	1	353	261	180–385	Acceptable
Calcium (mg $CaCO_3$/L)	1	127.2	130	119–139	Acceptable
pH units	1	9.25[b]	9.17	8.84–9.32	Acceptable
Alkalinity (mg $CaCO_3$/L)	1	37.5[b]	37.0	34.7–41.9	Acceptable
Corrosivity (Langelier ind. at 20°C)	1	0.950	0.85	0.597–1.18	Acceptable
Sodium (mg/L)	1	17.7	17.0	15.2–18.9	Acceptable
Sulfate (mg/L)	1	41.9	43.0	37.7–47.2	Acceptable
Total cyanide (mg/L)	1	0.479	0.460	0.312–0.567	Acceptable

[a]Based upon theoretical calculations or a reference value, when necessary.
[b]Significant general method bias is anticipated for this result.

Table 10.34. Water pollution performance evaluation study WP-026—K-25 Site, 1991

Parameter	Sample number	Values		Limits		Performance evaluation
		Reported[a]	True	Acceptable	Warning	
			Minerals (mg/L)			
pH	3	8.39	8.80	8.46–9.24	8.55–9.14	Unacceptable
	4	5.52	5.52	5.42–5.66	5.45–5.64	Acceptable
Special conditions,	1	116	119	104–128	107–125	Acceptable
μmhos/cm at 25°C	2	892	901	799–986	822–963	Acceptable
TDS at 180°C	1	60	59.1	31.9–90.0	39.2–82.7	Acceptable
	2	551	521	387–671	422–636	Acceptable
Total hardness	1	16	18.5	14.7–22.4	15.6–21.5	Acceptable
as $CaCO_3$	2	246	253	233–270	237–266	Acceptable
Total alkalinity	1	18	18.2	14.7–23.0	15.7–22.0	Acceptable
as $CaCO_3$	2	106	112	96.7–116	99.1–114	Acceptable
Chloride	1	13.3	13.4	10.6–15.5	11.2–14.9	Acceptable
	2	183	181	164–201	169–196	Acceptable
Fluoride	1	0.76	0.750	0.636–0.852	0.664–0.825	Acceptable
	2	2.89	2.90	2.38–3.27	2.50–3.16	Acceptable
Sulfate	1	11.2	11.0	8.35–13.4	8.98–12.8	Acceptable
	2	35.8	35.5	28.0–41.9	29.8–40.1	Acceptable
			Nutrients (mg/L)			
Ammonia as N	1	16.1	18.0	14.4–21.3	15.2–20.4	Acceptable
	2	3.76	4.20	3.30–5.09	3.51–4.88	Acceptable
Nitrate as N	1	7.42	8.0	6.47–9.52	6.83–9.15	Acceptable
	2	8.61	10.0	8.09–11.9	8.55–11.4	Acceptable
Orthophosphate	1	1.36	1.40	1.15–1.63	1.20–1.57	Acceptable
	2	0.30	0.320	0.251–0.385	0.267–0.369	Acceptable
Kjeldahl as N	3	3.02	3.10	1.96–4.21	2.23–3.94	Acceptable
	4	19.2	25.0	18.9–20.9	20.3–28.5	Warning
Total phosphorus	3	3.59	3.60	2.84–4.28	3.02–4.11	Acceptable
	4	1.76	1.80	1.38–2.13	1.47–2.04	Acceptable
			Demands (mg/L)			
COD	1	34	46.6	32.5–57.1	35.6–54.0	Warning
	2	65	65.4	49.3–75.8	52.7–72.3	Acceptable
TOC	1	22.4	18.4	15.5–21.7	16.3–20.9	Unacceptable
	2	31.2	25.9	21.9–29.8	22.9–28.8	Unacceptable
5-d BOD	1	29.4	30.0	15.8–44.2	19.3–40.6	Acceptable
	2	38.3	41.4	22.7–60.2	27.4–55.5	Acceptable
			Miscellaneous parameters (mg/L)			
Total cyanide	1	0.020	0.020	D.L.–0.0352	0.0020–0.0304	Acceptable
	2	0.549	0.530	0.365–0.676	0.404–0.637	Acceptable
Nonfilterable residue	1	55	63.3	46.1–67.2	48.7–64.5	Acceptable
	2	21	23.9	14.8–26.5	16.3–25.0	Acceptable
Oil and grease	1	13.4	13.0	6.48–17.7	7.88–11.3	Acceptable
	2	18.1	17.0	9.07–22.1	10.7–20.5	Acceptable
Total phenolics	1	0.470	0.455	0.195–0.714	0.261–0.648	Acceptable
	2	0.011	0.0146	0.0025–0.0266	0.0056–0.0236	Acceptable
Total residual chlorine	1	1.80	2.00	1.27–2.25	1.40–2.12	Acceptable
	2	0.095	0.110	D.L.–0.246	0.0099–0.210	Acceptable

