**PADUCAH GASEOUS DIFFUSION PLANT
ENVIRONMENTAL REPORT FOR 1989**

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EXECUTIVE SUMMARY

OVERVIEW OF 1989 ENVIRONMENTAL REPORT

SCOPE AND PURPOSE

This two-part report, *Paducah Gaseous Diffusion Plant Site Environmental Report for 1989*, is published annually. It reflects the results of a comprehensive, year-round program to monitor the impact of operations at Paducah Gaseous Diffusion Plant (PGDP) on the area's groundwater and surface waters, soil, air quality, vegetation, and wildlife. In addition, an assessment of the effect of PGDP effluents on the resident human population is made.

PGDP's overall goal for environmental management is to protect the environment and PGDP's neighbors and to maintain full compliance with all current regulations. The current environmental strategy is to identify any deficiencies and to develop a system to resolve them. The long-range goal of environmental management is to minimize the source of pollutants, to reduce the formation of waste, and to minimize hazardous waste by substitution of materials.

MONITORING NETWORKS

Environmental-monitoring systems at PGDP include emission-monitoring networks for airborne and aqueous discharges, groundwater monitoring, solid waste characterization, and ambient-sampling networks for air, surface water, vegetation, food crops, fish, wildlife, soil, surface stream sediments, and radionuclide levels.

Effluent and waste monitoring includes:

- regular laboratory analysis of delivered coal and an SO₂ monitor on steam plant stacks;
- a network of 16 sampling locations for monitoring plant wastewater prior to discharge;

- a sampling program for identification and characterization of solid waste streams generated by plant operations;
- an ongoing sampling program of stored wastes and sludges to characterize these materials in support of Resource Conservation and Recovery Act and Comprehensive Environmental Response, Compensation, and Liability Act activities;
- 50 PGDP groundwater-monitoring wells and several residential groundwater wells; and
- stack sampling for radionuclide and fluoride emissions.

Ambient sampling networks include:

- 12 air-sampling stations (i.e., 4 fence-line and 8 off-site),
- 4 surface water-sampling locations,
- 18 vegetation-sampling locations (i.e., 4 fence-line and 14 off-site),
- fish samples from 1 on-site location and several off-site locations,
- 10 soil-sampling locations [i.e., 4 fence-line, 4 that are 8 km (5 miles) from PGDP, and 2 that are 13 to 15 km (8 to 9 miles) from PGDP],
- 28 stream-sediment-sampling locations (i.e., 2 on-site and 26 off-site),
- 15 gamma-radiation-monitoring locations (i.e., 4 fence-line and 11 off-site), and
- a Biological Monitoring Program with several monitoring locations.

The results of analyses and investigations are presented in this report, and the major findings are summarized in the following subsections.

SUMMARY OF 1989 ENVIRONMENTAL SURVEILLANCE DATA

Waterborne Discharges and Surface Water Monitoring

Definitive compliance strategies reduce wastewater discharges to the environment and ensure high-quality effluent monitoring. These activities are all integral parts of ensuring compliance with the Clean Water Act currently administered for PGDP by the Kentucky Division of Water through the Kentucky Pollutant Discharge Elimination System (KPDES) permitting program. On October 12, 1987, the U.S. Department of Energy (DOE) entered into an Agreed Order with the state of Kentucky. The Agreed Order was reached when it was determined that PGDP's effluents could not meet water quality standards. Water quality parameters not achievable at the time of permitting were pH, total residual chlorine, temperature, and some metals.

During 1989, 98.27% compliance with the KPDES Agreed Order was achieved. The majority of noncompliances experienced under the Agreed Order were for pH, total residual chlorine, fecal coliform, temperature, and total suspended solids. The pH noncompliances are in part the result of the softening process of the water at the C-611 water treatment plant. Elevation of pH during hot summer days results from the photosynthetic action of algae. Once-through cooling water is a large portion of PGDP's effluent and accounts for most of the total residual chlorine noncompliances. The C-615 sewage treatment plant is also a contributor of total residual chlorine in effluent waters. Fecal coliform noncompliances are due to the malfunctioning of the flow-proportionate chlorinator at the C-615 sewage treatment plant. Temperature noncompliances result from the heat in once-through cooling water and steam condensate discharge. Total suspended solids noncompliances occur because of rainfall runoff that washes dust and solids down the ditches.

During October 1989 a temporary sodium thiosulfate feed station was placed in service at outfall 009 eliminating total residual chlorine noncompliances at this outfall.

Biological monitoring, a requirement of the Agreed Order, is being conducted by the University of Kentucky in collaboration with Oak Ridge National Laboratory (ORNL). Planned and implemented by the University of Kentucky, the monitoring program was patterned after the Biological Monitoring and Abatement Program developed by ORNL for the three DOE facilities in Oak Ridge, Tennessee. The purpose of the Biological Monitoring Program is to determine the effects of plant effluents on aquatic life in the receiving streams. The findings of the program were consolidated into a draft 2-year report and submitted to the state of Kentucky. These findings include a slight-to-moderate toxicity of plant effluents on test organisms and some impact on macroinvertebrates in the receiving stream, a total residual chlorine problem at outfall 008, and toxicity of the influent water from the Ohio River. Some evidence was seen that effluents are altering general water quality characteristics of the receiving stream. Elevated concentrations of some metals and total suspended solids may also contribute to in-stream impact. There is no evidence that pH is elevated in the receiving streams.

During 1989, 92 kg of uranium was discharged to surface waters (see Fig. 1). This represents an increase of 33 kg from 1988. Technetium releases to surface waters decreased from 37 g in 1988 to 8 g in 1989 (see Fig. 2). An investigation is being conducted to determine if runoff or process sources are the cause of the measured increase in uranium discharges. Reduction methods will be considered once this study is completed.

Fig. 1. Uranium discharges to surface water, 1985–1989.

Fig. 2. Technetium discharges to surface water, 1985–1989.

Airborne Discharges and Meteorological Monitoring

PGDP currently has 27 air pollution emission sources that are permitted by the Kentucky Division for Air Quality (KDAQ). Air pollution control equipment utilized at PGDP includes

venturi scrubbers, water sprays, electrostatic precipitators, filters, and chemical traps (i.e., NaF and CaCO_3).

The C-600 steam plant is the primary source of conventional pollutants. Emissions are controlled through the use of electrostatic precipitators on units 2 and 3 operating with a collection efficiency of greater than 99%. Testing and experience show compliance with state regulations. Unit 1 may be operated with natural gas or fuel oil. Fugitive emissions from coal and ash handling are controlled with water sprays.

PGDP monitors two sources that emit minute quantities of radionuclides that are air contaminants regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP). During 1989, 205 g of uranium was released to the atmosphere. Most of the uranium emission (i.e., 88.8%) occurred during October when chemical traps were not switched at the cylinder-burping station. Definitive procedures for switching the traps are now being followed. Trend data are shown in Fig. 3. Also, 3.6 mCi of technetium was released; trend data are shown in Fig. 4. No new introduction of ^{99}Tc into the cascade has occurred.

Regulations for airborne radionuclide emissions under NESHAP limit total plant off-site

Fig. 3. Millicuries of uranium released to the atmosphere from PGDP operations, 1985–1989.

Fig. 4. Millicuries of technetium released to the atmosphere from PGDP operations, 1985–1989.

radiological dosages to the public. The maximum off-site radiological dose attributable to 1989 PGDP emissions is a 50-year committed effective dose equivalent of 1×10^{-4} mrem. This dose is a small fraction of the limit imposed by the regulations. PGDP continues to improve radionuclide emission control and monitoring capabilities to ensure compliance with applicable Environmental Protection Agency (EPA) regulations and DOE orders.

Air pollution modeling is the accepted way of predicting the impact on air quality from a source if the meteorological and emission data used are accurate. To provide accurate data, a meteorological tower was installed at PGDP during 1987 with automated data collection and solid state telemetry data transfer to a computer. Appropriate wind and other meteorological parameters were monitored to provide data for dose calculations for the 1989 report.

On-site Groundwater Monitoring

Groundwater-monitoring wells exist at a number of active and inactive burial sites, and upgrading of the monitoring system is continuing. During 1989, 50 wells were monitored for several

parameters. Monitoring of groundwater wells except those at C-746-K, an inactive landfill, is on a quarterly basis.

On-site groundwater data collected during 1989 were compared with Safe Drinking Water Act (SDWA) and National Primary Drinking Water Regulations. Parameters exceeding reference values were Cr, Fe, turbidity, pH, trichloroethylene (TCE), Zn, Pb, sulfate, As, Se, Mn, and ^{99}Tc . Additionally, benzene, toluene, ethylbenzene, and xylene (BTEX) compounds were detected in on-site wells. Iron is common to groundwater in western Kentucky. Trichloroethylene and technetium contamination is evident on-site. Groundwater contamination extends off-site north of PGDP. Specific sources of contamination are not yet known; however, all sites monitored are included in the Remedial Action Program (RAP) and are scheduled for investigation.

Off-site Groundwater Monitoring

In August 1988 when off-site groundwater contamination was discovered north of PGDP, a comprehensive effort to sample off-site wells was initiated. To date, approximately 268 residential wells surrounding PGDP have been sampled. Initial analysis of the off-site wells was limited to TCE and ^{99}Tc after Appendix IX analysis of the most contaminated off-site and on-site wells revealed these to be the primary contaminants. (The Appendix IX list is a pollutant list developed by the EPA consisting of over 250 organic pollutants.)

Ongoing sampling of off-site wells serves two purposes: (1) detecting the spread of contamination to other wells and (2) gaining additional information about those wells already contaminated. Several residential wells are sampled weekly and monthly. Key plant wells that are contaminated are sampled monthly. An additional 19 residential wells are sampled bimonthly, and Tennessee Valley Authority monitoring wells are sampled quarterly.

The off-site wells are sampled for TCE and ^{99}Tc . Residents are notified of the results of each sample. If a well has a TCE result above $1 \mu\text{g/L}$ or a ^{99}Tc result above 25 pCi/L , it is considered

contaminated even though these limits are lower than the SDWA limits. Action is then taken to supply alternative water supplies. The sampling schedules are likely to change as the groundwater investigation progresses. To date, nine residential wells at five residences have been found to be contaminated. These residences are currently served with community water at the expense of DOE.

External Gamma Radiation

Ambient gamma radiation levels are monitored with thermoluminescent dosimeters (TLDs) at 15 locations surrounding PGDP. The mean exposure rate as measured by the TLDs (excluding perimeter fence data) is approximately 36.7 mrem/year. The exposure rate of the population of Kentucky and surrounding states is shown in Fig. 5.

PGDP does not emit radionuclides that are discernible from background levels. Because of the small amount of gamma radiation emitted, portions of the quality control data do not meet the American National Standards Institute standard governing TLDs. Therefore, the 36.7 mrem/year exposure rate measured by PGDP cannot be assumed to be accurate.

Biological Monitoring

A vegetation-sampling program is carried out by PGDP to determine total fluorides in broadleaf grasses. Eighteen locations on-site and off-site are sampled. The results are compared with the fluoride-in-foliage section of the Kentucky air pollution control regulations. The standard is 60 μg of fluorine per gram of dry grass for a 2-month average. Analyses ranged from <5 to <10% of the standard.

Fig. 5. External cosmic, terrestrial, and total gamma exposures.

No appreciable uptake of any of the manmade radionuclides has occurred. The preponderance of apparent positive values reflects the fact that all materials are slightly radioactive; this makes the sample determination process subject to biases in regard to contamination. But when the ± 1 value is taken off, it is equally likely that no negative activity is present.

Soil and Sediment Sampling

Soil sampled during 1989 from 10 locations surrounding the plant ranged from 0.7 $\mu\text{g/g}$ of uranium at a background location 15 km (9 miles) west of the plant to 5.6 $\mu\text{g/g}$ of uranium at the southern boundary of the plant. Since 1985, levels of uranium from areas between 8 and 15 km (5 and 9 miles) from PGDP have ranged from 0.7 to 4.2 $\mu\text{g/g}$ (see Table 1). These levels of uranium are typical of soils in western Kentucky.

Annual sediment samples are taken at 28 locations and analyzed for a wide variety of elements. Of special interest in these analyses are heavy metals, specific radionuclides, and polychlorinated biphenyls (PCBs). Analysis showed that PCBs, U, ^{99}Tc , ^{239}Pu , ^{237}Np , and ^{137}Cs concentrations were elevated in several locations compared with background data from Nasty Creek

and Brushy Creek (e.g., in the C-615 sewage treatment plant sludge). However, the sewage sludge is drummed for storage. Concentrations of PCBs are present above background in Little Bayou Creek. This creek was posted with a fish consumption advisory in April 1989.

Table 1. Concentration of uranium in soil at PGDP, 1985–1989 ($\mu\text{g/g}$)

Location	1985	1986	1987	1988	1989
<i>Property boundary</i>					
S1 (north)	5	6	4.8	4.9	2.2
S2 (east)	3	5	3.4	4.6	2.4
S3 (south)	2	6	5.5	4.3	5.6
S4 (west)	3	3	2.5	2.2	1.4
<i>8 km from plant</i>					
S5 (north)	3	4	3.9	4.2	2.2
S6 (east)	2	3	2.6	2.3	1.1
S7 (south)	3	4	2.7	2.5	1.2
S8 (west)	2	4	2.8	3.4	1.2
<i>13 to 15 km from plant</i>					
S9 (south)	1	2	2.4	2.5	0.8
S10 (west)	2	3	2.9	2.1	0.7

SUMMARY OF 1989 ENVIRONMENTAL ACTIVITIES

Audits and Reviews

The PGDP Environmental Monitoring Program regularly undergoes reviews and audits by both internal and external organizations. The external and DOE audits and reviews conducted in 1989 were:

- An environmental appraisal conducted by the DOE Oak Ridge Operations Office (ORO) (January 23-27). A final report was issued by DOE/ORO.
- A KDAQ emission inspection (January). This resulted in a Notice of Violation regarding fugitive emissions from the C-726 sandblast facility. The facility was shut down in May 1989 when measures to alleviate the excess emissions were not successful. PGDP plans to install a dust collection filter system to reduce fugitive emissions and to return the facility to compliance.
- A sampling of surface and well water at PGDP by the Kentucky Division of Radiation and Product Safety (June, September, and December). PGDP obtained and analyzed duplicate samples. PGDP and state results available at this time agree well.
- A technical operations evaluation conducted by Martin Marietta Energy Systems, Inc. (July 10-14). A corrective action plan to the findings and observations will be prepared in 1990.
- An annual air emission sources inspection performed by the KDAQ (August 24). A Notice of Violation for constructing and operating two cooling towers without a permit was received on November 13.
- A hazardous waste inspection by the Kentucky Division of Waste Management and EPA

Region IV (August). Several minor deficiencies were corrected.

- A compliance evaluation inspection and sanitary survey conducted by the Kentucky Division of Water Paducah Office (October 26). A satisfactory rating was received.
- A KPDES performance audit inspection by EPA Region IV (November 7-8). PGDP is responding to the minor findings.

Internal audits performed during 1989 included KPDES monitoring, KPDES sample analyses, spill control in the Plant and Personnel Protection Division, and air-permitted facilities. The internal audit program will continue in 1990.

Solid Waste Management

A new landfill cell was placed in operation during October 1989. The cell that had been previously operated was covered awaiting final closure in early 1990 under more favorable weather conditions. In mid-1989, as part of an effort to ensure full compliance with federal and state waste management regulations, PGDP conducted a survey of the entire plant to identify all unused materials and to place them into the waste management system. Over 800 drums were identified, sampled, or characterized with existing data and placed in appropriate storage areas. Also, over 5000 drums of solid PCB waste were placed in storage areas where secondary containment and aisle space meets Toxic Substances Control Act requirements.

PGDP has prepared a program strategy document including projects and budget requirements for waste management activities to ensure regulatory compliance. Projects for waste minimization, together with plans for new treatment, storage, and disposal facilities, are part

of this program. PGDP currently generates, and has generated in the past, several wastes that cannot be treated or disposed of at present. Beginning in 1990 and continuing for the next several years, PGDP will be identifying and evaluating technologies for the treatment and disposal of these wastes.

Remedial Action Program (RAP)

The Remedial Action Program (RAP) at PGDP was established to assess and to remediate environmental contamination resulting from plant operations. Its intent is to define the extent of existing contamination, to identify and to characterize sources of existing contamination, and to select the appropriate corrective measures for contaminated areas and contaminant sources. In addition, the RAP identifies, characterizes, and selects remedial actions for potential release sites.

In 1989 the RAP continued its efforts to protect the public, on-site personnel, and the environment and to meet regulatory requirements. Activities undertaken by the RAP included routine sampling of residential wells near the PGDP; identification of leaking underground storage tanks at the C-750 garage facility and coordination of the response to the leaking tanks; initial characterization of outfalls to identify contaminants of concern; and most importantly, developing, receiving EPA approval of, and implementation of a work plan for investigation of groundwater and surface water contamination.

As part of the routine residential well-sampling activities, an additional well was found to contain TCE. The resident was notified immediately by PGDP and placed on community water at DOE expense. As part of the groundwater investigation, indication of leaks from the underground storage tanks at the PGDP garage facility were found. As required by regulation, arrangements were made to have the tanks leak-tested within 7 days for confirmation. Within 24 h of confirmation of leaks, the tanks were taken out of service. Soil borings were initiated to begin characterizing the extent of contamination within 2 weeks. As a part of a project to upgrade the liquid-effluent-monitoring stations at PGDP, a

characterization of the outfall ditches was performed to identify contaminants of concern in the ditches. The contaminant-of-concern data may be used for waste management and protection of construction workers during installation of the new monitoring equipment.

The major effort of the RAP was devoted to development and implementation of a work plan for the investigation of groundwater contamination at PGDP. Development of the work plan is a requirement of the Administrative Consent Order (ACO) between the EPA and DOE. An environmental consultant was hired to develop the work plan; DOE and PGDP provided input and reviewed the plan before its submission to the EPA and the state of Kentucky for comments. Following incorporation of comments, PGDP resubmitted the work plan to the EPA, at which time it was approved except for two minor issues (these were later addressed by letter). A community relations plan was developed for support of activities under the ACO. (This plan was not required under the ACO.) A newsletter was issued, and a public briefing was held to discuss the work plan activities. As required by the ACO, field activities on implementation of the investigation began in May 1989. Investigation activities included sampling of residential and plant wells for the Target Compound List, sampling of deer from the West Kentucky Wildlife Management Area (WKWMA) in conjunction with the Kentucky Department of Fish and Wildlife, initiation of well installation, geophysical logging of residential wells and monitoring wells, and a United States Geological Survey characterization of the Little and Big Bayou creeks.

Polychlorinated Biphenyl Contamination in Fish

As a result of the Biological Monitoring Program being conducted by the University of Kentucky at PGDP, PCB-contaminated green sunfish were discovered in 1988 at one site on Big Bayou Creek and in outfall 011 that flows into Little Bayou Creek. The FDA limit for PCB in fish is 2 $\mu\text{g/g}$.

During 1989, edible fish tissues were collected for analyses of PCBs from Big and Little Bayou

creeks, the Bayou–Ohio River confluence area, Metropolis Lake, and five ponds on the WKWMA. Results showed that 5% of the fish collected from Big Bayou Creek contained PCB residues above the Food and Drug Administration (FDA) level. Principal contamination in Little Bayou Creek centered on monitoring stations LB2 and LB2A situated just downstream from the 011 outfall. A Fish Consumption Advisory was issued by the Kentucky Department for Environmental Protection in April 1989 for Little Bayou Creek. None of the fish analyzed from the Bayou–Ohio River confluence area, Metropolis Lake, or the five

ponds on the WKWMA contained PCBs above the FDA action level. PCB studies are continuing in 1990 with focus on water and sediment analyses.

Unusual Occurrences

During 1989, 369 spills or releases of various materials occurred. The magnitude of the releases ranged from a few drops (involving PCB gaskets) to 180,000 gal of sanitary water used for fighting fires. Approximately 189 of the incidents involved leaking PCB gaskets. Highlights are given in Subsects. 6.1.1 through 6.1.13.

1989 SUMMARY ASSESSMENT ENVIRONMENTAL COMPLIANCE ACTIVITY U.S. DEPARTMENT OF ENERGY

PADUCAH GASEOUS DIFFUSION PLANT

BACKGROUND AND OVERVIEW

The Paducah Gaseous Diffusion Plant (PGDP) must operate in conformance with environmental (and other) 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 major environmental statutes is summarized below.

Clean Water Act (CWA)

The compliance issues associated with CWA regulations include excursions of regulated effluent parameters mandated by the Kentucky Pollutant Discharge Elimination System (KPDES) permit. One KPDES permit for PGDP, HY0004049, allows the discharge of effluent via 17 outfalls to Little and Big Bayou creeks. Approximately 4753 analyses are performed annually as required by the subject permit. Permit compliance for 1989 was 98.3%. Excursions have occurred mainly for residual chlorine.

Clean Air Act (CAA)

PGDP operates under one Kentucky Division for Air Quality operating permit, which includes 27 discharge points. Major air emission sources at PGDP include three boilers (i.e., two coal-fired and one gas-fired) in the C-600 steam plant, the cascade purge vent stack at C-310, and a vapor degreaser in C-400. Should an incident occur, other air emissions reported include those associated with asbestos removal, boiler startup and shutdown, fire-training exercises, and chemical spills or process leaks. Permit excursions in 1989

have occurred mainly as a result of fluoride and fugitive dust emissions. Some unpermitted sources and procedural violations have been reported. Current efforts are focusing on ensuring that all sources are permitted and are operating in accordance with those permits.

Resource Conservation and Recovery Act (RCRA)

PGDP operates ten interim status RCRA units (i.e., four storage units and six treatment units). Part B permit applications have been submitted for seven of these units, and three units have been designated as permit-by-rule. An RCRA permit application has been submitted for the postclosure of the C-404 low-level radioactive waste burial ground. Approximately 96 solid waste management units have been identified for further study under the RCRA 3004(u) Remedial Action Program.

Toxic Substances Control Act (TSCA)

Polychlorinated biphenyls (PCBs) are used, and PCB waste is generated at PGDP. The storage, control, and disposal of these are regulated by the TSCA. Compliance issues do exist regarding PCB leaks from ventilation system gaskets and the storage of uranium-contaminated PCB wastes beyond the TSCA 1-year limit (see Current Issues below for details).

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

DOE entered into an Administrative Consent Order with the U.S. Environmental Protection Agency (EPA) to investigate off-site groundwater

contamination resulting from past PGDP waste disposal practices.

CURRENT ISSUES

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

KPDES Permit Noncompliances

PGDP effluents do not always meet KPDES limits. An Agreed Order established interim effluent limits and required a biological monitoring program. Engineering projects have been authorized to provide facilities that will ensure compliance with temperature and residual chlorine limits. Temporary sodium thiosulfate feed stations have eliminated total residual chlorine noncompliance at four KPDES outfalls.

PCBs in Big and Little Bayou Creek Fish

PCBs above the Food and Drug Administration limit were found in fish in Big and Little Bayou creeks. Little Bayou Creek has been posted with a fish consumption advisory by the Kentucky Department for Environmental Protection, and both creeks are identified on the CWA 304(1) list as streams impacted by a point source (i.e., PCBs from PGDP). Biological monitoring and remedial action site investigation studies have been initiated to determine the extent and source of PCBs.

KPDES Permit Modification

A modification to the KPDES permit to include outfall 018 (i.e., sanitary landfill surface runoff) has been submitted to the Kentucky Division of Water.

Land Disposal Restriction Wastes

Currently, PGDP is storing liquid, low-level radioactive waste that also contains RCRA hazardous waste. This waste is subject to RCRA land disposal restriction regulations that allow storage only for accumulating sufficient quantities

for treatment and disposal. This waste is being stored because of the lack of treatment or disposal facilities for the materials. DOE and the EPA are continuing to discuss the issue, and the inventory of such materials is reported to the regulators on an annual basis. DOE expects to negotiate with the EPA a Federal Facility Agreement that would detail the steps needed to attain compliance.

Plant Survey of Inadequately Stored Wastes

A plant survey was conducted in July 1989 to locate any unidentified or uncharacterized drums of waste being stored in areas not conforming to RCRA standards. Approximately 800 containers have been identified that require characterization to determine the appropriate packaging, storage, and disposal requirements. These containers are currently being characterized and placed in appropriate storage.

Leaking Underground Storage Tanks at the Vehicle Maintenance Facility

Two underground fuel tanks at the PGDP vehicle maintenance facility were discovered to be leaking. Product removal from both tanks has been completed. A 20-day progress report and an initial site characterization, as required by federal and state regulations, have been completed. The PGDP Engineering Department is currently writing excavation specifications.

Mixed TSCA Waste Storage

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

PCB-Contaminated Ventilation System Gaskets

Oil drips from PCB ventilation gaskets are considered PCB spills. The TSCA requires documentation and immediate cleanup action and verification after discovery. All new drips from ventilation gaskets are cleaned in accordance with the EPA spill cleanup policy. This includes daily

inspections to identify leaks, initiation of cleanup within 24 h, and sampling to verify cleanup results. In addition, immediate installation of drip collection troughs is performed on discovery of drips. Discussions are continuing between DOE and the EPA concerning the use of PCB gaskets and to determine appropriate cleanup procedures.

Inadequately Stored PCB/Uranium Mixed Wastes

Recent site inspections found that mixed (i.e., PCB/uranium) wastes including drummed liquids and solids and bulk liquids were not stored in accordance with the TSCA. Approximately 6000 drums of solids and liquids were triple-stacked without adequate aisle space for inspection. About 5000 drums of solids were stored without secondary containment. About 30,283 L (8000 gal) of liquid (i.e., RCRA/TSCA uranium) were stored in facilities that do not meet TSCA standards. Scrap metal and autoclaves contaminated with PCBs must also be stored in accordance with the TSCA. The creation of new storage facilities to meet TSCA requirements for storage of PCB wastes is complete, and wastes were transferred to these facilities in September 1989.

Dioxins and Furans in Cooling Tower Wood

Scrap wood removed from former PGDP cooling towers has been found to contain dioxins and furans that resulted from treatment by a pentachlorophenol-based fungicide. Sampling was conducted in late 1988 to determine if contaminants had entered the environment. The results of this effort indicated low concentrations of dioxins and furans in the PGDP wastewater lagoon sludges and in Big Bayou Creek sediments. DOE has informed EPA and state of Kentucky environmental officials of this situation. The wood is being stored on-site until a suitable disposal method can be found.

Trichloroethylene (TCE) and Technetium-99 (⁹⁹Tc) Contamination in Off-site Groundwater

In August 1988, ⁹⁹Tc contamination was discovered in an off-site drinking water well north of PGDP. A comprehensive monitoring effort of residential and other off-site wells, as well as on-site wells, was initiated. The results of the effort showed that TCE and ⁹⁹Tc were the primary groundwater contaminants. In November 1988 an Administrative Consent Order (ACO) was made final between DOE and the EPA with the cooperation of the state of Kentucky. This ACO addressed the investigation, monitoring, and remediation of off-site groundwater contamination.

Currently, groundwater monitoring is continuing at selected on-site and off-site wells. A subcontractor is performing a site investigation under a work plan approved by the EPA. Results continue to show elevated concentrations of TCE and ⁹⁹Tc. Residents whose wells are found to be contaminated are provided an alternate water supply at DOE expense.

CERCLA Reporting Requirements

A compliance assessment is needed to determine if continuous releases of hazardous substances reportable under 40 CFR 302.6(a) of CERCLA are occurring.

National Environmental Policy Act (NEPA) Program Deficiencies

Corrective actions for the NEPA Program shortcomings have been implemented as part of a new emphasis by PGDP on NEPA requirements. These actions include development of PGDP-specific NEPA implementation procedures, addition of new NEPA-dedicated personnel, and the revisiting of past NEPA issues to provide needed documentation that had not been provided previously.

CONTENTS

	Page
PART 1. NARRATIVE, SUMMARIES, AND CONCLUSIONS	1
1. INTRODUCTION AND GENERAL INFORMATION	3
1.1 GEOLOGY	3
1.2 SURFACE WATER SYSTEM	5
1.3 GEOHYDROLOGY	5
1.4 REGIONAL DEMOGRAPHY	8
1.5 CLIMATE	9
1.6 APPLICABLE ENVIRONMENTAL REQUIREMENTS	9
2. ENVIRONMENTAL MONITORING AND SAMPLING	
SUMMARY	11
2.1 AIR	11
2.1.1 Airborne Discharges	12
2.1.2 Ambient Air	15
2.1.3 Meteorological Monitoring	16
2.1.4 Conclusions	19
2.2 SURFACE WATER	19
2.2.1 Surface Water Monitoring	21
2.2.2 KPDES Monitoring	22
2.2.3 Biological Monitoring of Effluents and Receiving Waters at PDGP	29
2.2.4 Conclusions	30
2.3 GROUNDWATER	31
2.3.1 Description	31
2.3.2 Site Hydrogeology	33
2.3.3 Groundwater Monitoring	35
2.3.4 Groundwater Project Accomplishments	40
2.3.5 Off-site Groundwater Monitoring	41
2.3.6 Groundwater-Sampling Results	43
2.4 BIOLOGICAL MONITORING	46
2.4.1 Food Crop and Tissue Sampling	46
2.4.2 Vegetation Sampling	46
2.4.3 Polychlorinated Biphenyl Residues in Fish	49
2.5 SOIL AND SEDIMENT MONITORING	49
2.5.1 Soil Sampling	49
2.5.2 Sediment Sampling	52
2.6 EXTERNAL GAMMA RADIATION MONITORING	55
2.6.1 Sampling Program	55
2.6.2 Sample Collection	55
2.6.3 Conclusions	60
3. POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC	67

3.1 RADIATION DOSE	67
3.2 CHEMICAL DOSE	68
3.2.1 Terminology	68
3.2.2 Methods of Evaluation	70
4. REMEDIAL ACTION PROGRAM	73
4.1 INTRODUCTION	73
4.2 REMEDIAL ACTION PROCESS	74
4.3 GROUNDWATER CONTAMINATION	75
4.3.1 Administrative Consent Order	75
4.3.2 Terms of the Administrative Consent Order	75
4.3.3 Compliance with the Administrative Consent Order	76
4.4 REMEDIAL ACTION PROGRAM PLAN	78
4.4.1 Remedial Action Matrix Organization	78
4.4.2 Remedial Action Program Description	80
4.5 CURRENT STATUS AND PLANNING	81
5. SOLID WASTE MANAGEMENT PROGRAM	85
5.1 DESCRIPTION	85
5.1.1 Purpose	85
5.1.2 Regulatory Review	85
5.1.3 Compliance Activities	86
5.1.4 Program Strategy	86
5.2 WASTE GENERATION	87
5.2.1 Types of Waste Generated	87
5.2.2 Waste-Generating Activities	88
5.2.3 Waste Generation Summary	88
5.3 WASTE MANAGEMENT ACTIVITIES	89
5.3.1 Waste Management System	89
5.3.2 Waste Management Facilities	90
5.3.3 Off-site Disposal Activities	91
5.3.4 Waste Placed in Storage	92
5.3.5 Special Activities	92
6. UNUSUAL OCCURRENCES AND SPECIAL STUDIES	95
6.1 UNUSUAL OCCURRENCES	95
6.1.1 Oil Spill: C-355 Process Building	95
6.1.2 Chromated Water Spill: C-635 Pumphouse	96
6.1.3 Chromated Water Spill: C-720 Chilled Waterlines	96
6.1.4 Nitric Acid Leak: C-400	96
6.1.5 Chromated Water Spill: C-331 Seal Exhaust	96
6.1.6 Sulfuric Acid Spill: C-746-R Storage Yard	96
6.1.7 Oil Spill: C-746-R Storage Pad	96
6.1.8 Oil Spill: C-720 Welding Shop	96
6.1.9 Oil Spill: C-537 Switchyard	97
6.1.10 Oil Spill: C-333 Capacitor Bank	97
6.1.11 Chilled Water Spill: C-101 Basement	97
6.1.12 Chromated Water Spill: C-400 Heating System	97

6.1.13 Chromated Water Spill: C-337 RCW Line	97
6.2 SPECIAL STUDIES	97
6.2.1 Concrete Rubble Investigation	97
6.2.2 KPDES Outfall Investigation	98
6.2.3 DOE Headquarters Environmental Survey Data Accuracy Review	98
6.2.4 C-404 Low-Level Radioactive Waste Burial Ground Postclosure Activities	98
6.2.5 Polychlorinated Biphenyl Ventilation Gaskets	98
6.2.6 National Environmental Policy Act	99
6.2.7 Underground Storage Tank Investigation	99
6.2.8 Monthly Environmental Compliance Report	100
6.2.9 PGDP Environmental Advisory Committee	100
6.2.10 Deer Study	101
7. QUALITY ASSURANCE AND GENERAL REVIEWS	103
7.1 SAMPLING QUALITY ASSURANCE	104
7.1.1 Basic Concepts and Practices	104
7.1.2 Air Monitoring	104
7.1.3 Water Monitoring	104
7.1.4 Groundwater Monitoring	104
7.1.5 Biological Monitoring	105
7.1.6 Soil and Sediment	105
7.1.7 External Gamma	105
7.1.8 Solid Waste Monitoring	105
7.2 ANALYTICAL QUALITY ASSURANCE	105
7.2.1 Internal Quality Control	105
7.2.2 External Quality Control	106
7.3 AUDITS AND REVIEWS	107
7.3.1 External Regulatory	107
7.3.2 DOE Audits	108
7.3.3 Internal Audits	108
7.4 QUALITY INCIDENTS	109
7.4.1 Environmental Protection Agency Performance Evaluation Report DMR-QA	109
7.4.2 Proficiency Environmental Testing Program	109
7.4.3 Proficiency Analytical Testing Program	110
7.4.4 DOE Environmental Measurements Laboratory Quality Assessment Program	110
7.4.5 Internal Quality Incidents	110
PART 2. DATA PRESENTATION	111
REFERENCES	199
APPENDIX	201

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

ACO	Administrative Consent Order
ADI	acceptable daily intake
ADS	activity data sheet
ALARA	as low as reasonably achievable
APG	Analytical Products Group, Inc.
BMP	Biological Monitoring Program
BOD	biochemical oxygen demand
BRC	Below Regulatory Concern
BTEX	benzene, toluene, ethylbenzene, xylene
BWMA	Ballard Wildlife Management Area
°C	degrees Celsius
CAA	Clean Air Act
CDI	calculated daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curies
cm	centimeter
cm ²	square centimeter
COD	chemical oxygen demand
CPF	carcinogen potency factor
Cr ⁶⁺	hexavalent chromium
¹³⁷ Cs	cesium-137
CWA	Clean Water Act
d	day
DCG	derived concentration guide
DMR-QA	Discharge Monitoring Report–Quality Assurance
DOE	U.S. Department of Energy
EEI	Electric Energy Incorporated
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ESP	electrostatic precipitator
°F	degrees Fahrenheit
FDA	Food and Drug Administration
FFA	Federal Facility Agreement
ft	foot
FYP	Environmental Restoration and Waste Management Five-Year Plan
g	gram
gal	gallon
h	hour
ha	hectare
HAZWRAP	Hazardous Waste Remedial Action Program
HF	hydrofluoric acid

HSWA	Hazardous and Solid Waste Amendments
HQ	Headquarters
¹³¹ I	iodine-131
ICRP	International Commission on Radiological Protection
in.	inch
IRIS	Integrated Risk Information System
⁴⁰ K	potassium-40
KAR	Kentucky Administrative Regulations
KDAQ	Kentucky Division for Air Quality
KDOW	Kentucky Division of Water
kg	kilogram
km	kilometer
KPDES	Kentucky Pollutant Discharge Elimination System
L	liter
lb	pound
LCR	lowest concentration reported
m	meter
m ²	square meter
m ³	cubic meter
μCi	microcurie
μg	microgram
mCi	millicurie
mg	milligram
Mgd	million gallons per day
min	minute
mL	milliliter
mm	millimeter
mrem	millirem
NA	not applicable
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute for Standards and Testing
NO ₃ -N	nitrate as nitrogen
NO _x	nitrogen oxide
²³⁷ Np	neptunium-237
NPDES	National Pollutant Discharge Elimination System
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
P&PP	Plant and Personnel Protection
PAT	Proficiency Analytical Testing
PCB	polychlorinated biphenyl
PET	Proficiency Environmental Testing Program
PGDP	Paducah Gaseous Diffusion Plant
pCi	picocurie
pH	hydrogen ion concentration
PO ₄	phosphate
ppb	parts per billion

²³⁹ Pu	plutonium-239
PVC	polyvinylchloride
QA	quality assurance
QC	quality control
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SCS	Spill Containment System
SDWA	Safe Drinking Water Act
SO ₂	sulfur dioxide
SO ₄	sulfate
SPP	Environmental Restoration and Waste Management Site Specific Plan for ORR PGDP
⁹⁰ Sr	strontium-90
SWMU	solid waste management unit
⁹⁹ Tc	technetium-99
TCE	trichloroethylene
TCL	Target Compound List
TDS	total dissolved solids
²³⁰ Th	thorium-230
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRC	total residual chlorine
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
TSS	total suspended solids
TVA	Tennessee Valley Authority
UK	University of Kentucky
USGS	United States Geological Survey
UST	underground storage tank
WKWMA	West Kentucky Wildlife Management Area
yd	yard
²³⁵ U	uranium-235
VOC	volatile organic compound

PART 1

Narrative, Summaries, and Conclusions

1. INTRODUCTION AND GENERAL INFORMATION

This report presents environmental data and supporting narratives for the U.S. Department of Energy's (DOE's) Paducah Reservation Environmental Monitoring Program during 1989. Part 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 1989 data. Part 2 includes the detailed data summarized in a format designed to ensure that all environmental data are represented in the tables. Narratives are generally not included in Part 2.

The DOE Paducah Gaseous Diffusion Plant (PGDP) is a uranium enrichment facility consisting of a diffusion cascade and extensive support facilities. The cascade is housed in five buildings covering a total of about 30 ha (75 acres). The plant is located on a reservation consisting of about 545 ha (1350 acres) in western McCracken County about 16 km (10 miles) west of Paducah, Kentucky, and about 5 km (3 miles) south of the Ohio River. About 300 ha (740 acres) of the reservation is enclosed within a fenced security area. The raw water treatment plant, residential landfill, and inert landfill are the only operating areas outside of the security area. An uninhabited buffer zone of at least 365 m (400 yd) surrounds the entire fenced area. Beyond the DOE-owned buffer zone is an extensive wildlife management area consisting of 840 ha (2100 acres) either deeded or leased to the state of Kentucky. During World War II the Kentucky Ordnance Works, a trinitrotoluene (TNT) production facility, was operated in an area southwest of the plant on what is now the wildlife management area. The water treatment plant used by the plant was originally a Kentucky Ordnance Works facility. Figures 1.1 and 1.2 depict the PGDP vicinity.

Construction at the plant began in 1951; by 1952 operations were under way. The Paducah plant serves as a first step in the uranium enrichment process. Product from PGDP must be further enriched prior to its use as a nuclear fuel; thus the plant provides an enriched feed stream to the Portsmouth, Ohio, Gaseous Diffusion Plant and provided a similar feed stream to the Oak Ridge Gaseous Diffusion Plant in Oak Ridge, Tennessee, prior to its shutdown. Hazardous, nonhazardous, and radioactive wastes have been generated and disposed of as a result of plant operations.

PGDP enriches the ^{235}U isotope via a physical separation process. The separation is based on the faster rate at which ^{235}U diffuses through a barrier compared with the heavier ^{238}U isotope. Extensive support facilities are required to maintain the diffusion process. Some of the major support facilities include a steam plant, four major electrical switchyards, four sets of cooling towers, a chemical cleaning and decontamination building, a water treatment plant, a cooling water blowdown treatment facility, maintenance facilities, laboratory facilities, and two active landfills. Several inactive facilities are also located on the plant site.

1.1 GEOLOGY

PGDP is located in the Jackson Purchase region of western Kentucky and lies near the northern margin of the Mississippi Embayment. The Mississippi Embayment was a large sedimentary trough oriented nearly north-south that existed during Cretaceous and Tertiary time and received sediments shed off the central part of the North American continent. The sedimentary sequence found in the vicinity of PGDP consists mainly of fine- to medium-grained clastic materials

Fig. 1.1. Map showing the location of the Department of Energy's Paducah Reservation in the state of Kentucky.

Fig. 1.2. Map showing location of Paducah Gaseous Diffusion Plant in relationship to geographic region.

including (from oldest to youngest) a basal gravel (i.e., Tuscaloosa Formation), the McNairy Formation, the Porters Creek Clay, and undifferentiated, discontinuous Eocene sands. These strata dip gently to the southwest toward the axis of the embayment.

Following deposition, the embayment sediments were either uplifted and/or sea level was lowered resulting in the development of an erosional surface that truncated the sediments. Subsequently, during the late Tertiary and Quaternary time a formational unit designated as the Continental Deposits was laid down in the region creating an angular unconformity with the underlying sediments. Immediately overlying the Continental Deposits, Pleistocene loess (originating as wind-blown material generated by glacial activity to the north) was deposited in a layer of variable thickness.

The Continental Deposits can be subdivided into two components: a lower gravel or sandy gravel unit (i.e., gravel facies) that is reported to vary in thickness from 0 to 32 m (105 ft) and an upper clay-sand unit (i.e., clay facies) with a comparable range in thickness. The top of the gravel facies unit occurs at a depth of approximately 13 to 20 m (43 to 66 ft) in the vicinity of PGDP. Based on data from numerous auger holes drilled by the U.S. Geological Survey (USGS) throughout the region and by DOE at PGDP, the gravel appears to be continuous within the vicinity of the plant and extends northward to the Ohio River. South of PGDP it exists as a thin [<3 -m (10-ft)] veneer that thickens rapidly to the north where it is draped over an escarpment (near the southern boundary of PGDP) that was carved in the underlying sediments by an ancient river. North of the plant (near the Ohio River) the gravel thins once again. The clay facies of the Continental Deposits is believed to consist of discontinuous, fine, sand lenses enclosed by the dominant clay. This interpretation is based on limited data, and the lack of continuity of the interbedded sands cannot be definitively verified at present. Figure 1.1.1 is a geologic map of the PGDP site.

1.2 SURFACE WATER SYSTEM

Surface water from PGDP drains to tributaries of the Ohio River. Big Bayou Creek is located on the west side of the plant; Little Bayou Creek is located on the east side. These streams join north of the plant site and discharge into the Ohio River. The flow in the streams fluctuates greatly as a result of local precipitation. However, during most of the year the majority of the flow in both streams is the result of plant effluents. With the exception of the Paducah plant area, the drainage basin from both creeks is mostly woodland and farmland. Figures 1.2.1 and 1.2.2 show regional and local surface hydrology systems respectively.

1.3 GEOHYDROLOGY

Current understanding of shallow groundwater hydrology in the vicinity of PGDP is dominated by the recognized importance of the gravel facies of the Continental Deposits. This unit is termed the regional gravel aquifer. The hydrology of this aquifer was first investigated by the USGS in the mid-1960s. Results of these studies indicate that the gravel is saturated over most of its areal extent in the region of the plant, and wells completed within it are reported to be capable of producing yields of up to 3790 L/min (985 gal/min). Yields of between 189.5 and 1516 L/min (50 and 395 gal/min) have been observed.

In general, the potentiometric surface for the gravel aquifer slopes toward the Ohio River suggesting that groundwater flow within the aquifer trends northward toward the Ohio River. Groundwater-monitoring programs have been initiated at several waste management facilities within the plant; similar monitoring efforts have been made at the Tennessee Valley Authority (TVA) Shawnee Steam Plant approximately 5 km (3 miles) to the north. However, until recently (ERC 1989) no attempts had been made to reevaluate the potentiometric conditions in the regional gravel aquifer systematically since the studies by the USGS over two decades ago. Hydraulic head data gathered by the ERC on

Fig. 1.1.1. Geologic map of the PGDP site.

ORNL-DWG 87-8431

Fig. 1.2.1. The regional area primary surface hydrology systems.

January 11 and 12, 1989, from a series of PGDP and private wells yielded a more defined but less areal extensive picture of the potentiometric surface of the regional gravel aquifer. Data from current investigations are expected to lead to a more refined model of the groundwater flow in the vicinity of PGDP. Hydraulic conductivity values are discussed in Subsect. 2.3.2.

In contrast to the large production capability of the gravel aquifer, the sand lenses interbedded in the clay facies of the Continental Deposits are observed to have extremely low yields. Furthermore, the reported discontinuous nature of

these sands and ambiguities with respect to observed hydraulic heads supports the interpretation that they may not constitute a continuous aquifer.

Groundwater is used for drinking water and other domestic uses, irrigation of gardens, and watering livestock. No industrial users exist north of PGDP; however, a small pilot plant at the TVA Shawnee Steam Plant uses groundwater as a drinking water source for a few employees. Approximately 15 private residences north of the plant use groundwater.

Fig. 1.2.2. Local PGDP surface hydrology systems.

1.4 REGIONAL DEMOGRAPHY

The West Kentucky Wildlife Management Area (WKWMA) and lightly populated farmland are in the immediate environs of PGDP. The population within the 80-km (50-mile) radius (see Fig. 1.4.1) is about 535,000 persons. Of these, about 36,500 live within 16.1 km (10 miles) of the plant; about 104,000, within 32.2 km (20 miles). The unincorporated communities of Grahamville

and Heath are 2 to 3 km (1.24 to 1.86 miles) east of the plant. Portions of 28 counties, 11 of which are in Kentucky, 4 in Missouri, 10 in Illinois, and 3 in Tennessee, are included within an 80-km (50-mile) radius of the plant. The largest cities in the region are Paducah, Kentucky, located approximately 16 air km (10 miles) east of the plant, and Cape Girardeau, Missouri, located approximately 64 air km (40 miles) to the west.

ORNL-DWG 90-8768

Fig. 1.4.1. Population count by sectors and annuli within 80 km (50 miles) of PGDP (projected 1989 population from 1980 census).

1.5 CLIMATE

Paducah is located in the humid continental zone. Summers are generally dry; precipitation occurs mainly in the spring and fall. Winters are characterized by moderately cold days; the average temperature during the coldest month, January, averages about 1.7°C (35°F). Summers are warm and humid; the average temperature in July is

about 26°C (79°F). Yearly precipitation averages about 112 cm (44 in.). The prevailing wind direction is south to southwest.

1.6 APPLICABLE ENVIRONMENTAL REQUIREMENTS

It is PGDP policy to minimize the generation of waste and to protect people and the

environment. Internal procedures have been promulgated and implemented to accomplish these tasks. Under the authority of the Atomic Energy Act, DOE has issued orders covering waste minimization, pollution control, effluent and environmental monitoring, and periodic reporting. Federal Environmental Protection Agency (EPA) regulations that are designed to implement various federal laws and that apply to PGDP include the Clean Air Act (CAA), the Clean Water Act (CWA), the Toxic Substances Control Act (TSCA), the National Emissions Standards for Hazardous Air Pollutants, the Resource Conservation and Recovery Act (RCRA), the Safe

Drinking Water Act (SDWA), the Superfund Amendments and Reauthorization Act (SARA), the National Environmental Policy Act (NEPA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Kentucky environmental laws are implemented by regulations of the Cabinet for Natural Resources and Environmental Protection. PGDP air pollution sources, wastewater discharge, hazardous waste treatment, storage, and disposal, and waste management facilities are all permitted by the Kentucky Cabinet for Natural Resources and Environmental Protection.

2. ENVIRONMENTAL MONITORING AND SAMPLING SUMMARY

Routine monitoring and sampling for radiation, radioactive materials, and chemical substances on and off the DOE Reservation and PGDP are used to document compliance with appropriate standards, laws, and regulations; to identify trends; to provide information for the public; and to contribute to general environmental knowledge. The surveillance program assists in fulfilling the DOE policy (DOE Order 5400.1) of protecting the public, employees, and the environment from harm that could be caused by its activities and in reducing environmental impacts to the greatest degree practicable. Environmental-monitoring information complements data on specific releases, trends, and summaries.

PGDP established an Environmental Monitoring Program several years before such monitoring became required to meet environmental protection regulations. Published monitoring summary reports have been issued for each year since the late 1950s. The current monitoring program is designed primarily to meet regulatory requirements and DOE directives, but some sampling is done to provide a continuity of data on environmental media at unregulated locations.

The environmental monitoring includes source monitoring for airborne pollutants; ambient air sampling on-site and off-site for radioactive particulates and gaseous fluorides; surface water sampling at treatment plant effluents, plant ditches, and in receiving waters; groundwater sampling around various waste disposal areas and the plant perimeter; and food crop, fish, wildlife, vegetation, soil, and sediment sampling to help characterize the condition of the PGDP environs. Also, gamma-monitoring results are compared with background radiation levels. 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 up to 20 different parameters.

The need for meteorological monitoring has been recognized, and a system was installed in 1987. Data generated by the PGDP system were utilized to calculate doses to individuals. The radiation dose from plant operations received by people living near PGDP cannot be measured directly because it is so small compared with naturally existing background radiation; however, doses are estimated by calculations using emission measurements and meteorological data (see Sect. 3).

While quantities of nonradiological chemical emissions are not included in this report, a summary of the SARA Title III report is given in the appendix. The SARA report, required by the Superfund Amendments and Reauthorization Act of 1986, provides the community with the opportunity to learn about estimated quantities of certain toxic chemicals used at a facility that are routinely or potentially could be accidentally released into the environment. Chemical emissions also involve some additional "large-quantity" chemicals used or stored at the facilities that are not required to be reported by SARA Title III but are known to be emitted from the facilities. Emissions information on the major chemical emissions to the air, water, or land from processes at the facilities is also given. Steam plant emissions are also listed in the appendix.

2.1 AIR

Environmental monitoring is an integral part of the PGDP air pollution control program. The federal CAA, Kentucky Division for Air Quality (KDAQ) regulations, and DOE orders require the identification of potential and actual sources of air pollution, controls to abate pollution to within specified limits, and monitoring to demonstrate the results. The identification, controls, limits, and evidence of compliance are included in the

regulatory agency's permit. PGDP has 27 permitted sources; however, not all sources were operated in 1989. Table 2.1.1 in Part 2 lists the permitted sources and the types of control equipment used for pollution prevention.

PGDP has submitted applications to the KDAQ for the addition of eight sources to the permit and has submitted a plantwide Air Toxics Review to ensure compliance with KDAQ's Air Toxics Regulations. Upon completion of the review of the Air Toxics Review, KDAQ will issue a new plant-wide operating permit that will include air toxics emissions. Applications have been submitted to KDAQ for construction activities on five facilities. At present, these applications are being reviewed by the KDAQ Permit Review Branch. Table 2.1.1 lists the permit status of the sources.

The release of contamination into the atmosphere is minimized by avoiding any unnecessary generation of waste and by applying effective control technology to meet (1) all permit conditions and (2) the DOE requirement to maintain radionuclide emissions as low as reasonably achievable (ALARA). This control program to reduce emissions is continually evaluated. The primary basis for evaluation of the control achieved is emissions monitoring and ambient air monitoring. Performance of control devices may also be checked by state or federal inspections. The data generated by stack emissions monitoring were used to calculate radiation doses to the nearest neighbors and the surrounding population (see Sect. 3).

2.1.1 Airborne Discharges

The Clean Air Act of 1977 requires the EPA to administer, through the states, a program that requires air contaminant sources to obtain permits to operate. Subsequent to receiving and reviewing an application for a plant-wide operating permit, the KDAQ issued permit No. 0-85-110 to PGDP on Sept. 30, 1985, granting operation of an air contaminate source. The permit lists 27 emission points and has no expiration date. Not all of the emission points were active in 1989; the major sources in operation (see Fig. 2.1.1) were:

- two coal- and oil-fired boilers and one gas- and oil-fired boiler in the C-600 steam plant,
- the cascade purge vent stack at C-310, and
- two vapor degreasers in C-400.

Other air emissions reported should an incident occur are those resulting from asbestos removal, boiler startup and shutdown, fire-training exercises, chemical spills, process leaks, or emissions above normal levels.

