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Paducah

ENVIRONMENTAL REPORT FOR 1990

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**PADUCAH GASEOUS DIFFUSION PLANT
ENVIRONMENTAL REPORT FOR 1990**

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MASTER

EXECUTIVE SUMMARY

SCOPE AND PURPOSE

This two-part report, *Paducah Gaseous Diffusion Plant Site Environmental Report for 1990*, 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, and surface stream sediments.

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 (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act activities;
- PGDP groundwater-monitoring wells; and
- stack sampling for radionuclide and fluoride emissions.

Ambient sampling networks include:

- 12 air-sampling stations (4 fence-line and 8 off-site),
- 6 surface water-sampling locations,
- 18 vegetation-sampling locations (4 fence-line and 14 off-site),
- fish samples from 1 on-site location,
- 10 soil-sampling locations [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],
- 26 stream-sediment-sampling locations,
- 15 gamma-radiation-monitoring locations (4 fence-line and 11 off-site),
- a Biological Monitoring Program with several monitoring locations, and
- several groundwater-monitoring wells.

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

WATERBORNE DISCHARGES AND SURFACE WATER MONITORING

The Clean Water Act is administered for PGDP by the Kentucky Division of Water (KDOW) through the Kentucky Pollutant Discharge Elimination System (KPDES) permitting program. A KPDES permit and Agreed Order allow PGDP to discharge effluents into Big and Little Bayou creeks. During 1990, PGDP experienced a compliance rate of 99.31% with the

KPDES Agreed Order limits. The 1989 compliance rate was 98.27%. The number of noncompliances dropped from 82 in 1989 to 33 in 1990. Parameters intermittently out of compliance were total residual chlorine, pH, temperature, total suspended solids, and fecal coliform.

Sodium thiosulfate feed stations have caused the number of total residual chlorine noncompliances to drop from 64 in 1989 to 12 in 1990. Erosion control devices, such as silt fences, hay bales, and filter fabric, have been installed at construction sites. Improved oversight and erosion control devices have caused the number of total suspended solids noncompliances to drop from five in 1989 to three in 1990. Biological monitoring studies have indicated that slightly elevated pH in PGDP effluents is not causing pH in the receiving streams to be elevated above water quality criteria.

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 Department of Energy (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 have been consolidated into a three-year report and submitted to KDOW. ORNL is conducting an evaluation of the findings and will present its evaluation to KDOW in 1991.

Radiological effluent monitoring as required by DOE Order 5400.5 also was performed during 1990. Uranium releases are expressed as a percentage of the Derived Concentration Guide (DCG), the recommended screening level for treatment of effluents. The average concentrations of uranium in all PGDP effluents are well below the DCG guideline (Fig. 1). Technetium releases from PGDP continued to decrease in 1990. Only 5.12 g of ^{99}Tc were released to surface waters during that period (Fig. 2). The highest average concentration from any outfall corresponds to only 0.035% of the DCG for technetium.

AIRBORNE DISCHARGES AND METEOROLOGICAL MONITORING

PGDP currently has 27 air pollution emission sources that are listed on the Kentucky Division for Air Quality (KDAQ) operating permit. Air pollution control equipment used at PGDP includes venturi scrubbers, water sprays, electrostatic precipitators, filters, and chemical traps (i.e., NaF and Al_2O_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 the C-310 stack that emits minute quantities of radionuclides that are air contaminants regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP[®]). During 1990, 31.8 g of uranium was released to the atmosphere. Trend data are shown in Fig. 3. Also, 0.4 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 radiological dosages to the public. The maximum off-site radiological dose attributable to 1990 PGDP emissions is a 50-year committed effective dose equivalent of 1.8×10^{-4} mrem. This dose is a small fraction of the limit imposed by the regulations.

Air dispersion modeling is the accepted way of predicting the impact on air quality from a source. To provide accurate meteorological data, a meteorological tower was installed at PGDP during 1987 with automated data collection and solid state telemetry data transfer to a computer. Wind and other meteorological parameters were monitored to provide data for dose calculations for the 1990 report.

PGDP operates 12 ambient air monitors surrounding the plant to monitor concentrations of fluorides and radioactive particulates. Fluoride concentrations in the ambient air ranged from a low of 0.037 parts per billion (ppb) to a high of 0.333 ppb. All fluoride concentrations measured in 1990 were well below Kentucky air quality standards.

Fig. 1. Uranium concentrations in PGDP liquid effluents in 1990 (percentage of derived concentration guide).

Fig. 2. Technetium discharges to surface water, 1986-1990.

Fig. 3. Millicuries of uranium released to the atmosphere from PGDP operations, 1986-1990.

Fig. 4. Millicuries of technetium released to the atmosphere from PGDP operations, 1986-1990.

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, for indicator locations at or beyond the reservation boundary is approximately 67 mrem/year. The average background exposure in Kentucky is

60-70 mrem/year. There is no significant difference observed between indicator and background exposure rates at the 95% confidence level. Because the levels of gamma radiation cannot be distinguished from background, quantifiable measurements using TLDs are difficult to obtain.

Several walkover surveys were performed during 1990 to verify TLD results and map the gamma fields

surrounding PGDP. An aerial radiological survey also was performed to map the spatial distribution of man-made radionuclides at PGDP. All surveys indicate that levels of gamma radiation have not increased significantly over time. Figure 5 illustrates the trend over a three-year period at each location. The higher exposure rates at locations on the perimeter were attributed to direct radiation from the uranium cylinder storage and handling areas.

Fig. 5. PGDP external gamma radiation, 1988–1990.

BIOLOGICAL MONITORING

Vegetation samples are collected at 18 locations surrounding the plant and analyzed for fluorides. The primary objective of vegetation sampling is to determine the total fluorides in the vegetation for comparison with the fluoride-in-foilage section of the Kentucky air pollution control regulations. All samples taken in 1990 were well below the 60 µg/g standard. Samples taken from outside the fence area range from less than 5% to 7% of the standard.

During 1990, food crops and animal tissue from the PGDP vicinity were sampled to monitor the plant's effects on the ecology of the surrounding area. The doses from each type of crop were significantly below 1 mrem/year. The calculated worst-case dose from ingestion of all types of foodcrops over a one-year period was significantly less than the DOE dose limit of 10 mrem/year. In addition, eight deer were harvested in the West Kentucky Wildlife Management Area and two deer from the Land

Between the Lakes area for background comparison. Both the radionuclide and metals data indicated no significant difference (95% confidence) between the concentrations in the reservation and the background deer.

SOIL AND SEDIMENT SAMPLING

Soil sampled during 1990 from ten locations surrounding the plant ranged from 2.2 µg/g of uranium at a background location 15 km (9 miles) south of the plant to 7.1 µg/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 4.3 µg/g. These levels of uranium are typical of soils in western Kentucky.

Table 6.4 gives 1990 radionuclide and polychlorinated biphenyl (PCB) data. Both radionuclides and PCBs are elevated at SS7, the C-615 sewage treatment plant. The sewage sludge is drummed annually for storage. Sediments in the north/south diversion ditch, an on-site ditch, contain elevated levels of radionuclides and PCBs. Effluents from this ditch flow into the C-616 full-flow lagoon before discharge through KPDES outfall 001. Big Bayou Creek sediments, SS1, show levels of radionuclides above the upstream Big Bayou Creek station, SS20. In addition, Little Bayou Creek sediments (SS2) indicate radionuclide levels above those at the upstream Little Bayou Creek station (SS21). During 1990, a public advisory was issued for the Little Bayou Creek area and signs were posted to make the public aware that prolonged exposure to the sediments could result in a dose above background (see Sect. 2.4.2, Environmental Radiation Surveys). Many of the KPDES outfall sediments contain levels of radionuclides and PCBs above background. Cesium was present in all sediment samples and is present throughout the world from weapons testing.

A variety of metals is analyzed in each sediment sample. Metals analyses in each 1990 sediment sample were distinctly elevated above the 1989 metals data. However, the 1989 samples were not analyzed by PGDP, but the 1990 samples were. Archived 1989 samples were reanalyzed along with selected 1990 samples by PGDP. Analytical results were in good agreement, indicating the elevated 1990

metals levels are due to variability between the two laboratories.

UNUSUAL OCCURRENCES

During 1990, 536 spills or releases of various types of materials occurred. Approximately 261 of the incidents involved leaking PCB gaskets. The new DOE Order 5000.3A, "Occurrence Reporting and Processing of Operations Information," was issued in 1990. It governs the categorization, investigation, and reporting of all releases. Highlights of the incidents are given in Subjects. 9.1 through 9.1.11.

RCRA

PGDP maintains its interim status for the ten RCRA-regulated units (i.e., four storage units and six treatment units). Part B Permit applications have been

submitted for seven of these units, and three have been designated as permit-by-rule. Notices of violations (NOV) on the permit applications have been addressed and corrected. Highlights of the year include an Energy Systems co-operator agreement with DOE to operate PGDP; the toxicity characteristic leaching procedure rule, which greatly expanded the scope of material regulated as hazardous waste. NOVs were issued by the Kentucky Division of Waste Management (KDWM) and corrective actions were implemented by Energy Systems. Phase I of the RCRA Air Emission Standards applicable to hazardous waste management units and the semiannual assessment fee issued by KDWM to parties that either generate hazardous waste in or transport it into the state of Kentucky were issued in 1990.

1990 COMPLIANCE SUMMARY ENVIRONMENTAL COMPLIANCE ACTIVITY U.S. DEPARTMENT OF ENERGY

PADUCAH GASEOUS DIFFUSION PLANT

BACKGROUND AND OVERVIEW

The Paducah Gaseous Diffusion Plant (PGDP) operates in conformance with requirements established by a number of federal and state statutes and regulations, Executive Orders, Department of Energy (DOE) Orders, and Compliance and Settlement Agreements. Compliance status with regard to major environmental statutes is summarized below.

The DOE Order 5400.1, "General Environmental Protection Program," defines the mandatory environmental standards in effect at DOE operations. These environmental standards fall into three categories: (1) those imposed by federal statutes, regulations, and requirements;

(2) those imposed by state and local statutes, regulations, and requirements applicable to DOE; and (3) those imposed by DOE directives. This compliance summary section addresses the standards that are significant for PGDP environmental compliance.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at PGDP. DOE itself, through directives to field offices and compliance audits, is the initiating organization. Principal among other regulating agencies are EPA Region IV and the Kentucky Department for Environmental Protection (KDEP). These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards as directed by statutes

passed by the U.S. Congress. In some instances, EPA has delegated regulatory authority to KDEP when the Kentucky program meets or exceeds EPA's requirements. Where regulatory authority is not delegated, EPA Region IV is responsible for reviewing and evaluating compliance with the EPA regulations as they pertain to PGDP.

Although progress has been made toward achieving full regulatory compliance at PGDP, much remains to be done. Ongoing self assessments of compliance status and implementation of corrective actions continue to identify environmental issues. These issues are discussed openly with the regulatory agencies to ensure that compliance with all environmental regulations will be attained.

COMPLIANCE STATUS

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

PGDP has an ongoing program to maintain compliance with all regulations resulting from the CAA. A Notice of Violation (NOV) received from the Kentucky Division of Air Quality (KDAQ) during 1989 regarding the refurbishing of two cooling towers was successfully resolved in 1990 with no fines or penalties. The proposed Agreed Order resulting from the NOV was canceled, and the NOV was withdrawn. The major difficulty in complying with regulations resulting from the CAA is documenting compliance. Some sources are limited by throughput or operating rates, and documentation of compliance with permit limits is not always available. Fluoride emissions above permitted limits from the C-310 purge vent stack were documented in

1990. However, no exceedance of the ambient air standard for gaseous fluorides occurred due to these emissions. Emissions from the C-600 boilers due to malfunctions, startups, and shutdowns that temporarily exceeded the standards were reported in accordance with KDAQ regulations. PGDP did not receive an NOV from any air regulatory agency in 1990.

Clean Water Act (CWA)

The Clean Water Act applies to all nonradiological discharges to navigable surface waters. At PGDP, the regulations are applied through a Kentucky Pollutant Discharge Elimination system (KPDES) permit for effluent discharges to Big and Little Bayou creeks. KPDES Permit No. KY0004049 is enforced by the Kentucky Division of Water (KDOW). Effluent discharges occur via 16 outfalls. Approximately 4,752 analyses were performed in 1990, with a compliance rate of 99.31%. Noncompliances were due to total residual chlorine, pH, total suspended solids, temperature, and fecal coliform. (See Sect. 3 for a discussion of noncompliances and associated corrective actions.)

Four noncompliances with KPDES Agreed Order limits occurred in March 1991. Three of the noncompliances were total suspended solids at rainfall runoff locations. The other noncompliance was due to an iron exceedance.

Resource Conservation and Recovery Act (RCRA)

Hazardous waste facilities at PGDP are currently operated under interim status granted by the state of Kentucky (facility ID Number KY8890008982). The Part A application was revised to include waste streams listed under the new toxic characteristic leaching procedure and to request interim status for the C-746-A storage facility. Part B applications have been submitted for the eight storage and treatment units located on the plant site. A postclosure plan has been submitted for the C-404 low-level radioactive waste burial ground, and closure of the C-746-B waste chemical storage area is awaiting approval by the Kentucky Division of Waste Management (KDWM). At present, those units are still operating under interim status following the requirements of 401 Kentucky Administrative Regulations Chapter 35.

In CY 1990, the Annual Hazardous Waste Report and the Federal Facilities Biennial Hazardous Waste

Activities Report were completed for CY 1989 and submitted to KDWM. In the first quarter of CY 1991, the CY 1990 Annual Hazardous Waste Report was submitted to KDWM. The annual report identifies waste generated and shipped off-site and waste generated and remaining on-site. The biennial report, completed in odd years, includes information on programs such as environmental monitoring, environmental contamination, response actions, and permit status.

The closure of the C-746-B waste chemical storage area was completed on September 14, 1990, according to the closure plan approved by KDWM. DOE and an independent professional engineer registered in Kentucky certified that the unit was closed according to the closure plan. KDWM must perform a closure inspection of this facility.

Toxic Substances Control Act (TSCA)

Polychlorinated biphenyls (PCBs) are used at PGDP and are regulated under TSCA, Title 40 Code of Federal Regulations (CFR) 761. Authorized uses of PCBs under TSCA at PGDP include use in dielectric fluid in electrical equipment and in lube oil/hydraulic oil systems in concentrations of less than 50 parts per million (PPM). The compliance issues associated with TSCA regulations include use of PCBs in ventilation duct gaskets, historic PCB oil spills on process building floors, storage of uranium-contaminated wastes beyond the TSCA one-year limit, use of unauthorized containers for storage of 2 containers of PCB solid waste, the presence of PCBs above regulatory limits in two hydraulic systems, and leaking PCB capacitors inside switchyard potential devices. These issues are being addressed through a Federal Facilities Compliance Agreement (FFCA) being negotiated between DOE and EPA and through corrective actions taken by PGDP.

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

An Administrative Consent Order (ACO) under Sections 104 and 106 of CERCLA was produced in 1988 between EPA and DOE. The ACO was produced in response to the discovery of off-site groundwater contamination in residential wells north of PGDP. The contaminants in the wells are trichloroethylene (TCE), a degreasing solvent used at

PGDP, and technetium-99 (^{99}Tc), a man-made radionuclide developed during the fission of uranium. The source of ^{99}Tc at PGDP was the enrichment of reprocessed uranium from government reactors at other DOE facilities. The major requirements of the ACO include monitoring of residential wells potentially affected by the contamination, provision of alternative drinking water supplies to residents with contaminated wells, and investigation of the nature, extent, and source of the contamination to develop a plan for remediation.

National Environmental Policy Act (NEPA)

NEPA Compliance personnel review all Engineering Service Orders and submit appropriate NEPA documentation to DOE for project approval. Activities that do not require engineering involvement are handled via a Work Order system. Compliance with NEPA is maintained by following the guidelines set forth by CEQ, DOE, and Martin Marietta Energy Systems, Inc.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

No restricted-use pesticides are used by PGDP personnel. If application of a restricted-use pesticide at the plant is necessary, a certified contractor will be used to make the application. General-use pesticides used at the plant by plant personnel are used in a manner consistent with the product labeling. All product warnings and cautions are strictly adhered to. Applications of pesticides by plant and contractor personnel must be approved by the Plant Pesticide Coordinator. The Waste Management Department at PGDP currently is seeking a vendor that will dispose of the Napchlor-G fungicide being held on-site.

Safe Drinking Water Act (SDWA)

PGDP operates a "nontransient, noncommunity" public water system subject to regulation by KDOW. The PGDP water treatment facility is a Class II facility. There are ten operators on-site with the Class II certification or above. Monthly operational reports are provided to the state describing operational activity for the facility. The ongoing training required to maintain certification is provided by a program developed in-house. The state of Kentucky has approved the program as meeting state requirements.

Surveys of the sanitary water supply system indicate that the plant's drinking water meets all state and federal regulations for maximum contaminant levels. In 1989 KDOW completed a quarterly survey of PGDP's sanitary water system for 8 regulated and 51 unregulated volatile organic compounds (VOCs). None of the regulated VOCs was detected in the system, but 3 of the unregulated VOCs were detected. Because of the detection of the three unregulated VOCs, PGDP will monitor for all 59 VOCs annually, starting in 1991.

CURRENT ISSUES AND ACTIONS

NESHAP Compliance

The NESHAP regulation, promulgated in December 1989, pertains to DOE facilities emitting radionuclides other than radon. It requires documentation of compliance by March 15, 1990. It requires extensive evaluation of each potential radionuclide air emission point and either continuous measurements of each emission point (stack sampling), or documentation that emissions from each point are below a level that would cause the most affected individual to receive an annual effective dose equivalent of 0.1 mrem.

PGDP, in conjunction with DOE/ORO and the three Oak Ridge facilities, submitted a compliance plan to EPA Region IV in March 1990. Due to the enormous number of potential radiological air emission points (albeit small ones) and the difficulty of initially evaluating each point and periodically confirming the insignificant emissions, the plan requested approval to use ambient air samplers to collect data and demonstrate compliance with the 10-mrem standard established in the regulation. On February 8, 1991, DOE/ORO received correspondence from EPA stating that ambient air sampling could not be used to demonstrate compliance with any portion of the regulation except computation of dose. Therefore, PGDP and the Oak Ridge facilities will still be required to perform the stack sampling on each emission point or submit evidence that the emissions from each stack result in a dose less than 0.1 mrem. A revised compliance plan is scheduled for submittal to EPA Region IV by May 1. It is anticipated that an FFCA based on the compliance plan will be negotiated.

Currently, PGDP continuously samples only one stack, the C-310 purge vent. The sampling and analysis methods are not those specified in the regulation. PGDP has submitted information to Energy Systems Environment, Safety, and Health Organization (ES&H) to be sent to DOE and EPA in a request for approval of the present methods.

DOE Headquarters and EPA Headquarters are negotiating a Memorandum of Understanding (MOU) that would establish a schedule and responsibilities for complying with NESHAP. Sections of the document are substantially different from the NESHAP provisions. Also, information presented in a meeting between representatives from DOE/ORO, EPA Region IV, Energy Systems ES&H, the Oak Ridge facilities, and PGDP indicated that a Federal Facility Compliance Agreement could be the avenue of compliance with NESHAP for PGDP.

As of April 1991, PGDP intends to comply with all provisions of NESHAP to the extent possible by evaluating and documenting as many potential radiological emission points as possible until direct guidance from EPA and DOE are available. The information generated from the source evaluations will be included on the PGDP 1990 NESHAP report due to EPA by June 30, 1991.

Documentation of compliance, i.e., implementation of throughput/usage logbooks, is increasing throughout the plant. Some permitted usage rate exceedances have occurred (such as at the paint shop). Documentation of compliance with all regulations and permit conditions continues to be an unfulfilled goal.

Clean Water Act

PGDP effluents do not always meet discharge limits. Therefore, several corrective actions have been implemented. Total residual chlorine noncompliances have been reduced through the use of temporary sodium thiosulfate feed stations at several outfalls. The plant effluent chlorine and temperature control project now under construction will eliminate the remaining total residual chlorine noncompliances and temperature excursions. That project is 90% complete. Fecal coliform noncompliances have been alleviated through the use of additional chlorine for disinfecting the C-615 Sewage Treatment Plant effluent. The water is subsequently dechlorinated. Total suspended solids (TSS) noncompliances have been dealt with by using

silt fences, seeding outfall ditch areas, and covering dirt piles at construction sites. To alleviate pH noncompliances, alternate pH limits will be discussed with KDOW during the KPDES permit renewal process. (The current permit expires on October 21, 1991.)

During 1990, KDOW issued an NOV to PGDP for the discharge of PCBs into Big and Little Bayou creeks. Subsequent monitoring of the effluent waters indicated that PCBs may be intermittently present in some of the KPDES outfalls. It was decided that a new Agreed Order would be negotiated with KDOW to resolve the NOV.

During January 1991, KDOW issued PGDP a draft KPDES Agreed Order that will supersede the 1987 Agreed Order. Included in the draft document are requirements for a Best Management Practices Plan for TSS control. The plan will document TSS control measures and remove numerical TSS limits established by the 1987 Agreed Order. Toxicity testing and bioaccumulation studies will continue, with KDOW approving sampling and testing methods and locations. A toxicity identification/reduction plan will be prepared for KDOW approval that will discuss actions to be undertaken if toxicity is found. In addition, the Oak Ridge National Laboratory Environmental Sciences Division will conduct a critical evaluation of biological monitoring data gathered to date. The new Agreed Order also will increase the frequency of PCB analyses of effluents, and it may establish new discharge limits. A PCB Source Identification Project also will be conducted. It will involve simultaneous PCB analyses of creeks, outfalls, and sewers to determine whether PCBs are discharged during wet or dry periods and, if so, their sources.

Land Disposal Restrictions

Land disposal restricted (LDR) waste such as pentachlorophenol and mixed LDR waste have been stored in some areas at PGDP for longer than 1 year. These wastes are currently subject to LDR storage prohibitions that permit storage only for accumulation of sufficient quantities to facilitate proper treatment, recycling, or disposal. The waste is being stored because of the nationwide shortage of treatment and disposal facilities for such waste. PGDP is actively seeking treatment or disposal for the pentachlorophenol waste. DOE and EPA will continue to discuss the mixed LDR waste issue

during FY 1991 and FY 1992. DOE's Oak Ridge Operations Office expects to negotiate an FFCA that would detail the steps needed to attain compliance with regulations. A draft FFCA that addresses spent solvent and California-list mixed waste streams is under preparation.

In October 1991, PGDP Environmental Compliance and Waste Management Department personnel met with Energy Systems Central Waste Management and Hazardous Waste Remedial Action Programs personnel to discuss and update information regarding land disposal restrictions (LDR) on radioactive mixed waste (RMW). Data that had previously been submitted in the National LDR Report and in the Waste Management Information System (WMIS) Third Report were verified. LDR RMW inventories were updated, and planning activities with regard to RMW management systems were identified. Formal data input for the National Report on LDR RMW was provided to Central Waste Management in October 1990.

Unauthorized Mixed TSCA Waste Storage

Uranium-contaminated PCB wastes (mixed wastes) are being stored in excess of the one-year limit imposed by TSCA, due to the lack of treatment and mixed-waste disposal capabilities. EPA issued a complaint to Energy Systems about this issue on October 3, 1990. In addition, negotiation of an FFCA is continuing between DOE and EPA on compliance with TSCA and the PCB Regulations found at 40 CFR 761. The unauthorized storage of uranium-contaminated PCB wastes is being addressed in the negotiations. Negotiations between MMES and EPA over the fine are continuing. This issue will be included in the FFCA.

Unauthorized Storage Containers

An Energy Systems Environmental Compliance Review conducted in December 1990 found PCB solid wastes being stored in unauthorized containers. PCB- and uranium-contaminated wood pallets were found in C-746-A wrapped in plastic and placed in an undersized wooden box with no lid. Correspondence was submitted to the EPA Regional TSCA Coordinator in March 1991 to seek concurrence for using alternate packaging methods for storage of large PCB solid wastes.

1990 DOE Tiger Team Assessment of PGDP

Secretary of Energy James D. Watkins' ten-point initiative to strengthen safety, environmental protection, and waste management activities at DOE's production, research, and testing facilities resulted in the Tiger Team Assessment of the PGDP June 18 through June 29 and July 9 through July 20.

During its compliance assessment, the Tiger Team reported no noncompliance issues of a magnitude that would necessitate curtailing overall operations at the plant. The Tiger Team identified a total of 199 findings and 4 noteworthy practices. Of the 199 findings, 62 pertained to environmental issues, 123 involved safety and health issues, and 14 were related to management issues, 3 of which addressed DOE matters.

One hundred and fifty of the 199 findings (46 environmental, 94 safety and health, and 10 management) had been identified previously either by Energy Systems, or by prior external audits or reviews.

Key environmental findings were (1) environmental monitoring and evaluation lack some necessary elements for accurate monitoring and characterization; (2) a general lack of formal procedures exists; and (3) environmental programs are not supported by a fully effective quality assurance program. The Tiger Team noted that several of the more significant environmental compliance findings are beyond the ability of PGDP to address alone.

Key concerns identified by the safety and health subteam were (1) compliance with DOE orders and mandatory standards is deficient in a wide variety of activities; (2) the system of preparing or revising, reviewing, and approving administrative control documents has serious deficiencies; (3) training and certification programs and practices do not fulfill site needs; (4) instrument calibration practices in some areas do not meet minimum standards; (5) there is no long-range plan for safe storage of depleted uranium; and (6) no integrated site-wide management system is available to track and correct identified deficiencies. A total of 241 Occupational Safety and Health Administration violations were identified and included with the safety and health issues. Immediate abatement of these violations was started and a correction-tracking system was initiated.

Key management findings included (1) DOE's failure to provide effective oversight of PGDP Environmental, Safety, and Health (ES&H) activities; (2) Energy Systems' lack of a strategic plan to define, guide, and accomplish ES&H objectives; and (3) Energy Systems'/PGDP's inadequate development of fundamental management control systems.

An action plan was written to address formally all 199 findings and fifteen root causes issues cited by the Tiger Team Assessment. The action plan includes descriptions of the actions to be taken by the site to satisfy the findings, action schedules and milestones, and associated costs. Collectively, the action plans represent an integrated network of actions necessary to resolve ES&H deficiencies and the commitment by uranium enrichment management to pursue performance excellence diligently.

Comprehensive Environmental Response, Compensation, and Liability Act

Routine monitoring of residential wells near the area of known groundwater contamination continued. No additional residential wells were found to be contaminated with TCE or ⁹⁹Tc above action levels in 1990. Provision of water supplies continued to residents whose wells are contaminated.

The fieldwork for the Phase I Site Investigation was completed in 1990. The Draft Phase I Site Investigation Report was submitted to EPA and the state and made available to the public for comment on December 21, 1990. Regulatory agency comments on the report were received early in 1991. EPA and state comments were addressed and the report resubmitted for approval within the 30-day time frame required by the ACO.

TCE was discovered in two Phase I well clusters outside the plant security area. As a result, residents who live near those well clusters were contacted to identify additional well users and to collect samples from their wells. Seventy-seven contacts were made with residents, and 21 wells were identified and sampled. No TCE or ⁹⁹Tc was detected in any of the 21 wells. Routine monitoring was modified to include some of these wells, based upon their use and their proximity to contaminated monitoring wells.

A survey of plant discharges to the environment was conducted in the final quarter of 1990 to determine whether CERCLA reporting requirements pertain to any of these continuous or routine releases. Releases to the atmosphere of chromium,

trichloroethylene, and fluorine were found to exceed reportable quantities on a continuous or routine basis. They must be reported according to CERCLA reporting rules for continuous releases. Federal, state, and local authorities were initially notified by telephone, and written follow-up was sent to them 30 days after the telephone contact. The sources of the chromium, TCE, and fluorine emissions were the cooling tower drift, C-400 vapor degreaser, and cascade process vent, respectively.

The Phase II Site Investigation Work Plan was submitted to EPA and the state in July 1990. After comments from the regulatory agencies were incorporated, the work plan was conditionally approved in October 1990, and implementation began in November 1990. The Phase II investigation will focus on characterizing the sources of TCE and ⁹⁹Tc contamination on-site and on providing additional off-site data to better define the nature and extent of contamination off the DOE property.

The first Phase II groundwater sampling series was completed in early 1991, including residential wells, plant monitoring wells, wells installed as part of Phase I, wells at the Tennessee Valley Authority Shawnee Steam Plant, and the 35 on-site Phase II wells. Deep soil borings and sediment and surface water sampling have been completed on-site. Plans and schedules have been developed and are being implemented for another groundwater sampling series; off-site soil, sediment, and surface water sampling; and on-site sampling of PCB sources.

Resource Conservation and Recovery Act

On March 29, 1990, EPA promulgated the toxicity characteristic (TC) rule, the requirements of which went into effect on September 25, 1990. According to the toxicity characteristic leaching procedure, all waste streams must undergo a full characterization of components either by the new analytical method or by knowledge of the waste stream. PGDP has initiated reevaluation of waste streams under the TC rule and is coordinating this effort with other off-site laboratories to expedite the testing to comply with the new standard.

Six NOVs were received from the Kentucky Division of Waste Management (KDWM) regarding training, manifests, waste management, and spills. Manifests were not completely filled out; i.e., handling codes and other information were not available. Drums were stored past the allowable time

limit for accumulation, and sample evaluations were not performed for three drums in storage. A large number of spills were recorded, and the facility was not being operated to prevent releases. All these violations have been addressed and corrective actions taken to ensure compliance.

EPA Region IV issued a formal request to PGDP to submit the information specified in 40 CFR 270.24 and 270.25. This information specifies the equipment and facilities that are regulated and the inspections (visual or emission monitoring) that must be performed. A leak detection and repair plan has been developed to comply with Phase I of the RCRA Air Emission Standards. This plan will implement all record-keeping requirements, inspections, and emissions monitoring necessary for all applicable hazardous waste units.

On September 25, 1990, Energy Systems and DOE entered into a "co-operator" agreement to operate PGDP. This agreement is the result of the KDWM decision to regulate government-owned, contractor-operated facilities as one entity. DOE will be listed as the owner/operator and Energy Systems as co-operator of PGDP. It is hoped this move will streamline policies and decisions.

Notices of Deficiency have been received from KDWM regarding the RCRA part B permit. Most of the deficiencies were minor and were corrected and submitted to KDWM. Following submission of the corrections, a fourth revision of the permit application was completed. A letter from KDWM indicated that no deficiencies exist and that the permit application has been forwarded for public review and comment. After this procedure, the comments, if any, will be addressed and the final permit issued. PGDP will then be a permitted facility and must comply with regulations governing such operations.

The Annual Hazardous Waste Report was completed and submitted to KDWM before March 1, 1991. It contains a listing of all hazardous waste generated during CY 1990 that either was shipped off-site or still remains on-site.

Unauthorized Use of PCBs in Ventilation Duct Gaskets

Buildings at PGDP contain ventilation duct systems for heating and cooling both personnel space and process equipment. The gaskets in a number of these systems contain varying levels of PCBs. As a result, the gaskets constitute non-totally enclosed

PCB systems, which are prohibited by 40 CFR 761.20 (a). Certain systems (notably the motor exhaust duct systems) have come in contact with leaching media (chiefly oil), resulting in migration or drips of PCBs to the floors of the process buildings. These drips of PCB-contaminated oil are considered PCB spills.

TSCA requires documentation, cleanup action, and verification of cleanup after discovery of PCB spills. All new drips from the ventilation duct gaskets are cleaned in accordance with the EPA Spill Cleanup Policy. This includes daily inspections to identify leaks, initiation of cleanup within 24 hours, and sampling to verify cleanup results. In addition, immediate installation of spill containment/collection systems is carried out when drips are discovered.

Negotiations of an FFCA are continuing between DOE and EPA on compliance with TSCA and the PCB regulations found at 40 CFR 761. The unauthorized use of PCBs in ventilation duct gaskets is being addressed in those negotiations.

Historic PCB Oil Spills

PCB-contaminated oil drips from ventilation duct gaskets leaked onto the concrete floors of the process buildings and associated equipment under the ducts in the past before it was discovered that the leaks were PCB contaminated. Negotiations of an FFCA are continuing between DOE and EPA concerning compliance with TSCA and the PCB regulations found at 40 CFR 761. Historic PCB spills onto the floors of the process building are being addressed as part of the negotiations.

Unauthorized Use of Leaking PCB Capacitors in Potential Devices

The electrical switchyards at PGDP are designed to use up to 128 potential devices (PDs). The devices contain inaccessible small capacitors, a small transformer, and various other electrical components. Currently 122 PDs are in service. The capacitors in 92 of them are suspected to contain PCBs in concentrations greater than 500 ppm. About 60 of these small PCB capacitors were observed to have leaked and seeped onto the surfaces of the PDs in September 1990. Sample results from leaks of this type of capacitor contained 677 to 2500 ppm PCBs. Use of PCBs in leaking capacitors is unauthorized under TSCA regulations.

Negotiations of an FFCA are continuing between DOE and EPA concerning compliance with TSCA and PCB regulations found at 40 CFR 761. DOE proposed in February 1991 that PDs at PGDP be included in this agreement and that their continued use be allowed until their scheduled replacement by May 1993. In the interim, PGDP will continue to (1) conduct daily documented inspections to check for seepage of oil to the external surfaces; (2) initiate immediate documented cleanup of external surfaces if oil is found; (3) contain recurring seepage in clear plastic with daily change of the plastic and cleanup of the external surfaces; and (4) restrict access to PDs showing seepage by the use of flags and caution signs. Final compliance will be achieved by replacing all potential devices that are unauthorized for use.