[a]Based on theoretical calculations or a reference value when necessary.

Table 10.35. Water supply performance evaluation study number WP-027—K-25 Site, 1991

Parameter	Number of samples	Values[a]		Limits		Performance evaluation
		Reported	True	Acceptable	Warning	
			Minerals (mg/L, except as noted)			
pH, standard units	3	5.00	5.01	4.92–5.10	4.94–5.08	Acceptable
	4	7.22	7.21	7.00–7.40	7.05–7.35	Acceptable
Special conditions,	1	678	684	608–745	625–729	Acceptable
µmhos/cm at 25°C	2	167	171	152–189	157–185	Acceptable
TDS at 180°C	1	447	406	303–530	331–502	Acceptable
	2	123	107	55.2–126	64.0–117	Check for error
Total hardness,	1	107	113	102–122	105–119	Acceptable
as $CaCO_3$	2	48	51.1	44.8–55.4	46.1–54.1	Acceptable
Total alkalinity,	1	78	79.3	70.7–91.7	73.3–89.1	Acceptable
as $CaCO_3$	2	7	5.55	3.21–9.91	4.04–9.08	Acceptable
Chloride	1	82.1	81.7	70.7–86.2	72.6–84.2	Acceptable
	2	37.4	36.2	30.6–39.8	31.8–38.7	Acceptable
Fluoride	1	0.31	0.300	0.240–0.382	0.258–0.364	Acceptable
	2	3.52	3.60	3.03–4.11	3.16–3.97	Acceptable
Sulfate	1	114.5	125	107–142	111–138	Acceptable
	2	6.54	7.20	4.22–9.71	4.91–9.02	Acceptable
			Nutrients (mg/L)			
Nitrate-N	1	8.87	9.10	7.34–10.8	7.76–10.4	Acceptable
	2	0.349	0.330	0.212–0.448	0.241–0.420	Acceptable
Orthophosphate	1	0.69	0.730	0.608–0.849	0.637–0.820	Acceptable
	2	3.16	3.30	2.80–3.77	2.91–3.66	Acceptable
Total phosphorus	3	9.58	9.90	7.86–11.8	8.33–11.3	Acceptable
	4	1.49	1.40	1.09–1.17	1.16–1.63	Acceptable
			Demands (mg/L)			
COD	1	15.0	12.6	3.60–22.4	5.97–20.1	Acceptable
	2	240.0	248	180–286	194–273	Acceptable
TOC	1	5.11	5.00	3.77–7.07	4.20–6.63	Acceptable
	2	57.6	98.0	83.3–110	86.7–106	Unacceptable
			Miscellaneous parameters (mg/L)			
Total cyanide	1	1.35	0.970	0.683–1.27	0.757–1.20	Unacceptable
	2	0.122	0.090	0.0529–0.124	0.0619–0.115	Check for error
Nonfilterable residue	1	74.9	78.6	58.6–82.7	61.6–79.7	Acceptable
	2	33.3	37.5	26.5–40.2	28.2–38.5	Acceptable
Oil and grease	1	30.2	46.0	27.9–54.0	31.2–50.7	Check for error
	2	20.4	8.00	3.21–12.2	4.34–11.1	Unacceptable
Total phenolics	1	0.15	0.130	0.0482–0.191	0.0661–0.173	Acceptable
	2	2.46	2.40	0.941–3.51	1.26–3.19	Acceptable
Total residual chlorine	1	1.92	2.40	1.60–2.84	1.76–2.68	Acceptable
	2	1.02	1.20	0.765–1.53	0.865–1.43	Acceptable

[a]Based on theoretical calculations or a reference value, when necessary.