The pollution parameters that must be quantified to demonstrate compliance with permits or the DOE ALARA policy are sulfur dioxide, volatile organic compounds, radionuclides, and fluorides. The 1989 cumulative radiological emissions and steam plant emissions are tabulated by source in Table 2.1.2. The C-600 steam plant emissions routinely reported are sulfur dioxide (SO_2) and nitrogen oxides (NO_x). The SO_2 is continuously monitored in the stack as pounds of SO_2 per million Btu input to the boiler. Data from the continuous monitor and fuel usage data are combined to arrive at monthly and annual emissions. The NO_x emissions are calculated from fuel usage using handbook values (U.S. EPA 1986) of the quantity of NO_x produced per pound of fuel for each type of fuel burned in this typical boiler. The excess combustion air averages about 20% and is minimized to control NO_x in the flue gases and to optimize boiler efficiency. Total suspended particulates are not normally monitored. The KDAQ permit limit of 20% opacity is achieved by use of electrostatic precipitators (ESPs) operating at 99% efficiency for particulate removal. Tests have shown emission levels of less than 0.1 lb of total suspended particulates (TSPs) per million Btu boiler input.

The ESPs provide clear stack emissions while the boilers are operating, but visible emissions occur during startup, shutdown, and some maintenance activities. These periods are brief and infrequent and are reported to the KDAQ prior to the activities if possible. Table 2.1.2 shows the total steam plant emissions. Tables 2.1.2 and 2.1.3 of Part 2 present monthly emission and historical data.

Table 2.1.1. Status of construction and operating permit applications

Source	Date submitted
<i>Operating</i>	
C-400 nickel stripper stack	April 1987
C-724 carpenter shop cyclone	April 1987
C-726 sandblast facility	April 1987
C-600 fuel storage tanks for No. 2 fuel	April 1987
Portable gray mills degreaser tanks	April 1987
<i>Construction</i>	
C-633-2A cooling towers	September 1989
C-635-2 cooling towers	September 1989
C-726 sandblast facility	November 1989
C-633-2B cooling tower	November 1989
C-637-2B cooling tower	January 1990
C-600 flyash-handling system	October 1989
C-400 and C-720 vac-u-blast cabinets	December 1989
C-724 paint bake oven	December 1989
<i>Plant-wide operation</i>	
Plantwide air toxics review	May 1988

The C-310 stack is used as the vent for the cascade system. Low-molecular-weight gases travel up the cascade to be released via the C-310 stack. Gaseous fluorides and traces of uranium and technetium are released in small quantities. High-speed centrifugal separation and chemical traps are used to control stack emissions. The stack gases

are continuously sampled with daily analyses of the samples. Table 2.1.2 of Part 2 lists monthly and annual emission rates.

Another source of emissions (when used) is the C-400 UF₄ pulverizer. This facility's exhaust system is filtered, and the stack is continuously sampled for particulates. The sampling device is

Fig. 2.1.1. Location of major air emissions sources at PGDP.

frequently checked for evidence of filter leakage and is routinely analyzed for uranium. When in use, total uranium emissions from this source are reported monthly and annually (this facility was not used in 1989).

PGDP operates two vapor degreasers in the C-400 cleaning building. One of these is large enough [i.e., $1.5 \times 6.9 \times 5.4$ m ($5 \times 23 \times 18$

ft)] to accommodate the largest components of gaseous diffusion process equipment. This degreaser uses trichloroethylene (TCE) as a cleansing agent. The TCE is contained in troughs at the north and south ends of the degreaser. The troughs also contain steam coils that vaporize the TCE. The TCE vapor then migrates to the center of the degreaser (between the troughs) where the

Table 2.1.2. 1989 PGDP stack emissions summary

Stack ^a	Control equipment	Emission		
		Effluent	kg/year	Curies
C-310 cascade vent	Chemical traps	²³⁴ U	3.4×10^{-5}	2.12×10^{-4}
		²³⁵ U	3.7×10^{-3}	8.0×10^{-6}
		²³⁸ U	2.0×10^{-1}	6.7×10^{-5}
		⁹⁹ Tc	2.1×10^{-4}	3.6×10^{-3}
C-400 UF ₄ pulverizer ^b	High-efficiency cartridge filter	²³⁴ U	0	0
		²³⁵ U	0	0
		²³⁸ U	0	0
C-600 steam plant	Use of low-sulfur coal control of excess air	SO ₂	292,309	
		NO _x	282,380	
		Particu- lates	11,272	
		CO	8,179	

^aSee Fig. 2.1.1.^bDid not operate in 1989.

equipment to be cleaned is situated. Condensing coils are located near the top of the degreaser to condense and to recycle the vaporized TCE after it has been used to degrease the equipment.

The smaller degreaser [i.e., $1.5 \times 1.8 \times 1.5$ m ($5 \times 6 \times 5$ ft)] uses 1,1,1-trichloroethane as the degreasing agent. Steam coils that vaporize the 1,1,1-trichloroethane are located in the bottom of the degreaser. Condensing coils are used to condense and to recycle the vaporized 1,1,1-trichloroethane after use.

Both degreasers have movable covers that minimize the degreasing agent losses except during equipment insertion or removal. However, losses of the degreasing agents are inevitable because of the large area exposed and the high volatility of the agents. These losses are calculated and reported as a major plant emission. The Air Toxics Operating Application (submitted to the KDAQ in 1988) assumed that 90% of the agents are lost to the atmosphere. A project is under way to find a less volatile alternative for TCE and 1,1,1-trichloroethane. A less volatile aqueous degreaser is being tested at various locations in the plant as an alternative.

In November 1986 the KDAQ promulgated two Air Toxics Regulations. These regulations set emission limits for specific substances considered

toxic. The first regulation applies to facilities constructed prior to November 11, 1986, and lists 92 regulated substances. The second regulation applies to facilities constructed after November 11, 1986, and lists more than 730 regulated substances. In conjunction with an environmental subcontractor, PGDP submitted an Operating Permit Application with Air Toxics Review to KDAQ on April 27, 1988. This application contained calculations stating that PGDP's toxic emissions are either (1) below the Significant Emission Level and thus exempt from the regulations or (2) below the Threshold Ambient Limit as shown by computer modeling and in compliance with the regulations. The KDAQ Permit Review Branch has this application for review; however, they are far behind in reviewing operating permit applications because of a backlog. PGDP plans to develop a formal tracking system to ensure compliance with the Air Toxics regulations.

2.1.2 Ambient Air

PGDP maintains and operates an ambient air system, the purpose of which is to assess the impact on the ambient air of various air contaminants emitted by PGDP. The results of the

data generated by the ambient air system are also used to demonstrate compliance with the ambient air quality standards for gaseous fluorides established by the KDAQ.

Ambient air is sampled continuously for gaseous fluorides and radioactive particulates at the following locations:

1. Plant North (PN), Plant South (PS), Plant East (PE), and Plant West (PW) within the plant fence;
2. Boundary North (BN) and Boundary East (BE) at the plant boundary;
3. One North (1N), One South (1S), One West (1W), One East (1E), and One Southeast (1SE) at 1 mile from the fence; and
4. Grahamville (GR), the nearest community.

Figure 2.1.2 shows these locations. The sample collectors (consisting of filters treated with sodium carbonate for ambient collection of fluorides) are exchanged and analyzed each week for alpha and beta activity and fluoride concentrations. To ensure data accuracy, samples are discarded without analysis if final sample flow decreases more than 40% from the initial flow rate, if the sampler is found not to be running, or if, upon opening the filter holder, the analyst finds the filter cracked (Coker, C. B. March 9, 1988).

After the sample filters have been collected from the ambient-air-monitoring stations, they are stored at least 168 h to permit decay of the short-lived daughters of naturally occurring radon. They are then analyzed for alpha and beta activity by an automatic low-background alpha/beta proportional counter (PGDP May 1990). After the radioactivity measurements have been made, the filters are leached with water, and fluoride content is measured by specific ion electrode analysis (PGDP Nov. 26, 1979). The results of the analyses are logged onto a computer data base and used to demonstrate compliance with KDAQ gaseous fluoride ambient air quality standards. In response to the Ambient Environmental Monitoring Assessment performed by CH2M Hill in 1988, PGDP has proposed some improvements in the ambient-air-monitoring program. A five-plant team

has been formed to implement the improvements in the system. Tables 2.1.3 and 2.1.4 provide a summary of 1989 ambient air measurements.

2.1.3 Meteorological Monitoring

Representative meteorological data are required at DOE facilities by DOE 5400.1 to support environmental-monitoring activities. This information is essential to characterize atmospheric transport and diffusion conditions in the vicinity of PGDP and to represent other meteorological conditions (e.g., precipitation, temperature, and atmospheric moisture) that are important to environmental surveillance activities such as air quality and radiation monitoring.

At PGDP on-site meteorological data are used in calculating radiation doses to the public (see Sect. 3). In addition, on-site meteorological data are utilized by various groups within the plant such as Remedial Action for correlation of precipitation with groundwater flow and by Power Operations in investigation of electrical equipment failures. On-site meteorological data were also requested in 1989 in conjunction with studies on siting of the Atomic Vapor Laser Isotope Separation plant.

A 60-m tower located south of the Administration Building (C-100) contains instrumentation at 10- and 60-m (32.8- and 196.9-ft) heights. Appropriate meteorological parameters such as wind speed and direction, temperature, barometric pressure, relative humidity, rainfall, etc., are monitored to provide valuable data on atmospheric stability and other data essential to reliable atmospheric dispersion modeling.

Computer-aided atmospheric dispersion modeling is a valuable tool that utilizes emission and meteorological data. Modeling is used to determine the effect of operations with regard to the transport of air contaminants and in predicting air quality impacts from a source due to abnormal airborne emissions. In addition, PGDP can anticipate a multitude of emergency scenarios and estimate effects of unplanned releases on employees and population centers downwind of the source. PGDP utilizes the Hazardous Atmospheric Release Model Meteorological Computer Program.

Fig. 2.1.2. Location of air-sampling and meteorological monitoring stations at PGDP.

Table 2.1.3. 1989 PGDP environmental air sampling for fluorides

Point ^a	No. of samples	Concentration (ppb HF)			Percent of 1-week average
		Min	Max	Av ^b	
1 (PN) ^c	51	0.07	0.615	0.206	c
2 (PE) ^c	49	0.056	0.184	0.118	c
3 (PS) ^c	50	0.058	0.207	0.105	c
4 (PW) ^c	51	0.078	0.215	0.123	c
5 (BN)	51	0.068	0.312	0.138	7
6 (BE)	52	0.061	0.126	0.089	4
7 (IN)	49	0.061	0.147	0.093	5
8 (IE)	46	0.049	0.125	0.081	4
9 (ISE)	48	0.049	0.137	0.077	4
10 (IS)	49	0.053	0.188	0.081	4
11 (IW)	50	0.054	0.124	0.077	4
12 (GR)	47	0.026	0.149	0.083	4

^aSee Fig. 2.1.2.^bKentucky Secondary Ambient Air Quality Standards (401 KAR 53:010); maximum 24-h average is 3.5 ppb as HF; maximum 1-week average is 2.0 ppb as HF; monthly average is 1.0 ppb as HF.^cSampling locations are on government property inside the plant perimeter fence. For comparison, the 40-h occupational threshold limit value (TLV) for HF is 3000 ppb.

Table 2.1.4. 1989 PGDP environmental air sampling for radioactivity

Point ^a	Gross alpha ($\mu\text{Ci/mL} \times 10^{-14}$)			Gross beta ($\mu\text{Ci/mL} \times 10^{-13}$)			No. of samples
	Min	Max	Av	Min	Max	Av	
1 (PN)	-0.32 ^b	5.12	0.36	0.00	1.18	0.36	51
2 (PE)	-0.26	1.00	0.24	0.00	1.00	0.31	49
3 (PS)	-0.24	0.72	0.25	0.00	0.78	0.32	50
4 (PW)	-0.26	1.36	0.29	0.00	1.36	0.35	51
5 (BN)	-0.14	4.82	0.29	0.09	1.11	0.34	51
6 (BE)	-0.23	1.18	0.27	0.00	2.29	0.34	52
7 (IN)	-0.25	1.48	0.22	0.10	0.62	0.32	49
8 (IE)	-0.20	5.07	0.33	0.00	0.86	0.30	46
9 (ISE)	-0.34	0.79	0.21	0.08	0.60	0.31	48
10 (IS)	-0.11	4.77	0.32	0.00	0.78	0.32	49
11 (IW)	-0.20	0.72	0.24	0.06	0.91	0.31	50
12 (GR)	-0.41	5.40	0.33	0.00	0.66	0.31	47

^aSee Fig. 2.1.2.^bBecause of fluctuation in the instrument used to analyze for radioactivity, the background count is higher than that for the sample; this accounts for the negative count.

This is an atmospheric dispersion model that utilizes emission and meteorological data to simulate unplanned releases or events causing environmental concern.

2.1.4 Conclusions

During 1989, 0.29 mCi (205 g) of uranium was released to the atmosphere from PGDP. This number is up from 0.06 mCi of uranium emitted in 1988. The increase is a result of an upset in the cylinder-burping station in October in which the uranium effluent detector (i.e., space recorder) failed to detect an increase in uranium effluent concentrations from the chemical traps. The "burping" station is a facility that eliminates light-molecular-weight gases by venting them to the C-310 purge vent stack. (This upset accounted for 88.8% of the uranium emitted from the C-310 stack in 1989.) The failure to detect the increase in uranium was due to insufficient flow to the space recorder (i.e., an ion chamber monitor used to detect uranium). The space recorder data was the trigger for switching the chemical traps that control the uranium effluent concentrations. As a result of this incident, a number of corrective actions have been implemented. These corrective actions involve switching the chemical traps for regeneration on a tightly scheduled basis. The traps are also switched based on a maximum of 20 cylinders burped, a maximum uranium emission rate of 1 g/d, and when a total of 540 kg (1200 lb) have been burped to the traps on line. Instrumentation has been installed on the space recorder sample line for an indication of sample flow. These corrective actions are designed to lessen the possibility of uranium effluent increases above normal levels and to provide a quick indication of any upset that may occur.

Also during 1989, 3.6 mCi (211 mg) of technetium were released. This number is down from 3.7 mCi released in 1988. There has been no new introduction of ^{99}Tc into the cascade and no increase of ^{99}Tc in product withdrawal.

The stack-monitoring data, their characteristics, and the joint frequency distribution of wind speed are needed to calculate the amount of exposure of the surrounding population to plant

emissions. The wind roses shown in Figs. 2.1.3 and 2.1.4 summarize the wind speed frequency distribution data for the 1989 dose model estimates (see Sect. 3).

Tables 2.1.3 and 2.1.4 give ambient-air-monitoring data. The average concentration of fluoride is between 4 and 7% of the maximum weekly average of 2 ppb. Therefore, compliance with Kentucky Secondary Ambient Air Quality Standards (401 KAR 53:010) is continuously achieved.

2.2 SURFACE WATER

PGDP is located in the western part of the Ohio River basin. Surface drainage from the site is to two small tributaries of the Ohio River: Big Bayou Creek on the west and Little Bayou Creek on the east (Fig. 2.2.1). These two streams join north of the site and discharge to the Ohio River at about river kilometer 1524 (river mile 945), which is about 55 km (34 miles) upstream from the confluence of the Ohio and Mississippi rivers.

These creeks exhibit widely fluctuating discharge characteristics that are closely tied to local precipitation. Natural runoff makes up a small portion of the flow in Big Bayou and Little Bayou creeks during the dry periods. The PGDP site is not in the Ohio River 100-year floodplain [elevation 101.6 m (333.3 ft)], nor would it be affected by the historical high-water elevation of 104.2 m (341.8 ft). Figures 2.2.1 and 2.2.2 show the local PGDP surface hydrology systems and the regional area primary surface hydrology.

The vast majority of liquid effluents at PGDP consist of once-through cooling water, although a variety of liquid wastes (uranium-contaminated as well as noncontaminated) result from activities associated with uranium recovery and facility-cleaning operations. Conventional liquid waste discharges such as domestic sewage, steam plant wastewaters, and coal-pile runoff also exist. Routine monitoring provides data to calculate total discharges to surface water. Table 2.2.1 summarizes these discharges and also presents data from previous years to indicate trends. Table 2.2.1, Part 2, shows monthly data for 1989.

Fig. 2.1.3. Wind rose (10-m level) showing the wind speed frequency distribution data used for the 1989 estimates.

Fig. 2.1.4. Wind rose (60-m level) showing the wind speed frequency distribution data used for the 1989 estimates.

ORNL - DWG 87-8429

Fig. 2.2.1. PGDP site surface hydrology systems.

2.2.1 Surface Water Monitoring

SW13 (see Fig. 2.2.3), the north-south diversion ditch, is monitored on a weekly basis. This ditch receives coal-pile runoff, the C-400 decontamination solution filtrate, spent cylinder wash solution, and hydrostatic test water. A continuous leak sampler is used for the 7-day composite. The 7-day composite sample and a grab sample are analyzed for weekly parameters listed

in Table 2.2.2. Each week a 100-mL sample is poured into a yearly composite container. At the end of each year, the composite sample is analyzed for annual parameters listed in Table 2.2.2. Monthly sampling is conducted at Big Bayou Creek upstream (SW1), Ohio River upstream (SW29), and Ohio River downstream (SW30). Figure 2.2.3 shows the surface-water-monitoring locations at PGDP. Tables 2.2.17 through 2.2.20 of Part 2 provide surface-water-monitoring data.

ORNL-DWG 87-8431

Fig. 2.2.2. Regional area primary surface hydrology.

The surface runoff from the C-746-S residential landfill and the C-746-T inert landfill is monitored quarterly. The sampling is performed to comply with Kentucky Administrative Regulations (KAR). Background water quality is sampled on Big Bayou Creek at location 1 (SW1). Runoff from the existing C-746-S residential landfill cell is monitored at location 2. This cell is no longer in use but is awaiting final closure. After this cell is closed in 1990, monitoring will be discontinued at location 2. The new residential landfill cell is operating, and the monitoring is conducted at location 3 (Fig. 2.2.3). Table 2.2.2 gives the parameters monitored.

2.2.2 KPDES Monitoring

The CWA is currently administered for PGDP by the Kentucky Division of Water (KDOW) through the Kentucky Pollutant Discharge Elimination System (KPDES) wastewater-discharge-permitting program. The earlier National Pollutant Discharge Elimination System (NPDES) permit (KY0004049) was issued by Region IV EPA and became effective on February 15, 1975. It was revised on February 4, 1977, and was to expire in 1980. Although PGDP had applied for a new permit at the time the old one expired, no system was in place at the KDOW to

Table 2.2.1. Summary of PGDP discharges to surface water, 1985–1989

Location	1985	1986	1987	1988	1989
<i>Uranium</i>					
C-340 effluent ditch (kg)	37	18.0	5.5	7.2	6.7
C-400 decontamination solution filtrates (kg)	0.41	0.2	0.5	0.3	0.1
C-616 lagoon effluent (kg)	34	48.0	10.0	a	a
C-615 sewage treatment (kg)	2	1.9	2.1	2.2	3.2
KPDES 001 effluent (kg)				33.3	66.3
<i>Technetium-99</i>					
C-400 decontamination (g)	40	12.0	8.1	56.1	<1.76
C-400 decontamination (mCi)	680	200.0	136.49	947.4	<30.04
C-616 lagoon effluent (g)	24	20.0	27.0	a	a
C-616 lagoon effluent (mCi)	400	340.0	454.0	a	a
KPDES 001 effluent (g)				43.1	6.95
KPDES 001 effluent (mCi)				727	117
<i>Nitrates (NO₃)</i>					
C-400 decontamination (kg)	9000.00	1100.0	3815.0	3779	3759
<i>Chromium (Cr⁶⁺)</i>					
C-616 chromium treatment facility (kg) ^b	5.30	6.0	<3.4	<3.7	<4.5

^aLocation changed to KPDES 001 effluent.^bCr⁶⁺ analysis taken before flowing into the C-616 lagoon.

replace the old NPDES system, and a new permit could not be issued. PGDP operated under the original 1975 permit until October 22, 1986, when the state of Kentucky issued the KPDES permit (KY0004049). On November 5, 1986, the state permit was adjudicated because the permit limits were not achievable. Monitoring then resumed under the old NPDES permit. As a part of the negotiations associated with the adjudication process, an Agreed Order was proposed whereby interim limits were included in the KPDES permit while a biological-monitoring study (see Subsect. 2.2.3) was carried out at PGDP. Table 2.2.2 of Part 2 shows interim limits, sampling frequency, and the type of sample required by the Agreed Order. The Agreed Order was signed and became effective on October 12, 1987. Monitoring then resumed under the KPDES permit with the Agreed Order modifications.

Monitoring of 16 individual outfalls is conducted in accordance with the KPDES Agreed Order. Table 2.2.3 lists all outfalls and their contributing processes; Fig. 2.2.4 depicts these. Table 2.2.2 in Part 2 cites the limits set forth by the Agreed Order.

Tables 2.2.3 through 2.2.16 in Part 2 give monitoring data. Since no flow occurred at outfall 003 in 1989, no monitoring data were obtained. Flow from the north-south diversion ditch is normally channeled through outfall 001 via a lift station that pumps the effluent through the C-616 full-flow lagoon; however, during a rainfall with flows greater than 10 year/24 h (i.e., a maximum daily average flow over a 10-year occurrence interval), the lift station overflows to 003. This is the only time that 003 is monitored. Outfall 005 is not regularly monitored because its effluent flows into the C-611 secondary lagoon. Outfall 006, the

ORNL-DWG 89-6359R

Fig. 2.2.3. Surface-water-monitoring locations at PGDP.

Table 2.2.2. Summary of collection and analysis frequencies of surface water samples in 1989

Station	Parameter	Collection frequency	Sample type	Analysis frequency
<i>C-746-S and C-746-T landfill runoff</i>				
Location 1 (SW1), Location 2, Location 3	Chloride, sulfate, pH, Na, U, TOC, TSS, TDS, total solids, specific conductivity, gross alpha, gross beta	Quarterly	Grab	Quarterly
<i>Surface water locations</i>				
SW1, SW29	NO ₃ -N, SO ₄ , chloride, Cr ⁺⁶ , pH, PO ₄ , U, F ⁻ , dissolved alpha and beta, suspended alpha and beta, SW1-temperature weekly	Monthly	Grab	Monthly
SW30	NO ₃ -N, SO ₄ , chloride, Cr ⁺⁶ , pH, PO ₄ , U, F ⁻ , dissolved alpha and beta, suspended alpha and beta, 1,2-dichloroethane	Monthly	Grab	Monthly
SW13	NO ₃ -N, PO ₄ , chloride, Cr ⁺⁶ , pH, U, F ⁻ , dissolved alpha and beta, suspended alpha and beta, SO ₄	Weekly	Grab and 7-day composite	Weekly
SW13	U, Ni, Hg, Cd, As, Ba, Cu, Pb, Se, Ag, dissolved alpha and beta, suspended alpha and beta, ⁹⁹ Tc, ²³⁷ Np, ²³⁹ Pu, ²³⁰ Th, ²³⁵ U, Cr, spectrochemical	Annually	Annual composite	Annually

C-611 secondary lagoon, is monitored for the same parameters as those required by outfall 005. Outfall 007 is not allowed to experience any discharge. This outfall is a septic field for the C-611 water treatment plant. Outfall 014 was not monitored in 1989. This U-shaped lagoon experiences flow only when the C-611 sludge lagoon is dredged. Every 2 or 3 years the C-611 sludge lagoon is dredged, and the filter backwash is directed to outfall 014. Monitoring of outfall 014 occurs at this time.

Table 2.2.4 indicates the noncompliances experienced under the Agreed Order. The majority

of noncompliances experienced during 1989 were pH, total residual chlorine, temperature, fecal coliform, and total suspended solids. The pH noncompliances are, in part, the result of lime-softening of water at the C-611 water plant. Elevations of pH during hot summer days result from the photosynthetic action of algae. Once-through cooling water (i.e., sanitary water disinfected with chlorine for public consumption and usage) is a large portion of PGDP's effluent and accounts for most of the total residual chlorine noncompliances. The C-615 sewage treatment plant is also a contributor of total residual chlorine

Table 2.2.3. Kentucky Pollutant Discharge Elimination System outfalls at PGDP

Location ^a	Drainage source	Contributing process
001	C-616, C-600, C-400, C-410, C-635, C-335, C-337, C-535, C-537, C-746-A, C-747-A, C-635-6	Recirculating cooling water blowdown treatment effluent, coal pile runoff, once-through cooling water, surface runoff, roof and floor drains, treated uranium solutions, sink drains
002	C-360, C-637, C-337-A	Once-through cooling water, roof and floor drains, sink drains, extended aeration sewage treatment system
003	North edge of plant	Storm overflow of north-south diversion ditch discharges
004	C-615 sewage treatment plant, C-710, C-728, C-750, C-100, C-620, C-400	Domestic sewage, laboratory sink drains, motor cleaning, garage drains, laundry, X-ray processing and silver recovery unit effluent, machine coolant treatment filtrate, condensate blowdown, once-through cooling water, spent photographic solutions
005	C-611 primary sludge lagoon	Water treatment plant sludge, sand filter backwash, laboratory sink drains
006	C-611 secondary lagoon	Water treatment plant sludge, sand filter backwash, laboratory sink drains from outfall 005
007	Outfall eliminated	
008	C-743, C-742, C-741, C-723, C-721, C-728, C-729, C-400, C-420, C-410, C-727, C-411, C-331, C-310, C-724, C-744, C-600, C-405, C-409, C-631, C-720	Surface drainage, roof and floor drains, once-through cooling water, paint shop discharge, condensate, instrument shop cleaning area, metal cleaning rinse water, sink drains
009	C-810, C-811, C-331, C-333, C-310, C-100, C-102, C-101, C-212, C-200, C-300, C-320, C-302, C-750, C-710, C-720	Surface drainage, roof and floor drains, condensate, once-through cooling water, sink drains
010	C-531, C-331	Switchyard runoff, roof and floor drains, condensate, sink drains
011	C-340, C-533, C-532, C-315 C-333, C-331	Once-through cooling water, roof and floor drains, switchyard runoff, condensate, sink drains
012	C-633, C-533, C-333-A	Roof, floor, and sink drains, switchyard runoff, condensate, surface runoff, extended aeration sewage treatment system
013	Southeast corner of plant	Surface runoff
014	C-611 U-shaped sludge lagoon	Sand filter backwash, sanitary water
015	West central plant areas	Surface runoff
016	Southwest corner of plant	Surface runoff
017	Extreme south area of plant	Surface runoff

^aSee Fig. 2.2.4.

ORNL-DWG 87-6710R

Fig. 2.2.4. KPDES outfall locations at PGDP.

Table 2.2.4. Compliance experience under interim Kentucky Pollutant Elimination Discharge System limits for 1989
Interim limits^a and number of violations^b at each outfall

Permitted parameters	001	002	003	004	005	006	008	009	010	011	012	013	014	015	016	017
Flow (Mgd)	M ^c	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Cr	0.15	0.31	0.15				0.1	0.23	0.5(2)	0.85	0.76					
Zn	0.93	0.17	0.93				0.34	1.15	0.26	0.16	0.4					
Cl residual	0.1	0.15(2)	0.1				0.33(5)	0.01(24)	0.01(15)	0.14(1)	0.01(17)					
Temp (°F)	93	89	93				89	89	89	95(3)	90					
Fe	34.3	6.55	5.19				9.42	8.41	8.32	5.94	18.22					
Al	M	M	M				M	M	M	M	M			M	M	M
Cu	0.17	M	0.17				M	M	M	M	M			M	M	M
Ni	3.1	M	3.1				M	M	M	M	M			M	M	M
TSS	158	M	158	45	50	50	M	M	M	M	M	271(1)	50	427	45(1)	45(3)
Trichloroethylene	0.0807	M	0.027				0.027	M	M	M	M					
Fluoride	4.0	5.0	4.0				5	5	5	5	5	M		M		
Dissolved oxygen	5.0	5	5				5	5	5	5	5					
Oil and grease	15	M	15				M	M	M	M	M	M	M	M	6-9	6-9
pH (std. units)	6-10	6-10	6-10	6-9(1)	6-9	6-10.4	6-9(1)	6-10	6-9(3)	6-10	6-9	6-9	6-9	6-9	M	M
Uranium	M	M	M				M	M	M	M	M			M	M	M
Dissolved alpha (pCi/L)	M	M	M				M	M	M	M	M			M	M	M
Suspended alpha (pCi/L)	M	M	M				M	M	M	M	M			M	M	M
Dissolved beta (pCi/L)	M	M	M				M	M	M	M	M			M	M	M
Suspended beta (pCi/L)	M	M	M				M	M	M	M	M			M	M	M
PCB (µg/L)	0.1	0.1	0.1				0.1	0.1	0.1	0.1	0.1			0.1	0.1	0.1
BOD ₅				45												
Fecal coliform (col./100 mL)				400(3)												
Turbidity (NTU)					M	M							M			
COD					M							M				

^aChemical limits are milligrams per liter unless otherwise indicated.

^b() = number of violations.

^cM indicates monitoring requirement only.

Note: There were 82 violations in 4753 analyses related to permit limits (98.27% compliance).

(used in disinfection of the effluent) in effluent waters. Fecal coliform noncompliances were due to malfunctions of the flow-proportionate chlorinator at the C-615 sewage treatment plant. Temperature noncompliances are the result of the heat in once-through cooling water and steam condensate discharge. Total suspended solids noncompliances occur because of dust and solids washed down the ditches by rainfall runoff.

During 1989 the effluent profile listing each outfall and its contributing processes was updated and submitted to the KDOW. Also, a permit modification was submitted to the KDOW for the surface runoff from the C-746-S and C-746-T sanitary and inert landfills. On September 14, 1989, a meeting was held in Frankfort, Kentucky, to discuss the KPDES Agreed Order. Results of the meeting indicated that the interim discharge limits in the Agreed Order would continue indefinitely and that the biological-monitoring characterization phase would be extended 18 more months. The University of Kentucky (UK) presented the current status of the Biological Monitoring Program (BMP) and defined the goals of further study. PGDP personnel presented the information on current and planned projects to address stream impacts that have been identified.

2.2.3 Biological Monitoring of Effluents and Receiving Waters at PGDP

The BMP at PGDP is designed to evaluate the acceptability of PGDP effluents under KPDES regulations, to characterize the potential for health effects and environmental impacts of the effluents, and to make recommendations on the biological acceptability of planned effluent treatments. The BMP is being carried out by researchers at UK in consultation with staff from Oak Ridge National Laboratory (ORNL). The latter group works to make available their technical expertise gained from other biological-monitoring programs at DOE facilities.

The findings and recommendations of the BMP are presented in a draft report of the first 2 years' activities (Birge, Black, and Short, December 1989). The ecological studies conducted for the BMP provide data not only for evaluation

of the health and productivity of Big Bayou and Little Bayou creeks at present but also for retrospective and future analyses of the drainage system to detect changes. A reduction in the density and diversity of macroinvertebrate taxa and in the biomass of periphyton indicate an adverse impact of effluents in the region of Big Bayou Creek that receives continuous flow from four outfalls (i.e., 009, 008, 006, and 001). The observed impact is localized in that no effect is evident in downstream macroinvertebrate communities. Furthermore, studies of the fish fauna show no adverse impact on species diversity or abundance. The ecological data further indicate that a substantial improvement has occurred in the quality of the streams compared with a site survey completed in 1978 (Eischen et al. 1978).

Bioaccumulation studies are in progress to detect toxicants that may be of importance to human health and to determine whether organisms received elevated exposures to specific compounds regulated by the KPDES program. Residue analyses of caddisfly larvae, mayfly nymphs, and fish show a tendency for elevated body burdens of copper, cadmium, chromium, and iron in various locations of Big Bayou Creek. Aluminum, nickel, and zinc also accumulate in these organisms at various locations of Big Bayou Creek. These findings are consistent with the increased metal concentrations sometimes found in effluents as part of the chemical-monitoring activities.

Toxicity testing is an integral part of the BMP because it provides a means to evaluate the acute and chronic effects of PGDP effluents to aquatic biota as well as to obtain information on temporal changes in toxicity of the plant discharges. None of the eight major PGDP effluents was found to be consistently or highly toxic. However, moderate and statistically significant toxicity was detected in 23 of 51 on-site tests of the eight major effluents discharged in the Bayou drainage system. This toxicity was not persistent (i.e., it was not detectable after 24 to 48 h of sample storage).

Chemical-monitoring studies for the BMP are conducted not only to augment the existing data base on contaminants as specified in the KPDES permit but also to detect constituents of the effluents or the receiving waters that may

contribute to observed toxicity or ecological impact in the drainage system. For example, total residual chlorine (TRC) was found to exceed KPDES limits in several effluents and was often detected in the receiving system downstream of the effluent outfalls. Chlorine is used in the disinfection of the sanitary water for public consumption at PGDP. Also, chlorine is the disinfectant used at the C-615 sewage treatment plant. Correlated toxicity testing showed that TRC was toxic. Although pH frequently exceeded the numerical limitation for one effluent (006), there was no evidence that the receiving stream was significantly impacted as a result. Elevated total suspended solids and conductivity may be the cause of some deterioration in water quality downstream of effluent 001. Other chemicals that may have contributed to toxicity or impact on the Bayou system include ammonia, polychlorinated biphenyls (PCBs) and TCE.

The present emphasis of the BMP is to identify specific toxicants in effluents and to work with remediation experts at the plant to evaluate the probable biological consequences of candidate improvements in effluent treatment. For example, toxicity reduction studies for chlorine have shown that sodium thiosulfate is satisfactory for chlorine removal and that a concomitant reduction in toxicity is achieved. Further application of toxicity testing for the purpose of toxicity reduction is focused on an evaluation of metals and other effluent constituents. Specific tasks and future goals of the BMP are detailed in a 2-year report (Birge, Black, and Short, December 1989).

2.2.4 Conclusions

In addition to background monitoring, monitoring required by the KPDES Agreed Order provided the surface water characterization data. Tables 2.2.3 through 2.2.21 in Part 2 give the yearly minimum, maximum, and average for each parameter monitored. Negative radionuclide data indicate radioactivity below background levels. Tables 2.2.22 through 2.2.36 in Part 2 give the amounts of ^{234}U , ^{235}U , ^{238}U , and ^{99}Tc present at KPDES and surface water locations. Each radionuclide is compared with its derived

concentration guide (DOE Order 5400.5) and is presented as a percentage of the derived concentration guide (DCG). The average concentration of each radionuclide at the points monitored was a very small percentage of the corresponding DCG. During 1989 PGDP maintained a compliance rate of 98.27% with the KPDES Agreed Order. Table 2.2.4 gives the noncompliances experienced under the Agreed Order.

Most noncompliances experienced were for total residual chlorine, pH, temperature, fecal coliform, and total suspended solids. Figure 2.2.5 shows a comparison of 1988 vs 1989 noncompliances. Total residual chlorine is elevated at outfall 008 because of its use in disinfection at the C-615 sewage treatment plant. Sanitary water (which contains chlorine used for disinfection) usage for once-through cooling water accounts for the majority of total residual chlorine noncompliances. Elevation of pH is, in part, the result of the lime/soda ash water-softening process used at PGDP. Elevations of pH during hot summer days result from the photosynthetic action of algae. Once-through cooling water causes temperature noncompliances in the hot summer months and also total residual chlorine noncompliances. Total suspended solids noncompliances occur during periods of rain. The two chromium noncompliances were due to a chromated water spill (see Sect. 6). The fecal coliform noncompliances were due to a malfunction of the flow-proportionate chlorinator at the C-615 sewage treatment plant.

During 1989, design was completed on a project to lower the temperature in outfalls 001, 002, 010, 011, and 012 and to reduce the total residual chlorine in outfalls 001, 002, 008, 010, 011, and 012. Construction of this project will be completed during 1990. Associated with this project, a temporary sodium thiosulfate feed station was installed in October 1989 to reduce the total residual chlorine in outfall 009. Also, a project to reduce the pH at outfall 006 has been budgeted. However, biological monitoring has indicated that the slightly elevated pH does not have an adverse impact on Big Bayou Creek. An exception to criteria will be pursued in an attempt to gain a higher pH limit.

Fig. 2.2.5. Kentucky Pollutant Discharge Elimination System noncompliances: 1988 vs 1989. Field measurements for total residual chlorine started in February 1989.

During 1989, 66.3 kg of uranium were discharged through KPDES outfall 001 compared with 33.3 kg in 1988. An investigation is ongoing to determine the cause of the increase. The investigation includes sampling various streams that flow to outfall 001.

2.3 GROUNDWATER

Monitoring and protection of groundwater resources at PGDP is required by federal and state regulations and DOE orders; monitoring efforts have been initiated at PGDP to reflect these requirements. Additionally, a technically effective monitoring strategy can be developed only when guided by a clear and thorough understanding of the subsurface geology and hydrogeology. To this end, characterization activities have been undertaken that will culminate in resolving the recognized deficiencies in understanding site geology and hydrogeology. The following subsections describe the specific regulations and DOE orders governing groundwater monitoring at PGDP, discuss the current understanding of site hydrogeology, cite the current groundwater monitoring being conducted, identify specific

projects related to groundwater, and present a summary of the 1989 groundwater-monitoring results.

2.3.1 Description

2.3.1.1 RCRA interim status and permit-monitoring programs

The Resource Conservation and Recovery Act (RCRA) as amended recognizes three distinct programs requiring groundwater studies: RCRA interim status, RCRA permit programs, and the 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 and 265.92, and 401 KAR 35:060 Section 4(1)(a)] to determine if hazardous waste or

hazardous waste constituents have entered the groundwater underlying the facility; if so, then

- assessment monitoring [defined in 40 CFR 265.93(a) and 401 KAR 35:060 Section 4(1)(b) and (c)] to define the rate, extent, and concentration of hazardous waste or hazardous 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 or postclosure permit application to the regulatory authority. Final disposition of Part B permit applications for all land disposal facilities were made by November 8, 1988. At the time of issuance of the permit, a facility will shift from an interim status monitoring program to the appropriate permit-monitoring program required in the facility permit. Where no groundwater contamination has been found, detection monitoring will continue with minor modifications (40 CFR Pt. 264.98 and 401 KAR 34:060, Sect. 9). 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.

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 regulations contain no specific definitions of groundwater-monitoring requirements for 3004(u) facilities; instead, the 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.

2.3.1.2 Environmental surveillance monitoring

DOE Order 5400.1 requires groundwater monitoring at all DOE facilities to "determine and document the effects of operations on groundwater quality and quantity." The order specifically requires groundwater monitoring to be conducted on-site and in the vicinity of DOE facilities:

- to obtain data for determining baseline conditions of groundwater quality and quantity;
- to demonstrate compliance with, and implementation of, applicable regulations and DOE orders;
- to provide data permitting early detection of groundwater pollution or contamination;
- to provide a reporting mechanism for detected groundwater pollution or contamination;
- to identify existing and potential groundwater contamination sources and to maintain surveillance of these sources; and
- to provide data on which decisions can be made concerning land disposal practices and the management and protection of groundwater resources.

These requirements are met at the plant through the monitoring of (1) a number of wells with the stated purpose of surveillance monitoring and (2) specific wells as dictated by the RCRA.

2.3.1.3 Underground storage tank (UST) monitoring

Like the regulations governing solid waste management units (SWMUs) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, few specific requirements for groundwater monitoring have been established for USTs. In general, the UST regulations require groundwater monitoring in only two instances: (1) as one of several acceptable leak-detection alternatives and (2) during site characterization to determine the extent of a release of regulated substances from USTs. Currently, PGDP has no UST's that are in service; therefore, release-detection monitoring is not presently required at PGDP. Two UST's that were in use at PGDP were discovered to be leaking during the summer of 1989. (see Subsect 6.2.8). The current monitoring effort being conducted to target petroleum consists of sampling all wells in the immediate vicinity of the C-750 garage facility on a bimonthly basis for benzene, toluene, ethyl benzene, and xylene and total petroleum (see Subsect. 2.3.3).

2.3.1.4 Administrative Consent Order (ACO)

In August 1988 contamination by ^{99}Tc was discovered in an off-site drinking water well north of PGDP. As a result of this finding, the EPA and DOE developed an ACO under CERCLA Sects. 104 and 106 (see Sect. 4). The ACO requires that specific plant and residential wells be routinely monitored for TCE, ^{99}Tc , and/or gross alpha and beta. The monitoring effort initiated in response to the ACO is further discussed in Subsect. 2.3.5.

2.3.1.5 Technical objectives

While monitoring is conducted as required by the aforementioned regulations and orders, the technical objectives under these programs are similar:

- collect piezometric head measurements (i.e., groundwater table elevation at equilibrium with atmospheric pressure) to determine the direction of groundwater flow,
- obtain representative water samples from the geologic strata,
- determine the background water chemistry of each hydrogeologic unit from analysis of samples collected upgradient of waste disposal areas,
- evaluate the potential impact of waste disposal activities on the groundwater through a comparison of analyses from samples collected upgradient and downgradient of the disposal area,
- identify the hazardous waste or hazardous waste constituent(s) present should contamination be detected and compare with applicable standards and criteria, 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 RCRA monitoring programs are supported technically by extensive site characterization and regional studies of the geohydrologic and chemical aspects of the flow system.

Computer data bases optimize organization and distribution of the analytical results.

2.3.2 Site Hydrogeology

As is discussed in Subsect. 1.3, the current understanding of the local groundwater system suggests that shallow groundwater hydrogeology in the vicinity of PGDP is dominated by the gravel facies of the Continental Deposits. This unit is termed the regional gravel aquifer and is the primary source of groundwater in the near vicinity of PGDP. This subsection discusses the current level of understanding of the hydraulic properties of the local groundwater flow system and summarizes the geologic and hydrogeologic uncertainties that still exist.

Data from several USGS studies conducted in the 1960s indicate that groundwater flow in the vicinity of PGDP is generally northward toward the Ohio River. Hydraulic head data gathered by the ERC on January 11 and 12, 1989, from a series of PGDP and private wells yielded a more defined but less areal extensive picture of the potentiometric surface of the regional gravel aquifer but appear to substantiate these early investigations (ERC March 23, 1989). Data from current investigations are expected to lead to a more refined model of the groundwater flow in the vicinity of PGDP.

Based on measurements (both in the field and laboratory) and on estimations of grain size analysis, hydraulic conductivity values for the regional gravel aquifer range from 1.1×10^{-4} to 1 cm/s. These values are presented to give a rough estimate of the magnitudes and ranges of values for the regional gravel aquifer. Preliminary results from an aquifer test performed in the regional gravel aquifer near the C-404 area during August and September of 1989 indicate values ranging from 1.0×10^{-2} cm/s to 4.0×10^{-1} cm/s. Data now available from studies conducted by TVA at the Shawnee Steam Plant indicate values that fall between 1.0×10^{-3} cm/s and 1.0×10^{-1} cm/s or greater range. This wide range of values suggests that the gravel is heterogeneous. Considering the depositional history of the gravel, this is to be expected.

It is possible to take the available estimates for hydraulic data for the gravel aquifer and to make some estimates for the possible ranges of flow velocity that might be encountered. This calculation makes use of Darcy's flow equation:

$$\text{average linear velocity} = (K/n)(dh/dl),$$

where

K = hydraulic conductivity,

n = porosity,

dh/dl = head gradient.

Assuming that K for the gravel lies within the range of 10^{-4} to 10^{-1} cm/s, that n is approximately 0.3 (i.e., 30% voids), and that dh/dl is about 10^{-3} [i.e., 1.52 m/mile (5 ft/mile)], then the following results are obtained:

velocity = <1 ft/year (low K) to >300 ft/year (high K).

Early estimates of groundwater flow velocity within the gravel aquifer at the C-404 facility (based on hydraulic conductivity values derived from slug tests and measured head gradients) were in the range of 1.52 m/year (5 ft) (D'Appolonia 1983). Apparently, this and other low estimates of flow velocities for this region suggested that contaminant migration would be a very slow process. Now that it is recognized that K is highly variable, site-specific flow velocity estimates must be cautiously interpreted. The possibility that groundwater velocities as high as 90 m/year (300 ft) might be possible illustrates the importance of further, more detailed characterization work.

In contrast to the large production capability of the gravel aquifer, the sand lenses interbedded in the clay facies of the Continental Deposits are observed to have extremely low yields.

Furthermore, reports from earlier investigations at PGDP indicate that the sand and gravel lenses are discontinuous. Additionally, ambiguities regarding observed hydraulic heads support the interpretation that they may not constitute a continuous aquifer.

The major geologic and hydrologic uncertainties that face DOE in its quest for a more complete understanding of the PGDP site have been published (Early, Sigmon, and Williams 1989). These conclusions are summarized as follows:

- The subsurface configuration of the gravel aquifer (i.e., top and bottom) is poorly resolved in certain areas.
- Detailed lithologic descriptions that may have bearing on the understanding of groundwater flow within the gravel are sparse.
- The three-dimensional configuration of the sand intervals of the clay facies and their possible connection to the gravel facies is poorly understood.
- The hydraulic heads of the shallow groundwater system, the regional gravel aquifer, and underlying formations are not fully defined in the plant and surrounding areas.
- There is a lack of reliable hydraulic conductivity information for the important lithologies.
- The role of the sand intervals of the clay facies in contaminant migration is not understood.

Activities to address these recognized deficiencies in our understanding of PGDP site geology and hydrogeology are also recommended in that document. Several of these recommendations either being planned or implemented by PGDP are:

- High-resolution seismic survey. The main objective of this survey is twofold: (1) to determine the topography of the top and bottom of the regional gravel aquifer and (2) to produce a three-dimensional image of the sand lenses in the clay facies beneath the C-404 disposal area.
- Computer modeling. GeoTrans, Incorporated, is currently under contract to DOE to develop a three-dimensional flow model of the hydrologic regime beneath PGDP. This model is expected to be a valuable tool to help guide the plant in understanding important groundwater flow and contaminant transport processes.
- Groundwater monitoring Phase 3 and Phase 4. These projects are a continuation of an ongoing effort by the plant to further characterize the PGDP subsurface hydrology and geology. The design of these projects incorporates specific recommendations that are discussed in the Groundwater Monitoring Plan. In general, each project will include the installation of soil bor-

ings and monitoring wells and the performance of hydraulic testing in areas where such information is lacking.

- Utilization of additional sources of geologic data. Other projects that will add to the geologic data base at PGDP include the Site Investigation (discussed in Sect. 4), seismic drilling and testing being conducted for the Final Safety Analysis Report, and studies being conducted by the TVA, just north of PGDP. As pertinent information becomes available, it is being used to further refine the conceptual model of the site geology and hydrogeology.

Groundwater is used for drinking water and other domestic uses, irrigation of gardens, and watering livestock. No industrial users exist north of PGDP; however, a small pilot plant at the TVA Shawnee Steam Plant uses groundwater as a drinking water source for a few employees. Approximately 15 private residences north of the plant use groundwater.

2.3.3 Groundwater Monitoring

The primary objectives of PGDP's Groundwater-Monitoring Program are to detect (at the earliest time possible) contamination resulting from past and present land disposal of wastes and to provide the basis for developing groundwater quality assessments if contamination is detected. PGDP's current groundwater-monitoring effort is subdivided into three categories:

1. general environmental surveillance monitoring,
2. monitoring required under RCRA interim status and permit requirements, and
3. monitoring performed in support of the Remedial Action Program (RAP).

Selected wells at PGDP are monitored under more than one of the above categories; these three monitoring categories are integrated together to develop the plant-wide Groundwater Monitoring Program. All wells are sampled in accordance with Energy Systems environmental surveillance procedures that follow EPA protocol. The following three subsections briefly describe the wells that are monitored

under each program and the constituents that are analyzed.

2.3.3.1 Environmental surveillance monitoring

A total of 38 wells (see Table 2.3.1 and Figs. 2.3.1 and 2.3.2) are monitored as environmental surveillance sites. With the exception of wells 23–27, these wells are sampled on a quarterly basis for the constituents listed in Table 2.3.2. Also, on an annual basis during the first quarter of each year, these wells are sampled for the extra constituents listed in Table 2.3.3. Wells 23–27 are sampled only annually for the constituents listed in Tables 2.3.2 and 2.3.3. Additionally, wells 16, 17, 18, 19, 38, 39, 40, 41, 42, 43, and 44 are also analyzed for chloride during the first and third quarters of each year. Many wells presently monitored as environmental surveillance sites were installed adjacent to specific SWMUs located on the site (see Table 2.3.4 and Fig. 2.3.3). The following paragraphs give a brief discussion of these SWMUs.

Table 2.3.1. Environmental surveillance monitoring sites

Well piezometer	Monitored zone	Well piezometer	Monitored zone
16	SGS ^a	47	SGS
17	RGA ^b	48	RGA
18	SGS	50	RGA
19	RGA	51	RGA
20	RGA? ^c	52	RGA
21	RGA?	53	RGA
22	RGA?	54	RGA
23	PCC ^d	57	SGS
24	PCC	59	?
26	RGA	60	?
27	PCC	61	?
38	RGA	62	?
39	RGA	63	RGA
40	RGA	64	SGS
41	RGA	65	RGA
42	RGA	66	RGA
43	RGA	67	RGA
44	RGA	68	RGA
46	RGA	71	RGA

^aSGS—shallow groundwater system.

^bRGA—regional gravel aquifer.

^c?—not clear where screened interval is located.

^dPCC—Porter's Creek Clay.

ORNL-DWG 90-12467

Fig. 2.3.1. Existing on-site wells.

ORNL-DWG 90-12466

Fig. 2.3.2. Approximate locations of wells around the C-404 area.

Table 2.3.2. Monitoring of wells for quarterly parameters

Constituents analyzed	
Chromium	Total organic
Copper	carbons
Iron	NO ₃ -N
Lead	SO ₄
Nickel	Polychlorinated
Uranium	biphenyls
Zinc	Total organic
Dissolved alpha	halogens
Dissolved beta	Hydrogen ion
Suspended alpha	concentrations (pH)
Suspended beta	Temperature
Conductivity	Depth
Fluoride	Color
	Turbidity

Table 2.3.3. Monitoring of wells for annual parameters

Constituents analyzed	
Americium	Radium
Cadmium	Selenium
Calcium	Sodium
Cesium	Alkalinity
Chlorine	Dissolved
Cobalt	solids
Magnesium	Cr ⁶⁺
Manganese	PO ₄

Unit 5, the C-746-F classified burial yard, is used for the disposal of cascade equipment, paper, and electronic media (such as computer disks) that are classified or may reveal classified information. Unit 2, the C-749 uranium burial ground, was used from the late 1950s to the mid-1970s for the disposal of uranium scrap, some of which was pyrophoric in nature (i.e., easily ignitable in air). To stabilize the uranium for burial, it was submerged in waste oil. Unit 9, the C-746-S residential landfill, is used for the disposal of nonhazardous, putrescible wastes such as paper, cardboard, and cafeteria wastes. C-746-S is permitted by the Kentucky Division of Waste Management. Unit 10, the C-746-T inert landfill, is used for the disposal of fly ash from the steam plant and non-putrescible construction wastes such as wood

Table 2.3.4. Waste management units currently monitored at PGDP

Unit ^a	Name
5	C-746-F classified burial yard
2	C-749 uranium burial ground
3	C-404 low-level radioactive waste burial ground
9	C-746-S residential landfill
10	C-746-T inert landfill
7	C-747-A burial ground
30	C-747-A burn area
13	C-746-P clean scrap yard
12	C-747-A UF ₄ drum yard
14	C-746-E contaminated scrap yard
15	C-746-C scrap yard
8	C-746-K inactive sanitary landfill
17	C-616-E sludge lagoon
18	C-616-F full-flow lagoon
Well 20	Off-site horse barn, well north of PGDP
Wells 68, 69, 71	North of C-710, general monitoring wells

^aSee Fig. 2.3.3.

timbers and concrete. Unit 7, the C-747-A burial ground, was used for the disposal of all types of waste material from plant operations. Well 66 (see Fig. 2.3.1), the plant well with the highest level of TCE and ⁹⁹Tc contamination, is adjacent to this area. Unit 30, the C-747-A burn area, was used for burning combustible wastes until approximately 1970. This unit is located in the vicinity of the C-747-A burial ground.

Unit 13, the C-747-P clean scrap yard, is used to accumulate uncontaminated scrap metal for sale to reclaimers. Unit 12, the C-747-A UF₄ drum yard, consists of a large waste pile of crushed uranium tetrafluoride drums. Unit 14, the C-746-E contaminated scrap yard, consists of a scrap metal yard for contaminated metal scrap generated during plant operations. Scrap is segregated by metal type. Most contamination is from depleted, natural, or slightly enriched uranium on the metal surfaces. Unit 15, the C-746-C scrap yard, contains scrap metal of all types. The contamination is mostly from depleted, natural, or slightly enriched uranium.