Unauthorized Use of PCBs in Hydraulic Systems

Two hydraulic systems with PCB labels affixed were found in C-340 during an inspection conducted by PGDP personnel during February 1991. Due to lack of documentation that these systems were below 50 ppm PCBs, samples were taken of residual oil in the systems reservoir. After the inspection, documentation was found indicating that the systems had been drained and placed on standby status in 1982. Results of samples taken in February 1991 showed PCB concentrations in excess of 50 ppm, which is an unauthorized use of PCBs under TSCA and in non-compliance with 40 CFR 761.30 (e).

TSCA regulations require that within six months of a test that indicates that a hydraulic system contains more than 50 ppm PCBs, the system must be drained and refilled with a fluid that contains less than 50 ppm PCBs. However, EPA Region IV indicated in a phone conversation on March 11, 1991, that if data are not available to document that the systems were previously flushed to less than 50 ppm PCBs, then the system should be drained, flushed, and refilled within 30 days of discovery at 50 ppm or greater. Also, a documented decision could be made to remove these systems for disposal. Disposal would have to be completed within one year by TSCA. A compliance strategy for these systems will be developed and included in the FFCA being negotiated.

Underground Storage Tanks

A site inspection by KDWM was performed on March 18, 1991. The piping of the UST system was exposed for this inspection. An NOV was issued by KDWM for an unauthorized disposal (leak) from the storage tanks. A response will be prepared for KDWM. The tanks were removed from the ground in April and the disposition of the potentially contaminated soil is dependent upon analytical results.

National Environmental Policy Act

The NEPA process establishes general guidelines and responsibilities for addressing environmental considerations during project planning, design, and construction. PGDP will as much as possible use all practical means, consistent with the requirements of the act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any adverse effects of its actions on the quality of the human environment.

A number of options are available to projects depending on their scope. When evaluating a project, NEPA Compliance personnel initially complete a checklist to help determine the level of documentation the project may require. The checklist may lead to a request for a categorical exclusion, an environmental assessment, or an environmental impact statement. DOE will determine the type of document required.

A number of DOE Executive Orders and federal environmental protection statutes are integrated into the NEPA programs to ensure that the resources they are concerned with are protected against any adverse environmental impacts that might result from a plant activity or project. They include DOE Executive Order 11988, Floodplain Management; DOE Executive Order 11990, Protection of Wetlands; the Endangered Species Act; the Fish and Wildlife Coordination Act; the Farmland Protection Policy Act; the National Historic Preservation Act, which protects national historic landmarks; the American Indian Religious Freedom Act, which protects the freedoms of American Indians; and the Wild and Scenic Rivers Act.

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ABBREVIATIONS, ACRONYMS, AND INITIALISMS

ACO	Administrative Consent Order
ALARA	as low as reasonably achievable
Al ₂ O ₃	Aluminum oxide
ANSI	American National Standards Institute
APG	Analytical Products Group, Inc.
BMP	Biological Monitoring Program
BOD	biochemical oxygen demand
BTEX	benzene, toluene, ethylbenzene, xylene
°C	degrees Celsius
CAA	Clean Air Act
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	curies
cm	centimeter
cm ²	square centimeter
COD	chemical oxygen demand
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
DOT	U.S. Department of Transportation
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ERP	Environmental Restoration Program
ESP	electrostatic precipitator
°F	degrees Fahrenheit
FDA	Food and Drug Administration
ft	foot
g	gram
gal	gallon
GC	gas chromatograph
GMP	groundwater monitoring plan
GWPP	groundwater protection plan
GWPP-MP	groundwater protection plan-management plan
h	hour
ha	hectare
HCl	hydrochloric acid
HF	hydrofluoric acid
HSS	hydrogeologic services section
HSWA	Hazardous and Solid Waste Amendments
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
KDWM	Kentucky Division of Waste Management
L	liter
lb	pound
LCR	lowest concentration reported
LLW	low-level waste
m	meter
m ²	square meter
m ³	cubic meter
μCi	microcurie
μg	microgram
μmho	micro mho
mCi	millicurie
mg	milligram
Mgd	million gallons per day
min	minute
mL	milliliter
mm	millimeter
mrem	millirem
NA	not applicable
NaF	sodium fluoride
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NO ₃ -N	nitrate as nitrogen
NO _x	nitrogen oxides
NOV	Notice of Violation
²³⁷ Np	neptunium-237
NPDES	National Pollutant Discharge Elimination System
OCB	oil circuit breaker
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
PAT	Proficiency Analytical Testing
PCB	polychlorinated biphenyl
pCi	picocurie
PD	potential device
PET	Proficiency Environmental Testing Program
PGDP	Paducah Gaseous Diffusion Plant
pH	hydrogen ion concentration
PO ₄	phosphate
ppb	parts per billion
ppm	parts per million
²³⁹ Pu	plutonium-239
PVC	polyvinylchloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
RFI	RCRA Facility Investigation
RGA	Regional groundwater aquifer
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SCS	Spill Containment System
SDWA	Safe Drinking Water Act
SGS	shallow ground system
SO ₂	sulfur dioxide
SO ₄	sulfate

⁹⁰ Sr	strontium-90
SWMU	solid waste management unit
⁹⁹ Tc	technetium-99
TCA	tetrachloroethane
TCE	trichloroethylene
TCL	Target Compound List
TDS	total dissolved solids
²³⁰ Th	thorium-230
TLD	thermoluminescent dosimeter
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
U	uranium
UK	University of Kentucky
USGS	United States Geological Survey
UST	underground storage tank
WKWMA	West Kentucky Wildlife Management Area
yd	yard
VOC	volatile organic compound

1. INTRODUCTION

This report presents environmental data and supporting narratives for the U.S. Department of Energy's (DOE's) Paducah Reservation Environmental Monitoring Program during 1990. 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 1990 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.

Paducah Gaseous Diffusion Plant (PGDP) is an active uranium enrichment facility consisting of a diffusion cascade and extensive support facilities. Construction of PGDP began in 1951. The plant began operating in 1952 and was fully operational by 1955, supplying enriched uranium for commercial reactors and military defense reactors. Enriched uranium is uranium in which the concentration of the fissionable ^{235}U has been increased. Natural uranium is mostly ^{238}U with about 0.72% ^{235}U and 0.0051% ^{234}U . Uranium mills process the ores to produce a concentrated uranium oxide, U_3O_8 , which is then commercially converted to gaseous uranium hexafluoride (UF_6) for enrichment at a gaseous diffusion plant. The enrichment mechanism is based on the fact that a UF_6 molecule containing ^{235}U is slightly lighter than a UF_6 molecule containing ^{238}U . As the UF_6 molecules move through the miles of tubing in a cascade system, slightly more ^{235}U than ^{238}U escapes through the small holes in the tubing. As the process is repeated (cascading), the ^{235}U concentration increases. About two-thirds of the ^{235}U in the natural ore is removed during enrichment, so there are two product streams: enriched uranium and depleted uranium tailings.

Currently, uranium enriched at PGDP is further enriched at another DOE gaseous diffusion plant managed by Martin Marietta Energy Systems in Portsmouth, Ohio. Most of the uranium from PGDP is

ultimately designated for the commercial sector as fuel for nuclear power reactors in the United States and abroad. The fuel in commercial power reactors is about 3% ^{235}U , fuel for the production reactor at the Savannah River site is typically 60% ^{235}U , and naval reactor fuel is 97.3% ^{235}U . Depleted uranium is used for components in both nuclear and conventional weapons.

Extensive support facilities are required to maintain the diffusion process. These include a steam plant, four electrical switchyards, four sets of cooling towers, a chemical cleaning and decontamination facility, water and wastewater treatment plants, a chromium reduction facility, maintenance and laboratory facilities, and two active landfills. Several inactive facilities also are located on the plant site.

The area surrounding PGDP is predominantly rural. Residences and farms surround the plant. Immediately adjacent to PGDP is the West Kentucky Wildlife Management Area (WKWMA), which is used by a considerable number of hunters and fishermen each year. About 20 of the 35 ponds in the wildlife management area support fishing. Approximately 200 deer are harvested from the area each year through hunting. Figures 1.1 and 1.2 show the geographic location of PGDP.

1.1 GEOLOGY

PGDP is located in the Jackson Purchase region of western Kentucky and lies in 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. The sedimentary sequence overlying Mississippian age bedrock in the vicinity of PGDP consists mainly of fine- to medium-grained clastic materials including (from oldest to youngest) a basal gravel (i.e., Tuscaloosa Formation), the McNairy Formation, the Porters Creek Clay, and

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

ORNL-DWG 87-8430

Fig. 1.2. Map showing the location of PGDP in relationship to the geographic region.

undifferentiated Eocene sands. These strata dip gently to the south-southwest toward the axis of the embayment.

Following deposition of the embayment sediments, the embayment was 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. As a result of changes in base level during Pleistocene time, terraces were formed by streams that eroded and later alluviated their valleys, reworking the Continental Deposits at different elevations. 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. Figure 1.3 is a geologic map of the PGDP site.

The Continental Deposits can be subdivided into two stratigraphic components: a lower gravel or sandy gravel unit (i.e., gravel facies) that reportedly varies 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 to extend northward to the Ohio River. Near the southern boundary of PGDP, the gravel exists as a thin [<3 m (10 ft)] veneer where it is draped over an escarpment or terrace slope that was carved in the underlying sediments by an ancient river system. The gravel thickens immediately north of this terrace and thins once again near the Ohio River. Figure 1.4 depicts the erosional surface beneath the Continental Deposits. Figures 1.5 and 1.6 show the thickness of the gravel facies and the elevation of the upper surface of the gravel facies, respectively. The clay facies of the Continental Deposits is thought to consist of discontinuous, fine, sand lenses enclosed by clay. Figure 1.7 is a geologic cross section that illustrates some of the stratigraphic relationships at the PGDP site. This interpretation is based on limited data, and

the degree of interconnectedness of the interbedded sand lenses cannot be verified definitely at present.

1.2 SURFACE WATER SYSTEM

PGDP is located in the western part of the Ohio River basin. The confluence of the Ohio River and the Tennessee River is approximately 15 miles upstream of the site, and the confluence with the Mississippi River is approximately 56 miles downstream. PGDP is located within the drainage areas of Big and Little Bayou creeks, which meet about 3 miles north of the site and discharge into the Ohio River. (See Figs. 1.8 and 1.9).

PGDP is located on a local drainage divide; surface flow is to the east and northeast toward Little Bayou Creek and to the west and northwest toward Big Bayou Creek. Big Bayou Creek is a perennial stream whose drainage extends from approximately 2.5 miles south of PGDP to the Ohio River. It flows toward the river along a 9-mile course that passes along the western boundary of the plant. Little Bayou Creek originates in the wildlife management area and flows north toward the Ohio River along a 6.5-mile course that includes parts of the eastern boundary of the plant. Big Bayou Creek has an 11,910-acre drainage basin, and the watershed for Little Bayou Creek consists of about 6,000 acres.

During dry weather, much of the flow in both creeks is due to liquid releases from PGDP. Effluents from PGDP operations constitute about 85% of the normal flow in Big Bayou Creek and 100% of the normal flow in Little Bayou Creek.

1.3 HYDROGEOLOGY

The recognized importance of the gravel facies of the Continental Deposits dominates current understanding of local groundwater hydrology in the vicinity of PGDP. This unit is termed the regional gravel aquifer (RGA) and is the primary source of groundwater in this area. This section discusses the current level of understanding of the hydraulic properties of the local groundwater flow system.

The hydrology of the RGA 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 reportedly capable of producing yields of up to 3790 L/min (985 gal/min).

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Fig. 1.3. Geologic map of the PGDP site.

Fig. 1.4. Elevation of erosional surface cut on sediments of Eocene, Paleocene, and late Cretaceous Age in the vicinity of PGDP (contours are in feet above MSL).

Fig. 1.5. Isopach map of the lower Continental Deposits (gravel facies) in the vicinity of PGDP (thicknesses are in feet).

Fig. 1.6. Elevation of the top of the lower Continental Deposits (gravel facies) in the vicinity of PGDP (contours are in feet above MSL).

Fig. 1.7. Geologic cross section.

Fig. 1.8. Local PGDP surface hydrology systems.

Fig. 1.9. The regional area primary surface hydrology system.

Yields of between 189.5 and 1516 L/min (50 and 395 gal/min) have been observed.

In general, the potentiometric surface for the RGA slopes toward the Ohio River, suggesting that groundwater flow within the aquifer trends northward toward the Ohio River. Until recently, no attempts had been made to reevaluate potentiometric conditions in the RGA since the studies by the USGS over two decades ago. Hydraulic head data gathered during 1990 (CH2M Hill 1990) from a series of PGDP and Tennessee Valley Authority (TVA) wells yielded a more refined picture of the potentiometric surface of the RGA, but they appear to substantiate earlier investigations. Systematic potentiometric data collection has recently been initiated, and subsequent analyses of this data are expected to lead to a refined model of groundwater flow in the vicinity of PGDP.

Based on measurements (both field and laboratory) and on estimations of grain size analysis, hydraulic conductivity values for the RGA 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 RGA. Results from an aquifer test performed in the RGA near the C-404 area in late 1989 indicated values ranging from 1.0×10^{-2} to 4.0×10^{-2} cm/s. Slug tests performed in RGA monitoring wells by CH2M Hill in 1990 resulted in values ranging from 2.1×10^{-4} to 6.4×10^{-2} cm/s. Data available from the TVA at the Shawnee Steam Plant indicate values that fall between 3.0×10^{-4} and 1.0×10^{-1} cm/s or even greater values. This wide range in conductivity values suggests that the RGA is heterogeneous. Considering the depositional history of the gravel, this is to be expected.

It is possible to take available estimates of hydraulic conductivity data for the gravel aquifer and estimate possible ranges of groundwater flow velocity that might be encountered. This calculation uses Darcy's flow equation:

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

where

$$\begin{aligned} K &= \text{hydraulic conductivity,} \\ n &= \text{porosity,} \\ dh/dl &= \text{head gradient.} \end{aligned}$$

Assuming that K for the gravel lies within the range of 10^{-4} to 10^{-1} cm/s, that n is ~ 0.3 (i.e., 30%

voids), and that dh/dl is approximately 10^{-3} [i.e., 1 m/1000 m (5.3 ft/mile)], then the following results are obtained:

$$\text{velocity} = <1 \text{ ft/year (low } K) \text{ to } >300 \text{ ft/year (high } K).$$

The above results agree generally with estimates provided by CH2M Hill (PGDP 1990). Earlier 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/year) (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. It is now recognized that K is highly variable and site-specific flow velocity estimates must be interpreted cautiously. In addition, head gradients have been observed to vary considerably during the year. The possibility that groundwater velocities as high as 90 m/year (300 ft/year) might be possible illustrates the importance of detailed site characterization work.

In contrast to the large production capability of the gravel aquifer, sand lenses interbedded in the clay facies of the Continental Deposits are observed to have extremely low yields. In 1990, CH2M Hill performed slug tests on several monitoring wells completed in the upper Continental Deposits and obtained hydraulic conductivity values ranging from approximately 2.0×10^{-7} to 5.0×10^{-3} cm/s. Furthermore, earlier investigations at PGDP indicated that sand and gravel lenses within the upper Continental Deposits are fairly discontinuous. Ambiguities in observed hydraulic head data support interpretations that these lenses may not constitute a continuous aquifer.

Several activities were undertaken in 1990 to address geologic and hydrogeologic uncertainties. High-resolution seismic data have been collected, and their interpretation should provide additional subsurface information to resolve further the configuration of the RGA. Also, GeoTrans, Inc., has developed a numerical computer model. This three-dimensional groundwater flow model was designed to provide a quantitative integration of all available hydrogeologic data, evaluate hydrogeologic controls on groundwater flow beneath the site, and identify data inadequacies or areas of uncertainty.

Groundwater is used for drinking water and other domestic uses, irrigation of gardens, and watering livestock. No industrial groundwater users exist north of PGDP. About 15 private residences north of the plant use groundwater.

1.4 REGIONAL DEMOGRAPHY

The WKWMA and lightly populated farmland are in the immediate environs of PGDP. The population within the 80-km (50-mile) radius (see Fig. 1.10) is about 535,000 persons. Of these, about 36,500 live within 16.1 km (10 miles) of the plant; about 104,000 live within 32.2 km (20 miles). The unincorporated communities of Grahamville and Heath are located 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.

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 or eliminate waste generation and to protect people and the environment. Internal procedures have been established and implemented to accomplish these tasks. Under the authority of the Atomic Energy Act, DOE has issued a multitude of 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 (NESHAP), 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 discharges; hazardous waste treatment, storage, and disposal; and waste management facilities are all permitted by the Natural Resources and Environmental Protection Cabinet.

1.7 ENVIRONMENTAL PROGRAM INFORMATION

During May 1990, PGDP performed a self assessment of environmental program activities that identified specific findings and corrective actions. The action plans developed for each of the findings have been prioritized and are now being implemented.

The major finding was that environmental programs lack formality and control. This finding has required PGDP to provide additional emphasis in its training and procedures programs. PGDP's environmental program development also has been hindered by a lack of technical expertise. This issue is being resolved by recruiting and hiring of experienced environmental professionals in the expanding Environmental Compliance Department.

In 1990, the Environmental Management Division was directed to provide environmental training on several issues. In May 1990, an overview of Hazardous Waste Regulations and Contingency Plan and Spill Reporting procedures was given to employees involved in elements of the RCRA Part B application implementation. In June and July 1990, PGDP hosted a DOE Tiger Team Assessment. This effort was sponsored by DOE to provide an independent oversight of PGDP's management of environmental, safety, health, and management

programs. The scope of this effort included the following:

- Address PGDP status with federal, Kentucky, and local environmental regulations.
- Consider impacts on all environmental media.
- Identify noteworthy practices that warrant communication throughout the DOE system.
- Assess potential root causes of any noted environmental weaknesses to aid in developing corrective actions.
- Provide PGDP with information to improve environmental programs and compliance status.

Sixty-three compliance and best management practice findings were identified during the assessment. Four noteworthy practices were also identified. None of the findings identified were serious enough to discontinue operation of any facility. Action plans have been developed and are being implemented to resolve the findings. In November 1990, all PGDP supervisors received a four-hour environmental checklist training course that required each supervisor to "walk-your-space" and identify potential environmental problems. In December 1990, PGDP supervisors received 8 hours of environmental laws and regulations training that included an overview of RCRA, CERCLA, CWA, SDWA, CAA, TSCA, and NEPA.

The Pollution Prevention Awareness Program (PPAP) Committee was formed in CY 1990 to comply with DOE Order 5400.1, "General Environmental Protection Program" and other regulations (i.e., EPA, KDEP, and Energy Systems policies). This group is responsible for managing the

program and increasing pollution awareness throughout PGDP. The scope of the PPAP includes education and public relations activities associated with pollution prevention. Its objectives will be accomplished by environmental pollution recognition and prevention, training, special awareness campaigns, and awards and incentives programs. The committee will meet quarterly to evaluate the effectiveness of the PPAP and provide ideas for improvement.

During the year, the committee has developed waste minimization suggestion forms, issued pollution prevention bulletins, and contacted EPA for waste reduction information. These programs have been implemented by the Waste Minimization Program Manager.

The PGDP Waste Minimization Program is a continual review and evaluation of production, production support, operation, maintenance, and administrative activities that generate waste. This review process has led to several modifications in activities performed at PGDP, including substituting nonhazardous products for hazardous ones, modifying operations, and performing feasibility studies in areas to reduce generation of hazardous waste.

Feasibility studies were performed in CY 1990 on reducing paint waste, recovering solvents for recycling, eliminating chlorinated solvents, recycling spent lead from bullets used at the target range, and monitoring chemical and regulated substances inventory. A statement on the progress of the waste minimization program was included in the Annual Hazardous Waste Report submitted to the Kentucky Division of Waste Management.

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

Environmental monitoring is an integral part of the PGDP air pollution control program. The federal Clean Air Act (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 measurements to demonstrate the results. The identification, controls, and emission or throughput limits are included in the regulatory agency's permit. PGDP has 27 sources listed on the operating permit; however, not all sources were operated in 1990. Table 2.1 lists the permitted sources and the types of control equipment used for air pollution prevention.

PGDP maintains an ongoing program to identify and evaluate air contaminant emission sources not listed on the operating permit. When the emission sources are evaluated and air contaminant emissions are determined, application addendums are forwarded to KDAQ for evaluation of permit applicability. (PGDP has not received an updated operating permit

since January 1986 due to lack of resources and manpower at KDAQ. Even so, PGDP continues to submit application addendums to KDAQ to ensure compliance with KDAQ regulations.) This effort was initiated in April 1987 with the submission of an application to add five sources to the existing operating permit. After promulgation of the KDAQ Air Toxics Regulations in November 1986, PGDP submitted an additional comprehensive Air Toxics Review application to KDAQ in May 1988. This application increased the number of emission points that have been evaluated by PGDP to 70, and each evaluation has indicated compliance with the Air Toxics Regulations in terms of emission limits and ambient air impact. Extensive corporate and DOE audits and surveys by frontline supervisors have identified additional sources that have been evaluated and submitted to KDAQ for permit evaluation.

Although a number of the sources are not operating or no longer exist, PGDP has identified 104 potential air contaminant sources for evaluation of permit

Table 2.1. 1990 PGDP stack emissions summary

Stack ^a	Control equipment	Emission		
		Effluent	kg/year	Curies ^b
C-310 cascade vent	Chemical traps	²³⁴ U	3.6×10^{-6}	2.22×10^{-5}
		²³⁵ U	4.8×10^{-4}	1.03×10^{-6}
		²³⁸ U	3.1×10^{-2}	1.05×10^{-5}
		⁹⁹ Tc	2.3×10^{-5}	3.9×10^{-4}
C-600 steam plant	Use of low-sulfur coal, control of excess air, electrostatic precipitators	SO ₂	276,380	
		NO _x	278,613	
		Particulates	11,284	
		CO	9,091	

^aSee Fig. 2.1.

^bBased on a product assay of 1.5% ²³⁵U.

applicability, and expects to increase that number in CY 1991. Not all of the potential emission points require permitting, and information documenting this is forwarded to KDAQ. The primary goal of the air compliance program is to identify each air contaminant emission point at PGDP, quantify the emissions from the source, document compliance with the applicable regulation, and submit this information to KDAQ for permit evaluation.

PGDP submitted one construction permit application to KDAQ in 1990, which was for upgrading the C-637-2B cooling tower. The KDAQ Permit Review Branch subsequently determined that the work to be performed on the C-637-2B tower and the work performed on other towers did not require construction permits.

PGDP was issued a construction permit on January 23, 1990, to install a cartridge filter on the C-726 blasting facility to control particulate emissions. A successful compliance demonstration was performed for KDAQ in March 1991. PGDP will submit an addendum to the pending operating application to include the blasting facility and the new cartridge filter in the operating permit.

The release of contamination into the atmosphere is minimized by avoiding any unnecessary waste generation 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 evaluated continually. Table 2.4 of Part 2 compares selected actual emissions with limits or standards set by regulations or permits. The primary basis for evaluating the control achieved is by emissions sampling and ambient air monitoring. Performance of control devices also may be checked by state or federal inspections. The data generated by stack emissions sampling were used to calculate radiation doses to the nearest neighbors and the surrounding population (see Sect. 7).

2.1 AIRBORNE DISCHARGES

The CAA of 1977 requires EPA to administer through the states a program that requires air contaminant sources to obtain permits to construct and operate. After receiving and reviewing an application for a plant-wide operating permit, KDAQ issued permit No. 0-85-110 to PGDP on

September 30, 1985, granting operation of an air contaminant source. The permit lists 27 emission points and has no expiration date. Not all of the emission points were active in 1990; the major sources in operation (see Fig. 2.1) 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 include 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 particulates, opacity, sulfur dioxide, volatile organic compounds (VOCs), radionuclides, and fluorides. Certain processes also are regulated by throughput limits and usage rates. The 1990 cumulative radiological emissions and steam plant emissions are tabulated by source in Table 2.1. The C-600 steam plant emissions routinely reported are sulfur dioxide (SO₂), nitrogen oxides (NO_x), particulates, carbon monoxide (CO), non-methane VOCs, and methane. The SO₂ is continuously monitored in the stack in terms of pounds of SO₂ per million BTU input to the boiler. Data from the continuous SO₂ monitor and fuel usage data are combined to determine monthly and annual emissions. Emissions other than SO₂ are calculated from fuel usage using emission factors from EPA guidance document AP-42. The excess combustion air averages about 20% and is minimized to control NO_x in the flue gases and to optimize boiler efficiency. Monitoring is not required for total suspended particulates. The KDAQ permit limit of 20% opacity is achieved by use of electrostatic precipitators (ESPs) operating at 99% efficiency for particulate removal. Performance tests and emission factor calculations have shown emission levels of less than 0.1 lb of total suspended particulates per million BTU boiler input. A PGDP procedure requires monthly visible emission evaluations of boiler stack effluent by EPA method 9 for documentation of the 20% opacity limit.

The ESPs provide minimal stack particulate emissions while the boilers are operating, but visible

Fig. 2.1. Location of major air emissions sources at PGDP.

emissions occur during malfunctions, startups, shutdowns, and some maintenance activities. These periods are brief and infrequent and are reported to KDAQ prior to the activities if possible. Table 2.1 shows the total steam plant emissions. Tables 2.2 and 2.3 of Part 2 present monthly emissions and historical data.

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, and samples are analyzed daily. Tables 2.2 and 2.3 of Part 2 lists monthly and annual emission rates.

Stack-sampling trend analysis performed on the C-310 stack indicates a dramatic decrease in uranium emissions since 1983. In 1983 the average monthly uranium emission was 336 grams. Discounting anomalous averages due to system upsets, this monthly average decreased each year to an average monthly emission of 2.6 grams in 1990. This monthly

emission rate is slightly higher than in the previous two years (discounting above average emissions due to system upsets) due to the development of a statistical lower limit of detection. Prior to September 1990, daily uranium emissions could be reported as low as <0.01 gram. The results of a statistical study in September 1990 indicated that the lower limit of detection for daily uranium emissions was 0.07 grams. The development of this new lower limit of detection raised the minimum monthly emission rate from 0.3 grams to 2.1 grams. It should be stressed that this is not an actual increase in emissions; it is merely the establishment of a level of confidence that is higher than that previously used.

PGDP operates two vapor degreasers in the C-400 cleaning building. One of the degreasers is large enough [$1.5 \times 6.9 \times 5.4$ 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 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 [$1.5 \times 1.8 \times 1.5$ 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 plant emissions. The Air Toxics Operating Application (submitted to KDAQ in 1988) assumed that 90% of the agents are lost to the atmosphere, and the rest are contained in the degreaser sludge. A project is in process to identify 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, KDAQ promulgated two Air Toxics Regulations. These regulations established emission limits for specific substances considered toxic. The first regulation applies to facilities constructed before 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, it is 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.

2.2 AMBIENT AIR

PGDP maintains and operates an ambient air system 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 KDAQ.

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

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

Figure 2.2 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 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 then are analyzed for alpha and beta activity by an automatic low-background alpha/beta proportional counter (PGDP 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 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. An

Fig. 2.2. Location of air-sampling and meteorological monitoring stations at PGDP.

ambient-air-monitoring plan is being developed to implement these improvements to the monitoring system. Tables 2.2 and 2.3 provide a summary of 1990 ambient air measurements. All fluoride samples were well below the Kentucky ambient air standards for fluorides. The highest annual average for fluorides was 0.159 ppb at the plant north (PN) site. This concentration was well below the annual arithmetic mean standard of 500 ppb for fluorides. The maximum weekly concentration of fluorides of 0.333 ppb at the Plant North location was only 17% of the Kentucky secondary fluoride maximum weekly standard of 2 ppb.

2.3 METEOROLOGICAL MONITORING

Representative meteorological data are required at DOE facilities by DOE Order 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. 7). In addition, on-site meteorological data are used by various groups within the plant, for example, by Environmental Restoration to correlate precipitation with groundwater flow and by Power Operations to investigate electrical equipment failures.

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

Table 2.2. 1990 PGDP environmental air sampling for fluorides

Point ^a	No. of samples	Concentration (ppb)		
		Min	Max ^b	Av ^c
1 (PN)	51	0.061	0.333	0.159
2 (PE)	49	0.056	0.199	0.107
3 (PS)	49	0.037	0.149	0.085
4 (PW)	49	0.060	0.248	0.098
5 (BN)	49	0.057	0.224	0.107
6 (BE)	49	0.056	0.106	0.073
7 (IN)	51	0.059	0.143	0.079
8 (IE)	49	0.055	0.121	0.074
9 (ISE)	49	0.055	0.103	0.070
10 (IS)	50	0.049	0.134	0.068
11 (IW)	49	0.052	0.133	0.067
12 (GR)	51	0.057	0.135	0.074

^aSee Fig. 2.2.^bKentucky Secondary Air Quality Standard (401 KAR 53:010) for maximum 1-week average is 2.0 ppb as HF.^cKentucky Primary Air Quality Standard (401 KAR 53:010) for annual arithmetic mean is 500 ppm.

Table 2.3. 1990 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)	0.00	1.34	0.39	0.00	0.78	0.33	51
2 (PE)	-0.10 ^b	1.62	0.30	0.09	0.92	0.32	49
3 (PS)	0.00	1.36	0.27	0.00	0.53	0.31	49
4 (PW)	-0.37	0.96	0.28	0.00	0.96	0.31	49
5 (BN)	-0.11	0.74	0.26	0.10	0.60	0.31	49
6 (BE)	-0.09	0.69	0.30	0.10	0.77	0.31	49
7 (IN)	-0.22	0.98	0.32	0.11	0.87	0.31	51
8 (IE)	0.00	0.91	0.26	0.10	0.82	0.33	49
9 (ISE)	-0.11	1.96	0.33	0.05	1.01	0.31	49
10 (IS)	-0.12	1.38	0.32	0.00	0.59	0.29	50
11 (IW)	-0.21	0.97	0.30	0.10	0.76	0.30	49
12 (GR)	-0.10	1.19	0.25	0.10	1.00	0.32	51

^aSee Fig. 2.2.^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 counts.

pressure, relative humidity, and rainfall, 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 uses emission and meteorological data. Modeling is used to determine the impacts of operations with regard to the transport of air contaminants and to predict air quality impacts from a source due to abnormal airborne emissions. In addition, PGDP can postulate a multitude of emergency scenarios and estimate effects of unplanned releases on employees and population centers downwind of the source. PGDP uses the Hazardous Atmospheric Release Model Meteorological Computer Program. This is an atmospheric dispersion model that uses emission and meteorological data to simulate unplanned releases or events causing environmental concern.

2.4 EXTERNAL GAMMA RADIATION MONITORING

One of the potential pathways of exposure for population groups living within the vicinity of DOE facilities is exposure to external radiation. Dose rates from penetrating radiation (gamma rays) were measured at a number of locations in the PGDP environs during 1990. Long-term measurements were made using thermoluminescent dosimeters (TLDs). Instantaneous dose rates were also measured with hand-held meters during radiation surveys conducted at numerous locations on and around the PGDP Site.

2.4.1 Thermoluminescent Dosimeter Sampling Program

During 1990, TLDs were placed in the environment to obtain data on external gamma radiation. These TLDs react to gamma and neutron radiation and, to some extent, to cosmic radiation. Fifteen monitoring dosimeters were in use during three quarters of 1990. Measurements for the first quarter of 1990 were not available due to a change made in the sampling program. Figure 2.3 provides the locations of the monitoring dosimeters. Ten quality control TLDs were in use during each quarter; Fig. 2.4 shows their locations.

The external gamma radiation program is conducted using guidance from ANSI Standard

N545-1975. The TLDs are identified, annealed, calibrated, packaged, and shipped by Oak Ridge National Laboratory (ORNL). When they arrive at PGDP, they are promptly positioned in the PGDP environment approximately 1 m (3 ft) above the ground. The TLD packages are placed in four types of locations: along the plant perimeter fence, at the reservation boundary, at nearby residences or communities, and at two background locations more distant from the site. After the quarterly exposure period, the TLDs are collected and returned to ORNL for exposure determination.

Although the TLD exposures were measured in microrentgens per hour ($\mu\text{R/h}$), measured doses are also reported in dose equivalent units (mrem) to allow comparison with dose standards and dose equivalents reported elsewhere in this document. To convert to mrem/year, some exposure period must be assumed. To allow for comparison, continuous exposure has been assumed at all locations. In reality, exposure will vary depending on public access to that location. Table 2.4 shows the average exposure rates for each TLD location. Table 2.5 lists quality control data for the TLDs. The mean exposure rate for indicator locations as measured by the TLDs (excluding perimeter fence data) is approximately $7.49 \mu\text{R/h}$. When that rate is compared with the mean background exposure rates, there is no significant difference at the 95% confidence level. Assuming continuous exposure at this level, the external whole-body dose would be approximately 67 mrem/year. This corresponds to the average external whole-body dose estimated to be received by people throughout Kentucky and Tennessee, which is between 60 and 70 mrem/year (Klement 1972). Dose rates at the plant perimeter were somewhat higher than the background rates. The higher exposure rates at locations near the perimeter fence were attributed to direct radiation from the uranium cylinder storage and handling areas. Although the rates are elevated, these areas have only limited access and actually allow for very low exposure periods.

Because of the extremely small amounts of gamma radiation emitted by PGDP compared with natural background radiation, accurate measurements using TLDs are difficult to obtain. The exposure rates measured by the TLD system during 1990 have a high level of uncertainty because of the lack of agreement of the quality control measurements with ANSI

Fig. 2.3. Thermoluminescent dosimeter locations at PGDP.

ORNL-DWG 89M-6361R2

Fig. 2.4. Quality control thermoluminescent dosimeter locations at PGDP.