Table 10.36. Water supply performance evaluation study number WS-027—K-25 Site, 1991

Parameter	Sample number	Values		Acceptance limits	Performance evaluation
		Reported	True[a]		
		Trace metals (μg/L)			
Sb	2	5.1[b]	7.0	5.20–10.5	Acceptable
As	1	30.1	30.0	24.6–34.0	Acceptable
Ba	1	950	953	849–1030	Acceptable
Be	2	4.8	4.67	3.41–5.81	Acceptable
Cd	1	31.5	29.3	25.2–33.1	Acceptable
Cr	1	80	75.3	65.8–84.6	Acceptable
Cu	1	120	122	109–133	Acceptable
Pb	1	79.8	91.3	78.6–102	Acceptable
Hg	1	1.10	1.29	0.903–1.73	Acceptable
Ni	2	470	451	393–495	Acceptable
Se	1	56.6[b]	59.9	46.3–66.8	Acceptable
Ag	1	31.8	48.5	39.7–55.6	Unacceptable
Tl	2	22.5	26.9	20.7–31.8	Acceptable
		Nitrate/nitrite/fluoride (mg/L)			
Nitrate as N	1	0.551	0.550	0.381–0.778	Acceptable
Nitrite as N	1	0.289	0.250	0.214–0.290	Acceptable
Fluoride	1	4.36	4.35	3.91–4.79	Unacceptable
		Volatile organic compounds in (μg/L)			
Tert-butylbenzene	2	14.0	14.1	11.3–16.9	Acceptable
1,2-Dichlorobenzene	2	6.76	6.50	3.90–9.10	Acceptable
Ethylbenzene	2	11.2	11.6	9.28–13.9	Acceptable
Isopropylbenzene	2	12.2	12.3	9.84–14.8	Acceptable
N-propylbenzene	2	8.24	7.83	4.70–11.0	Acceptable
Styrene	2	8.29	9.16	5.50–12.8	Acceptable
Tetrachloroethylene	2	7.90	7.76	4.66–10.9	Acceptable
1,2,4-Trichlorobenzene	2	<0.5	8.83	5.30–12.4	Unacceptable
Total xylenes	2	7.88	8.45	5.07–11.8	Acceptable
		Miscellaneous analytes			
Turbidity (NTUs)	2	1.3	0.910	0.432–1.42	Acceptable

[a]Based on theoretical calculations, or a reference value when necessary.
[b]Significant general method bias is anticipated for this result.
[c]The problem with the metals was operational and due to poor technique.

Table 10.37. CLP performance evaluation results

Inorganics—ORNL, 1991

Scoring classification	Points deducted			
	1st quarter	2nd quarter	3rd quarter[a]	4th quarter[a]
Duplicate precision	0.0	1.0	0.0	0.0
Matrix spikes	1.5	0.5	0.0	0.0
Water sample				
Identification	0.0	0.0	0.0	0.0
Quantitation	9.6	6.0	0.0	0.0
False positives and unmet CRDLs[b]	0.0	4.7	0.0	0.0
Soil sample				
Identification	0.0	0.0	0.0	0.0
Quantitation	5.4	7.6	0.0	0.0
False positives and unmet CRDLs[b]	0.0	3.3	0.0	0.0
Total points deducted	16	23	0.0	0.0
Laboratory score[c]	84	77	0.0	0.0

[a]PE samples not analyzed due to ICP instrument problems.
[b]Points deducted for false positive values and for not meeting the contract-required detection limits (CRDLs).
[c]The maximum number of possible points is 100.