Unit 8, the C-746-K inactive sanitary landfill, was used for the disposal of fly ash from 1951 to 1982. Sanitary trash was also placed in this landfill

Fig. 2.3.3. Waste management units currently monitored at PGDP.

until 1982. A 15.24-cm (6-in.) clay cap was placed on this landfill in 1982. Unit 17, the C-616-E sludge lagoon, is an on-grade surface impoundment that receives the sludge from the C-616 chromium reduction facility. The chromium hydroxide sludge has been subjected to the extraction procedure toxicity tests and found to be nonhazardous under RCRA. Unit 18, the C-616-F full-flow lagoon, is an on-grade surface impoundment that receives the overflow from the C-616-E sludge lagoon and the liquid effluent from the clarifiers at the C-616 chromate reduction facility. In addition, effluents from the C-400 cleaning and decontamination building and coal pile runoff are piped to this impoundment.

2.3.3.2 RCRA monitoring

The only RCRA unit at PGDP that requires groundwater monitoring is the C-404 low-level radioactive waste burial ground; this unit is presently under interim status regulations awaiting postclosure permit (see Subsect. 6.2.5). The 12 wells located at this facility are listed in Table 2.3.5 and shown in Figs. 2.3.1 and 2.3.2. They are monitored quarterly for the constituents listed in Table 2.3.6.

2.3.3.3 Remedial Action Program monitoring

Groundwater-monitoring activities performed in support of the RAP are categorized as follows:

Table 2.3.5. Resource Conservation and Recovery Act interim status monitoring sites

Well	Monitored zone
84	RGA
85	SGS
86	RGA
87	RGA
88	SGS
89	RGA
90	RGA
91	SGS
92	RGA
93	RGA
94	SGS
95	RGA

Table 2.3.6. C-404 low-level radioactive waste burial ground

Detection-monitoring parameters

Selenium—total and dissolved
 Cadmium—total and dissolved
 Lead—total and dissolved
 Uranium
 Arsenic—total and dissolved
 Trichloroethylene
 Total organic halogens
 Total organic carbon
 Hydrogen ion concentrations (pH)
 Temperature
 Conductivity
⁹⁹Tc

1. groundwater monitoring conducted as required to comply with the letter and intent of the ACO between DOE and the EPA, and
2. groundwater monitoring associated with the UST Program.

At present, the majority of the monitoring conducted under the ACO consists of off-site residential and industrial (i.e., TVA) well sampling. The conditions of the ACO and the off-site sampling developed in response to the ACO are addressed in Sect. 4 and Subsect. 2.3.5 respectively. Specific on-site sampling under the ACO consists of sampling wells 20, 38, 41, 43, 44, and 66 on a monthly basis for TCE, ⁹⁹Tc, and gross alpha and beta. These wells have been identified by the RAP as showing either TCE or ⁹⁹Tc levels greater than 1.0 µg/L or 25 pCi/L respectively (i.e., plant action levels for these constituents). PGDP also monitors wells 47, 52, 68, 69, 70, 71, and 96 for benzene, toluene, ethyl benzene, and xylene on a bimonthly basis in support of the UST Program.

2.3.4 Groundwater Project Accomplishments

Studies conducted and/or completed during 1989 relating to groundwater include (1) Groundwater Monitoring Phase 2, (2) a stream investigation conducted by the USGS, (3) development of the Groundwater Monitoring Plan for PGDP (pursuant to DOE 5400.1), (4) the geophysical logging of selected plant and residential wells, and (5)

completion of the conceptual design of Groundwater Monitoring Phase 3.

Groundwater Monitoring Phase 2 was a hydrogeologic investigation initiated during 1988. Data from the boring and well installation stage of this project was submitted in report form in May 1989 and added a great deal of refinement to the conceptual model of the subsurface geology beneath the PGDP site. A pump test was also performed as part of this project in September 1989. Preliminary results from this test were submitted in draft form in November 1989. The final report is expected early in 1990.

The USGS collected stream flow, specific-conductance, and temperature data for the Big and Little Bayou creeks during August of 1989. The data is currently being reviewed to assess the gaining and losing characteristics of the creeks.

Persuant to DOE 5400.1 requiring the development of a Groundwater Monitoring Plan for each DOE facility, personnel from the ORNL developed the Groundwater Monitoring Plan for PGDP. Implementation of this plan is to begin in 1990 with the initiation of a computer flow and transport study and a high-resolution seismic survey of the site. Additionally, specific recommendations concerning boring, well, and piezometer placement were incorporated into the conceptual design Groundwater Monitoring Phase 3. Formal design is expected to be completed in early 1990; construction is expected to begin by late summer 1990.

Selected wells were geophysically logged by personnel from ORNL as part of the Site Investigation being conducted under the Administrative Consent Order between the DOE and the EPA. Selected plant and residential wells lacking completion data were logged to determine the zone of completion and overlying lithology.

2.3.5 Off-site Groundwater Monitoring

When off-site groundwater contamination by TCE and ^{99}Tc was discovered north of PGDP in August 1988, a comprehensive effort was initiated to sample off-site wells. Through December 31, 1989, approximately 257 residential wells were sampled in an area circling PGDP. A detailed discussion of the contamination, efforts taken to

respond to residents' needs, and investigation and remedial planning activities is included in Sect. 4. This discussion is limited to ongoing groundwater-sampling activities in response to the contamination.

Analysis of the off-site wells was limited to TCE and ^{99}Tc after a more exhaustive analysis (RCRA, Appendix IX) of the most contaminated off-site and on-site wells identified these as the primary contaminants. Figure 2.3.4 and Table 2.3.7 show the location and analytical results, respectively, of any residential or TVA Shawnee Steam Plant monitoring well showing TCE or ^{99}Tc contamination. An off-site drinking well is considered contaminated if any sample shows levels above the DOE/PGDP action limits of 25 pCi/L for ^{99}Tc and 1 $\mu\text{g/L}$ for TCE. During 1989 TCE was detected in two additional wells. These wells, locations 16 and 245, had previously shown no contamination and were sampled weekly. These locations were connected to a city waterline at DOE expense. Following the discovery of the TCE, these wells were included in the monthly sampling program for contaminated wells.

Ongoing sampling of off-site wells performs two functions: (1) detecting the spread of contamination to other wells and (2) gaining additional information about those wells already contaminated. Each sample is analyzed for TCE and ^{99}Tc , and residents are notified of the results of each sample. The residences are also sampled periodically for gross alpha and beta. Action is taken to supply alternate water supplies if the action levels are exceeded. A safety margin of 900 pCi/L for ^{99}Tc is used; this is comparable to the drinking water standard of 5 $\mu\text{g/L}$ for TCE and the 4-mrem/year exposure standard for manmade beta-emitting radionuclides. To exceed the standard (based on consumption of 2 L/d), water would have to contain 900 pCi/L or more of ^{99}Tc .

Figure 2.3.5 shows the locations of the wells sampled weekly and monthly. Wells sampled weekly are all residential wells; wells sampled monthly include both residential and key plant wells that are contaminated and a small group of residential wells with a lower potential for contamination than that for wells sampled weekly. An additional 19 residential wells are sampled bimonthly in a wider area surrounding the plant.

ORNL-DWG 89-8336R

Fig. 2.3.4. Off-site groundwater-sampling locations where ⁹⁹Tc and trichloroethylene were detected.

Table 2.3.7. Analytical results of off-site contaminated wells

Location	Trichloroethylene range (ppb)	Technetium-99 range (pCi/L)
2 Residence	940 to 1900	651 to 1292
3 Outbuilding	800 to 1450	633 to 892
4 Outbuilding	18 to 84	5 to 82
5 Residence	<1 to 7	<25
16 Residence	<1 to 7	<25
17 Residence	120 to 440	123 to 410
18 Residence	<1	<25
113 Residence, capped well	<1 to 1040	<25 to 580
156 TVA well D-3	<1 to 2	<25
157 TVA well D-4	1 to 3	<25
172 TVA well D-14	<1	<25
173 TVA well D-27	<1	114 to 226
245 barn well	<1 to 5	<25

Figure 2.3.6 shows all TVA monitoring wells; these are sampled quarterly. This scheduled sampling is likely to be modified during the investigation of groundwater contamination.

2.3.6 Groundwater-Sampling Results

The range of analytical results from the off-site monitoring of residential and TVA wells (in support of the RAP) is presented in Table 2.3.7 of this section. At present, there is no conclusive evidence to suggest that apparent trends in contaminant levels are statistically significant. These data are currently being statistically analyzed; as more data become available through the continuing off-site sampling program and the installation of additional off-site monitoring facilities, contaminant trends may become more evident.

Tables 2.3.2 through 2.3.11 in Part 2 summarize results of analyses performed on 1989 groundwater samples. Not applicable means the parameter does not have a detection limit. The count minus background is reported for radioactive parameters even if the number is negative. Each table presents the results of wells associated with a particular unit or location. For a particular constituent each table shows (1) the number of samples analyzed, (2) the number of times the constituent was detected, (3) the minimum and maximum concentrations detected, and (4) the average concen-

trations above detection limit. Also indicated is the reference used to determine applicable acceptable limits for each constituent and how many times the constituent concentration exceeded this value.

Nearly all wells show elevated levels of iron and turbidity, but this is not considered anomalous. Additionally, ^{99}Tc was detected in wells around many units and in well 20 (i.e., an off-site monitoring well). While it was in many cases below regulatory concern (i.e., <900 pCi/L), its presence is indicative of a release into the groundwater regime since there are no natural sources of ^{99}Tc . Also, lead is shown in the tables as exceeding the reference value in nearly all samples. However, PGDP's lower reporting limit for lead is above the reference value in the SDWA. Nearly all samples analyzed for lead were below the analytical lower reporting limit.

The pH values of groundwater in the area are between the range of 6.5 and 8.5 listed in the SDWA. Trichloroethylene and ^{99}Tc contamination is evident both on-site and off-site and is being investigated as part of the RAP.

Because of the close proximity of many units within the plant, contamination in wells associated with a particular unit may or may not be conclusive evidence that a release has occurred from that unit. Further study (to be conducted under the RAP) will be needed to provide this evidence. Wells covered by data presented in Tables 2.3.2 through 2.3.11 of Part 2 include:

Fig. 2.3.5. Wells sampled weekly and monthly.

ORNL-DWG 89-8412

Fig. 2.3.6. Wells sampled quarterly.

- Well 20. This well continues to show elevated levels of TCE; also noted is the presence of zinc and ^{99}Tc but at levels below the reference values.
- Wells 21 and 22. Located at the C-616 lagoon, these wells indicate the presence of ^{99}Tc and elevated levels of manganese. Additionally, elevated levels of sulfate and TCE were detected in 1989.
- Wells 46, 48, 50, 51, 67, 47, 57, and 58. Associated with the C-404 and C-749 units, these wells continue to show elevated levels of chromium, manganese, and TCE. Contamination by ^{99}Tc is also evident. Elevated levels of As, Se, and Zn also appeared during 1989.
- Wells at the C-746-S and C-746-T areas. These wells continue to show elevated levels of copper, manganese, and TCE as well as the presence of ^{99}Tc . Additionally, elevated levels of chromium were reported.
- Wells 63, 64, 65, and 66. Results continue to show elevated levels of manganese, TCE, and ^{99}Tc . Additionally, elevated levels of chromium and selenium were reported.
- Wells 68, 69, and 71. Located south of the C-400 decontamination building, these wells continue to show elevated levels of chromium and TCE as well as the presence of ^{99}Tc .
- Wells 84 through 95. Located at the C-404 low-level waste burial ground, these wells indicate elevated levels of TCE and the presence of ^{99}Tc .
- Wells 52, 53, and 54. Located at the C-746-F burial area, these wells show elevated levels of manganese and the presence of ^{99}Tc .
- Wells 23 through 37. These wells continue to show elevated levels of manganese and zinc.
- Wells 47, 52, 68, 69, 70, 71, and 96. These wells were monitored for petroleum products during 1989. Benzene, ethyl benzene, and toluene were detected above reference values; xylene was detected but at levels less than the reference value.

2.4 BIOLOGICAL MONITORING

2.4.1 Food Crop and Tissue Sampling

The PGDP staff sampled food crop and animal tissue during 1989. Animal tissue samples collected were deer, rabbit, raccoon, squirrel, and fish. Food crop samples collected were apples, corn, tomatoes, persimmons, okra, green beans, lima beans, purple hull peas, potatoes, pepper, and shelly beans. Figure 2.4.1 shows the locations where samples were obtained. Table 2.4.1 shows the concentration of various radionuclides analyzed (dry weight basis) in edible vegetation and animal tissue. Tissues were analyzed for ^{239}Pu , ^{99}Tc , ^{230}Th , ^{235}U , ^{237}Np , ^{234}U , and ^{238}U .

No appreciable uptake of any of the manmade radionuclides has occurred. The preponderance of apparent positive values reflects the fact that all materials are slightly radioactive; this makes the sample determination process subject to biases in regard to contamination. But when the $\pm$ value is taken off, it is equally likely that no negative activity is present.

Uranium is present throughout the environment in a natural state. However, some of the uranium data may not be accurate because of the low levels analyzed. For example, V8 (i.e., apples) appears to contain some enriched uranium because natural uranium has equal ^{234}U and ^{238}U activity. However, the ^{235}U value is higher than the ^{238}U value (which is impossible). Regardless of the assay enrichment, ^{235}U never has activity of more than 1% of the ^{234}U or ^{238}U values. Therefore, no appreciable uptake of enriched uranium has occurred.

2.4.2 Vegetation Sampling

Vegetation (i.e., grass) samples are collected at 18 locations every 3 months. The samples are returned to the laboratory, dried, and analyzed for fluorides. The primary objective of vegetation sampling is to determine the total fluorides in foliage for comparison with the fluoride-in-foliage section of the Kentucky air pollution control

Fig. 2.4.1. Fruit, vegetable, and animal collection locations.

Table 2.4.1. 1989 vegetation and tissue analysis (pCi/g)

Location (sample) ^a	²³⁷ Np	²³⁹ Pu	⁹⁹ Tc	²³⁰ Th	²³⁴ U	²³⁵ U	²³⁸ U
<i>Food crops and fruit</i>							
V1 (deer)	0.041 ± 0.029	-0.008 ± 0.017	-0.054 ± 0.703	0.005 ± 0.010	0.122 ± 0.068	0.016 ± 0.035	0.043 ± 0.041
V2 (rabbit)	0.015 ± 0.014	-0.027 ± 0.022	0.757 ± 0.703	0.027 ± 0.020	0.065 ± 0.038	0.057 ± 0.041	0.027 ± 0.027
V3 (raccoon)	-0.002 ± 0.005	-0.010 ± 0.027	0.059 ± 0.757	0.012 ± 0.015	0.127 ± 0.051	0.054 ± 0.038	0.097 ± 0.049
V4 (gray squirrel)	0.029 ± 0.027	-0.027 ± 0.041	0.811 ± 0.946	0.059 ± 0.038	0.514 ± 0.216	0.157 ± 0.151	0.351 ± 0.189
V5 (raccoon)	0.006 ± 0.014	-0.006 ± 0.015	0.351 ± 0.622	0.021 ± 0.021	0.081 ± 0.081	0.041 ± 0.038	0.029 ± 0.035
V6 (squirrel)	0.013 ± 0.011	-0.002 ± 0.019	-0.054 ± 0.595	0.027 ± 0.024	0.324 ± 0.297	0.029 ± 0.184	0.459 ± 0.297
V7 (fish)	0.002 ± 0.011	0.043 ± 0.062	1.541 ± 1.378	0.029 ± 0.029	0.784 ± 0.216	0.008 ± 0.057	1.081 ± 0.243
V8 (apples)	0.026 ± 0.025	-0.001 ± 0.021	0.595 ± 1.027	0.038 ± 0.035	1.162 ± 0.243	0.784 ± 0.189	0.622 ± 0.189
V9 (field corn)	-0.007 ± 0.011	-0.014 ± 0.020	-0.054 ± 0.622	0.004 ± 0.023	0.059 ± 0.038	-0.005 ± 0.032	-0.006 ± 0.024
V10 (okra)	0.008 ± 0.017	-0.008 ± 0.035	1.351 ± 1.568	-0.062 ± 0.837	0.211 ± 0.108	0.016 ± 0.041	0.019 ± 0.054
V11 (green beans)	-0.005 ± 0.027	-0.003 ± 0.041	0.054 ± 1.946	0.014 ± 0.049	0.097 ± 0.086	0.003 ± 0.049	0.046 ± 0.062
V12 (lima beans)	0.011 ± 0.032	0.011 ± 0.038	0.189 ± 1.324	0.041 ± 0.059	0.105 ± 0.065	0.051 ± 0.051	0.032 ± 0.035
V13 (tomatoes)	0.011 ± 0.065	-0.122 ± 0.103	-0.270 ± 2.973	0.049 ± 0.057	0.197 ± 0.173	0.095 ± 0.132	0.241 ± 0.157
V14 (purple hull peas)	0.002 ± 0.011	-0.007 ± 0.014	0.108 ± 0.892	0.011 ± 0.014	0.054 ± 0.051	0.030 ± 0.038	0.009 ± 0.027
V15 (potatoes)	-0.001 ± 0.013	-0.003 ± 0.027	0.054 ± 0.919	0.005 ± 0.012	0.068 ± 0.038	0.038 ± 0.035	0.027 ± 0.027
V16 (hot peppers)	0.001 ± 0.014	-0.027 ± 0.032	0.729 ± 1.189	0.015 ± 0.016	0.089 ± 0.062	0.011 ± 0.025	0.027 ± 0.038
V17 (sweet corn)	0.001 ± 0.015	-0.012 ± 0.022	-0.729 ± 1.324	-0.001 ± 0.006	0.027 ± 0.062	0.016 ± 0.046	0.022 ± 0.043
V18 (field corn)	0.003 ± 0.005	-0.008 ± 0.014	0.081 ± 0.459	0.007 ± 0.008	0.035 ± 0.043	0.005 ± 0.010	-0.002 ± 0.007
V19 (sweet corn)	0.003 ± 0.032	-0.027 ± 0.038	0.162 ± 1.649	0.016 ± 0.030	-0.003 ± 0.019	0.035 ± 0.087	0.019 ± 0.041
V20 (shelly beans)	0.001 ± 0.008	-0.012 ± 0.022	0.622 ± 1.054	0.008 ± 0.008	0.003 ± 0.046	0.024 ± 0.041	0.027 ± 0.030
V21 (tomatoes)	0.038 ± 0.122	-0.235 ± 0.197	-4.324 ± 4.595	0.514 ± 0.216	0.676 ± 0.459	0.081 ± 0.297	0.141 ± 0.197
V22 (field corn)	0.005 ± 0.011	-0.004 ± 0.011	-0.189 ± 0.378	0.006 ± 0.009	-0.022 ± 0.032	-0.027 ± 0.041	0.011 ± 0.038
V23 (garden mixture)	-0.014 ± 0.035	-0.051 ± 0.070	-2.140 ± 2.410	0.027 ± 0.032	0.119 ± 0.124	-0.022 ± 0.114	0.059 ± 0.105
V24 (sweet corn)	-0.001 ± 0.011	-0.018 ± 0.016	0.324 ± 0.378	0.006 ± 0.006	0.046 ± 0.029	0.017 ± 0.019	0.017 ± 0.023
V25 (garden mixture)	-0.002 ± 0.024	0.032 ± 0.081	-0.324 ± 1.950	0.027 ± 0.065	0.154 ± 0.176	0.062 ± 0.132	0.046 ± 0.122
V26 (persimmons)	-0.005 ± 0.009	0.001 ± 0.014	-0.054 ± 0.729	0.007 ± 0.009	0.049 ± 0.046	0.062 ± 0.051	0.013 ± 0.025
V27 (persimmons)	-0.003 ± 0.005	0.016 ± 0.022	0.270 ± 1.410	0.003 ± 0.010	0.073 ± 0.054	0.032 ± 0.041	0.027 ± 0.032
V28 (persimmons)	0.002 ± 0.010	0.001 ± 0.014	-0.486 ± 0.703	0.012 ± 0.011	0.084 ± 0.065	0.024 ± 0.041	0.003 ± 0.027
V29 (persimmons)	-0.001 ± 0.007	-0.013 ± 0.024	0.243 ± 0.595	0.005 ± 0.014	0.133 ± 0.079	0.005 ± 0.027	0.024 ± 0.038

^aSee Fig. 2.4.1.

regulations. Figure 2.4.2 shows the locations of the grass-sampling points. These locations represent the perimeter fence, property boundary, and 1.6- and 8-km (1- and 5-mile) areas as related to the primary emission point. Samples are delivered to the laboratory, air-dried for 1 month, digested, and analyzed for fluoride. Table 2.4.2 summarizes the analyses.

Samples collected outside the fence area are compared with the Kentucky Ambient Air Quality Standard of 60 $\mu\text{g/g}$ for a 2-month average. All samples were well below the 60- $\mu\text{g/g}$ standard. Samples taken outside the fence area range from <5% to <10% of the standard.

2.4.3 Polychlorinated Biphenyl Residues in Fish

Under the BMP being conducted by UK in collaboration with ORNL, PCBs were detected in fish tissues near the end of 1988 in Little Bayou Creek and outfall 011. This prompted development of a special PCB-monitoring plan that was implemented late in 1988. It emphasized the analysis of PCBs in edible tissues of fish collected from monitoring sites in Big and Little Bayou creeks, the Bayou/Ohio River confluence area, Metropolis lake, and five ponds on the WKWMA (see Fig. 2.4.3). The nature of fish populations within the Bayou drainage significantly limited the size and species of organisms available for study. Collecting methods included seining and electro-shocking. Data are given in Table 2.4.3 for sampling sites with fish containing PCB concentrations above 2 $\mu\text{g/g}$, the Food and Drug Administration (FDA) action level. Asterisks indicate instances where total PCB concentrations exceed 2 $\mu\text{g/g}$. Values below detection (indicated by a "less than" sign) were not included in these totals.

Five percent of the fish collected from Big Bayou Creek contained PCB residues above the FDA action level. The frequency and extent of contamination were somewhat higher for fish taken from sampling stations BB4 through BB7, a region that receives discharges from KPDES outfalls 008, 006, and 001. The lowest PCB residues were recorded for BB9, an area that is 7.6 km (4.71 miles) below the last flowing effluent that drains Big Bayou Creek.

Principal contamination in Little Bayou Creek centered on monitoring stations LB2 and LB2A situated just downstream from the 011 outfall. Eighty-four percent of fish analyzed from stations LB2 and LB2A contained PCB residues that exceeded the FDA limit. The frequency of FDA exceedences dropped to 42% in fish taken from LB3, and no exceedences were seen at LB4. Based on the PCB data obtained by UK, a fish consumption advisory was issued by the Kentucky Department for Environmental Protection in April 1989 for Little Bayou Creek.

Twenty-five fish were analyzed from the Bayou-Ohio River confluence site (i.e., CF1, CF2, and CF3). None of the fish analyzed contained PCBs above the FDA action level. Fish analyzed from Metropolis Lake, New Pond, Three-Lane Pond, Coon Club Pond, and Metzger Pond (all on the WKWMA) contained no PCBs above the FDA action level. However, 1.7 ppm PCB was discovered in one fish taken from Pond 1. Discussions by UK personnel with the Kentucky Department of Fish and Wildlife Resources revealed that carp has never been stocked by the department in the WKWMA ponds; therefore, this organism was introduced from an unknown source.

PCB studies focusing on water and sediment analyses are continuing in 1990. Also, the RAP is being implemented to define the sources of PCB contamination and to make provisions for cleanup activities.

2.5 SOIL AND SEDIMENT MONITORING

Soil and sediment data are collected to show the accumulation (if any) of pollutants that may have been deposited from airborne or waterborne sources. Although sampling procedures are designed to minimize the well-known variability found in soils and sediments, the significance of individual data points is small. Data collected over a period of years may detect trends if they exist.

2.5.1 Soil Sampling

Soil samples are taken annually at 10 locations: north, south, east, and west at the property boundary and at distances of 8 km

Fig. 2.4.2. Grass-sampling locations.

Table 2.4.2. PGDP fluoride in grass, 1989 (dry weight)

Growing season is April through September

Point ^a	No. of samples	Min (μg/g)	Max (μg/g)	Annual Av (μg/g)	Av during growing season (μg/g)	Std ^b (μg/g)	% Std
G1	4	4	14.1	8.8	11.1	c	
G2	4	<3	12	<6.6	11.3	c	
G3	4	<3	8.3	<6.3	<5.7	c	
G4	4	<3	6.8	<4.7	<4.9	c	
G5	4	4.5	11	6.8	4.6	60	8
G6	4	<3	8.4	5.9	<5.7	60	<10
G7	4	3.9	9	5.7	3.9	60	7
G8	4	<3	7	<4.5	<3	60	<5
G9	4	<3	9	<5.3	<3.6	60	<6
G10	4	<3	12	<6.2	<3.4	60	<6
G11	4	<3	8.5	<5.4	<5.8	60	<10
G12	4	<3	6	<4.5	<3	60	<5
G13	4	<3	9	<5.2	<4	60	<7
G14	4	<3	6	<3.8	<3	60	<5
G15	4	3.9	8	6.3	5.2	60	<9
G16	4	<3	5	<4.1	<3.7	60	<6
G17	4	<3	8	<4.9	<3.4	60	<6
G18	4	<3	13	<7.3	<4.6	60	<8

^aSee Fig. 2.4.2.^bKentucky Ambient Air Quality Standards (401 KAR 53:010): Fluoride measured in and on forage is not to exceed an average of 40 μg/g over the growing season, 60 μg/g for a 2-month average, or 80 μg/g for a 1-month average (dry weight).^cSampling locations are on government property inside the plant security fence.Note: Lower limit of detection is 3 μg F⁻/g.

(5 miles) beyond the property boundary (see Fig. 2.5.1). Remote (background) samples are taken at two locations 13 to 15 km (8.08 to 9.32 miles) from PGDP. Each sampling site was selected because the soil appeared (or was known) to have been undisturbed for a number of years. Two 1-m² (11-ft²) areas 3 m (10 ft) apart are measured out. The vegetation to a height of 10 to 20 mm (0.4 to 0.8 in.) above the soil is removed. Samples from the center and each corner of the 1-m² area are removed by pushing down and twisting the sampler into the soil to a depth of 5 cm (2 in.). The plugs of soil are composited into a labeled plastic bag. Table 2.5.1 lists samples analyzed for parameters.

Table 2.5.2 gives the concentrations of uranium in soil samples from 1985 through 1989. The average uranium content of all property boundary samples is higher than the average for

the 8-km (4.97-mile) samples and three and one-half times that for the background samples. The range of sample analyses during 1989 was from lows of 0.7 μg of uranium per gram of soil at the background site west of PGDP to a high of 5.6 μg/g at the south boundary. The concentrations of uranium in soil (Table 2.5.2) are typical of soils in western Kentucky.

Table 2.5.3 lists the concentrations for PCBs and radionuclides. No significant differences between property boundary locations and remote locations were noted except for ⁹⁹Tc and PCB. The concentrations of ⁹⁹Tc and PCBs were higher at property boundary locations than at other locations. Analysis of each soil sample for 36 metals revealed no significant differences in concentration of any element between each location.

ORNL-DWG 89-6364 R

Fig. 2.4.3. Fish-sampling locations at PGDP.

2.5.2 Sediment Sampling

The stream bottom is a very important constituent of the aquatic environment. If a pollutant is a suspended solid or attached to suspended sediment, it can settle to the bottom (hence the need for sediment sampling), be filtered by certain organisms, or become attached to plant surfaces. Pollutants in solution can adsorb on suspended organic and inorganic solids or be assimilated by plants and animals. The suspended solids, dead biota, or excreta settle to the bottom and become part of the organic substrate that supports the bottom-dwelling community of organisms. Figure 2.5.2 shows possible exposure

routes (Jinks and Eisenbud 1972) of trace metals (including uranium) in an aquatic ecosystem.

Sediments play a dominant role in aquatic ecology by serving as a repository for radioactive or chemical substances that pass via the bottom-feeding biota to the higher trophic levels. Soluble pollutants introduced into a body of water reach the bottom sediment primarily by adsorption on suspended solids that later deposit on the bottom. The deposited remains of biota having absorbed pollutants may also be an important source of radioactive and chemical pollutants that enter the food chain.

Sediment samples were taken from 28 locations. Figure 2.5.3 shows the location of each

**Table 2.4.3. Polychlorinated biphenyl muscle residues in fish collected through July 1989
from Big Bayou Creek (BB), McCracken County, Kentucky**

Stream station	Fish species and number	Collection date	Otolith age (years)	Length (mm)	Wet wt (g)	Muscle lipid (mg/g) ^a	Aroclor concentration (μg PCN/g muscle) ^b		
							1248	1254	1260
BB4	Green sunfish (1)	12/16/87	2+	128.0	34.72	3.60	<0.07	0.16	0.08
	Green sunfish (2)	12/16/87	2+	100.0	16.38	4.16	<0.09	0.47	0.10
	Green sunfish (3)	12/16/87	2+	105.0	17.12	3.83	<0.10	0.57	0.15
	Green sunfish (4)	12/16/87	1+	95.0	12.45	4.11	<0.13	0.86	1.17*
	Green sunfish (1)	12/15/88	3+	147.0	48.21	4.03	<0.04	0.24	0.25
	Green sunfish (2)	12/15/88	2+	139.0	43.00	4.82	2.24	2.00	0.47*
	Green sunfish (3)	12/15/88	3+	141.0	45.10	0.77	<0.05	0.06	<0.05
	Green sunfish (4)	12/15/88	2+	124.0	29.69	4.78	<0.07	0.21	0.10
	Bluegill (1)	12/15/88	1+	80.0	8	8.22	<0.11	0.44	0.20
	Longear sunfish (1)	12/15/88	2+	130.0	34.37	5.46	<0.06	0.23	0.21
	Longear sunfish (2)	12/15/88	3+	119.0	30.64	5.35	<0.06	0.45	0.36
	Longear sunfish (3)	12/15/88	2+	118.0	23.49	5.91	<0.08	0.26	0.10
	Yellow Bullhead (1)	12/15/88		144.0	29.77	6.05	<0.10	0.34	0.34
	Green sunfish (1)	2/09/89	3+	134.0	35.60	4.33	<0.07	0.11	0.12
BB6	Longear sunfish (1)	2/09/89	2+	113.0	24.27	5.46	<0.08	0.52	0.34
	Longear sunfish (2)	2/09/89	2+	108.0	22.46	4.73	<0.10	0.40	0.25
	Green sunfish (1)	12/15/88	2+	147.0	48.87	3.57	1.54	1.40	0.16*
	Green sunfish (2)	12/15/88	3+	126.0	28.04	2.08	0.39	0.17	0.13
	Green sunfish (3)	12/15/88	2+	121.0	26.67	4.27	0.77	0.34	0.16
	Green sunfish (4)	12/15/88	2+	120.0	26.48	3.34	<0.09	2.30	2.41*
	Longear sunfish (1)	12/15/88	3+	140.0	41.84	4.44	<0.05	0.73	0.37
	Green sunfish (1)	3/29/89	3+	106.0	20.11	5.28	<0.10	0.55	0.49
	Green sunfish (2)	3/29/89	2+	115.0	24.44	4.48	0.25	<0.08	0.24
	Green sunfish (3)	3/29/89	3+	122.0	27.55	4.53	0.62	0.51	0.55
	Green sunfish (4)	3/29/89	2+	126.0	31.53	4.43	1.49	1.27	0.56*
	Green sunfish (5)	3/29/89	3+	153.0	50.60	3.61	<0.05	0.23	0.38
	Longear sunfish (1)	3/29/89	3	102.0	20.75	4.87	<0.09	0.49	0.20
	Longear sunfish (2)	3/29/89	1+	114.0	25.94	5.31	1.02	1.21	0.33*
BB9	Spotted bass (1)	3/29/89	1+	160.0	47.00	3.97	<0.04	0.20	0.21
	Bluegill (1)	7/20/89	3+	96.0	14	3.80	0.19	0.15	0.08
	Bluegill (2)	7/20/89	3+	143.0	67	4.45	0.26	0.25	0.07
	Longear sunfish (1)	7/20/89	3+	137.0	58	3.85	0.53	0.47	0.19
	Longear sunfish (2)	7/20/89	3+	132.0	49	3.56	1.83	0.96	0.68*
	Yellow bullhead (1)	7/20/89		134.0	26	3.40	<0.06	0.24	0.13
	Largemouth bass (1)	7/20/89	4+	183.0	80	4.74	0.27	0.21	0.11
	Bluegill (1)	3/30/89	2	92.0	16.88	7.80	<0.11	<0.11	<0.11
	Bluegill (2)	3/30/89	1+	103.0	21.49	7.70	<0.09	<0.09	<0.09
	Longear sunfish (1)	3/30/89	3+	106.0	25.64	8.37	<0.08	0.10	<0.08
	Spotted bass (1)	3/30/89	1+	193.0	107.92	7.00	<0.08	0.16	0.12
	Spotted bass (2)	3/30/89	2+	287.0	306.64	5.35	<0.04	0.16	0.04
	Spotted bass (3)	3/30/89	2+	294.0	397.39	4.86	<0.04	0.09	0.05
	Carp (1)	3/30/89		565.0	2419.00	74.74	<0.04	3.60	0.46*
BB9	Longear sunfish (1)	7/20/89	3+	104.0	23	5.49	<0.09	<0.09	<0.09
	Longear sunfish (2)	7/20/89	2+	90.0	14	5.74	<0.08	0.08	<0.08
	Longear sunfish (3)	7/20/89	1+	96.0	21	11.72	<0.08	<0.08	<0.08
	Longear sunfish (4)	7/20/89	3+	106.0	27	11.53	<0.07	0.11	<0.07
	Longear sunfish (5)	7/20/89	4+	113.0	30	8.34	<0.07	<0.07	<0.07
	Longear sunfish (6)	7/20/89	4+	132.0	41	4.05	<0.05	0.15	0.12
	Longear sunfish (7)	7/20/89	3+	114.0	30	8.23	<0.07	<0.07	<0.07
	Longear sunfish (8)	7/20/89	4+	126.0	44	3.70	<0.07	0.11	0.07
	Spotted bass (1)	7/20/89	2+	227.0	178	5.61	<0.06	0.18	0.08

Table 2.4.3 (continued)

Stream station	Fish species and number	Collection date	Otolith age (years)	Length (mm)	Wet wt (g)	Muscle lipid (mg/g) ^a	Aroclor concentration (μ g PCN/g muscle) ^b		
							1248	1254	1260
011	Green sunfish (1)	12/16/87	2+	137.0	40.92	3.08	7.04	9.46	4.03*
	Green sunfish (2)	12/16/87	1+	88.0	10.01	5.38	9.19	8.88	4.93*
	Green sunfish (3)	12/16/87	1+	94.0	10.66	7.71	3.17	4.56	2.59*
LB2A	Green sunfish (1)	12/15/88	0+	59.4	3.15	16.93	3.52	<0.57	1.32*
	Green sunfish (2)	12/15/88	1+	91.6	12.15	6.27	1.33	0.47	<0.16
	Bluegill (1)	12/15/88	1+	101.2	16.06	4.96	4.63	2.54	0.49*
	Bluegill (2)	12/15/88	1+	93.8	13.44	5.81	3.65	2.89	0.63*
	Bluegill (3)	12/15/88	0+	94.3	14.05	11.84	0.65	11.64	1.93*
	Bluegill (4)	12/15/88	0+	70.0	5.97	28.49	2.88	<0.40	1.28*
	Longear sunfish (1)	12/15/88	2+	130.0	45.39	2.32	0.53	<0.03	0.09
	Longear sunfish (2)	12/15/88	2+	123.4	29.41	3.13	<1.19	4.39	1.48*
	Longear sunfish (3)	12/15/88	2+	126.0	32.12	3.89	<0.62	15.81	4.45*
	Largemouth bass (1)	12/15/88	0+	147.0	41.51	4.26	0.42	1.82	0.70*
	Bluegill (1)	7/20/89	3+	170.0	97	3.55	1.50	1.24	0.27*
	Longear sunfish (1)	7/20/89	4+	195.0	142	3.70	1.46	1.15	0.53*
	Longear sunfish (2)	7/20/89	3+	152.0	64	2.41	7.64	5.54	1.97*
	Longear sunfish (3)	7/20/89	4+	180.0	142	11.37	0.20	0.20	0.07
	Largemouth bass (1)	7/20/89	2+	194.0	112	7.57	3.85	4.38	1.48*
LB2	Green sunfish (1)	12/15/88	2+	143.0	51.69	4.05	0.89	0.34	0.09
	Green sunfish (2)	12/15/88	2+	137.2	39.85	4.59	1.75	1.03	0.49*
	Green sunfish (3)	12/15/88	2+	123.0	29.36	5.23	3.04	3.15	0.80*
	Green sunfish (4)	12/15/88	1+	117.0	27.03	5.95	4.01	4.17	0.89*
	Bluegill (1)	12/15/88	3+	171.0	96.7	4.53	2.04	0.84	0.59*
	Bluegill (2)	12/15/88	4+	166.0	84.9	4.62	2.26	1.08	0.33*
	Bluegill (3)	12/15/88	2+	142.0	54.61	2.82	0.25	<0.04	0.19
	Bluegill (4)	12/15/88	3+	154.0	65.12	2.02	3.41	3.01	0.75*
	Longear sunfish (1)	12/15/88	3+	152.0	82.4	7.61	2.97	<0.42	0.42*
	Longear sunfish (2)	12/15/88	2+	143.3	58.01	4.22	2.03	1.13	0.31*
	Longear sunfish (3)	12/15/88	2+	134.0	44.83	6.09	2.33	1.51	0.36*
	Largemouth bass (1)	12/15/88	2+	301.0	374.2	4.65	4.49	<0.41	1.07*
	Largemouth bass (2)	12/15/88	2+	291.0	312.1	1.51	2.98	1.63	0.52*
	Largemouth bass (3)	12/15/88	0+	174.0	47.7	4.07	<0.29	0.42	0.45
	Black bullhead (1)	12/15/88		79.4	5.53	4.05	2.84	1.68	0.60*
	Green sunfish (1)	3/30/89	1+	72.0	6.36	6.71	1.85	1.57	0.61*
	Green sunfish (2)	3/30/89	1	82.0	7.95	5.75	3.73	3.37	0.53*
	Green sunfish (3)	3/30/89	1+	83.0	9.53	5.24	2.82	3.96	1.64*
	Green sunfish (4)	3/30/89	2+	87.0	10.55	5.77	1.16	1.64	0.69*
	Longear sunfish (1)	3/30/89	1+	82.0	10.04	6.68	3.26	4.41	1.43*
	Longear sunfish (2)	3/30/89	2	86.0	11.34	5.03	1.04	2.33	0.78*
	Longear sunfish (3)	3/30/89	2+	96.0	15.52	5.17	2.26	5.60	2.55*
	Longear sunfish (4)	3/30/89	2+	115.0	25.64	3.68	2.33	4.89	2.18*
LB3	Green sunfish (1)	12/15/88	2+	93.0	11.63	4.26	2.60	0.98	0.78*
	Green sunfish (2)	12/15/88	3+	130.8	34.77	2.87	0.69	<0.05	0.39
	Bluegill (1)	12/15/88	0+	64.5	3.77	6.50	1.97	1.57	0.53*
	Longear sunfish (1)	12/15/88	2+	98.8	15.92	5.70	<0.10	7.32	2.18*
	Longear sunfish (2)	12/15/88	1+	88.7	13.63	5.18	0.41	1.22	0.60*
	Creek chub (1)	12/15/88		122.8	18.55	11.33	0.28	<0.09	0.13
	Creek chub (2)	12/15/88		97.6	9.79	17.73	1.61	<0.15	0.38
	Creek chub (3)	12/15/88		91.0	7.60	16.81	0.31	0.37	0.24
	Creek chub (4)	12/15/88		98.4	9.99	12.68	0.45	0.38	0.21

Table 2.4.3 (continued)

Stream station	Fish species and number	Collection date	Otolith age (years)	Length (mm)	Wet wt (g)	Muscle lipid (mg/g) ^a	Aroclor concentration (μg PCN/g muscle) ^b		
							1248	1254	1260
	Green sunfish (1)	3/30/89	1+	89.0	11.13	5.93	0.55	0.61	0.29
	Green sunfish (2)	3/30/89	1+	86.0	11.09	6.82	3.21	3.15	0.65*
	Green sunfish (3)	3/30/89	1+	95.0	16.14	5.56	1.25	1.61	0.44*
	Green sunfish (4)	3/30/89	2+	124.0	34.48	4.31	0.37	0.44	0.15
	Bluegill (1)	3/30/89	2+	110.0	23.69	3.46	0.48	0.49	0.21
	Longear sunfish (1)	3/30/89	1+	86.0	12.41	6.32	1.58	1.92	0.38*
	Longear sunfish (2)	3/30/89	1+	89.0	14.27	6.05	0.59	0.86	0.22
	Longear sunfish (3)	3/30/89	2	96.0	17.37	4.67	0.86	0.91	0.38*
	Yellow bullhead (1)	3/30/89		195.0	85.68	4.00	0.92	0.81	0.17
	Yellow bullhead (2)	3/30/89		151.0	39.76	4.12	0.78	0.53	0.30

^aShift decimal point one place to the left for percent lipid.

^bAsterisks denote Aroclor concentration totaling 2 μg/g or more.

sampling point. At each location a clean sampling scoop is used to scoop up material (taking as few rocks as possible) from the bottom of the stream or lagoon. Approximately 2 kg (4.5 lb) of sediment is placed in a new plastic bag. The samples are dried and delivered to the analytical laboratory. Table 2.5.1 lists a summary of the collection and analyses frequencies.

Table 2.5.4 gives radionuclide and PCB data. Analysis showed that PCBs, U, Tc, Pu, Np, and Cs concentrations were elevated in several on-site ditches compared with background data from Nasty Creek and Brushy Creek. (Cesium is present throughout the world from weapons testing.) For example, elevated U, PCBs, Tc, Np, Pu, and Cs levels were seen in the C-615 sewage treatment plant sludge. However, the sewage sludge is drummed annually for storage. Also, concentrations of PCBs, U, Cs, Np, Pu, and Tc are present above background levels in the north/south diversion ditch. PCBs are also present above background in Little Bayou Creek. This creek was posted with a fish consumption advisory in April of 1989.

2.6 EXTERNAL GAMMA RADIATION MONITORING

2.6.1 Sampling Program

Thermoluminescent dosimeters (TLDs) are placed in the environment to obtain data on external gamma radiation. Fifteen monitoring dosimeters were in use during each of the four quarters. Figure 2.6.1 gives the locations of the monitoring dosimeters. Ten quality control TLDs were in use during each quarter; Fig. 2.6.2 shows their locations.

2.6.2 Sample Collection

The external gamma radiation program is conducted using guidance from ANSI Standard N545-1975. The TLDs are identified, annealed, calibrated, packaged, and shipped by ORNL. When they are received by PGDP, they are promptly positioned in the PGDP environment approximately 1 m (3 ft) above the ground. The TLD packages are placed adjacent to the housings of air-sampling stations, at a nearby resident's

ORNL-DWG 87-6712B

Fig. 2.5.1. PGDP soil-sampling locations.

Table 2.5.1. Summary of collection and analysis frequencies of soil and sediment samples in 1989

Station	Parameter	Collection frequency	Sample type	Analysis frequency
S1, S2, S3, S4, S5, S6, S7, S8, S9, S10 ^a	Soil U, ²³⁹ Pu, ²³⁷ Np, ¹³⁷ Cs, ²³⁵ U, ²³⁰ Th, ⁹⁹ Tc, ⁴⁰ K, PCB, Ag, Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Ru, Sb, Si, Sn, Sr, Ta, Th, Ti, Tl, V, W, Zn, Zr, As and Hg on S5-S10	Annually	Grab	Annually
SS1, SS2, SS3, SS4, SS5, SS6, SS7, SS8, SS9, SS10, SS11, SS12, SS13, SS14, SS15, SS16, SS17, SS18, SS19, SS20, SS21, SS22, SS23, SS24, SS25, SS26, SS27, SS28 ^b	¹³⁷ Cs, ⁴⁰ K, ²³⁷ Np, ²³⁹ Pu, ⁹⁹ Tc, ²³⁰ Th, ²³⁴ U, ²³⁸ U, ²³⁵ U, PCB, Ag, Al, Ba, Be, Bi, Cd, Ca, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Ru, Sb, Si, Sn, Sr, Ta, Th, Ti, Tl, V, W, Zn, Zr, As on SS19, SS20, SS21, SS27, SS28	Annually	Grab	Annually

^aSee Fig. 2.5.1.^bSee Fig. 2.5.3.

Table 2.5.2. Concentration of uranium in soil at PGDP, 1985–1989^a
($\mu\text{g/g}$)

Location	1985	1986	1987	1988	1989
<i>Property boundary</i>					
S1 (north)	5	6	4.8	4.9	2.2
S2 (east)	3	5	3.4	4.6	2.4
S3 (south)	2	6	5.5	4.3	5.6
S4 (west)	3	3	2.5	2.2	1.4
<i>8 km from plant</i>					
S5 (north)	3	4	3.9	4.2	2.2
S6 (east)	2	3	2.6	2.3	1.1
S7 (south)	3	4	2.7	2.5	1.2
S8 (west)	2	4	2.8	3.4	1.2
<i>13 to 15 km from plant</i>					
S9 (south)	1	2	2.4	2.5	0.8
S10 (west)	2	3	2.9	2.1	0.7

^aSee Fig. 2.5.1.

Table 2.5.3. Radionuclide and polychlorinated biphenyl concentration in soil at PGDP in 1989

Location ^a	²³⁵ U (wt %)	¹³⁷ Cs (pCi/g)	⁴⁰ K (pCi/g)	²³⁷ Np (pCi/g)	²³⁹ Pu (pCi/g)	²³⁰ Th (pCi/g)	⁹⁹ Tc (pCi/g)	PCB ($\mu\text{g/g}$)
<i>Property boundary</i>								
S1 (north)	0.74	0.173	9.99	0.003	0.006	0.891	0.035	<0.1
S2 (east)	0.63	0.486	8.91	0.0001	0.002	0.540	0.068	0.1
S3 (south)	0.74	1.755	1.08	0.008	0.051	0.248	0.205	0.2
S4 (west)	0.55	1.053	3.78	0.0002	0.019	0.165	0.224	0.2
<i>8 km from plant</i>								
S5 (north)	0.40	0.324	10.80	0.008	0.008	0.594	0.111	<0.1
S6 (east)	0.63	1.252	10.26	0.002	0.030	0.351	0.057	<0.1
S7 (south)	0.65	0.351	10.80	0.002	0.006	0.459	0.008	<0.1
S8 (west)	0.94	0.594	9.450	-0.006	0.001	0.459	0	<0.1
<i>13 to 15 km from plant</i>								
S9 (south)	0.57	0.216	10.26	0.003	0.008	0.297	0.014	<0.1
S10 (west)	0.65	0.111	11.61	-0.0005	-0.006	0.513	-0.011	<0.1

^aSee Fig. 2.5.1.

ORNL - DWG 86-9977

Fig. 2.5.2. Routes of trace metals in an aquatic ecosystem. Source: Jinks and Eisenbud 1972.

house, and at two background locations. After the quarterly exposure period the TLDs are collected and returned to ORNL for exposure determination.

Ten quality control TLDs are used. Field cycle dependence controls are manipulated with six of the control TLDs (i.e., freezer cycle, oven cycle, and office cycles at one-half and whole field cycles for each control). Light dependence checks are performed on four TLDs at the EG3 location. One freezer cycle TLD is left in the freezer for a full

quarter, and one is removed after half a quarter and placed in a lead pig for the rest of the quarter. The results of the full cycle TLD and twice the one-half cycle TLD must agree within 85%. One oven cycle TLD is left in a 95°F oven for a full quarter, and one is removed after half a quarter and placed in a lead pig for the rest of the quarter. The results of the full cycle TLD and twice the one-half cycle TLD must agree within 85%. One office cycle TLD is left out for a whole quarter, and one is placed in a lead pig after half a quarter.

Fig. 2.5.3. PGDP sediment-sampling locations.

The results of the full cycle TLD and twice the one-half cycle TLD must agree within 90%. The light dependence TLDs are placed at the PS location (EG3) because of the low-level gamma radiation given off from the cylinder yard at this location. One is unaltered; the second is wrapped in aluminum foil. The third and fourth TLDs are exposed to 100 mrem of gamma, and then the fourth is wrapped in aluminum foil. Results for each of the pairs must agree within 10%. ORNL also analyzes the quality control TLDs.

2.6.3 Conclusions

Table 2.6.1 shows the average exposure for each TLD location. Table 2.6.2 lists quality control data for the TLDs. The mean exposure rate as measured by the TLDs (excluding perimeter fence data) is approximately 36.7 mrem/year. The 1988 mean exposure rate measured by PGDP was 38 mrem/year. The average external whole-body

doses received by people throughout Kentucky and Tennessee are 60 and 70 mrem/year respectively (see Fig. 2.6.3). The higher exposure rates at locations on the east, south, and west perimeter fences potentially reflect the low-level gamma radiation from uranium in the cylinder storage yards. Figure 2.6.4 shows cosmic and terrestrial radiation levels in various states.

The 9 mrem/year exposure rate measured by the TLD system during 1989 cannot be assumed to be accurate because of the lack of agreement of the quality control measurements with ANSI Standard N545-1975. None of the office cycle TLDs were within the 90% agreement specification set by the ANSI standard. Two quarters of the oven cycle and one quarter of freezer cycle measurements did not meet ANSI requirements. One quarter of light dependence, unspiked measurements did not agree with the ANSI standard requirements. One quarter of the light dependence, spiked data did not agree with the

Table 2.5.4. 1989 PGDP sediment data

Location ^a	⁹⁹ Tc (pCi/g)	²³⁷ Np (pCi/g)	²³⁹ Pu (pCi/g)	²³⁰ Th (pCi/g)	¹³⁷ Cs (pCi/g)	⁴⁰ K (pCi/g)	²³⁵ U (wt %)	U (μg/g)	PCB (μg/g)
SS1 Big Bayou	0.513	0.002	0.003	0.076	0.05	1.11	0.52	3.0	<1.0
SS2 Little Bayou	0.297	-0.0008	-0.002	0.251	0.057	1.76	0.33	3.6	0.4
SS3 N/S diversion ditch (L-13)	143	1.19	0.65	11.34	0.13	10.80	1.46	50.3	0.3
SS4 C-340 ditch (K-011)	1.13	0.006	0.001	0.81	0.14	9.18	0.15	545	5.1
SS5 C-616 full-flow lagoon	351	1.94	0.29	0.41	1.19	10.53	0.60	137	<0.1
SS6 C-616 sludge lagoon	0.76	0.015	0.0008	0.432	0.03	2.35	0.57	3.5	4.2
SS7 C-615 sewage sludge	13.5	0.19	0.22	0.76	1.54	6.75	0.64	1796	96
SS8 C-335 ditch (K-001)	29.7	0.073	0.014	37.8	0.003	6.75	0.60	19.3	0.1
SS9 overflow diversion ditch (K-003)	37.8	0.73	1.89	0.65	0.68	10.26	0.98	32.3	0.5
SS10 C-337 ditch east (K-002)	0.135	0.004	0.0003	0.297	0.043	5.67	0.94	1.6	<0.1
SS11 C-331 ditch (K-010)	0.999	0.024	0.004	45.9	0.14	5.94	0.31	8.8	0.1
SS12 C-333 ditch (K-012)	-0.008	0.009	0.002	0.378	0.032	7.56	0.57	1.2	<0.1
SS13 southwest ditch (K-009)	1.32	0.021	0.012	0.238	0.068	5.13	0.45	2.5	<0.1
SS14 west ditch dam 7 (K-008)	32.4	0.38	0.41	2.30	0.24	8.91	0.82	58.1	1.1
SS15 west ditch dam 8 (K-015)	0.59	0.018	0.010	0.46	0.19	9.18	0.43	10.4	<0.1
SS16 C-720 parking lot into southwest ditch	4.05	0.032	0.097	0.62	0.11	7.83	0.64	5.4	0.4
SS17 C-333 ditch into southwest ditch	0.111	0.008	-0.004	0.65	0.003	8.37	0.63	1.4	0.1
SS18 C-611 sludge	0.14	-0.002	0.0003	-0.35	0.059	-1.81	0.72	2.2	<0.1
SS19 upstream Big Bayou wooden bridge	0.194	0.001	0.003	0.16	0.014	1.41	0.63	2	<0.1
SS20 upstream Big Bayou (L-1)	0.022	-0.0003	-0.0003	0.351	0.054	6.75	0.76	0.8	0.1
SS21 upstream Little Bayou	0.116	0.008	-0.003	0.513	0.081	8.37	0.63	5.8	<0.1
SS22 K-013	0.567	0.0003	0.003	0.594	0.12	9.72	0.34	5.1	<0.1
SS23 K-016	1.19	0.010	-0.014	0.43	0.41	7.56	0.72	1.0	0.2
SS24 K-017	-0.068	0.0003	0.001	0.32	0.016	9.99	0.39	0.7	<0.1
SS25 K-018	14.04	0.14	0.837	15.66	0.186	4.59	0.58	13.1	0.2
SS26 upstream of C-340 oil dam	1.57	0.013	0.004	1.08	0.11	8.37	0.15	366	<0.1
SS27 Brushy Creek	1.94	0.04	0.002	0.125	0.02	1.6	0.71	3.0	<0.1
SS28 Nasty Creek	1.56	0	0.02	0.125	0.073	5.7	0.71	4.0	<0.1

^aSee Fig. 2.5.3.

standard. Because of the extremely small amount of gamma radiation emitted by PGDP in comparison with natural background radiation, accurate measurements using TLDs are difficult to

obtain. The program is currently being evaluated to determine whether to change to a different gamma measurement system or to discontinue the program.