Table 2.4. Maximum potential 1990 PGDP external gamma exposure rates

ID ^a	Location	Average	
		$\mu\text{R/hr}$	(mrem/year)
EG1	Air sampler perimeter north (PN)	6.68	58.5
EG2	Air sampler perimeter east (PE)	7.25	63.5
EG3	Air sampler perimeter south (PS)	47.01	411.8
EG4	Air sampler perimeter west (PW)	16.92	148.2
EG5	Air sampler boundary north (BN)	6.44	56.4
EG6	Air sampler boundary east (BE)	8.79	77.0
EG7	Air sampler 1 mile north (1N)	6.95	60.9
EG8	Air sampler 1 mile east (1E)	8.04	70.4
EG9	Air sampler 1 mile south (1S)	7.85	68.8
EG10	Air sampler 1 mile southeast (1SE)	8.68	76.0
EG11	Air sampler 1 mile west (1W)	7.68	67.3
EG12	Air sampler in Grahamville	6.27	54.9
EG13	House in McGruder Village	6.71	58.8
EG14	House in Paducah near Noble Park	8.02	70.2
EG15	House south of Paducah on Oaks Road	8.78	76.9

^aSee Fig. 2.3.

Table 2.5. 1990 QC data for PGDP external gamma exposure

ID ^a	Location and description	Second quarter ($\mu\text{R/hr}$)	Third quarter ($\mu\text{R/hr}$)	Fourth quarter ($\mu\text{R/hr}$)	Average ($\mu\text{R/h}$)
QC1	Office cycle, C-710	3.15	2.98	2.13	2.75
QC2	1/2 office cycle, C-710	3.39	3.02	3.70	3.37
					81.6% agreement
QC3	Freezer cycle, C-710	3.15	2.06	2.13	2.45
QC4	1/2 freezer cycle, C-710	2.42	3.70	2.78	2.97
					82.5% agreement
QC5	Oven cycle, C-710	0.63	-0.69	0.43	0.12
QC6	1/2 oven cycle, C-710	0.48	-1.0	0.92	0.13
					92.3% agreement
QC7	Light dependence, unwrapped, EG3	38.93	57.46	44.64	47.01
QC8	Light dependence, wrapped, EG3	49.45	50.59	52.72	50.92
					92.3% agreement
QC9	Light dependence, unwrapped, spiked 100 mrem, EG3		46.93	54.42	50.67
QC10	Light dependence, wrapped, spiked 100 mrem, EG3	83.96	51.97	54.0	63.31
					80.0% agreement

^aSee Fig. 2.4.

Standard N545-1975. However, the data indicate that levels of gamma radiation both at and beyond the plant perimeter have not increased significantly over time. Figure 2.5 compares the trend over a 3-year period at each location. The radiation fields surrounding the cylinder storage yard are also somewhat static.

2.4.2 Environmental Radiation Surveys

Results of an aerial radiological survey performed in May 1990 compared with a similar survey performed in August 1976 show that, over the past 15 years, only subtle changes have occurred in the spatial distribution of man-made radionuclides at PGDP. No significant gamma activity attributable to PGDP was detected outside the reservation boundary. The anomalous radiation levels detected by the survey were attributed to the known location of uranium cylinder storage areas.

Roadways, creeks, and random locations within WKWMA were surveyed during 1990 with BICRON microR-meters to detect levels of radioactivity. Measurements were taken along the perimeter fence and at distances up to 30 feet perpendicular to the

fence to identify "hot spots." Measurements then were taken at 24 locations on the reservation to which the public has limited access. A subsequent survey was performed using the grid system over the Wildlife Management Area surrounding the reservation boundary. The banks and creek beds of both Little and Big Bayou creeks also were surveyed.

All measurements taken at or beyond the reservation boundary were within the background range. Elevated radiation levels were observed on the plant entrance road, adjacent to the plant fence around the C-745 cylinder storage areas, and within the Little Bayou Creek bed. Because each of these areas is within the reservation boundaries, public access is administratively controlled and limited. Radiation measurements made in the Little Bayou Creek bed on DOE property were consistently above background levels. The highest dose rate observed along the creek banks during 1990 was 0.039 mrem/h, or about 4 times the background dose rate normally observed. Measurements taken along the plant entrance road directly across from the C-745 cylinder storage areas were also above background levels. Dose rates ranged from 0.035 to 0.040 mrem/h. Based on appropriate exposure periods and administrative

Fig. 2.5. PGDP external gamma radiation, 1988-1990.

controls, none of these locations should result in a dose to a member of the public that would exceed the public dose limit of 100 mrem/year.

2.5 CONCLUSIONS

During 1990, 0.03 mCi (31.8 g) of uranium was released to the atmosphere from the C-310 stack. This number is considerably lower than the 0.29 mCi (205 g) of uranium released in 1989. The relatively high emissions of 1989 were due to an upset in the cylinder burping station in October 1989 in which the uranium effluent detector (space recorder) failed to detect an increase in uranium effluent concentrations from the chemical traps. Corrective actions implemented as a result of the 1989 upset have been successful in maintaining the lowest possible emissions in accordance with the ALARA concept. An interesting comparison can be drawn between PGDP's actual uranium emissions from the C-310 stack, and the new limit (standard) for DOE-owned facilities established by EPA under the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulation. In December 1989, EPA established a standard of 10 mrem effective dose equivalent to the most affected off-site person. This means that PGDP must not expose the most affected off-site person to radionuclides from atmospheric releases that would result in an annual effective dose equivalent of 10 mrem or more. Air dispersion

modeling performed for PGDP by ORNL indicates that an annual effective dose equivalent of 10 mrem to the most affected off-site person would require an emission rate of 10,685 grams (23.5 pounds) per day for an entire year. This rate is considerably more than the total 1990 emissions of 31.8 grams, indicating that uranium emissions from the C-310 stack are well below those that would cause undue health effects.

Also during 1990, 0.4 mCi (23 mg) of technetium were released. This number is down from 3.6 mCi released in 1989. There has been no new introduction of ^{99}Tc into the cascade and no increase of ^{99}Tc in product withdrawal. Air dispersion modeling also was performed to identify the technetium emissions that would result in an effective dose equivalent of 10 mrem to the most affected off-site person. Results indicate that it would require an emission rate of 68,500 milligrams (0.151 pounds) per day for an entire year to achieve the 10 mrem standard. This rate is much greater than the total 1990 technetium emission of 23 milligrams.

The stack-monitoring data, their characteristics, and the joint frequency distribution of wind speed, stability, and wind direction are needed to calculate the amount of exposure of the surrounding population to plant emissions. The wind roses shown in Figs. 2.6 and 2.7 summarize the wind speed frequency distribution data for the 1990 dose model estimates (see Sect. 7).

ORNL-DWG 90-10124

Fig. 2.6. Wind rose (10-m level) showing the wind speed frequency distribution data used for the 1990 estimates.

ORNL-DWG 90-10125

Fig. 2.7. Wind rose (60-m level) showing the wind speed frequency distribution data used for the 1990 estimates.

3. 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. 3.1). 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 56 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 located 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 3.1 and 3.2 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 effluents (uranium-contaminated as well as noncontaminated) result from activities associated with uranium precipitation and facility-cleaning operations. Conventional liquid discharges such as domestic sewage, steam plant wastewaters, and coal-pile runoff also exist. Routine monitoring activities provide data to quantify total discharges to surface water, demonstrate compliance with federal, state, and DOE requirements, and assist in evaluating the effectiveness of effluent treatment and control programs.

3.1 SURFACE WATER MONITORING

SW13 (see Fig. 3.3), the north-south diversion ditch, is monitored on a weekly basis. This ditch receives coal-pile runoff, the C-400 decontamination solution filtrate, 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 3.1. 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 3.1. Analysis of samples indicates elevated levels of uranium and alpha and beta activity. However, this ditch is on-site and flows into the C-616 lagoon before discharging through outfall 001.

Monthly sampling is conducted at Big Bayou Creek upstream (SW1), Big Bayou downstream (SW5), Little Bayou downstream (SW10), Ohio River upstream (SW29), and Ohio River downstream (SW30). Tables 3.15 through 3.22 of Part 2 provide surface water monitoring data.

Comparisons of the radiological results from upstream and downstream locations on Big Bayou Creek indicate that there is no significant difference (95% confidence level) between the two data sets for either gross beta activity or technetium-99. The gross alpha results do indicate elevated levels of alpha activity in Big Bayou Creek downstream from PGDP. This activity most likely reflects the release of uranium in plant effluents.

Two locations on the Ohio River, L29 and L30, are monitored monthly for parameters listed in Table 3.1. The data are presented in Tables 3.19 and 3.20 of Part 2. Samples tested for 1,2-dichloroethane, discharged by Calvert City's industrial complex, were $<5 \mu\text{g/L}$.

The surface runoff from the C-746-S residential landfill and the C-746-T inert landfill is monitored quarterly. Sampling is performed to comply with Kentucky Division of Waste Management requirements for landfill operations. Background water quality is sampled at Big Bayou Creek location 1 (SW1). Comparisons of the radiological results from Big Bayou Creek with each landfill location indicate that there is no significant different (95%

Fig. 3.1. PGDP site surface hydrology systems.

Fig. 3.2. Regional area primary surface hydrology.

ORNL-DWG 89M-6359R2

Fig. 3.3. Surface water monitoring locations at PGDP.

**Table 3.1. Summary of collection and analysis frequencies
of surface water samples in 1989**

Station ^a	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>				
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, 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, ICP metals scan	Annually	Annual composite	Annually
SW1	NO ₃ -N, SO ₄ , chloride, Cr ⁺⁶ , pH, PO ₄ , U, F ⁻ , ⁹⁹ Tc, % ²³⁵ U, ²³⁷ Np, ²³⁹ Pu, gross alpha and beta, temperature weekly	Monthly	Grab	Monthly
SW5, SW10	Gross alpha and beta, ⁹⁹ Tc, % ²³⁵ U, ²³⁷ Np, ²³⁹ Pu	Monthly	Grab	Monthly

^aSee Fig. 3.3.

confidence level) between each data set. However, comparisons of the iron, total suspended solids, dissolved solids, and total solids between the background and indicator locations indicate a significant difference (95% confidence level) is present. Extra emphasis on erosion control at the landfill should lower the solids content in the runoff.

3.2 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 KDOW to 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. 3.4) was carried out at PGDP. Table 3.1 of Part 2 shows interim limits, sampling frequency, and the type of sample required by the Agreed Order. The Agreed Order became effective on October 12, 1987. Monitoring then resumed under the KPDES permit with the Agreed Order modifications. The KPDES permit will expire in October 1991. Permit renewal applications are currently being prepared and are due to KDOW in May 1991.

Monitoring of 16 individual outfalls is conducted in accordance with the KPDES Agreed Order. Table 3.2 lists all outfalls and their contributing processes; Fig. 3.4 depicts the location of the outfalls. Table 3.1 in Part 2 cites the effluent limits set forth by the Agreed Order.

Tables 3.2 through 3.14 in Part 2 give the yearly minimum, maximum, and average for each outfall monitored. Since no flow occurred at outfall 003 in 1990, no monitoring data were obtained. Flow from

Fig. 3.4. KPDES outfall locations at PGDP.

Table 3.2. 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-550 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 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. 3.4.

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 discharges and is monitored. Outfall 005 is not regularly monitored because its effluent flows into the C-611 secondary lagoon. Outfall 006, the 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 1990. 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.

During 1990, PGDP experienced a compliance rate of 99.31% with the KPDES Agreed Order effluent limits. (The 1989 compliance rate was 98.27%.) The number of noncompliances in 1990 was 33, compared with 82 in 1989. Table 3.3 indicates the noncompliances experienced under the Agreed Order. The noncompliances during 1990 were total residual chlorine, pH, temperature, total suspended solids, and fecal coliform. Once-through cooling water (sanitary water disinfected with chlorine for public consumption and usage) was a large portion of PGDP's effluent and accounted for most of the total residual chlorine noncompliances. The C-615 sewage treatment plant, which uses chlorine to disinfect its effluent, also contributed to total residual chlorine in effluent waters. Fecal coliform noncompliances were due to malfunctions of the flow-proportionate chlorinator. Temperature noncompliances were the result of the heat in once-through cooling water and steam condensate discharge. Total suspended solids noncompliances occurred because of dust and solids washed down the ditches by rainfall runoff.

Corrective measures have been taken to alleviate the number of KPDES noncompliances. Sodium thiosulfate feed stations exist at outfalls 008, 009, 010, 011, and 012 to reduce the total residual chlorine in the effluent water. After installation of the sodium thiosulfate feed stations, the number of total residual chlorine noncompliances dropped from 64 in 1989 to

12 in 1990. The plant effluent chlorine and temperature control project, currently under construction, will provide facilities to lower the temperature in outfalls 001, 002, 010, 011, and 012 and reduce the total residual chlorine in outfalls 001, 002, 008, 010, 011, and 012. Construction should be complete in June 1991.

Erosion control devices, such as silt fences, hay bales, and filter fabric, have been installed at construction sites. The use of such devices and improved oversight have caused the number of total suspended solids noncompliances to drop from 5 in 1989 to 3 in 1990.

Biological-monitoring studies have indicated that slightly elevated pH in PGDP effluents is not causing elevation of pH in the receiving streams above water quality criteria. Therefore, a pH range of 6.0 to 10.0 will be pursued during the KPDES permit renewal process.

During 1990, two meetings were held with KDOW. The first meeting was on June 7, 1990. Items discussed included the potential issuance of a new Agreed Order for PGDP by KDOW. Some of the requirements in the Agreed Order would be monitoring of outfall 013 (landfill rainfall runoff point), completion of the plant effluent chlorine and temperature control project by June 1991, total suspended solids monitoring requirements for rainfall runoff outfalls, and PCB effluent limits. On August 31, 1990, a notice of violation (NOV) for discharges of PCBs above water quality criteria in Big and Little Bayou Creeks was received. The NOV was the subject of the second meeting with KDOW. October 3, 1990, was the meeting date. PCB source investigation plans and the PCB management program were discussed. A draft Agreed Order will be issued by KDOW in 1991. Compliance with the Agreed Order will resolve the NOV.

During 1990, installation of new flow measuring devices at KPDES outfalls was completed. Also, several refrigerated autosamplers were placed in service. The installation of the new flow measuring devices corrected a 1988 EPA Region IV compliance sampling inspection finding.

3.3 RADIOLOGICAL MONITORING OF EFFLUENTS

During 1990, the effluent outfalls were reevaluated based on their potential for release of

Table 3.3. Compliance experience under Interim Kentucky Pollutant Elimination Discharge System limits for 1990
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, total recoverable	0.15	0.31	0.15				0.1	0.23	0.5	0.85	0.76					
Zn, total recoverable	0.93	0.17	0.93				0.34	1.15	0.26	0.16	0.4					
Cl, residual	0.1	0.15	0.1				0.33(6)	0.01(3)	0.01(1)	0.14(1)	0.01(1)					
Temp (°F)	93	89	93				89(1)	89	89	95(7)	90(1)					
Fe, total recoverable	34.3	6.55	5.19				9.42	8.41	8.32	5.94	18.22					
Al, total recoverable	M	M	M				M	M	M	M	M			M	M	M
Cu, total recoverable	0.17	M	0.17				M	M	M	M	M			M	M	M
Ni, total recoverable	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	50	427	45(2)	45(1)
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	M	
pH (std. units)	6-10	6-10	6-10	6-9(1)	6-9	6-10.4	6-9	6-10(3)	6-9(1)	6-10	6-9	6-9	6-9	6-9	6-9	6-9
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 (ug/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(4)	M	M						M	M			
Turbidity (NTU)					M											
COD																

^aChemical limits are milligrams per liter unless otherwise indicated.^b() = number of violations.^cM indicates monitoring requirement only.

Note: There were 33 violations in 4752 analyses related to permit limits (99.31% compliance).

radioactive material and the results of historical radiological monitoring. Based on this evaluation, continuous monitoring was determined not to be required by DOE order. Radiological sampling was periodically conducted by random grab sampling. Although there are no specific effluent limits for radiological parameters in the KPDES permit, DOE Orders 5400.5 and Draft 5400.6 set guidelines for allowable concentrations of radiological species in various effluents and require radiological monitoring to protect the public health.

Beginning in 1991, in addition to sampling required by the KPDES permit, each sampling point with annual average radionuclide concentrations greater than 1% of the Derived Concentration Guide (DCG) for any radionuclide will be sampled on a weekly basis. Two locations currently monitored on a quarterly basis will be increased to weekly to generate a sufficient amount of data to characterize these discharges.

Tables 3.23 and 3.24 in Part 2 give the yearly minimum, maximum, and average concentrations of uranium and technetium at each effluent monitoring location. Each radionuclide is compared with the DCG and is presented as a percentage of that standard. The average concentrations were small percentages of the corresponding DCGs for both uranium and technetium at all locations.

Routine monitoring also provides data to estimate the total radionuclide discharge to surface waters. Because current monitoring provides only instantaneous measurements for both concentration of radionuclides and flow, there is a large uncertainty associated with this estimation. During 1990, 180.7 kg of uranium was discharged to surface waters. Technetium releases to surface waters decreased from 8 g in 1989 to 5.2 g in 1990. Table 3.25 in Part 2 shows monthly data for the major contributors to the total discharge during 1990.

3.4 BIOLOGICAL MONITORING OF EFFLUENTS AND RECEIVING WATERS

The Biological Monitoring Program (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 performed by researchers at the University of Kentucky (UK) in consultation with staff from Oak Ridge National Laboratory (ORNL). The latter group work 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 3 years' activities (Birge, Short, and Lauth December 1990). 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 (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 PGDP effluents was found to be consistently or highly toxic. However, moderate and statistically significant toxicity was detected occasionally in some of the effluents discharged in the Bayou drainage system.

4. 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, characterization activities have been undertaken that will resolve the recognized deficiencies in understanding of the site geology and hydrogeology. These activities are intended to develop a clear, thorough understanding of the subsurface geology and hydrogeology to aid in developing technically effective monitoring strategies.

DOE Order 5400.1 outlines requirements for groundwater monitoring at all DOE facilities and specifies the development of three documents relating to the groundwater monitoring: an Environmental Monitoring Plan, a Groundwater Protection Program Management Plan (GWPP MP), and a Groundwater Monitoring Plan (GMP). The GWPP MP for PGDP (KY/ER-2) and the GMP (Early et al. 1989) for PGDP have been completed.

The general objective of the GWPP MP is to formalize and to structure the PGDP GWPP by identifying specific responsibilities and assigning them to the various entities within the plant who are matrixed to the program. The GWPP management structure coordinates and manages all projects and initiatives relevant to groundwater protection so that the objectives defined in DOE 5400.1 can be reached. As much as possible, Environmental Restoration and Environmental Compliance initiatives are coordinated and integrated to be complementary.

The GMP ensures the development of an adequate understanding of the geologic and hydrogeologic characteristics of the entire reservation so that future activities will be technically valid and justifiable. The general objective of the GMP is to provide a comprehensive blueprint for DOE to follow at each specific facility that (1) targets the environmental protection of groundwater, (2) is

consistent with DOE's commitment to operate its facilities in an environmentally safe manner, and (3) complies with all relevant environmental laws. The goal of the document is to fulfill these objectives for PGDP by providing a monitoring plan that accomplishes the following:

- develops an appropriate level of understanding of (1) site subsurface geology and groundwater hydrology, and (2) flow pathways and rates of contamination migration from existing waste disposal sites to underlying aquifers;
- provides the framework within which an integrated strategy for long-term monitoring of existing disposal sites can be developed to aid evaluation of remedial action alternatives; and
- creates a data base and fundamental geotechnical understanding of the site to facilitate future waste disposal decisions.

The third component of DOE Order 5400.1 relating to groundwater monitoring, a written environmental monitoring plan, is currently being developed to reflect the above-mentioned documents. This plan will contain the rationale and design criteria for the monitoring programs, the extent and frequency of monitoring and measurements, procedures for laboratory analyses, quality assurance requirements, program implementation procedures, and the directions for the preparation and disposition of reports.

This section discusses the objectives of the monitoring programs conducted at PGDP (Subsect. 4.1), current monitoring being conducted (Subsect. 4.2), and related activities (Subsect. 4.3). The 1990 groundwater monitoring results are presented in Sect. 4, Part 2).

4.1 TECHNICAL OBJECTIVES

The primary objectives of groundwater monitoring are to detect as early as possible any contamination resulting from past and present land disposal of wastes and to provide the basis for developing groundwater quality assessments if contamination is detected. Additional objectives outlined in DOE Order 5400.1 require that groundwater monitoring at all DOE facilities “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 to determine baseline conditions of groundwater quality and quantity;
- demonstrate compliance with, and implementation of, all applicable regulations and DOE orders;
- provide data to permit early detection of groundwater pollution or contamination;
- provide a reporting mechanism for detected groundwater pollution or contamination;
- identify existing and potential groundwater contamination sources and maintain surveillance of these sources; and
- provide data for making decisions about land disposal practices and the management and protection of groundwater resources.

4.2 DESCRIPTION

The monitoring and protection of groundwater at PGDP are required by federal and state regulations and DOE orders. Federal groundwater regulations generally are promulgated and enforced by EPA. PGDP lies within EPA Region IV jurisdiction, which encompasses the southeastern United States. The EPA regional headquarters is located in Atlanta, Georgia.

State groundwater regulations are promulgated and enforced by the Kentucky Division of Waste Management (KDWM), located in Frankfort, Kentucky. A KDWM field office for western Kentucky is located in Paducah, Kentucky, but most

interactions between PGDP and KDWM concerning groundwater involve the Hazardous Waste Branch of KDWM in Frankfort.

Groundwater-monitoring activities at PGDP are described as “effluent monitoring” or “environmental surveillance monitoring.” Effluent monitoring as applied to groundwater is monitoring to achieve compliance with one or more federal or state regulations, permit conditions, or environmental commitments made in Environmental Impact Statements, Environmental Assessments, or other official documents. Included under this heading is groundwater monitoring at either interim-status or permitted-status RCRA units, monitoring of 3004 (u/v) RCRA facilities, monitoring in conjunction with CERCLA actions (e.g., RI/FSs), monitoring around landfills in compliance with permit regulations, and monitoring around underground storage tanks (USTs). In addition, groundwater monitoring in response to administrative orders or a memorandum of understanding (e.g., Agreed Order between the facility and EPA) is included as effluent monitoring.

Environmental surveillance monitoring is defined as perimeter exit pathway monitoring and off-site water well monitoring. Perimeter exit pathway monitoring is conducted to aid understanding of the effects of facility operations on the regional groundwater quality and quantity. In addition to verifying compliance with regulatory requirements at the reservation boundary, perimeter exit pathway monitoring provides a means of detecting previously unidentified on-site groundwater quality problems. Off-site water well monitoring is conducted to address public concerns about off-site groundwater contamination, especially of drinking water sources.

The general characteristics that differentiate groundwater effluent and surveillance monitoring are summarized in Table 4.1. Subsects. 4.2.1 and 4.2.2 describe the existing effluent and environmental surveillance monitoring conducted by PGDP. For a more detailed description of the groundwater-monitoring requirements prescribed by the applicable regulations and DOE orders, the reader is referred to the PGDP GWPP MP (KY/ER-2). Analytical results from the sampling described below are included in Tables 4.1–4.10 of Part 2.

Table 4.1. Comparison of general characteristics of groundwater effluent and groundwater surveillance monitoring

Groundwater effluent monitoring	Groundwater surveillance monitoring
Regulation, permit, or investigation driven	DOE order driven
Monitors individual units, facilities, or waste area groupings	Monitors entire plant
Monitoring locations are generally on-site	Monitoring locations are at the plant perimeter and off-site
Short, intermediate, and/or long-term monitoring	Permanent
Constantly changes sites, adds wells, deletes wells, changes parameters, changes frequencies	Rarely changes after full implementation

4.2.1 Effluent Monitoring

4.2.1.1 RCRA interim status and permit-monitoring programs

RCRA groundwater monitoring is required under two separate sections of the regulations applying to units that are under interim status or are regulated (and therefore have a RCRA permit). Kentucky is an authorized state and maintains the permitting/enforcement authority for the PGDP RCRA units.

Currently, the only RCRA facility at PGDP that requires groundwater monitoring is the C-404 low-level radioactive waste burial ground, which is currently under interim status regulations awaiting a post-closure permit. The C-404 unit was a low-level waste burial ground until 1986, when routine testing programs indicated that the gold precipitate disposed of in early 1986 was hazardous due to the characteristics of extraction procedure toxicity. The unit was certified closed in 1987 as a hazardous waste landfill. A postclosure permit application was prepared and submitted to the state of Kentucky in June 1989. Twelve detection-monitoring wells were subsequently installed to monitor groundwater quality during the postclosure-care period (see Fig. 4.1 and Table 4.2). The detection wells were installed in the shallow ground system (SGS) and the underlying regional gravel aquifer (RGA), which is considered to be the uppermost aquifer. A statistical evaluation of the indicator parameters was conducted utilizing quarterly sample results from the initial year of monitoring. The evaluation indicated that well 88 had significantly greater levels of contamination for TCE, uranium, ⁹⁹Tc, and arsenic than well 94, which was assumed to be upgradient. As a result, the state of

Kentucky determined that additional information was needed to support the postclosure permit application.

The state of Kentucky was notified, and an assessment-monitoring plan was proposed to the state. The plan included further assessment of the plume, using the groundwater investigation currently being conducted at PGDP pursuant to a CERCLA Administrative Consent Order (ACO) between DOE and EPA. Additionally, Appendix IX sampling was to be performed at C-404. As a result of a meeting conducted on August 27, 1990, among Kentucky, DOE, and Martin Marietta Energy Systems, Inc., the state suggested entering into an Agreed Order outlining the proposed plan and schedules for assessment monitoring at C-404. The state indicated that a draft Agreed Order would be prepared and submitted to DOE for review. Until specific details relating to assessment monitoring are defined, monitoring continues at this unit on a quarterly basis for the constituents listed in Table 4.3. Table 4.1 in Part 2 contains the quarterly sampling results for this unit collected during 1990.

KDWM regulations governing hazardous waste management require that groundwater information for interim status units be reported in conjunction with the Annual Hazardous Waste Treatment, Storage and Disposal Report (401KAR 35:060). This report was submitted to DOE before March 1, 1991, and contained the following data collected at C-404 during 1990:

- quarterly sampling results,
- Appendix IX sampling results,
- water-level data, and
- results from an aquifer test performed at C-404.

Fig. 4.1. Approximate locations of wells around the C-404 area.

Table 4.2. RCRA monitoring wells
at C-404

Well No.	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 4.3. C-404 detection monitoring parameters

Analyte	Method
Selenium (total and dissolved)	EC-1040
Cadmium (total and dissolved)	EC-1400
Lead (total and dissolved)	EC-1400
Uranium	EC-1910
Arsenic (total and dissolved)	EC-1040
Trichlorethylene	EC-1704
Total organic halogens	
Total organic carbon	EC-1873
pH	ES-14
Temperature	ES-14
Conductivity	EC-1240
⁹⁹ Tc	EC-1860

Additionally, the report presented a preliminary evaluation of contaminant migration based on an analysis of groundwater flow beneath C-404 and listed activities being conducted during the CERCLA investigation that are expected to impact assessment monitoring at C-404. For more information concerning this facility, the reader is referred to this report.

4.2.1.2 Underground storage tank monitoring

As with regulations governing solid waste management units (SWMUs) and 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 the UST.

During a scheduled well evaluation in July 1989, evidence of combustible vapors was discovered in a plant well. Subsequent investigation of two underground tanks at the C-750 garage confirmed that they were leaking. These tanks were emptied of product, exploratory soil borings were conducted, and a monitoring well was installed. The current monitoring effort being conducted to target petroleum consists of sampling wells 47, 52, 68, 69, 70, 71, and 96 on a bimonthly basis for BTEX and total petroleum hydrocarbons. This sampling is in addition to the regular quarterly sampling that these wells

undergo. The 1990 sampling results for these wells are presented in Table 4.2 in Part 2.

A general UST investigation also is scheduled during 1991 that will target two USTs at the C-750 garage and four additional USTs in the general vicinity. The intent of the investigation is to determine if any tanks not previously investigated have leaked, to identify possible pathways of contamination, and to suggest alternatives and recommended actions for the remediation of the site. A minimum of 12 wells are to be installed during this investigation (CDM 1991). Subsequent long-term monitoring requirements for these wells will be determined when the investigation is completed.

4.2.1.3 CERCLA/Administrative Consent Order monitoring

Off-site well monitoring

With the discovery of contamination in groundwater north of the plant in August 1988, DOE and EPA entered into an ACO under CERCLA Sects. 104 and 106 to determine the nature and extent of off-site contamination. The EPA ACO, Docket No. 88-35-c, Part V, Sect. J, 2 and 3, requires monthly sampling of potentially affected wells and plant well 66 for TCE, ⁹⁹Tc, and gross alpha and beta. Any levels exceeding the national interim primary drinking water standards for alpha (>15 pCi/L) and beta (>50 pCi/L) must be analyzed further to determine the cause.

Extensive groundwater monitoring of residential and plant wells was initiated. Over 280 plant and off-site wells have been sampled and analyzed for TCE and ^{99}Tc . Action levels for the Environmental Restoration Program are 1 $\mu\text{g/L}$ TCE and 25 pCi/L ^{99}Tc . Wells showing levels above this are defined as contaminated.

Based on the results of this initial sampling, PGDP established a sampling program that exceeds the EPA ACO requirements. This program includes:

- Monthly sampling for the wells already showing contamination. These wells are monitored monthly for TCE, ^{99}Tc , gross alpha, and gross beta to establish any changes in concentration that might indicate contaminant plume migration.
- Weekly sampling of wells with the highest potential for contamination. These wells are sampled weekly for TCE and ^{99}Tc . Additionally, during the first week of the monthly sampling period, the wells are sampled for gross alpha and gross beta.
- Bimonthly sampling of wells with little chance of contamination. These wells are sampled on a bimonthly basis for only TCE and ^{99}Tc .
- Quarterly sampling of Tennessee Valley Authority (TVA) wells by a TVA sampling team from Muscle Shoals, Alabama. PGDP obtains a portion of its water for its analysis of TCE and ^{99}Tc .
- Monthly sampling of noncontaminated wells and residential wells. These wells have not shown contamination, but they are sampled monthly for TCE, ^{99}Tc , and gross alpha and beta because of their proximity to TVA wells showing contamination.

Table 4.4 lists the wells included within each category.

Figure 4.2 shows the location of any residential or TVA well having TCE or ^{99}Tc contamination. An off-site drinking well is considered contaminated if any sample has levels above the DOE/PGDP action limits of 25 pCi/L for ^{99}Tc and 1 $\mu\text{g/L}$ for TCE. Ongoing sampling of residential 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 regularly for gross alpha and beta. Action is taken to supply alternate water supplies if the action levels are exceeded. The 25 pCi/L action level is well below 900 pCi/L for ^{99}Tc , which is approximately equivalent to the 4-mrem/year exposure standard for manmade beta-emitting radionuclides. This exposure is based upon the consumption of 2 L/d of water. Residential wells sampled weekly and monthly are shown in Fig. 4.3. TVA monitoring wells are sampled quarterly (Fig. 4.4).

Data generated by this sampling program (see Tables 4.3–4.5, Part 2) aid PGDP in protecting the health of affected residents by giving advance warning of increases in contaminant levels so appropriate actions can be taken. They also are being used by plant personnel and consultants to identify the sources and to quantify the extent of contamination.

Site investigation for groundwater contamination

The ACO also required a site investigation to determine the nature and extent of off-site contamination and to assess remedial alternatives for the possible on-site sources for this contamination. DOE/Energy Systems contracted with CH2M Hill to develop and implement a work plan for the site investigation that would determine the nature and extent of contamination off-site to protect human health and the environment. Phase 1 of the two-part investigation has been completed. Thirty-five new monitoring wells were installed upgradient and downgradient of the plant (Table 4.5).

Each of these wells was sampled at least once for constituents listed in the Target Compound List (TCL) and for selected radionuclides. Additionally, 80 existing monitoring wells and nearby residential wells were inspected and evaluated, with 40 wells selected for water quality monitoring during the investigation. Each of the 40 wells was sampled up to four times during the investigation for constituents listed in the TCL and for selected radionuclides. An additional 29 wells were sampled once for TCL and radionuclides. A complete discussion of the investigation and results is presented in the draft Results of the Site Investigation, Phase I (CH2M Hill 1990).

Table 4.4. Wells included in the CERCLA/ACO well-monitoring program

Monthly (contaminated)	Weekly	Bimonthly	Quarterly	Monthly (noncontaminated)
RA 2 ^a	RA 10	RA 8	RA 154	RA 21
RA 4 (MW 20)	RA 12	RA 9	RA 155	RA 43
RA 5	RA 13	RA 20	RA 156	RA 72
RA 16	RA 14	RA 22	RA 157	RA 82
RA 17	RA 19	RA 23	RA 158	RA 83
RA 18	RA 39	RA 24	RA 159	RA 84
RA 113	RA 40	RA 25	RA 161	RA 6
RA 245	RA 54	RA 26	RA 162	
MW 38 ^b	RA 31	RA 28	RA 163	
MW 41	RA 294	RA 41	RA 164	
MW 43		RA 42	RA 165	
MW 44		RA 53	RA 166	
MW 66		RA 69	RA 167	
		RA 79	RA 168	
		RA 88	RA 169	
		RA 89	RA 170	
		RA 112	RA 171	
		RA 293	RA 172	
			RA 173	
			RA 174	
			RA 182	
			RA 183	
			RA 184	
			RA 229	
			RA 230	
			RA 231	
			RA 232	

^aOff-site residential well or TVA monitoring well.^bPGDP monitoring well (located on-site, monitoring required by ACO).