Table 10.38. CLP performance evaluation results

Organics—ORNL, 1991

Scoring classification	Points deducted			
	1st quarter[a]	2nd quarter	3rd quarter[b]	4th quarter[b]
Number of TCL compounds not-identified	0.0	5.5	0.0	0.0
Number of TCL compounds misquantified	0.0	2.8	0.0	0.0
Number of TCL contaminants	0.0	0.0	0.0	0.0
Number of non-TCL compounds not identified	0.0	0.0	0.0	0.0
Number of non-TCL contaminants	0.0	0.0	0.0	0.0
Total points deducted	0.0	8.3	0.0	0.0
Laboratory score[c]	0.0	91.7	0.0	0.0

[a]PE samples not sent due to EPA budget problems.
[b]PE samples analyzed, but no score received.
[c]The maximum number of possible points is 100.

Table 10.39. CLP performance evaluation results—inorganics (K-25 Site, 1991)

Scoring classification	Points deducted			
	1st quarter	2nd quarter	3rd quarter	4th quarter
Duplicate precision[a]	0	*b*	*b*	0
Matrix spikes[c]	2	*b*	*b*	0
Water sample				
Identification	0	*b*	*b*	8
Quantitation	6	*b*	*b*	25
False positives and unmet CRDLs[d]	0	*b*	*b*	0
Soil sample				
Identification	0	*b*	*b*	5
Quantitation	0	*b*	*b*	1
False positives and unmet CRDLs[d]	0	*b*	*b*	0
Total points deducted	20.2	*b*	*b*	100
Laboratory score[e]	79.8	*b*	*b*	0

[a]Maximum of 10 points deducted based on number of duplicate results that are outside of the control limits.
[b]No data submitted to EPH for evaluation.
[c]Maximum of 10 points deducted based on number of matrix spike results that are outside of the control limits.
[d]Points deducted for false positive values and for not meeting the contract-required detection limits (CRDLs).
[e]The maximum number of possible points is 100.

Table 10.40. CLP performance evaluation results—organics (K-25 Site, FY 1991)

Scoring classification	Points deducted			
	1st quarter	2nd quarter	3rd quarter[a]	4th quarter
Number of TCL compounds not identified	*b*	0	1	1
Number of TCL compounds misquantified	*b*	4	4	6
Number of TCL contaminants	*b*	0	0	0
Number of non-TCL compounds not identified	*b*	0	0	1
Number of non-TCL contaminants	*b*	0	0	3
Total points deducted	*b*	11.1	23.4	35.8
Laboratory score[c]	*b*	88.9	76.6	64.2

[a]EPA did not evaluate any data.
[b]No data submitted to EPA for evaluation.
[c]The maximum number of possible points is 100.

Table 10.41. Environmental audits and reviews at the Y-12 Plant during 1991

Date	Audit	Reviewer	Subject	Findings
January 7–11	Environmental Compliance Review	Energy Systems	Environmental Compliance	18
April 9–12	Compliance Evaluation Inspection (CEI)	TDEC	Groundwater	2
April 13	Surveillance	DOE-OR	RCRA Waste Sampling	2
June 24–25	CEI	EPA	NPAES	0
July 16–17	Surveillance	DOE-OR	Spill Response	6
August 5–9	Inspection	TDEC	RCRA	0
August 13	Inspection	TDEC	Air	0
August 13	Inspection	City of Oak Ridge	Industrial Pretreatment Compliance	0
September 10–13	Technical Audit	MMC	Environmental Management	92
September 16–October 10	Surveillance	DOE-OR	NEPA	6
December 19	Inspection	TDEC	Sanitary Landfill II and Industrial Waste Landfille IV	0