Fig. 2.6.1. Thermoluminescent dosimeter locations at PGDP.

ORNL-DWG 89-6361

Fig. 2.6.2. Quality control thermoluminescent dosimeter locations at PGDP.

Table 2.6.1. 1989 PGDP external gamma exposure

ID ^a	Location	Average (mrem/year)
EG1	Air sampler perimeter north (PN)	40.2
EG2	Air sampler perimeter east (PE)	478.7
EG3	Air sampler perimeter south (PS)	471.9
EG4	Air sampler perimeter west (PW)	117.3
EG5	Air sampler boundary north (BN)	42.6
EG6	Air sampler boundary east (BE)	32.1
EG7	Air sampler 1 mile north (1N)	26.2
EG8	Air sampler 1 mile east (1E)	22.4
EG9	Air sampler 1 mile south (1S)	37.7
EG10	Air sampler 1 mile southeast (1SE)	40.3
EG11	Air sampler 1 mile west (1W)	40.2
EG12	Air sampler in Grahamville	34.8
EG13	House in McGruder Village	38.8
EG14 ^b	House in Paducah near Noble Park	37.2
EG15 ^b	House south of Paducah on Oaks Road	51.0

^aSee Fig. 2.6.1.^bNot shown in Fig. 2.6.1.

Table 2.6.2. 1989 QC data for PGDP external gamma exposure

ID ^a	Location and description	First quarter (mrem/h)	Second quarter (mrem/h)	Third quarter (mrem/h)	Fourth quarter (mrem/h)
QC1	Office cycle, C-710	0.0017	0.00127	0.00243	0.00121
QC2	1/2 office cycle, C-710	0.00049	0.00269	0.00190	0.00154
		29% agreement	47% agreement	78% agreement	79% agreement
QC3	Freezer cycle, C-710	0.00631	0.00337	0.00206	0.00102
QC4	1/2 freezer cycle, C-710	0.00543	0.00321	0.00218	-0.00062
		86% agreement	95% agreement	94% agreement	Not calculated
QC5	Oven cycle, C-710	0.00216	0.00289	0.0028	0.00073
QC6	1/2 oven cycle, C-710	0.00114	0.00154	0.00322	0.00067
		53% agreement	53% agreement	87% agreement	92% agreement
QC7	Light dependence, unwrapped, EG3	0.0528	0.0523	0.0574	0.0536
QC8	Light dependence, wrapped, EG3	0.0429	0.0486	0.0572	0.0499
		81% agreement	93% agreement	100% agreement	93% agreement
QC9	Light dependence, unwrapped, spiked 100 mrem, EG3	0.0817	0.103	0.104	0.079
QC10	Light dependence, wrapped, spiked 100 mrem, EG3	0.0772	0.095	0.107	0.0944
		94% agreement	92% agreement	97% agreement	84% agreement

^aSee Fig. 2.6.2.

Fig. 2.6.3. External whole-body gamma exposure for residents of Kentucky, neighboring states, and the United States.

Fig. 2.6.4. External cosmic and terrestrial radiation levels.

3. POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

The PGDP emits effluents, some of which are radioactive and some of which are chemically or biologically reactive. Waste minimization and pollution abatement systems reduce these effluents, and emission and environmental monitoring is used to evaluate these controls and compliance with regulations and to enable estimations of the radiation and chemical doses received by members of the public.

3.1 RADIATION DOSE

Radioactive emissions to air and water are monitored to determine the extent to which the general public could be exposed and to demonstrate compliance with EPA regulations and DOE directives on radiation exposure to the public. EPA regulations for emissions of radionuclides from PGDP to the atmosphere are regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP). For 1989, NESHAP limits annual radionuclide emissions to a level that will not cause any member of the general public to receive total radiation dose equivalents that are equal to or greater than 25 mrem to the whole body or 75 mrem to any organ. Beginning in 1990 the NESHAP limit will be expressed in the currently accepted units of radiation dose, the effective dose equivalent. The new limit will be based on a total effective dose equivalent of less than 10 mrem to any member of the public. Since use of new limit is conservative with respect to the old limits and it uses contemporary units, all dose estimates are presented as effective dose equivalents. Calculated whole-body and maximum-organ dose equivalents were only 0.000008% and 0.001%, respectively, of their limits and were reported to the EPA (Mitchell Apr. 18, 1990). In Order 5400.5 related to off-site exposure, DOE limits the dose to members of the public to

less than 100 mrem per year from all pathways resulting from the operation of a DOE facility.

Liquid effluents are monitored to determine the total quantity of waterborne radionuclides going to the environment. The concentrations of various radionuclides are measured in the creeks and in groundwater under the plant.

The airborne radioactivity from PGDP operations is normally too low to be detected in the presence of natural background radiation in the environment. Therefore, potential doses to the public are calculated through the use of a dispersion model. This model calculates how measured quantities of released radionuclides mix with the atmosphere, where they travel, how they are diluted, and where they may deposit. Once the dispersion is calculated, population data and concentration/dose conversion factors are used to calculate individual and population doses.

The calculations were made using the AIRDOS-EPA suite of computer codes (Moore et al. 1979; Sjoreen and Miller 1984; Begovich et al. 1981). The computer codes used plant-specific radionuclide emission data for 1989, meteorological data collected during 1989 at the 60-m station at the Paducah site, and dose conversion factors based on the International Commission on Radiological Protection (ICRP). Organ weighting factors used in estimating effective dose equivalents are based on ICRP recommendations (ICRP 1977). Also, it was assumed that one-third of the food consumed was grown locally and that two-thirds was imported.

The calculated 50-year committed effective dose equivalent to the maximally exposed individual is estimated to be 1×10^{-4} mrem (well below the 10-mrem limit). Table 3.1.1 shows historical data for doses to the maximally exposed individual, who, under most circumstances, is the person living closest to the plant in the

Table 3.1.1. Maximum off-site radiological dose to a resident near PGDP

Year	Effective ^a
1985	NC ^b
1986	NC
1987	0.0092
1988	0.0029
1989	0.00014

^aFifty-year committed effective dose equivalent rate (mrem).

^bNC = not calculated.

predominant wind direction. The effective dose equivalent takes into account the total risk associated with the exposure of each part of the body in which radioactive material may accumulate as well as the exposure of the body as a whole. The calculations use retention factors to arrive at the dose that may be received over the next 50 years from exposure in 1989. Such doses are called the 50-year committed dose and account for exposure resulting from inhalation and ingestion of the radioactive material, immersion in air or water containing such materials, and exposure to radiation from material deposited on surfaces.

The maximally exposed individual for 1989 is located 3050 m (10,000 ft) north-northeast of the plant site. Ingestion doses were calculated assuming that one-third of the food was grown in the maximally exposed individual's backyard and that two-thirds was imported from outside the 80-km (50-mile) region (i.e., uncontaminated) (Baker 1985). The primary pathway of exposure is ingestion. Uranium-238 and ²³⁴U are the primary contributors to the inhalation dose, and ⁹⁹Tc plays an important role in the ingestion dose calculations.

Another measure of long-term radiation effects over a wide area is the collective dose equivalent, which is calculated by multiplying the average dose within defined areas by the number of persons residing in those areas. For this report, a collective effective dose equivalent was calculated for plant effluents in 1989 for the 535,211 persons residing within 80 km (50 miles) of the plant site.

The collective effective dose equivalent to this population was estimated to be 2×10^{-3}

person-rem from PGDP emissions. This can be compared with a collective dose of 2×10^5 person-rem per year from natural background.

Population doses may be used to predict health effects (i.e., fatal cancers) in a population by multiplying by a risk factor. The commonly used risk factor (i.e., 4×10^{-4} fatal cancers per person-rem) is based on effects on populations receiving large doses of radiation, such as the people surviving in the cities of Hiroshima and Nagasaki following the atomic explosions. A simple ratio is then applied to report the health effects of low doses. For very low doses the risk factor for health effects itself could well be zero, in which case no effects would be associated with low doses of radiation. Even assuming that the 4×10^{-4} risk factor is applicable, the risk that one fatal cancer will develop in the population (i.e., 535,211 persons) within 80 km (50 miles) of PGDP from 1989 radionuclide emissions is 8×10^{-7} . This means that it would take (as an average) about a million years of such exposures for a fatal cancer to have a chance of developing in the entire population.

3.2 CHEMICAL DOSE

Varying amounts of chemicals were released to the environment from operations at PGDP during 1989. Those releases are quantified in Table 3.2.1 in Subsect. 3.2 and compared with acceptable levels of exposure for humans to each chemical. Methodology used for determining acceptable chemical exposure levels for humans is described.

3.2.1 Terminology

Chemicals gain access to the human body by inhalation, ingestion, absorption, and other routes. Whether or not these chemicals produce a toxic effect in the body depends on a number of factors including the physical and chemical properties of the compound, the exposure conditions (i.e., duration and frequency), and susceptibility of the human. Lack of available environmental measurement data precludes an analysis of all pathways of concern for human exposure to chemicals. For example, no measurements of organics in air have been made precluding an analysis of the inhalation pathway. However, a

Table 3.2.1. Potential chemical dose comparison for PGDP surface waters—1989 average values

Chemical	Calculated daily intake ^a (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI	Chemical	Calculated daily intake ^a (mg/d)	Acceptable daily intake (mg/d)	CDI/ADI
<i>Discharge point 001</i>				<i>Discharge point 011</i>			
Arsenic	<0.01	0.100	<0.1	Chromium	<0.1	0.100	<1
Chromium	<0.1	0.100	<1	Copper	<0.02	2.6	<0.0077
Copper	<0.02	2.6	<0.008	Nickel	0.12	1.4	0.086
Nickel	<0.1	1.4	<0.071	PCBs	<0.001	0.0002	<5
PCBs	<0.001	0.0002	<5	Trichloroethylene	<0.0062	0.014	<0.4429
Trichloroethylene	<0.002	0.014	<0.1429	Zinc	<0.038	14.7	<0.003
Zinc	<0.04	14.7	<0.0027	<i>Discharge point 012</i>			
<i>Discharge point 002</i>				Chromium	<0.1	0.100	<1
Chromium	<0.12	0.100	<1.2	Copper	<0.02	2.6	0.0077
Copper	<0.02	2.6	<0.0077	Nickel	<0.1	1.4	<0.07
Nickel	<0.1	1.4	<0.071	PCBs	<0.001	0.0002	<5
PCBs	<0.001	0.0002	<5	Trichloroethylene	<0.002	0.014	<0.1429
Trichloroethylene	<0.002	0.014	<0.1429	Zinc	0.06	14.7	0.004
Zinc	<0.05	14.7	<0.0034	<i>Discharge point 013</i>			
<i>Discharge point 008</i>				Copper	<0.02	2.6	<0.0077
Chromium	0.1	0.100	1	Nickel	<0.1	1.4	<0.07
Copper	<0.02	2.6	<0.0077	PCBs	<0.001	0.0002	<5
Nickel	0.1	1.4	0.0714	<i>Discharge point 015</i>			
PCBs	<0.001	0.0002	<5	Copper	<0.04	2.6	<0.02
Trichloroethylene	<0.0026	0.014	<0.1857	Nickel	<0.16	1.4	0.11
Zinc	<0.072	14.7	<0.0049	PCBs	<0.001	0.0002	<5
<i>Discharge point 009</i>				<i>Discharge point 016</i>			
Chromium	<0.3	0.100	<3	Copper	<0.02	2.6	<0.01
Copper	<0.02	2.6	<0.0077	Nickel	<0.1	1.4	<0.07
Nickel	<0.1	1.4	<0.07	PCBs	<0.001	0.0002	<5
PCBs	<0.001	0.0002	<5	<i>Discharge point 017</i>			
Trichloroethylene	<0.0022	0.014	<0.1571	Copper	<0.02	2.6	<0.01
Zinc	<0.05	14.7	<0.0034	Nickel	<0.1	1.4	<0.07
<i>Discharge point 010</i>				PCBs	<0.001	0.0002	<5
Chromium	<0.16	0.100	<1.6				
Copper	<0.02	2.6	<0.0077				
Nickel	0.1	1.4	0.07				
PCBs	<0.001	0.0002	<5				
Trichloroethylene	<0.002	0.014	<0.1429				
Zinc	<0.058	14.7	<0.0039				

^aValues represent annual averages.

relevant and practical analysis of the ingestion pathway via drinking water is possible; therefore, a characterization of human exposure to chemicals via drinking water is provided. It is necessary to define pertinent terms. They are as follows:

- *Acceptable daily intake (ADI)* is the intake of a toxic chemical (measured in micrograms per

day) that is not anticipated to result in any adverse health effect following exposure. The ADI represents an EPA-established value.

- *Calculated daily intake (CDI)* is the intake of a toxic chemical (in milligrams per day) based on the assumption that humans drink 2 L (0.5 gal) of water per day (an overestimate).

- *Carcinogen potency factor (CPF)* is an estimate based on a lifetime probability that a carcinogenic chemical will cause cancer at a dose of 1 mg/kg/d. The *actual* risk is probably lower than the predicted risk or may even be zero.
- *Kentucky Pollutant Discharge Elimination System (KPDES)* is a permit that requires evaluation of area source discharges from within and around the PGDP facility to determine their impact on water quality.

3.2.2 Methods of Evaluation

3.2.2.1 Airborne chemicals

The release of airborne chemicals into the atmosphere at PGDP is minimized by avoiding unnecessary generation of wastes and by applying effective control technology to meet all permit conditions and DOE requirements. Emission sources may release permitted quantities of chemicals into the atmosphere. Further discussion can be found in Subsect. 2.1.

3.2.2.2 Waterborne chemicals

Health criteria for water were set so that chemical intake from consumption of 2 L of water per day would not exceed the ADI. For noncarcinogenic toxic chemicals, the ADI is the intake of a toxicant (measured in micrograms per day) that is not anticipated to result in any adverse health effects after chronic exposure to the general human population including sensitive subgroups (Hoffman et al. 1984). For carcinogenic chemicals, there is no accepted threshold limit. For the purposes of this document, a specific risk of developing cancer over a human lifetime of 1 in 100,000 was used to establish acceptable levels of exposure to carcinogens (Hoffman et al. 1984). The ADI for carcinogenic chemicals was derived using the formula

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

where

BW = 70 kg (reference adult, healthy male).

CPF = carcinogen potency factor, which is the "upper limit" on the lifetime probability that the carcinogen will cause cancer at a dose of 1 mg/kg/d. The term "upper limit" means that the *actual* risk is probably lower than the predicted risk or may even be zero.

All ADIs were derived primarily from the U.S. EPA Integrated Risk Information System (IRIS) data base, which contains updated ADIs for 1988. For those chemicals not included in the data base, the most current ADIs from other available sources were used and are referenced in Table 3.2.1.

The term ADI represents an allowable daily intake for both carcinogens and noncarcinogens. For example, in establishing water quality criteria for the chemicals of greatest concern, the EPA used the following relationship:

$$C_w = ADI/I_w$$

where

C_w = water quality criteria level ($\mu\text{g/L}$),

ADI = EPA-established value for an "acceptable daily intake" ($\mu\text{g/d}$),

I_w = EPA-assumed value for daily water consumption (i.e., 2 L/d).

A review of water quality criteria documents appears in Sittig (1980). Table 3.2.1 lists the CDI of chemicals from surface water on and off the PGDP site. If the CDI/ADI ratio is >1 , then an unacceptable level of risk would result from consumption of water from PGDP discharge points. This means the chemical is designated as one that warrants further investigation. If the CDI/ADI ratio is expressed as less than ($<$) a particular numerical value, this is based on a "less-than" concentration for the CDI because of the detection limitations of the instruments used to measure for chemicals. Information compiled in Table 3.2.1 was obtained from the KPDES outfall data on surface water quality. If one KPDES outfall discharged into another KPDES outfall, only the applicable data associated with the second outfall were reviewed.

Estimates of CDI are based on the assumption that total daily intake of drinking water (i.e., 2 L/d) comes from the stream (which is unlikely). In reality, outfalls are generally located within areas of DOE facilities not readily accessible to the general public; thus, public consumption of water from the outfalls is highly unlikely. Further, as the pollutant moves downstream from the outfall and as the volume of water increases, the concentration of the pollutant decreases. For example, the flow rate at discharge point 002 outfall (see Fig. 2.2.4) is 0.23 ft³/s. This flow rate is divided by the flow rate of the Ohio River (160,000 ft³/s) at Metropolis, Illinois, where public consumption is more likely, and then multiplied by the CDI for chromium of 0.12 mg/d. This calculation yields a new CDI for chromium of 1.73×10^{-7} mg/d. A dilution factor of 6.94×10^5 is, therefore, determined. Thus, it is important to recognize that the values given in Table 3.2.1 represent *overestimates* of intake.

3.2.2.3 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 organics in vegetation, beef, or milk in the vicinity of the PGDP facility have not been made.

3.2.2.4 Direct exposure

Direct exposure to chemicals does not represent a likely pathway of exposure at the

PGDP facility. For airborne releases, concentrations off-site are too small to be a problem 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. Public consumption of water from the outfalls is highly unlikely; however, ingestion of chemicals in water downstream could occur and thus is addressed in Subsect. 3.2.2.2.

3.2.2.5 Current year summary

Chemicals where the CDI/ADI ratio exceeds 1 warrant further investigation. Of the 75 CDI/ADI ratios reviewed at the PGDP facility, only the ratio for chromium at discharge point 002 (see Fig. 2.2.4) exceeded 1.0; the ratio was found to be 1.2. However, taking into consideration a dilution factor for chromium, a new CDI of 1.73×10^{-7} mg/d was determined (see Subsect. 3.2.2); this yielded a new CDI/ADI screening ratio of 1.73×10^{-6} . Thus, concentrations of chromium at PGDP are within acceptable guidelines.

The ADIs used in this screening process are the most up-to-date values available from the EPA IRIS data base (U.S. EPA 1988). These values will be updated annually to ensure that the most current ADIs are used in the derivation of the screening ratio.

4. REMEDIAL ACTION PROGRAM

4.1 INTRODUCTION

The Remedial Action Program (RAP) represents an effort to meet regulatory requirements and to protect both on-site and off-site personnel, as well as the environment, through investigations and, if necessary, corrective actions at SWMUs and spill sites. SWMUs include landfills, surface impoundments, treatment units, scrap yards, and other units that have received wastes at any time regardless of the type of waste placed in the unit. The three-fold objective of the program is (1) to identify those SWMUs and spill sites that are releasing hazardous constituents to the environment, (2) to stop such releases, and (3) to remediate any environmental contamination that has resulted from the release. The ultimate goal of the program will be to ensure that (1) all units are in a stable configuration that prevents releases from occurring and (2) releases will be detected if they should occur.

In 1986 PGDP began the implementation of a RAP to characterize any releases of hazardous waste or hazardous constituents that may have occurred. During 1986 and 1987 PGDP identified sites that received wastes in the past and sites where spills or possible spills of hazardous materials have occurred. PGDP conducted a preliminary assessment of SWMUs during 1987.

The initial intent of the program was to characterize each SWMU or spill site on an individual basis. However, the discovery of contamination in residential groundwater wells north of the plant in August 1988, the Administrative Consent Order (ACO) developed in response to the groundwater contamination, and the discovery of PCB contamination in tissues of fish taken from plant effluent ditches have redefined the RAP. The first priority of the RAP is Phase I of the Site Investigation; this focuses on

groundwater contaminated with TCE and ^{99}Tc and includes identification of the sources of PCB contamination in fish in Big and Little Bayou creeks. The characterization and corrective action selection for sources of TCE and ^{99}Tc in groundwater will occur during Phase II of the Site Investigation.

The first regulatory requirements for corrective action came with CERCLA, also known as Superfund, requiring the EPA to develop a listing of abandoned waste management units that represented a hazard to the public or the environment. DOE sites were brought under the CERCLA program in August 1985 with the issuance of DOE Order 5480.14. This order directed DOE facilities to implement a corrective action program over a 10-year period. Completed in April 1986, a portion of the program has been published. In this report (PGDP April 1986), 20 waste management units are evaluated according to the Modified Hazard Ranking System as directed by DOE Order 5480.14.

In 1984 the RCRA was amended by the Hazardous and Solid Waste Amendments (HSWA). Section 3004(u) of the RCRA as amended by the HSWA authorizes the EPA to require corrective action for all releases of hazardous wastes or constituents from any SWMU at permitted treatment, storage, or disposal facilities. However, Sect. 3008(h) of the RCRA authorizes the EPA to require corrective action at interim status facilities as deemed necessary to protect human health and the environment. The statutory requirement for corrective actions was promulgated by 40 CFR 264 in July 1985 and supercedes the CERCLA corrective action requirements for SWMUs. Under the new regulation all SWMUs at facilities seeking a Part B permit are subject to corrective action requirements; this includes both active and inactive

SWMUs. Considerable overlap exists between the CERCLA requirements and the RCRA 3004(u) requirements. One specific exemption concerns spills not linked to SWMUs that occurred prior to November 19, 1980. However, because these spill sites would be subject to corrective actions under CERCLA, they have been included in the RAP in a consolidation of RCRA and CERCLA remedial action activities into a single program at PGDP.

4.2 REMEDIAL ACTION PROCESS

The first step in the remedial action process is the identification of SWMUs and spill sites. This is accomplished through research of plant records, reports, engineering drawings, maps, and aerial photographs as well as personal interviews with past and present plant employees. Additionally, evaluation of processes and operating procedures that are now in use or were used in the past may give indications of the generation and handling of wastes.

The preliminary assessment documents addressed the available information for each unit and determined whether the data characterize the site. If the available data were not satisfactory to characterize the site, further investigation in later phases of the program will be required; the order of investigation will be based on a priority determined by PGDP and the regulating agencies. If the available data adequately characterize the unit, no additional characterization will be performed. Corrective actions will be performed on the site if necessary. If no corrective actions are required, the site will enter the monitoring phase of the process or be dropped from the program.

Sites for which characterization data are inadequate will be investigated during the program. This investigation will involve sampling of media that may be contaminated by hazardous wastes or waste constituents to determine if a release of any hazardous waste or waste constituents is occurring or occurred in the past. This characterization will also obtain adequate physical and geological data to support corrective actions at the site.

The site characterizations involve field work to gather data necessary to determine if a release of hazardous constituents has occurred and, if so, the extent of the release. This phase involves sampling and analyses of air, soil, surface water and sediment, subsurface gases, groundwater, and biota. The sampling and analyses are performed according to a work plan that is reviewed and approved by the regulating agencies. The work plan will outline the quality assurance (QA) and quality control (QC) program necessary to ensure data of adequate quality to support the later phases of the RAP. Additionally, health and safety, community relations, data reporting and evaluation, and other kinds of information are included in the work plan.

An evaluation of data gathered during the site characterization will be performed during the alternatives assessment. During this phase the corrective action necessary to remediate a problem will be chosen. This process will involve an evaluation of the risks associated with several possible corrective actions including the evaluation of a no-action alternative to determine a risk baseline. The selection of an alternative will be based on the risk reduction, the feasibility of implementation, the effectiveness of the alternative, the time required to implement, the length of time over which an alternative will remain effective, and the cost-effectiveness of the alternative. The alternatives assessment will address all applicable, relevant, and appropriate requirements including (but not limited to) the CWA, the SDWA, the RCRA, the CERCLA, the TSCA, the NEPA, and the CAA.

During the corrective action phase the remediation methods chosen during the alternatives assessment will be designed and implemented. This phase may require several months or even years (e.g., for groundwater contamination remediation when aquifer restoration is a part of the process). The monitoring phase is performed to evaluate the effectiveness of the corrective action program and to ensure that no further releases to the environment occur. Monitoring of sites may be required to ensure that the status of the unit does

not change and that additional releases do not occur in the future.

4.3 GROUNDWATER CONTAMINATION

In August 1988 ^{99}Tc contamination was discovered in an off-site drinking water well north of PGDP. Technetium-99 is a manmade radionuclide created as a by-product of the fission of uranium. Technetium-99 was introduced to PGDP as a contaminant in feed material during a program in which reactor returns were fed into the cascade. After the initial identification of ^{99}Tc , further sampling revealed the presence of a commonly used solvent, TCE, in off-site wells. A community water line was extended (at DOE expense) to the residents with contaminated wells for an alternate water supply. The cost of the water is also being paid by DOE.

As a result of the initial discovery of the contamination, the most-contaminated plant well and the residential well showing the highest level of contamination were analyzed for the RCRA Appendix IX list, a pollutant list developed by the EPA consisting of over 250 pollutants. The only contaminants found in the residential well were TCE and ^{99}Tc . Based on the Appendix IX results, a program monitoring off-site groundwater was established. Initially, ten residential wells were sampled on a weekly basis for TCE and ^{99}Tc to ensure that the contamination was not spreading to other residential wells. These ten wells are located nearest the area of contamination. In June a sample from one of these wells (previously uncontaminated) was found to contain approximately 2 ppb TCE. Trichloroethylene became detectable later in the year at a second well (used for watering livestock) at the same residence. The residential well and the well used for watering livestock at this residence were connected to the extended waterline at DOE expense at the first detection of TCE. At present, eight wells are being sampled weekly. Additionally, six residential wells located near a TVA well showing contamination are sampled on a monthly basis for protection of the residents.

4.3.1 Administrative Consent Order

To establish a schedule for investigation and remediation of the groundwater contamination, the EPA and DOE developed an ACO under CERCLA Sects. 104 and 106. The ACO was agreed to by DOE and the EPA and approved by the U.S. Department of Justice. The effective date of the ACO was November 23, 1988. The intent of the ACO is outlined in four major objectives:

- to determine the nature and extent of the threat to human health or welfare and the environment caused by the off-site contamination of groundwater;
- to ensure that the environmental effects of the releases and threatened releases are thoroughly investigated and that appropriate actions are taken to protect the public health, welfare, and the environment;
- to establish a schedule and work plan for developing, implementing, and monitoring any necessary response actions at the site; and
- to promote cooperation (i.e., exchange of information and participation of DOE, the EPA, and the state of Kentucky in achieving the first three objectives).

4.3.2 Terms of the Administrative Consent Order

The ACO defines work to be performed by DOE-PGDP in response to the discovery of the groundwater contamination and establishes the schedule for completion of certain elements of the work. By signing the ACO, DOE agreed to the following:

- submit to the EPA and to the state of Kentucky within 60 days of the effective date of the ACO a draft work plan for investigation of groundwater and surface water contamination (this plan shall include a sampling plan; identification of potential sources, pathways, and receptors; a field sampling and analytical plan; a QA/QC plan; a health and safety plan; and a schedule for completion of the investigation);
- submit a final work plan within 30 days of the receipt of the EPA's comments on the draft;

- implement the work plan within 45 days of its approval;
- submit monthly written reports during the investigation;
- provide a preliminary and final investigation report to the EPA according to the schedule in the work plan;
- negotiate an amendment to the ACO with the EPA after the final investigation report is submitted providing for carrying out to completion remediation of contamination;
- undertake measures to protect human health including but not limited to (1) supplying drinking water to residents having contaminated wells, (2) conducting sampling on at least a monthly basis of potentially affected residents' wells and plant well No. 66 (the most contaminated well on the plant site), and (3) identifying constituents of any elevated gross alpha and gross beta levels and evaluating those concentrations against the National Interim Primary Drinking Water Regulations; and
- provide to the EPA and to the state of Kentucky within 30 days of the effective date a summary of any emergency measures already taken and any further necessary interim measures.

The ACO requires the designation of a project coordinator by DOE. The project coordinator for DOE is the DOE-PGDP site manager. Additionally, the EPA and the state of Kentucky designated project coordinator; however, the state of Kentucky is not a signatory party to the consent order. All official correspondence and documents will be directed through the project coordinators. The ACO also contains sections establishing dispute resolution procedures, allowing for reasonable site access and investigation data and document access to regulating agencies, obtaining access to sampling locations that are on property owned by someone other than DOE, QA, schedule modifications, enforceability, stipulated penalties, funding, public participation, confidential information, and modification or termination of the order.

4.3.3 Compliance with the Administrative Consent Order

4.3.3.1 Protection of residents

To protect residents living near the area of the contaminated wells, PGDP personnel sample eight residential wells for ^{99}Tc and TCE (Fig. 4.3.1) on a weekly basis. The eight residential wells are those located closest to the contaminated residential wells. Six residential wells located near a nonresidential monitoring well at the TVA Shawnee Steam Plant that is contaminated with ^{99}Tc are sampled for TCE and ^{99}Tc on a monthly basis. If TCE or ^{99}Tc is discovered in any of these six residential wells, residents will be supplied with an alternative source of water at DOE expense. Contaminated residential wells that are accessible to PGDP are sampled on a monthly basis, as is plant monitoring well 66 (the most highly contaminated). Monthly sampling is required by the ACO.

Samples were taken from all eight of the weekly sampled residential wells and from five of the six monthly sampled residential wells for the EPA Target Compound List (TCL) and for radionuclides common to PGDP (the sixth well was not sampled because the owner did not want to sign a consent agreement allowing contractor personnel to take the samples). Laboratory staff performing the PCB, pesticides, volatile organics, and semivolatile organics analyses were unable, however, to provide validated data for all samples; this was due in part to a freezing of volatile organics samples and on exceeding of holding times on other samples. These wells were resampled for organics fractions, and the results of all analyses are currently under review. No new contaminants of concern have been identified in residential wells as a result of the TCL sampling.

4.3.3.2 Investigation Work Plan for the PGDP

PGDP contracted with CH2M Hill to develop the Phase I Site Investigation Work Plan for PGDP. The initial draft of the work plan was submitted to the EPA and to the state of Kentucky on January 23, 1989. Copies were also placed in

ORNL-DWG 89-6362R

Fig. 4.3.1. Ongoing residential well sampling at PGDP.

the Paducah Public Library for public review. A public briefing was held at the Heath Elementary School on February 13, 1989, to inform the public about the contamination and the contents of the work plan. The briefing, attended by approximately 60 people, followed an open house format. Small groups of attendees were "walked through" a presentation providing background information and planned investigation activities. PGDP staff members familiar with the situation served as guides. A slide presentation was provided after the presentations were completed. No public comments were received on the work plan.

State of Kentucky and EPA comments were received within the 30-day schedule required by the ACO. A comment-resolution meeting was held with the regulating agencies on February 28, 1989. Comments were incorporated, and the final work plan was issued to the state of Kentucky and the EPA on March 21, 1989. The work plan was approved by EPA Region IV on April 7, 1989, with two minor exceptions (these were addressed in a letter from DOE to the regulating agencies).

4.3.3.3 Implementation of the Site Investigation Work Plan for PGDP

The work plan was implemented on May 19, 1989, as required by the ACO. A contract was issued to CH2M Hill to begin existing data analyses, field reconnaissance, existing well development, and sampling of off-site wells for the TCL and for radionuclides. The activities were seen as critical path steps for completion of the investigation. Contracting activities were ongoing for implementation of the remainder of the work plan. In June, 1989, a DOE Inspector General audit of the proposal began (this audit was required because the cost of the project was considerably higher than had been expected). To get field activities under way, a letter subcontract was placed with CH2M Hill allowing the investigation to begin while awaiting the results of the Inspector General audit. The letter subcontract released CH2M Hill to begin activities on August 18, 1989.

As a result of the delays (including the unexpected Inspector General audit), an extension

on the investigation was requested under Sect. XI, Extensions, and Sect. XIV, Force Majeure. The EPA concurred that due diligence had been exercised in contracting efforts and that good cause existed for granting an extension. A 60-day extension on the project schedule was granted. The report on the investigation is due to the EPA on July 19, 1990.

Several activities have been completed as a part of the investigation. Off-site residential wells and plant monitoring wells have been sampled for the TCL and for radionuclides, the results of which are currently being validated. A well has been installed between Rossington and PGDP, and development efforts are under way. Existing plant wells have been evaluated (and redeveloped where necessary). Soil samples have been taken from on-site borings, and installation has begun on three of five well clusters. Up to nine well clusters will be installed in the first quarter of 1990. Additionally, results from soil samples and groundwater samples taken in 1989 will be validated. These results will be in the investigation report prepared for the EPA and the state of Kentucky in July 1990 together with summaries in monthly progress reports.

As a part of the biota-sampling effort for the Site Investigation, twelve deer were sampled in conjunction with the Kentucky Department of Fish and Wildlife Resources. ORNL staff analyzed samples from the deer for PCBs, metals, and radionuclides. Additionally, two deer were included as background samples from the Land Between the Lakes Recreation Area. A summary of the deer results is included in Subsection 6.2.10. The results from the deer sampling have been provided to the Kentucky Department of Fish and Wildlife, the Department for Environmental Protection, and the EPA.

4.4 REMEDIAL ACTION PROGRAM PLAN

4.4.1 Remedial Action Matrix Organization

A remedial action organization has been created at PGDP (see Fig. 4.4.1). This group will be responsible for the management of the PGDP RAP including activities related to the ACO and

ORNL-DWG 80M 9997112

Fig. 4.4.1. PGDP remedial action organization.

the program for individual units and spill sites at the plant. The RAP manager and his staff will be responsible for organizing and coordinating efforts of CH2M Hill and PGDP support staff during the investigation and remediation of the groundwater contamination. Additionally, the RAP staff will

coordinate the investigation of SWMUs under the HSWA permit.

The remedial action organization consists of a RAP manager, staff, and a matrix organization of Martin Marietta Energy Systems employees. The matrix organization provides support to the RAP

in the areas of industrial hygiene, environmental compliance, health physics, public relations, waste management, quality and technical services, quality assurance, environmental sciences, plant engineering, and computer services. The responsibilities of the matrix organization include:

- *Industrial hygiene.* Auditing and overseeing the subcontractors' program to prevent chemical exposure to investigation team members, PGDP employees, and the public during the RAP will be the responsibility of the Industrial Hygiene Department.
- *Environmental compliance.* The Environmental Compliance Department will provide guidance regarding meeting the requirements of applicable environmental laws. Additionally, any treatment or disposal permits necessary will be obtained by this department.
- *Health Physics.* Auditing and overseeing the subcontractors' program to protect the investigation team members, PGDP employees, and the public from radiological hazards during the RAP will be the responsibility of the Health Physics Department.
- *Public Relations.* The Public Relations Department will support the RAP manager in implementation of the Community Relations Plan and in other matters requiring releases of information to the news media.
- *Waste management.* The investigation and remediation phases of the RAP will generate significant quantities of solid wastes and wastewaters that will require packaging, handling, storage, treatment, and disposal. These activities will be the responsibility of the Waste Management Department.
- *Quality and technical services.* The Quality and Technical Services Division will support the RAP manager through evaluation of sampling and analysis plans, auditing subcontractor laboratory procedures, and other functions required by the RAP manager. The Quality and Technical Services Division is also responsible for routine monitoring of residential wells.
- *Quality assurance.* The QA specialist will ensure that data of known, defensible quality are obtained during the investigation through evaluation and audits of the subcontractors' QA/QC programs and QA project plan.
- *Plant engineering.* Project and construction management and review of specifications for monitoring wells and piezometers will be supplied by PGDP Plant Engineering.
- *ORNL Environmental Sciences Division.* The ORNL Environmental Sciences Division provides technical support and expertise such as hydrogeologic support and geochemistry to the PGDP RAP.
- *Financial officer.* The financial officer provides support to the RAP manager for the development of budgets and tracking of costs of RAP projects.
- *Computer services.* The computer services representative is responsible for the development, installation, and operation of a data base for the management of data generated by the RAP. A geographic information system is being purchased for this purpose.

4.4.2 Remedial Action Program Description

One initiative of the Secretary of Energy is a comprehensive Environmental Restoration and Waste Management Five-Year Plan (FYP) for all DOE facilities, the intent of which is development of a consistent approach to waste management and bringing of facilities into compliance with air, water, and solid waste regulations (DOE 1989).

The FYP includes an activity data sheet (ADS) for each major activity. The ADS includes a funding summary, the type of activity, a narrative describing the activity, and a set of milestones for the activity. Additionally, a priority category ranging from one to four is assigned based on definitions determined by DOE. The priorities take into account agreements with regulatory agencies, hazards presented, justifications for projects, and other factors. PGDP has an ADS for both phases of the investigation

under the ACO, an ADS for remediation of the groundwater contamination, and a total of four ADSs for the investigation and remediation of SWMUs under the HSWA permit.

In addition to the comprehensive FYP for all DOE facilities, an *Environmental Restoration and Waste Management Site Specific Plan for Oak Ridge Operations Office Paducah Gaseous Diffusion Plant* (SSP) is being prepared. The SSP provides details on the implementation of the activities described in the FYP. While in draft form at present, this document will include an overview of activities, a description of the organization and management implementing the activities, the needed resources, funding, and milestones. Additionally, installation descriptions, an explanation of drivers for the activities, a description of NEPA compliance, plans for reporting and data management, a list of QA objectives, and a description of planned interactions with federal, state, and local agencies is presented in the SSP. Release of the SSP in final form is scheduled for 1990.

4.5 CURRENT STATUS AND PLANNING

PGDP personnel have identified approximately 96 solid waste management units and spill sites that may have released hazardous waste constituents into the environment (Table 4.5.1). The identification of sites included review of plant maps, drawings, records, and personal interviews with persons who had responsibility for the management of wastes, supervisors of areas that generated or handled wastes in the past, and other individuals familiar with plant operations. Additionally, PGDP personnel performed a preliminary assessment on 89 units by gathering and evaluating the available data regarding each site. As a result of this evaluation, two documents were published in 1987: the first contains information regarding SWMUs at Paducah (PGDP July 1987a); the second contains information regarding spill sites that fall under CERCLA (PGDP July 1987b). Seven additional units have been added to the RAP since the preliminary assessment documents were issued.

The preliminary assessment documents include a data sheet summarizing information regarding

each unit. The information presented includes a process or unit description, the type of material or waste handled, a summary of known releases or documentation that no releases have occurred, and a color photograph of each unit. In addition, PGDP personnel made a recommendation on whether the unit should be investigated further or if available information adequately characterizes the site and no further action is necessary. Concurrence from the regulatory agencies on sites requiring no further action has not been received.

A work plan for Phase II of the Site Investigation will be developed based on the results of Phase I of the Site Investigation. Phase II will characterize the unit or units that are releasing TCE or ^{99}Tc to groundwater and surface water and units that are releasing PCBs to groundwater and surface water. The purpose of Phase II is to gather additional data for each unit and to select a corrective action to stop any contaminant releases.

PGDP will use outside consultants to perform Phase II of the Site Investigation and the individual SWMU and spill site characterizations. Site characterizations at PGDP will be performed under the Hazardous Waste Remedial Action Program (HAZWRAP) subcontract. The HAZWRAP subcontractor and his lower-tier subcontractors will be responsible for developing investigation plans and for performing the investigations. Developing and compiling the results into an alternatives evaluation to select the most appropriate corrective actions at each SWMU may require hiring a second subcontractor by DOE to avoid conflicts of interest.

Discussions have been held with DOE, PGDP, EPA, and state of Kentucky personnel regarding the draft HSWA permit for the PGDP. The draft HSWA permit, issued under Sect. 3004(u) of the RCRA as amended, will drive investigation of SWMUs and spill sites not addressed under Phase I or Phase II of the Site Investigation. Schedules and plans for investigation were discussed, as was the coordination of the HSWA investigations with Phase I and Phase II of the Site Investigation. The HSWA permit for PGDP will be issued with either the facility Part B permit for treatment and storage units or the postclosure permit for the C-404 landfill (whichever is issued first). The earliest expected date for the HSWA permit to be issued is the third quarter of 1990.

Table 4.5.1. PGDP Remedial Action Program sites

Unit number	Name
1	C-747-C oil landfarm
2	C-749 uranium burial ground
3	C-404 low-level radioactive waste burial ground
4	C-747 contaminated burial yard
5	C-746-F classified burial yard
6	C-747-B burial ground
7	C-747-A burial ground
8	C-746-K inactive sanitary landfill
9	C-746-S residential landfill
10	C-746-T inert landfill
11	C-400 trichloroethylene leak site
12	C-747-A UF ₄ drum yard
13	C-746-P clean scrap yard
14	C-746-E contaminated scrap yard
15	C-746-C scrap yard
16	C-746-D classified scrap yard
17	C-616-E sludge lagoon
18	C-616-F full-flow lagoon
19	C-410-B HF neutralization lagoon
20	C-410-E HF emergency holding pond
21	C-611-W sludge lagoon
22	C-611-Y overflow lagoon
23	C-611-V lagoon
24	C-750-D underground storage tank
25	C-750 1000-gallon waste oil tank
26	C-400 to C-404 underground transfer line
27	C-722 acid neutralization tank
28	C-712 acid neutralization tank
29	C-746-B TRU storage area
30	C-747-A burn area
31	C-720 compressor pit water storage tank
32	C-728 clean waste oil tank
33	C-728 motor cleaning facility
34	C-746-M PCB waste storage area
35	C-337 PCB waste storage area
36	C-337 PCB waste staging area
37	C-333 PCB waste staging area
38	C-615 sewage treatment plant
39	C-746-B PCB waste storage area
40	C-403 neutralization tank
41	C-410-C neutralization tank
42	C-616 chromate reduction facility
43	C-746-B waste chemical storage area
44	C-733 hazardous waste storage area
45	C-746-R waste solvent storage area
46	C-409 hazardous waste pilot plant
46A	C-746-Q hazardous and low-level waste storage building
47	C-400 technetium storage tank area
48	C-400-A gold dissolver storage tank
49	C-400-B waste solution storage tank
50	C-400-C nickel stripper evaporation tank
51	C-400-D lime precipitation tank
52	C-400 waste decontamination solution storage tanks
53	C-400 NaOH precipitation unit
54	C-400 degreaser solvent recovery unit

Table 4.5.1 (continued)

Unit number	Name
55	C-405 incinerator
56	C-540-A PCB waste staging area
57	C-541-A PCB waste staging area
58	N-S diversion ditch (outside plant security area)
59	N-S diversion ditch (inside plant security area)
60	C-375-E2 effluent ditch
61	C-375-E5 effluent ditch
62	C-375-S6 southwest ditch
63	C-375-S7 skimmer ditch
64	Little Bayou Creek
65	Big Bayou Creek
66	C-375-E3 effluent ditch
67	C-375-E4 effluent ditch
68	C-375-W8 effluent ditch
69	C-375-W9 effluent ditch
70	C-333-A vaporizer
71	C-337-A vaporizer
72	C-200 underground gasoline tanks
73	C-710 underground gasoline tanks
74	C-340 PCB spill site
75	C-633 PCB spill site
76	C-632-B H ₂ SO ₄ storage tank
77	C-634-B H ₂ SO ₄ storage tank
78	C-420 PCB spill site
79	C-611 PCB spill site
80	C-540-A PCB spill site
81	C-541-A PCB spill site
82	C-531 switchyard
83	C-533 switchyard
84	C-535 switchyard
85	C-537 switchyard
86	C-631 pump house and cooling tower
87	C-633 pump house and cooling tower
88	C-635 pump house and cooling tower
89	C-637 pump house and cooling tower
90	C-720 underground petroleum naphtha pipe
91	UF ₆ cylinder drop test area
92	Fill area for dirt from C-420 PCB spill site
93	Concrete disposal area east of plant security area
94 ^a	KOW trickling filter and leach field
95 ^a	KOW burn area
96	Storage area for cooling tower wood wastes

^aUnits 94 and 95 are facilities that were part of the Kentucky Ordnance Works, which was a munitions production facility during World War II. These facilities were never used by PGDP. They are included with the PGDP Remedial Action Program because they are within the existing DOE property boundary.

5. SOLID WASTE MANAGEMENT PROGRAM

5.1 DESCRIPTION

5.1.1 Purpose

The purpose of the PGDP solid waste management program is to protect the environment, the public, and on-site personnel through the proper management of solid wastes generated by plant operations and eventually to dispose of the wastes in an environmentally acceptable manner. A "cradle-to-grave" system provides management services for all types of waste from the point of generation through ultimate disposal. The system ensures that wastes are managed in accordance with state and federal regulations; DOE Orders 5480.3, 5400.3, 5820.2A, and 5480.1B; and accepted industry practices. In addition to waste disposal, the program includes efforts to minimize the quantities of wastes generated and to treat wastes to reduce volume and toxicity.

In addition to the day-to-day waste management activities, the solid waste management program must anticipate future needs in both the technical and regulatory areas. Staff members provide technology development and regulatory review services to ensure that the program remains in compliance, that future waste management needs are anticipated, and that proper planning in response to these needs occurs. These efforts are coordinated with personnel at the other Oak Ridge Operations (ORO) sites to facilitate the consolidation of work and the enhancement of communications between sites.

5.1.2 Regulatory Review

The RCRA regulates the generation, storage, transportation, treatment, and disposal of hazardous wastes and facilities involved in these activities. The state of Kentucky has been authorized by the EPA to administer specific

sections of the RCRA in lieu of the federal program. This authorization has resulted in the promulgation of regulations in the KAR. The state also administers the disposal of sanitary and inert wastes through regulations published in the KAR. PGDP is subject to most of the requirements of these regulations. However, radioactive wastes such as source, special nuclear, and by-product materials are exempt from RCRA regulation by the Atomic Energy Act of 1954. The hazardous components of mixed waste (i.e., hazardous wastes containing radionuclides) are regulated by the RCRA.

Wastes containing PCBs are regulated by the TSCA. As in the case of mixed wastes, PCB wastes containing radionuclides are also managed under the TSCA. PCB wastes containing hazardous wastes are managed in accordance with the RCRA and the TSCA with the more stringent regulation being applied.

The CWA and the CAA do not directly affect solid waste management activities. However, the operation of waste management facilities must not adversely affect the ability of PGDP to comply with these regulations. Such compliance is also planned for in accordance with NEPA requirements, one of which is that the environmental impacts of plant projects be considered during the project planning process.

DOE has issued orders establishing policies in waste management areas: DOE Order 5632.1A prescribes requirements for the physical protection of classified wastes; DOE Order 5400.3 addresses the management of hazardous and mixed wastes at DOE facilities and directs that such wastes will be managed in an environmentally acceptable manner. Low-level radioactive wastes without hazardous or toxic constituents at DOE facilities are regulated under the federal Atomic Energy Act. These wastes are managed under DOE Order 5820.2A, which was issued in September 1988. This order

establishes handling and disposal policies and a waste classification system to be implemented throughout DOE.

5.1.3 Compliance Activities

Hazardous waste facilities at PGDP are currently operated under interim status granted by the state of Kentucky (facility EPA ID Number KY8890008982). The Part A application is updated as hazardous waste management needs dictate. Part B applications have been submitted for the seven storage and treatment units located on the plant site and the postclosure of the C-404 low-level radioactive waste burial ground. The Kentucky Division of Waste Management is evaluating the latest version of the permit application. Until such time as a full permit is issued, PGDP facilities will continue to operate according to the interim status provisions of 401 KAR Chap. 35.

Two Notices of Deficiency were received from the Kentucky Division of Waste Management regarding the C-404 Postclosure Part B Application for groundwater monitoring data and signature of the Part A application by Energy Systems as operator. Two Notices of Violation were received from the Kentucky Division of Waste Management for failure to submit the Annual Registration of Hazardous Waste Activity form by July 15, 1989, and failure by DOE to submit a signed annual registration on the cabinet-provided form complete with the existing certification. The latest hazardous waste inspection was performed by the Kentucky Division of Waste Management and EPA Region IV in August 1989. The RCRA Comprehensive Evaluation Inspection revealed several minor deficiencies that were corrected in 1989.

In mid-1989, as part of an effort to ensure full compliance with federal and state waste management regulations, PGDP conducted a survey of the entire plant to identify all unused materials and to place them into the waste management system. Over 800 drums were identified, sampled, or characterized with existing data, and placed in appropriate storage areas. Also, a portion of the effort included placing over 5000

drums of solid PCB waste in storage awaiting ultimate disposal in areas where secondary containment and aisle space meet TSCA requirements.

In October 1989 a new residential landfill cell was placed into operation. The cell that had been operated previously was covered awaiting final closure in early 1990 under more favorable weather conditions.

5.1.4 Program Strategy

Proper identification, characterization, and classification of waste materials is essential in ensuring that waste management activities are performed safely, efficiently, and in compliance with regulations and policies. This is an ongoing process that must react to changes within the plant and to changes in regulations and policies beyond the control of plant management. A system of administrative controls assigns responsibilities for waste-handling activities and specifies criteria that must be met before a waste is accepted by the Waste Management Department. These controls include plant-wide Standard Practice Procedures; job-specific Standard Operating Procedures; waste sampling, analysis, and handling requirements of the facility Part B draft permit; and other requirements. For wastes that are not handled through the Waste Management Department (such as process wastes discharged directly from a treatment unit), a system of administrative controls and, in some cases, physical controls (e.g., valve lock-outs, etc.) are used to ensure that the waste is properly characterized prior to discharge. The primary control in these instances is the KPDES permit under the CWA. RCRA characterizations are periodically performed on these wastes at the point of generation and, where necessary, following treatment.

PGDP has in place a program to minimize the amount of waste being generated. Under the direction of the plant waste minimization program manager, a team of waste management, technical, operations, and maintenance personnel is charged with identifying opportunities and strategies for waste minimization and coordinating efforts to accomplish strategies. Where possible, the

avoidance or minimization of waste is to be accomplished through process changes that eliminate the waste stream or recycle it back into use. However, given the nature of the processes at PGDP, opportunities for waste elimination and recycling at the source are limited.

Other options include the reduction of waste stream toxicity and hazard through the use of less toxic or hazardous raw materials or the limitation of the use of toxic and hazardous materials. For example, limiting the use of TCE to large degreasing units and the use of less-toxic solvents in field use has led to a reduction in the quantity of waste oil requiring disposal as a hazardous waste. Installation of new treatment processes or modifications to existing processes can also reduce waste stream toxicity and volume. The segregation of waste materials to reduce the volume of hazardous or radionuclide-contaminated materials requiring special handling and disposal is a common practice.

Several options are available for waste disposal. Some wastes are treated and disposed of directly (e.g., the neutralization of waste acids). Sanitary and inert wastes are also disposed of on-site. Most hazardous and all PCB wastes are disposed of off-site, preferably by incineration. All off-site disposal facilities must meet RCRA and TSCA regulatory requirements. Some wastes (such as mixed and low-level radioactive wastes) must be placed in on-site long-term storage until treatment or disposal technology is developed and demonstrated.