The major findings of the CH2M Hill Phase I Site Investigation include the following:

- The primary on-site contaminants in the shallow groundwater system are ⁹⁹Tc and TCE with occasional detectable toluene.
- No off-site contaminants were detected in the SGS, although one off-site SGS well indicated the presence of ⁹⁹Tc. However, this result was not substantiated by additional sampling and analysis.
- The primary off-site contaminants in the regional gravel aquifer are TCE and ⁹⁹Tc, with bis(2-ethylhexyl)phthalate seen occasionally; however, a source for bis(2-ethylhexyl)phthalate at PGDP has not been found.
- TCE and ⁹⁹Tc contamination was found on site.
- The following parameters were detected in one well each in the deep groundwater system: benzene, toluene, ethylbenzene, xylene, and ⁹⁹Tc. However, it should be noted that the BTEX compounds were detected in only one well for one sampling event. Other sampling events of the same wells showed no BTEX contamination, suggesting that detections of BTEX compounds in the deep groundwater system were erroneous.
- The parameters ²³⁴U and ²³⁸U were detected in several wells in the deep groundwater system at the detection limit. However, the uranium results are questionable because no pathway is evident for the uranium to reach the deep gravel system. Additionally, no uranium was detected in the RGA or SGS of these same well clusters. The anomalous uranium results for the deep groundwater system appear to be related to analytical difficulties.

Fig. 4.2. Off-site groundwater-sampling locations where ⁹⁹Tc and TCE were detected.

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Fig. 4.3. Wells sampled weekly and monthly.

Fig. 4.4. TVA wells sampled quarterly.

Table 4.5. Environmental restoration monitoring wells installed during 1990

Well	Monitored zone	Well	Monitored zone
120	McN ^a	137	RGA
121	McN	138	SGS
122	McN	139	RGA
123	RGA ^b	140	McN
124	RGA	141	RGA
125	RGA	142	RGA
126	RGA	143	SGS
127	SGS ^c	144	RGA
128	SGS	145	RGA
129	RGA	146	RGA
130	RGA	147	RGA
131	SGS	148	RGA
132	RGA	149	SGS
133	EoC ^d	150	RGA
134	RGA	151	RGA
135	RGA	152	RGA
136	RGA	153	SGS
		154	SGS

^aMcNairy Formation.

^bRegional gravel aquifer.

^cShallow groundwater system.

^dUndifferentiated Eocene sands.

4.2.1.4 State solid waste disposal regulations

Compliance-monitoring requirements exist at the KDWM-permitted facilities C-746-S and C-746-T. Sample frequency and analytes are dictated by the specific permit for each facility. Wells 16–19 and 38–44 (see Fig. 4.5) serve as monitoring stations for these facilities. These wells are sampled quarterly for the constituents in Table 4.6 and annually for the additional constituents in Table 4.7. Additionally, the wells are analyzed for chloride during the first and third quarters of each year.

4.2.1.5 RCRA 3004

Additional groundwater monitoring to be performed by the ERP relates to RCRA 3004(u and v) and CERCLA requirements for characterizing contamination from all nonregulated sources (i.e., SWMUs not regulated under a RCRA permit or interim status) at a facility that has had releases that may contaminate groundwater. Results of this monitoring will be used to determine and implement remedial actions as necessary to protect human health

and the environment. Prescriptive regulations, such as those governing RCRA interim status and regulated units, do not exist for remedial action groundwater monitoring at this time.

Sites at PGDP that are clearly SWMUs as defined by RCRA have been assessed in PGDP 1987a. This report contains a description of each unit, including its approximate location, size, and status; information on the types and amounts of waste (if known) associated with the unit; and a description of releases if available. Additionally, an initial determination has been made of the need for a RCRA Facility Investigation (RFI) for each unit. As a rule, all treatment, storage, or disposal units with known releases that were unmonitored, or for which the operating history was completely or partially unknown, were considered to need an RFI.

A second report under separate cover, PGDP 1987b, provides information on 24 known and potential spill sites on the PGDP plant site. While these sites are presented in a separate report from the SWMUs, they have been integrated into the PGDP

ORNL-DWG 90M12467R

Fig. 4.5. Existing on-site wells.

Table 4.6. Quarterly analytical parameters

Parameter	Method
Dissolved alpha	EC-1010
Dissolved beta	EC-1010
Suspended alpha	EC-1010
Suspended beta	EC-1010
Uranium	EC-1910
Flouride	EC-1330
Total organic halogens	
Total organic carbon	EC-1873
Chromium	EC-1400
Copper	EC-1400
Nickel	EC-1400
Iron	EC-1400
Lead	EC-1400
Zinc	EC-1400
Nitrate	EC-1400
Sulfate	EC-1500
PCBs	EC-1130
TCE	EC-1704
⁹⁹ Tc	EC-1860
pH	ES-14
Temperature	ES-14
Conductivity	EC-1240
Depth	ES-2
Color	EC-1220
Turbidity	EC-1880

Table 4.7. Annual analytical parameters

Parameter	Method
Americium	EC-1020
Cobalt	
Cesium	
Radium	
Hexavalent chromium	EC-1180
Dissolved solids	EC-1760
Alkalinity	EC-1005
Phosphate	EC-1610
Chloride	EC-1130
Calcium	EC-1400
Cadmium	EC-1400
Magnesium	EC-1400
Manganese	EC-1400
Sodium	EC-1400
Selenium	EC-1040

Table 4.8. Waste management units currently monitored at PGDP

Unit No. (from preliminary assessment)	Name
5	C-746-F classified burial ground
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

Fig. 4.6. Waste management units currently monitored at PGDP.

Table 4.9. Wells monitored at SWMUs

Well	Monitored zone	Well	Monitored zone
16	SGS ^a	46	RGA
17	RGA ^b	47	SGS
18	SGS	48	RGA
19	RGA	50	RGA
20	RGA	51	RGA
21	RGA	52	RGA
22	RGA	53	SGS
23	PCC ^c	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	PCCRGA	67	RGA
44	RGA	68	RGA
54	RGA	71	RGA

^aShallow groundwater system.^bRegional gravel aquifer.^cPorters Creek Clay.

Note: Wells 59–62 are residential wells located off-site and are monitored for background purposes.

ERP without regard for their classification. All these sites likely will require further investigation.

To date, no ERP groundwater monitoring has been initiated at SWMUs pursuant to RCRA 3004 u and v and CERCLA requirements. PGDP is awaiting guidance from EPA about which units are to be investigated under the HSWA permit. The HSWA permit is expected to be issued to PGDP in 1991.

4.2.1.6 Solid waste management unit monitoring

Groundwater monitoring is conducted at several SWMUs at PGDP (see Table 4.8, Fig. 4.6). Well installation at selected units began in 1979 and continued through the mid-1980s. This monitoring effort was initially based in part on DOE orders that required monitoring at low-level radioactive waste sites. Currently, with the exception of wells 23–27, these wells are monitored quarterly for the constituents listed in Table 4.6 and annually for the additional constituents listed in Table 4.7. Wells 23–27 are sampled only annually for the constituents listed in Table 4.7. As indicated earlier, many of these units are targeted for investigation under the

ERP. As characterization continues during these projects, monitoring at these facilities will be changed accordingly. A total of 38 wells, including wells located at C-746-S and C-746-T, monitor SWMUs (Table 4.9).

The 1990 monitoring data are presented in Part 2 Tables 4.6–4.10. The following paragraphs give a brief discussion of the SWMUs currently monitored.

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 (i.e., easily ignitable in air). To stabilize the uranium, 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 KDWM. Unit 10, the C-746-T inert landfill, is used for the disposal of fly ash from the steam plant and nonputrescible construction wastes such as wood

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, the monitoring well with the highest level of TCE and ^{99}Tc 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 UF_4 drum yard, consists of a large waste pile of crushed UF_4 drums. Unit 14, the C-746-E contaminated scrap yard, contains contaminated scrap metal generated during plant operations. Scrap material is separated 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 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.

4.2.2 Environmental Surveillance Monitoring

Implementation of groundwater surveillance monitoring, as prescribed by DOE Order 5400.1 and defined previously, is required during 1991. Formal definition of this new program as required by DOE 5400.1 is nearing completion, with implementation expected to begin when funding is approved.

Environmental surveillance monitoring will consist of two components. The first component will

require monitoring at the plant perimeter via installation of new monitoring wells and the use of selected wells installed during the ongoing environmental restoration groundwater investigation. The second component will require the use of selected residential wells in the area. The Groundwater Surveillance Plan for PGDP (Forstrom et al. in press) describes in detail the rationale and criteria to be used to design the plant perimeter and off-site water well surveillance networks for PGDP.

The 1991 Environmental Monitoring Report will present the results of this monitoring program under two new sections entitled "Plant Perimeter Surveillance" and "Off-Site Water Well Surveillance."

4.2.3 Groundwater Monitoring Results

Technetium was detected in many plant and off-site wells and is being investigated as part of the ERP. While it was, in many cases, below regulatory concern (<900 pCi/L), its presence indicates a release into the groundwater regime because there are no natural sources of ^{99}Tc .

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 ERP) will be needed to provide this evidence. A summary of results for wells by SWMUs and monitoring programs is presented below. Table 4.10 presents the parameter analyzed, the recommended limit, and the wells exceeding this limit.

Wells 47, 57, and 58, shallow groundwater system wells in the C-404 and C-749 areas, continue to yield samples with high TCE and/or ^{99}Tc concentrations. In addition, elevated levels of arsenic, chromium, and manganese were present in samples from one well each. Nearby wells 46, 48, 50, 51, and 67, completed in the regional gravel aquifer, provided samples during 1990 without detectable TCE concentrations and with ^{99}Tc levels below the reference level. Manganese concentrations were elevated in one well.

Wells 16–19 and 38–44 are used to monitor groundwater in the C-746-S and C-746-T areas. High levels of chromium, manganese, and TCE were present in samples from two wells each in the RGA. Three RGA wells produced ^{99}Tc concentrations above the reference level. The three shallow groundwater

Table 4.10. Annual and semiannual effluent monitoring at SWMUs

Parameter	Applicable value	Reference	Wells exceeding reference value at least once during 1990
Cr	0.05 mg/L	1	MW17, 47, 71
Cu	1.0 mg/L	2	None
Fe	0.3 mg/L	2	MW16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 39, 41, 42, 43, 46, 47, 48, 54, 57, 62, 63
Ni	None	NA	NA
Pb	0.05 mg/L	1	(Detection limit of 0.2 mg/L)
Zn	5.0 mg/L	2	MW23, 24, 26, 27
Total As	0.05 mg/L	1	MW88
Total Cd	0.01 mg/L	1	None
Total Pb	0.05 mg/L	1	None
Total Se	0.01 mg/L	1	None
Dissolved As	None	NA	NA
Dissolved Cd	None	NA	NA
Dissolved Pb	None	NA	NA
Dissolved Se	None	NA	NA
Ca	None	NA	NA
Mg	None	NA	NA
Mn	0.05 mg/L	2	MW18, 21, 22, 23, 27
Na	None	NA	NA
Cr ⁶⁺	None	NA	NA
pH	6.5–8.5 units	2	MW16, 19, 20, 22, 27, 38, 39, 40, 41, 42, 43, 44, 46, 47, 63, 65, 66, 67, 68, 71, 84, 86, 87, 88, 89, 90
Temperature	None	NA	NA
Cl	250 mg/L	2	None
NO ₃ -N	10 mg/L	1	None
SO ₄	250 mg/L	2	MW21
Turbidity	5 NTU	1	MW16, 17, 18, 19, 20, 21, 22, 23, 39, 41, 42, 43, 46, 47, 48, 54, 57, 62, 63, 64, 66
Color	15 units	2	MW22, 46, 57
F	4.0 mg/L	1	None
Conductivity	None	NA	NA
TOC	None	NA	NA
TDS	500 mg/L	2	MW16, 17, 18, 21, 23
Alkalinity	None	NA	NA
PO ₄ -P	None	NA	NA
TCE	5 µg/L	4	MW20, 21, 22, 38, 40, 41, 44, 47, 57, 66, 68, 71, 88, 91, 94, R2, R5, R17, R113, R157
PCB	None	NA	NA
TOX	None	NA	NA
U	None	NA	NA
²⁴¹ Am	1 pCi/L	3	MW16, 22, 26, 27, 40, 42, 63, 64, 65, 66
⁶⁰ Co	400 pCi/L	1	None
⁹⁹ Tc	900 pCi/L	1	MW66, 88, R2
²²² Rn	2 × 10 ⁷ pCi/L	3	None

Table 4.10 (continued)

Parameter	Applicable value	Reference	Wells exceeding reference value at least once during 1990
Dissolved alpha	None	1	NA
Suspended alpha	None	1	NA
Dissolved beta	None	1	NA
Suspended beta	None	1	NA
Gross alpha	15 pCi/L	1	MW66, R2, R17
Gross beta	50 pCi/L	1	MW20, 66, R2, R17, R113
Benzene	5 µg/L	1	MW47, 68, 69, 96
Toluene	2 mg/L	5	None
Xylene	10 mg/L	5	None
Ethylbenzene	700 µg/L	5	MW69, 96

NA = not applicable.

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.* 54(97) (May 22, 1989).

system wells produced water with high manganese levels. Well 20 continues to show elevated levels of TCE and ⁹⁹Tc. TCE and ⁹⁹Tc levels have increased over the 1989 levels reported. Iron and chromium concentrations exceeded the drinking water standards once each during 1990.

Wells 21 and 22 located at the C-616 lagoon indicate the presence of ⁹⁹Tc. Technetium and TCE exceed the reference standards in well 22, but no TCE has been detected in well 21. Both wells 21 and 22, based upon the one annual sample, show elevated manganese concentrations. Sulphate concentrations in well 21 are above the drinking water standard of 250 mg/L.

Wells 47, 52, 68, 69, 70, and 71 were monitored for petroleum products during 1990. No benzene, ethylbenzene, toluene, or xylene was detected in wells 52 and 70 during 1990. Well 47 showed slightly elevated levels of benzene, toluene, and xylene, with no ethylbenzene present. Well 68 had elevated levels of benzene, toluene, and xylene from May through September, with ethylbenzene remaining elevated. Benzene was the only petroleum product present in well 71. Wells 69 and 96 have elevated

concentrations of benzene, ethylbenzene, toluene, and xylene. Wells 47, 52, 68, and 71 show elevated concentrations of TCE and ⁹⁹Tc.

Wells 84 through 95 are located at the C-404 low-level waste burial ground. TCE was not elevated in wells 84, 85, 86, 89, 92, and 95 during 1990. All wells in this area indicate the presence of ⁹⁹Tc, with wells 84, 85, 88, 89, 90, and 94 having ⁹⁹Tc activities greater than 25 pCi/L during 1990.

Wells 52, 53, and 54 are located at the C-746-F burial area. Wells 52 and 53 were not sampled during 1990 because the pumps were inoperable. Iron concentrations in well 54 are extremely elevated.

Wells 68, 69, and 71 are located south of the C-400 decontamination building. No TCE or ⁹⁹Tc data are available for well 69. TCE and ⁹⁹Tc concentrations are elevated in wells 68 and 71.

Wells 23, 24, 26, and 27 are located on the southwest side of the plant. All wells show concentrations of zinc above the drinking water standards. Wells 23 and 27 reported manganese concentrations above the drinking water limit in 1990, and chromium was elevated in well 23.

Wells 63, 64, 65, and 66 are associated with the C-746 scrap yard. The highest concentrations of ^{99}Tc and TCE during 1990 were reported from well 66. An elevated ^{99}Tc level was also monitored in well 65. High chromium and manganese concentrations were reported also from single wells.

4.3 PROJECT ACCOMPLISHMENTS

As discussed in the introduction to Sect. 4, work continues under the auspices of the GWPP to address recognized deficiencies in the understanding of the site hydrogeology and geology (Early et al. 1989). Activities consist of specific projects performed and directed by the Environmental Restoration Department's Hydrogeologic Services Section (HSS) and the coordination of related activities conducted by other organizations. These activities are designed to complement existing compliance and restoration initiatives. Information from related activities is assimilated and analyzed with respect to addressing global deficiencies identified in the GMP.

The next two sections describe special projects that were conducted during 1991 and related projects that have served to augment progress toward characterization of the site.

4.3.1 Hydrogeological Services Section

The HSS has three main responsibilities: (1) oversee and maintain the PGDP GPP, (2) provide technical oversight and input on environmental restoration projects, and (3) provide technical services as requested to line organizations within the plant. Embodied within item 1 is implementation of the GMP, which identifies deficiencies in the understanding of the site flow system and prescribes activities to address these deficiencies. Toward this end, several activities designed to complement ongoing compliance and environmental restoration activities were conducted and/or completed during 1990.

4.3.1.1 Modeling

GeoTrans, Inc., was contracted to provide a calibrated three-dimensional numerical groundwater flow and transport model for the PGDP site. GeoTrans was chosen because it possesses relevant experience, having performed a similar study for the TVA Shawnee Steam Plant located just north of

PGDP. The project, performed under the direction of the HSS, consisted of a three-stage study completed with submission of the final report (GeoTrans, Inc. 1990), source code, and data files in October 1990.

The first objective of the study was to assimilate available geologic and hydraulic data to support model development. A general approach for the modeling effort was then defined and agreed upon by the HSS. Initial modeling efforts consisted of two-dimensional numerical modeling to identify roughly the sensitivity of the flow system to various parameters and to identify boundary conditions. The last stage consisted of developing the three-dimensional model and performing calibration and sensitivity runs. The model then was used to assess the current hydrogeologic conceptualization and to evaluate the effect of hypothesized paleochannels as preferential flow paths.

It was decided that insufficient data existed to support a far-field transport model. Particle tracking using the flow model was performed instead to assess possible advective transport pathways within the RGA.

The modeling effort and results from the study are discussed in great detail in the final report. Major conclusions resulting from the study are:

- The hypothesized paleochannels within the RGA, as modeled, do not appear to play a significant role in transport migration.
- The time to traverse the SGS to the RGA ranged from 6.5 to 29.3 years.
- Traverse time to the Ohio River, once contaminants entered the RGA, ranged from 7.1 to 20 years.

In addition, the analysis emphasized the following data needs in order of importance:

- additional water-level monitoring on the terrace face,
- expansion to a regional water-level monitoring program that is measured regularly and contemporaneously,
- delineation of transmissivity or gravel thickness near the Ohio River,
- continuous water-level measurements on the Ohio River and along a line of at least three wells,
- continued monitoring/construction of cluster wells,
- aquifer testing in typical areas,

be considered. The final report discussing the study is expected by April 1991.

CH2M Hill was asked to obtain monthly water-level measurements from up to 100 existing wells in and around the DOE Reservation. Additionally, as new wells are completed during Phase 2, they will be included in the monthly measurements. This project was initiated in October 1990 and will continue until the completion of Phase 2 of the Site Investigation, at which time HSS will assume responsibility for the water-level measurements.

Efforts to develop a sufficient level of understanding of the hydraulics and geochemistry of the flow system will continue through implementation of the GMP. Staff within HSS are assigned specific technical tasks related to areas of expertise that include geology, hydrogeology, and geochemistry. Every effort is made to gather and analyze all relevant data, with the overall goal of developing an adequate understanding of the site hydrogeology, geochemistry, and geology.

4.3.2 Related Activities

As indicated earlier, efforts are made to coordinate all related activities to ensure that maximum information is gained to augment the overall technical and programmatic goals of the GWPP. This is done by assigning a hydrogeologist within HSS to a particular related project. He or she tracks the project and provides technical input to ensure that the specific project objectives and the overall GWPP objectives are met to the extent possible. Specific projects are discussed below.

4.3.2.1 Environmental Restoration Program (CERCLA Phase 1, UST, HSWA)

Specific projects conducted by the ERP that will affect the GWPP are the Site Investigation, Phase 1 (completed, see Subsect. 4.2.1.3); Site Investigation, Phase 2 (ongoing during 1991); the C-750 UST investigation (ongoing during 1991); and

investigations expected under HSWA (see Subsect. 4.2.1.3).

Input was provided during 1990 by HSS to ensure that the design of the planned ERP projects was technically justifiable based on the current understanding of the site. Additionally, where possible, recommendations were made to ensure that the various projects complement one another and minimize replication of effort. Information from these projects will be used by the subcontractor to fulfill the stated objectives of each project and by HSS, where applicable, to ensure that the overall objectives of the GWPP are achieved.

4.3.2.2 Facility Safety Analysis Report

Work continues on development of the Facility Safety Analysis Report. Of particular interest to the GWPP is work related to natural phenomena that involves characterizing the seismic hazard and site hydrology.

The Gaseous Diffusion Plant Upgrade Program and the PGDP GWPP have similar goals in the area of subsurface hydrogeologic investigations and analyses. A meeting was held in December 1990 involving members of both programs to gain a more nearly complete understanding of the purposes of the two programs and to examine potential areas of cooperation. As a result of this meeting, it was agreed that quarterly technical workshops would be conducted to discuss efforts involving the geology, hydrogeology, and computer modeling. Also, key PGDP HSS personnel will become closely involved in the groundwater modeling effort conducted by the Upgrade Program. The PGDP HSS will potentially provide a summary and evaluation of the local geology and hydrogeology to support the safety analysis report effort.

Specific data from the upgrade effort have already been made available to HSS, including lithologic and geophysical data, stream gage data, and technical input relating to ongoing ER activities.

5. BIOLOGICAL SAMPLING

5.1 FOOD CROP AND TISSUE SAMPLING

The PGDP staff sampled food crops and animal tissue during 1990 from the vicinity of the Paducah plant. Animal tissue samples collected were deer, raccoon, squirrel, carp, bluegill, and a frog. Food crop samples collected were cucumbers, corn, squash, tomatoes, purple hull peas, peppers, cabbage, shelly beans, grapes, and persimmons. Figure 5.1 shows the locations where samples were obtained. Table 5.1 shows the concentration of various radionuclides analyzed (wet weight basis) in edible vegetation and animal tissue. Each was analyzed for ^{239}Pu , ^{230}Th , ^{235}U , ^{237}Np , ^{234}U , and ^{238}U . Only the radionuclides that were present above the detection limit (99% confidence level) were included.

Also displayed in Table 5.1 is the calculated worst-case dose from ingestion of each food crop over a 1-year period. The assumptions used in the calculations were that the individuals obtained one-third of their vegetables and one-fourth of their fruits from a garden in the vicinity of PGDP. The ingestion rates for each type of food were obtained from a national survey (95th percentile values). An individual was assumed to eat a portion of each food type every day of the year. The doses from each type of crop were significantly below 1 mrem/year. Assuming an individual eats produce from a garden containing all 10 types of crops represented by this sampling, the total dose is less than the DOE dose limit of 10 mrem/year from any one pathway.

All food crops sampled were obtained from areas in the vicinity of PGDP. Since no background locations were sampled, no comparison can be made. However, all doses are within the DOE recommendations for acceptable dose.

5.2 VEGETATION SAMPLING

Vegetation (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 regulations. Figure 5.2 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) distances as related to the primary emission point. Samples are delivered to the laboratory, air-dried for 1 month, digested, and analyzed for fluoride. Table 5.2 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 less than 5% to less than 7% of the standard.

5.3 DEER HARVEST

In August 1990, eight deer were harvested in the West Kentucky Wildlife Management Area (WKWMA) to monitor the effects of PGDP on the ecology surrounding the plant. In addition, two deer were harvested in the Land Between the Lakes area for background comparison. Liver and muscle samples were analyzed for metals, radionuclides, and PCBs. Bone and thyroid samples were analyzed for radionuclides, fat samples for PCBs, and hair samples for technetium. The results for muscle samples are shown in Table 5.3.

Fig. 5.1. Fruit, vegetable, and animal collection locations.

Table 5.1. Annual food crop and tissue sampling

Location ^a (sample)	²³⁷ Np (pCi/g)	²³⁹ Pu (pCi/g)	⁹⁹ Tc (pCi/g)	²³⁰ Th (pCi/g)	²³⁴ U (pCi/g)	²³⁵ U (pCi/g)	²³⁸ U (pCi/g)	Worst-case dose (mrem/year)
1 Raccoon	0	0	0	0	0	0	0	0
2 Squirrel	0	0	0.410	0	0.014	0	0	<i>b</i>
3 Squirrel	0	0	0	0	0.008	0	0	<i>b</i>
4 Carp	0	0	0	0.011	0.017	0	0	0.097
5 Bluegill	0	0	0	0	0.020	0.007	0	0.028
5 Frog	0	0	0	0	0	0	0	0
7 Deer	0	0	0	0	0.008	0	0	0.089
8 Cucumber	0	0	0	0	0.020	0	0	0.080
9 Grapes	0	0	0	0	0.017	0	0	0.057
10 Corn	0	0	0	0	0	0	0	0
11 Beans	0	0	0	0	0.008	0	0	0.035
12 Squash	0	0	0.216	0	0.009	0	0	0.110
13 Mix Veg	0	0	0	0	0	0	0	0
14 Peas	0	0	0	0	0.030	0	0	0.085
15 Squash	0	0	0	0	0.008	0	0	0.054
16 Peppers	0	0	0	0	0.012	0	0	0.043
17 Cucumber	0	0	0	0	0.011	0	0	0.040
18 Cabbage	0	0	0	0	0.010	0	0	0.140
19 Tomato	0	0	0	0	0.030	0.016	0.011	0.259
20 Corn	0	0	0	0	0.024	0	0	0.194
21 Corn	0	0	0	0	0.007	0	0	0.055
22 Corn	0	0	0	0	0.032	0	0	0.262
23 Persimmon	0	0	0	0	0.007	0	0	0.035
24 Persimmon	0	0	0	0	0.026	0	0	0.124
25 Persimmon	0	0	0	0	0.010	0	0	0.048
26 Persimmon	0	0	0	0	0.032	0	0	0.151

^aSee Fig. 5.1.^bNot calculated.

The ²³⁴U values were the only radionuclide results that were statistically different from zero. Also, one background deer showed detectable levels of ²³⁵U in the muscle, and detectable levels of ²³⁸U were observed in both background and reservation deer bone samples. The mean concentration of ²³⁴U for the reservation deer is 0.0097 pCi/g. The radiological data indicate no significant difference (95% confidence) between the concentrations of ²³⁴U in the reservation and background deer.

Potential health effects from ingestion of deer meat (muscle) were evaluated by ORNL. Analytical data on concentrations of PCBs and 27 metals were evaluated. Since all PCB concentrations were below the limits of detection, no evaluation was made of the potential PCB intake. Only seven metals were found at detectable levels, and these are all essential elements for humans.

The potential health implications from consuming deer from the PGDP reservation were evaluated by comparing metal concentrations in the deer meat to those typically found in domestic beef and by comparing possible intakes to U.S. EPA intake criteria. The metal concentrations were also compared to the background locations. The data (Tables 5.1 and 5.2 in Part 2) indicate no significant difference in metal concentrations found in the reservation and the background deer. There was also general agreement with concentrations found in composite samples of edible portions of domestic beef. Therefore, any risks associated with eating the deer from the PGDP reservation area are similar to risks from eating deer meat from the Land Between the Lakes area. Also, any risks would be similar to those associated with eating beef.

Fig. 5.2. Grass sampling locations.

Table 5.2. PGDP fluoride in grass, 1990 (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	3.9	13	7.7	7	c	c
G2	4	<3	8.2	5.6	6.6	c	c
G3	4	<3	3	<3	<3	c	c
G4	4	<3	3	<3	<3	c	c
G5	4	3.2	4	3.8	<4	60	7
G6	4	<3	3	<3	<3	60	<5
G7	4	<3	3	<3	<3	60	<5
G8	4	<3	3	<3	<3	60	<5
G9	4	<3	<3	<3	<3	60	<5
G10	4	<3	<3	<3	<3	60	<5
G11	4	<3	<3	<3	<3	60	<5
G12	4	<3	3.6	<3.2	<3.3	60	<6
G13	4	<3	3.6	<3.2	<3.3	60	<6
G14	4	<3	<3	<3	<3	60	<5
G15	4	<3	3.4	<3.1	<3.2	60	<5
G16	4	<3	<3	<3	<3	60	<5
G17	4	<3	<3	<3	<3	60	<5
G18	4	<3	4	<3	<3.5	60	<6

^aSee Fig. 5.2.^bKentucky Ambient Air Quality Standards (401 KAR 53:010): Fluoride measured 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.**Table 5.3. Annual deer harvest, 1990**

(Confidence that contaminants are present in samples is 99%)

Deer	Ca (µg/g)	Cu (µg/g)	Fe (µg/g)	Mg (µg/g)	Na (µg/g)	P (µg/g)	Zn (µg/g)	²³⁴ U (pCi/g)	²³⁵ U (pCi/g)
1	25	1.2	35	250	350	2,300	20	0.0046	a
2	22	1.2	27	270	310	2,500	18	0.0205	a
3	21	1.3	23	280	350	2,500	14	0.0105	a
4	23	1.3	24	280	290	2,500	17	0.0059	a
5	20	1.7	35	270	340	2,400	17	0.0062	a
6	19	1.4	44	250	230	2,300	16	0.0067	a
7	22	1.4	30	260	390	2,400	22	0.0057	a
8	17	1.5	35	240	280	2,300	12	0.0176	a
BG-1	25	1.0	34	250	300	2,300	24	0.0195	0.0068
BG-2	20	1.3	32	250	270	2,300	19	a	a

^aNot detected.

6. 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 reveal trends if they exist.

6.1 SOIL SAMPLING

Soil samples are taken annually at ten locations: north, south, east, and west at the property boundary and at distances of 8 km (5 miles) beyond the property boundary (see Fig. 6.1). 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 6.1 lists samples analyzed for parameters.

Table 6.2 gives the concentrations of uranium in soil samples from 1985 through 1990. The average uranium content of all property boundary samples is higher than the average for the 8-km (4.97-mile) samples and approximately two times the average for the background samples. The range of sample analyses during 1990 was from a low of 2.2 µg of uranium per gram of soil at the background site west of PGDP to a high of 7.1 µg/g at the south boundary. The concentrations of uranium in soil (Table 6.2) are typical of soils in western Kentucky.

Table 6.3 lists the concentrations for PCBs and radionuclides. No significant differences between property boundary locations and remote locations were noted. Analysis of each soil sample for 36 metals revealed no significant differences in concentration of any element among the locations. Concentrations of radionuclides in the soil showed a consistent increase over concentrations reported in 1989. Because the concentrations were higher in each group of samples, including background, the increases were probably due to laboratory variability.

6.2 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 6.2 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 that have absorbed pollutants may also be an important source of radioactive and chemical pollutants that enter the food chain.

Sediment samples were taken from 26 locations. Figure 6.3 shows the location of each sampling point.

Fig. 6.1. PGDP soil-sampling locations.

Table 6.1. Summary of collection and analysis frequencies of soil and sediment samples in 1990

Station	Parameter	Collection frequency	Sample type	Analysis frequency
<i>Soil^a</i>				
S1, S2, S3, S4, S5, S6, S7, S8, S9, S10	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
<i>Sediment^b</i>				
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	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	Annually	Grab	Annually

^aSee Fig. 6.1.Table 6.2. Concentrations of uranium in soil at PGDP, 1985–1990^a

(μg/g)						
Location	1985	1986	1987	1988	1989	1990
<i>Property boundary</i>						
S1 (north)	5	6	4.8	4.9	2.2	5.0
S2 (east)	3	5	3.4	4.6	2.4	3.9
S3 (south)	2	6	5.5	4.3	5.6	7.1
S4 (west)	3	3	2.5	2.2	1.4	3.3
<i>8 km from plant</i>						
S5 (north)	3	4	3.9	4.2	2.2	4.3
S6 (east)	2	3	2.6	2.3	1.1	2.5
S7 (south)	3	4	2.7	2.5	1.2	2.8
S8 (west)	2	4	2.8	3.4	1.2	2.9
<i>13 to 15 km from plant</i>						
S9 (south)	1	2	2.4	2.5	0.8	2.2
S10 (west)	2	3	2.9	2.1	0.7	2.7

^aSee Fig. 6.1.

Table 6.3. Radionuclide and polychlorinated biphenyl concentrations in soil at PGDP in 1990

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 (μg/g)
<i>Property boundary</i>								
S1 (north)	0.66	0.625	15.25	-0.014	0.030	0.940	0.090	<0.1
S2 (east)	0.56	0.840	14.70	-0.003	0.009	1.615	0.00	<0.1
S3 (south)	0.55	1.548	11.59	0.002	0.038	1.640	0.00	<0.1
S4 (west)	0.61	1.910	13.40	-0.011	0.019	2.120	0.35	<0.1
<i>8 km from plant</i>								
S5 (north)	0.69	0.560	17.24	0.006	0.004	0.800	0.72	<0.1
S6 (east)	0.69	2.450	13.20	-0.014	0.014	0.580	0.00	<0.1
S7 (south)	0.70	1.835	17.86	-0.005	0.004	1.300	0.190	<0.1
S8 (west)	0.69	1.210	16.10	0.006	0.012	2.650	0.042	<0.1
<i>13 to 15 km from plant</i>								
S9 (south)	0.71	4.000	16.10	-0.007	-0.007	1.090	0.032	<0.1
S10 (west)	0.71	0.233	18.56	0.007	0.006	2.295	0.040	<0.1

^aSee Fig. 6.1.

At each location a clean sampling scoop is used to obtain a sample (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 6.1 lists a summary of the collection and analyses frequencies.

Table 6.4 gives 1990 radionuclide and PCB data. Both radionuclides and PCBs are elevated at SS7, the C-615 sewage sludge. The sludge is drummed annually for storage. Sediments in the N/S diversion ditch, an on-site ditch, contain elevated levels of radionuclides and PCBs. Effluents from this ditch flow into the C-616 full-flow lagoon before discharge through KPDES outfall 001. Big Bayou Creek sediments (SS1) show levels of radionuclides above those at the upstream Big Bayou Creek station (SS20). In addition, Little Bayou Creek sediments (SS2) indicate levels above those found at the

upstream Little Bayou Creek station (SS21). During 1990, a public advisory was issued for the Little Bayou Creek area and signs were posted to make the public aware that prolonged exposure could result in a dose above background (see Subsect. 2.4.2, Environmental Radiation Survey). Many of the KPDES outfall sediments contain levels of radionuclides and PCBs above background. Cesium was present in all sediment samples and is present throughout the world from weapons testing.