Table 10.42. Environmental audits and reviews at ORNL during 1991

Date	Audit/review	Reviewer	Subject	Findings/outcome
February–November	Review of ORNL air-permitted sources	DOE-OR, Thirty-five air-permitted sources X-10 Site Office	No findings were cited; were reviewed during 9 separate surveillances	several observations have been resolved
February–October	Surveillance of ORNL RCRA satellite and 90-day accumulation areas and sampling and analytical QA	DOE-OR, RCRA Waste Generator, X-10 at Y-12 Site were X-10 Site ffice	Areas at X-10 Site and identified reviewed on 5 separate occasions	No previously regulatory concerns were cited. owever, there were several observations of which have been resolved
March 18–19	RCRA inspection	TDEC	RCRA TSD facilities	No findings were cited
April 10	Mixed waste storage facilities	DOE-OR, X-10 Site Office	Compliance with RCRA and DOE orders	Several observations were noted; areas of concern have been resolved
April 17	Air emission source inspection	TDEC	Selected air-permitted sources	No findings were cited
May 20–25	Review of ORNL Environmental Compliance Program	Energy Systems	Multimedia compliance review of environmental management	Eighteen previously unidentified findings were cited
June 27	NPDES Compliance evaluation inspection	EPA-IV	Review of ORNL NPDES Permit Monitoring Program	No findings were cited; areas of concern have been resolved
July 8–18	Clean Water Act surveillance	DOE-OR, X-10 Site Office	Review of ORNL NPDES Program, ORNL Surface Water Compliance Status	Findings have been resolved or scheduled for resolution
July 30–31	RCRA inspection	TDEC	RCRA Waste Generator Areas at X-10 Site and X-10 facilities at Y-12 Plant	No findings were cited; two areas of potential concern were resolved
August 19–20	RCRA groundwater comprehensive monitoring evaluation	TDEC	Review of ORNL SWSA 6 Groundwater Monitoring Program	No findings were cited

Table 10.43. K-25 Site internal and external environmental audits, 1991

Subject	Auditors	Date	Findings
TDEC review of the K-1413 closure plan	TDEC	1/91	
Inspection of the K-1417 container storage area	EPA/TDEC Corps of Engineers	1/91	
Inspection for the QA operations and records and the analytical laboratory quality assurance operations and records	DOE	2/91	
K-25 Site review	EPA Region IV/Env Mgmt Dept. (EMD)	2/91	
Review of the NPDES permit	TDEC/DOE/ EMD	2/91	
Comprehensive monitoring evaluation of the K-1407-B Pond groundwater-monitoring system	TDEC	3/91	
Preliminary inspection of water retention structures on the K-25 Site	Federal Energy Reg. Commission (FERC)	4/91	
Air program audit	TDEC	5/91	
Satellite and 90-day accumulation area training program	DOE Technical Review	5/91	
Toxic Substances Control Act (TSCA) Incinerator storage and treatment units for Resource Conservation and Recovery Act (RCRA) Part B permit application	DOE Technical Review	6/91	
Inspection of the RCRA operations, units, and records	TDEC	6/91	
Compliance with the NPDES	EPA Region IV	6/91	
Inspection of the K-900 bottle smasher unit	TDEC	7/91	
Tours to determine permitting requirements: (1) proposed stream crossing on Mitchell Branch, and (2) proposed bank stabilization areas on Poplar Creek	TDEC/Corps of Engineers	7/91	
Review of the Satellite and 90-day accumulation areas	DOE Technical Review	7/91	
Energy Systems corporate audit	Energy Systems	7,8/91	78 Findings, 81 neg. obs, 13 pos. obs
Tour of the NPDES monitoring points on the K-25 Site	DOE/EPA	8/91	
Review of the TSCA NPDES requirements	TDEC/EMD/ DOE/TSCA	8/91	
Review of options for K-1515-C Lagoon	TDEC/EMD/ DOE/Utilities	8/91	
Inspection of water retention structures on the K-25 Site	FERC/DOE/ EMD	10/91	
Asbestos management and program audit	Energy Systems	4/91	
Tiger Team review	DOE	11/91	10 (env.)
Groundwater audit	K-25 Site	8/91	18F, 4ob
Material safety data sheets	K-25 Site	11/91	10F, 2ob
Hazardous material spill response training for emergency personnel	K-25 Site	10/91	3ob
Radiochemistry laboratory	K-25 Site	9/91	4F, 5ob
Medical waste disposal	K-25 Site	9/91	7F, 4ob
Tank farm transfer operations	K-25 Site	7/91	0F, 0ob
PCB equipment inspection recordkeeping	K-25 Site	4/91	3ob
X-10 rad waste shipped to K-25 Site	K-25 Site	3/91	2ob, 2F
Internal dosimetry program	K-25 Site	6/91	7F, 2ob

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