PGDP has prepared a plan including projects and budget requirements for waste management activities needed to ensure regulatory compliance. As part of the overall DOE effort (PGDP Feb. 14, 1990), this plan (discussed in Subsect. 4.4.2) is to be used as a program strategy document. Projects for waste minimization and new storage, treatment, and disposal facilities are part of the plan. PGDP also currently generates or has generated in the past several wastes that cannot be treated or disposed of at this time. Beginning in 1990 and continuing for the next several years, PGDP will be identifying and evaluating technologies for the treatment and disposal of these wastes.

5.2 WASTE GENERATION

5.2.1 Types of Waste Generated

Residential. This waste category includes office, cafeteria, and similar wastes.

Industrial. Fly ash for coal-fired boilers and construction spoils make up the bulk of this category.

RCRA hazardous. This class of wastes is defined by RCRA regulations. Characteristic hazardous wastes at PGDP include waste acids such as sulfuric and nitric acids, solutions containing metals such as chromium, and ignitable wastes such as paint solvents. Listed hazardous wastes include TCE and various laboratory chemicals.

Mixed. These wastes consist of RCRA hazardous wastes contaminated with radionuclides. Uranium is the most common contaminant.

PCBs. All wastes containing more than 50 ppm of PCBs by weight and wastes resulting from PCB spill cleanup operations are handled as PCB wastes. Waste containing detectable (i.e., >1 ppm, >0.5 ppb in water, and >2 ppm in oil) PCBs are disposed of as PCB wastes but are not classified as such.

PCB/uranium. This category consists of PCB wastes (as defined in the preceding) that are contaminated with >50 ppm depleted U, detectable Np, Pu, Th, and/or Tc.

Transuranic. These wastes contain more than 100 nCi/g of transuranic radionuclides. The most common radionuclides are ²³⁹Pu and ²³⁷Np. A small quantity of this type of waste is stored at PGDP. This waste is not currently produced at the plant.

Low-level radioactive. These wastes contain U, Th, Tc, or less than 100 nCi/g of transuranics.

Asbestos. This waste, classified as either "clean" or "contaminated" depending on the absence or presence of uranium, consists of friable asbestos generated by plant maintenance operations.

Scrap metal. This stream, also classified as either "clean" or "regulated," consists of scrap metal generated by maintenance operations and machine shop work.

Nonhazardous. This category consists of miscellaneous wastes not fitting into one of the preceding categories. An example of this would be nonhazardous liquids not suitable for on-site disposal.

Classified. Wastes considered to contain sensitive security information are accorded special handling. Wastes in any of the preceding categories may also be considered classified.

5.2.2 Waste-Generating Activities

Utilities operations. Wastes produced during the operation of plant auxiliary systems include fly ash produced by the generation of steam from coal-fired boilers, sludge produced by the treatment of sewage, and sludges produced by the lime-soda ash softening of water from the Ohio River for process use. In the past, sewage treatment sludges have contained PCBs and uranium. The sewage sludge is drummed and stored. Another plant waste stream is the blowdown from the recirculating cooling water system. The blowdown, which contains about 8 ppm chromium, is hazardous and is treated to remove the chromium.

Chemical operations. The majority of the low-level radioactive waste produced at PGDP is produced by the Chemical Operations Department. The major contaminant is uranium, and trace quantities of ^{99}Tc , ^{237}Np , ^{230}Th , and ^{239}Pu are also present. The largest low-level waste stream is the filter cake produced by the lime precipitation treatment of spent decontamination, cylinder wash, and laboratory waste solutions. Smaller amounts of other low-level wastes include contaminated floor sweep, articles of clothing, small parts, and supplies.

Some hazardous wastes are also produced by the Chemical Operations Department. These include spent TCE used in degreasing, small quantities of spent cyanide plating solutions, and waste from a small-parts nickel-deplating process.

Fabrication and maintenance. Maintenance activity is generally divided into two types—shop and field. Shop activities include major equipment repair, rebuilding and construction, metal machining, forming and welding, instrument

repair, carpentry, and painting. Scrap metal, both clean and contaminated, is produced by shop activity. A variety of machining fluids (generally oils), lubricating oils, and cutting fluids are used. Most of the wastes produced from these materials are nonhazardous. Small amounts of spent chlorinated solvents including TCE and 1,1,1-trichloroethane are produced by degreasing operations. Other hazardous wastes include painting wastes, which are hazardous because of their ignitability. Most of the other wastes, such as scrap wood, boxes, and other containers, are classified as nonhazardous sanitary or industrial waste.

Waste lubricating oil forms a large-volume waste stream produced by field maintenance activities. The oil is classified as hazardous, nonhazardous, or contaminated depending on the chlorinated solvent or radionuclide content. Clean and contaminated asbestos wastes result from the repair of systems such as steam-heating systems that were insulated during plant construction. Clean and contaminated scrap metal, nonhazardous construction debris, PCBs and PCB-contaminated wastes, and waste oils are also produced at PGDP through maintenance activity.

Laboratory operations. Small quantities of hazardous, nonhazardous, low-level radioactive, and PCB wastes are generated by laboratory operations. The bulk of the wastes are residues or leftovers from analytical work. Uranium salvage solutions are mixed waste. Waste oils, solvents, and other organic materials are also hazardous, as are discarded laboratory chemicals.

Remedial action activities. PGDP has begun an extensive RAP designed to investigate the current groundwater contamination problem and on-site waste management units and spill sites. Drill tailings, grout, equipment wash water, and water from sampling activities are being generated and are managed in accordance with regulations and plant procedures. See Sect. 4 for further details.

5.2.3 Waste Generation Summary

Table 5.2.1 summarizes the waste generated on-site during 1989. The types of waste are

Table 5.2.1. 1989 PGDP waste generation summary

Waste	Volume (m ³)	Mass (kg)
Hazardous	43.0	27,406.8
Residential	4,045.7	NA
Industrial	2,794.3	NA
Mixed	18.2	17,745.1
PCB	152.7	170,597.3
PCB/uranium	83.3	34,361.9
Low-level	133.8	109,657.6
Asbestos		
Clean	555.4	NA
Contaminated	44.0	13,546.9
Classified	1.6	NA
Miscellaneous		
Nonhazardous	38.2	30,735.9
Redwood	1,295	304,287.0

described in Sect. 5.2.1. The quantities are indicated in the table. Table 5.2.2 shows a further breakdown by radionuclide and curie quantities of the low-level waste generated. No significant wastes were generated from site cleanup activities.

Table 5.2.2. 1989 solid radioactive waste generated at PGDP^a

Radionuclide	Curies
²³⁴ U	0.4727
²³⁵ U	0.0235
²³⁸ U	1.1720
²³⁷ Np	0.0009
²³⁹ Pu	0.0007
²³⁰ Th	0.0219
⁹⁹ Tc	0.1049

^aIncludes only available data from sampled drums. Numerous drums were placed in storage in 1989 awaiting monitoring in the drum curie monitor.

5.3 WASTE MANAGEMENT ACTIVITIES

5.3.1 Waste Management System

Containerized wastes and wastes requiring off-site disposal are managed by the Waste Management Department. All wastes are required to have a Request for Disposal form completed before they can be moved. This form functions as an internal manifest. Should the information on the form be insufficient, the waste is sampled and characterized before being disposed of or stored. Characterization is routinely performed on several waste streams in accordance with the Waste Analysis Plan in the facility Part B permit application, off-site disposal facility requirements, general RCRA, TSCA, and CWA requirements, and other criteria set forth by DOE and internal procedures.

Once a waste has been properly identified and characterized, it is packaged for shipment and/or storage. U.S. Department of Transportation criteria are used to select containers such as drums. Small quantities of chemicals are lab-packed by either PGDP personnel or off-site disposal facility personnel.

Wastes are managed at several on-site facilities. Residential and industrial waste, clean scrap metal, clean asbestos, and treated medical wastes are disposed of on-site. Some hazardous wastes are treated to render them nonhazardous prior to disposal. Some low-level radioactive wastes are treated to reduce their volume. Clean (i.e., without technetium, uranium, or transuranic contamination) PCB and hazardous wastes are disposed of off-site at inspected and permitted incinerators. Off-site landfills are used only under special circumstances. Some wastes, such as mixed and PCB/uranium wastes, cannot currently be disposed of and are placed in indefinite storage. Medical wastes are treated by autoclaving. They are then packaged in containers appropriate for the type of waste and are disposed of in the residential landfill.

All waste management units are operated in accordance with appropriate regulations. Hazardous, mixed, PCB, PCB/uranium, and low-level radioactive wastes are tracked and accounted

for using a computerized inventory system. Each container is assigned a unique identification number that is entered into a computer data base. Bulk liquids are inventoried at the time they are placed in tanks. Quantities of other wastes are estimated.

Wastes not managed by the Waste Management Department are discharged directly from treatment units or activity areas. Such wastes are routinely characterized to ensure that they are being properly handled.

5.3.2 Waste Management Facilities

A number of waste management units are located on the PGDP site. Each unit handles a limited number of types of waste. Units are grouped according to three general types—storage, treatment, and disposal. Table 5.3.1 shows the 1989 waste treatment data; Table 5.3.2 shows the 1989 on-site disposal information. The PGDP waste management units are listed in the following subsection.

5.3.2.1 RCRA hazardous and mixed waste facilities

RCRA-permitted units

- *C-733 hazardous waste storage area.* A diked, roofed storage area for container and tank storage. Capacity is approximately 189,000 L (50,000 gal).

Table 5.3.2. 1989 PGDP on-site waste disposal

Waste	Disposal method	Quantity (m ³)
Residential	Landfill	4,045.7
Industrial	Landfill	2,794.3

- *C-746-Q hazardous waste storage area.* A diked, totally enclosed area for container storage. No ignitable wastes are to be stored in the area. Capacity is approximately 189,000 L (50,000 gal).
- *C-746-R waste solvent storage area.* A diked area used for the temporary storage of drummed waste oils during sampling activities. Some mixed, hazardous, and PCB wastes are also stored in tanks.
- *C-400-B waste solution storage tank.* An 18,900-L (5000-gal) stainless steel storage tank. The tank is contained in a concrete, stainless-steel-lined containment area.
- *C-400-C nickel stripper evaporation unit.* A hazardous waste treatment unit. Hazardous wastes are evaporated in a 756-L (200-gal) stainless steel steam-heated tank.

Table 5.3.1. 1989 PGDP waste treatment

Type	Quantity ^a (m ³)	Treatment
U-salvage (mixed)	3.6	Neutralization/precipitation
Fixer solution (hazardous)	0.3	Reclamation
Machine coolant (nonhazardous)	2.9	Coagulation/filtration
Sodium hydroxide (hazardous)	1.5	Neutralization
Chromate water (hazardous)	3.1	Recycled

- *C-400-D lime precipitation tank.* A 15,120-L (4000-gal) stainless-steel tank used for neutralization and metals precipitation.
- *C-409 hazardous waste pilot plant.* Used for technology development work and the limited treatment and disposal of small quantities of hazardous wastes.

Permit-by-rule facilities

- *C-616 chromium reduction facility.* A wastewater treatment unit used to remove chromium from the recirculating cooling water blowdown. This is an RCRA "permit-by-rule" facility.
- *C-403 neutralization tank.* An in-ground tank used as a holding tank for wastewater from the C-400 building. It has limited use as a "permit-by-rule" elementary neutralization unit.
- *C-410-C neutralization tank.* An in-ground tank used for the neutralization of spent battery acids and fluorine cell electrolytes. This is a "permit-by-rule" elementary neutralization unit.

5.3.2.2 PCBs and PCB/uranium waste facilities

- *C-746-M storage building.* A diked, totally enclosed drum storage area. The capacity of the area is approximately 60 drums.
- *C-746-A storage area.* A storage area located in the C-746-A warehouse. The area is diked and has a capacity of approximately 3000 drums. PCB and PCB/uranium wastes are stored here.
- *C-337 and C-333 PCB waste storage areas.* Container storage areas located in the C-337 and C-333 process buildings. These areas are lined and diked with a synthetic material meeting EPA requirements. Approximately 2300 drums are stored in these areas.

5.3.2.3 Nonhazardous waste management areas

- *C-746-S residential landfill.* Used for the disposal of sanitary trash. Currently one cell is being utilized.

- *C-746-T industrial landfill.* Used for the disposal of fly ash, clean asbestos, and construction debris.
- *C-728 waste oil storage.* A diked area that includes two clean oil storage tanks with capacities of 15,120 and 30,240 L (4000 and 8000 gal). Waste oil is stored here until disposed of off-site.

5.3.2.4 Scrap metal facilities

- *C-746-P1 west clean scrap metal yard.* Used for the accumulation of clean scrap metal for resale.
- *C-746-P east regulated scrap yards.* Areas used for the storage of scrap metal containing nontransferable radioactive contamination.

5.3.2.5 Low-level radioactive waste facilities

- *C-746-Q low-level waste storage area.* Located within the C-746-Q building. The building is enclosed and diked. Approximately 1600 drums may be stored here. The area may be expanded as space becomes available.

5.3.3 Off-site Disposal Activities

Incineration is the preferred method for off-site treatment/disposal of waste. Landfills and other types of disposal are used only on a limited basis under special circumstances. All commercial sites are visited by Energy Systems personnel prior to use. These visits are used to inspect the facilities and to review management, permit, and insurance information. Site visits are repeated annually.

Off-site treatment/disposal is arranged for by the Waste Management and Purchasing Departments. Unless special circumstances warrant other arrangements, all such disposals are bid and awarded to the qualified contractor with the lowest bid. Commercial transporters or transportation provided by the waste management firm are used to move the waste from the PGDP site. Table 5.3.3 shows the off-site waste treatment/disposal quantities for 1989.

All containers of waste must meet DOT shipping requirements. Packages are inspected and inventoried prior to shipment.

Table 5.3.3. 1989 PGDP off-site waste disposal^a

Waste	Disposal method	Quantity (m ³)
Hazardous	Incineration	8.0
PCB	Incineration	264.0
Waste oil	Incineration	3.7

^aIncludes some wastes generated prior to 1989.

5.3.4 Waste Placed in Storage

In some cases wastes are accumulated to provide for cost-effective off-site disposal. These wastes are placed in interim storage. In some cases waste generated in 1989 will be retained on-site in storage until suitable disposal options are available. Table 5.3.4 shows the waste placed in on-site storage facilities in 1989. Several waste streams including mixed and PCB/uranium wastes cannot be disposed of currently by any means. These wastes are placed in indefinite storage on-site (see Table 5.3.5). The quantities in the table represent the total amount of waste in inventory at the end of 1989.

Table 5.3.4. 1989 PGDP waste placed in storage

Waste	Quantity (m ³)
Hazardous	30.1
Mixed	14.6
PCB	119.6
PCB/uranium	83.3
Low-level	133.8
Asbestos	
Clean	225.4
Contaminated	44.0
Redwood	1295.0

^aIncludes waste placed in storage and subsequently shipped for off-site treatment and/or disposal.

Table 5.3.5. PGDP 1989 ending waste inventory

Waste category	Inventory (m ³)
Hazardous	54.1
Mixed	352.6
Nonhazardous	95.6
Low-level	345.8
PCB	119.1
PCB/uranium	1,229.2
Asbestos	
Clean	225.4
Contaminated	52.0
Scrap metal	
Clean	20,451.0
Contaminated	245,314.0
Technetium and transuranics	3.2
Redwood	2,723.0

5.3.5 Special Activities

5.3.5.1 Waste identification and characterization program

In mid-July 1989 a plant-wide survey was performed to identify any unusable materials that had not been previously placed into the waste management system. Approximately 850 208-L (55-gal) drums of waste were identified. About 600 of these drums were sampled for characterization, and about 200 were characterized using existing data. All of these drums were placed in appropriate storage areas. About 50 drums of waste that potentially present significant hazards to waste management personnel were identified. These drums are being handled by a special plant team.

5.3.5.2 PCB waste storage

In mid-July PGDP was directed to place all solid PCB wastes in storage areas meeting TSCA requirements for secondary containment and aisle

space. A project to modify the C-746-A warehouse by repairing the structural steel and roof and by placing steel plate over the floor areas to provide an impermeable surface, together with 8-in. dikes, was begun in August and finished in September. Nearly 30,000 ft² of steel plate was installed during the project. In addition to the C-746-A project, several temporary storage areas were created within the C-337 and C-333 process buildings using an EPA-accepted synthetic liner built up over 8-in. dikes. A total of about 5000 208-L (55-gal) drums of solid PCB waste were placed in these storage areas. About 3500 of these drums required overpacking because of deterioration.

A total of about 20 tons of PCB-contaminated scrap metal were decontaminated to less than 10 μ g of PCB per 100 cm² of surface area or were placed in containers for storage.

5.3.5.3 Landfill operational modifications

In early August 1989 contamination control policies were implemented for residential and inert wastes. The program involves the monitoring (for radioactive contamination) of all residential and inert refuse from radiological areas.

5.3.5.4 Low-level waste disposal studies

In accordance with DOE Order 5820.2A, studies (including hydrogeology) were begun in 1989 to determine the suitability of the PGDP site for low-level waste disposal. Studies to establish a Below Regulatory Concern (BRC) level for radionuclides at the residential landfill were also begun. The objective of the BRC study is to establish a maximum radionuclide content for waste being disposed of in the landfill.

6. UNUSUAL OCCURRENCES AND SPECIAL STUDIES

The PGDP had a total of 369 spills or releases of various types of materials during CY 1989. A record of each incident is kept in the PGDP Shift Superintendent's office. All cleanup debris generated was handled in accordance with PGDP standard operating procedures. The PGDP Shift Superintendent's office reports all spills or releases to various levels of PGDP management and/or DOE officials as appropriate. The magnitude of the material released ranged from a few drops (i.e., involving PCB gaskets) to 180,000 gal (i.e., sanitary water used for fighting fires).

Most of the spills during CY 1989 were from PCB gaskets (Fig. 6.1). No system for notifying the PGDP Shift Superintendent of these leaks existed prior to July 12, 1989 (50 incidents is a reasonable assumption for that time period). A

total of 139 incidents were recorded between July 12 and December 31; this amounted to approximately 189 incidents of leaking PCB gaskets during CY 1989. Efforts to enhance spill prevention such as the construction of a spill containment system (i.e., troughs) not only beneath PCB gaskets but also beneath all applicable materials are under way. Highlights of the incidents are given in Subjects. 6.1 through 6.1.13.

6.1 UNUSUAL OCCURRENCES

6.1.1 Oil Spill: C-335 Process Building

On March 7, 1989, a large high-voltage PCB capacitor ruptured and released approximately 3.78 L (1 gal) of 82 to 100% PCB into an indoor low-contact restricted access area. The spill was

Fig. 6.1. Spills or releases at PGDP during 1989.

contained immediately, and cleanup was initiated. The rupture caused oil to spray onto the outside of a metal cabinet; the oil subsequently ran down onto the concrete floor. All metal surfaces were successfully decontaminated. However, after multiple washings and even with the removal of the top ¼ in. of concrete, the concrete floor was still above the surface decontamination level of 10 µg of PCB per 100 cm². A variance was requested and granted from EPA Region IV. The use of an epoxy-based sealant system to encapsulate the PCBs remaining in the concrete was approved by EPA Region IV. The cleanup of this site is now complete.

6.1.2 Chromated Water Spill: C-635 Pumphouse

On March 30, 1989, a 5.08-cm (2-in.) line on a recirculating cooling water pump broke resulting in the release of a significant quantity of chromated water. The chromated water contained 9 mg/L of hexavalent chromium. Most of the water was contained in the building; however, approximately 3780 L (1000 gal) was released outside of the building to surface ditches in the immediate vicinity. No detectable chromium was found at KPDES sampling points 001 and 015. Most of the chromated water was returned to the system.

6.1.3 Chromated Water Spill: C-720 Chilled Waterlines

On June 6, 1989, during an inspection of electrical manholes, chromated water was found in five manholes east of the C-720 building. The leak was found to be in the chilled waterlines entering C-720. Approximately 58,590 L (15,500 gal) of chromated water leaked to the manholes. Weekly KPDES sampling showed no detectable chromium in KPDES Location 009. The leak was repaired, and the chromated water was returned to the system.

6.1.4 Nitric Acid Leak: C-400

On June 16, 1989, during transfer of concentrated nitric acid (pH < 1), a leak developed in the seal of the transfer pump. Approximately 226.8 L (60 gal) of nitric acid

leaked into a diked area containing approximately 4914 L (1300 gal) of rainwater. The spill was contained in the diked area. The resulting solution was neutralized with sodium hydroxide to a pH of 7 to 8 and subsequently discharged.

6.1.5 Chromated Water Spill: C-331 Seal Exhaust

On July 19, 1989, analysis of water taken from KPDES sampling point 010 revealed a chromium content of 0.8 ppm. The ditch was dammed, and the water was returned to the recirculating cooling water basin. The source was discovered to be the C-331 seal exhaust pump. The dam was removed after the chromate levels were reduced.

6.1.6 Sulfuric Acid Spill: C-746-R Storage Yard

On July 24, 1989, 40 waste cascade batteries were dropped while being moved. Spilled were 135 kg (370 lb) of sulfuric acid. All of the acid was contained in the area. The spilled acid was neutralized with soda ash prior to discharge.

6.1.7 Oil Spill: C-746-R Storage Pad

On September 25, 1989, approximately 9.45 L (2.5 gal) of uranium/PCB-contaminated (>500 ppm PCB) TCE solvent was spilled on the ground near the storage pad. This occurred during the transfer of the TCE solvent from a permanent storage tank to a portable storage tank. The sight glass on the portable tank was plugged allowing tank overfill. The spill was contained to the immediate area. The spill was cleaned up in accordance with the EPA PCB spill cleanup requirements. Postcleanup sampling showed 8 ppm PCB still present. A variance was granted by the Kentucky Department of Environmental Protection to delay further cleanup until Remedial Action Investigations are complete.

6.1.8 Oil Spill: C-720 Welding Shop

On October 12, 1989, approximately 189 L (50 gal) of hydraulic oil spilled during operation of a hydraulic press. No oil migrated to any drains or outside of the building. All of the oil was contained in the area and was cleaned up.

6.1.9 Oil Spill: C-537 Switchyard

On November 8, 1989, an outdoor capacitor failed and ruptured spilling approximately 9.83 L (2.6 gal) (nearly 100% PCB) of oil. The spill was confined to the immediate area that included an electrical cable pit. The drain in the cable pit was later plugged, and analysis of the water in the pit confirmed the presence of PCBs. The spill occurred in an area in which PCB contamination was already present. It is not known if any PCBs were able to enter the drain because of this spill. This area will be addressed by the RAP in the future. The spill is being cleaned up in accordance with PCB regulations.

6.1.10 Oil Spill: C-333 Capacitor Bank

On December 6, 1989, a capacitor failed in the C-333 building spilling approximately 7.57 L (2 gal) of 70% PCB oil. The spill was immediately contained within the building. Sample results for verification of cleanup are pending.

6.1.11 Chilled Water Spill: C-101 Basement

On December 16, 1989, approximately 34,020 L (9000 gal) of chilled water (300 ppm hexavalent chromium) spilled into the basement of C-101. The total chromium content was calculated to be 10.13 kg (22.5 lb). The leak was from a chilled water coil. Sandbags and pipe plugs were used to contain the spill. Analysis revealed that no chromium above the KPDES Agreed Order limit had reached Big Bayou Creek. The recovered water was returned to the cooling tower basins.

6.1.12 Chromated Water Spill: C-400 Heating System

On December 22, 1989, a leak occurred in the north heating system in C-400 when coolant tubes froze and burst. Approximately 756 L (200 gal) of chromated water containing 8 ppm hexavalent chromium leaked to the floor; less than 18.9 L (5 gal) entered the floor drain. The cooling system was immediately isolated shutting off the supply. The spill site was cleaned.

6.1.13 Chromated Water Spill: C-337 RCW Line

On December 25, 1989, a valve on a recirculating cooling water line in C-337 broke. Approximately 5670 L (1500 gal) of chromated water (8.2 ppm chromium) was released to a diked area. All of the water was contained within the building. The spill site was cleaned.

6.2 SPECIAL STUDIES

6.2.1 Concrete Rubble Investigation

During a preliminary site investigation, above-background levels of radioactive contamination were found on a large concrete rubble pile north of the plant. The finding initiated further investigations to determine the nature and extent of the contamination. The first investigation involved reviewing historical records, talking with employees, and conducting field investigations to determine other sites where concrete rubble from the plant had been dumped. Approximately 35 sites were identified both in McCracken and Ballard counties where the rubble had been either stored for future use or used as construction material. Most of the sites are located in the WKWMA and the Ballard Wildlife Management Area (BWMA). The rubble had been used as core material for pond embankments, rip-rap along creek banks, and as core material for small dams and bridges.

IT Corporation was hired to conduct a more detailed investigation of the rubble pile north of the plant. This site was chosen because it was to be the site for the electrical substation being built by Electric Energy Incorporated (EEI). It is also one of the more easily accessible sites. The individual concrete chunks were surveyed using field radiation detection equipment. Soil samples were also taken from drainage ditches around the rubble pile to determine if the contamination was migrating. Further scanning using field detection equipment was conducted at many of the other sites. These surveys were not as meticulous as the investigation of the substation site. The investigations revealed that only a small percentage (i.e., approximately

10 to 15%) of the easily accessible surfaces exhibited radioactive contamination. Those surfaces that were contaminated had relatively low levels of contamination; however, the levels are above the off-site release limits.

Based on permanent annual occupancy and using the maximum surface radioactivity from one isolated area, the sum of the highest doses from all internal and external pathways would total 3.5 mrem/year. This total dose would include internal exposure from both ingestion and inhalation and external exposure. In all cases the highest dose is due to uranium exposure. The NESHAP requires emissions to be limited so that no member of the public would receive in one year more than 10 mrem effective dose equivalent.

6.2.2 KPDES Outfall Investigation

The purpose of this investigation was to determine the contaminants present in the plant outfall ditches. Also, water samples were taken from each ditch and analyzed for PCBs to aid in the PCB minimization program. Ditches 001, 002, 003, 008, 009, 010, 011, 012, 013, 015, 017, and the sanitary landfill drainage ditch were sampled during the investigation.

The sampling was performed to support the refrigerated autosamplers project and the plant effluent chlorine and temperature control project. These two projects required construction in the ditches. The Occupational Health and Safety Administration requires that the levels of contamination in the ditches be determined so that adequate protection of personnel can be implemented during construction activities.

The ditches were sampled for the Target Compound List, Appendix IX contaminants, dioxins, and radionuclides. Samples were taken at two locations in each ditch. Generally, two boreholes were drilled at the outfall of each ditch, and one borehole was drilled in a depositional area of each ditch. The outfall area and depositional area were identified as the two areas of the ditches most likely to have contamination because of the nature of contaminant migration.

Two samples were taken from each borehole. One sample was taken from the surface sediments,

and the second sample was taken from a depth of 1.22 to 1.52 m (4 to 5 ft). The surface samples were taken to identify those contaminants that tend to sorb to soil particles. The deeper samples were taken to identify those contaminants that are more mobile and to detect contamination from past spills that may have occurred in the ditches.

6.2.3 DOE Headquarters Environmental Survey Data Accuracy Review

The data accuracy review portion of the environmental survey was conducted on May 18–19, 1989. The first purpose of the review was to ensure that the best available data are used to rank the category II and III findings; the second purpose, to update the findings and to determine if any could be excluded from the ranking. Information regarding subjects such as chromium air releases, underground storage tanks, and off-site groundwater contamination was provided to the survey team. The information is being utilized to rank and/or to exclude findings from the ranking system.

6.2.4 C-404 Low-Level Radioactive Waste Burial Ground Postclosure Activities

In early 1986 it was determined that waste classified as hazardous under RCRA criteria had been placed in C-404. Activity at the site was halted immediately, and closure began. During 1987 C-404 was closed and capped. During 1988 12 RCRA quality wells were installed completing the postclosure activities. During 1989 quarterly sampling was conducted, and data were submitted to EPA Region IV and the Kentucky Division of Waste Management. Statistical analysis of the quarterly sampling revealed that groundwater contamination has occurred. A compliance groundwater monitoring plan will be submitted to the Kentucky Division of Waste Management for approval in 1990.

6.2.5 Polychlorinated Biphenyl Ventilation Gaskets

At PGDP PCBs have been determined to be present in ventilation gaskets both in process and nonprocess ventilation systems. Results have shown

that PCBs in the gaskets range in concentration from a few parts per million to percent levels. The presence of the PCBs in the gaskets is currently interpreted as an unauthorized use of PCBs by the Region IV office of the EPA. According to regulations promulgated by the TSCA (40 CFR 761.20a), PCBs are banned from use unless authorized by the EPA.

In areas where oil is present in the ventilation system, such as the motor exhaust system, PCB leaks occur when the migrating oil leaches PCBs from the gaskets. Therefore, one of the ongoing actions that has been implemented is the installation of a PCB Spill Containment System (SCS) to minimize exposure to the environment. This PCB containment system includes polyvinylchloride (PVC) troughs underneath the leaking gaskets and a PVC manifold system that collects the PCB-contaminated oil into collection drums. By the end of 1989, approximately 4000 troughs had been installed under leaking PCB gaskets. Moreover, on July 12, 1989, a program for tracking newly identified PCB gasket spills was initiated at PGDP to meet EPA PCB spill cleanup requirements. The major components of the tracking program include documented identification of new spills, containment of the spills through installation of the SCS, decontamination of the spill area, and verification of cleanup by postcleanup sampling and analysis.

The pursuance of an authorization by EPA for PGDP to use the PCB gaskets and the containment system is being coordinated through DOE Headquarters. A proposed Federal Facility Agreement was submitted by DOE Headquarters to EPA Headquarters in early 1990. The proposal addressed the PCB gasket issue including use of the gaskets and the SCS plus spill cleanup requirements. The EPA's response is expected in the second quarter of 1990. A 1991 line item has been identified for further installation of the PCB SCS for the remaining PCB gaskets that have a potential for leaking. The cost of the line item project is estimated at \$30 million.

6.2.6 National Environmental Policy Act

Implementing the NEPA is a decision-making process that considers the need for a proposed

action and an alternative action with emphasis on minimizing environmental impacts. It establishes policy, sets goals, and provides means for carrying out the policy. NEPA contains "action-forcing" provisions to ensure that federal agencies act according to the letter and spirit of the act.

Through the implementation of NEPA, the plant has a practicable means (consistent with the requirements of the act and other essential considerations of national policy) to restore and to enhance the quality of the human environment and to avoid or to minimize any possible effects of their actions upon the quality of the human environment.

During 1989 the NEPA coordinator attended a workshop entitled Implementing the National Environmental Policy Act on Federal Lands and Facilities conducted by Duke University and a symposium entitled The Scientific Challenges of NEPA: Future Directions Based on 20 Years of Experience. As a result of the NEPA courses and additional guidance from DOE, the plant's NEPA compliance program began making some substantial changes. These changes include:

- field surveillance reports,
- heightened wetlands awareness,
- monthly NEPA status reports, and
- letters to engineering to confirm NEPA approval from DOE for specific projects.

During 1989 approximately 110 engineering service orders were opened. Seventy environmental and health reviews were issued, and 9 action description memorandums were issued to DOE for approval. Several field trips to construction sites have been documented. In addition, approximately 4800 work orders have been reviewed for environmental concerns; others have been sent to environmental, safety, and health departments for further review in their areas of expertise. No environmental assessments or environmental impact statements were required on any plant projects during 1989.

6.2.7 Underground Storage Tank Investigation

On July 20, 1989, during a scheduled well evaluation being conducted by a subcontractor of

PGDP, evidence of combustible vapors was discovered in well 69. Well 69 is the most shallow of four wells that compose a well cluster located northeast of the C-750 garage facility. As a result of the suspected contamination in well 69, water sampling and analyses for all wells in the well cluster were conducted on July 21, 1989. Analysis of these samples confirmed the presence of petroleum contamination in well 69. The three deeper wells in the cluster showed no signs of petroleum contamination. Following this discovery, an underground storage tank (UST) investigation was begun. Two USTs confirmed to be leaking were emptied. As part of the investigation, a new groundwater sampling plan was begun.

For all wells in the immediate vicinity of the C-750 garage facility, special sampling is being conducted on a bimonthly basis for benzene, toluene, ethylbenzene, and xylene (BTEX) and total petroleum hydrocarbons (TPH). This sampling is in addition to the regular quarterly sampling of wells 68 and 71. The wells in this area that are sampled bimonthly include 68, 69, 70, 71, and 96 providing they contain sufficient water to obtain samples. Wells 47 and 52, which are located northwest of the UST area, will also be sampled. Well 52 will be sampled so that the levels of contamination previously found can be monitored, and well 47 will be sampled to check for the possible spread of contamination in the shallow sands. The analyses to be run on these samples, BTEX and TPH, will monitor for the presence and spread of petroleum contamination.

6.2.8 Monthly Environmental Compliance Report (SEN-7-89)

On May 19, 1989, the Secretary of Energy issued a notice (SEN-7-89) clarifying DOE policy on management's responsibility to achieve environmental compliance at all DOE facilities. Included in the directive was the requirement to establish a process to provide DOE Headquarters with up-to-date information on the status of each facility's environmental compliance. To comply with the directive, management was directed to perform a continuous evaluation of the facility's compliance activities and to prepare a monthly

environmental compliance report containing the following information:

- the status of management's compliance with all environmental requirements including compliance agreements, operating permits, reporting, and notification;
- an evaluation of the operating contractor's performance in meeting environmental requirements;
- corrective actions being taken in areas not in compliance and the date when compliance is expected; and
- any outstanding or possible lawsuits that could threaten DOE's program obligations.

The first report was issued on August 1, 1989, and subsequent reports are being issued monthly.

6.2.9 PGDP Environmental Advisory Committee

During 1989 the PGDP Environmental Advisory Committee continued to be active in reviewing PGDP environmental programs. The committee, made up of local citizens having a variety of backgrounds who bring a wealth of knowledge and a fresh perspective to the plant environmental program, was formed at PGDP in 1986. The committee has met on a regular basis since its formation and has gained an understanding of the majority of environmental and health-related issues at PGDP.

Four meetings were held during 1989. Key topics discussed at these meetings included:

- groundwater contamination and investigation activities;
- PCBs in ventilation ducts, fish, water, and sediments;
- dioxin assessment plans;
- scrap metal plans;
- KPDES/biological monitoring;
- the Environmental Restoration and Waste Management Five-Year Plan;
- the Health and Safety Advisory Committee joint meeting; and

- underground storage tank activities.

The input from the committee continues to be valuable in determining the direction of ongoing and future environmental activities at PGDP.

6.2.10 Deer Study

In August of 1989 twelve deer were harvested in the WKWMA as part of a study to determine the effects of PGDP on the ecology surrounding the plant. In addition, two deer were harvested in the Land Between the Lakes area for comparison. Liver and muscle samples were analyzed for metals, radionuclides, and PCBs. Bone and thyroid samples were analyzed for radionuclides, and a

hair sample was analyzed for technetium. A fat sample was also taken and analyzed for PCBs. The results for muscle samples are shown in Table 6.2.1.

A health assessment was performed using the analytical results by ORNL. One fat sample showed 388 $\mu\text{g}/\text{kg}$ PCBs. The health risk from ingesting PCBs from contaminated deer liver falls within routinely used EPA carcinogen guidelines. Concentrations of inorganic chemicals in the liver and muscle are below the long-term federal criteria for ingestion. A health assessment was not performed for radionuclides. A statistical analysis was performed on the technetium and uranium results; there was no statistical evidence that technetium or uranium was above background.

Table 6.2.1. 1989 PGDP deer study^a

Deer	Ca	Cu	Fe	Mg	Na	P	Zn	Al	⁹⁹ Tc	²³⁸ U	²³⁵ U
1	110	0.99	34	200	580	2100	79	2.5	0.1890	0.0062	0.0046
2	26	1.4	42	240	250	2500	29	ND ^b	0.1350	0.0009	0.0003
3	140	1.2	25	250	450	2600	17	ND	0.1377	0.0010	0.0037
4	27	1.4	42	250	310	2500	25	ND	-0.0135	0.0032	0.0018
5	27	1	37	250	260	2500	14	ND	0.1188	0.0019	0.0014
6	26	1.2	20	270	330	2600	15	ND	0.	0.0025	0.0021
7	26	1.3	37	260	350	2600	16	ND	-0.1188	0.0013	0.0008
8	26	1.1	31	250	260	2500	15	ND	0.0351	0.0009	-0.0001
9	27	1.1	59	260	250	2500	16	ND	-0.1350	0.0027	0.0019
10	69	1.3	28	250	270	2600	18	ND	0.0837	0.0038	0.0014
11	26	1.3	29	260	270	2600	17	ND	0.0108	0.0035	0.0024
12	25	1.2	23	250	340	2600	16	ND	-0.0837	0.0019	0.0013
BG-1 ^c	28	1.5	36	240	330	2500	38	ND	0.0621	0.0008	0.0027
BG-2	34	0.91	20	250	350	2500	14	ND	0.0702	0.0014	0.0002

^aData for muscle tissue only. Only those metals above detection limits were reported. ⁹⁹Tc, ²³⁸U, and ²³⁵U reported in pCi/g. All others reported in $\mu\text{g}/\text{g}$. PCBs in muscle tissue were below analytical detection limits.

^bND—not detected.

^cBG—background deer.

7. QUALITY ASSURANCE AND GENERAL REVIEWS

Quality assurance (QA) planning is integrated into every step of the environmental surveillance effort. Each contributor is totally responsible for the quality of his or her contribution. Developed and evolved over many years of such activity and careful study of appropriate regulatory guidance, the surveillance program can be roughly divided into three major efforts: sampling of the environment, analysis of the samples, and treatment or interpretation of the results.

The analytical laboratories, the Environmental Services Section consisting of the Environmental Sampling Group, and the Measurements Control Group have begun two internal programs to monitor the quality of analyses reported on surface water and groundwater samples. These programs use purchased standard materials prepared by Measurements Control that are submitted according to regulatory guidance to the groups performing the analyses. These results are used to monitor the analyses further and to provide more immediate feedback to analysts and customers involved in the programs. In the Environmental Sciences Section a new procedure was implemented to perform total residual chlorine analyses in the field using an EPA-approved procedure. A modification was made to the chain-of-custody procedure to ensure improved documentation of sample transfers. An engineering design project was initiated to replace flow-monitoring devices and to provide better sampling instrumentation at the KPDES outfalls. All of these changes were made in response to EPA audits of PGDP programs.

Finally, a system was developed to provide better support of subcontractor and RAP goals. This system monitors the laboratory turnaround times for analyses to provide timely feedback for

decision making. In the Radiochemistry and Mass Spectrometer Section a new computer data collection system for the thermal ionization mass spectrometer was added. This allows improved and more reliable data storage capabilities. A new gas flow proportional counter was purchased for counting low-activity alpha and beta radiation increasing capacity and providing backup for instruments already in service. Two new procedures were also implemented. The first uses liquid scintillation analyses to provide calculation of gross alpha and beta activity for radiation-screening samples. This procedure provides the rapid turnaround of sample results for subcontractors allowing them to ship their samples off-site and meet shipping and holding time guidelines. The second procedure reduced the time and effort required to analyze soil and sediments. It involves using larger containers to spread the sample; this reduces self-shielding and eliminates a time-consuming leaching process.

In the Spectroscopy and Microanalysis section a new Zeeman graphite furnace atomic absorption analyzer was purchased. This instrument provides state-of-the-art automated analyses by method of additions with autostandardization capability. Method of additions is a technique used to compensate for interferences. It provides backup to existing instrumentation and also decreases the analytical time spent analyzing samples for metals.

The Organic Analysis Section has an additional computer data system for the gas chromatograph/mass spectrometer as backup to the system now in use for volatile organic analyses. A personal computer data system was also added to one of the gas chromatographs used in PCB analysis. Two new procedures were also implemented to measure groundwater

contamination by gasoline and diesel tank leaks. One procedure was implemented for TPH; another, for BTEX analyses.

7.1 SAMPLING QUALITY ASSURANCE

7.1.1 Basic Concepts and Practices

From the point of conception of any sampling program, QA plays an important role. Each monitoring or sampling organization plans a project, sets objectives, identifies responsibilities, and selects sampling methods and the appropriate sampling instruments or devices according to use and cleaning practices recommended by the American Society for Testing and Materials, the EPA, or other established authorities. The number of samples, location of sampling sites, sampling methods, sampling schedule, and coordination of sampling and analytical resources to meet critical completion times must all be decided. The rationale for these decisions and others is mainly the responsibility of the sampling organization with input from compliance and analytical organizations. Sampling plans and field documentation are prepared as appropriate. Chain-of-custody documentation is prepared from the point of sampling, and the samples are properly protected until they are placed into the custody of analytical laboratory control programs. In the laboratory, chain of custody continues until the sample is analyzed. For hazardous waste samples, chain of custody is maintained to the point of sample disposal. The performance of all field analytical procedures is documented using EPA-approved methods when available. Table 7.1.7 of Part 2 lists these procedures.

7.1.2 Air Monitoring

The design of the ambient air samplers is based on an internal study that determined the efficiency of potassium carbonate-impregnated filter paper for collecting gaseous fluorides. The procedure requires that flows be measured using a calibrated flow meter. If the flow drops more than 40% of the initial reading, the sample is not used; this helps to ensure that reported data accurately reflect plant emissions. Air-filter-sampling data are

recorded in the field logs and the chain-of-custody logs, and they are entered into the computer system. Table 7.1.1 of Part 2 lists the analytical procedures. See Subsects. 7.2.2.4 and Table 7.2.14 (Part 2) for quality control (QC) data.

7.1.3 Water Monitoring

Water sampling is conducted both for PGDP's information and to meet regulatory requirements. Procedures have been written for surveillance samples and for KPDES permit sampling. Guidance for developing these procedures has been codified (40 CFR Pt. 136.3) and may also be found in other applicable sources. Records are kept in the field logs and the chain-of-custody logs and are entered into the computer system. The chain-of-custody logs also record the subsampling (i.e., procedure by which aliquots of a sample are divided for specific analysis) and preservation for each sample. The chain-of-custody logs are stored in the Environmental Sampling office. The analytical procedures for these samples are listed in Tables 7.1.2, 7.1.3, and 7.1.7 of Part 2. See Subsect. 7.2.2.1 through 7.2.2.3 and Tables 7.2.1 through 7.2.14 (Part 2) for QC data.

7.1.4 Groundwater Monitoring

Water samples from plant wells are collected according to written procedures based on published guidelines (U.S. EPA December 1987). Field measurements used for reporting analytical data are taken using calibrated instruments to ensure accurate data. Records are kept in the field logbook and on the chain-of-custody logs for wells and are entered into the computer system. The chain-of-custody logs also record subsampling and preservation for each sample. The analytical procedures for these samples are listed in Tables 7.1.2, 7.1.3, 7.1.6, and 7.1.7 of Part 2. See Subsects. 7.2.2.1 through 7.2.2.4 and Tables 7.2.1 through 7.2.14 (Part 2) for QC data.

7.1.5 Biological Monitoring

Plant monitoring consists of a quarterly sampling of grass from the surrounding area to

determine levels of fluoride concentrations and annual sampling of wildlife, vegetation, and garden materials for radioactive analytes. Analytical procedures for these samples are listed in Table 7.1.4 of Part 2.

7.1.6 Soil and Sediment

Samples of soil and sediment are collected according to published procedures (Watson Mar. 23, 1989; Malis 1989). Included in both these types are background samples that are used to establish the baseline from which the plant's contribution can be calculated. No field measurements are taken in these sampling procedures. Potassium-40 in these samples is analyzed as a QC check on the accuracy of the data. Because the ^{40}K levels are not affected by plant operations and are analyzed by the same method as the other analyses, any deviation from expected values indicates procedural problems. Records are kept in the field logs and the chain-of-custody logs and are entered into the computer system. The analytical procedures for these samples are listed in Table 7.1.5 of Part 2. Because of sample loads in the Paducah analytical laboratory, these samples were analyzed at ORNL for PCBs and radionuclides. Some minor variance is expected between current and past data because of different analytical practices and capabilities between ORNL and PGDP.

7.1.7 External Gamma

Monitoring for gamma radiation is mandated by DOE Orders 5400.XY, 5400.1, 5480.4, and 5400.5. Guidance for procedures is found in ANSI Standard N545-1975. The calibration, preparation, and analysis of PGDP TLDs is performed by ORNL.

7.1.8 Solid Waste Monitoring

Solid waste sampling and characterization is conducted to ensure storage and disposal of solid waste in accordance with TSCA, RCRA, and DOE Order 5820.2A. Data come from both routine sampling and special requests by Environmental Compliance and Waste

Management personnel. Guidance for sampling and characterization is obtained from EPA guidelines (U.S. EPA December 1987) and other applicable regulations. Records are kept in the field logs, the laboratory notebook, and the chain-of-custody book, entered into the computer system, and stored in the Environmental Technology office.

7.2 ANALYTICAL QUALITY ASSURANCE

The analytical laboratories of the Energy Systems installations continue a long tradition of QA. Such terms as sound methodology, safe practices, analytical recovery, precision, accuracy, and QC are well established. Since the beginning of each installation's operation, the laboratories have been involved in the handling and analysis of hazardous materials, materials for which strict accountability is required, and materials of high purity. QA is, therefore, a daily responsibility.

Upon receiving the samples from the sampling group or the sample transporter, the laboratory custodian assumes responsibility for the proper protection and handling of the samples. Using guidance from EPA, the laboratories document the steps in handling, analysis, and approval of results. The performance of all analytical procedures is documented using EPA-approved methods when they are available. These procedures for air, water, soil, sediment, biota, and groundwater (with traceability to EPA methods), are listed in Tables 7.1.1 through 7.1.6 of Part 2.

A key feature in analytical QA is QC. PGDP participates in programs that are (1) internal to the laboratory, (2) internal to the Quality and Technical Services Division but external to the laboratory, and (3) external to the plant.

7.2.1 Internal Quality Control

All analytical activities are supported by the use of standard materials or reference materials. The compositions of these materials are well known and are used in calibration of instruments, method standardization, spike additions for recovery testing, and other practices. Certified standards from the National Institute for

Standards and Testing, the EPA, or from other DOE laboratories are often used in such work.

These internal programs are the mainstay of analytical QC. They are the basis for ensuring reliable results on a daily basis and between batches. The total effort in these programs is at least 10% of the total laboratory effort (in accordance with EPA expectations) and probably reaches 20% in some activities.

The internal QC and QA programs have become a major factor in the environmental analysis procedures because of the low levels of pollutants measured and the relationships of these measured values to regulatory limits. These QC programs also provide for laboratory analyst training and qualification in the many procedures involved. The daily QC data are stored in a retrievable manner so they can be related to the analytical results they support. Tables 7.2.1. and 7.2.2 (Part 2) are examples of some of these programs.

7.2.2 External Quality Control

All of the Energy Systems installations are directed by DOE and by the EPA regulators to participate in external quality control programs. PGDP also participates in voluntary external programs to provide for improved analytical QC. These programs generate data that are readily recognizable as objective measures that permit the participating laboratories and the government agencies a periodic review of performance. Although participation is mandated, the degree of participation is voluntary, so each laboratory can select parameters that are of particular interest to that plant. The sources of these programs are laboratories in the EPA, DOE, and even the commercial sector. The PGDP laboratories participate in these external programs. Examples are given in Tables 7.2.3 through 7.2.14 (Part 2) for both radiological and nonradiological areas.

The analytical laboratory has an appointed measurements control coordinator who is functionally independent of the laboratory. In addition to monitoring the general quality of analytical data, the officer administers a program of generating QC samples of known composition

(including some shown in Table 7.2.1 of Part 2) and periodically submitting these to the laboratory as known controls of unknown levels. This officer also coordinates and evaluates the results of the external QC programs discussed in the following subsections.

7.2.2.1 Environmental Protection Agency Discharge Monitoring Report (DMR) QA Program

The 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 annually and evaluates the results. The state of Kentucky follows PGDP's performance in this program. PGDP is required to analyze those parameters on its permit that are included in the DMR-QA Program. Other parameters may be analyzed on a voluntary basis for documentation or method checking. Table 7.2.3 (Part 2) shows all parameters within acceptable limits. Results in the "check for error" category are still considered acceptable but are investigated. Refer to Subject. 7.4 for information about the investigations.

7.2.2.2 Proficiency Environmental Testing Program

The PGDP laboratory participates in the Proficiency Environmental Testing Program (PET), an external measurement control program, using samples purchased from the Analytical Products Group the (APG), Inc., a commercial supplier. Samples at two concentration levels are analyzed bimonthly and reported to APG. An evaluation report is received in approximately 3 weeks. Most samples are evaluated by comparing (in standard deviations) the reported value to the mean of the reporting laboratories. Samples for dissolved and suspended solids are compared with average percent recovery in the same way. The performance evaluation in the tables is derived using the same criteria as those in the EPA DMR-QA program. The measurement control coordinator keeps control charts on these analyses. Tables 7.2.4 through 7.2.9 (Part 2) present the results of the 1989 PET testing. The data have been modified to reflect the number of significant

figures that the laboratory methods are routinely reporting.

Measurements that have unacceptable recoveries of more than 2.58 standard deviations from the mean are investigated to determine the cause. Of 388 measurements, 5 were deemed not acceptable. Refer to Subsect. 7.4 for information about investigations.

7.2.2.3 Proficiency Analytical Testing Program

The PGDP laboratory participates in the Proficiency Analytical Testing Program (PAT), an external measurement control program from the National Institute for Occupational Safety and Health (NIOSH). This program targets industrial hygiene analyses but also has application to environmental factors because the concerns in both fields overlap. One of the rounds of this program had outliers (Part 2, Tables 7.2.10 through 7.2.13). The performance evaluations for these tables are provided by NIOSH. The laboratory maintained a "proficient" rating for all analyses through 1989. Refer to Subsect. 7.4 for information about the investigations.

7.2.2.4 DOE Environmental Measurements Laboratory Quality Assessment Program

The PGDP laboratory participated in the Environmental Measurements Laboratory (EML) measurements control program as required by DOE Order 5400.1. The results are given in Table 7.2.14 of Part 2. The performance evaluation is determined by using the three ratio ranges given in the EML report to determine acceptable, marginal, or not acceptable categories. There were no "not acceptable" results out of the 15 results reported. Refer to Subsect. 7.4 for information about investigation.

7.3 AUDITS AND REVIEWS

7.3.1 External Regulatory

An RCRA Comprehensive Evaluation Inspection was performed in August 1989 by the Kentucky Division of Waste Management and EPA Region IV. Several minor deficiencies identified were corrected including an inventory of

PGDP waste subject to the land disposal restrictions, modification of the PGDP Part A Permit, and revision of the PGDP Contingency Plan.

On August 24, 1989, the KDAQ performed its annual inspection of PGDP. The inspection report cited nine facilities for possible construction and operation without permits. Seven of the nine possible violations were resolved in a meeting between PGDP, DOE, and KDAQ on August 29, 1989. A Notice of Violation for constructing and operating the C-635-2 and C-633-2A cooling towers without a permit was issued on November 13, 1989.

KDAQ inspections in July 1988 and in January 1989 resulted in Notices of Violation regarding fugitive emissions from the C-726 sandblast facility. Measures to alleviate the excess emissions were not successful, and the facility was shut down in May 1989. PGDP plans to install a dust collection filter system to reduce fugitive emissions and to return the facility to regulatory compliance. The application for the permit to install the dust collection is presently being reviewed by the KDAQ Permit Review Branch.

On October 26, 1989, the KDOW Paducah, Kentucky, office conducted a Compliance Evaluation Inspection and Sanitary Survey. Inspected were the KPDES outfalls, the C-611 water treatment plant, the C-615 sewage treatment plant, and the C-616 chromium reduction facility. A satisfactory rating was received.

On November 7-8, 1989, a Performance Audit Inspection was conducted by EPA Region IV. Items covered included field sampling, sample analysis, record keeping, QA/QC, and data reporting. A formal report was not received in 1989.

The State Radiation Control Branch of the Division of Radiation and Product Safety conducted three sets of surface and well sampling to verify the results obtained by PGDP in their surveillance and monitoring of areas affected or potentially affected by the groundwater contamination. The state sampled areas on all sides of the plant to obtain background data for comparison with data from the contaminated areas. During June, September, and December the state

obtained samples from these areas. During their sampling PGDP obtained duplicate samples from all locations. Some of these samples were to be used for analytical comparisons and QC. The rest were held as backups in case analytical results did not agree. The results from the December sampling were not received in 1989. A comparison of the results from the June sampling and the September sampling indicated that PGDP results agreed well with the state's results. Some differences were seen in the alpha measurements at some locations, but these were traced to different methods of stripping out beta interferences on the alpha. The state concurred that the differences in alpha were of no concern.