A variety of metals is analyzed in each sediment sample. Metals analyses in each 1990 sediment sample were distinctly elevated above the 1989 metals data. PGDP had analyzed the 1990 samples, but not the 1989 samples. PGDP reanalyzed archived 1989 samples and selected 1990 samples. The analytical results were in good agreement, indicating the difference in the initial results was due to variability between the two laboratories.

Fig. 6.2. Routes of trace metals in an aquatic ecosystem. Source: Jinks and Eisenbud 1972.

Fig. 6.3. PGDP sediment-sampling locations.

Table 6.4. 1990 PGDP sediment data

Location ^a	⁹⁹ Tc (pCi/g)	²³⁷ Np ^b (pCi/g)	²³⁹ Pu ^b (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	9.37	0.075	0.021	1.90	0.31	7.90	0.48	24	<0.1
SS2 Little Bayou	1.35	0.012	0.009	0.49	0.05	3.50	0.19	39	0.2
SS3 N/S diversion ditch (L-13)	176.80	4.13	2.653	18.00	0.39	24.00	0.59	123	0.2
SS4 C-340 ditch (K-011)	0.16	-0.02	-0.004	2.400	0.01	11.70	0.19	48	<0.1
SS5 C-616 full-flow lagoon	10.09	0.069	-0.009	1.80	0.27	12.30	0.59	9	<0.1
SS6 C-616 sludge lagoon	0.57	0.058	-0.007	0.59	0.04	0.90	0.63	4	<1.0
SS7 C-615 sewage sludge	63.85	0.300	0.992	1.47	3.05	12.38	0.69	1850	41
SS8 C-335 ditch (K-001)	21.40	0.150	0	2.04	0.11	10.40	0.48	22	<0.1
SS9 overflow diversion ditch (K-003)	60.18	0.700	1.590	43.60	0.80	15.50	0.53	26	<0.1
SS10 C-337 ditch east (K-002)	0.33	0.006	-0.004	1.80	0.10	9.95	0.62	3	0.2
SS11 C-331 ditch (K-010)	0.64	0.003	0.072	1.01	0.05	8.13	0.47	4	<0.5
SS12 C-333 ditch (K-012)	1.32	0.012	-0.010	1.60	0.01	10.20	0.65	3	<0.5
SS13 southwest ditch (K-009)	1.30	0.027	0.010	0.65	0.07	7.00	0.64	2	<0.1
SS14 west ditch dam 7 (K-008)	19.20	0.045	0.068	1.70	0.10	5.12	0.55	14	<0.1
SS15 west ditch dam 8 (K-015)	3.15	0.260	0.14	2.90	2.64	13.08	0.42	17	<0.1
SS16 C-720 parking lot into southwest ditch	3.90	0.150	0.18	2.34	0.27	9.48	0.57	10	0.3
SS17 C-333 ditch into southwest ditch	2.21	-0.010	-0.003	2.04	0.11	8.60	0.65	2	<0.1
SS18 C-611 sludge	0.74	-0.011	0	16.09	0.08	5.04	0.71	3	0.3
SS19 upstream Big Bayou wooden bridge	0.04	-0.014	-0.010	1.23	0.07	5.00	0.70	1.4	<0.1
SS20 upstream Big Bayou (L-1)	0.10	0.012	-0.003	1.73	0.06	5.9	0.70	1.1	<0.5
SS21 upstream Little Bayou	0	-0.010	-0.005	2.30	0.11	15.74	0.70	3	<0.6
SS22 K-013	0.35	0.016	0	2.13	0.22	14.37	0.46	6	<1.0
SS23 K-016	0	0.011	-0.003	1.60	0.24	12.20	0.63	2	<0.1
SS24 K-017	0.47	0.020	0.010	2.02	0.12	12.69	0.60	3	<0.5
SS25 K-018	24.10	0.195	0.627	9.30	0.50	9.85	0.53	16	0.4
SS26 upstream of C-340 oil dam	8.80	0.044	0.002	1.59	0.19	14.00	0.21	507	4.7

^aSee Fig. 6.3.^bNegative numbers indicate that analytical result minus background is less than zero.

7. POTENTIAL RADIATION DOSE TO THE PUBLIC

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, to determine compliance with regulations, and to allow estimates of the radiation and chemical doses received by members of the public.

DOE Order 5400.1 limits the dose to members of the public to less than 100 mrem/year effective dose equivalent from all pathways resulting from the operation of a DOE facility. Knowledge of the demography and land use of the area surrounding the plant and identification of on-site sources have indicated certain radionuclides and exposure pathways by which groups of people can be exposed to radiation. Figures 7.1 and 7.2 give a comprehensive view of the pathways between radioactive materials released to the environment and human beings. In practice, only a few pathways are the major sources of exposure in any given situation. A preliminary assessment of risk from PGDP contaminants to the health of the public living off-site was conducted by CH2M Hill for the Phase I Site Investigation. This study identified four primary pathways that could potentially contribute greater than 1% to the total off-site dose: groundwater ingestion, sediment ingestion, ingestion of wildlife and food crops, and exposure to direct radiation. To assess fully the potential dose to the public, a hypothetical group of extreme characteristics is used to postulate an upper limit to the dose of any real group. The assumptions used to calculate the dose from those exposures are summarized in Tables 7.1–7.6 of Part 2. In addition, the dose from all pathways from atmospheric releases is also calculated as required for compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAP) regulations.

7.1 TERMINOLOGY

- *Committed effective dose equivalent* (CEDE) is the total internal dose (measured in mrem/year) received over a 50-year period resulting from the intake of radionuclides in a 1-year period. The CEDE is the product of the annual intake (pCi) and the dose conversion factor for each radionuclide (mrem/pCi).
- *Collective effective dose equivalent* is a measure in person-rem of long-term radiation effects over a wide area. It is calculated by multiplying the average dose within defined areas by the number of persons living in that area.
- *Effective dose equivalent* includes the committed effective dose equivalent from internal deposition of radionuclides and the dose from penetrating radiation from sources external to the body. This is a risk-equivalent value and can be used to estimate the health-effects risk to the exposed individual.

7.2 WATERBORNE RADIONUCLIDES

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. A survey of surface water and groundwater users in the vicinity of PGDP was conducted in 1990 to determine the number of residents using water wells within a 4-mile radius of PGDP and to determine the number of surface water intakes on the Ohio River within 15 miles downstream of the plant.

No residents or businesses that responded to the questionnaire reported using a private surface water intake on the Ohio River or on Little or Big Bayou Creeks for any part of their water supply. The nearest downstream water intake point on the Ohio River used for drinking purposes is at Cairo, Illinois, which

ORNL-DWG 91M-8296

Fig. 7.1. Pathways between radioactive material released to the atmosphere and individuals.

ORNL-DWG 91M-8297

Fig. 7.2. Pathways between radioactive material released to the groundwater and individuals.

is beyond the scope of impact from PGDP. Private groundwater wells were the major water supply of residents surrounding the Paducah plant. Most residents reported using water from their residential wells for drinking, irrigation, and domestic uses.

A dose to the maximally exposed individual from consuming well water can be calculated using the assumptions outlined in Table 7.1 of Part 2. Under conditions of continuous exposure, members of the public are assumed to ingest 730 L of drinking water per year. Based on this criterion, the dose to the maximally exposed individual from drinking well water contaminated with technetium at the PGDP detection limit (25 pCi/L) would be 0.024 mrem/year. This dose can be compared with the dose from ingestion of water contaminated at the Safe Drinking Water Act level of 900 pCi/L ^{99}Tc . This dose would be 0.85 mrem/year. A risk estimation was prepared for the Phase I Site Investigation to assess the potential risk to individuals who might have been previously exposed to contaminated groundwater.

7.3 DIRECT RADIATION

The exposed pathway for external gamma radiation was evaluated using the results of radiation surveys covering the banks of Little and Big Bayou Creeks and areas on Hobbs road across from the cylinder storage area. These areas were determined to have elevated radioactive contamination or elevated count rates. The dose values are the product of the exposure rate (mR/h) from the radiological survey and the exposure time at a particular location.

Exposures on Hobbs road are limited to through traffic; therefore, the exposure time is minimal and a dose will not be calculated. To determine a realistic exposure time for the Little Bayou Creek area, several assumptions were used. During 1990, the WKWMA allowed hunting and dog trials in this area for a period ranging from September 1 to March 30 (213 days). For exposure in the creeks, an individual was assumed to hunt every day during this period and spend a total of one-half hour in the Little Bayou Creek bed. This exposure time is probably exaggerated because signs are posted in this area stating that prolonged exposure could result in a dose above background. Using the maximum exposure rate measured in the creek as worst-case, the dose to this maximally exposed individual would be 4.15 mrem/year. These assumptions are summarized

in Table 7.6 of Part 2. Even using these extreme assumptions, the dose is within the guideline value of less than 10 mrem/year from any one pathway.

7.4 CONTAMINATED SEDIMENT IN LITTLE BAYOU CREEK

Exposure to contaminated sediment in Little and Big Bayou Creeks could occur during fishing, hunting, or other recreational activities. Contact and exposure may occur primarily through incidental ingestion of contaminated sediment or inhalation of contaminated particles. According to the exposure assumptions in Tables 7.2 and 7.3, Part 2, and the maximum detected concentration of each radionuclide in the sediment samples, the worst-case dose would be received by an individual who was assumed to spend time in the WKWMA every day during the season as in Sect. 7.3. The estimated total dose would be 0.65 mrem/year from this pathway.

7.5 INGESTION OF TERRESTRIAL FOODSTUFFS

Terrestrial wildlife, such as deer, can come into contact with contaminated soil, ingest plants that have taken up contaminants or have become coated with contaminated dust, or ingest contaminated water. Hunting is permitted in the Wildlife Management Area surrounding PGDP, and the limit for deer harvest is two deer per person per season. Assuming that an individual kills two average-weight deer and consumes the edible portions of those deer during the year, the dose to this individual based on the maximum detected concentrations of each radionuclide in the deer muscle would be 0.22 mrem/year. Uranium-234 was the only radionuclide present above the detection limits. Dose calculations are summarized in Table 7.4, Part 2.

Similarly, ingestion doses from homegrown fruits and vegetables were calculated using the assumptions summarized in Table 7.5 of Part 2. Using the maximum detected concentrations of each radionuclide in all ten food types, the worst-case individual dose is calculated to be 1.15 mrem/year. This assumes that an individual ate a portion of each food crop every day of the year. Both ingestion doses include radionuclides that are naturally occurring in addition to any contribution from PGDP.

7.6 AIRBORNE RADIONUCLIDES

In addition to the primary pathways, radioactive emissions to air 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. 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. These doses include exposure from all pathways represented in Fig. 7.1.

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 1990, meteorological data collected during 1990 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 also based on ICRP recommendations (ICRP 1977).

EPA regulations for emissions of radionuclides from PGDP to the atmosphere are regulated under NESHAP. Beginning in 1990, the NESHAP limit is 10 mrem/year effective dose equivalent to any

member of the public from all atmospheric pathways. Since use of the new limit is conservative with respect to the old limits and since it uses contemporary units, all dose estimates are presented as effective dose equivalents.

The calculated 50-year committed effective dose equivalent to the maximally exposed individual is estimated to be 1.8×10^{-4} mrem (well below the 10-mrem limit). Table 7.4 of Part 2 shows historical data for doses to the maximally exposed individual, who, under most circumstances, is the person living closest to the plant in the predominant wind direction. The maximally exposed individual for 1990 is located 3050 m (10,000 ft) north-northeast of the plant site.

The primary pathway of exposure is inhalation. Neptunium-237 is the primary contributor to the inhalation dose, and ^{99}Tc plays an important role in the ingestion dose calculations.

The collective dose equivalent is a good measure of long-term radiation effects over a wide area. The collective effective dose equivalent in 1990 for the 535,211 persons residing within 80 km (50 miles) of the plant site was estimated to be 1.5×10^{-3} person-rem from PGDP emissions. This can be compared with a collective dose for the same population of 2×10^5 person-rem/year from natural background.

7.7 CONCLUSIONS

Table 7.1 summarizes the annual dose from radiological contaminants that could potentially be received by a member of the public living near PGDP, assuming worst-case exposure from all major

Table 7.1. Summary of annual dose from radiological contaminants

Worst case combined exposure pathways

Pathway	Dose (mrem/year)	Percent of total
Ingestion of groundwater	0.024	0.4
Ingestion of sediments	0.65	10.5
Ingestion of foodcrops	1.15	18.5
Ingestion of deer meat	0.22	3.5
Direct external gamma—		
Little Bayou Creek	4.15	67.0
Atmospheric releases	0.00018	<0.1
Total annual dose		
all pathways	6.20	100.0

pathways. The calculated maximum combined dose is 6.2 mrem/year. This level is substantially in compliance with the DOE annual dose limit of 100 mrem/year. The major contributor to the dose is

direct external radiation that could be received by extended exposure to the Little Bayou Creek bed. This area has been posted to notify the public of that risk.

8. SOLID WASTE MANAGEMENT PROGRAM

8.1 DESCRIPTION

8.1.1 Purpose

The Solid Waste Management Program at PGDP is designed 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.

8.1.2 Regulatory Review

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 EPA to administer specific sections of RCRA in lieu of the

federal program. This authorization has resulted in the promulgation of regulations in the Kentucky Administrative Regulations (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 RCRA.

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

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.

8.1.3 Compliance Activities

Hazardous waste facilities at PGDP currently are operated under interim status granted by the state of Kentucky (facility EPA ID KY8890008982). The Part A application is updated as hazardous waste management needs dictate. Part B applications have been submitted for the eight 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 a permit is issued, PGDP facilities will continue to operate according to the interim status provisions of 401 KAR Chap. 35.

8.1.4 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 Permit application; 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 Kentucky Pollutant Discharge Elimination System (KPDES) Permit under the CWA. RCRA characterizations are performed periodically on these wastes at the point of generation and, where necessary, following treatment.

To facilitate waste management activities, a new Generator Waste Management Program was developed. Implemented in 1990, the program focuses on the proper identification, segregation, and packaging of wastes at the point of generation. Following completion of a successful pilot program in the C-720 area, implementation in the rest of the plant is under way.

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, avoiding or minimizing 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 reducing waste stream toxicity and hazard through the use of less toxic or hazardous raw materials or limiting the use of toxic and hazardous materials. For example, limiting the use of TCE to large degreasing units and using less toxic solvents in the field has reduced the quantity of waste oil requiring disposal as a hazardous waste. Installing new treatment processes or modifying existing processes can also reduce waste stream toxicity and volume. Segregating 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.

8.2 WASTE GENERATION

8.2.1 Types of Waste Generated

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

Inert (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 parts per million (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 in soil, >0.5 parts per billion (ppb) in water, and >2 ppm in oil) PCBs are disposed of as PCB wastes but are not classified as such.

PCB/radioactive. 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 ^{239}Pu and ^{237}Np . A small quantity of this type of waste is stored at PGDP. This waste is not currently produced at the plant.

Low-level radioactive. This category consists of any nonhazardous, non-PCB or PCB-contaminated, or nontransuranic waste containing uranium ≥ 17 pCi/g total uranium activity and/or containing uranium with

a determinable assay >0.711% and/or containing detectable quantities of Tc, Np, Pu, Am, or other reactor-produced or artificially created radionuclides.

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.

8.2.2 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. Sewage treatment sludges contain 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; 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 and waste from a small-parts nickel-deplating process. The lime

precipitation process waste is occasionally a mixed waste.

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 also are 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.

Environmental restoration activities. PGDP has begun an extensive Environmental Restoration Program (ERP) 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.

8.2.3 Waste Generation Summary

Table 8.1 summarizes the waste generated on-site during 1990. The types of waste are described in Sect. 8.2.1. The quantities are indicated in the table.

The most significant changes in waste generation rates between 1989 and 1990 occurred in the low-level radioactive waste (LLW), hazardous, and mixed waste areas. The increase in the hazardous and mixed waste categories was primarily due to the implementation of the toxicity characteristic leaching procedure test. This procedure resulted in reclassification of some previously nonhazardous wastes as hazardous or mixed in 1990.

Uranium-contaminated waste oils represent the major type of waste that was reclassified as mixed.

Table 8.1. 1990 PGDP waste generation summary

Waste type	Volume (m ³)	Mass (kg)
Hazardous	52.7	55,207
Mixed	53.4	49,309
Residential	4,746.0	NA ^a
Inert	2,144.0	NA
PCB	150.0	77,318
PCB/radioactive	85.0	82,321
Low-level	685.0	536,167
Asbestos	48.0	NA
Classified	0.0	0
Clean metal	404.0	NA
Contaminated metal	264.0	NA
Miscellaneous nonhazardous	44.0	33,600

^aNot applicable.

The increase in LLW was due to two factors. First, 86,300 kg of material previously classified as "Recoverable" was redesignated as LLW in 1990. The reclassification was due to the shutdown of off-site recovery processes. Second, approximately 367,750 kg of radioactivity contaminated soils were generated by KPDES compliance projects.

8.3 WASTE MANAGEMENT ACTIVITIES

8.3.1 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 (DOT) 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/radioactive 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 LLW 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.

8.3.2 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 8.2 shows the 1990 waste treatment data; Table 8.3 shows the 1990 on-site disposal information. The PGDP waste management units are listed in the following subsection.

Table 8.2. 1990 PGDP waste disposal

Waste type	Quantity (m ³)	Treatment
Uranium salvage (mixed)	3.6	Neutralization/precipitation
Machine coolant (nonhazardous)	11.4	Coagulation/filtration

Table 8.3. 1990 PGDP on-site waste disposal

Waste type	Disposal method	Quantity (m ³)
Residential	Landfill	4,746
Inert	Landfill	2,144

8.3.2.1 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 190,890 L (50,500 gal).

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 190,890 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 454-L (120-gal) stainless steel steam-heated tank.

C-400-D lime precipitation tank. A 16,254-L (4300-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 a 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.

8.3.2.2 PCBs and PCB/uranium waste facilities

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.

8.3.2.3 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 recycled off-site.

8.3.2.4 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.

8.3.2.5 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.

C-746-M storage building. A diked, totally enclosed drum storage area. The capacity of the area is approximately 60 drums.

8.3.3 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 and approved 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 8.4 shows the off-site waste treatment/disposal quantities for 1990.

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

8.3.4 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 1990 will be retained on-site in storage until suitable disposal options are available. Several waste streams including mixed and PCB/radioactive wastes cannot be disposed of currently by any means. These wastes are placed in indefinite storage on-site (see Table 8.5). The quantities in the table represent the total amount of waste in inventory at the end of 1990.

8.3.5 Special Activities

8.3.5.1 Waste generation program

To improve regulatory compliance and reduce costs associated with waste management activities, a waste generation program was developed and implemented in the C-720 Maintenance Facility. The program established waste identification, segregation, packaging, and management standards for waste generators. The program has eliminated the presence of unidentified waste containers, improved waste segregation practices, and prevented the buildup of wastes in generation areas. Full implementation is scheduled for 1991.

8.3.5.2 Waste treatment technologies demonstrations

In conjunction with the Process and Long-range Technical Support (P&LRTS) Program, requests for expressions of interest in treating two PGDP waste streams (cooling tower debris and PCB/radioactive wastes currently in storage) were distributed to commercial waste treatment and disposal firms. A number of firms responded positively, and a qualified bidders' list was established. Technology demonstration projects will be under way in 1991.

8.3.5.3 Off-site low-level waste disposal

At the direction of DOE/ORO, PGDP began developing a program to dispose of LLW at other DOE facilities. PGDP personnel visited the Hanford Reservation in Washington state, and Hanford personnel conducted a preliminary audit of the PGDP waste management and certification program. Tentative plans are to initiate shipments in 1992.

Table 8.4. 1990 PGDP off-site waste disposal

Waste type	Disposal method	Quantity	
		(m ³)	(kg)
PCB	Incineration	91.6	100,930
PCB (solids)	Landfill	41.5	48,879
PCB		155.0	28,061
transformers	Smelter		
Hazardous	Incineration	105.9	88,393
Hazardous	Landfill	1.5	35

9. SPECIAL STUDIES

PGDP had a total of 536 spills or releases of various types of materials during CY 1990. A record of each incident is kept by 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. Occurrences are categorized and notifications made in accordance with DOE Order 5000.3A "Occurrence Reporting and Processing of Operations Information."

Most of the spills during CY 1990 were from PCB gaskets (Fig. 9.1). A total of 261 incidents of leaking PCB gaskets was recorded during CY 1990. Troughs are installed beneath leaking ventilation gaskets immediately upon discovery of leaks. All gasket leaks were inside buildings. Highlights of the incidents are given in Sects. 9.1 through 9.1.11.

9.1 UNUSUAL OCCURRENCES

9.1.1 Chromated Water Spill: C-335 Process Building

On January 10, 1990, maintenance activities were being performed on the "A" booster water strainer. Approximately 400 gal of recirculating cooling water (RCW) containing 18 parts per million (ppm) sodium bichromate was released when a test valve broke due to corrosion. The water was contained inside the building. Composite sampling was initiated on outfall K001 and indicated chromium concentrations were below Kentucky Pollutant Discharge Elimination System (KPDES) Agreed Order limits. The water was drummed for disposal.

9.1.2 PCB Capacitor Failure: C-533 Switchyard

On April 26, 1990, two large high-voltage PCB capacitors in the "E" bank failed. The failure resulted

in a release of approximately 4 oz. of 82 to 100% PCB onto the gravel below the capacitor bank. E-bank was taken out of service and the failed capacitors were removed for disposal. The spill site was cleaned up and closed out under the TSCA PCB spill cleanup policy.

9.1.3 Diesel Fuel Spill: C-611 Diesel Generator

On July 11, 1990, a fuel line fitting failed, releasing approximately 20 gal of diesel fuel into the basement of C-611. The line, which fed the generator from an outside storage tank, was valved off. Area drains were isolated and the free liquid was cleaned up with absorbent materials. Some diesel did reach the plant drainage system, as evidenced by a sheen on the sludge and secondary lagoons into which the building effluents drain. Absorbent booms/pads were used to contain and clean up the release.

9.1.4 Chromated Water Leak: C-337 Truck Alley

On July 24, 1990, chromated water was noticed seeping up through cracks in the concrete of the C-337 truck alley. An RCW line had developed a leak due to corrosion. The RCW was flowing into a storm drain at approximately 5 gpm. It was estimated that 400 gal entered the storm drain system before the drain was plugged. Effluent at KPDES outfall K002 was contained with a sandbag dam and an inflatable plug. The water was pumped for transfer to the cooling tower basins and composite sampling was initiated to ensure that the release had been contained. The RCW line was taken out of service and repaired. No KPDES noncompliance occurred as a result of this leak.

9.1.5 Sprinkler Water Spill: C-333 Filter Room 2

On July 30, 1990, a leak developed in the A-6 sprinkler system inside filter room 2. Approximately

Fig. 9.1. Spills or releases at PGDP during 1990.

4000 gal of water leaked to the diked area inside the filter room. About 5 gal overflowed to the ground outside of the building. The water was pumped into storage tanks for characterization and treatment/disposal. No water reached the plant drainage system.

9.1.6 Chromated Water Spill: C-633 Cooling Tower

On July 31, 1990, an elevated result in a routine hexavalent chromium grab sample prompted an investigation into possible sources. A concentration of 0.61 mg/L Cr⁶⁺ was indicated at KPDES outfall K012, while just upstream a pool containing approximately 2000 gal of water was discovered to have 7.6 mg/L Cr⁶⁺. The flow at K012 was contained and the water pumped for transfer to the cooling tower basins. A 60-in. RCW supply line was discovered to be leaking underground, allowing the chromated water to seep into the storm drain system. Pumping of the effluent to cooling tower basins continued until the leaking line was uncovered and repaired and sampling indicated acceptable discharge

levels of chromium. No KPDES Agreed Order limits were violated as a result of the spill.

9.1.7 PCB Capacitor Failure: C-331

On August 4, 1990, a large high-voltage PCB capacitor failed, releasing approximately 0.5 gal of 100% PCBs. The oil was discovered puddled on the floor surrounding the capacitor cabinet. Power was shut off to the bank and absorbent materials were used to contain the spill. The capacitor was removed for disposal, and cleanup was initiated in accordance with the TSCA PCB spill cleanup policy. This cleanup included removal of free liquid and double wash/rinse of all affected surfaces, followed by statistical sampling for verification. Verification is pending.

9.1.8 Potential Devices Leaking PCBs: Plant Switchyards

On September 4, 1990, during a routine inspection of plant switchyards, approximately 60 potential devices (PDs) on the Oil Circuit Breakers (OCBs) were found to have PCB oil drips, weeps, and

leaks. Only four had leaks that actually hit the ground, and the rest had drips or weeps forming on the cabinets. According to TSCA regulations, any PCBs on the external surface of equipment are a spill and must be treated accordingly. The PDs contain small PCB capacitors that apparently leak inside the PD cabinet. Eventually the leaks inside migrate through seams onto the external surface. The OCBs were immediately flagged and labeled as PCB spill sites, and the external surfaces were decontaminated in accordance with TSCA PCB regulations. However, full compliance with the regulations will not be achieved until the leaking PDs are replaced. There is a replacement project currently under way; until it is completed, the PDs must be inspected on a daily basis and any new leaks cleaned immediately.

9.1.9 Sludge Discharge: C-616-E Lagoon

On September 12, 1990, during routine mowing activities at the C-616-E lagoon, a cleanout on the sludge discharge line from the C-616 clarifier was damaged. This caused the release of approximately 400 gal of sludge-bearing water onto the ground. Shutting down the sludge discharge system then resulted in approximately 100 gal of the water overflowing into a plant drainage ditch. The sludge discharge water contains chromium (III) hydroxide and residual iron (II) sulfate. The cleanout was repaired and spilled material was cleaned up and drummed for disposal. Sampling was conducted of KPDES outfall K001 as a precautionary measure. No KPDES noncompliances occurred.

9.1.10 PCB Capacitor Failure: C-331

On October 22, 1990, a capacitor failed in the C-331 building, spilling approximately 3 gal (30 lb) of 100% PCB oil. The spill was immediately contained within the building, and the area was flagged and marked as a PCB spill site. Cleanup was initiated in accordance with TSCA PCB regulations. Sample results for verification of cleanup are pending.

9.1.11 Current Transformer Failure: C-533 Switchyard

On December 27, 1990, approximately 345 gal of non-PCB oil was released when the Y-line A phase current transformer (CT) failed. The oil spread over a large area of the switchyard gravel. Due to water flow

from the fire sprinkler system and heavy precipitation, the oil leached out of the switchyard and into KPDES outfall K012, forming a visible sheen on the ditch. On one occasion, the sheen broke through containment devices and reached Little Bayou Creek, prompting reports to Kentucky Division of Water and the National Response Center. Approximately 120 55-gal drums of gravel and soil have been excavated from the switchyard in an effort to remove as much of the free oil as possible. Efforts to contain and remove the oil from K012 are ongoing.

9.2 SPECIAL STUDIES

9.2.1 Uranium Release Study

Review of uranium quantities being discharged from KPDES Outfall 001 has shown an increasing trend in recent years. A contaminant-tracking sampling study was developed in early 1990 to address the potential problem. This study included monitoring of areas suspected of contributing to the total uranium discharge. Several locations were eliminated from the sampling plan, which indicated that they either were not major contributors or were contributing a known amount to the total uranium discharges.

Based on the data generated by this study through September, two areas were identified as major contributors to the total uranium discharge. Batch releases from the C-400 uranium treatment system contribute to the total concentration. A Best Available Technology (BAT) treatment evaluation is currently being performed on this operation. Recommendations for improvements to the system should allow further minimization of its contribution. The metals scrapyard has also been determined to be a major contributor of uranium to liquid effluents that flow from Outfall 001 during rainfall. The cause of the increase in uranium contributions from the area has not been directly determined. The extent of the contamination and possible remediation is being investigated as part of the Phase II Site Investigation Program.

The average concentration of uranium discharged from Outfall 001 for 1990 equals 4.52% of the discharge standard. This represents a 65% increase over 1989. Although this level is well below the limit, PGDP will continue environmental monitoring activities to track and trend the releases.

9.2.2 National Environmental Policy Act

Implementing 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 enhance the quality of the human environment and to avoid or minimize any possible effects of its actions upon the quality of the human environment.

During 1990 the NEPA section added two employees. Programs that have continued in 1990 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 1990 approximately 109 categorical exclusion determinations were submitted for approval, and 24 action description memorandums were issued to DOE for approval. Several field trips to construction sites have been documented. In addition, approximately 5500 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. Two environmental assessments were issued. No impact statements were issued during 1990.

9.2.3 Environmental Advisory Committee

The PGDP Environmental Advisory Committee is composed of five individuals who represent a cross section of scientists, educators, health professionals, and local businessmen. The committee was formed in 1986 and has been chartered with the following responsibilities:

- review the sources of environmental pollutants, the control systems, and the surveillance activities associated with operation of PGDP;
- evaluate plans for remedial activities and studies to correct, enlarge, or close waste management facilities, and provide recommendations for appropriate changes in strategy or direction;
- assess the long-term fate and health effects of trace quantities of uranium, other radionuclides, and other pollutants of concern in PGDP environs;
- advise on both scientific and community-concern aspects of environmental and health issues to the PGDP plant manager or the Director, Office of Environment, Safety, and Health, Martin Marietta Energy Systems, Inc., and
- advise on appropriate methods and forms of reporting environmental and health data to the general public.

The existence of the PGDP Environmental Advisory Committee is expected to continue until current needs are assessed and environmental problems are resolved.

During 1990, the PGDP Environmental Advisory Committee continued to participate in reviewing PGDP environmental programs. Two meetings were held in 1990 (May and November). The topics discussed at these meetings included the following:

- environmental nonconformance issues
- PGDP Tiger Team assessment (review process and findings)
- groundwater investigation update (Phase I)
- groundwater investigation (Phase II Work Plan)
- PCBs in Big and Little Bayou Creeks
- FSAR upgrade
- NESHAP air monitoring
- asbestos building survey results
- underground storage tank investigation/removal
- PCB gasket Federal Facility Compliance Agreement

The information exchange between PGDP and the Advisory Committee members continues to be utilized to improve PGDP's environmental programs and its relations with local community members.

9.2.4 PCB-Contaminated Ventilation Duct Gaskets

Buildings at PGDP contain ventilation duct systems for heating and cooling of both personnel space and process equipment. The gaskets in a number of these systems contain varying levels of PCBs. The gaskets therefore constitute non-totally enclosed PCB activities, which are prohibited by 40 CFR 761.20(a). Certain systems (notably the motor exhaust duct systems) have come in contact with leaching media (chiefly oil), resulting in migration or drips of PCBs to the floors of the process buildings. These drips of PCB-contaminated oil are considered PCB spills.

Three mechanisms have been identified that cause PCB leaks from the ventilation duct gaskets. First, oil is drawn into the motor exhaust duct systems along with exhaust air from the motors. The oil comes from leaks in the process motor bearings. Once in the duct, the oil will contact and saturate the gaskets in the duct system. It leaches PCBs from the gaskets and then drips onto the process building floor below the duct. Second, some PCB-contaminated oil drips occur when oil from equipment leaks on the second floor of the process buildings migrates through penetrations in the floor and falls on top of the ducts. If the oil falls on a duct gasket, a PCB-contaminated oil drip can occur. Third, PCB drips from gaskets are possible without oil as a leaching medium during very high temperature excursions. Physical properties of the gasket components appear to be temperature dependent. The preceding two mechanisms can occur in either the motor exhaust or supply duct systems. However,

installing spill containment/collection systems below the gaskets will contain PCB-contaminated drips resulting from these two mechanisms in the same manner as drips caused by oil within the motor exhaust duct systems.

Therefore, one of the ongoing actions that has been implemented is the installation of spill containment/collection systems below leaking gaskets. The systems consist of either polyvinyl chloride (PVC) or sheet metal troughs installed underneath the gaskets and PVC piping manifolds that connect large numbers of the troughs to common PCB oil collection points. Approximately 5000 of these troughs have been installed through 1990. Also, a program for documenting and tracking newly identified PCB gasket drips is ongoing at PGDP to meet EPA PCB spill cleanup requirements. The major components of this program are documenting and identifying new spills, containing the spills by installing spill containment/collection systems, decontaminating the spill area, and verifying cleanup by post-cleanup sampling and analysis.

DOE and EPA are negotiating an agreement concerning compliance with TSCA and the PCB Regulations found at 40 CFR 761. The agreement will allow the use of PCB gaskets and spill containment/collection systems at PGDP. It will require installing containment/collection systems on all motor exhaust duct gaskets. A line item project is continuing to accomplish this task. Engineering design was initiated during March 1991. The most recent total estimated cost of this project at PGDP is approximately \$20 million dollars.

10. QUALITY ASSURANCE

Quality assurance (QA) planning is integrated into every step of the environmental surveillance and monitoring 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 and monitoring programs 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 Laboratory Department, the Environmental Services Department consisting of the Environmental Sampling Section, and the Quality Support Section are continuing to implement two laboratory internal programs to monitor the quality of analyses reported on surface water and groundwater samples. These programs use purchased certified standard materials prepared by Measurements Control that are submitted according to regulatory guidance to the groups performing the analyses. These results are used to assess lab performance and to provide more immediate feedback to analysts and customers involved in the programs.

The report for surface monitoring will be issued on a quarterly basis to inform lab supervisors and managers of data quality measurements in the Technical Services Division. The section has added a professional position to provide backup to the Measurement Control functions and to coordinate procedure preparation. This has resulted in a schedule and reminder system for writing and updating procedures, and development of a specific format for procedures that meets plant policy.