7.3.2 DOE Audits

During January 23–27, 1989, DOE/ORO (including the Environmental Protection Division) and DOE Headquarters conducted an environmental protection appraisal of PGDP, the overall purpose of which was to evaluate the effectiveness of Energy Systems implementation of DOE environmental protection requirements. Included in the appraisal were:

- examination of the status of past appraisal recommendations,
- determination of the compliance status of PGDP regarding all appropriate state and federal regulations and DOE orders,
- review of the effectiveness of PGDP programs regarding environmental protection, and
- preparation of recommendations (as necessary) for regulation compliances and/or improvements in existing programs.

In February 1989, PGDP environmental personnel received a draft version of the final report for review. Comments were prepared and will be included in the final printed document. The draft report revealed that PGDP management and staff have a clear understanding of environmental protection needs and that priority is being given to ensure this protection. Overall, the environmental protection program was found to be sound; however, areas for improvement (i.e., regulatory

violations and DOE requirement implementation) were noted.

7.3.3 Internal Audits

Calendar year 1989 was the second year that PGDP had planned and conducted an organized internal audit program at both plant and division levels. All PGDP audits related to environmental aspects were derived from the Plant and Personnel Protection (P&PP) Division Internal Audit/Review Management Plan issued on March 10, 1989. The plan provides a 5-year projection of internal audits and other related activities that the department heads in the P&PP Division identified as being helpful to ensure procedural and regulatory compliance in various PGDP activities. This plan is updated and reissued at the beginning of each calendar year to ensure that the audit topics identified meet current needs (Table 7.3.1).

Only trained personnel were permitted to lead or to staff an audit team at PGDP. The Energy Systems lead auditor or auditor training course was required for all team members on plant audits. A somewhat shorter course on conducting division audits (or the Energy Systems course) was required for all team members on the division audits. Audit protocol for both types were in accordance with PGDP Standard Practice Procedure P-GP-39 entitled "Technical Audits." Personnel trained for 1988 audits were preferentially assigned to the 1989 audits to provide more experienced staffing on these teams and to reduce the number of training hours needed. New personnel were trained as needed to complete the staffing of these audit teams.

On October 14–15, 1989, the Environmental Safety Activities organization at Energy Systems conducted a walkthrough PCB inspection of the PGDP facilities. The inspection covered the PCB gasket program, PCB use, handling, waste storage, disposal, and waste-tracking documentation. Results of the inspection included 6 commendable findings; however, 13 general findings of concern ranging from spill response for PCB gaskets to general housekeeping were noted. All the general findings have been addressed since the inspection.

On July 10–14, 1989, Energy Systems representatives conducted a technical operations

Table 7.3.1. Internal audit program data at Paducah Gaseous Diffusion Plant

Audit topic	Year		Final report issued	Findings	Observations
	Initiated	Completed			
<i>Plant-level audits planned, scheduled, and conducted</i>					
"KPDES Monitoring"	1989	1989	1/19/90	5	8 ^a
"KPDES Sample Analyses"	1989	1989	1/12/90	0	13 ^b
<i>Division-level audits planned, scheduled, and conducted</i>					
"Spill Control in P&PP Division"	1988	1989	8/10/89	3	2 ^c
"Air Permitted Facilities"	1989	1989	11/30/89	0 ^d	12
"Spill Control in Cascade Operations"	1988	<i>e</i>			
"Hazardous Waste Compliance—RCRA"	1989	<i>f</i>			
"Air Permitted Facilities"	1988	<i>g</i>			
"Environmental Monitoring Program"	1988	<i>h</i>			

^aSix of the observations were negative indicating minor weaknesses in the program; however, no serious problems were found.

^bAll observations were negative indicating minor weaknesses in the program.

^cAll observations were negative.

^dNo plant, divisional, or environmental department procedures were available to use as audit criteria.

^eUnder way.

^fNot started.

^gCanceled and replaced by a 1989 audit on the same subject.

^hCanceled because scope was adequately covered by external audits and reviews.

evaluation at PGDP. Environmental protection was among the programs covered. Six findings, six observations, and two positive observations were listed in the final report. A corrective action plan will be prepared in 1990.

7.4 QUALITY INCIDENTS

7.4.1 Environmental Protection Agency Performance Evaluation Report DMR-QA

The analysis of biochemical oxygen demand (BOD) in this program resulted in the "check for error" rating. While still acceptable according to EPA criteria, a search for possible causes for the problem was undertaken. Internal and external controls analyzed during this period were well within control limits. The problem seemed to be caused by a low oxygen depletion obtained during incubation. The seed water blank was higher than

normal and may have been a factor. The replicate sample with the highest depletion was within the EPA warning limits. These problems are controlled in the laboratory by using past data to predict the optimum sample size for meeting oxygen depletion criteria.

7.4.2 Proficiency Environmental Testing Program

Standard practice for PET results is to investigate all results rated "not acceptable." Those results rated "marginal" are reported to the laboratories as warnings but do not have formal investigations. The January 1989 round had one result rated "not acceptable." The zinc high-level result was investigated, but no cause was found for the deviation. All internal QC checks were in order.

The March 1989 round resulted in a "not acceptable" rating for low-level nitrate as nitrogen

analysis. This result was not surprising because the theoretical value for the control was 0.20 mg/L. PGDP's lowest concentration reported (LCR) on this analysis is 1.0 mg/L using method EC-1130. The LCR is the lowest value the laboratory can report with sufficient confidence. The absolute difference between the value and PGDP's reported result (i.e., 0.3 mg/L) was 0.1 mg/L; this would be very good agreement in higher level samples.

The "not acceptable" result for the thallium in the July round was attributed to the degradation of the thallium standard. The measured thallium results tend to decrease with time. Thallium controls are now analyzed as soon as they are received.

The two total organic carbon results rated "not acceptable" during the November 1989 round were the result of incorrect computer entry. The results for Level 1 and Level 2 were switched. A comparison of the results with their correct values indicates good analytical agreement.

In addition to the external program from PET, an internal program was also begun in 1989 to monitor environmental results. Standard material from the PET Program is submitted along with routine environmental KPDES and well samples to provide quick feedback to the analytical labs. These data will be used to generate a KPDES QA report each month for the Environmental Compliance Department to assure them of the quality of the analytical results they are using in reports to regulatory agencies.

7.4.3 Proficiency Analytical Testing Program

The zinc and lead outliers in the July round of this program were due to a calculation error in the

analytical laboratory. The value reported was a factor of 10 lower than it should have been. Supervision has instructed analysts on checking calculations.

7.4.4 DOE Environmental Measurements Laboratory Quality Assessment Program

No unacceptable results were reported in this program for 1989. Results listed as marginal are considered acceptable.

7.4.5 Internal Quality Incidents

In the fall of 1989, a procedural modification was made to the field TRC analysis. An investigation of TRC noncompliances at KPDES outfalls and comparisons with biological monitoring and analytical laboratory procedures led to the belief that an interferrant was present in many of the samples; this biased the field TRC results high. The new procedure [which utilizes published Method 408E and a portion of Method 408D (APHA et al. 1985)] drastically reduced the noncompliances for TRC.

Expanded areas of sampling due to Remedial Action and Waste Management activities have caused contamination problems in the analytical laboratories. These samples, while thought to be low level, were actually high and causing analytical difficulties. Higher than normal backgrounds in contaminated positions required extensive cleaning and analytical downtime. Many procedural modifications such as large initial dilutions were made to prevent or to minimize these problems, but they continue to be an area of concern in environmental programs.

PART 2

Data Presentation

2.1 AIR

Table 2.1.1. Permitted air sources at PGDP

Permit No.	Location	Control equipment
1	C-600 No. 2 boiler	Electrostatic precipitators and low-sulfur coal
2	C-600 No. 3 boiler	Electrostatic precipitators and low-sulfur coal
4	C-405 incinerator (north) ^a	Venturi scrubber
5	C-405 incinerator (south) ^a	Venturi scrubber
7	C-310 purge vent	NaF traps, high-speed centrifuge
8	C-410 fluorine production	Cold condensers
15	C-400 UF ₄ pulverizer	Filters
26	C-746 reverberatory furnace ^a	
27	C-746 aluminum sweat furnace ^a	
29	C-400 gold recovery ^a	
31	C-724 paint spray booth	Water wash scrubber
32	C-725 paint spray booth	Water wash scrubber
33	C-746-A rotary calciner ^a	CaCO ₃ traps
34(a)	Smelter—central dust collector ^a	Filters
35	C-600 No. 1 boiler	
36	Smelter—induction furnace ^a	Torit filters
37	C-600 coal handling equipment	Water sprays
38	C-400 Detrex open-top vapor degreaser	Covered systems and condensing coils
39	C-400 Blakeslee open-top vapor degreaser	Covered systems and condensing coils
40	C-720 Branson open-top vapor degreaser [trichloroethylene]	
41	C-720 cold cleaning degreaser ^a	
42	Chemical unloading	Wet cyclone scrubber
43	C-340 uranium alloy remelting operation ^a	Filters

^aShut down with no plans to restart.

Table 2.1.2. 1989 PGDP monthly stack effluent pollutant emissions^a

	January	February	March	April	May	June	July	August	September	October	November	December
Uranium												
C-310 purge vent stack (g)	2	2	3	2	2	2	1	3	2	182	2	2
C-400 pulverizer (g) ^b	0	0	0	0	0	0	0	0	0	0	0	0
Technetium												
C-310 purge vent stack (mg)	8	2	<1	8	5	1	116	48	5	13	3	1
C-310 purge vent stack (μ Ci)	135.2	33.8	<16.9	135.2	84.5	16.9	1,960.4	811.2	84.5	219.7	50.7	16.9
Nitrogen oxide (NO _x)												
C-600 stack (kg)	25,960	25,633	26,061	26,173	20,736	19,085	19,450	19,431	19,579	23,327	25,455	31,490
Sulfur oxide (SO ₂)												
C-600 stack (kg)	26,970	26,414	26,805	27,189	21,517	19,786	20,190	20,177	20,262	24,174	26,390	32,435
Particulates												
C-600 stack (kg)	1,039	1,021	1,037	1,046	829	762	777	777	781	932	1,017	1,254
Carbon monoxide (CO) (kg)	744	753	769	750	596	550	559	558	567	674	734	925

^aSee discussion in Subsect 2.1.^bIncludes data only for the period the process was in operation.

Table 2.1.3. 1989 PGDP annual stack effluent pollutant emissions^a

	1989 Total	1988 Total	1987 Total	1986 Total	1985 Total
Uranium					
C-310 purge vent stack (g)	205	16	34	46	2,900
C-400 pulverizer (g) ^b	0	119	529	636	1,332
Technetium					
C-310 purge vent stack (mg)	211	221	56	520	600
C-310 purge vent stack (μ Ci)	3,565.9	3,732	890	8,956	10,250
Nitrogen oxide (NO _x)					
C-600 stack (kg)	282,380	256,800	252,900	262,900	314,400
Sulfur oxide (SO ₂)					
C-600 stack (kg)	292,309	188,000	178,700	176,400	212,400
Particulates					
C-600 stack (kg)	11,272				
Carbon monoxide (CO) (kg)	8,179				

^aSee discussion in Subsect 2.1.^bIncludes data only for the period the process was in operation.

2.2 SURFACE WATER

Table 2.2.1. 1989 PGDP discharges to surface water

Month	Uranium (kg)			Technetium (mCi)	Nitrates (kg)	Cr ⁶⁺ (kg)
	C-340 Ditch	C-615	KPDES 001	KPDES 001	C-400 Process	C-616 Treatment
January	0.5	0.36	8.15	5	1812	<0.30
February	1.6	0.54	7.37	8	774	<0.28
March	1.0	0.44	14.14	11	346	<0.43
April	1.1	0.37	10.00	23	0	<0.30
May	0.5	0.12	3.76	11	0	<0.13
June	0.3	0.16	7.74	18	0	<0.37
July	0.2	0.42	1.77	8	0	<0.31
August	0.2	0.18	0.66	5	0	<0.61
September	0.1	0.16	3.14	6	0	<0.20
October	0.3	0.19	3.37	8	0	<0.45
November	0.6	0.12	4.31	10	606	<0.62
December	0.3	0.10	1.86	4	221	<0.53
Total	6.7	3.16	66.27	117	3759	<4.53

Table 2.2.2. Interim limitations for Agreed Order—PGDP

	Monthly average	Daily maximum	Frequency	Sample
<i>Outfall 001</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.15 mg/L	1/week	Composite
Zn, total recoverable		0.93 mg/L	1/week	Composite
Cl, total residual		0.1 mg/L	1/week	Grab
Temperature		93°F	1/week	Grab
Fe, total recoverable		34.3 mg/L	2/month	Composite
Al, total recoverable			2/month	Composite
Cu, total recoverable		0.17 mg/L	2/month	Composite
Ni, total recoverable	2.36 mg/L	3.1 mg/L	2/month	Composite
TSS ^a		158 mg/L	2/month	Composite
Trichloroethylene		0.0807 mg/L	2/month	Composite
Fluoride	3.5 mg/L	4.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease	10 mg/L	15 mg/L	2/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 002</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.31 mg/L	1/week	Composite
Zn, total recoverable		0.17 mg/L	1/week	Composite
Cl, total residual		0.15 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Fe, total recoverable		6.55 mg/L	2/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 003</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.15 mg/L	1/week	Composite
Zn, total recoverable		0.93 mg/L	1/week	Composite
Cl, total residual		0.1 mg/L	1/week	Grab
Temperature		93°F	1/week	Grab
Fe, total recoverable		5.19 mg/L	2/month	Composite

Table 2.2.2 (continued)

	Monthly average	Daily maximum	Frequency	Sample
Al, total recoverable			2/month	Composite
Cu, total recoverable		0.17 mg/L	2/month	Composite
Ni, total recoverable	0.26 mg/L	3.1 mg/L	2/month	Composite
TSS		158 mg/L	2/month	Composite
Trichloroethylene		0.027 mg/L	2/month	Composite
Fluoride	3.5 mg/L	4.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease	10 mg/L	15 mg/L	2/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 004</i>				
Flow			2/month	Instantaneous
BOD ₅ ^b	30 mg/L	45 mg/L	2/month	Composite
TSS	30 mg/L	45 mg/L	2/month	Composite
Fecal coliform	200	400	2/month	Grab
pH	6.0 (min)	9.0	2/month	Grab
<i>Outfall 005</i>				
Flow			1/week	Instantaneous
TSS	30 mg/L	50 mg/L	1/week	Composite
COD ^c			1/week	Grab
Turbidity			1/week	Grab
pH	6.0 (min)	9.0	1/week	Grab
<i>Outfall 006</i>				
Flow			1/week	Instantaneous
TSS	30 mg/L	50 mg/L	1/week	Grab
COD			1/week	Grab
Turbidity			1/week	Grab
pH	6.0 (min)	10.4	1/week	Grab
<i>Outfall 008</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.1 mg/L	1/week	Composite
Zn, total recoverable		0.34 mg/L	1/week	Composite
Cl, total residual		0.33 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Fe, total recoverable		9.42 mg/L	2/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS			1/month	Composite
Trichloroethylene		0.027 mg/L	1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab

Table 2.2.2 (continued)

	Monthly average	Daily maximum	Frequency	Sample
pH	6.0 (min)	9.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 009</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.23 mg/L	1/week	Composite
Zn, total recoverable		1.15 mg/L	1/week	Composite
Cl, total residual		0.01 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Fe, total recoverable		8.41 mg/L	2/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5.0 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 010</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.5 mg/L	1/week	Composite
Zn, total recoverable		0.26 mg/L	1/week	Composite
Cl, total residual		0.01 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Fe, total recoverable		8.32 mg/L	2/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab

Table 2.2.2 (continued)

	Monthly average	Daily maximum	Frequency	Sample
<i>Outfall 011</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.85 mg/L	1/week	Composite
Zn, total recoverable		0.16 mg/L	1/week	Composite
Cl, total residual		0.14 mg/L	1/week	Grab
Temperature		95°F	1/week	Grab
Fe, total recoverable		5.94 mg/L	2/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 012</i>				
Flow			1/week	Instantaneous
Cr, total recoverable		0.76 mg/L	1/week	Composite
Zn, total recoverable		0.40 mg/L	1/week	Composite
Cl, total residual		0.01 mg/L	1/week	Grab
Temperature		90°F	1/week	Grab
Fe, total recoverable		18.22 mg/L	2/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 013</i>				
Flow			1/month	Instantaneous
Fe, total recoverable			1/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite

Table 2.2.2 (continued)

	Monthly average	Daily maximum	Frequency	Sample
TSS		271 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 014</i>				
Flow			1/week	Instantaneous
TSS	30 mg/L	50 mg/L	1/week	Grab
COD			1/week	Grab
Turbidity			1/week	Grab
pH	6.0 (min)	9.0	1/week	Grab
<i>Outfall 015</i>				
Flow			1/month	Instantaneous
Fe, total recoverable			1/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS		427 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab
<i>Outfall 016</i>				
Flow			1/month	Instantaneous
Fe, total recoverable			1/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS		45 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab

Table 2.2.2 (continued)

	Monthly average	Daily maximum	Frequency	Sample
<i>Outfall 017</i>				
Flow			1/month	Instantaneous
Fe, total recoverable			1/month	Composite
Al, total recoverable			1/month	Composite
Cu, total recoverable			1/month	Composite
Ni, total recoverable			1/month	Composite
TSS		45 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
PCB		0.1 mg/L	1/quarter	Grab

^aTSS = total suspended solids.^bBOD₅ = 5-day biological oxygen demand.^cCOD = chemical oxygen demand.

Table 2.2.3. 1989 annual data summary for discharge point 001^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	4.84	<0.1	<0.78	26
As (mg/L)	<0.005	<0.005	<0.005	4
Cr (mg/L)	0.05	<0.05	<0.05	57
Cu (mg/L)	0.02	<0.01	<0.01	26
Dissolved alpha (pCi/L)	93.6	2.6	26.8	6
Dissolved beta (pCi/L)	180.0	3.0	69.5	6
Dissolved oxygen (mg/L)	13.3	4.7	7.8	28
Fe (mg/L)	3.50	<0.01	<0.63	26
Fluoride (mg/L)	1.50	0.25	0.50	26
Grease and oil (mg/L)	10.4	<5.0	<5.2	26
Ni (mg/L)	0.06	<0.05	<0.05	26
PCB (μg/L)	<0.5	<0.5	<0.5	6
Total residual Cl ₂ (mg/L)	0.09	<0.01	<0.04	54
Suspended alpha (pCi/L)	4.7	-0.4	2.7	6
Suspended beta (pCi/L)	30.0	-8.0	12.5	6
Trichloroethylene (μg/L)	1.0	<1.0	<1.0	25
⁹⁹ Tc (pCi/L)	104.0	0	39.8	54
Temperature (°F)	93.0	44.0	70.7	54
Total suspended solids (mg/L)	135.0	<4	<14.9	26
Uranium (mg/L)	0.120	0.001	0.026	55
Water flow (Mgd)	3.880	0.550	1.59	54
Zn (mg/L)	0.140	<0.005	<0.020	54
pH (units)	9.7	6.6	NA	54

^aSee Fig. 2.2.4.

Table 2.2.4. 1989 annual data summary for discharge point 002^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	5.76	0.16	0.94	12
Cr (mg/L)	0.15	<0.05	<0.06	52
Cr ⁶⁺ (mg/L)	0.15	0.13	0.14	2
Cu (mg/L)	0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	19.9	1.0	10.0	4
Dissolved beta (pCi/L)	18.0	5.0	12.3	4
Dissolved oxygen (mg/L)	16.3	5.6	8.9	25
Fe (mg/L)	4.72	0.15	0.63	24
Fluoride (mg/L)	0.23	<0.1	<0.16	24
Oil and grease (mg/L)	<5	<5	<5	12
Ni (mg/L)	0.08	<0.05	<0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	4
Total residual Cl ₂ (mg/L)	0.19	<0.01	<0.05	50
Suspended alpha (pCi/L)	5.4	-2.7	1.4	4
Suspended beta (pCi/L)	12.0	-14.0	6.3	4
Trichloroethylene (μg/L)	<1.0	<1.0	<1.0	12
Temperature (°F)	85.0	39.0	63.5	51
Total suspended solids (mg/L)	311.0	<4	<30.1	12
Uranium (mg/L)	0.007	0.001	0.004	4
Water flow (Mgd)	0.309	0.027	0.082	51
Zn (mg/L)	0.090	<0.005	<0.026	51
pH (units)	9.6	7.0	NA	51

^aSee Fig. 2.2.4.

Table 2.2.5. 1989 annual data summary for discharge point 004^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
BOD ₅ (mg/L)	15.0	6.0	9.9	24
Fecal coli (col./100 mL)	>600.0	<1	<6.5	25
Total suspended solids (mg/L)	19.0	<4	<6.8	24
Water flow (Mgd)	0.776	0.272	0.423	24
pH (units)	9.4	6.3	NA	25

^aSee Fig. 2.2.4.

Table 2.2.6. 1989 annual data summary for discharge point 006^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
BOD ₅ (mg/L)	19.0	<5	<12.2	52
Total suspended solids (mg/L)	28.0	<4	<14.3	52
Turbidity (NTU)	12.0	3.0	7.9	52
Water flow (Mgd)	2.030	0.196	0.785	52
pH (units)	10.2	6.2	NA	52

^aSee Fig. 2.2.4.

Table 2.2.7. 1989 annual data summary for discharge point 008^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	2.57	<0.1	<0.62	12
Cr (mg/L)	0.05	0.02	0.05	53
Cu (mg/L)	0.02	<0.01	<0.01	12
Dissolved alpha (pCi/L)	20.9	3.5	10.7	4
Dissolved beta (pCi/L)	60.0	5.0	22.3	4
Dissolved oxygen (mg/L)	14.1	6.2	8.7	25
Fe (mg/L)	2.75	0.14	0.61	24
Fluoride (mg/L)	0.77	0.15	0.42	24
Oil and grease (mg/L)	<5	<5	<5	13
Ni (mg/L)	0.07	0.02	0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	6
Total residual Cl ₂ (mg/L)	0.46	0.04	0.23	54
Suspended alpha (pCi/L)	5.4	-1.1	2.2	4
Suspended beta (pCi/L)	16.0	-16.0	2.0	4
Trichloroethylene (μg/L)	3.0	<1.0	<1.3	12
⁹⁹ Tc (pCi/L)	60.0	0	15.8	52
Temperature (°F)	88.0	47.0	67.9	52
Total suspended solids (mg/L)	37.0	<4	<9.8	13
Uranium (mg/L)	0.125	0.002	0.008	53
Water flow (Mgd)	1.830	0.519	0.946	52
Zn (mg/L)	0.080	<0.005	<0.036	52
pH (units)	8.6	5.8	NA	53

^aSee Fig. 2.2.4.

Table 2.2.8. 1989 annual data summary for discharge point 009^a
 KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	2.02	0.32	0.80	12
Cr (mg/L)	5.64	<0.005	<0.15	54
Cu (mg/L)	0.02	<0.01	<0.01	12
Dissolved alpha (pCi/L)	10.0	5.2	7.3	4
Dissolved beta (pCi/L)	50.0	15.0	27.8	4
Dissolved oxygen (mg/L)	16.9	6.0	9.0	38
Fe (mg/L)	2.43	0.35	0.83	24
Fluoride (mg/L)	0.32	0.10	0.19	24
Oil and grease (mg/L)	<5	<5	<5	13
Ni (mg/L)	0.07	0.02	0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	4
Total residual Cl ₂ (mg/L)	0.13	<0.01	<0.03	67
Suspended alpha (pCi/L)	5.4	-1.8	0.7	4
Suspended beta (pCi/L)	13.0	1.0	7.8	4
Trichloroethylene (μg/L)	2.0	<1.0	<1.1	12
Temperature (°F)	85.0	38.0	64.2	65
Total suspended solids (mg/L)	18.0	<4	<11.0	12
Uranium (mg/L)	0.006	0.001	0.004	5
Water flow (Mgd)	1.840	0.027	0.176	52
Zn (mg/L)	0.070	<0.005	<0.025	53
pH (units)	9.3	6.1	NA	52

^aSee Fig. 2.2.4.

Table 2.2.9. 1989 annual data summary for discharge point 010^a
 KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	2.30	0.36	1.14	12
Cr (mg/L)	0.82	<0.005	<0.08	53
Cu (mg/L)	0.02	<0.01	<0.01	12
Dissolved alpha (pCi/L)	34.2	-0.8	12.2	4
Dissolved beta (pCi/L)	40.0	8.0	23.0	4
Dissolved oxygen (mg/L)	18.8	5.0	9.3	25
Fe (mg/L)	2.15	0.30	0.96	24
Fluoride (mg/L)	0.43	0.10	0.24	24
Oil and grease (mg/L)	<5	<5	<5	12
Ni (mg/L)	0.10	0.02	0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	4
Total residual Cl ₂ (mg/L)	0.15	<0.01	<0.02	52
Suspended alpha (pCi/L)	4.7	-1.8	1.5	4
Suspended beta (pCi/L)	17.0	-14.0	2.5	4
Trichloroethylene (μg/L)	<1.0	<1.0	<1.0	12
Temperature (°F)	88.0	36.0	62.6	52
Total suspended solids (mg/L)	24.0	<4	<11.7	12
Uranium (mg/L)	0.071	0.002	0.028	4
Water flow (Mgd)	0.144	0.019	0.055	52
Zn (mg/L)	0.120	<0.005	<0.029	52
pH (units)	9.5	6.7	NA	52

^aSee Fig. 2.2.4.

Table 2.2.10. 1989 annual data summary for discharge point 011^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	0.68	0.09	0.23	12
Cr (mg/L)	0.12	<0.005	<0.05	53
Cu (mg/L)	0.02	<0.01	<0.01	12
Dissolved alpha (pCi/L)	67.6	7.6	25.4	4
Dissolved beta (pCi/L)	49.0	9.0	24.5	4
Dissolved oxygen (mg/L)	10.0	5.1	6.6	25
Fe (mg/L)	0.84	0.05	0.29	24
Fluoride (mg/L)	0.38	0.11	0.18	24
Oil and grease (mg/L)	<5	<5	<5	12
Ni (mg/L)	0.19	0.02	0.06	12
PCB (μg/L)	<0.5	<0.5	<0.5	7
Total residual Cl ₂ (mg/L)	0.18	<0.01	<0.06	53
Suspended alpha (pCi/L)	4.1	0.2	1.7	4
Suspended beta (pCi/L)	20.0	— 3.0	3.75	4
Trichloroethylene (μg/L)	13.0	<1.0	<3.1	12
⁹⁹ Tc (pCi/L)	42.0	0	10.2	52
Temperature (°F)	98.0	54.0	79.1	52
Total suspended solids (mg/L)	16.0	<4	<7.4	12
Uranium (mg/L)	0.190	0.009	0.052	52
Water flow (Mgd)	0.227	0.003	0.088	52
Zn (mg/L)	0.060	<0.005	<0.019	52
pH (units)	8.8	7.1	NA	52

^aSee Fig. 2.2.4.

Table 2.2.11. 1989 annual data summary for discharge point 012^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	0.69	0.19	0.48	12
Cr (mg/L)	<0.05	<0.005	<0.05	52
Cu (mg/L)	0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	14.2	-1.7	4.8	4
Dissolved beta (pCi/L)	18.0	5.0	10.0	4
Dissolved oxygen (mg/L)	14.2	4.6	8.4	25
Fe (mg/L)	1.56	0.29	0.51	24
Fluoride (mg/L)	0.41	0.11	0.25	24
Oil and grease (mg/L)	8.4	<5	<5.3	13
Ni (mg/l.)	0.06	<0.005	<0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	5
Total residual Cl ₂ (mg/L)	0.06	<0.01	<0.02	52
Suspended alpha (pCi/L)	2.9	-0.2	0.9	4
Suspended beta (pCi/L)	8.0	-8.0	1.3	4
Trichloroethylene (μg/L)	<1.0	<1.0	<1.0	12
Temperature (°F)	88.0	42.0	66.2	52
Total suspended solids (mg/L)	24.0	<4	<7.5	12
Uranium (mg/L)	0.029	0.002	0.012	4
Water flow (Mgd)	0.414	0.025	0.073	52
Zn (mg/L)	0.100	0.006	0.030	52
pH (units)	8.3	7.0	NA	52

^aSee Fig. 2.2.4.

Table 2.2.12. 1989 annual data summary for discharge point 013^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	12.1	0.35	2.41	12
Cu (mg/L)	0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	12.5	-3.2	6.3	4
Dissolved beta (pCi/L)	17.0	-4.0	5.6	4
Fe (mg/L)	8.80	0.38	1.88	12
Fluoride (mg/L)	0.77	0.14	0.45	12
Oil and grease (mg/L)	<5	<5	<5	12
Ni (mg/L)	0.08	<0.05	<0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	4
Suspended alpha (pCi/L)	7.0	-0.8	2.3	4
Suspended beta (pCi/L)	12.0	-10.0	0.5	4
Total suspended solids (mg/L)	810.0	<4	<85.5	12
Uranium (mg/L)	0.004	<0.001	<0.003	4
Water flow (Mgd)	6.530	0.227	1.485	12
pH (units)	8.2	7.5	NA	12

^aSee Fig. 2.2.4.

Table 2.2.13. 1989 annual data summary for discharge point 015^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	14.90	0.50	4.26	12
Cr (mg/L)	<0.05	<0.05	<0.05	1
Cu (mg/L)	0.06	<0.01	<0.02	12
Dissolved alpha (pCi/L)	43.0	21.4	35.0	4
Dissolved beta (pCi/L)	173.0	24.0	81.5	4
Fe (mg/L)	4.64	0.35	2.11	12
Fluoride (mg/L)	1.50	0.21	0.56	12
Oil and grease (mg/L)	9.4	<5	<5.4	12
Ni (mg/L)	0.26	<0.05	<0.08	12
PCB (μg/L)	<0.5	<0.5	<0.5	4
Suspended alpha (pCi/L)	8.8	0	3.40	4
Suspended beta (pCi/L)	21.0	-5.0	8.5	4
Total suspended solids (mg/L)	293.0	6.0	61.8	12
Uranium (mg/L)	0.135	0.044	0.098	4
Water flow (Mgd)	0.780	0.012	0.253	12
pH (units)	8.1	6.5	NA	12

^aSee Fig. 2.2.4.

Table 2.2.14. 1989 annual data summary for discharge point 016^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	5.49	0.32	1.46	12
Cu (mg/L)	0.02	<0.01	<0.01	12
Dissolved alpha (pCi/L)	9.6	4.5	6.7	4
Dissolved beta (pCi/L)	30.0	-7.0	11.0	4
Fe (mg/L)	4.48	0.24	1.19	12
Fluoride (mg/L)	0.30	0.12	0.22	12
Oil and grease (mg/L)	9.4	<5	<5.4	12
Ni (mg/L)	0.05	<0.05	<0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	4
Total residual Cl ₂ (mg/L)	<0.01	<0.01	<0.01	1
Suspended alpha (pCi/L)	9.7	2.9	5.4	4
Suspended beta (pCi/L)	16.0	-11.0	1.3	4
Total suspended solids (mg/L)	471.0	<4	<54.2	13
Uranium (mg/L)	0.007	0.003	0.005	4
Water flow (Mgd)	1.840	0.063	1.002	12
pH (units)	8.9	6.7	NA	12

^aSee Fig. 2.2.4.

Table 2.2.15. 1989 annual data summary for discharge point 017^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	3.68	0.21	1.26	12
Cu (mg/L)	0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	10.2	0.5	5.2	4
Dissolved beta (pCi/L)	53.0	-5.0	18.5	4
Fe (mg/L)	3.21	<0.01	<1.04	12
Fluoride (mg/L)	0.67	0.14	0.39	12
Oil and grease (mg/L)	<5	<5	<5	12
Ni (mg/L)	0.05	<0.05	<0.05	12
PCB (μg/L)	<0.5	<0.5	<0.5	4
Suspended alpha (pCi/L)	4.3	-1.4	2.0	4
Suspended beta (pCi/L)	16.0	-10.0	2.3	4
Total suspended solids (mg/L)	116.0	<4	<28.2	12
Uranium (mg/L)	0.007	0.003	0.005	4
Water flow (Mgd)	1.240	0.010	0.208	12
pH (units)	8.4	7.5	NA	12

^aSee Fig. 2.2.4.

**Table 2.2.16. 1989 annual data summary for Upstream Big Bayou Creek
Location SW1^a**

Parameter	Max	Min	Av	Number of samples
Chloride (mg/L)	7.0	7.0	7.0	1
Conductivity (μmhos/cm)	241.0	56.3	148.6	4
Cr ⁶⁺ (mg/L)	0.01	<0.01	<0.01	11
Dissolved alpha (pCi/L)	-3.5	-3.5	3.5	1
Dissolved beta (pCi/L)	-9.0	-9.0	9.0	1
Dissolved solids (mg/L)	156.0	14.0	94.0	4
Fe (mg/L)	148.50	0.46	51.43	4
Fecal coli (col./100 mL)	48.0	48.0	48.0	1
Fluoride (mg/L)	0.18	0.18	0.18	1
Gross alpha (pCi/L)	92.0	-1.2	30.8	5
Gross beta (pCi/L)	106.0	-3.0	44.2	5
NO ₃ -N (mg/L)	<1	<1	<1	1
Na (mg/L)	28.06	1.93	10.69	3
PO ₄ -P (mg/L)	<2	<2	<2	11
Sulfate (mg/L)	34.0	6.0	20.7	15
Suspended alpha (pCi/L)	3.8	-0.7	1.6	11
Suspended beta (pCi/L)	18.0	-18.0	0.2	11
TOC (mg/L)	15.0	5.0	8.5	4
⁹⁹ Tc (pCi/L)	12.0	12.0	12.0	1
Temperature (°F)	67.0	67.0	67.0	1
Total solids (mg/L)	174.0	166.0	170.0	2
Total suspended solids (mg/L)	7800.0	18.0	2307.3	4
Total alpha (pCi/L)	0.4	0.4	0.4	1
Total beta (pCi/L)	3.0	3.0	3.0	1
Uranium (mg/L)	<0.001	<0.001	<0.001	1
pH (units)	7.4	7.4	NA	1

^aSee Fig. 2.2.3.

**Table 2.2.17. 1989 annual data summary for north-south diversion ditch
Discharge point SW13^a**

Parameter	Max	Min	Av	Number of samples
Chloride (mg/L)	1020.0	23.0	144.6	53
Cr ⁶⁺ (mg/L)	0.02	0	0.01	53
Dissolved alpha (pCi/L)	1436.2	0	69.7	53
Dissolved beta (pCi/L)	1448.0	46.0	259.2	53
Fluoride (mg/L)	9.50	0.13	1.98	53
NO ₃ -N (mg/L)	25.9	<1	<3.5	52
PO ₄ -P (mg/L)	6.8	<2	<2.1	53
Sulfate (mg/L)	162.0	<5	<98.8	53
Suspended alpha (pCi/L)	17.6	-3.2	3.4	53
Suspended beta (pCi/L)	132.0	-10.0	19.8	53
Temperature (°F)	94.0	39.0	64.3	52
Uranium (mg/L)	1.600	0.003	0.131	57
Water flow (Mgd)	4.540	0.109	0.319	52
pH (units)	10.2	6.8	NA	52

^aSee Fig. 2.2.3.

**Table 2.2.18. 1989 annual data summary for Ohio River upstream of PGDP
Location SW29^a**

Parameter	Max	Min	Av	Number of samples ^a
Chloride (mg/L)	9.0	5.0	7.1	12
Cr ⁶⁺ (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	5.8	-3.8	2.1	12
Dissolved beta (pCi/L)	37.0	-5.0	10.5	12
Fluoride (mg/L)	0.16	<0.1	<0.13	12
NO ₃ -N (mg/L)	1.4	<1	<1.03	12
PO ₄ -P (mg/L)	6.0	<2	<2.3	12
Sulfate (mg/L)	35.0	12.0	17.1	12
Suspended alpha (pCi/L)	4.0	-2.5	0.7	12
Suspended beta (pCi/L)	35.0	-12.0	7.0	12
Uranium (mg/L)	<0.001	<0.001	<0.001	12
pH (units)	8.6	7.0	NA	12

^aSee Fig. 2.2.3.

**Table 2.2.19. 1989 annual data summary for Ohio River downstream of PGDP
Location SW30^a**

Parameter	Max	Min	Av	Number of samples
1,2 DCA ($\mu\text{g/L}$)	<5	<5	<5	10
Chloride (mg/L)	10.00	6.00	7.83	10
Cr ⁶⁺ (mg/L)	<0.01	<0.01	<0.01	10
Dissolved alpha (pCi/L)	7.80	-1.60	2.31	10
Dissolved beta (pCi/L)	19.0	1.0	9.1	10
Fluoride (mg/L)	0.16	0.10	0.13	10
NO ₃ -N (mg/L)	<1	<1	<1.0	10
PO ₄ -P (mg/L)	<2	<2	<2.0	10
Sulfate (mg/L)	34.0	12.0	20.5	10
Suspended alpha (pCi/L)	7.6	-3.4	2.2	10
Suspended beta (pCi/L)	37.0	-5.0	7.10	10
Uranium (mg/L)	0.002	<0.001	<0.001	10
pH (units)	9.8	7.3	NA	10

^aSee Fig. 2.2.3.**Table 2.2.20. C-746-S and C-746-T sanitary and inert landfills
Sampling point 2^a**

Parameter	Max	Min	Av	Number of samples
Fe (mg/L)	330	1.75	128.7	3
Chloride (mg/L)	41	3.1	16.7	3
Sulfate (mg/L)	182	25	81.3	3
Conductivity ($\mu\text{mhos/cm}$)	678	237	390.7	3
Dissolved solids (mg/L)	480	126	261.3	3
Total suspended solids (mg/L)	65,000	30	22,075	3
Total solids (mg/L)	65,000	510	32,755	2
TOC (mg/L)	22.8	6	14.3	3
pH (units)	8.5	7.9	NA	3
Uranium (mg/L)	0.104	0.007	0.075	3
Gross alpha (pCi/L)	288.3	11.3	109.9	3
Gross beta (pCi/L)	364	35	246	3
Na (mg/L)	15.10	9.85	12.48	2

^aSee Fig. 2.2.3.

**Table 2.2.21. C-746-S and C-746-T sanitary and inert landfills
Sampling point 3^a**

Parameter	Result	Number of samples
Chloride (mg/L)	48.8	1
Sulfate (mg/L)	167	1
Conductivity (μ mhos/cm)	607	1
Dissolved solids (mg/L)	407	1
Total suspended solids (mg/L)	370	1
Total solids (mg/L)	777	1
TOC (mg/L)	14	1
pH (units)	8.6	1
Uranium (mg/L)	0.003	1
Gross alpha (pCi/L)	8.7	1
Gross beta (pCi/L)	42	1
Na (mg/L)	28.3	1

^aSee Fig. 2.2.3.

Table 2.2.22. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 001^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	55	3.37×10^1	2.81×10^{-1}	7.3×10^0	1.46×10^0	5×10^2
²³⁵ U	55	1.56×10^0	1.3×10^{-2}	5.62×10^{-2}	5.6×10^{-2}	6×10^2
²³⁸ U	55	4.01×10^1	3.34×10^{-1}	8.68×10^0	1.45×10^0	6×10^2
⁹⁹ Tc	54	1.04×10^2	0	3.98×10^1	3.98×10^{-2}	1×10^5

^aSee Fig. 2.2.4.

Table 2.2.23. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 002^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	4	3.1×10^0	4.43×10^{-1}	1.77×10^0	3.54×10^{-1}	5×10^2
²³⁵ U	4	1.42×10^{-1}	2.03×10^{-2}	8.12×10^{-2}	1.35×10^{-2}	6×10^2
²³⁸ U	4	2.33×10^0	3.33×10^{-1}	1.33×10^0	2.22×10^{-1}	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.24. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 008^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	53	4.88×10^0	7.8×10^{-1}	3.12×10^0	6.24×10^{-1}	5×10^2
²³⁵ U	53	2.21×10^0	3.54×10^{-2}	1.42×10^{-1}	2.36×10^{-2}	6×10^2
²³⁸ U	53	4.17×10^1	6.67×10^{-1}	2.67×10^0	4.44×10^{-1}	6×10^2
⁹⁹ Tc	52	6×10^1	0	1.58×10^1	1.58×10^{-2}	1×10^5

^aSee Fig. 2.2.4.

Table 2.2.25. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 009^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	5	1.27×10^0	2.12×10^{-1}	8.42×10^{-1}	1.69×10^{-1}	5×10^2
²³⁵ U	5	5.8×10^{-2}	9.72×10^{-3}	3.89×10^{-2}	6.48×10^{-3}	6×10^2
²³⁸ U	5	2.01×10^0	3.35×10^{-1}	1.34×10^0	2.23×10^{-1}	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.26. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 010^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	4	1.05×10^1	2.97×10^{-1}	4.16×10^0	8.32×10^{-1}	5×10^2
²³⁵ U	4	4.75×10^{-1}	1.34×10^{-2}	1.88×10^{-1}	3.13×10^{-2}	6×10^2
²³⁸ U	4	2.38×10^1	6.7×10^{-1}	9.38×10^0	1.56×10^0	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.27. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 011^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	52	1.33×10^1	6.32×10^{-1}	3.65×10^0	7.3×10^{-1}	5×10^2
²³⁵ U	52	6.16×10^{-1}	2.92×10^{-2}	1.69×10^{-1}	2.81×10^{-2}	6×10^2
²³⁸ U	52	6.38×10^1	3.02×10^0	1.75×10^1	2.91×10^0	6×10^2
⁹⁹ Tc	52	4.2×10^1	0	1.0×10^1	1.02×10^{-2}	1×10^3

^aSee Fig. 2.2.4.

Table 2.2.28. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 012^a

Radionuclide	Number of samples	Concentration (pCi/L)		Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min		
²³⁴ U	4	3.57×10^{-1}	5.37×10^{-1}	3.24×10^0	5×10^2
²³⁵ U	4	7.78×10^0	2.46×10^{-2}	1.48×10^{-1}	6×10^2
²³⁸ U	4	9.69×10^0	6.68×10^{-1}	4.01×10^0	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.29. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 013^a

Radionuclide	Number of samples	Concentration (pCi/L)		Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min		
²³⁴ U	4	6.49×10^{-1}	$<1.62 \times 10^{-1}$	$<4.88 \times 10^{-1}$	5×10^2
²³⁵ U	4	2.94×10^{-2}	$<7.34 \times 10^{-3}$	$<2.20 \times 10^{-2}$	6×10^2
²³⁸ U	4	1.34×10^0	$<3.35 \times 10^{-1}$	$<1.01 \times 10^0$	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.30. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 015^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	4	2.69×10^1	8.73×10^0	1.97×10^1	3.94×10^0	5×10^2
²³⁵ U	4	1.25×10^0	4.09×10^{-1}	9.1×10^{-1}	1.52×10^{-1}	6×10^2
²³⁸ U	4	4.52×10^1	1.47×10^1	3.28×10^1	5.46×10^0	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.31. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 016^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	4	2.39×10^0	1.03×10^0	1.71×10^0	3.42×10^{-1}	5×10^2
²³⁵ U	4	1.09×10^{-1}	4.67×10^{-2}	7.77×10^{-2}	1.3×10^{-2}	6×10^2
²³⁸ U	4	2.34×10^0	1×10^0	1.67×10^0	2.8×10^{-1}	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.32. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 Discharge point 017^a

Radionuclide	Number of samples	Concentration (pCi/L)		Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min		
²³⁴ U	4	1.27×10^0	5.43×10^{-1}	9.1×10^{-1}	5×10^2
²³⁵ U	4	5.9×10^{-2}	2.53×10^{-2}	4.21×10^{-2}	6×10^2
²³⁸ U	4	2.34×10^0	1.0×10^0	1.67×10^0	6×10^2

^aSee Fig. 2.2.4.

Table 2.2.33. 1989 radionuclide concentrations in water
 SW1—Upstream Big Bayou^a

Radionuclide	Number of samples	Concentration (pCi/L)		Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min		
²³⁴ U	1	3.62×10^{-1}	3.62×10^{-1}	7.24×10^{-2}	5×10^2
²³⁵ U	1	1.64×10^{-2}	1.64×10^{-2}	2.7×10^{-3}	6×10^2
²³⁸ U	1	3.33×10^{-1}	3.33×10^{-1}	5.56×10^{-2}	6×10^2

^aSee Fig. 2.2.3.

Table 2.2.34. 1989 radionuclide concentrations in water
 KPDES Permit Number KY0004049
 SW13—North-south diversion ditch^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	57	1.11×10^3	2.08×10^0	9.07×10^1	1.81×10^1	5×10^2
²³⁵ U	57	5.05×10^1	9.46×10^{-2}	4.13×10^0	6.68×10^{-1}	6×10^2
²³⁸ U	57	5.29×10^2	9.93×10^{-1}	4.34×10^1	7.23×10^0	6×10^2

^aSee Fig. 2.2.3.

Table 2.2.35. 1989 radionuclide concentrations in water
 SW29—Ohio River Upstream of PGDP^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	12	6.74×10^{-1}	$<3.37 \times 10^{-1}$	$<3.37 \times 10^{-1}$	$<6.74 \times 10^{-2}$	5×10^2
²³⁵ U	12	3.07×10^{-2}	$<1.53 \times 10^{-2}$	$<1.53 \times 10^{-2}$	$<2.55 \times 10^{-3}$	6×10^2
²³⁸ U	12	6.67×10^{-1}	$<3.34 \times 10^{-1}$	$<3.34 \times 10^{-1}$	$<5.57 \times 10^{-2}$	6×10^2

^aSee Fig. 2.2.3.

Table 2.2.36. 1989 radionuclide concentrations in water
SW30—Ohio River Downstream of PGDP^a

Radionuclide	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide	Derived concentration guide (DCG)
		Max	Min	Av		
²³⁴ U	10	6.74×10^{-1}	$<3.37 \times 10^{-1}$	$<3.37 \times 10^{-1}$	$<6.74 \times 10^{-2}$	5×10^2
²³⁵ U	10	3.07×10^{-2}	$<1.53 \times 10^{-2}$	$<1.53 \times 10^{-2}$	$<2.55 \times 10^{-3}$	6×10^2
²³⁸ U	10	6.68×10^{-1}	$<3.34 \times 10^{-1}$	$<3.34 \times 10^{-1}$	$<5.57 \times 10^{-2}$	6×10^2

^aSee Fig. 2.2.3.

2.3 GROUNDWATER

The following references are referred to in Tables 2.3.1–2.3.11.

REFERENCES

1. 40 CFR Pt. 141, "Safe Drinking Water Act—National Primary Drinking Water Regulations," as amended.
2. 40 CFR Pt. 143, "Safe Drinking Water Act—National Secondary Drinking Water Regulations," as amended.
3. "Derived Concentration Guides (DCGs) for Air and Water," DOE Order 5400.5.
4. U.S. Environmental Protection Agency, "National Primary Drinking Water Regulations; Synthetic Organic Chemicals," *Fed. Regist.* 25690–25717 (July 8, 1987).
5. *Fed. Regist.* 54(97) (May 22, 1989).

Table 2.3.1. 1989 PGDP groundwater comparison data

Parameter	Applicable value	Reference
Cr	0.05 mg/L	1
Cu	1.0 mg/L	2
Fe	0.3 mg/L	2
Ni	None	NA ^a
Pb	0.05 mg/L	1
Zn	5.0 mg/L	2
Total As	0.05 mg/L	1
Total Cd	0.01 mg/L	1
Total Pb	0.05 mg/L	1
Total Se	0.01 mg/L	1
Dissolved As	None	NA
Dissolved Cd	None	NA
Dissolved Pb	None	NA
Dissolved Se	None	NA
Ca	None	NA
Mg	None	NA
Mn	0.05 mg/L	2
Na	None	NA
Cr ⁶⁺	None	NA
pH	6.5–8.5 units	2
Temperature	None	NA
Chloride	250 mg/L	2
NO ₃ -N	10 mg/L	1
SO ₄	250 mg/L	2
Turbidity	5 NTU	1
Color	15 units	2
Fluoride	4.0 mg/L	1
Conductivity	None	NA
TOC	None	NA
Dissolved solids	500 mg/L	2
Alkalinity	None	NA
PO ₄ -P	None	NA
Trichloroethylene	5 µg/L	4
PCB	None	NA
TOX	None	NA
U	None	NA
²⁴¹ Am	1 pCi/L	3
Ra	5 pCi/L	1
⁶⁰ Co	400 pCi/L	3
¹³⁷ Cs	100 pCi/L	3
⁹⁹ Tc	900 pCi/L	1
²³⁷ Np	1 pCi/L	3
²²² Rn	2 × 10 ⁷	3
Dissolved alpha	15 pCi/L gross alpha	1
Suspended alpha	15 pCi/L gross alpha	1
Dissolved beta	4 mrem/year gross beta	1
Suspended beta	4 mrem/year gross beta	1
Gross alpha	15 pCi/L	1
Gross beta	4 mrem/year	1
Benzene	5 µg/L	1
Toluene	2,000 µg/L	5
Xylene	10,000 µg/L	5
Ethyl benzene	700 µg/L	5

^aNA = not applicable.

Table 2.3.2. Constituents in the groundwater at horse barn during 1989^a
Well 20

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Alkalinity (mg/L)	1/1	76.0	76.0	76.0	NA	NA
²⁴¹ Am (pCi/L)	NA ^b /1	-0.4	-0.4	NA	NA	NA
Ca (mg/L)	1/1	16.7	16.7	16.7	NA	NA
Chloride (mg/L)	1/1	32.0	32.0	32.0	2	0
⁶⁰ Co (pCi/L)	NA/1	-0.1	-0.10	NA	3	0
Color (units)	4/4	5.0	42.0	14.3	2	1
Conductivity (μmho/cm)	16/16	290.0	321.0	311.75	NA	NA
Cr (mg/L)	0/4	<0.05	<0.05	NONE	1	0
Cr ⁶⁺ (mg/L)	0/1	0.01	0.01	NONE	NA	NA
Cs (pCi/L)	NA/1	0.1	0.1	NA	3	0
Cu (mg/L)	4/4	0.07	0.15	0.11	2	0
Dissolved alpha (pCi/L)	NA/4	2.1	9.6	NA	1	0
Dissolved beta (pCi/L)	NA/4	14.0	37.0	NA	1	NA
Dissolved solids (mg/L)	1/1	161.0	161.0	161.0	2	0
Fe (mg/L)	4/4	6.45	20.38	13.91	2	4
Fluoride (mg/L)	4/4	0.14	0.20	0.17	1	0
Gross alpha (pCi/L)	NA/3	2.0	3.0	NA	1	0
Gross beta (pCi/L)	NA/3	16.0	40.0	NA	1	NA
Mg (mg/L)	1/1	7.25	7.25	7.25	NA	NA
Mn (mg/L)	1/1	0.03	0.03	0.03	2	0
NO ₃ -N (mg/L)	0/4	<1	<1	NONE	1	0
Na (mg/L)	1/1	29.45	29.45	29.45	NA	NA
Ni (mg/L)	0/4	<0.05	<0.05	NONE	NA	NA
PCB (μg/L)	0/4	<0.5	<0.5	NONE	NA	NA
PO ₄ -P (mg/L)	0/1	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/1	0	0	NA	1	0
²²² Rn (pCi/L)	NA/2	131.0	166.0	NA	3	0
Sulfate (mg/L)	4/4	6.0	12.0	10.2	2	0
Suspended alpha (pCi/L)	NA/4	-6.1	2.7	NA	1	0
Suspended beta (pCi/L)	NA/4	-5.0	4.0	NA	1	NA
TOC (mg/L)	1/16	<1	2.0	2.0	NA	NA
TOX (ug/L)	16/16	19.0	78.0	42.31	NA	NA
Trichloroethylene (ug/L)	7/7	18.0	96.0	57.4	4	7
⁹⁹ Tc (pCi/L)	NA/7	10.0	68.0	NA	1	0
Temperature (°F)	NA/4	57.0	64.0	NA	NA	NA
Total Cd (mg/L)	0/1	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	0/4	<0.2	<0.2	NONE	1	4
Total Se (mg/L)	0/1	<0.005	<0.005	NONE	1	0
Turbidity (NTU)	4/4	42.0	80.0	60.3	1	4
Uranium (mg/L)	0/4	<0.001	0.001	NONE	NA	NA
Zn (mg/L)	4/4	0.08	0.16	0.108	2	0
pH (units)	NA/16	6.40	6.70	NA	2	2

^aSee Fig. 2.3.3.^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.3. Constituents in the groundwater at C-616 lagoon during 1989^a
Wells 21 and 22
Units 17 and 18

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Alkalinity (mg/L)	2/2	23.3	297.0	160.2	NA	NA
²⁴¹ Am (pCi/L)	NA ^b /2	0	0.1	NA	NA	NA
Ca (mg/L)	2/2	8.17	32.7	20.4	NA	NA
Chloride (mg/L)	2/2	4.5	37.0	20.8	2	0
⁶⁰ Co (pCi/L)	NA/2	0	0.1	NA	3	0
Color (units)	9/9	3.0	50.0	18.7	2	3
Conductivity (μmho/cm)	33/33	89.4	1550.0	692.7	NA	NA
Cr (mg/L)	0/9	<0.05	<0.05	NONE	1	0
Cr ⁶⁺ (mg/L)	0/2	<0.01	<0.01	NONE	NA	NA
¹³⁷ Cs (pCi/L)	NA/2	-0.4	0.6	NA	3	0
Cu (mg/L)	1/9	<0.01	0.02	0.01	2	0
Depth (feet)	NA/7	42.7	51.96	NA	NA	NA
Dissolved alpha (pCi/L)	NA/9	-5.4	10.7	NA	1	0
Dissolved beta (pCi/L)	NA/9	-15.0	42.0	NA	1	NA
Dissolved solids (mg/L)	2/2	47.0	592.0	319.5	2	1
Fe (mg/L)	9/9	0.58	31.9	10.3	2	9
Fluoride (mg/L)	9/9	0.15	0.42	0.26	1	0
Mg (mg/L)	2/2	3.56	17.10	10.33	NA	NA
Mn (mg/L)	2/2	0.15	1.57	0.86	2	2
NO ₃ -N (mg/L)	0/9	<1	<1	NONE	1	0
Na (mg/L)	2/2	6.43	120.0	63.22	NA	NA
Ni (mg/L)	4/9	<0.05	0.24	0.18	NA	NA
PCB (μg/L)	1/9	<0.5	<1.0	NONE	NA	NA
PO ₄ -P (mg/L)	0/2	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/2	0	0.5	NA	1	0
Sulfate (mg/L)	9/9	8.0	353.3	104.2	2	2
Suspended alpha (pCi/L)	NA/9	-6.5	7.0	NA	1	0
Suspended beta (pCi/L)	NA/9	-8.0	11.0	NA	1	NA
TOC (mg/L)	25/33	<1	6.0	2.2	NA	NA
TOX (ug/L)	32/33	<5	62.0	30.8	NA	NA
Trichloroethylene (ug/L)	3/11	<1	20.0	9.7	4	2
⁹⁹ Tc (pCi/L)	NA/11	0	37.0	NA	1	0
Temperature (°F)	NA/9	57.0	67.0	NA	NA	NA
Total Cd (mg/L)	0/2	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	0/9	<0.2	<0.2	NONE	1	9
Total Se (mg/L)	0/2	<0.005	<0.005	NONE	1	0
Turbidity (NTU)	9/9	1.4	1325.0	184.2	1	7
Uranium (mg/L)	4/9	<0.001	0.004	0.003	NA	NA
Zn (mg/L)	8/9	<0.005	0.160	0.078	2	0
pH (units)	NA/33	5.8	7.0	NA	2	13

^aSee Fig. 2.3.3.

^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.4. Constituents in the groundwater at C-404/C-749 burial area during 1989^a
Wells 46, 48, 50, 51, 67, 47, 49,^b 57, and 58^b
Units 2 and 3

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Ag (mg/L)	1/1	<0.03	<0.03	NONE	NA	NA
Al (mg/L)	1/1	277.0	277.0	277.0	NA	NA
Alkalinity (mg/L)	7/7	62.0	394.0	124.7	NA	NA
²⁴¹ Am (pCi/L)	NA ^c /6	-0.2	0.3	NA	3	0
Ba (mg/L)	1/1	1.3	1.3	1.3	NA	NA
Be (mg/L)	1/1	0.01	0.01	0.01	NA	NA
Ca (mg/L)	7/7	10.1	30.5	17.7	NA	NA
Chloride (mg/L)	7/7	10.0	109.0	25.3	2	0
⁶⁰ Co (pCi/L)	NA/6	-0.2	0.6	NA	3	0
Color (units)	17/17	2.0	120.0	33.1	2	8
Conductivity (μmho/cm)	61/61	170.0	1197.0	243.3	NA	NA
Cr (mg/L)	2/18	<0.05	1.01	0.54	1	2
Cr ⁶⁺ (mg/L)	0/7	<0.01	<0.01	NONE	NA	NA
Cs (pCi/L)	NA/2	-0.1	0.6	NA	3	0
¹³⁷ Cs (pCi/L)	NA/5	-0.1	1.0	NA	3	0
Cu (mg/L)	4/18	<0.006	0.370	0.080	2	0
Depth (feet)	NA/14	20.57	61.79	NA	NA	NA
Dissolved alpha (pCi/L)	NA/17	-2.9	52.0	NA	1	4
Dissolved beta (pCi/L)	NA/17	-10.0	271.0	NA	1	NA
Dissolved solids (mg/L)	7/7	54.0	786.0	220.0	2	1
Fe (mg/L)	18/18	<0.06	706.0	54.71	2	15
Fluoride (mg/L)	15/16	0.10	0.18	0.13	1	0
Mg (mg/L)	7/7	4.42	23.85	8.39	NA	NA
Mn (mg/L)	8/8	0.02	5.87	1.13	2	7
NO ₃ -N (mg/L)	0/17	<1	<1	NONE	1	0
Na (mg/L)	8/8	10.65	500.0	74.74	NA	NA
Ni (mg/L)	5/18	0.01	1.02	0.31	NA	NA
²³⁷ Np (pCi/L)	NA/1	<1	<1	NA	3	0
PCB (μg/L)	1/17	<0.5	<0.5	NONE	NA	NA
PO ₄ -P (mg/L)	0/7	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/6	0	0.2	NA	1	0
²²² Rn (pCi/L)	NA/3	265.0	411.0	NA	3	0
Sulfate (mg/L)	17/17	<5	108.0	23.7	2	0
Suspended alpha (pCi/L)	NA/17	-2.7	2.5	NA	1	0
Suspended beta (pCi/L)	NA/17	-9.0	83.0	NA	1	NA
TOC (mg/L)	6/61	<1	18.0	4.6	NA	NA
TOX (ug/L)	24/63	<5	82.0	20.0	NA	NA
Trichloroethylene (ug/L)	8/21	<1	54.0	17.2	4	7
⁹⁹ Tc (pCi/L)	NA/21	0	340.0	NA	1	0
Temperature (°F)	NA/16	55.0	69.0	NA	NA	NA
Total As (mg/L)	1/1	0.156	0.156	0.156	1	1
Total Cd (mg/L)	0/8	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	1/18	<0.006	1.250	1.250	1	17
Total Se (mg/L)	1/8	<0.005	0.014	0.014	1	1
Turbidity (NTU)	17/17	0.5	4400.0	305.7	1	10
Uranium (mg/L)	9/21	<0.001	0.050	0.030	NA	NA
Zn (mg/L)	15/18	<0.005	21.800	1.479	2	1
pH (units)	NA/61	5.9	7.8	NA	2	44

^aSee Fig. 2.3.3.

^bNo samples were successfully taken from wells 49 and 58 during 1989.

^cNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.5. Constituents in the groundwater at C-746-S/C-746-T landfill during 1989^a
 Wells 16, 17, 18, 19, 38, 39, 40, 41, 42, 43, and 44
 Units 9 and 10

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Alkalinity (mg/L)	12/12	83.0	596.0	201.1	NA	NA
²⁴¹ Am (pCi/L)	NA ^b /12	-1.3	0.8	NA	3	0
Ca (mg/L)	12/12	18.3	73.0	32.9	NA	NA
Chloride (mg/L)	22/22	3.0	44.0	27.9	2	0
⁶⁰ Co (pCi/L)	NA/12	-1.7	1.2	NA	3	0
Color (units)	42/42	2.0	42.0	6.9	2	1
Conductivity (μmho/cm)	162/162	220.0	1440.0	597.4	NA	NA
Cr (mg/L)	1/42	<0.01	0.16	0.16	1	1
Cr ⁶⁺ (mg/L)	1/12	<0.01	0.02	0.01	NA	NA
Cs (pCi/L)	NA/9	-0.8	0.4	NA	3	0
¹³⁷ Cs (pCi/L)	NA/3	0	0.7	NA	3	0
Cu (mg/L)	15/42	<0.01	4.43	0.93	2	3
D.pth (ft)	NA/36	11.52	78.15	NA	NA	NA
Dissolved alpha (pCi/L)	NA/42	-7.3	14.4	NA	1	0
Dissolved beta (pCi/L)	NA/42	-16.0	42.0	NA	1	NA
Dissolved solids (mg/L)	11/12	<10	846.0	338.1	2	3
Fe (mg/L)	42/42	0.05	383.0	10.60	2	31
Fluoride (mg/L)	42/42	0.16	0.91	0.34	1	0
Gross alpha (pCi/L)	NA/19	-4.0	8.5	NA	1	0
Gross beta (pCi/L)	NA/19	-5.0	19.0	NA	1	NA
Mg (mg/L)	12/12	8.2	38.6	16.0	NA	NA
Mn (mg/L)	9/12	<0.005	1.700	0.229	2	4
NO ₃ -N (mg/L)	22/42	<1	4.0	1.9	1	0
Na (mg/L)	12/12	26.8	82.0	48.2	NA	NA
Ni (mg/L)	7/42	<0.05	0.11	0.08	NA	NA
PCB (μg/L)	0/42	<0.5	<0.5	NONE	NA	NA
PO ₄ -P (mg/L)	0/12	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/12	0	0.8	NA	1	0
²²² Rn (pCi/L)	NA/11	215.0	627.0	NA	3	0
Sulfate (mg/L)	42/42	7.9	217.0	54.0	2	0
Suspended alpha (pCi/L)	NA/42	-5.4	9.9	NA	1	0
Suspended beta (pCi/L)	NA/42	-22.0	35.0	NA	1	NA
TOC (mg/L)	51/167	<1	8.5	3.3	NA	NA
TOX (μg/L)	129/163	<5	56.0	18.7	NA	NA
Trichloroethylene (μg/L)	36/73	<1	21.0	10.7	4	22
⁹⁹ Tc (pCi/L)	NA/73	0	99.0	NA	1	0
Temperature (°F)	NA/42	54.0	79.0	NA	NA	NA
Total Cd (mg/L)	0/12	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	2/42	<0.05	0.48	0.35	1	38
Total Se (mg/L)	0/12	<0.005	0.005	NONE	1	0
Turbidity (NTU)	42/42	0.76	60.0	13.39	1	22
Uranium (mg/L)	8/42	<0.001	0.017	0.005	NA	NA
Zn (mg/L)	37/42	<0.005	1.920	0.262	2	0
pH (units)	NA/162	6.1	7.7	NA	2	72

^aSee Fig. 2.3.3.

^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.6. Constituents in the groundwater at C-746 scrap yard during 1989^a
 Wells 63, 64, 65, and 66
 Units 7, 12, 13, 14, and 30

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Alkalinity (mg/L)	4/4	64.0	378.0	171.8	NA	NA
²⁴¹ Am (pCi/L)	NA ^a /4	-0.03	0.6	NA	3	0
Ca (mg/L)	4/4	13.5	44.0	29.9	NA	NA
Chloride (mg/L)	4/4	11.0	32.0	20.3	2	0
⁶⁰ Co (pCi/L)	NA/4	-0.80	0.04	NA	3	0
Color (units)	15/15	3.0	12.0	5.3	2	0
Conductivity (μmho/cm)	51/51	196.0	743.0	337.0	NA	NA
Cr (mg/L)	3/17	<0.01	0.08	0.07	1	3
Cr ⁶⁺ (mg/L)	0/4	<0.01	<0.01	NONE	NA	NA
Cs (pCi/L)	NA/1	0	0	NA	3	0
¹³⁷ Cs (pCi/L)	NA/3	0.1	0.5	NA	3	0
Cu (mg/L)	6/17	<0.01	0.13	0.05	2	0
Depth (ft)	NA/18	9.4	50.2	NA	NA	NA
Dissolved alpha (pCi/L)	NA/16	-5.6	8.5	NA	1	0
Dissolved beta (pCi/L)	NA/16	-3.0	2518.0	NA	1	NA
Dissolved solids (mg/L)	4/4	102.0	400.0	250.5	2	0
Fe (mg/L)	16/17	<0.01	4.48	1.58	2	9
Fluoride (mg/L)	14/15	<0.1	0.34	0.19	1	0
Gross alpha (pCi/L)	NA/5	0	8.6	NA	1	0
Gross beta (pCi/L)	NA/5	493.0	1368.0	NA	1	NA
Mg (mg/L)	4/4	6.1	18.0	10.1	NA	NA
Mn (mg/L)	3/4	<0.005	0.140	0.070	2	2
NO ₃ -N (mg/L)	7/15	<1	9.0	5.7	1	0
Na (mg/L)	4/4	13.2	60.5	27.6	NA	NA
Ni (mg/L)	6/17	<0.05	0.18	0.13	NA	NA
PCB (μg/L)	0/14	<0.5	<0.5	NONE	NA	NA
PO ₄ -P (mg/L)	0/4	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/4	0	0.5	NA	1	0
²²² Rn (pCi/L)	NA/1	248.0	248.0	NA	3	0
Sulfate (mg/L)	15/15	8.9	31.0	13.1	2	0
Suspended alpha (pCi/L)	NA/16	-4.5	6.5	NA	1	0
Suspended beta (pCi/L)	NA/16	-8.0	33.0	NA	1	NA
TOC (mg/L)	3/51	<1	3.0	1.6	NA	NA
TOX (μg/L)	32/56	<5	3126.0	1262.7	NA	NA
Trichloroethylene (μg/L)	10/22	<1	6200.0	4135.0	4	10
⁹⁹ Tc (pCi/L)	NA/23	0	3670.0	NA	1	11
Temperature (°F)	NA/16	56.0	81.0	NA	NA	NA
Total Cd (mg/L)	0/4	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	0/17	<0.2	<0.2	NONE	1	17
Total Se (mg/L)	1/4	<0.005	0.011	0.011	1	1
Turbidity (NTU)	15/15	0.63	150.0	20.45	1	7
Uranium (mg/L)	4/17	<0.001	0.006	0.005	NA	NA
Zn (mg/L)	15/17	<0.005	0.270	0.043	2	0
pH (units)	NA/52	5.1	7.2	NA	2	29

^aSee Fig. 2.3.3.

^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.7. Constituents in the groundwater at south of C-400 during 1989^a
Wells 68, 69, and 71

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Alkalinity (mg/L)	2/2	83.0	87.0	85.0	NA	NA
²⁴¹ Am (pCi/L)	NA ^b /2	0	0.1	NA	3	0
Ca (mg/L)	2/2	26.5	47.2	36.8	NA	NA
Chloride (mg/L)	2/2	57.0	88.0	72.5	2	0
⁶⁰ Co (pCi/L)	NA/2	0.1	0.2	NA	3	0
Color (units)	7/7	2.0	5.0	3.8	2	0
Conductivity (μmho/cm)	31/31	410.0	571.0	481.7	NA	NA
Cr (mg/L)	3/7	<0.05	0.10	0.07	1	3
Cr ⁶⁺ (mg/L)	0/2	<0.01	<0.01	NONE	NA	NA
¹³⁷ Cs (pCi/L)	NA/2	-0.4	0.2	NA	3	0
Cu (mg/L)	1/7	<0.01	0.02	0.02	2	0
Depth (ft)	NA/7	51.03	56.41	NA	NA	NA
Dissolved alpha (pCi/L)	NA/7	2.9	11.9	NA	1	0
Dissolved beta (pCi/L)	NA/7	14.0	93.0	NA	1	NA
Dissolved solids (mg/L)	2/2	253.0	301.0	277.0	2	0
Fe (mg/L)	7/7	0.08	1.08	0.48	2	4
Fluoride (mg/L)	7/7	0.12	0.19	0.16	1	0
Mg (mg/L)	2/2	12.1	22.9	17.5	NA	NA
Mn (mg/L)	2/2	0.01	0.02	0.02	2	0
NO ₃ -N (mg/L)	3/7	<1	3.8	2.3	1	0
Na (mg/L)	2/2	47.15	57.44	52.30	NA	NA
Ni (mg/L)	4/7	<0.05	0.24	0.13	NA	NA
PCB (μg/L)	0/7	<0.5	<0.5	NONE	NA	NA
PO ₄ -P (mg/L)	0/2	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/2	0	0.7	NA	1	0
²²² Rn (pCi/L)	NA/1	471.0	471.0	NA	3	0
Sulfate (mg/L)	7/7	7.6	15.0	10.6	2	0
Suspended alpha (pCi/L)	NA/7	-2.0	3.4	NA	1	0
Suspended beta (pCi/L)	NA/7	-7.0	0	NA	1	NA
TOC (mg/L)	7/31	<1	1.3	1.1	NA	NA
TOX (μg/L)	31/31	12.0	41.0	26.9	NA	NA
Trichloroethylene (μg/L)	8/8	7.0	25.0	13.9	4	8
⁹⁹ Tc (pCi/L)	NA/8	0	137.0	NA	1	0
Temperature (°F)	NA/7	59.0	72.0	NA	NA	NA
Total Cd (mg/L)	0/2	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	0/7	<0.2	<0.2	NONE	1	7
Total Se (mg/L)	0/2	<0.005	<0.005	NONE	1	0
Turbidity (NTU)	7/7	1.5	9.0	3.2	1	2
Uranium (mg/L)	0/7	<0.001	0.001	NONE	NA	NA
Zn (mg/L)	6/7	<0.005	0.090	0.030	2	0
pH (units)	NA/23	6.0	6.7	NA	2	15

^aSee Fig. 2.3.3.^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.8. Constituents in the groundwater at C-404 low-level waste burial ground during 1989^a
Wells 94, 85, 88, 91, 93, 95, 84, 86, 87, 89, 90, and 92
Unit 3

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Conductivity ($\mu\text{mho}/\text{cm}$)	60/60	168.0	1360.0	403.3	NA	NA
Depth (ft)	NA ^a /59	13.2	54.5	NA	NA	NA
Dissolved As (mg/L)	4/45	<0.005	0.011	0.009	NA	NA
Dissolved Cd (mg/L)	0/36	<0.01	0.01	NONE	NA	NA
Dissolved Pb (mg/L)	0/36	<0.2	<0.2	NONE	NA	NA
Dissolved Se (mg/L)	1/44	<0.005	0.006	0.005	NA	NA
²²² Rn (pCi/L)	NA/10	47.0	775.0	NA	3	0
TOC (mg/L)	28/240	<1	5.7	3.0	NA	NA
TOX ($\mu\text{g}/\text{L}$)	82/239	<5	130.0	48.4	NA	NA
Trichloroethylene ($\mu\text{g}/\text{L}$)	18/62	<1	140.0	55.3	4	17
⁹⁹ Tc (pCi/L)	NA/63	0	1465.0	NA	1	7
Temperature ($^{\circ}\text{F}$)	NA/60	49.0	72.0	NA	NA	NA
Total As (mg/L)	12/60	<0.005	0.024	0.012	1	0
Total Cd (mg/L)	0/60	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	0/60	<0.2	<0.2	NONE	1	60
Total Se (mg/L)	2/60	<0.005	0.008	0.006	1	0
Uranium (mg/L)	14/60	<0.001	0.006	0.002	NA	NA
pH (units)	NA/60	5.4	7.2	NA	2	35

^aSee Fig. 2.3.3.

^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.9. Constituents in the groundwater at C-746-F burial ground during 1989^a
Wells 52, 53, and 54
Unit 5

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Alkalinity (mg/L)	3/3	62.0	136.0	92.7	NA	NA
²⁴¹ Am (pCi/L)	NA ^b /3	-0.2	0.6	NA	3	0
Ca (mg/L)	3/3	12.95	30.15	20.0	NA	NA
Chloride (mg/L)	3/3	7.0	10.0	8.3	2	0
⁶⁰ Co (pCi/L)	NA/3	-0.2	0.4	NA	3	0
Color (units)	5/5	<5	22.0	10.5	2	1
Conductivity (μmho/cm)	23/23	183.0	319.0	236.6	NA	NA
Cr (mg/L)	0/5	<0.05	<0.05	NONE	1	0
Cr ⁶⁺ (mg/L)	0/3	<0.01	<0.01	NONE	NA	NA
Cs (pCi/L)	NA/1	0	0	NA	3	0
¹³⁷ Cs (pCi/L)	NA/2	0	1.4	NA	3	0
Cu (mg/L)	0/5	<0.01	<0.01	NONE	2	0
Depth (ft)	NA/5	44.72	49.5	NA	NA	NA
Dissolved alpha (pCi/L)	NA/5	-0.2	4.3	NA	1	0
Dissolved beta (pCi/L)	NA/5	-8.0	8.0	NA	1	NA
Dissolved solids (mg/L)	3/3	20.0	152.0	96.0	2	0
Fe (mg/L)	5/5	0.59	16.7	6.95	2	5
Fluoride (mg/L)	5/5	0.14	0.22	0.17	1	0
Grease and oil (mg/L)	0/1	2.6	2.6	NONE	NA	NA
Mg (mg/L)	3/3	3.82	8.80	6.02	NA	NA
Mn (mg/L)	3/3	0.06	1.14	0.46	2	3
NO ₃ -N (mg/L)	0/5	<1	<1	NONE	1	0
Na (mg/L)	3/3	13.15	17.25	14.80	NA	NA
Ni (mg/L)	0/5	<0.05	<0.05	NONE	NA	NA
PCB (μg/L)	0/5	<0.5	<0.5	NONE	NA	NA
PO ₄ -P (mg/L)	0/3	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/3	-0.1	0.4	NA	1	0
²²² Rn (pCi/L)	NA/3	119.0	394.0	NA	3	0
Sulfate (mg/L)	5/5	<5	9.0	6.8	2	0
Suspended alpha (pCi/L)	NA/5	-1.6	1.4	NA	1	0
Suspended beta (pCi/L)	NA/5	-8.0	8.0	NA	1	NA
TOC (mg/L)	0/23	<1	1.0	NONE	NA	NA
TOX (μg/L)	5/23	<5	12.0	8.2	NA	NA
Trichloroethylene (μg/L)	0/5	<1	1.0	NONE	4	0
⁹⁹ Tc (pCi/L)	NA/5	0	27.0	NA	1	0
Temperature (°F)	NA/5	53.0	73.0	NA	NA	NA
Total Cd (mg/L)	0/3	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	0/5	<0.2	<0.2	NONE	1	5
Total Se (mg/L)	0/3	<0.005	<0.005	NONE	1	0
Turbidity (NTU)	5/5	3.2	62.0	29.180	1	4
Uranium (mg/L)	0/5	<0.001	0.001	NONE	NA	NA
Zn (mg/L)	3/5	<0.005	0.040	0.024	2	0
pH (units)	NA/23	6.2	7.3	NA	2	15

^aSee Fig. 2.3.3.

^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.10. Constituents in the groundwater at C-746-K landfill during 1989^a
Wells 23, 24, 25, 26, 27, 28, 29, 30, 32, 35, 36, and 37
Unit 8

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Reference	Number of values exceeding reference
		Min	Max			
Alkalinity (mg/L)	1/1	101.0	101.0	101.0	NA	NA
²⁴¹ Am (pCi/L)	NA ^a /3	-0.4	1.0	NA	3	0
Ca (mg/L)	4/4	7.4	26.7	14.9	NA	NA
Chloride (mg/L)	1/1	79.5	79.5	79.5	2	0
⁶⁰ Co (pCi/L)	NA/3	-0.4	0.4	NA	3	0
Color (units)	1/1	8.0	8.0	8.0	2	0
Conductivity (μmho/cm)	1/1	481.0	481.0	481.0	NA	NA
Cr (mg/L)	0/4	<0.05	<0.05	NONE	1	0
Cr ⁶⁺ (mg/L)	0/1	<0.01	<0.01	NONE	NA	NA
¹³⁷ Cs (pCi/L)	NA/3	0	0.6	NA	3	0
Cu (mg/L)	1/4	<0.01	0.02	0.02	2	0
Depth (ft)	NA/4	11.52	34.08	NA	NA	NA
Dissolved alpha (pCi/L)	NA/5	1.8	10.1	NA	1	0
Dissolved beta (pCi/L)	NA/5	-8.0	14.0	NA	1	NA
Dissolved solids (mg/L)	1/1	297.0	297.0	297.0	2	0
Fe (mg/L)	4/4	0.3	2.9	1.9	2	3
Fluoride (mg/L)	1/1	0.14	0.14	0.14	1	0
Mg (mg/L)	4/4	3.27	30.4	11.72	NA	NA
Mn (mg/L)	4/4	0.02	0.30	0.16	2	3
NO ₃ -N (mg/L)	0/1	<1	<1	NONE	1	0
Na (mg/L)	4/4	11.3	30.0	17.4	NA	NA
Ni (mg/L)	1/4	<0.05	0.09	0.07	NA	NA
PCB (μg/L)	0/2	<0.5	<0.5	NONE	NA	NA
PO ₄ -P (mg/L)	0/1	<2	<2	NONE	NA	NA
²²⁶ Ra (pCi/L)	NA/3	0	0	NA	1	0
Sulfate (mg/L)	1/1	10.3	10.3	10.3	2	0
Suspended alpha (pCi/L)	NA/5	1.0	3.2	NA	1	0
Suspended beta (pCi/L)	NA/5	-1.0	10.0	NA	1	NA
TOC (mg/L)	1/3	1.0	16.5	6.2	NA	NA
TOX (μg/L)	3/3	9.0	69.0	31.7	NA	NA
Trichloroethylene (μg/L)	1/5	<1	2.0	2.0	4	0
⁹⁹ Tc (pCi/L)	NA/5	2.0	25.0	NA	1	0
Temperature (F)	NA/1	78.0	78.0	NA	NA	NA
Total Cd (mg/L)	0/4	<0.01	<0.01	NONE	1	0
Total Pb (mg/L)	0/4	<0.2	<0.2	NONE	1	4
Total Se (mg/L)	0/3	<0.005	<0.005	NONE	1	0
Turbidity (NTU)	1/1	11.0	11.0	11.0	1	1
Uranium (mg/L)	2/4	<0.001	0.013	0.010	NA	NA
Zn (mg/L)	4/4	9.2	69.0	46.6	2	4
pH (units)	NA/1	6.4	6.4	NA	2	1

^aSee Fig. 2.3.3.

^bNA = not applicable. See Sect. 2.3.6 of Part 1 for clarification of NA entries.

Table 2.3.11. Petroleum products found in PGDP monitoring wells 47, 52, 68, 69, 70, 71, 96

Parameter	Number detected/ number of samples	Concentration		Average of values above the detection limit	Number of values exceeding reference	Reference
		Min	Max			
Benzene ($\mu\text{g/L}$)	3/8	<5	140.000	103.000	3	1
Ethyl benz ($\mu\text{g/L}$)	2/7	<5	1800.000	1295.000	2	5
Toluene ($\mu\text{g/L}$)	3/8	<5	2400.000	1495.667	2	5
Xylene ($\mu\text{g/L}$)	3/8	<5	8100.000	4466.667	0	5

7. QUALITY ASSURANCE

Table 7.1.1. Energy Systems environmental analysis procedures for air

Parameter	Energy Systems procedure	NIOSH or EPA method	Lowest concentration reported (LCR)
Gross alpha, beta, air filters, radiochemistry	EC-2100	APHA 601, 602 ^a	Alpha 0.005 pCi/m ³ Beta 0.025 pCi/m ³
Dustfall, gravimetric	EC-2270		Procedure in preparation
Fluoride, air, SIE	EC-2360		5 µg/sample
Fluoride, stacks, SIE	EC-2370		30 µg/m ³
Gamma-ray spectroscopy, air filters	EC-2400		Procedure in preparation
¹³¹ I, gamma-ray spectroscopy, air filter	EC-2420		2.5 pCi/filter
Metals in air particulates, emission spectroscopy	EC-2440		For 48 metals, mostly 1–10 µg each/sample
Pu, air filters, radiochemistry	EC-2500	EPA-680/4-75-001	0.04 pCi/filter
⁹⁰ Sr, air filters, radiochemistry	EC-2580		2 pCi/filter
⁹⁹ Tc, air filters, radiochemistry	EC-2600		300 pCi/filter
Th, alpha isotopes, radiochemistry	EC-2640		0.04 pCi/filter
U, air filters, fluorometric	EC-2850		0.05 µg/sample
U isotopes, air filters, radiochemistry	EC-2870	EPA-680/4-75-001	0.04 pCi/filter
U, stack gases, spectroscopy/fluorometric	EC-2890		1.7 µg/m ³
Dichlorotetrafluoroethane, GC method	IHA-230	NIOSH S108	3500 mg/m ³
Diethyl phthalate, air, GC method	IHA-235	NIOSH S40	2 mg/m ³
Formaldehyde, air	IHA-237	NIOSH 125	0.1 mg/m ³
Isopropanol, air	IHA-240	NIOSH S64	180 mg/m ³
Oil mist, air, infrared	IHA-247		0.5 mg/m ³
Organic solvents, air, GC method	IHA-250	NIOSH 127 ^b	18 cpds; 0.01 to 1.0 mg/sample
Pentachlorophenol, air, HPLC	IHA-260	NIOSH S297	0.27 mg/m ³
PCBs, air, GC	IHA-270	NIOSH 244	10 µg/m ³
Quinoline, air	IHA-273		Procedure in preparation
Toluene diisocyanate, air	IHA-239	NIOSH 141	7 µg/m ³
Tributyl phosphate air, GC method	IHA-285	NIOSH S208	2.7 mg/m ³
Vinyl chloride, air, GC method	IHA-294	NIOSH 178	8 µg/m ³

^aAPHA Methods, American Public Health Assoc., 1977.^bNIOSH Manual of Analytical Methods, Second Ed., U.S. Dept. of Health, Education, and Welfare, 1977.

Table 7.1.2. Energy Systems environmental analysis procedures for water

Parameter	Energy Systems procedure	EPA method	Lowest concentration reported (LCR) ^a (mg/L)
Alkalinity (CaCO ₃)	EC-1005	310.1	5
Gross alpha activity	EC-1010	900.0	1.0 pCi/L
Gross beta activity	EC-1010	900.0	4.0 pCi/L
²⁴¹ Am and ²⁴⁴ Cm	EC-1020		3.0 pCi/L each (ORNL) 0.05 pCi/L
As and Se, furnace-AA			
As	EC-1400	206.2	0.005
Se	EC-1400	270.2	0.005
Asbestos	EC-1050		0.3 × 10 ⁶ fibers/L
BOD (5-d)	EC-1060	405.1	5
Bromide, titrimetric	EC-1070	320.1	2
COD (low-level), titration method	EC-1090	410.2	5
COD, spectro photometric method	EC-1100	Hach 8000	5
Chloride, titration (HgNO ₃)	EC-1120	325.3	2
Anions, ion chromatograph ^b			
Chloride	EC-1130	300.0	2
Nitrate (N)	EC-1130	300.0	1
Sulfate	EC-1130	300.0	5
Phosphate (P)	EC-1130	300.0	2
Chlorine (total residual), amperometric	EC-1150	330.1	0.05 (PGDP) 0.01
Chromium (VI), spectrophotometric	EC-1180	USGS ^c	0.01
Coliform bacteria (fecal)	EC-1190	909C Std. Mth. ^d	1 colony/100 mL
Coliform bacteria (total)	EC-1200	909A Std. Mth.	1 colony/100 mL
Color	EC-1220	110.2	1 color unit
Conductance (specific)	EC-1240	120.1	0.5 μmho/cm
Cyanide (total)	EC-1270	335.2	0.004 (5-cm cell)
Dissolved oxygen, membrane electrode method	EC-1300	360.1	0.1
Fluoride	EC-1330	340.2	0.1
Gamma-ray emitters	EC-1340		2.5 pCi/L
Herbicides (chlorinated phenoxy acid), GC method			
2, 4-D	EC-1370	509B Std. Mth.	0.1 μg/L
Silvex	EC-1370	509B Std. Mth.	0.02 ug/L
¹³¹ I	EC-1380		4.0 pCi/L
Hg (total)	EC-1390	245.1	0.0002
Methylene-blue-active substances (MBAS)	EC-1450	425.1	0.05
²³⁷ Np	EC-1460		1.0 pCi/L (ORNL) 4 × 10 ⁻² pCi/L
Nitrogen, ammonia, spectrophotometric	EC-1470	350.2	0.2
Nitrogen, ammonia, SIE	EC-1480	350.3	0.2
Nitrogen, Kjeldahl (total), spectrophotometric	EC-1500	351.3	0.2

Table 7.1.2 (continued)

Parameter	Energy Systems procedure	EPA method	Lowest concentration reported (LCR) ^a (mg/L)
Nitrogen, Kjeldahl (total), volumetric	EC-1510	351.3	0.2
Nitrogen, Kjeldahl (total) SIE	EC-1520	351.4	0.2
Nitrogen, nitrate, brucine method	EC-1530	352.1	0.1
Nitrogen, nitrate-nitrite, Cd-Redn.	EC-1540	353.3	0.1
N-nitrosomorpholine, spectrophotometric	EC-1550		1.0
Oil and grease, gravimetric	EC-1560	413.1	5
Oil and grease, infrared	EC-1570	413.2	2.0
Pentachlorophenol, HPLC	EC-1583		50 µg/L
Pesticides (organochlorine), GC method			
Lindane	EC-1586	608 ^e	0.01 µg/L
Endrin	EC-1586	608	0.05 µg/L
Toxaphene	EC-1586	608	1.0 µg/L
Methoxychlor	EC-1586	509A Std. Mth.	0.2 µg/L
Phenols	EC-1590	420.1	50 µg/L
			(w/o concentration)
			5 µg/L (with concentration)
pH, electrometric	EC-1600	150.1	Nearest 0.1 pH unit
Phosphorus (all forms), spectrophotometric	EC-1610	365.2	0.1
Pu isotopes	EC-1615		1.0 pCi/L
			(Y-12 and ORNL) 5×10^{-2} pCi/L
PCBs	EC-1620	608	0.5 µg/L each
Priority pollutants, organic (base/neutral/acid)	EC-1701	625	Mostly 10–50 µg/L each ^f
Priority pollutants, organic (volatile, purgeable)	EC-1704	624	Mostly 10–30 µg/L each ^g
			TCE 1 µg/L
Solids (dissolved)	EC-1760	160.1	10
Solids (settleable)	EC-1770	160.5	1.0 mL/L/h
Solids (total)	EC-1790	160.3	10
Solids (undissolved)	EC-1800	160.2	4
Solids (volatile)	EC-1820	160.4	5
⁹⁰ Sr	EC-1840		4.0 pCi/L
			(ORNL) 2.0 pCi/L
Sulfate, turbidimetric method	EC-1850	375.4	5
⁹⁹ Tc	EC-1860		300 pCi/L
Thorium isotopes	EC-1870		0.4 pCi/L
			(ORNL) 5×10^{-2} pCi/L

Table 7.1.2 (continued)

Parameter	Energy Systems procedure	EPA method	Lowest concentration reported (LCR) ^a (mg/L)
Thorium, spectrophotometric	EC-1871		2×10^{-3} mg/L
Total organic carbon, combustion or oxidation	EC-1873	415.1	1
Tritium	EC-1879		5000 pCi/L (ORNL) 1500 pCi/L
Turbidity	EC-1880	180.1	0.05 NTU
Uranium (total), fluorometric	EC-1910		1×10^{-3} mg/L
Uranium isotopes	EC-1920		1 pCi/L (ORNL) 5×10^{-2} pCi/L
Uranium isotopic abundances	EC-1960		0.001 wt %

^aThe 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.

^bApproved 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; "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," N. W. Skougstad et al., U.S. Geological Survey, Techniques of Water-Resources Investigation, Book 5, Chapter A1, 1979.

^dAll references to Standard Methods for the 15th Edition, 1980.

^e*Federal Register* 49 (209), 43,261, October 26, 1984.

^fFor 81 compounds.

^gFor 31 compounds.

Table 7.1.3. Energy Systems atomic absorption and ICP environmental analysis procedures for waters
[lowest concentration reported (LCR)^a]

Element	Energy Systems EC-1400 EPA 200 series flame AA (mg/L)	Energy Systems EC-1400 EPA 200 series graphite furnace AA (mg/L)	Energy Systems EC-1410 EPA 200.7 ICP (mg/L)
Ag	0.05	0.01	0.03
Al	0.3	0.01	0.1
As	<i>b</i>	0.005	0.1
Ba	0.2	0.01	0.005
Ca	0.05	<i>b</i>	0.01
Cd	0.02	0.002	0.01
Cr	0.2	0.01	0.05
Cu	0.05	0.004	0.01
Fe	0.05	<i>b</i>	0.01
K	0.2	<i>b</i>	2.0
Li	0.01	<i>b</i>	0.02
			(ORNL) 0.2
Mg	0.02	<i>b</i>	0.002
Mn	0.03	0.01	0.005
Mo	0.2	0.01	0.05
Na	0.05	<i>b</i>	0.04
			(ORNL) 0.5
Ni	0.1	0.01	0.05
Pb	0.2	0.004	0.2
Se	<i>b</i>	0.005	0.2
Zn	0.02	<i>b</i>	0.005

^aThe 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 limit (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.

^bElement not normally determined using this technique.

Table 7.1.4. Energy Systems environmental analysis procedures for biota

Parameter	Energy Systems procedure	EPA method	Lowest concentration reported (LCR) (mg/kg)
Fluoride in vegetation	EC-4100		3
Gamma-ray spectrometry of deer muscle	EC-4130		Procedure in preparation
Gamma-ray spectrometry of fish	EC-4150		Procedure in preparation
Gamma-ray spectrometry of vegetation	EC-4170		Procedure in preparation
¹³¹ I and ⁹⁰ Sr in raw milk	EC-4180		¹³¹ I, 1 pCi/L ⁹⁰ Sr, 1 pCi/L
Metals in fish, AA	EC-4250	600-4-81/055 ^a	See below
Metals in vegetation, AA	EC-4300		See below
Pu isotopes in fish	EC-4360		20 pCi/kg (ORNL) 4 pCi/kg
Pu isotopes in vegetation	EC-4380		40 pCi/kg (ORNL) 4 pCi/kg
PCBs in fish and animal tissue	EC-4400	600/4-81-055 ^a	0.1
⁹⁰ Sr in fish	EC-4600		1000 pCi/kg (ORNL) 200 pCi/kg
⁹⁰ Sr in vegetation	EC-4620		1000 pCi/kg (ORNL) 200 pCi/kg
⁹⁹ Tc in fish	EC-4630		Procedure in preparation
⁹⁹ Tc in vegetation	EC-4635		Procedure in preparation
Th isotopes in vegetation	EC-4640		40 pCi/kg (ORNL) 4 pCi/kg
U (total) in vegetation	EC-4700		0.5
U (total and isotopic) in vegetation	EC-4720		10 ng/sample
U isotopes in animal tissue	EC-4800		Procedure in preparation
U isotopes in vegetation	EC-4840		40 pCi/kg (ORNL) 4 pCi/kg
<i>Procedures for atomic absorption</i>			
Metals in fish, furnace AA	EC-4250	600/4-81-055 ^a	
Cd			0.01
Cr			0.05
Cu			0.10
Ni			0.50
Pb			0.05
Metals in vegetation, flame AA	EC-4300		
Cd			0.5
Cr			3.0
Cu			2.0
Ni			3.5
Zn			0.5

^a"Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue," EPA, Rev. October 1980.

Table 7.1.5. Energy Systems environmental analysis procedures for soil and sediment

Parameter	Energy Systems procedure	EPA method	Lowest concentration reported (LCR) (mg/kg)
Fluoride	EC-3050		Procedure in preparation
Gamma-ray spectrum analysis	EC-3070		Procedure in preparation
Hg (total), flameless AA	EC-3100	245.5	0.2
Np, direct gamma spectrum	EC-3300		Procedure in preparation
²³⁷ Np, radiochemical	EC-3305		20 pCi/kg
Pu, radiochemical	EC-3360		20 pCi/kg
PCBs, gas chromatographic	EC-3400		0.1
⁹⁰ Sr, radiochemical	EC-3500	704 Std. Mth. ^a	200 pCi/kg
⁹⁹ Tc, radiochemical	EC-3550		2 × 10 ⁴ pCi/kg
Th, spectrophotometric	EC-3600		3
Th (alpha-emitting) isotopes, radiochemical	EC-3650		4 pCi/kg
U (total), fluorometric	EC-3700		0.5
U (total and isotopic), isotope dilution mass spectrometric	EC-3740		10 ng total U
U isotopes, radiochemical	EC-3780		4 pCi/kg
Aluminium	EC-3250	200.7	6.0
Arsenic	EC-3200	200 series	0.5
Barium	EC-3250	200.7	0.04
Beryllium	EC-3250	200.7	0.1
Boron	EC-3250	200.7	0.8
Cadmium	EC-3250	200.7	0.6
Calcium	EC-3250	200.7	2.0
Chromium	EC-3250	200.7	0.4
Cobalt	EC-3250	200.7	0.4
Copper	EC-3250	200.7	0.2
Iron	EC-3250	200.7	1.0
Lead	EC-3250	200.7	4.0
Magnesium	EC-3250	200.7	0.1
Manganese	EC-3250	200.7	0.1
Molybdenum	EC-3250	200.7	1.6
Nickel	EC-3250	200.7	0.8
Niobium	EC-3250	200.7	1.0
Phosphorus	EC-3250	200.7	4.0
Potassium	EC-3250	200.7	10
Scandium	EC-3250	200.7	0.1
Selenium	EC-3200	200 series	0.5
Silver	EC-3250	200.7	0.6
Sodium	EC-3250	200.7	1.0
Strontium	EC-3250	200.7	0.04
Thorium	EC-3250	200.7	4.0
Titanium	EC-3250	200.7	0.2
Vanadium	EC-3250	200.7	0.6
Zinc	EC-3250	200.7	0.4
Zirconium	EC-3250	200.7	0.2

^aReferences to Standard Methods are from the 14th Edition, 1975.

Table 7.1.6. PGDP analysis procedures for off-site well waters

Parameter	Energy Systems Proc. No.	EPA method	Lowest concentration reported
Gross alpha activity	EC-1010	900.0	Report result obtained
Gross beta activity	EC-1010	900.0	Report result obtained
Trichloroethylene	EC-1704	RCRA 8240	1 µg/L
⁹⁹ Tc	EC-1862		25 pCi/L

Table 7.1.7. PGDP analysis procedures for field measurements

Parameter	Energy Systems Proc. No.	EPA method	Lowest concentration reported
pH	ES-14	150.1	0.1 ^a
Dissolved oxygen	ES-14	360.1	0.1 mg/L
Temperature	ES-14	170.1	0.1 °
Total residual chlorine	ES-16	330.5	0.01 mg/L
Depth	ES-2	NA	0.01 in.

^aNearest pH unit.Table 7.2.1. PGDP internal measurement control program
laboratory control data (Inorganic)

Measurement identification	Accepted mean ^a	Ratio of observed mean to T ^{a,b}	Percent bias	Number of analyses	Percent limit of error per analysis ^c
<i>Fluorimetric analysis</i>					
Low-level uranium	0.035 mg/L(T)	0.99 ± 0.01	-1.18 ± 1.07	247	17
<i>Thermal ionization mass spectrometer</i>					
Uranium	10-20 mg/L(T)	1.005 ± 0.010	0.53 ± 1.02	11	3.3
Assay (wt % ²³⁵ U)	0.0-1.00(T)	1.007 ± 0.004	0.66 ± 0.38	11	1.2

^aSamples sent at various theoretical levels. Statistics are reported on the ratio of reported result to the theoretical value with 1.000 indicating agreement.^bT = theoretical value.^cLimit of error of the 95% confidence level.

**Table 7.2.2. PGDP internal measurement control program
laboratory control data (organic)**

Measurement identification	Accepted mean	Observed mean ± limit of error	Number of analyses	Percent limit of error per analysis ^a	% Recovery
<i>Total organic halogens (µg/L)</i>					
TOX, as trichloro- phenol, in water (RCRA 9020)	100	102.0 ± 1.78	48	12	102.0
	100	102.4 ± 1.20	90	11	102.4
<i>Polychlorinated biphenyls (µg/L)</i>					
PCB, spike recovery, in water (EPA 608)	43.3	34.1 ± 6.4	4	37.3	79.5
PCB, spike recovery, in groundwater (RCRA 8080)	43.3	32.7 ± 2.5	6	18.6	77.5
	50.0	43.9 ± 7.4	7	44.4	87.7
<i>Trichloroethylene (µg/L)</i>					
TCE, spike recovery, in groundwater (RCRA 8240)	5.0	4.47 ± 0.11	91	23.0	89.3
TCE, spike recovery, in water (EPA 624)	5.0	4.69 ± 0.26	14	20.4	93.8

^aLimit of error of the 95% confidence level.

**Table 7.2.3. PGDP Environmental Protection Agency Performance Evaluation
Report DMR-QA Study Number 009**

Parameter	Reported value	True ^a value	Acceptable limits	Warning limits	Performance ^b evaluation
<i>Trace metals (µg/L)</i>					
Aluminum	336	350	269–439	290–418	Acceptable
Chromium	599	600	485–703	512–676	Acceptable
Copper	801	820	753–893	770–876	Acceptable
Iron	1880	1827	1650–2030	1690–1980	Acceptable
Nickel	383	370	319–419	331–407	Acceptable
Zinc	391	401	347–446	359–434	Acceptable
<i>Miscellaneous parameters (mg/L)^c</i>					
pH (units)	5.7	5.80	5.66–5.91	5.69–5.88	Acceptable
Total suspended solids	31	29.7	24.2–33.3	25.3–32.2	Acceptable
Oil and grease	12.0	12.0	6.32–16.4	7.57–15.1	Acceptable
Total residual chlorine	0.69	0.700	0.440–0.925	0.504–0.861	Acceptable
<i>Demand (mg/L)</i>					
COD	38	28.5	19.7–44.0	22.7–40.9	Acceptable
5-day BOD	29	18.6	13.1–30.9	15.3–28.7	Check for error

^aBased on theoretical calculations or a reference value when necessary.

^bPerformance evaluation by EPA. 0–1.96 standard deviation for acceptable; 1.96–2.58 standard deviation for check for error; outside 2.58 standard deviation for unacceptable.

^cUnits are in mg/L except for pH, which is reported in pH units.

Table 7.2.4. January 1989 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Alkalinity as CaCO ₃ (mg/L)	1	31.0	33.1	34.54	0.941	Acceptable
	2	60.0	64.2	63.54	0.684	Acceptable
Aluminum (μg/L)	1	49.8	35.19	37.06	1.176	Acceptable
	2	236.1	206.0	195.0	1.376	Acceptable
Ammonia as N (mg/L)	1	0.57	0.553	0.610	0.343	Acceptable
	2	2.2	2.12	2.21	0.044	Acceptable
Arsenic (μg/L)	1	55	48.89	48.4	0.743	Acceptable
	2	336	241	232.8	2.243	Marginal
Barium (μg/L)	1	360.9	376.0	368.0	0.323	Acceptable
	2	1144	1198	1181.5	0.493	Acceptable
Beryllium (μg/L)	1	108.1	100.6	97.9	1.619	Acceptable
	2	127.2	118.0	115.4	1.297	Acceptable
BOD (mg/L)	1	133	138.58	136.7	0.188	Acceptable
	2	14	15.78	16.0	0.562	Acceptable
Cadmium (μg/L)	1	20.2	19.0	18.6	0.868	Acceptable
	2	237.7	238.0	236.2	0.101	Acceptable
Chloride (mg/L)	1	82	82.3	83.60	0.376	Acceptable
	2	94	93.0	93.80	0.054	Acceptable
Chromium (μg/L)	1	38	38.3	38.9	0.162	Acceptable
	2	256.6	261.0	255.7	0.030	Acceptable
COD (mg/L)	1	210	223.0	212.9	0.158	Acceptable
	2	31	25.41	25.36	0.767	Acceptable
Conductivity (μmho/cm)	1	416	443	401.3	0.428	Acceptable
	2	526	582	501.3	0.447	Acceptable
Copper (μg/L)	1	68	69.5	70.3	0.326	Acceptable
	2	170.4	177.0	176.0	0.480	Acceptable
Fluoride (mg/L)	1	1.4	1.35	1.42	0.143	Acceptable
	2	6.8	6.74	6.74	0.099	Acceptable
Hexavalent chromium (mg/L)	1	0.07	0.067	0.068	0.285	Acceptable
	2	0.27	0.278	0.285	0.371	Acceptable
Iron (μg/L)	1	91.4	82.9	85.4	0.376	Acceptable
	2	582	559.0	568.1	0.261	Acceptable
Lead (μg/L)	1	32.0	40.6	40.2	1.173	Acceptable
	2	257.5	275.0	272.7	0.459	Acceptable
Manganese (μg/L)	1	75.3	78.3	78.4	0.455	Acceptable
	2	207.7	218.0	215.4	0.430	Acceptable
Nickel (μg/L)	1	56.8	53.2	53.0	0.666	Acceptable
	2	124.4	119.0	120.8	0.378	Acceptable
Nitrate as N (mg/L)	1	0.30	0.28	0.30	0.060	Acceptable
	2	1.9	1.71	1.75	0.733	Acceptable

Table 7.2.4 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Oil and grease (mg/L)	1	14.6	15.6	13.39	0.338	Acceptable
	2	27.4	28.4	25.34	0.554	Acceptable
Orthophosphate as P (mg/L)	1	0.50	0.466	0.479	0.376	Acceptable
	2	1.5	1.486	1.487	0.071	Acceptable
pH (units)	1	9.5	9.55	9.38	0.362	Acceptable
	2	9.2	9.19	8.87	0.540	Acceptable
Selenium (μg/L)	1	22	19.7	22.5	0.125	Acceptable
	2	72	71.6	72.4	0.038	Acceptable
Silver (μg/L)	1	22.1	22.05	22.5	0.147	Acceptable
	2	308	301.0	301.6	0.279	Acceptable
Sulfate (mg/L)	1	28	29.2	28.9	0.432	Acceptable
	2	39	39.5	39.2	0.072	Acceptable
TDS ^b (mg/L)	1	156	131.9	111.0 ^c	0.270	Acceptable
	2	252	245.1	105.0 ^c	0.207	Acceptable
TOC ^d (mg/L)	1	90	83.99	86.34	0.280	Acceptable
	2	10	9.57	10.50	0.305	Acceptable
Thallium (μg/L)	1	27.6	49.32	47.6	2.065	Marginal
	2	160.8	260.0	266.1	2.137	Marginal
Total hardness as CaCO ₃ (mg/L)	1	36	36.4	37.03	0.302	Acceptable
	2	101	104.6	100.8	0.031	Acceptable
Total organic halides (μg/L)	1	57	46.95	45.9	2.003	Marginal
	2	451	440.1	383.5	0.997	Acceptable
Total residual chlorine (mg/L)	1	0.860	0.913	0.829	0.236	Acceptable
	2	6.5	7.40	6.72	0.166	Acceptable
TSS ^e (mg/L)	1	60	63.6	91.1 ^c	0.258	Acceptable
	2	140	152.5	94.2 ^c	0.334	Acceptable
Uranium (μg/L)	1	84	90.45	90.9	0.793	Acceptable
	2	720	753.75	754.5	1.114	Acceptable
Zinc (μg/L)	1	84.2	72.55	75.4	1.021	Acceptable
	2	152.9	115.0	118.9	2.791	Not acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.96–2.58 standard for marginal; more than 2.58 standard deviations for not acceptable.

^bTDS = total dissolved solids

^cAverage percent recovery for the participating laboratories.