In the Environmental Sampling Section, the surface water/ambient group has started using the new flow-monitoring devices installed as part of an engineering project to upgrade the sampling locations. These devices were built to EPA specifications to monitor flows to be reported in the Discharge Monitoring Report. A new procedure was

implemented to calibrate the field Total Residual Chlorine (TRC) analyzer. The procedure involves immediately comparing field instrument results to the referee amperometric titration method for determining TRC, eliminating the concern about volatile standard material.

The groundwater group has prepared a schedule for well-sampling activities to better utilize manpower and equipment and coordinate with laboratory and external contractor schedules. A monthly report was begun to update Environmental Restoration personnel in charge of these scheduled activities on the status of the activities and on problems encountered in carrying them out. A purge water collection procedure was written and implemented to separate water known to need treatment from water that could be discharged to surface drainage ditches. This procedure reduced the analytical workload and the amount of waste materials on the plant site. A professional position was created for supervising groundwater activities because of the increased workload and complexity in this area. Personnel in both groups in the Environmental Sampling Section have attended courses in groundwater sampling and Office of Safety and Health Administration hazardous worker training.

The Organic and Process Analysis Section of the Analytical Laboratory Department has procured analytical instruments and equipment to provide greater capacity for sample analyses and better quantification, or improved sample preparation. One gas chromatograph/mass spectrometer (GC/MS) and one gas chromatograph (GC) and autosampler were purchased to increase analytical capability. The new GC will allow the laboratory to lower further its lower reporting limit for PCBs. A purge and trap device for the GC/MS was obtained to improve sample quantification by rigidly controlling sample injection. A Lab Data System (LDS) also will enhance sample quantification by making more

consistent recognition of chromatographic patterns possible and retaining these data for future use. Two liquid/liquid extractors and a concentrator were put into use to aid in sample preparation for PCB analysis.

The Spectroscopy and Microanalysis Section has added three staff members to meet the need for more metal analytical data. Several actions have been taken to reduce potential contamination in the analysis of metals. Glassware has been dedicated to Kentucky Pollutant Discharge Elimination System (KPDES) surface water analyses to eliminate the chance of cross contamination from high-level process or waste samples. Metal hoods have been lined with Teflon to prevent metal flakes from entering the digestion apparatus. Teflon tubing also has been applied to metal tips on dishwasher trays. These trays have metal rods over which glassware, such as volumetrics and breakers, are hung. The movement of the glassware was thought to cause metal particles to embed in the glass. The particles then might be extracted when acidified samples are left in the glassware for a significant time. Finally, a new digestion procedure from the EPA 600 Series for sediments and soils eliminates a concentration step, thus reducing the blank associated with the analysis and the sample turnaround time and freeing an analyst for other work. The new procedure also has eliminated a digestion step using HCl for silver, thallium, and lead. In past analyses, the recovery of these elements was poor due to their insolubility as chloride compounds or volatility.

A new staff member has been added to the Inorganic Analysis Section. The Chemical Analysis Lab has begun to use Analis control charting capabilities for producing control charts to monitor analytical results.

The Radiochemistry and Analytical Mass Spectroscopy Section has purchased new analytical equipment and computer software. A new liquid scintillation counter will increase analytical capability and result in lower background limits. Thirty-two alpha spectrometers were purchased and assembled for future use in transuranic analyses. Both types of instruments came with computer software, and a new set of software was purchased to handle quality assurance/quality control data and checks. A microwave sample preparation system was implemented to allow improved digestion and evaporation of sample material. All low-level

environmental work was confined to a clean area containing dedicated equipment and glassware to prevent contamination. One professional and one technician were added to the section's staff.

10.1 SAMPLING QUALITY ASSURANCE

10.1.1 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 10.7 of Part 2 lists these procedures.

10.1.2 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 10.1 of Part 2 lists

the analytical procedures. See Subsect. 10.2.2.4, Tables 10.21 and 10.22 (Part 2) for quality control (QC) data.

10.1.3 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 10.2, 10.3, and 10.7 of Part 2. See Subsects. 10.2.2.1 through 10.2.2.3 and Tables 10.8 through 10.21 (Part 2) for QC data.

10.1.4 Groundwater Monitoring

Water samples from plant wells are collected according to written procedures based on published guidelines (U.S. EPA 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 10.2, 10.3, 10.6, and 10.7 of Part 2. See Subsects. 10.2.2.1 through 10.2.2.4 and Tables 10.8 through 10.21 (Part 2) for QC data.

10.1.5 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 10.4 of Part 2.

10.1.6 Soil and Sediment

Samples of soil and sediment are collected according to published procedures (Watson 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 10.5 of Part 2. Because of sample loads in the Paducah analytical laboratory, these samples were analyzed at Oak Ridge National Laboratory (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.

10.1.7 External Gamma

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

10.1.8 Solid Waste Monitoring

Solid waste sampling and characterizations are conducted to ensure storage and disposal of solid waste in accordance with TSCA, RCRA, and DOE Order 5820.2A. Requests for both routine and special sampling and characterizations are issued by Environmental Compliance and Waste Management personnel. Guidance for sampling and characterization is obtained from EPA guidelines (U.S. EPA 1987) and other applicable regulations. Records are maintained in field logs, laboratory notebooks, and chain-of-custody books, and in the AnaLIS data management computer system. Results from RCRA evaluations of waste streams and special

RCRA evaluations are summarized in quarterly, semi-annual, and/or annual reports.

10.2 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 10.1 through 10.6 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.

10.2.1 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 Technology, EPA, or 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 10.8 and 10.9 (Part 2) are examples of some of these programs.

10.2.2 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 EPA, DOE, and even the commercial sector. The PGDP laboratories participate in these external programs. Examples are given in Tables 10.10 through 10.21 (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 10.8 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.

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

EPA conducts a national QA program in support of the National Pollutant Discharge Elimination System (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 10.10 (Part 2) shows all parameters within acceptable limits.

10.2.2.2 Proficiency Environmental Testing Program

The PGDP laboratory participates in the Proficiency Environmental Testing Program (PET), a voluntary external measurement control program, using samples purchased from the Analytical Products Group (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 10.11 through 10.16 (Part 2) present the results of the 1990 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 534 measurements, 2 were deemed not acceptable. Refer to Sect. 10.3 for information about investigations.

10.2.2.3 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. Of 64 measurements, 3 were outliers (Part 2, Tables 10.17 through 10.20). The performance evaluations for these tables are provided by NIOSH. The laboratory maintained a "proficient" rating for all analyses through 1990. Refer to Subsect. 10.3 for information about the investigations.

10.2.2.4 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 Tables 10.21 and 10.22 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 25 results reported.

10.3 QUALITY INCIDENTS

10.3.1 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 November 1990 round had two results rated "not acceptable." Investigation showed that reported values for both high-level orthophosphate and nitrate-nitrogen were calculated incorrectly because of a nonroutine dilution. Both results are analyzed from the same solution on the same instrument; therefore, the error in both values resulted from the same analysis error. Recalculation of the raw data resulted in values within acceptable limits. The error did not affect routine analyses. All internal QC checks were in order. The results for the low-level samples were within acceptable limits for both analyses.

In addition to the external program from PET, an internal program was used in 1990 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 the quality of the analytical results it is using in reports to regulatory agencies.

10.3.2 Proficiency Analytical Testing Program

The chromium and lead outliers in the October 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.

The asbestos outlier in the October round of this program was investigated, but no specific cause was determined. All internal QC was within acceptable limits. It was noted that for the sample involved, 123 laboratories reported results that were outliers, with 94 being low outliers. This information leads the laboratory to question the homogeneity of the material used for that sample.

10.3.3 Internal Quality Incidents

Results from samples sent for analysis to laboratories outside DOE have been returned with significant quality problems. The results have shown instances of laboratory contamination, holding time exceedances, and problems with required QC data. Problems of this type may cause the data to be unusable or, at a minimum, require extensive investigation and justification before it is used. In many cases, a resample is required, causing delay in plant projects depending on the data.

Samples from the Sanitary and Inert Landfill wells did not include all the required analytical requests to satisfy the permit with the state of Kentucky. Samples were taken to supply data required by the Environmental Restoration Department and plant surveillance policies.

During the review of results from the soil and sediment sampling, many of the metal and radionuclide results were noted as not agreeing with past data. This trend was investigated by sampling and analytical personnel. The elevated metal results were traced to the procedural changes discussed in the opening of Sect. 10 that provided better

quantification of materials present in the samples. The cause for changes in radiochemical results was less obvious. A reanalysis was performed on selected archived 1989 samples and the corresponding 1990 samples. The results of the reanalyses of 1990 samples agreed with the results first reported. The results on the 1989 samples originally analyzed by ORNL increased, agreeing with the 1990 PGDP data. It was assumed that the changes were caused by small but noticeable changes in analytical technique. The change was not attributed to changes in PGDP emissions, because the same increases also were noted in all the background samples that are not influenced by PGDP emissions.

Elevated beta radiation results were found in several monitoring wells northeast of the plant. Investigations into these problems determined that natural beta radiation from K-40 was the cause. These wells are located in agricultural areas of the West Kentucky Wildlife Management Area. Fertilizers used in the fields contain potassium that would leach into the groundwater.

Isopropyl alcohol, used to decontaminate sampling equipment, has caused both analytical and pollution problems for the plant. The use of these materials caused the KPDES monitoring requirements to change in the affected ditch. Requirements also were added for sampling and analysis of collected purge and cleaning water to quantify this contaminant. Some of the isopropyl alcohol will degrade into acetone upon exposure to sunlight, adding a second analytical monitoring requirement. The analytical technique used to measure these compounds is relatively difficult to perform due to the solubility of acetone and isopropyl alcohol. The compounds also were found in varying concentrations unexpected by the analytical laboratory. This caused contamination of the instrument, requiring downtime for cleaning.

Beta radiation levels due to ^{99}Tc have caused elevated results for alpha measurements due to a phenomenon called "cross talk." Cross talk is caused by some of the beta energy's being detected in the alpha energy channels, resulting in erroneous counts. The phenomenon was recognized by the laboratory and is corrected routinely in final reports.

1. INTRODUCTION

All information for this section is presented in Part 1.

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

Table 2.1. Permitted air sources at PGDP^a

Source 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) ^b	Venturi scrubber
5	C-405 incinerator (south) ^b	Venturi scrubber
7	C-310 purge vent	Chemical traps, high-speed centrifuge
8	C-410 fluorine production	Cold condensers ^c
15	C-400 UF ₄ pulverizer	Filters
26	C-746 reverberatory furnace ^b	
27	C-746 aluminum sweat furnace ^b	
29	C-400 gold recovery ^b	
31	C-724 paint spray booth	Water wash scrubber
32	C-725 paint spray booth	Water wash scrubber
33	C-746-A rotary calciner ^b	CaCO ₃ traps
34(a)	Smelter—central dust collector ^b	Filters
35	C-600 No. 1 boiler	
36	Smelter—induction furnace ^b	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 ^b	
42	Chemical unloading	Wet cyclone scrubber
43	C-340 uranium alloy remelting operation ^b	Filters

^aPermit No. 0-85-110 issued on Sept. 30, 1985.^bShut down with no plans to restart.^cNot used due to low production.

Table 2.2. 1990 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	1	3	3	3	2	1	1	<2.1	<4	<5.2	<4.5
Technetium C-310 purge vent stack (mg)	2	1	1	3	7	2	1	2	1	1	<1	1
C-310 purge vent stack (μCi)	33.6	16.8	16.8	50.4	117.6	33.6	16.8	33.6	16.8	16.8	<16.8	16.8
Nitrogen oxide (NO _x) ^b C-600 stack (kg)	30,457	25,694	27,435	25,877	22,699	15,005	15,479	18,640	21,180	25,229	23,824	27,094
Sulfur oxide (SO ₂) ^b C-600 stack (kg)	30,594	25,635	27,614	26,019	22,471	11,436	9,031	18,232	22,525	27,253	26,102	29,465
Sulfur oxide (SO ₂) ^b C-600 stack (lb/M BTU) ^c	0.85	0.84	0.86	0.85	0.82	0.47	0.29	0.72	0.84	0.86	0.89	0.87
Particulates ^b C-600 stack (lb/M BTU) ^{d,e}	0.03	0.03	0.03	0.03	0.03	0.01	0.04	0.02	0.03	0.03	0.03	0.03
Particulates ^b C-600 stack (kg)	1.209	1,007	1,093	1,029	878	337	1,371	632	794	964	926	1,044
Carbon monoxide ^b (CO) (kg)	881	758	789	747	685	744	972	650	644	745	684	790

^aSee discussion in Subsect 2.1.^bBased on emission calculations from AP-42.^cKDAQ permit limit = 3.1 lb/M Btu (Boilers No. 2 and 3) and 0.8 lb/M Btu (Boiler No. 1).^dKDAQ permit limit = 0.242 lb/M Btu (Boilers No. 2 and 3) and 0.1 lb/M Btu (Boiler No. 1).^eThe lb/M Btu values are a composite of all three boilers. There were no exceedances of the permit limits.

Table 2.3. 1990 PGDP annual stack effluent pollutant emissions^a

	1990 Total	1989 Total	1988 Total	1987 Total	1986 Total
Uranium					
C-310 purge vent stack (g)	31.8	205	16	34	46
C-400 pulverizer (g) ^b	0	0	119	529	636
Technetium					
C-310 purge vent stack (mg)	23	211	221	56	520
C-310 purge vent stack (μCi)	386	3,565.9	3,732	890	8,956
Nitrogen oxide (NO _x) ^c					
C-600 stack (kg)	278,613	282,380	250,800	252,900	262,900
Sulfur dioxide (SO ₂) ^c					
C-600 stack (kg)	276,380	292,309	188,000	178,700	176,400
Particulates ^c					
C-600 stack (kg)	11,284	11,272			
Carbon monoxide ^c (CO) (kg)	9,091	8,179			

^aSee discussion in Subsect 2.1.^bIncludes data only for the period the process was in operation.^cBased on emission calculations from AP-42.

Table 2.4. Comparison of selected actual emissions and limits/standards

Source	Pollutant	Emission	Limit/Standard
C-310 stack	Uranium	31.80 g/year	3.9E06 g/year ^a
	⁹⁹ Tc	0.023 g/year	2.5E04 g/year ^a
	Fluorides	17.37 lb/12 h ^b	50 lb/12 h
C-600 stack	SO ₂	0.76 lb/m Btu ^b	0.8 lb/M Btu ^c
			3.1 lb/M Btu ^d
	Particulates	0.03 lb/m Btu ^b	0.1 lb/M Btu ^c
			0.24 lb/M Btu ^d

^aBased on emissions required to exceed the 10 mrem NESHAP limit.^bAnnual average of all boilers combined.^cBoiler No. 1.^dBoilers No. 2 and No. 3.

3. SURFACE WATER

Table 3.1. Interim limitations for Agreed Order—PGDP

	Monthly average	Daily maximum	Sample frequency	Sample type ^a
<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		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 3.1 (continued)

	Monthly average	Daily maximum	Sample frequency	Sample type ^a
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	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			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 3.1 (continued)

	Monthly average	Daily maximum	Sample frequency	Sample type ^a
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 3.1 (continued)

	Monthly average	Daily maximum	Sample frequency	Sample type ^a
<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 3.1 (continued)

	Monthly average	Daily maximum	Sample frequency	Sample type ^a
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	Composite
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/month	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	Composite
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/month	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 3.1 (continued)

	Monthly average	Daily maximum	Sample frequency	Sample type ^a
<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

^aComposite samples are 24-h samples.Table 3.2. 1990 annual data summary for discharge point 001^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Acetone (µg/L)	<10.0	<10.0	<10.0	17
Al (mg/L)	1.52	<0.10	<0.60	24
Cr (mg/L)	0.07	<0.05	<0.05	56
Cu (mg/L)	0.01	<0.01	<0.01	24
Dissolved alpha (pCi/L)	22.7	2.1	14.1	4
Dissolved beta (pCi/L)	73.0	23.0	48.5	4
Dissolved oxygen (mg/L)	14.0	5.5	8.7	24
Fe (mg/L)	1.75	0.12	0.51	24
Fluoride (mg/L)	0.75	0.29	0.44	24
Isopropanol (µg/L)	<50.0	<25.0	<27.9	17
Oil and Grease (mg/L)	<5.0	<5.0	<5.0	24
Ni (mg/L)	<0.05	<0.05	<0.05	24
PCB (µg/L)	<0.5	<0.1	<0.4	9
Total residual Cl ₂ (mg/L)	0.05	<0.01	<0.02	52
Suspended alpha (pCi/L)	3.8	-1.1 ^b	1.4	4
Suspended beta (pCi/L)	12.0	-5.0 ^b	1.8	4
Trichloroethylene (µg/L)	<5.0	<1.0	<1.2	25
⁹⁹ Tc (pCi/L)	107.0	-890.0 ^b	4.2	53
Temperature (°F)	92.0	48.0	69.6	52
Total suspended solids (mg/L)	33.0	<4.0	<10.7	23
Uranium (mg/L)	0.240	<0.001	<0.042	53
Water flow (Mgd)	16.600	0.546	1.677	51
Zn (mg/L)	0.180	<0.005	<0.015	52
pH (units)	9.4	6.8		52

^aSee Fig. 3.4.^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.3. 1990 annual data summary for discharge point 002^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	0.52	<0.10	<0.30	12
Cr (mg/L)	0.19	<0.05	<0.09	54
Cu (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	6.0	0.5	3.4	4
Dissolved beta (pCi/L)	20.0	-2.0 ^b	5.5	4
Dissolved oxygen (mg/L)	15.2	5.5	9.1	24
Fe (mg/L)	3.50	0.04	0.45	24
Fluoride (mg/L)	0.23	0.10	0.16	24
Oil and grease (mg/L)	<5.0	<5.0	<5.0	12
Ni (mg/L)	<0.05	<0.05	<0.05	12
PCB (µg/L)	<0.5	<0.1	<0.4	5
Total residual Cl ₂ (mg/L)	0.15	<0.01	<0.03	52
Suspended alpha (pCi/L)	1.8	-4.3 ^b	-0.3 ^b	4
Suspended beta (pCi/L)	10.0	-8.0 ^b	-1.8 ^b	4
Trichloroethylene (µg/L)	<5.0	<1.0	<1.3	13
Temperature (°F)	86.0	45.0	66.1	52
Total suspended solids (mg/L)	12.0	<4.0	<5.7	12
Uranium (mg/L)	0.012	<0.001	<0.005	5
Water flow (Mgd)	1.640	0.033	0.156	52
Zn (mg/L)	0.065	<0.005	<0.024	52
pH (units)	9.1	7.0		52

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.4. 1990 annual data summary for discharge point 004^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Ammonia (mg/L)	1.1	<0.2	<0.6	9
BOD ₅ (mg/L)	20.0	<5.0	<8.5	24
Fecal coli (col./100 mL)	600	<1.0	<103.3	24
Total suspended solids (mg/L)	12.0	<4.0	<5.3	24
Water flow (Mgd)	0.416	0.264	0.346	24
pH (units)	9.2	6.9		24

^aSee Fig. 3.4.

Table 3.5. 1990 annual data summary for discharge point 006^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
COD (mg/L)	34.0	<5.0	<14.6	54
Total suspended solids (mg/L)	43.0	4.0	17.3	52
Turbidity (NTU)	21.0	3.0	9.4	52
Water flow (Mgd)	3.880	0.390	0.942	52
pH (units)	10.3	6.2		53
Total residual Cl ₂ (mg/L)	0.01	<0.01	<0.01	18
PCB (µg/L)	<1.0	<0.1	<0.4	4

^aSee Fig. 3.4.

Table 3.6. 1990 annual data summary for discharge point 008^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	0.61	<0.10	<0.16	12
Cr (mg/L)	0.09	<0.05	<0.05	53
Cu (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	11.4	3.2	6.8	4
Dissolved beta (pCi/L)	31.0	-20.0 ^b	8.8	4
Dissolved oxygen (mg/L)	14.4	5.4	8.1	24
Fe (mg/L)	0.70	0.07	0.28	24
Fluoride (mg/L)	1.00	0.15	0.42	24
Oil and grease (mg/L)	<5.0	<5.0	<5.0	13
Ni (mg/L)	<0.05	<0.05	<0.05	12
PCB (µg/L)	<1.0	<0.1	<0.4	7
Total residual Cl ₂ (mg/L)	0.61	<0.01	<0.13	54
Suspended alpha (pCi/L)	8.0	1.1	3.3	4
Suspended beta (pCi/L)	2.0	-6.0 ^b	-0.5 ^b	4
Trichloroethylene (µg/L)	1.0	<1.0	<1.0	13
⁹⁹ Tc (pCi/L)	960.0	0	27.5	53
Temperature (°F)	91.0	50.0	68.9	52
Total suspended solids (mg/L)	26.0	<4.0	<6.1	12
Uranium (mg/L)	0.039	<0.001	<0.007	53
Water flow (Mgd)	3.830	0.497	1.046	51
Zn (mg/L)	0.13	<0.005	<0.03	52
pH (units)	8.6	6.1		52

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.7. 1990 annual data summary for discharge point 009^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	1.67	0.36	0.91	12
Cr (mg/L)	0.05	<0.05	<0.05	52
Cu (mg/L)	0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	4.2	0.5	2.0	4
Dissolved beta (pCi/L)	19.0	6.0	12.8	4
Dissolved oxygen (mg/L)	15.8	5.8	9.6	24
Fe (mg/L)	1.35	0.42	0.78	24
Fluoride (mg/L)	0.26	0.11	0.17	24
Oil and grease (mg/L)	5.6	<5.0	<5.0	14
Ni (mg/L)	0.05	<0.02	<0.05	12
PCB (µg/L)	<1.0	<0.1	<0.4	8
Total residual Cl ₂ (mg/L)	0.05	<0.01	<0.01	54
Suspended alpha (pCi/L)	4.3	-1.1 ^b	1.3	4
Suspended beta (pCi/L)	2.0	-10.0 ^b	-3.5 ^b	4
Trichloroethylene (µg/L)	<5.0	<1.0	<1.3	13
Temperature (°F)	89.0	43.0	63.9	52
Total suspended solids (mg/L)	32.0	<4.0	<16.3	12
Uranium (mg/L)	0.006	0.002	0.004	5
Water flow (Mgd)	6.480	0.035	0.283	51
Zn (mg/L)	0.04	<0.005	<0.02	52
pH (units)	10.1	5.7		52

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.8. 1990 annual data summary for discharge point 010^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	2.36	0.41	1.18	12
Cr (mg/L)	0.34	<0.005	<0.06	53
Cu (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	26.3	5.9	15.1	4
Dissolved beta (pCi/L)	69.0	9.0	29.0	4
Dissolved oxygen (mg/L)	15.7	4.6	9.0	24
Fe (mg/L)	2.63	0.35	1.15	24
Fluoride (mg/L)	0.39	0.15	0.25	24
Oil and grease (mg/L)	<5.0	<5.0	<5.0	12
Ni (mg/L)	<0.05	<0.05	<0.05	12
PCB (µg/L)	<1.0	<0.1	<0.5	5
Total residual Cl ₂ (mg/L)	0.02	<0.01	<0.01	52
Suspended alpha (pCi/L)	1.8	-3.6 ^b	-0.3 ^b	4
Suspended beta (pCi/L)	14.0	-3.0 ^b	3.3	4
Trichloroethylene (µg/L)	<5.0	<1.0	<1.3	13
Temperature (°F)	89.0	40.0	62.6	52
Total suspended solids (mg/L)	48.0	<4.0	<16.3	12
Uranium (mg/L)	0.074	0.002	0.040	5
Water flow (Mgd)	1.090	0.012	0.097	52
Zn (mg/L)	0.07	<0.005	<0.018	52
pH (units)	9.3	7.0		52

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.9. 1990 annual data summary for discharge point 011^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	1.89	<0.10	<0.29	12
Cr (mg/L)	0.05	<0.05	<0.05	53
Cu (mg/L)	0.02	<0.01	<0.01	12
Dissolved alpha (pCi/L)	32.2	1.1	17.6	4
Dissolved beta (pCi/L)	36.0	6.0	17.3	4
Dissolved oxygen (mg/L)	10.9	4.4	7.2	24
Fe (mg/L)	1.87	<0.01	<0.24	24
Fluoride (mg/L)	0.21	0.10	0.15	24
Oil and grease (mg/L)	<5.0	<5.0	<5.0	12
Ni (mg/L)	<0.05	<0.05	<0.05	12
PCB (µg/L)	<1.0	<0.1	<0.4	7
Total residual Cl ₂ (mg/L)	0.22	<0.01	<0.04	52
Suspended alpha (pCi/L)	0.8	-0.7 ^b	0.3	4
Suspended beta (pCi/L)	29.0	-5.0 ^b	5.8	4
Trichloroethylene (µg/L)	19.0	<1.0	<5.5	13
⁹⁹ Tc (pCi/L)	25.0	-940.0 ^b	-10.9 ^b	53
Temperature (°F)	100.0	56.0	80.6	52
Total suspended solids (mg/L)	50.0	<4.0	<8.9	12
Uranium (mg/L)	0.220	0.004	0.059	54
Water flow (Mgd)	1.070	0.051	0.138	52
Zn (mg/L)	0.069	<0.005	<0.013	52
pH (units)	8.5	6.9		52

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.10. 1990 annual data summary for discharge point 012^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	4.25	0.22	0.76	12
Cr (mg/L)	0.52	<0.05	<0.07	52
Cu (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	4.5	-6.2 ^b	0.7	4
Dissolved beta (pCi/L)	110.0	0	31.5	4
Dissolved oxygen (mg/L)	13.7	5.2	8.6	24
Fe (mg/L)	3.51	0.13	0.56	24
Fluoride (mg/L)	0.38	0.15	0.25	24
Oil and grease (mg/L)	5.4	<5.0	<5.0	14
Ni (mg/L)	0.11	<0.05	<0.05	12
PCB (µg/L)	<1.0	<0.1	<0.5	6
Total residual Cl ₂ (mg/L)	0.04	<0.01	<0.01	53
Suspended alpha (pCi/L)	12.4	1.6	5.6	4
Suspended beta (pCi/L)	11.0	1.0	4.5	4
Trichloroethylene (µg/L)	<5.0	<1.0	<1.3	13
⁹⁹ Tc (pCi/L)	490.0	0	35.2	41
Temperature (°F)	91.0	47.0	67.7	52
Total suspended solids (mg/L)	50.0	<4.0	<9.3	12
Uranium (mg/L)	0.08	0.002	0.02	7
Water flow (Mgd)	2.390	0.025	0.187	52
Zn (mg/L)	0.14	<0.005	<0.03	52
pH (units)	8.3	6.3		52

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.11. 1990 annual data summary for discharge point 013^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	13.25	0.18	3.38	12
Cu (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	6.3	-16.7 ^b	-1.1 ^b	4
Dissolved beta (pCi/L)	43.0	-9.0 ^b	14.5	4
Fe (mg/L)	10.60	0.15	2.74	12
Fluoride (mg/L)	1.10	0.19	0.66	12
Oil and grease (mg/L)	6.4	<5.0	<5.1	12
Ni (mg/L)	<0.05	<0.05	<0.05	12
PCB (µg/L)	<0.5	<0.1	<0.4	4
Suspended alpha (pCi/L)	2.9	-3.8 ^b	-0.08 ^b	4
Suspended beta (pCi/L)	4.0	-7.0 ^b	-1.5 ^b	4
Total suspended solids (mg/L)	265.0	<4.0	<63.9	12
Uranium (mg/L)	0.007	0.003	0.005	4
Water flow (Mgd)	8.350	0.134	1.530	12
pH (units)	8.4	7.4		12

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.12. 1990 annual data summary for discharge point 015^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	6.85	0.63	2.54	12
Cu (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	49.0	7.5	28.4	4
Dissolved beta (pCi/L)	89.0	19.0	45.3	4
Fe (mg/L)	4.59	0.51	1.91	12
Fluoride (mg/L)	2.70	0.28	0.66	12
Oil and grease (mg/L)	6.6	<5.0	<5.2	12
Ni (mg/L)	0.16	<0.05	<0.06	12
PCB (µg/L)	<0.5	<0.1	<0.4	4
Suspended alpha (pCi/L)	2.8	-4.1 ^b	0.4	4
Suspended beta (pCi/L)	17.0	-7.0 ^b	1.8	4
Total suspended solids (mg/L)	219.0	7.0	56.4	12
Uranium (mg/L)	0.130	0.015	0.065	4
Water flow (Mgd)	3.850	0.001	0.383	12
pH (units)	8.8	7.6		12

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.13. 1990 annual data summary for discharge point 016^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	7.81	<0.10	<2.03	10
Cu (mg/L)	0.02	<0.01	<0.01	10
Dissolved alpha (pCi/L)	6.1	-3.8 ^b	1.3	4
Dissolved beta (pCi/L)	65.0	-2.0 ^b	23.8	4
Fe (mg/L)	7.07	0.36	1.84	10
Fluoride (mg/L)	0.32	0.17	0.25	10
Oil and grease (mg/L)	5.7	<5.0	<5.1	10
Ni (mg/L)	<0.05	<0.05	<0.05	10
PCB (µg/L)	<0.5	<0.1	<0.4	4
Suspended alpha (pCi/L)	5.2	-1.1 ^b	2.2	4
Suspended beta (pCi/L)	24.0	-14.0 ^b	-0.8 ^b	4
Total suspended solids (mg/L)	557.0	6.0	75.6	10
Uranium (mg/L)	0.006	<0.001	<0.003	4
Water flow (Mgd)	6.1	0.001	1.035	9
pH (units)	8.9	7.3		10

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 3.14. 1990 annual data summary for discharge point 017^a
KPDES Permit Number KY0004049

Parameter	Max	Min	Av	Number of samples
Al (mg/L)	2.18	0.17	0.82	12
Cu (mg/L)	<0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	9.3	-9.0 ^b	2.3	4
Dissolved beta (pCi/L)	74.0	-6.0 ^b	20.0	4
Fe (mg/L)	2.39	0.18	0.80	12
Fluoride (mg/L)	0.66	0.28	0.49	12
Oil and grease (mg/L)	5.1	<5.0	<5.0	12
Ni (mg/L)	<0.05	<0.05	<0.05	12
PCB (µg/L)	<0.5	<0.1	<0.4	4
Suspended alpha (pCi/L)	8.0	-4.5 ^b	2.3	4
Suspended beta (pCi/L)	33.0	-9.0 ^b	4.0	4
Total suspended solids (mg/L)	73.0	4.0	21.7	12
Uranium (mg/L)	0.009	0.003	0.005	4
Water flow (Mgd)	1.960	0.001	0.315	12
pH (units)	8.3	7.7		12

^aSee Fig. 3.4.

^bNegative numbers indicate that analytical result minus background was less than zero.

**Table 3.15. 1990 annual data summary for upstream Big Bayou Creek
Location SW1^a**

Parameter	Max	Min	Av	Number of samples
% ²³⁵ U (% wt)	0.874	0	0.522	3
Chloride (mg/L)	132.0	5.0	21.4	16
Conductivity (µmhos/cm)	254	151	214	4
Cr ⁶⁺ (mg/L)	0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	6.4	-6.8 ^b	-0.3 ^b	12
Dissolved beta (pCi/L)	27.0	-15.0 ^b	8.7	12
Dissolved Solids (mg/L)	153.0	118.0	137.5	4
Fluoride (mg/L)	0.18	<0.10	<0.14	12
Fe (mg/L)	2.25	0.55	1.46	4
Na (mg/L)	24.2	7.5	15.9	2
NO ₃ -N (mg/L)	1.7	<1.0	<1.1	12
²³⁷ Np (pCi/L)	<5.0	<5.0	<5.0	3
²³⁹ Pu (pCi/L)	<5.0	<5.0	<5.0	3
Suspended alpha (pCi/L)	8.9	-2.7 ^b	0.7	12
Suspended beta (pCi/L)	7.0	-17.0 ^b	-0.9 ^b	12
Total suspended solids (mg/L)	48.0	12.0	26.3	4
⁹⁹ Tc (pCi/L)	18.0	3.0	10.7	3
Temperature (°F)	86.0	37.0	58.2	63
Uranium (mg/L)	0.003	<0.001	<0.001	19
pH (units)	8.7	7.3		14
Gross alpha (pCi/L)	5.5	-1.6 ^b	1.19	7
Gross beta (pCi/L)	66.0	-1.0 ^b	14.6	7
PO ₄ -P (mg/L)	5.9	<2.0	<2.5	12
SO ₄ (mg/L)	123.0	16.0	31.1	16
Total solids (mg/L)	201	145.0	163.5	4
TOC (mg/L)	5.0	1.0	3.5	4

^aSee Fig. 3.3.^bNegative numbers indicate that analytical result minus background was less than zero.**Table 3.16. 1990 annual data summary for downstream Big Bayou Creek
Location SW5^a**

Parameter	Max	Min	Av	Number of samples
% ²³⁵ U (% wt)	0.47	0	0.31	3
²³⁷ Np (pCi/L)	<5.0	<5.0	<5.0	3
²³⁹ Pu (pCi/L)	<5.0	<5.0	<5.0	3
⁹⁹ Tc (pCi/L)	27.0	5.0	17.0	3
Uranium (mg/L)	0.032	0.006	0.018	3
Gross alpha (pCi/L)	13.9	7.1	10.3	3
Gross beta (pCi/L)	34.0	15.0	21.7	3

^aSee Fig. 3.3.