^dTOC = total organic carbon

^eTSS = total suspended solids

**Table 7.2.5. March 1989 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Alkalinity as CaCO ₃ (mg/L)	1	34	33.1	33.3	0.201	Acceptable
	2	81	84.5	83.6	0.368	Acceptable
Aluminum (μg/L)	1	42	30.2	30.9	1.832	Acceptable
	2	225	231.3	223.7	0.055	Acceptable
Ammonia as N (mg/L)	1	0.55	0.613	0.629	0.941	Acceptable
	2	2.8	2.94	2.90	0.347	Acceptable
Arsenic (μg/L)	1	40	30.4	31.4	1.512	Acceptable
	2	459	371.7	338.7	1.253	Acceptable
Barium (μg/L)	1	419	433.7	431.8	0.276	Acceptable
	2	1385	1446.1	1447.7	0.598	Acceptable
Beryllium (μg/L)	1	96	90.5	87.6	1.057	Acceptable
	2	191	176.1	170.9	1.185	Acceptable
BOD (mg/L)	1	132	124.2	119.9	0.813	Acceptable
	2	18	15.2	14.2	1.044	Acceptable
Cadmium (μg/L)	1	91	87.4	85.4	0.661	Acceptable
	2	178	171.0	169.1	0.662	Acceptable
Chloride (mg/L)	1	44	44.7	44.5	0.170	Acceptable
	2	96	98.3	97.8	0.320	Acceptable
Chromium (μg/L)	1	42	43.1	42.6	0.103	Acceptable
	2	126	129.4	130.2	0.277	Acceptable
COD (mg/L)	1	205	200	189.7	1.219	Acceptable
	2	27	24.5	23.5	0.557	Acceptable
Conductivity (μmho/cm)	1	299	321.3	302.4	0.145	Acceptable
	2	564	626.6	555.7	0.208	Acceptable
Copper (μg/L)	1	39	36.0	38.8	0.036	Acceptable
	2	124	131.1	132.7	0.827	Acceptable
Fluoride (mg/L)	1	1.1	1.09	1.09	0.102	Acceptable
	2	7.3	7.54	7.40	0.182	Acceptable
Hexavalent chromium (mg/L)	1	0.08	0.086	0.078	0.146	Acceptable
	2	0.18	0.192	0.178	0.105	Acceptable
Iron (μg/L)	1	12.9	127.2	130.9	0.105	Acceptable
	2	447	455.1	460.8	0.562	Acceptable
Lead (μg/L)	1	125	116.7	104.9	0.674	Acceptable
	2	302	291.8	282.9	0.620	Acceptable
Manganese (μg/L)	1	67	69.6	70.0	0.462	Acceptable
	2	217	226.2	227.0	0.790	Acceptable
Mercury (μg/L)	1	1.2	1.00	1.18	0.050	Acceptable
	2	4.2	4.50	4.19	0.019	Acceptable
Nickel (μg/L)	1	82	77.2	75.0	0.689	Acceptable
	2	137	132.6	135.5	0.079	Acceptable

Table 7.2.5 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Nitrate as N (mg/L)	1	0.3	0.20	0.20	2.899	Not Acceptable
	2	1.4	1.30	1.30	0.680	Acceptable
Oil and grease (mg/L)	1	11.5	12.60	11.04	0.110	Acceptable
	2	27.9	28.62	24.92	0.467	Acceptable
Orthophosphate as P (mg/L)	1	0.4	0.37	0.39	0.087	Acceptable
	2	1.6	1.56	1.54	0.426	Acceptable
pH (units)	1	8.7	8.91	8.91	0.520	Acceptable
	2	7.3	7.47	7.47	0.580	Acceptable
Selenium (μg/L)	1	47	42.1	46.1	0.161	Acceptable
	2	84	95.4	95.4	0.676	Acceptable
Silver (μg/L)	1	43	44.1	43.8	0.119	Acceptable
	2	126	129.0	128.2	0.128	Acceptable
Sulfate (mg/L)	1	33	34.4	34.5	0.581	Acceptable
	2	31	32.9	33.1	0.609	Acceptable
TDS ^b (mg/L)	1	129	121.5	106.6 ^c	0.022	Acceptable
	2	288	282.1	106.1 ^c	0.244	Acceptable
TOC ^d (mg/L)	1	70	75.3	73.9	0.636	Acceptable
	2	8	9.2	9.4	1.095	Acceptable
Thallium (μg/L)	1	40	72.9	68.1	1.852	Acceptable
	2	618	750.0	673.5	0.291	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	21.2	22.15	21.97	0.471	Acceptable
	2	63.3	63.86	61.73	0.532	Acceptable
Total organic halides (μg/L)	1	18	15.0	18.7	0.081	Acceptable
	2	250	225.5	200.0	1.735	Acceptable
Total residual chlorine (mg/L)	1	0.30	0.320	0.328	0.291	Acceptable
	2	5.6	6.05	5.31	0.323	Acceptable
TSS ^e (mg/L)	1	71	74.5	91.1 ^c	0.417	Acceptable
	2	334	359.8	93.9 ^c	0.166	Acceptable
Uranium (μg/L)	1	40	40.2	40.7	0.337	Acceptable
	2	890	945	949.1	0.895	Acceptable
Zinc (μg/L)	1	52	45.0	49.6	0.288	Acceptable
	2	160	160.2	157.8	0.137	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.96–2.58 standard for marginal; more than 2.58 standard deviations for not acceptable.

^bTDS = total dissolved solids

^cAverage percent recovery for the participating laboratories.

^dTOC = total organic carbon

^eTSS = total suspended solids

**Table 7.2.6. May 1989 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Alkalinity as CaCO ₃ (mg/L)	1	46.8	52.66	50.74	0.837	Acceptable
	2	35.3	37.14	36.65	0.510	Acceptable
Aluminum (μg/L)	1	76	53.1	55.8	1.497	Acceptable
	2	216	212.6	220.8	0.087	Acceptable
Ammonia as N (mg/L)	1	0.51	0.504	0.505	0.059	Acceptable
	2	1.7	1.67	1.75	0.182	Acceptable
Arsenic (μg/L)	1	42.0	33.7	34.0	1.715	Acceptable
	2	183	156.1	152.5	1.844	Acceptable
Barium (μg/L)	1	563	579.6	583.7	0.507	Acceptable
	2	1220	1242.9	1229.3	0.086	Acceptable
Beryllium (μg/L)	1	72	67.9	67.1	1.205	Acceptable
	2	166	148.4	148.6	1.073	Acceptable
BOD (mg/L)	1	313	235.7	205.8	2.031	Marginal
	2	29	16.0	16.6	2.249	Marginal
Cadmium (μg/L)	1	71	66.5	66.7	0.862	Acceptable
	2	155	142.5	143.9	1.385	Acceptable
Calcium (mg/L)	1	21.42	23.03	23.236	1.592	Acceptable
	2	6.72	6.744	7.059	0.863	Acceptable
Chloride (mg/L)	1	112	111.6	111.2	0.126	Acceptable
	2	47	47.2	47.0	0.00	Acceptable
Chromium (μg/L)	1	33	35.9	35.8	0.744	Acceptable
	2	175	179.7	180.9	0.479	Acceptable
COD (mg/L)	1	335	379.5	362.6	1.324	Acceptable
	2	21	25.7	25.8	0.444	Acceptable
Conductivity (μmho/cm)	1	530	579.3	526.6	0.070	Acceptable
	2	313	338.7	312.2	0.038	Acceptable
Copper (μg/L)	1	81	79.0	77.7	0.460	Acceptable
	2	139	136.1	136.8	0.213	Acceptable
Fluoride (mg/L)	1	1.81	1.87	1.78	0.087	Acceptable
	2	5.7	5.73	5.87	0.439	Acceptable
Hexavalent chromium (mg/L)	1	0.08	0.086	0.081	0.104	Acceptable
	2	0.24	0.24	0.22	0.419	Acceptable
Iron (μg/L)	1	42	30.5	36.8	0.375	Acceptable
	2	387	381.7	391.3	0.186	Acceptable
Lead (μg/L)	1	149	145.9	143.6	0.313	Acceptable
	2	306	291.8	293.8	0.718	Acceptable
Magnesium (mg/L)	1	7.88	7.83	7.722	0.374	Acceptable
	2	8.05	7.893	7.825	0.409	Acceptable
Manganese (μg/L)	1	39	39.2	39.4	0.168	Acceptable
	2	297	302.4	300.9	0.240	Acceptable

Table 7.2.6 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Mercury ($\mu\text{g/L}$)	1	1.25	1.600	1.604	1.577	Acceptable
	2	2.07	2.245	2.313	0.596	Acceptable
Nickel ($\mu\text{g/L}$)	1	36	40.0	38.8	0.346	Acceptable
	2	188	188.4	188.8	0.072	Acceptable
Nitrate as N (mg/L)	1	0.38	0.313	0.329	1.146	Acceptable
	2	1.6	1.41	1.46	0.489	Acceptable
Oil and grease (mg/L)	1	8.2	7.01	6.61	0.543	Acceptable
	2	29.9	31.62	26.73	0.382	Acceptable
Orthophosphate as P (mg/L)	1	0.14	0.154	0.193	0.448	Acceptable
	2	1.4	1.32	1.70	0.327	Acceptable
pH (units)	1	8.2	8.06	8.19	0.028	Acceptable
	2	6.1	6.12	6.24	0.614	Acceptable
Potassium (mg/L)	1	6.59	6.561	6.521	0.130	Acceptable
	2	9.15	9.001	9.269	0.083	Acceptable
Selenium ($\mu\text{g/L}$)	1	31	23.7	24.4	1.635	Acceptable
	2	85	72.1	70.2	1.465	Acceptable
Silver ($\mu\text{g/L}$)	1	19	19.6	19.4	0.109	Acceptable
	2	208	215.0	211.7	0.167	Acceptable
Sodium (mg/L)	1	64.47	63.691	65.028	0.143	Acceptable
	2	36.32	35.84	36.875	0.198	Acceptable
Sulfate (mg/L)	1	25	25.4	25.8	0.231	Acceptable
	2	33	33.9	33.5	0.134	Acceptable
TDS ^b (mg/L)	1	61	67.9	106.0 ^c	0.552	Acceptable
	2	339	365	103.8 ^c	1.013	Acceptable
TOC ^d (mg/L)	1	140	142.9	141.9	0.137	Acceptable
	2	10	9.7	10.4	0.203	Acceptable
Thallium ($\mu\text{g/L}$)	1	24	65.6	69.1	2.043	Acceptable
	2	56	540	482.4	1.653	Acceptable
Total hardness as CaCO_3 (mg/L)	1	86	89.76	88.11	0.631	Acceptable
	2	48	49.34	49.53	0.343	Acceptable
Total organic halides ($\mu\text{g/L}$)	1	20	17.6	19.0	0.145	Acceptable
	2	160	164.0	145.9	0.839	Acceptable
Total residual chlorine (mg/L)	1	0.17	0.190	0.174	0.138	Acceptable
	2	1.02	1.230	1.139	0.863	Acceptable
TSS ^e (mg/L)	1	38	44.7	90.1 ^c	0.562	Acceptable
	2	199	228	93.7 ^c	0.904	Acceptable

Table 7.2.6 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Uranium ($\mu\text{g/L}$)	1	88	100.5	98.9	1.805	Acceptable
	2	450	472	463.14	0.593	Acceptable
Vanadium ($\mu\text{g/L}$)	1	78	100.0	96.4	2.468	Marginal
	2	1071	1116.4	1132.8	1.032	Acceptable
Zinc ($\mu\text{g/L}$)	1	30	27.0	28.9	0.224	Acceptable
	2	120	115.1	116.9	0.298	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.96–2.58 standard for marginal; more than 2.58 standard deviations for not acceptable.

^bTDS = total dissolved solids

^cAverage percent recovery for the participating laboratories.

^dTOC = total organic carbon

^eTSS = total suspended solids

**Table 7.2.7. July 1989 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Alkalinity as CaCO ₃ (mg/L)	1	37.2	37.01	36.60	0.248	Acceptable
	2	47.8	47.88	47.80	0.001	Acceptable
Aluminum (μg/L)	1	65	47.8	53.4	0.649	Acceptable
	2	171	164.7	173.6	0.096	Acceptable
Ammonia as N (mg/L)	1	0.34	0.30	0.32	0.243	Acceptable
	2	2.7	2.85	2.86	0.385	Acceptable
Arsenic (μg/L)	1	43.7	52.27	50.76	1.110	Acceptable
	2	356	370.9	376.08	0.408	Acceptable
Barium (μg/L)	1	500	507.2	509.8	0.400	Acceptable
	2	1546	1564.9	1561.4	0.156	Acceptable
Beryllium (μg/L)	1	40	35.2	36.0	1.284	Acceptable
	2	161	145.9	146.4	1.504	Acceptable
BOD (mg/L)	1	172	167.9	156.4	0.617	Acceptable
	2	20	21.1	19.8	0.056	Acceptable
Cadmium (μg/L)	1	58	53.2	53.8	1.062	Acceptable
	2	116	104.5	107.5	0.798	Acceptable
Calcium (mg/L)	1	5.74	5.977	5.896	0.389	Acceptable
	2	15.2	15.60	15.09	0.112	Acceptable
Chloride (mg/L)	1	58	57.4	57.7	0.096	Acceptable
	2	62	62.3	61.3	0.195	Acceptable
Chromium (μg/L)	1	82	86.7	82.9	0.089	Acceptable
	2	241	251.4	247.8	0.201	Acceptable
COD (mg/L)	1	205	270.4	258.2	2.447	Marginal
	2	23	33.9	31.5	0.850	Acceptable
Conductivity (μmho/cm)	1	330	352.4	320.9	0.309	Acceptable
	2	342	368.2	330.1	0.414	Acceptable
Copper (μg/L)	1	44	44.2	44.6	0.113	Acceptable
	2	132	131.1	131.8	0.022	Acceptable
Fluoride (mg/L)	1	2.2	2.27	2.25	0.255	Acceptable
	2	6.5	6.66	6.66	0.240	Acceptable
Hexavalent chromium (mg/L)	1	0.02	0.038	0.035	1.462	Acceptable
	2	0.19	0.192	0.191	0.041	Acceptable
Iron (μg/L)	1	137	132.3	132.3	0.261	Acceptable
	2	214	213.8	212.7	0.080	Acceptable
Lead (μg/L)	1	53	49.6	51.2	0.339	Acceptable
	2	244	233.4	234.7	0.344	Acceptable
Magnesium (mg/L)	1	2.12	2.075	2.022	0.745	Acceptable
	2	7.99	7.778	7.446	1.013	Acceptable

Table 7.2.7 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Manganese ($\mu\text{g/L}$)	1	77	78.3	77.0	0.000	Acceptable
	2	170	175.4	171.2	0.140	Acceptable
Mercury ($\mu\text{g/L}$)	1	1.0	0.90	0.93	0.336	Acceptable
	2	2.6	2.49	2.47	0.269	Acceptable
Nickel ($\mu\text{g/L}$)	1	80	73.3	72.5	0.922	Acceptable
	2	180	175.1	174.7	0.330	Acceptable
Nitrate as N (mg/L)	1	1.0	0.86	0.87	1.555	Acceptable
	2	1.2	1.20	1.22	0.209	Acceptable
Oil and grease (mg/L)	1	12.1	13.14	10.70	0.391	Acceptable
	2	38.1	40.93	33.80	0.497	Acceptable
Orthophosphate as P (mg/L)	1	0.16	0.154	0.171	0.297	Acceptable
	2	2.9	2.75	2.68	0.650	Acceptable
pH (units)	1	6.9	7.02	6.94	0.172	Acceptable
	2	9.3	9.49	9.37	0.215	Acceptable
Potassium (mg/L)	1	18.7	18.07	17.90	0.518	Acceptable
	2	10.5	10.38	10.41	0.114	Acceptable
Selenium ($\mu\text{g/L}$)	1	26.5	32.88	34.78	1.448	Acceptable
	2	64.0	67.3	65.57	0.174	Acceptable
Silver ($\mu\text{g/L}$)	1	35	34.3	35.5	0.143	Acceptable
	2	209	215	214	0.533	Acceptable
Sodium (mg/L)	1	45.5	43.62	43.72	0.550	Acceptable
	2	32.1	30.61	30.89	0.525	Acceptable
Sulfate (mg/L)	1	22	22.7	22.0	0.022	Acceptable
	2	14	14.5	14.0	0.003	Acceptable
TDS ^b (mg/L)	1	135	130.7	107.5 ^c	0.266	Acceptable
	2	399	392.5	102.7 ^c	0.124	Acceptable
TOC ^d (mg/L)	1	113	101.8	103.1	1.242	Acceptable
	2	14	12.8	13.4	0.346	Acceptable
Thallium ($\mu\text{g/L}$)	1	46	80.2	81.3	5.381	Not acceptable
	2	464	600.0	587.8	1.896	Acceptable
Total hardness as CaCO_3 (mg/L)	1	23.6	23.47	23.22	0.273	Acceptable
	2	68.4	70.98	69.24	0.215	Acceptable
Total organic halides ($\mu\text{g/L}$)	1	16	14.8	18.9	0.381	Acceptable
	2	115	113.0	112.0	0.365	Acceptable
Total residual chlorine (mg/L)	1	0.55	0.64	0.59	0.377	Acceptable
	2	5.2	6.57	6.36	0.974	Acceptable
TSS ^e (mg/L)	1	42	51.4	93.2 ^c	1.914	Acceptable
	2	135	152.1	94.9 ^c	1.298	Acceptable

Table 7.2.7 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Uranium ($\mu\text{g/L}$)	1	123	136	135.2	1.426	Acceptable
	2	430	482	481.8	1.484	Acceptable
Vanadium ($\mu\text{g/L}$)	1	367	405.0	403.2	2.038	Marginal
	2	1120	1178.9	1166.4	0.996	Acceptable
Zinc ($\mu\text{g/L}$)	1	29	24.2	26.7	0.300	Acceptable
	2	118	115.1	114.2	0.351	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.96–2.58 standard for marginal; more than 2.58 standard deviations for not acceptable.

^bTDS = total dissolved solids

^cAverage percent recovery for the participating laboratories.

^dTOC = total organic carbon

^eTSS = total suspended solids

**Table 7.2.8. September 1989 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Alkalinity as CaCO ₃ (mg/L)	1	37	39.1	39.0	1.000	Acceptable
	2	46	47.3	48.2	0.486	Acceptable
Aluminum (μg/L)	1	30	31.9	43.4	0.620	Acceptable
	2	348	372.0	365.6	0.420	Acceptable
Ammonia as N (mg/L)	1	0.70	0.712	0.724	0.264	Acceptable
	2	2.1	2.14	2.13	0.149	Acceptable
Arsenic (μg/L)	1	70	48.9	48.5	2.032	Marginal
	2	190	136.6	138.2	2.054	Marginal
Barium (μg/L)	1	379	391.3	387.8	0.300	Acceptable
	2	1262	1296.6	1322.7	0.558	Acceptable
Beryllium (μg/L)	1	24	22.6	22.7	0.262	Acceptable
	2	353	324.4	338.4	0.446	Acceptable
BOD (mg/L)	1	136	147.2	136.1	0.004	Acceptable
	2	40	41.6	38.8	0.097	Acceptable
Cadmium (μg/L)	1	30	27.4	27.2	0.903	Acceptable
	2	291	262.7	264.0	1.415	Acceptable
Calcium (mg/L)	1	9.70	9.552	9.477	0.342	Acceptable
	2	3.99	3.878	3.883	0.458	Acceptable
Chloride (mg/L)	1	55	54.8	54.1	0.382	Acceptable
	2	57	56.3	55.2	0.632	Acceptable
Chromium (μg/L)	1	84	94.2	93.8	1.421	Acceptable
	2	141	148.7	153.3	0.864	Acceptable
COD (mg/L)	1	218	236.9	224.2	0.199	Acceptable
	2	57	66.9	55.8	0.200	Acceptable
Conductivity (μmho/cm)	1	300	321.4	296.8	0.252	Acceptable
	2	310	335.3	309.2	0.042	Acceptable
Copper (μg/L)	1	72	69.5	68.6	0.549	Acceptable
	2	119	116.0	118.8	0.020	Acceptable
Fluoride (mg/L)	1	1.7	1.70	1.69	0.061	Acceptable
	2	7.5	7.57	7.62	0.130	Acceptable
Hexavalent chromium (mg/L)	1	0.06	0.069	0.067	0.450	Acceptable
	2	0.24	0.268	0.252	0.307	Acceptable
Iron (μg/L)	1	24	25.4	27.9	0.652	Acceptable
	2	305	304.5	307.5	0.137	Acceptable
Lead (μg/L)	1	28	29.2	31.1	0.517	Acceptable
	2	251	245.3	244.5	0.278	Acceptable
Magnesium (mg/L)	1	6.08	5.797	5.624	1.640	Acceptable
	2	8.39	8.049	7.622	1.758	Acceptable

Table 7.2.8 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Manganese ($\mu\text{g/L}$)	1	78	78.3	76.8	0.208	Acceptable
	2	190	187.5	185.1	0.452	Acceptable
Mercury ($\mu\text{g/L}$)	1	1.5	1.80	1.75	1.549	Acceptable
	2	3.5	4.00	3.90	0.561	Acceptable
Nickel ($\mu\text{g/L}$)	1	49	44.0	43.7	0.717	Acceptable
	2	172	148.1	153.4	1.310	Acceptable
Nitrate as N (mg/L)	1	0.400	0.359	0.362	1.019	Acceptable
	2	1.20	1.126	1.117	1.097	Acceptable
Oil and grease (mg/L)	1	11.3	11.64	10.06	0.287	Acceptable
	2	40.1	43.36	35.84	0.351	Acceptable
Orthophosphate as P (mg/L)	1	0.3	0.33	0.34	1.883	Acceptable
	2	2.2	2.16	2.19	0.061	Acceptable
pH (units)	1	5.9	5.50	5.83	0.222	Acceptable
	2	8.2	7.82	7.92	0.585	Acceptable
Potassium (mg/L)	1	14.1	12.96	12.99	1.254	Acceptable
	2	9.17	8.32	8.56	0.88	Acceptable
Selenium ($\mu\text{g/L}$)	1	46	35.5	37.7	1.585	Acceptable
	2	91	86.6	85.8	0.372	Acceptable
Silver ($\mu\text{g/L}$)	1	11	14.7	15.2	1.381	Acceptable
	2	309	322.5	328.6	0.734	Acceptable
Sodium (mg/L)	1	32.9	30.44	31.46	0.656	Acceptable
	2	42.0	39.15	39.20	0.647	Acceptable
Sulfate (mg/L)	1	13	13.8	13.3	0.232	Acceptable
	2	11	11.7	11.0	0.020	Acceptable
TDS ^b (mg/L)	1	202	219.3	111.0 ^c	0.932	Acceptable
	2	290	289.1	102.4 ^c	0.236	Acceptable
TOC ^d (mg/L)	1	89	89.2	92.4	0.373	Acceptable
	2	25	25.2	25.7	0.252	Acceptable
Thallium ($\mu\text{g/L}$)	1	124	131.3	114.1	0.271	Acceptable
	2	251	290.0	286.7	0.934	Acceptable
Total hardness as CaCO_3 (mg/L)	1	47	47.7	47.5	0.155	Acceptable
	2	44	42.8	42.2	0.610	Acceptable
Total organic halides ($\mu\text{g/L}$)	1	49	49.2	38.9	0.612	Acceptable
	2	240	263.0	247.0	0.407	Acceptable
Total residual chlorine (mg/L)	1	0.84	0.883	0.804	0.336	Acceptable
	2	3.8	5.35	5.36	1.595	Acceptable
TSS ^e (mg/L)	1	45	59.7	88.5 ^c	1.072	Acceptable
	2	176	220.4	94.4 ^c	1.968	Marginal

Table 7.2.8 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Uranium ($\mu\text{g/L}$)	1	45	100.5	89.8	2.181	Marginal
	2	33	804	657.8	2.197	Marginal
Vanadium ($\mu\text{g/L}$)	1	45	70.0	70.1	2.517	Marginal
	2	1255	1378.2	1397.0	1.125	Acceptable
Zinc ($\mu\text{g/L}$)	1	26	24.2	23.5	0.498	Acceptable
	2	125	120.1	123.2	0.174	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.96–2.58 standard for marginal; more than 2.58 standard deviations for not acceptable.

^bTDS = total dissolved solids

^cAverage percent recovery for the participating laboratories.

^dTOC = total organic carbon

^eTSS = total suspended solids

**Table 7.2.9. November 1989 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Alkalinity as CaCO ₃ (mg/L)	1	38.8	41.04	41.19	0.873	Acceptable
	2	56.3	58.44	58.34	0.683	Acceptable
Aluminum (μg/L)	1	46	42.5	44.6	0.182	Acceptable
	2	106	106.3	117.0	0.561	Acceptable
Ammonia as N (mg/L)	1	0.4	0.37	0.40	0.019	Acceptable
	2	2.1	2.11	2.12	0.095	Acceptable
Arsenic (μg/L)	1	50	50.6	48.6	0.387	Acceptable
	2	376	370.8	323.7	0.541	Acceptable
Barium (μg/L)	1	371	362.3	365.4	0.188	Acceptable
	2	1290	1274.2	1297.6	0.091	Acceptable
Beryllium (μg/L)	1	45	42.8	43.6	0.560	Acceptable
	2	155	145.9	148.6	0.593	Acceptable
BOD (mg/L)	1	118	106.8	110.8	0.373	Acceptable
	2	45	42.7	41.2	0.429	Acceptable
Cadmium (μg/L)	1	95	88.2	88.4	0.904	Acceptable
	2	170	154.8	156.3	1.150	Acceptable
Calcium (mg/L)	1	6.25	6.458	6.404	0.292	Acceptable
	2	13.4	13.58	13.58	0.237	Acceptable
Chloride (mg/L)	1	39	40.5	39.7	0.462	Acceptable
	2	80	80.0	78.5	0.549	Acceptable
Chromium (μg/L)	1	79	81.8	82.2	0.502	Acceptable
	2	272	272.5	272.3	0.013	Acceptable
COD (mg/L)	1	150	171.9	166.8	1.031	Acceptable
	2	60	68.8	64.6	0.699	Acceptable
Conductivity (μmho/cm)	1	273	295.4	264.4	0.597	Acceptable
	2	466	510.0	448.9	0.688	Acceptable
Copper (μg/L)	1	29	28.4	28.4	0.123	Acceptable
	2	279	272.3	274.2	0.409	Acceptable
Fluoride (mg/L)	1	4.0	4.04	4.02	0.114	Acceptable
	2	5.2	5.25	5.23	0.079	Acceptable
Hexavalent chromium (mg/L)	1	0.06	0.069	0.062	0.147	Acceptable
	2	0.19	0.198	0.179	0.362	Acceptable
Iron (μg/L)	1	26	25.4	26.8	0.141	Acceptable
	2	269	274.0	280.2	0.490	Acceptable
Lead (μg/L)	1	29	29.2	28.2	0.220	Acceptable
	2	390	397.5	407.5	0.448	Acceptable
Magnesium (mg/L)	1	3.07	3.070	2.938	0.670	Acceptable
	2	6.51	6.560	6.282	0.204	Acceptable

Table 7.2.9 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Manganese (µg/L)	1	98	95.7	92.1	0.608	Acceptable
	2	139	139.1	134.8	0.459	Acceptable
Mercury (µg/L)	1	0.7	1.00	1.01	1.357	Acceptable
	2	2.4	2.24	2.24	0.507	Acceptable
Nickel (µg/L)	1	39	37.3	38.5	0.086	Acceptable
	2	219	226.1	228.9	0.579	Acceptable
Nitrate as N (mg/L)	1	0.6	0.51	0.51	1.845	Acceptable
	2	1.8	1.65	1.60	1.209	Acceptable
Oil and grease (mg/L)	1	15	15.7	12.4	0.636	Acceptable
	2	36.7	39.2	33.3	0.516	Acceptable
Orthophosphate as P (mg/L)	1	0.5	0.46	0.46	0.515	Acceptable
	2	2.8	2.70	2.56	0.322	Acceptable
pH (units)	1	6.3	5.85	5.94	1.431	Acceptable
	2	6.3	6.05	6.11	0.848	Acceptable
Potassium (mg/L)	1	11.9	10.54	10.74	1.218	Acceptable
	2	20.63	19.500	19.628	0.620	Acceptable
Selenium (µg/L)	1	28	23.7	24.8	0.796	Acceptable
	2	66	62.5	61.7	0.404	Acceptable
Silver (µg/L)	1	45	49.0	49.6	1.309	Acceptable
	2	143	152.1	151.7	1.300	Acceptable
Sodium (mg/L)	1	37.76	36.200	36.210	0.780	Acceptable
	2	57.41	55.710	55.793	0.505	Acceptable
Sulfate (mg/L)	1	22	22.1	21.4	0.319	Acceptable
	2	34	34.5	33.7	0.095	Acceptable
TDS ^b (mg/L)	1	119	134.6	102.7 ^c	1.180	Acceptable
	2	227	282.1	101.6 ^c	0.558	Acceptable
TOC ^d (mg/L)	1	26	64.7	65.2	7.285	Not acceptable
	2	70	25.9	25.6	22.098	Not acceptable
Thallium (µg/L)	1	200	192.1	180.5	0.641	Acceptable
	2	276	285.0	292.2	0.356	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	29.9	28.77	28.88	0.472	Acceptable
	2	60.4	60.92	60.40	0.001	Acceptable
Total organic halides (µg/L)	1	40	30.7	31.7	1.048	Acceptable
	2	193	188.7	175.0	0.997	Acceptable
Total residual chlorine (mg/L)	1	0.65	0.699	0.623	0.263	Acceptable
	2	4.8	5.94	5.33	0.522	Acceptable
TSS ^e (mg/L)	1	28	34.1	90.28 ^c	0.931	Acceptable
	2	255	291.7	93.46 ^c	0.939	Acceptable

Table 7.2.9 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Uranium ($\mu\text{g/L}$)	1	76	80.4	85.6	0.843	Acceptable
	2	320	322.0	351.3	0.879	Acceptable
Vanadium ($\mu\text{g/L}$)	1	65	90.0	88.5	0.903	Acceptable
	2	985	1058.6	1101.3	0.956	Acceptable
Zinc ($\mu\text{g/L}$)	1	26	24.2	26.5	0.099	Acceptable
	2	130	130.1	132.2	0.267	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.96–2.58 standard for marginal; more than 2.58 standard deviations for not acceptable.

^bTDS = total dissolved solids

^cAverage percent recovery for the participating laboratories.

^dTOC = total organic carbon

^eTSS = total suspended solids

Table 7.2.10. January 1989 National Institute for Occupational Safety and Health Proficiency Analytical Testing Program

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	No. of labs
Lead (total mg)	1	0.0393	0.0395	0.0336–0.0455	Acceptable	356
	2	0.0239	0.0244	0.0204–0.0285	Acceptable	356
	3	0.0773	0.0785	0.0696–0.0874	Acceptable	356
	4	0.0521	0.0523	0.0453–0.0595	Acceptable	356
Cadmium (total mg)	1	0.0078	0.0079	0.0067–0.0092	Acceptable	356
	2	0.0121	0.0125	0.0109–0.0143	Acceptable	356
	3	0.0171	0.0176	0.0157–0.0197	Acceptable	356
	4	0.0097	0.0101	0.0086–0.0116	Acceptable	356
Zinc (total mg)	1	0.0821	0.0880	0.0751–0.1010	Acceptable	355
	2	0.1123	0.1222	0.1027–0.1417	Acceptable	355
	3	0.1932	0.2091	0.1844–0.2340	Acceptable	355
	4	0.1409	0.1521	0.1310–0.1733	Acceptable	355
Asbestos (fibers/mm ²)	1	396.0	466.9	240.9–767.2	Acceptable	1025
	2	749.0	666.6	331.3–1118.2	Acceptable	1025
	3	219.0	305.9	145.5–525.3	Acceptable	1025
	4	755.0	944.3	428.9–1660.5	Acceptable	1025
Carbon tetrachloride (total mg)	1	0.648	0.6518	0.5473–0.7564	Acceptable	362
	2	0.852	0.8600	0.7252–0.9949	Acceptable	362
	3	1.076	1.0786	0.9126–1.2447	Acceptable	362
	4	0.382	0.3852	0.3023–0.4683	Acceptable	362
1,2-Dichloroethane (total mg)	1	0.681	0.6848	0.5836–0.7861	Acceptable	362
	2	0.822	0.8276	0.7379–0.9173	Acceptable	362
	3	0.534	0.5403	0.4649–0.6158	Acceptable	362
	4	1.108	1.1063	0.9724–1.2402	Acceptable	362
Trichloro- ethylene (total mg)	1	1.173	1.1675	1.0106–1.3245	Acceptable	362
	2	0.752	0.7561	0.6625–0.8497	Acceptable	362
	3	1.039	1.0490	0.9214–1.1767	Acceptable	362
	4	0.584	0.5083	0.5000–0.6766	Acceptable	362

^aReference value is calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

**Table 7.2.11. April 1989 National Institute for Occupational Safety and Health
Proficiency Analytical Testing Program**

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	No. of labs
Lead (total mg)	1	0.0177	0.0175	0.0147–0.0205	Acceptable	353
	2	0.0322	0.0310	0.0271–0.0350	Acceptable	353
	3	0.0590	0.0585	0.0539–0.0633	Acceptable	353
	4	0.0449	0.0434	0.0382–0.0487	Acceptable	353
Cadmium (total mg)	1	0.0196	0.0187	0.0169–0.0207	Acceptable	352
	2	0.0148	0.0139	0.0125–0.0154	Acceptable	352
	3	0.0092	0.0090	0.0084–0.0098	Acceptable	352
	4	0.0072	0.0069	0.0062–0.0078	Acceptable	352
Zinc (total mg)	1	0.1336	0.1328	0.1164–0.1492	Acceptable	351
	2	0.1788	0.1718	0.1479–0.1957	Acceptable	351
	3	0.1023	0.1031	0.0907–0.1155	Acceptable	351
	4	0.1623	0.1589	0.1425–0.1754	Acceptable	351
Asbestos (fibers/mm ²)	1	358	247.1	57.6–568.8	Acceptable	1048
	2	997	731.1	221.8–1535.8	Acceptable	1048
	3	508	549.4	176.1–1129.6	Acceptable	1048
	4	917	795.8	286.7–1559.4	Acceptable	1048
Chloroform (total mg)	1	0.677	0.6971	0.6000–0.7942	Acceptable	346
	2	0.900	0.9318	0.8333–1.0303	Acceptable	346
	3	0.357	0.3610	0.3007–0.4214	Acceptable	346
	4	0.494	0.5036	0.4262–0.5810	Acceptable	346
Carbon tetrachloride (total mg)	1	0.745	0.7702	0.6636–0.8768	Acceptable	346
	2	0.358	0.3670	0.2739–0.4603	Acceptable	346
	3	0.974	1.0115	0.8605–1.1626	Acceptable	346
	4	0.793	0.8082	0.6541–0.9625	Acceptable	346
1,2- Dichloroethane (total mg)	1	0.973	1.0080	0.8631–1.1529	Acceptable	346
	2	1.118	1.1524	1.0244–1.2804	Acceptable	346
	3	0.893	0.9205	0.8154–1.0256	Acceptable	346
	4	0.762	0.7835	0.6844–0.8827	Acceptable	346

^aReference value is calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

**Table 7.2.12. July 1989 National Institute for Occupational Safety and Health
Proficiency Analytical Testing Program**

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	No. of labs
Lead (total mg)	1	0.0770	0.0774	0.0689–0.0859	Acceptable	354
	2	0.0062	0.0622	0.0549–0.0696	Outlier	354
	3	0.0530	0.0515	0.0436–0.0594	Acceptable	354
	4	0.0355	0.0348	0.0307–0.0389	Acceptable	354
Cadmium (total mg)	1	0.0128	0.0129	0.0116–0.0143	Acceptable	354
	2	0.0060	0.0060	0.0052–0.0068	Acceptable	354
	3	0.0102	0.0098	0.0088–0.0110	Acceptable	354
	4	0.0172	0.0167	0.0150–0.0185	Acceptable	354
Zinc (total mg)	1	0.0985	0.1022	0.0890–0.1154	Acceptable	351
	2	0.0138	0.1369	0.1216–0.1523	Outlier	351
	3	0.0770	0.0762	0.0658–0.0867	Acceptable	351
	4	0.1785	0.1807	0.1621–0.1994	Acceptable	351
Asbestos (fibers/mm ²)	1	978	802.5	454.2–1249.6	Acceptable	1136
	2	1647	1130.9	602.3–1824.9	Acceptable	1136
	3	794	602.2	348.2–425.3	Acceptable	1136
	4	371	371.7	174.0–643.6	Acceptable	1136
Benzene (total mg)	1	0.144	0.1418	0.1063–0.1774	Acceptable	357
	2	0.182	0.1754	0.1438–0.2070	Acceptable	357
	3	0.277	0.2704	0.2201–0.3207	Acceptable	357
	4	0.238	0.2337	0.1864–0.2811	Acceptable	357
O-Xylene (total mg)	1	1.017	1.0565	0.9296–1.1834	Acceptable	357
	2	1.493	1.4097	1.2295–1.5901	Acceptable	357
	3	0.921	0.9372	0.8037–1.0707	Acceptable	357
	4	1.672	1.5765	1.3886–1.7644	Acceptable	357
Toluene (total mg)	1	0.996	1.0315	0.8984–1.1647	Acceptable	357
	2	1.369	1.3212	1.1677–1.4747	Acceptable	357
	3	1.663	1.5831	1.4021–1.7642	Acceptable	357
	4	0.858	0.8665	0.7571–0.9760	Acceptable	357

^aReference value is calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

Table 7.2.13. October 1989 National Institute for Occupational Safety and Health Proficiency Analytical Testing Program

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	No. of labs
Lead (total mg)	1	0.0497	0.0485	0.0440-0.0531	Acceptable	362
	2	0.0668	0.0658	0.0597-0.0719	Acceptable	362
	3	0.0339	0.0334	0.0297-0.0373	Acceptable	362
	4	0.0434	0.0426	0.0387-0.0461	Acceptable	362
Cadmium (total mg)	1	0.0120	0.0119	0.0108-0.0131	Acceptable	360
	2	0.0146	0.0148	0.0133-0.0164	Acceptable	360
	3	0.0089	0.0090	0.0080-0.0100	Acceptable	360
	4	0.0098	0.0100	0.0090-0.0110	Acceptable	360
Zinc (total mg)	1	0.0873	0.0885	0.0774-0.0996	Acceptable	360
	2	0.1176	0.1170	0.1058-0.1282	Acceptable	360
	3	0.1574	0.1589	0.1416-0.1763	Acceptable	360
	4	0.1898	0.1909	0.1702-0.2118	Acceptable	360
Asbestos (fibers/mm ²)	1	135	148.5	37.3-334.1	Acceptable	1203
	2	395	399.6	138.6-793.8	Acceptable	1203
	3	683	823.6	279.9-1654.0	Acceptable	1203
	4	226	241.4	72.6-508.9	Acceptable	1203

^aReference value is calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

**Table 7.2.14. March 1, 1989, Environmental Measurements Laboratory,
Semiannual Report of the DOE Operational Safety, Health, and
Environment Division, Quality Assessment Program**

Isotope	EML value	Reported value (Rp)	Ratio (Rp/EML)	Performance evaluation ^a
<i>Air (pCi/filter)</i>				
⁷ Be	0.195×10^4	0.180×10^4	0.92	Acceptable
¹⁴⁴ Ce	0.327×10^3	0.359×10^3	1.10	Acceptable
⁶⁰ Co	0.126×10^3	0.133×10^3	1.06	Acceptable
¹³⁷ Cs	0.189×10^3	0.182×10^3	0.96	Acceptable
²³⁹ Pu	0.270	0.380	1.41	Marginal
¹³⁴ Cs	0.158×10^3	0.156×10^3	0.99	Acceptable
<i>Soil (pCi/g)</i>				
⁴⁰ K	0.241×10^2	0.270×10^2	1.12	Acceptable
¹³⁷ Cs	0.208×10^2	0.243×10^2	1.17	Acceptable
<i>Water (pCi/mL)</i>				
¹³⁴ Cs	0.273×10^1	0.231×10^1	0.85	Acceptable
⁵⁷ Co	0.88	0.772	0.88	Acceptable
⁵⁴ Mn	0.300	0.291	0.97	Acceptable
⁶⁰ Co	0.940	0.901	0.96	Acceptable
¹³⁷ Cs	0.255×10^1	0.260×10^1	1.02	Acceptable
²³⁹ Pu	0.590×10^{-2}	0.700×10^{-2}	1.19	Acceptable
U ($\mu\text{g/mL}$)	0.130×10^{-1}	0.130×10^{-1}	1.00	Acceptable

^aPerformance evaluation determined by using the ratio of our value to EML. Acceptable range is 0.8–1.2; marginal range is 0.5–1.5; not acceptable range is <0.5 or >1.5.

REFERENCES

- American Public Health Association (APHA) et al. 1985. *Standard Methods for the Examination of Water and Wastewater*, 16th ed., American Public Health Association, American Waterworks Association, Water Pollution Control Fed., Washington.
- Baker, R. C. 1985. Personal communication to S. J. Cotter, October 2.
- Begovich, C. L. et al. August 1981. *DARTAB: A Program to Combine Airborne Radionuclide Environmental Exposure Data with Dosimetric and Health Effects Data To Generate Tabulations of Predicted Health Impacts*, ORNL-5692, Union Carbide Corp. Nuclear Div., Oak Ridge Natl. Lab.
- Birge, W. J., Black, J. A., and Short, T. M. December 1989. *Biological Monitoring Program for the Paducah Gaseous Diffusion Plant, Two-Year Report* (draft). University of Kentucky, Lexington.
- Coker, C. B. Mar. 9, 1988. "Environmental Air Sampling," ES-1.R0, Martin Marietta Energy Systems, Paducah Gaseous Diffusion Plant, Kentucky.
- D'Appolonia June 1983. *Final Report, Groundwater Monitoring Program, PGDP, Paducah, Ky.*, Project 82-1397, ESO 15603, Paducah Gaseous Diffusion Plant, Paducah, Ky.
- Early, T. O., Sigmon, C. F., and Williams, R. T. 1989. *Groundwater Monitoring Plan for the Paducah Gaseous Diffusion Plant*, Martin Marietta Energy Systems, Oak Ridge Natl. Lab.
- Eischen, M. A. et al. 1978. *Environmental Studies at the Paducah Gaseous Diffusion Plant. Paducah, Kentucky*, Battelle Columbus Labs., Ohio.
- ERC March 23, 1989. *Groundwater Monitoring Phase 2*, ESO 16749, ERC Environ. and Energy Serv., Nashville, Tenn.
- Hoffman, F. O., et al., 1984. *Preliminary Screening of Contaminants in Sediments*, ORNL/TM-9370, Union Carbide Corp. Nuclear Div., Oak Ridge Natl. Lab.
- International Commission on Radiological Protection (ICRP) 1977. *Annals of the ICRP 1*, ICRP Publication 26, Pergamon, Oxford.
- Jinks, S. M. and Eisdendub, M. 1972. "Concentration Factors in the Aquatic Environment," *Radia. Data Rep.* 13, 243.
- Malis, W. D. 1989. *Soil Sampling* (draft), ES-8R0, Martin Marietta Energy Systems, Paducah Gaseous Diffusion Plant, Kentucky
- Mitchell, M. E. Apr. 18, 1990. Environmental and Safety Activities, Martin Marietta Energy Systems, Inc., Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tenn., letter to P. J. Gross, Environmental Protection Division, Oak Ridge Operations Office, Oak Ridge, Tenn., "Annual Radionuclide Air Emissions Report for the Oak Ridge Reservation (ORR), Paducah Gaseous Diffusion Plant (PGDP), and the Portsmouth Gaseous Diffusion Plant (PORTS) for CY 1989—40 CFR 61.94(c)."
- Moore, R. E. et al. 1979. *AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides*, EPA-520/1-79-009, Environ. Protection Agency; reprint, Union Carbide Corp. Nuclear Div., Oak Ridge Natl. Lab., ORNL-5532.
- Paducah Gaseous Diffusion Plant (PGDP) Nov. 26, 1979. *Fluoride in Ambient Air. Gaseous and Water Soluble Particulate Treated Filter—SIE Method*, EC-2360, Martin Marietta Energy Systems.
- Paducah Gaseous Diffusion Plant (PGDP) April 1986. *Phase I CERCLA Assessment of Inactive Waste Disposal Sites at the Paducah Gaseous Diffusion Plant, KY/B-250*, Martin Marietta Energy Systems.

- Paducah Gaseous Diffusion Plant (PGDP) July 1987a. *Preliminary Assessment of Paducah Gaseous Diffusion Plant Solid Waste Management Units*, KY/B-262, Martin Marietta Energy Systems.
- Paducah Gaseous Diffusion Plant (PGDP) July 1987b. *Preliminary Assessment of Paducah Gaseous Diffusion Plant CERCLA Units*, KY/B-263, Martin Marietta Energy Systems.
- Paducah Gaseous Diffusion Plant (PGDP) Feb. 14, 1990. *Environmental Restoration and Waste Management Site Specific Plan for Oak Ridge Operations Office Paducah Gaseous Diffusion Plant*, KY/H-104, final draft, Martin Marietta Energy Systems.
- Paducah Gaseous Diffusion Plant (PGDP) May 1990. *Low-Level Gross Alpha and Beta Activity on Air Filters*, R-1-8, Martin Marietta Energy Systems.
- Sittig, M. 1980. *Priority Toxic Pollutants: Health Impact and Allowable Limits*, Noyes Data Corp., Parkridge, N.J., p. 370.
- Sjoreen, A. L. and Miller, C. W. 1984. *PREPAR—A User-Friendly Preprocessor To Create AIRDOS-EPA Input Data Sets*, ORNL-5952, Martin Marietta Energy Systems, Oak Ridge Natl. Lab.
- U.S. DOE May 15, 1984. *DOE Manual*, "Environmental Protection, Safety, and Health Protection Standards," DOE Order 5480.4.
- U.S. DOE July 9, 1985. *DOE Manual*, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Waste," DOE Order 5480.3.
- U.S. DOE May 11, 1988. *DOE Manual*, "Personnel Selection, Qualification and Training Requirements," DOE Order 5400.XY.
- U.S. DOE Sept. 26, 1988. *DOE Manual*, "Radioactive Waste Management," DOE Order 5820.2A.
- U.S. DOE Nov. 9, 1988. *DOE Manual*, "General Environmental Protection Program," DOE Order 5400.1.
- U.S. DOE Feb. 22, 1989. *DOE Manual*, "Hazardous and Radioactive Mixed Waste Management Program," DOE Order 5400.3.
- U.S. DOE Apr. 20, 1989. *DOE Manual*, "Environmental, Safety and Health Program for Department of Energy Operations," DOE Order 5480.1B.
- U.S. DOE 1989. *Environmental Restoration and Waste Management Five-Year Plan*, DOE/S-0070.
- U.S. DOE Feb. 8, 1990. *DOE Manual*, "Radiation Protection to the Public and the Environment," DOE Order 5400.5.
- U.S. Environmental Protection Agency (EPA) October 1986. *Compilation of Air Pollutant Emission Factors*, Vol. 1 (Suppl. A).
- U.S. Environmental Protection Agency (EPA) December 1987. *Test Methods for Evaluating Solid Waste*, SW-846.
- U.S. Environmental Protection Agency (EPA) 1988. *Integrated Risk Information System (IRIS) Data Base*.
- Watson, D. D. Mar. 23, 1989. *Environmental Sediment Sampling*, ES-7.R1, Martin Marietta Energy Systems, Paducah Gaseous Diffusion Plant, Kentucky.

Appendix

PADUCAH GASEOUS DIFFUSION PLANT CHEMICAL RELEASE DATA

In addition to indicating the concentrations of various chemicals present in the environment near U.S. Department of Energy (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 additional 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) 1989. Radiological chemical releases for CY 1989 are not included in this appendix; they are reported in the applicable sections in this report.

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 information currently being compiled for the SARA Title III, Section 313 report, required by the Superfund Amendments and Reauthorization Act of 1986 (SARA). This report is submitted on July 1 of each year for the previous calendar year and contains chemicals on the Environmental Protection Agency's (EPA's) toxic substance list. Currently, 309 specific chemicals and 20 chemical categories must be reviewed and possibly reported under SARA Sect. 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 1989, 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, inventory estimates, or emission factors were readily available, and release estimates were based on "best engineering judgement." "Best engineering judgement" was the principal method used to derive "Quantity released." Information obtained from air permits, rate of operation, quantities used, and known treatment efficiencies were used to estimate quantities released into the environment. Typically, assumptions based on "best engineering judgement" were required in order 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.

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 the additional chemicals (i.e., those that may be of interest to the general public) used and released at Paducah Gaseous Diffusion Plant (PGDP).

The third category, "Steam plant emissions," is release estimates of certain chemicals from the coal- and/or gas-fired steam plants located at each site.

Information contained in this appendix may not coincide for all chemicals with the information to be reported under SARA, Title III, Sect. 313. The SARA 313 report must be submitted to the EPA and the Kentucky Department of Environmental Protection no later than July 1, 1990. The information for this appendix was generated in the March and April time frame;

additional refinements are under way. It is imperative that May and June be utilized to ensure compliance under SARA Title III, the community

right-to-know law. The following table summarizes the chemical release information for PGDP.

Paducah Gaseous Diffusion Plant 1989 chemical release information

Chemical name	Type of release	Quantity released (lb/kg)	Major release source	Basis of estimate
<i>SARA 313</i>				
Chromium ^a	Air: fugitive emissions	3,300/1,500	Cooling tower system	Material balance
	Water: Big Bayou Creek	11/5	C-616 chromium reduction facility	Monitoring
	Water: Little Bayou Creek	12/5	Cooling tower system	Monitoring
	Land: to C-616 sludge lagoon	8,800/4,000	C-616 chromium reduction facility sludge	Monitoring
Trichloroethylene	Air: point source	90,000/41,000	C-400 degreaser/storage tanks	Material balance
	Water: Big Bayou Creek	<1/<0.5	C-400 degreasing operations	Monitoring
	Water: Little Bayou Creek	<1/<0.5	Degreasing operations	Monitoring
Sulfuric acid	Air: fugitive emissions	750/340	Cooling tower system	Engineering calculations
Chlorine	Air: fugitive emissions	7,300/3,300	Cooling tower system	Engineering calculations
	Water: Big Bayou Creek	570/260	C-615 sewage treatment plant	Monitoring
	Water: Little Bayou Creek	29/13	Once-through cooling water	Monitoring
Nitric acid	Air: point source	2/1	C-400 storage tank	Engineering calculations

Paducah Gaseous Diffusion Plant 1989 chemical release information (continued)

Chemical name	Type of release	Quantity released (lb/kg)	Major release source	Basis of estimate
<i>Other large inventory chemicals</i>				
Fluorides	Air: stack emissions	15,000/6,800	C-310 stack emissions	Engineering calculations/ continuous stack sampling
Nitrogen	Air: fugitive emissions	1,700,000/770,000	General plant cooling	Material balance
Freon 114	Air: fugitive emissions	470,000/210,000	Process cooling	Engineering calculations
Ammonia	Air: fugitive emissions	450/200	Blueprint machines	Material balance
Freon 11	Air: fugitive emissions	2,600/1,200	Air-conditioning systems	Material balance
Freon 22	Air: fugitive emissions	1,000/450	Air-conditioning systems	Material balance
Freon 113	Air: fugitive emissions	1,400/640	C-360 flush solution for sample cool-down	Material balance
<i>Steam plant emissions</i>				
Sulfur dioxide ^b	Air: stack emissions	640,000/290,000	Fossil fuels combustion	Emission factors
Nitrogen oxides ^b	Air: stack emissions	620,000/280,000	Fossil fuels combustion	Emission factors
Particulates ^b	Air: stack combustion	25,000/11,000	Fossil fuels combustions	Emission factors
Carbon monoxide ^b	Air: stack emissions	18,000/8,200	Fossil fuels combustion	Emission factors

^aQuantity calculated as chromium; chemical compound is sodium bichromate.

^bU.S. Environmental Protection Agency (EPA) October 1986. *Compilation of Air Pollutant Emission Factors*, Vol. 1 (Suppl. A).

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