**Table 3.17. 1990 annual data summary for downstream
Little Bayou Creek
Location SW10^a**

Parameter	Max	Min	Av	Number of samples
% ²³⁵ U (% wt)	0.281	0.238	0.267	3
Cr ⁶⁺ (mg/L)	0.06	0.06	0.06	1
²³⁷ Np (pCi/L)	<5.0	<5.0	<5.0	2
²³⁹ Pu (pCi/L)	<5.0	<5.0	<5.0	2
⁹⁹ Tc (pCi/L)	13.0	6.0	10.3	3
Uranium (mg/L)	0.047	0.009	0.025	3
Gross alpha (pCi/L)	17.6	4.3	9.0	3
Gross beta (pCi/L)	25.0	13.0	17.3	3

^aSee Fig. 3.3.

**Table 3.18. 1990 annual data summary for north-south diversion ditch
Location SW13^a**

Parameter	Max	Min	Av	Number of samples
Chloride (mg/L)	1440.0	10.0	209.9	52
Cr ⁶⁺ (mg/L)	0.05	<0.01	<0.01	52
Dissolved alpha (pCi/L)	959.0	-13.0 ^b	59.2	51
Dissolved beta (pCi/L)	1113.0	-12.0 ^b	101.6	51
Fluoride (mg/L)	6.8	0.4	1.1	52
NO ₃ -N (mg/L)	9.9	<1.0	<2.6	52
Suspended alpha (pCi/L)	8.8	-13.3 ^b	1.8	51
Suspended beta (pCi/L)	44.1	-13.0 ^b	6.3	51
Temperature (°F)	95.0	39.0	67.1	53
Water flow (Mgd)	0.795	0.059	0.217	52
pH (units)	10.7	6.9		52
PO ₄ -P (mg/L)	2.3	<1.2	<2.0	52
SO ₄ (mg/L)	196.0	19.0	120.6	52
Uranium (mg/L)	2.000	0.002	0.110	52

^aSee Fig. 3.3.

^bNegative numbers indicate that analytical result minus background was less than zero.

**Table 3.19. 1990 annual data summary for Ohio River upstream of PGDP
Location SW29^a**

Parameter	Max	Min	Av	Number of samples
Chloride (mg/L)	23.0	4.0	10.3	12
Cr ⁶⁺ (mg/L)	0.01	<0.01	<0.01	12
Dissolved alpha (pCi/L)	6.4	-10.9 ^b	0.1	12
Dissolved beta (pCi/L)	24.0	-9.0 ^b	6.1	12
Fluoride (mg/L)	0.19	<0.10	<0.13	12
NO ₃ -N (mg/L)	1.5	<1.0	<1.1	12
PCB (μg/L)	<0.5	<0.5	<0.5	3
Suspended alpha (pCi/L)	5.2	-3.2 ^b	0.7	12
Suspended beta (pCi/L)	28.0	-18.0 ^b	1.3	12
pH (units)	8.8	7.4		12
SO ₄ (mg/L)	62.0	10.0	29.0	12
Uranium (mg/L)	<0.001	<0.001	<0.001	12

^aSee Fig. 3.3.^bNegative numbers indicate that analytical result minus background was less than zero.**Table 3.20. 1990 annual data summary for Ohio River downstream of PGDP
Location SW30^a**

Parameter	Max	Min	Av	Number of samples
Chloride (mg/L)	22.0	5.0	11.0	11
Cr ⁶⁺ (mg/L)	0.01	<0.01	<0.01	11
Dissolved alpha (pCi/L)	12.1	-7.6 ^b	2.9	11
Dissolved beta (pCi/L)	21.0	-12.0 ^b	6.5	11
Fluoride (mg/L)	0.26	<0.10	<0.15	11
NO ₃ -N (mg/L)	1.4	<1.0	<1.1	11
PO ₄ -P (mg/L)	<2.0	<2.0	<2.0	11
Suspended alpha (pCi/L)	7.9	-1.8 ^b	1.9	11
Suspended beta (pCi/L)	42.0	-18.0 ^b	3.7	11
⁹⁹ Tc (pCi/L)	0	0	0	1
Uranium (mg/L)	0.002	<0.001	<0.001	11
pH (units)	8.9	7.4		11
1,2-dichloroethane (μg/L)	<5.0	<5.0	<5.0	11
SO ₄ (mg/L)	66.0	14.0	31.9	11

^aSee Fig. 3.3.^bNegative numbers indicate that analytical result minus background was less than zero.

**Table 3.21. C-746-S and C-746-T sanitary and inert landfills
Sampling point 2^a**

Parameter	Max	Min	Av	Number of samples
Chloride (mg/L)	11.0	2.0	7.75	4
Conductivity (μmhos/cm)	370	119.0	232.75	4
Dissolved Solids (mg/L)	322.0	224.0	270.5	4
Fe (mg/L)	82.0	3.5	29.6	4
Gross alpha (pCi/L)	71.7	6.9	37.8	4
Gross beta (pCi/L)	58.0	10.0	32.3	4
Na (mg/L)	13.2	4.7	7.7	4
pH (units)	8.2	7.9		4
SO ₄ (mg/L)	78.0	16.0	35.3	4
Total suspended solids (mg/L)	6069.0	724.0	3709.8	4
Total solids (mg/L)	6370.0	948.0	3980.3	4
TOC (mg/L)	29.0	1.0	9.5	4
Uranium (mg/L)	0.009	0.002	0.006	4

^aSee Fig. 3.3.**Table 3.22. C-746-S and C-746-T sanitary and inert landfills
Sampling point 3^a**

Parameter	Max	Min	Av	Number of samples
Chloride (mg/L)	18.0	<2	8.5	4
Conductivity (μmhos/cm)	446.0	214.0	356.3	4
Dissolved Solids (mg/L)	346.0	213.0	279.3	4
Fe (mg/L)	113.9	1.2	33.7	4
Gross alpha (pCi/L)	30.4	1.6	11.8	4
Gross beta (pCi/L)	53.0	8.0	28.3	4
Na (mg/L)	14.6	5.8	10.3	4
pH (units)	8.4	7.9		4
SO ₄ (mg/L)	129.0	<5	81.5	4
Total suspended solids (mg/L)	2996.0	161.0	1031.3	4
Total solids (mg/L)	3270.0	374.0	1310.5	4
TOC (mg/L)	9.0	1.0	6.0	4
Uranium (mg/L)	0.010	0.004	0.007	4

^aSee Fig. 3.3.

Table 3.23. 1990 radionuclide concentrations in effluents
Uranium

Location ^a	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide ^b
		Max	Min	Av	
001	53	162.0	0.68	26.8	4.52
002	5	8.1	0.68	3.38	0.56
008	53	26.3	0.68	4.39	0.74
009	5	4.0	1.35	2.43	0.40
010	5	50.0	1.35	27.0	4.56
011	54	148.5	2.7	39.5	6.67
012	6	52.6	1.35	17.7	2.99
013	4	4.72	2.02	3.04	0.50
015	4	87.8	10.12	43.74	7.29
016	4	4.0	0.68	2.02	0.34
017	4	6.1	2.02	3.58	0.60
018	2	60.8	18.90	39.82	6.64
SW13	52	1350.0	1.35	74.25	12.38

^aSee Figs. 3.3 and 3.4.

^bDerived Concentration Guide for uranium total is 600 pCi/L.

Table 3.24. 1990 radionuclide concentrations in water
KPDES Permit Number KY0004049
Technetium-99

Location ^a	Number of samples	Concentration (pCi/L)			Percent of derived concentration guide ^b
		Max	Min	Av	
001	52	107	0.0	21.44	2.14×10^{-2}
008	52	56	0.0	9.62	9.62×10^{-3}
011	52	25	0.0	17.87	1.78×10^{-2}
012	40	306	0.0	23.85	2.38×10^{-2}

^aSee Fig. 3.4.

^bDerived Concentration Guide for ⁹⁹Tc is 1×10^5 pCi/L.

Table 3.25. 1990 PGDP major discharges to surface water^a

Month	Uranium (kg)			Technetium (mCi)		
	KPDES 001	KPDES 008	KPDES 011	KPDES 001	KPDES 008	KPDES 011
January	12.0	0.74	0.50	3.71	1.80	0.16
February	10.4	0.70	0.53	5.93	1.49	0.08
March	5.7	0.71	0.66	5.44	1.45	0.11
April	36.7	6.47	2.57	3.81	1.22	0.02
May	19.9	2.38	0.80	5.00	2.50	0.08
June	0.6	0.59	0.50	1.68	0.23	0.07
July	1.9	0.33	0.14	2.45	0.67	0.06
August	0.9	0.20	0.12	1.16	0.46	0.02
September	0.6	0.28	0.08	1.61	0.28	0.01
October	13.9	0.45	1.76	16.76	1.49	0.15
November	1.4	0.18	1.34	1.34	0.10	0.10
December	42.1	1.82	6.49	17.42	2.26	0.42
Total	146.1	14.85	15.49	66.31	13.95	1.28

^aSee Fig. 3.4.

4. GROUNDWATER

Table 4.1 (continued)

Date	pH (unit)	Cond. ^a (µmho/cm)	Temp. (°F)	⁹⁹ Tc (pCi/L)	TCE (µg/L)	TOC ^b (mg/L)	TOX ^c (µg/L)	As (mg/L)	Diss. As ^d (mg/L)	Cd (mg/L)	Diss. Cd ^d (mg/L)	Pb (mg/L)	Diss. Pb ^d (mg/L)	Se (mg/L)	Diss. Se ^d (mg/L)	U (mg/L)
W95																
12/07	6.2	208.0	59.0	0.0	<1.0	<1.0	9.0	0.008	0.006	<0.010		<0.200		<0.005		<0.001
						<1.0	<5.0									
						<1.0	<5.0									
						<1.0	<5.0									

^aConductivity.^bTotal organic carbon.^cTotal organic halogen.^dDissolved.

Table 4.2. Effluent monitoring at underground storage tanks

Date	Benzene ($\mu\text{g/L}$)	Ethylbenzene ($\mu\text{g/L}$)	Toluene ($\mu\text{g/L}$)	Petro hydrocarbon (mg/L)	Xylene ($\mu\text{g/L}$)
W47					
01/12	<5	<5	<5	0.20	<5
03/22	<5	<5	<5		<5
03/23				0.10	
05/18	<5	<5	<5	1.70	<5
08/01	7	<5	10		8
10/24				<0.10	
12/20	<5	<5	<5	<0.10	<5
W52					
01/11	<5	<5	<5	<0.10	<5
03/16	<5	<5	<5	0.80	<5
05/11	<5	<5	<5	0.20	<5
07/10	<5	<5	<5	<0.10	<5
10/12	<5	<5	<5	<0.10	<5
W68					
01/12	<5	<5	<5	<0.10	<5
03/23	<5	<5	<5	<0.10	<5
05/11	<5	<5	6	<0.10	6
07/11	15	<5	18	<0.10	11
09/28	<5	<5	<5	<0.10	<5
11/06	<5	<5	+5	<0.10	+5
W69					
01/05	55	930	<20	1.50	1200
03/16	53	960	<20	1.80	920
05/11	59	930	12	1.80	900
07/13	<100	1000	<100	2.11	700
09/28	<100	690	<100	2.30	460
11/06	-40	850	<100	0.81	540
W70					
01/05	<5	<5	<5	0.10	<5
03/16	<5	<5	<5	<0.10	<5
05/11	<5	<5	<5	0.30	<5
07/10	<5	<5	<5	0.10	<5
09/28	<5	<5	<5	<0.10	<5
11/06	<5	<5	<5	<0.10	<5

Table 4.2 (continued)

Date	Benzene ($\mu\text{g/L}$)	Ethylbenzene ($\mu\text{g/L}$)	Toluene ($\mu\text{g/L}$)	Petro hydrocarbon (mg/L)	Xylene ($\mu\text{g/L}$)
W71					
01/12	<5	<5	<5	<0.10	<5
03/23	<5	<5	<5	<0.10	<5
05/11	<5	<5	<5	<0.10	<5
07/11	<5	<5	<5	<0.10	<5
09/28	<5	<5	<5	<0.10	<5
11/06	<5	<5	<5	<0.10	<5
W96					
01/04	<100	750	760	264.00	4200
03/16	100	900	900	283.00	6300
05/11	<500	1300	1100	160.00	6700
07/10	~100	1500	1300	34.40	7300
09/28	~100	1500	1100	32.30	7400
11/06	~100	1600	1100	7.15	8000

Table 4.3. ACO/CERCLA off-site quarterly monitoring results for TCE and ⁹⁹Tc

Date	TCE (μg/L)	⁹⁹ Tc (pCi/L)
R154		
04/11	<1.0	<25.0
06/20	<1.0	<25.0
09/18	<1.0	<25.0
12/12	<1.0	<25.0
R155		
04/11	<1.0	<25.0
06/19		<25.0
09/18	<1.0	<25.0
12/11	<1.0	<25.0
R156		
04/10	<1.0	<25.0
06/19		<25.0
09/18	1.0	<25.0
12/12	+1.0	<25.0
R157		
04/11	3.0	<25.0
06/19		<25.0
09/18	2.0	<25.0
12/11	2.0	<25.0
R158		
09/18	<1.0	<25.0
12/11	<1.0	<25.0
R159		
04/11	<1.0	<25.0
06/19		<25.0
09/18	<1.0	<25.0
12/12	<1.0	<25.0
R161		
04/10	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	2.0
R162		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	2.0

Table 4.3 (continued)

Date	TCE ($\mu\text{g/L}$)	^{99}Tc (pCi/L)
R163		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	5.0
R164		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	1.0
	<1.0	8.0
R165		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
R166		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	0.0
R167		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	9.0
R168		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	1.0
12/10	<1.0	
R169		
04/10	<1.0	<25.0
06/18	<1.0	<25.0
09/17	<1.0	4.0
12/11	<1.0	<25.0
R170		
04/11	<1.0	<25.0
06/20	<1.0	<25.0
09/18	<1.0	<25.0
12/12	<1.0	<25.0

Table 4.3 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)
R171		
04/10	<1.0	<25.0
06/19		<25.0
09/17	<1.0	1.0
12/11	<1.0	<25.0
R172		
04/09	<1.0	<25.0
06/18	<1.0	<25.0
09/17	1.0	4.0
R173		
04/11	<1.0	89.0
06/20	<1.0	44.0
09/18	<1.0	92.0
12/12	<1.0	126.0
R174		
04/11	<1.0	<25.0
06/20	<1.0	<25.0
09/18	<1.0	<25.0
12/12	<1.0	<25.0
R182		
09/18	<1.0	<25.0
12/12	<1.0	<25.0
R183		
04/11	<1.0	<25.0
06/20	<1.0	<25.0
09/18	<1.0	<25.0
12/12	<1.0	<25.0
R184		
09/18	<1.0	<25.0
12/12	<1.0	<25.0
W20		
01/18	77.0	57.0
04/19	110.0	54.0
10/10	210.0	129.0
11/01	220.0	112.0
12/13	160.0	37.0

Table 4.3 (continued)

Date	TCE ($\mu\text{g/L}$)	^{99}Tc (pCi/L)
W38		
02/08	3.0	16.0
03/07	2.0	16.0
04/11	2.0	14.0
05/15	2.0	5.0
06/08	2.0	9.0
07/24	3.0	15.0
08/01	3.0	3.0
09/21	3.0	26.0
10/11	3.0	28.0
11/08	3.0	39.0
12/27	4.0	29.0
W41		
02/22	12.0	2.0
03/07	14.0	23.0
04/19	17.0	0.0
05/24	15.0	4.0
06/18	14.0	9.0
07/19	17.0	12.0
08/02	12.0	0.0
09/21	17.0	6.0
10/11	15.0	7.0
10/31	19.0	11.0
11/09	15.0	27.0
12/19	16.0	1.0
W43		
02/28	<1.0	12.0
03/07	<1.0	11.0
04/18	<1.0	0.0
05/22	<1.0	0.0
06/18	<1.0	13.0
07/20	<1.0	11.0
08/08	<1.0	1.0
09/26	<1.0	8.0
10/04	<1.0	2.0
11/20	<1.0	0.0
12/11	<1.0	8.0

Table 4.3 (continued)

Date	TCE ($\mu\text{g/L}$)	^{99}Tc (pCi/L)
W44		
01/09	18.0	19.0
02/13	15.0	0.0
03/07	21.0	9.0
04/24	18.0	0.0
05/30	14.0	0.0
06/19	14.0	8.0
07/19	18.0	1.0
08/07	18.0	5.0
09/21	21.0	0.0
10/16	22.0	7.0
11/19	22.0	0.0
12/11	21.0	2.0
W58		
04/17		12.0
05/30	<20.0	
W66		
01/18	5000.0	2558.0
02/22	2900.0	2378.0
03/14	4900.0	2318.0
04/10	5900.0	2212.0
05/17	4100.0	2091.0
06/22	4200.0	2128.0
07/25	3500.0	1658.0
08/22	4700.0	2235.0
09/20	1600.0	1184.0
10/17	3900.0	1982.0
11/09	<1.0	<25.0
11/12	<1.0	<25.0
	<1.0	<25.0
	<1.0	<25.0
	<1.0	<25.0
11/13	2000.0	1289.0
12/26	2200.0	1691.0

Table 4.4. ACO/CERCLA off-site quarterly monitoring results for gross alpha and gross beta

Date	Gross alpha (pCi/L)	Gross beta (pCi/L)
W20		
10/10	2.3	93.0
12/13	2.5	58.0
W38		
02/08	5.8	16.0
03/07	2.0	10.0
05/15	2.4	16.0
06/08	5.4	16.0
07/24	6.0	5.0
09/21	1.0	10.0
10/11	3.8	13.0
12/27	4.2	32.0
W41		
02/22	4.9	1.0
03/07	2.7	6.0
05/24	5.0	8.0
06/18	0.2	0.0
07/19	0.4	9.0
09/21	2.5	3.0
10/11	0.7	2.0
11/09	8.4	24.0
12/19	5.2	4.0
W43		
03/07	3.8	7.0
05/22	15.6	24.0
06/18	1.1	1.0
07/20	0.4	6.0
09/26	1.0	2.0
10/04	1.2	2.0
11/20	0.1	3.0

Table 4.4 (continued)

Date	Gross alpha (pCi/L)	Gross beta (pCi/L)
W44		
02/13	2.0	4.0
03/07	0.2	2.0
05/30	6.1	2.0
06/19	1.0	2.0
07/19	2.3	5.0
09/21	7.7	2.0
10/16	1.6	3.0
11/19	7.9	6.0
W58		
04/17	2703.2	2884.0
W66		
02/22	7.2	728.0
03/14	118.4	1632.0
05/17	2.4	3106.0
06/22	8.8	1895.0
09/20	10.5	907.0
11/09	6.9	14.0
11/13	4.1	1001.0
12/26	2.3	1638.0

Table 4.5. ACO/CERCLA off-site effluent monitoring—weekly, monthly, and bimonthly

Date	TCE ($\mu\text{g/L}$)	^{99}Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R2					
02/07	1300.0	1088.0	17.6	633.0	
03/09	560.0	1192.0	33.1	976.0	
03/14			1.1	2.0	
			5.0	1814.0	
04/05	1300.0	941.0	44.5	1460.0	
04/08	1600.0	867.0	23.6	1313.0	
05/10	1600.0	491.0	3.2	575.0	
06/06	1300.0	897.0	0.2	718.0	
07/03	1700.0	658.0	4.4	451.0	
08/07	1700.0	1232.0	10.9	1818.0	
09/18	2000.0	1352.0	5.0	1126.0	
10/10	1400.0	1216.0	3.8	1597.0	
11/19	1800.0	1290.0	0.1	1326.0	
11/28	1700.0	1163.0	1.8	2256.0	
12/12	1500.0	1039.0	2.3	1169.0	
R5					
03/23	2.0	<25.0	0.4	1.0	
04/17	1.0	<25.0	0.5	19.0	
05/10	<1.0	<25.0	1.5	3.0	
06/06	4.0	<25.0	0.3	1.0	
07/06	2.0	<25.0	3.2	0.0	
08/07	1.0	<25.0	1.5	3.0	
09/18	4.0	<25.0	1.6	1.0	
10/05	1.0	<25.0	2.9	0.0	
11/28	4.0	<25.0	1.0	7.0	
12/13	2.0	<25.0	3.4	6.0	
R6					
03/07	<1.0	<25.0	3.9	24.0	
03/14	<1.0	<25.0	0.2	2.0	
04/19	<1.0	<25.0	2.7	6.0	
05/09	<1.0	<25.0	4.1	3.0	
06/06		<25.0	1.1	1.0	
06/11	<1.0				
07/02	<1.0	<25.0	1.9	12.0	
08/20	<1.0	<25.0	1.4	3.0	
09/18	<1.0	<25.0	1.8	5.0	
10/16	<1.0	<25.0	2.9	3.0	
11/06	<1.0	<25.0	10.1	24.0	
11/28	<1.0	<25.0	0.4	6.0	
12/17	<1.0	<25.0	6.6	7.0	
R8					
01/05	<1.0	<25.0			
03/07	<1.0	<25.0			
05/09	<1.0	<25.0			
07/17	<1.0	<25.0			
09/17	<1.0	<25.0			
11/19	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R9					
02/22	<1.0	<25.0			
04/24	<1.0	<25.0			
06/27	<1.0	<25.0			
08/28	<1.0	<25.0			
10/24	<1.0	<25.0			
12/28	<1.0	<25.0			
R10					
01/04	<1.0	<25.0	4.3	4.0	768.0
01/08	<1.0	<25.0			
01/25	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0			
02/05	<1.0	<25.0	4.5	16.0	832.0
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0			
03/05	<1.0	<25.0	1.8	0.3	800.0
03/14	<1.0	<25.0	0.0	1.0	
03/19	<1.0	<25.0			
03/26	<1.0	<25.0			
04/02	<1.0	<25.0	1.2	1.0	656.0
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0			
04/30	<1.0	<25.0	8.2	4.0	895.0
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0			
05/30	<1.0	<25.0			
06/06	<1.0	<25.0	1.7	4.0	1064.0
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	0.5	4.0	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0	4.0	8.0	
07/09	<1.0	<25.0			799.0
07/16	<1.0	<25.0			
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0	5.4	19.0	
08/13	<1.0	<25.0			745.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			
09/04	<1.0	<25.0	6.1	5.0	665.0
09/10	<1.0	<25.0			
09/18	<1.0	<25.0	2.5	8.0	
09/24	<1.0	<25.0			
10/01	<1.0	<25.0	3.0	6.0	802.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R10					
11/05	<1.0	<25.0	0.6	5.0	319.0
11/28	<1.0	<25.0	3.6	21.0	
12/03	<1.0	<25.0	1.9	10.0	383.0
12/10	<1.0	<25.0			780.0
12/17	<1.0	<25.0			
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			
R12					
01/04	<1.0	<25.0	0.9	3.0	373.0
01/08	<1.0	<25.0			
01/15	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0			
02/05	<1.0	<25.0	0.6	7.0	401.0
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0			
03/05	<1.0	<25.0	2.0	6.0	330.0
03/12	<1.0	<25.0			
03/19	<1.0	<25.0			
03/26	<1.0	<25.0			
04/02	<1.0	<25.0	1.4	2.0	342.0
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0			
04/30	<1.0	<25.0	4.3	17.0	426.0
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0			
05/30	<1.0	<25.0			
06/04	<1.0	<25.0	4.3	6.0	352.0
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	0.7	0.0	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0	3.5	4.0	
07/09	<1.0	<25.0			457.0
07/16	<1.0	<25.0			
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0	7.2	5.0	
08/13	<1.0	<25.0			391.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			
09/04	<1.0	<25.0	3.4	1.0	428.0
09/10	<1.0	<25.0			
09/17	<1.0	<25.0			
09/24	<1.0	<25.0			
10/01	<1.0	<25.0	2.5	4.0	424.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R12					
11/05	<1.0	<25.0	3.0	8.0	240.0
11/12	<1.0	<25.0			
11/19	<1.0	<25.0			
11/26	<1.0	<25.0			329.0
12/03	<1.0	<25.0	1.4	8.0	459.0
12/10	<1.0	<25.0			435.0
12/17	<1.0	<25.0			
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			
R13					
01/04	<1.0	<25.0	1.6	8.0	361.0
01/08	<1.0	<25.0			
01/15	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0			
02/05	<1.0	<25.0	1.6	4.0	374.0
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0			
03/05	<1.0	<25.0	1.0	1.0	344.0
03/12	<1.0	<25.0			
03/19	<1.0	<25.0			
03/26	<1.0	<25.0			
04/02	<1.0	<25.0	0.0	1.0	
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0			
04/30	<1.0	<25.0	0.0	4.0	434.0
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0			
05/30	<1.0	<25.0			
06/04	<1.0	<25.0	5.0	12.0	371.0
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	0.9	2.0	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0	4.1	10.0	
07/09	<1.0	<25.0			427.0
07/16	<1.0	<25.0			
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0	7.5	1.0	
08/13	<1.0	<25.0			319.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			
09/04	<1.0	<25.0	9.0	23.0	417.0
09/10	<1.0	<25.0			
09/17	<1.0	<25.0			
09/24	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R13					
10/01	<1.0	<25.0	1.4	3.0	334.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0	10.1	30.0	215.0
11/05	<1.0	<25.0			
11/12	<1.0	<25.0			
11/19	<1.0	<25.0			
11/26	<1.0	<25.0	2.4	1.0	309.0
12/03	<1.0	<25.0			378.0
12/10	<1.0	<25.0			382.0
12/17	<1.0	<25.0			
12/28	<1.0	<25.0			
12/31	<1.0	<25.0			
R14					
01/04	<1.0	<25.0	4.2	2.0	1473.0
01/08	<1.0	<25.0			
01/15	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0	0.6	4.0	1797.0
02/05	<1.0	<25.0			
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0	0.8	2.0	1742.0
03/05	<1.0	<25.0			
03/12	<1.0	<25.0			
03/19	<1.0	<25.0			
03/26	<1.0	<25.0	1.2	4.0	
04/02	<1.0	<25.0			
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0	0.0	6.0	1721.0
04/30	<1.0	<25.0			
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0	0.5	4.0	1425.0
05/30	<1.0	<25.0			
06/04	<1.0	<25.0			
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	0.9	1.0	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0			
07/09	<1.0	<25.0			
07/16	<1.0	<25.0	2.5	5.0	1686.0
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0			
08/13	<1.0	<25.0	4.5	16.0	1623.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R14					
09/04	<1.0	<25.0	3.0	3.0	1603.0
09/10	<1.0	<25.0			
09/17	<1.0	<25.0			
09/24	<1.0	<25.0			
10/01	<1.0	<25.0	1.2	0.0	1684.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			
11/05	<1.0	<25.0	3.4	15.0	315.0
11/12	<1.0	<25.0			
11/19	<1.0	<25.0			
11/26	<1.0	<25.0			1234.0
12/03	<1.0	<25.0	3.8	2.0	1585.0
12/10	<1.0	<25.0			1641.0
12/17	<1.0	<25.0			
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			
R16					
01/17	<1.0	<25.0	0.9	3.0	
02/06	<1.0	<25.0	3.8	13.0	
03/02	<1.0	<25.0	2.3	7.0	289.0
03/14			2.6	1.0	
04/18	<1.0	<25.0	3.0	12.0	
05/18	<1.0	<25.0	2.0	17.0	
06/06	6.0	<25.0	0.5	5.0	
07/25	<1.0	<25.0	1.5	2.0	503.0
08/15	3.0	<25.0	8.5	8.0	
09/18	5.0	<25.0	2.5	4.0	
10/22	<1.0	<25.0	0.6	2.0	
11/28	4.0	<25.0	2.3	40.0	
12/18	+1.0	<25.0	2.7	12.0	
R17					
01/18	100.0	81.0	1.5	91.0	
02/21	65.0	89.0	2.3	68.0	
03/14	100.0	111.0	6.4	67.0	
04/27	220.0	163.0	18.9	176.0	
05/24	200.0	167.0	5.3	141.0	
06/06	240.0	175.0	2.6	191.0	
07/26	220.0	161.0	9.6	179.0	
08/15	180.0	190.0	10.0	150.0	
09/18	180.0	155.0	5.5	177.0	
10/24	140.0	95.0	1.1	140.0	
11/28	120.0	95.0	1.1	123.0	
12/20	76.0	112.0	2.3	105.0	

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R18					
01/16	<1.0	<25.0	2.1	9.0	
02/02	<1.0	<25.0	2.4	4.0	
03/02	<1.0	<25.0	2.7	4.0	
04/05	<1.0	<25.0	2.5	0.0	
05/10	<1.0	<25.0	2.7	5.0	
06/07	<1.0	<25.0	1.3	3.0	
07/03	<1.0	<25.0	2.3	4.0	
08/03	<1.0	<25.0	1.9	5.0	
09/06	<1.0	<25.0	6.1	19.0	
10/05	<1.0	<25.0	1.7	2.0	
11/09	<1.0	<25.0	6.9	14.0	
12/18	<1.0	<25.0	8.0	11.0	
R19					
01/04	<1.0	<25.0	4.5	4.0	531.0
01/08	<1.0	<25.0			
01/15	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0			
02/05	<1.0	<25.0	0.1	10.0	572.0
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0			
03/05	<1.0	<25.0	1.1	0.0	558.0
03/12	<1.0	<25.0			
03/19	<1.0	<25.0			
03/26	<1.0	<25.0			
04/02	<1.0	<25.0	6.0	4.0	
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0			
04/30	<1.0	<25.0	0.0	2.0	699.0
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0			
05/30	<1.0	<25.0			
06/04	<1.0	<25.0	8.3	3.0	491.0
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	1.2	2.0	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0	2.5	6.0	
07/09	<1.0	<25.0			579.0
07/16	<1.0	<25.0			
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0	6.4	7.0	
08/13	<1.0	<25.0			527.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			
09/04	<1.0	<25.0	4.3	2.0	585.0
09/10	<1.0	<25.0			
09/17	<1.0	<25.0			
09/24	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R19					
10/01	<1.0	<25.0	0.5	0.0	595.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			
11/05	<1.0	<25.0	9.4	28.0	313.0
11/12	<1.0	<25.0			
11/19	<1.0	<25.0			
11/26	<1.0	<25.0			457.0
12/03	<1.0	<25.0	3.8	0.0	616.0
12/10	<1.0	<25.0			482.0
12/17	<1.0	<25.0			
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			
R20					
09/10	<1.0	<25.0			
10/24	<1.0	<25.0			
R21					
01/10	<1.0	<25.0	0.4	2.0	
02/15	<1.0	<25.0	3.4	2.0	
03/14	<1.0	<25.0	1.1	1.0	
04/05	<1.0	<25.0	1.3	2.0	
05/17	<1.0	<25.0	0.7	8.0	
06/14	<1.0	<25.0	1.2	1.0	
07/10	<1.0	<25.0	2.3	2.0	
08/13	<1.0	<25.0	2.0	6.0	
09/12	<1.0	<25.0	0.8	4.0	
10/08	<1.0	<25.0	1.8	0.0	
11/13	<1.0	<25.0	2.0	3.0	
12/13	<1.0	<25.0	5.7	11.0	
R22					
02/26	<1.0	<25.0			
04/19	<1.0	<25.0			
06/21	<1.0	<25.0			
08/20	<1.0	<25.0			
10/16	<1.0	<25.0			
12/17	<1.0	<25.0			
R23					
01/10	<1.0	<25.0			
03/02	<1.0	<25.0			
05/17	<1.0	<25.0			
07/17	<1.0	<25.0			
09/17	<1.0	<25.0			
11/19	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R24					
02/22	<1.0	<25.0			
04/19	<1.0	<25.0			
06/21	<1.0	<25.0			
08/20	<1.0	<25.0			
10/16	<1.0	<25.0			
12/17	<1.0	<25.0			
R25					
01/05	<1.0	<25.0			
03/07	<1.0	<25.0			
05/09	<1.0	<25.0			
07/02	<1.0	<25.0			
09/06	<1.0	<25.0			
11/06	<1.0	<25.0			
R26					
02/22	<1.0	<25.0			
04/19	<1.0	<25.0			
06/06	<1.0	<25.0	0.6	2.0	
08/20	<1.0	<25.0			
09/18	<1.0	<25.0	1.0	4.0	
10/16	<1.0	<25.0			
12/17	<1.0	<25.0			
R28					
01/05	<1.0	<25.0			
03/07	<1.0	<25.0			
05/09	<1.0	<25.0			
07/02	<1.0	<25.0			
09/06	<1.0	<25.0			
11/06	<1.0	<25.0			
R31					
01/04	<1.0	<25.0			
03/02	<1.0	<25.0			
06/21	<1.0	<25.0			
07/17	<1.0	<25.0			
09/06	<1.0	<25.0			
09/19	<1.0	<25.0			
09/24	<1.0	<25.0			
10/01	<1.0	<25.0	4.5	0.0	208.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			
11/05	<1.0	<25.0	11.9	25.0	788.0
11/12	<1.0	<25.0			
11/19	<1.0	<25.0			
11/26	<1.0	<25.0			
12/03	<1.0	<25.0	4.5	3.0	178.0
12/10	<1.0	<25.0			195.0
12/17	<1.0	<25.0			260.0
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R39					
01/04	<1.0	<25.0	3.9	6.0	501.0
01/08	<1.0	<25.0			
01/15	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0			
02/05	<1.0	<25.0	1.7	14.0	863.0
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0			
03/05	<1.0	<25.0	1.7	3.0	871.0
03/12	<1.0	<25.0			
03/19	<1.0	<25.0			
03/26	<1.0	<25.0			
04/02	<1.0	<25.0	0.5	1.0	690.0
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0			
04/30	<1.0	<25.0	4.1	1.0	937.0
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0			
05/30	<1.0	<25.0			
06/04	<1.0	<25.0	12.8	5.0	818.0
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	0.3	1.9	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0	2.1	4.0	
07/09	<1.0	<25.0			856.0
07/16	<1.0	<25.0			
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0	9.0	9.0	
08/13	<1.0	<25.0			731.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			
09/04	<1.0	<25.0	3.9	8.0	689.0
09/10	<1.0	<25.0			
09/17	<1.0	<25.0			
09/24	<1.0	<25.0			
10/01	<1.0	<25.0	2.3	1.0	691.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			
11/05	<1.0	<25.0	4.3	16.0	237.0
11/12	<1.0	<25.0			
11/19	<1.0	<25.0			
11/26	<1.0	<25.0			500.0
12/03	<1.0	<25.0	0.6	10.0	682.0
12/10	<1.0	<25.0			553.0
12/17	<1.0	<25.0			
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R40					
01/04	<1.0	<25.0	1.3	2.0	316.0
01/08	<1.0	<25.0			
01/15	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0			
02/05	<1.0	<25.0	3.1	9.0	358.0
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0			
03/05	<1.0	<25.0	1.3	1.0	355.0
03/14	<1.0	<25.0	0.0	7.0	
03/19	<1.0	<25.0			
03/26	<1.0	<25.0			
04/02	<1.0	<25.0	0.7	1.0	325.0
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0			
04/30	<1.0	<25.0	3.3	4.0	341.0
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0			
05/30	<1.0	<25.0			
06/06	<1.0	<25.0	2.0	3.0	453.0
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	2.9	3.0	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0	0.3	7.0	
07/09	<1.0	<25.0			378.0
07/16	<1.0	<25.0			
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0	5.6	8.0	
08/13	<1.0	<25.0			369.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			
09/04	<1.0	<25.0	3.8	4.0	375.0
09/10	<1.0	<25.0			
09/18	<1.0	<25.0	2.3	10.0	
09/24	<1.0	<25.0			
10/01	<1.0	<25.0	0.9	1.0	353.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			
11/05	<1.0	<25.0	1.5	3.0	176.0
11/28	<1.0	<25.0	0.2	19.0	
12/03	<1.0	<25.0	0.9	8.0	776.0
12/10	<1.0	<25.0			327.0
12/17	<1.0	<25.0			
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R41					
07/30	<1.0	<25.0			
09/17	<1.0	<25.0			
11/20	<1.0	<25.0			
R42					
01/10	<1.0	<25.0			
03/07	<1.0	<25.0			
05/09	<1.0	<25.0			
07/17	<1.0	<25.0			
09/17	<1.0	<25.0			
11/07	<1.0	12.0			
11/19	<1.0	<25.0			
R43					
01/11	<1.0	<25.0	1.7	1.5	
02/15	<1.0	<25.0	2.0	1.0	
03/14	<1.0	<25.0	2.5	1.0	
04/05	<1.0	<25.0	0.6	1.0	
05/17	<1.0	<25.0	1.5	2.0	
06/14	<1.0	<25.0	2.3	2.0	
07/10	<1.0	<25.0	3.1	3.0	
08/13	<1.0	<25.0	2.0	4.0	
09/12	<1.0	<25.0	1.1	2.0	
10/10	<1.0	<25.0	2.3	1.0	
11/14	<1.0	<25.0	6.6	9.0	
12/12	<1.0	<25.0	1.4	10.0	
R53					
06/11	<1.0	<25.0			343.0
08/14	<1.0	<25.0	3.4	3.0	
10/22	<1.0	<25.0			
R54					
01/04	<1.0	<25.0	0.2	1.0	374.0
01/08	<1.0	<25.0			
01/15	<1.0	<25.0			
01/22	<1.0	<25.0			
01/31	<1.0	<25.0			
02/05	<1.0	<25.0	1.2	2.0	439.0
02/13	<1.0	<25.0			
02/20	<1.0	<25.0			
02/26	<1.0	<25.0			
03/05	<1.0	<25.0	0.6	1.0	383.0
03/12	<1.0	<25.0			
03/19	<1.0	<25.0			
03/26	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R54					
04/02	<1.0	<25.0	0.2	1.0	391.0
04/09	<1.0	<25.0			
04/16	<1.0	<25.0			
04/23	<1.0	<25.0			
04/30	<1.0	<25.0	3.1	7.0	474.0
05/08	<1.0	<25.0			
05/14	<1.0	<25.0			
05/21	<1.0	<25.0			
05/30	<1.0	<25.0			
06/04	<1.0	<25.0	4.6	6.0	365.0
06/11	<1.0	<25.0			
06/18	<1.0	<25.0	0.4	0.0	
06/26	<1.0	<25.0			
07/02	<1.0	<25.0	2.4	9.0	
07/09	<1.0	<25.0			396.0
07/16	<1.0	<25.0			
07/23	<1.0	<25.0			
07/30	<1.0	<25.0			
08/06	<1.0	<25.0	9.0	4.0	
08/13	<1.0	<25.0			452.0
08/20	<1.0	<25.0			
08/27	<1.0	<25.0			
09/04	<1.0	<25.0	1.7	4.0	423.0
09/10	<1.0	<25.0			
09/17	<1.0	<25.0			
09/24	<1.0	<25.0			
10/01	<1.0	<25.0	2.9	0.0	449.0
10/08	<1.0	<25.0			
10/15	<1.0	<25.0			
10/22	<1.0	<25.0			
10/29	<1.0	<25.0			
11/05	<1.0	<25.0	2.3	7.0	335.0
11/12	<1.0	<25.0			
11/19	<1.0	<25.0			
11/26	<1.0	<25.0			319.0
12/03	<1.0	<25.0	1.8	8.0	332.0
12/10	<1.0	<25.0			373.0
12/17	<1.0	<25.0			
12/26	<1.0	<25.0			
12/31	<1.0	<25.0			
R69					
01/05	<1.0	<25.0			
03/07	<1.0	<25.0			
05/09	<1.0	<25.0			
07/02	<1.0	<25.0			
09/12	<1.0	<25.0			
11/06	<1.0	<25.0			

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R72					
01/11	<1.0	<25.0	0.5	2.0	
02/15	<1.0	<25.0	2.5	4.0	
03/14	<1.0	<25.0	1.2	1.0	
04/05	<1.0	<25.0	1.0	1.0	
05/17	<1.0	<25.0	0.6	8.0	
06/14	<1.0	<25.0	4.1	6.0	
07/11	<1.0	<25.0	3.2	1.0	
08/13	<1.0	<25.0	2.5	6.0	
09/17	<1.0	<25.0	2.3	3.0	
10/10	<1.0	<25.0	1.0	0.0	
11/14	<1.0	<25.0	3.2	14.0	
12/13	<1.0	<25.0	0.6	3.0	
R79					
02/22	<1.0	<25.0			
04/24	<1.0	<25.0			
06/27	<1.0	<25.0			
08/28	<1.0	<25.0			
10/29	<1.0	<25.0			
12/28	<1.0	<25.0			
R82					
01/10	<1.0	<25.0	0.7	3.0	
02/15	<1.0	<25.0	2.5	1.0	
03/14	<1.0	<25.0	2.0	2.0	
04/05	<1.0	<25.0	0.3	2.0	
05/17	<1.0	<25.0	7.3	8.0	
06/14	<1.0	<25.0	2.1	3.0	
07/10	<1.0	<25.0	4.5	1.0	
08/13	<1.0	<25.0	1.6	6.0	
09/12	<1.0	<25.0	1.6	5.0	
10/08	<1.0	<25.0	2.8	2.0	
11/13	<1.0	<25.0	1.0	8.0	
12/13	<5.0	<25.0	1.0	5.0	
R83					
01/10	<1.0	<25.0	1.1	5.0	
02/15	<1.0	<25.0	0.2	1.0	
03/14	<1.0	<25.0	0.0	1.0	
04/05	<1.0	<25.0	0.7	5.0	
05/23	<1.0	<25.0	2.4	5.0	
06/14	<1.0	<25.0	0.1	0.0	
07/10	<1.0	<25.0	3.1	0.0	
08/13	<1.0	<25.0	0.9	7.0	
09/12	<1.0	<25.0	0.2	5.0	
10/08	<1.0	<25.0	2.0	2.0	
11/14	<1.0	<25.0	3.6	14.0	
12/13	<1.0	<25.0	2.3	7.0	

Table 4.5 (continued)

Date	TCE ($\mu\text{g/L}$)	^{99}Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R84					
01/10	<1.0	<25.0	0.6	3.0	
02/15	<1.0	<25.0	0.8	2.0	
03/14	<1.0	<25.0	2.0	1.0	
04/05	<1.0	<25.0	5.2	2.0	
05/17	<1.0	<25.0	1.1	3.0	
06/14	<1.0	<25.0	1.1	0.0	
07/10	<1.0	<25.0	3.8	3.0	
08/13	<1.0	<25.0	6.0	1.0	
09/12	<1.0	<25.0	0.8	7.0	
10/08	<1.0	<25.0	5.1	1.0	
11/13	<1.0	<25.0	7.5	6.0	
12/13	<1.0	<25.0	6.1	8.0	
R88					
02/22	<1.0	<25.0			
04/24	<1.0	<25.0			
06/21	<1.0	<25.0			
10/24	<1.0	<25.0			
12/28	<1.0	<25.0			
R89					
06/27	<1.0	<25.0			
08/28	<1.0	<25.0			
10/29	<1.0	<25.0			
R112					
02/22	<1.0	<25.0			
04/24	<1.0	<25.0			
06/27	<1.0	<25.0			
08/28	<1.0	<25.0			
10/24	<1.0	<25.0			
12/28	<1.0	<25.0			
R113					
01/24	14.0	58.0	0.9	21.0	
02/07	340.0	222.0	8.0	176.0	
03/09	520.0	402.0	11.5	230.0	
04/20	720.0	319.0	0.2	245.0	
05/18	520.0	266.0	1.6	177.0	
06/18	850.0	440.0	0.3	542.0	
07/24	860.0	376.0	2.0	296.0	
09/25	1400.0	655.0	9.2	546.0	
10/30	1600.0	286.0	7.4	116.0	
11/16	1000.0	404.0	0.4	225.0	
12/12	1000.0	486.0	2.3	226.0	

Table 4.5 (continued)

Date	TCE (µg/L)	⁹⁹ Tc (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radon (pCi/L)
R157					
12/26	2200.0	1691.0	2.3	1638.0	
R219					
11/05	<1.0	<25.0	9.5	27.0	212.0
R293					
03/02	<1.0	<25.0			
05/05	<1.0	<25.0			
07/17	<1.0	<25.0			
09/06	<1.0	<25.0			
11/19	<1.0	<25.0			
W20					
01/17		40.0	1.5	20.0	
02/02	69.0	30.0	2.3	2.0	
03/09	112.0	86.0	3.8	48.0	
04/07	<1.0	<25.0	1.8	5.0	
05/15	89.0	79.0	3.8	44.0	
06/13	110.0	94.0	8.6	55.0	
07/06	210.0	124.0	5.8	65.0	
W41					
01/17	<1.0	<25.0	0.8	6.0	
02/06	<1.0	<25.0	3.4	7.0	
03/02	<1.0	<25.0	0.6	1.0	104.0
03/14			1.1	1.0	
04/18	<1.0	<25.0	1.7	6.0	
05/18	<1.0	<25.0	1.2	5.0	
06/06	4.0	<25.0	1.2	2.0	
07/25	<1.0	<25.0	6.8	0.0	41.0
08/15	2.0	<25.0	1.1	2.0	
09/18	4.0	<25.0	0.7	3.0	
10/22	<1.0	<25.0	0.8	4.0	
11/28	3.0	<25.0	0.8	1.0	
12/18	<1.0	<25.0	4.3	12.0	

Table 4.6. Quarterly results of effluent monitoring at solid waste management units—field measurements and physical parameters

Date	pH (units)	Conductivity (µmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W16						
01/10	6.60	498.00	60.00	10.00	5.00	
	6.60	494.00				
	6.60	497.00				
	6.70	496.00				
05/22	7.20	502.00	62.00	6.00	7.00	
	7.30	501.00				
	7.30	504.00				
	6.90	501.00				
08/09	6.10	499.00	72.00	5.00	8.00	18.44
11/14	6.30	496.00	63.00	5.00	3.00	20.45
	6.40	486.00				
	6.40	493.00				
	6.50	492.00				
W17						
01/04	6.50	1350.00	58.00	4.00	7.00	
05/22	7.30		59.00			44.99
08/29					7.00	47.58
11/29					7.00	51.22
12/14	6.90	1370.00	55.00	10.00	3.00	51.46
W18						
01/09	7.00	1430.00	61.00	80.00	10.00	34.99
	7.00	1430.00				
	7.00	1440.00				
	7.10	1430.00				
05/16	7.40	1390.00	61.00	70.00	8.00	32.51
	7.40	1400.00				
	7.40	1410.00				
	7.40	1410.00				
08/21	6.90	1390.00	61.00	70.00	12.00	33.60
	6.90	1390.00				
	6.90	1400.00				
	6.90	1390.00				
11/14	6.80	1390.00	61.00	60.00	9.00	34.34
	6.80	1360.00				
	6.80	1410.00				
	6.80	1390.00				
W19						
01/11	6.30	235.00	53.00			40.99
08/23						36.64
10/04	6.60	218.00	74.00	16.00	8.00	35.30
	6.50	219.00				
	6.40	218.00				
	6.10	218.00				

Table 4.6 (continued)

Date	pH (units)	Conductivity (µmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W20						
01/18	6.30	325.00	57.00	76.00	4.00	
	5.30	327.00				
	6.30	326.00				
04/19	6.30	327.00	58.00	40.00	4.00	
	6.20	320.00				
	6.20	314.00				
	6.20	319.00				
11/01	6.20	319.00	58.00	50.00	4.00	
	6.50	321.00				
	6.50	324.00				
	6.50	323.00				
	6.50	323.00				
W21						
01/24	7.50	1500.00	60.00	7.00	8.00	47.50
	7.50	1510.00				
	7.50	1520.00				
06/14	7.50	1520.00	69.00	2.00	7.00	41.62
	6.50	1480.00				
	6.50	1480.00				
	6.50	1490.00				
08/30	6.50	1500.00	66.00	0.55	7.00	43.10
	6.50	1560.00				
	6.50	1560.00				
	6.50	1560.00				
10/23	6.50	1560.00	61.00	2.00	23.00	45.23
	6.60	1560.00				
	6.60	1560.00				
	6.60	1560.00				
	6.60	1560.00				
W22						
01/23	6.60	302.00	57.00	200.00	13.00	45.74
	6.60	304.00				
	6.70	305.00				
06/21	6.70	301.00	67.00	4.00	17.00	39.25
	6.10	321.00				
	6.10	323.00				
	6.10	323.00				
08/21	6.10	323.00	68.00	1.50	27.00	40.82
	6.10	324.00				
	6.20	332.00				
	6.20	333.00				
10/31	6.20	332.00	64.00	5.00	7.00	43.55
	6.20	332.00				
	6.10	329.00				
	6.10	334.00				
	6.10	332.00				
	6.10	334.00				
W23						
09/04						16.73

Table 4.6 (continued)

Date	pH (units)	Conductivity (µmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W24						
09/05						11.45
W26						
09/04						32.27
W27						
09/05	6.20	438.00	73.00	60.00	10.00	18.00
W38						
04/11	6.30	439.00	59.00	3.00	12.00	57.34
	6.30	444.00				
	6.30	443.00				
	6.30	443.00				
08/01	6.60	446.00	59.00	0.20	4.00	55.47
	6.60	440.00				
	6.60	441.00				
	6.60	445.00				
11/08	6.30	439.00	58.00	1.50	4.00	59.00
	6.30	439.00				
	6.30	439.00				
	6.30	438.00				
W39						
01/11	6.50	762.00	59.00	12.00	2.00	57.65
	6.50	763.00				
	6.50	764.00				
	6.50	764.00				
04/11	6.50	716.00	59.00	7.00	3.00	54.39
	6.50	719.00				
	6.50	716.00				
	6.50	713.00				
08/01	6.40	715.00	60.00	5.00	3.00	52.55
	6.40	719.00				
	6.40	720.00				
	6.40	719.00				
11/08	6.20	745.00	58.00	8.00	6.00	56.20
	6.20	749.00				
	6.20	749.00				
	6.20	750.00				
W40						
01/11	6.20	345.00	59.00	2.00	6.00	57.98
	6.20	345.00				
	6.20	344.00				
	6.20	344.00				
04/23	6.30	343.00	60.00	2.00	7.00	54.00
	6.30	343.00				
	6.30	344.00				
	6.30	343.00				

Table 4.6 (continued)

Date	pH (units)	Conductivity (µmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W40						
08/02	6.10	340.00	59.00	1.50	3.00	53.00
	6.10	344.00				
	6.10	345.00				
	6.10	344.00				
11/07	6.30	353.00	59.00	1.50	3.00	56.62
	6.30	352.00				
	6.30	352.00				
	6.30	351.00				
W41						
04/19	6.20	358.00	59.00	16.00	7.00	51.25
	6.20	361.00				
	6.20	360.00				
	6.20	361.00				
08/02	6.00	352.00	61.00	5.00	6.00	55.50
	6.00	360.00				
	6.00	360.00				
	6.00	359.00				
10/31	6.10	359.00	59.00	7.00	5.00	53.15
	6.10	361.00				
	6.10	359.00				
	6.10	358.00				
W42						
02/27	6.30	677.00	60.00	50.00	5.00	38.00
	6.30	682.00				
	6.30	682.00				
	6.30	683.00				
04/24	6.50	696.00	60.00	6.00	7.00	35.00
	6.50	698.00				
	6.50	700.00				
	6.50	700.00				
08/08	6.50	689.00	60.00	6.00	8.00	34.35
	6.50	690.00				
	6.50	691.00				
	6.50	692.00				
11/07	6.10	688.00		15.00		
	6.10	689.00				
	6.10	687.00				
W43						
02/28	6.40	311.00	58.00	12.00	7.00	48.74
	6.40	313.00				
	6.40	313.00				
	6.40	314.00				

Table 4.6 (continued)

Date	pH (units)	Conductivity (µmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W43						
03/07	6.20	316.00	58.00	15.00	4.00	46.62
	6.20	316.00				
	6.20	315.00				
	6.20	316.00				
08/08	6.20	313.00	58.00	2.50	8.00	45.00
	6.20	316.00				
	6.20	316.00				
	6.20	316.00				
12/11	6.40	311.00	58.00	1.50	2.00	48.77
	6.40	313.00				
	6.40	313.00				
	6.40	313.00				
W44						
01/09	6.20	370.00	59.00	2.00	5.00	78.93
	6.20	372.00				
	6.20	371.00				
	6.20	372.00				
04/24	6.40	352.00	59.00	2.00	5.00	75.16
	6.40	353.00				
	6.40	353.00				
	6.40	354.00				
08/07	6.40	363.00	59.00	1.50	7.00	74.27
	6.40	365.00				
	6.40	365.00				
	6.40	366.00				
12/11	6.10	378.00	59.00	0.98	3.00	78.17
	6.10	378.00				
	6.10	379.00				
	6.10	381.00				
W46						
03/06	6.30	218.00	61.00	20.00	33.00	51.50
	6.30	220.00				
	6.30	220.00				
	6.30	217.00				
05/16	6.80	213.00	61.00	21.00	7.00	47.47
	6.80	215.00				
	6.80	216.00				
	6.80	216.00				
08/16	6.20	230.00	60.00	7.00	7.00	47.16
	6.20	231.00				
	6.20	231.00				
	6.20	230.00				
10/17	6.40	241.00	60.00	5.00	19.00	48.90
	6.40	240.00				
	6.40	241.00				
	6.40	241.00				

Table 4.6 (continued)

Date	pH (units)	Conductivity (μ mho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W47						
03/22	8.90		59.00			19.31
10/25				2500.00		26.54
W48						
05/16	6.90	195.00	60.00	14.00	7.00	48.49
	6.90	199.00				
	6.90	199.00				
	6.90	198.00				
W54						
05/31	6.40	263.00	62.00	170.00	12.00	44.44
	6.40	262.00				
	6.40	265.00				
	6.40	246.00				
08/16	6.70	273.00				
08/17	6.70	268.00	71.00	31.00	11.00	44.85
	6.70	272.00				
	6.60	260.00				
10/16	6.50	266.00	72.00	28.00	13.00	47.10
	6.50	282.00				
	6.60	279.00				
	6.60	278.00				
W57						
03/06	6.80	376.00	65.00	230.00	20.00	23.45
	6.80	374.00				
	6.30	375.00				
	6.60	378.00				
05/30	6.60	361.00	64.00	160.00	10.00	22.78
	6.80	365.00				
	6.80	367.00				
	6.90	366.00				
08/30	6.00	383.00	63.00	100.00	18.00	21.97
	6.30	375.00				
	6.40	374.00				
	6.50	372.00				
10/30	6.40	379.00	65.00	80.00	6.00	22.00
	6.40	377.00				
	6.40	378.00				
	6.40	374.00				
W58 (well abandoned 9/13/90)						
08/16	6.70	478.00	73.00	40.00	11.00	11.78

Table 4.6 (continued)

Date	pH (units)	Conductivity (μmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W62						
11/13	6.90	307.00	58.00	70.00	8.00	
	6.90	306.00				
	6.90	307.00				
	6.90	306.00				
W63						
01/23	6.30	275.00	60.00	20.00	7.00	48.24
	6.30	274.00				
	6.30	272.00				
	6.30	273.00				
04/03	6.40	262.00	60.00	9.00	6.00	45.70
	6.40	264.00				
	6.40	264.00				
	6.40	265.00				
07/12	6.20	297.00	60.00	29.00	12.00	42.63
	6.20	298.00				
	6.20	297.00				
	6.20	297.00				
10/02	6.30	285.00	60.00	10.00	7.00	45.67
	6.30	287.00				
	6.30	285.00				
	6.30	284.00				
W64						
01/25	6.80	743.00	59.00	110.00		9.68
04/05	7.00		64.00			21.15
07/18	6.80	661.00	71.00	6.00	6.00	19.76
	6.80	689.00				
07/18		679.00	69.00	7.00	3.00	9.45
		673.00				
10/03	6.80	592.00				
	6.90	613.00				
	6.80	587.00				
	6.80	702.00				
W65						
02/02		193.00	59.00	2.00	3.00	48.61
		196.00				
		196.00				
		194.00				
02/13	6.50		61.00			48.10
	6.40					
	6.40					
	6.40					
04/03	6.20	205.00	60.00	2.00	5.00	45.67
	6.20	204.00				
	6.20	203.00				
	6.20	203.00				

Table 4.6 (continued)

Date	pH (units)	Conductivity (µmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W65						
07/17	6.10	196.00	60.00	2.00		42.88
	6.10	198.00				
	6.10	198.00				
	6.10	198.00				
10/02	6.10	194.00	60.00	0.60	4.00	45.67
	6.10	196.00				
	6.10	196.00				
	6.10	195.00				
W66						
01/18	6.10	371.00	58.00	5.00	3.00	47.32
	6.10	370.00				
	6.10	369.00				
	6.10	370.00				
04/10	6.40	429.00	59.00	7.00	4.00	43.61
	6.40	427.00				
	6.40	425.00				
	6.40	435.00				
07/25	6.50	356.00	60.00	0.20	7.00	41.48
	6.50	357.00				
	6.50	359.00				
	6.50	359.00				
08/22	6.30	338.00	60.00	2.00		42.22
	6.30	339.00				
	6.30	343.00				
	6.30	343.00				
10/17	6.30	329.00	59.00	3.00	7.00	43.21
	6.30	333.00				
	6.30	333.00				
	6.30	335.00				
W67						
02/01	6.00	177.00	59.00	3.00	2.00	50.45
	6.00	179.00				
	6.00	179.00				
	6.00	179.00				
04/02	6.30	181.00	60.00	3.00	5.00	48.00
	6.30	181.00				
	6.30	182.00				
	6.30	176.00				
07/19	6.00	180.00	61.00	2.00	6.00	44.70
	6.00	180.00				
	6.00	179.00				
	6.00	179.00				
10/02	6.10	179.00	60.00	1.30	6.00	47.12
	6.10	178.00				
	6.10	178.00				
	6.10	178.00				

Table 4.6 (continued)

Date	pH (units)	Conductivity (µmho/cm)	Temp. (°F)	Turbidity (NTU)	Color (units)	Depth (ft)
W68						
03/13	6.40	416.00	63.00	4.00	3.00	53.48
	6.40	415.00				
	6.40	416.00				
	6.40	416.00				
04/03	6.30	412.00	60.00	3.00	4.00	52.75
	6.30	413.00				
	6.30	413.00				
	6.30	411.00				
07/11	6.40	408.00	63.00	2.00	6.00	48.11
	6.40	408.00				
	6.40	409.00				
	6.40	409.00				
10/03	6.50	411.00	60.00	0.70	3.00	51.45
	6.50	412.00				
	6.50	410.00				
	6.50	411.00				
W71						
03/13	5.90	538.00	62.00	5.00	3.00	53.60
	5.90	538.00				
	5.90	538.00				
	5.90	537.00				
04/04	6.00	549.00	62.00	4.00	5.00	52.46
	6.00	551.00				
	6.00	546.00				
	6.00	549.00				
07/11	6.10	567.00	65.00	3.00	7.00	48.10
	6.10	568.00				
	6.10	571.00				
	6.10	564.00				
10/03	5.80	567.00	62.00	35.00	6.00	51.43
	5.80	568.00				
	5.80	567.00				
	5.80	568.00				

Table 4.7. Quarterly effluent monitoring of organic and inorganic parameters at solid waste management units

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W16									
01/10	15.00	128.00	<1.00	0.40	<1.00 <1.00 <1.00 <1.00	9.00 <5.00 <5.00 6.00	<1.00	8.00	<0.50
05/22		32.00	3.00	0.35	2.00 1.00 <1.00 <1.00	<5.00 17.00 12.00 8.00	<1.00	5.00	<0.50
08/09	8.00	32.00	2.70	0.35	1.00	6.00	<1.00	18.00	<0.50
11/14	12.00	30.00	2.80	0.37	1.00 1.00 1.00 1.00	8.00 <5.00 10.00 28.00	<1.00	20.00	<0.10
W17									
01/04	22.00	157.00	<1.00	0.54	4.00	41.00	<1.00	7.00	<0.50
05/22						53.00	<1.00	3.00	<0.50
08/29					3.00	46.00	<1.00	9.00	<0.50
11/29						46.00	<1.00	10.00	<0.10
12/14	21.00	188.00	<1.00	0.53	3.00				
W18									
01/09	15.00	127.00	<1.00	0.94	7.00 8.00 7.00 7.00	27.00 27.00 32.00 43.00	<1.00	8.00	<0.50
05/16		116.00	<1.00	0.82	5.00 6.00 6.00 6.00	27.00 24.00 26.00 26.00	<1.00	1.00	<0.50
08/21	15.00	124.00	<1.00	0.84	7.00 7.00 7.00 7.00	13.00 <5.00 14.00 13.00	<1.00	3.00	<0.50
11/14	15.00	134.00	<1.00	0.88	7.00 7.00 7.00 7.00	18.00 24.00 25.00 13.00	<1.00	18.00	<0.10
W19									
01/11				0.34	7.00	<5.00	<1.00		<0.50
05/24					1.00	6.00	<1.00	4.00	
08/23					1.00	<5.00	<1.00	0.00	<0.50
10/04	6.00	12.00	1.00	0.27	<1.00 <1.00 1.00 <1.00	<5.00 6.00 <5.00 6.00	<1.00	0.00	1.90

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (µg/L)	TCE (µg/L)	⁹⁹ Tc (pCi/L)	PCB (µg/L)
W20									
01/18	41.00	12.50	<1.00	0.15	<1.00 <1.00 <1.00 <1.00	55.00 48.00 42.00	77.00	57.00	<0.50
04/19		12.00	<1.00	0.13	<1.00 1.00 <1.00 2.00	75.00 87.00 85.00 93.00	110.00	54.00	<0.50
11/01		11.00	1.40	0.13	<1.00 <1.00 <1.00 <1.00	153.00 157.00 154.00 150.00	210.00 220.00	129.00 112.00	<0.10
12/13							160.00	37.00	
W21									
01/24	180.00	372.00	<1.00	0.24	1.00 1.00 1.00 1.00	38.00 44.00 55.00 41.00	<1.00	22.00	<0.50
06/14		330.00	<1.00	0.27	2.00 2.00 2.00 2.00	57.00 37.00 48.00 42.00	<1.00	20.00	<0.50
08/30		401.00	<1.00	0.24	2.00 2.00 2.00 2.00	45.00 52.00 38.00 45.00	<1.00	9.00	<0.50
10/23		399.00	<1.00	0.24	1.00 1.00 1.00 1.00	31.00 43.00 50.00 58.00	<1.00	5.00	<0.10
W22									
01/23	41.00	13.00	<1.00	0.13	<1.00 <1.00 <1.00 <1.00	17.00 23.00 22.00 11.00	10.00	6.00	<0.50
06/21		13.00	<1.00	0.13	<1.00 <1.00 <1.00 <1.00	38.00 45.00 45.00 43.00	46.00	11.00	<0.50
08/21	41.00	13.00	<1.00	0.12	<1.00 <1.00 <1.00 <1.00 <1.00	45.00 49.00 49.00 50.00 53.00	54.00	26.00	<0.50
10/31		13.00	<1.00	0.11	<1.00 1.00 <1.00 <1.00	65.00 54.00 69.00 58.00	59.00	30.00	<0.10

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W23									
09/04					1.00	15.00		7.00	
W24									
09/05								0.00	
W26									
09/04					15.00	75.00	<1.00	8.00	
W27									
09/05	79.00	14.00	<1.00		1.00	14.00	<1.00	7.00	<0.50
W38									
02/08							3.00	16.00	
03/07							2.00	16.00	
04/11		8.00	1.90	0.27	<1.00	6.00	2.00	14.00	<0.50
					<1.00	<5.00			
					<1.00	7.00			
					<1.00	6.00			
05/15							2.00	5.00	
06/08							2.00	9.00	
07/24							3.00	15.00	
08/01	38.00	8.00	2.00	0.25	1.00	7.00	3.00	3.00	<0.50
					1.00	9.00			
					1.00	11.00			
					1.00	<5.00			
09/21							3.00	26.00	
10/11							3.00	28.00	
11/08	37.00	7.00	2.10	0.27	<1.00	23.00	3.00	39.00	0.10
					<1.00	10.00			
					<1.00	12.00			
					<1.00	8.00			
12/27							4.00	29.00	
W39									
01/11	35.00	78.00	1.30	0.31	<1.00	9.00	<1.00	18.00	<0.50
					<1.00	10.00			
					<1.00	8.00			
					<1.00	6.00			
04/11		62.00	1.40	0.30	<1.00	16.00	<1.00	4.00	<0.50
					1.00	12.00			
					<1.00	12.00			
					<1.00	13.00			
08/01	33.00	66.00	4.20	0.28	1.00	15.00	<1.00	0.00	<0.50
					1.00	13.00			
					1.00	14.00			
					1.00	9.00			

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W39									
11/08	36.00	70.00	1.40	0.29	1.00	16.00	<1.00	10.00	<0.10
					1.00	17.00			
					1.00	8.00			
					1.00	18.00			
W40									
01/11	30.00	12.00	1.50	0.18	1.00	<5.00	<1.00	0.00	<0.50
					<1.00	5.00			
					2.00	<5.00			
					1.00	<5.00			
02/08							<1.00	5.00	
04/23		13.00	1.60	0.16	<1.00	5.00	4.00	6.00	<0.50
					<1.00	8.00			
					<1.00	5.00			
					<1.00	10.00			
08/02	18.00	13.00	1.60	0.15	1.00	<5.00	<1.00	7.00	<0.50
					1.00	<5.00			
					1.00	<5.00			
11/07	33.00	12.00	1.60	0.17	<1.00	1.00	<5.00	2.00	<0.10
					<1.00	<5.00	+1.00		
					<1.00	<5.00			
					<1.00	<5.00			
W41									
02/22							12.00	2.00	
03/07							14.00	23.00	
04/19		10.00	1.60	0.16	<1.00	5.00	17.00	0.00	<0.50
					1.00	9.00			
					<1.00	9.00			
					<1.00	11.00			
05/24							15.00	4.00	
06/18							14.00	9.00	
07/19							17.00	12.00	
08/02	22.00	11.00	1.20	0.16	1.00	19.00	12.00	0.00	<0.50
					1.00	16.00			
					1.00	17.00			
					1.00	20.00			
09/21							17.00	6.00	
10/11							15.00	7.00	
10/31	39.00	11.00	1.30	0.16	<1.00	19.00	19.00	11.00	<0.10
					<1.00	11.00			
					<1.00	22.00			
					<1.00	18.00			
11/09							15.00	27.00	
12/19							16.00	1.00	
W42									
02/27	38.00	168.00	<1.00	0.17	2.00	11.00	<1.00	27.00	<0.50
					1.00	7.00			
					<1.00	9.00			
					<1.00	10.00			

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W42									
04/24		187.00	<1.00	0.17	1.00	<5.00	<1.00	12.00	<0.50
					1.00	7.00			
					1.00	6.00			
					1.00	10.00			
08/08	23.00	186.00	<1.00	0.16	1.00	8.00	<1.00	17.00	<0.50
					1.00	<5.00			
					<1.00	6.00			
					<1.00	6.00			
11/07	29.00	175.00	<1.00		<1.00	<5.00			
					<1.00	8.00			
					<1.00	6.00			
					<1.00				
W43									
02/28	29.00	8.00	<1.00	0.15	<1.00	10.00	<1.00	12.00	<0.50
					<1.00	6.00			
					<1.00	8.00			
					<1.00	<5.00			
03/07							<1.00	11.00	
03/07		9.00	<1.00	0.16	1.00	8.00	<1.00	0.00	<0.50
					1.00	10.00			
					<1.00	7.00			
					1.00	9.00			
05/22							<1.00	0.00	
06/18							<1.00	13.00	
07/20							<1.00	11.00	
08/08	18.00	9.00	<1.00	0.15	<1.00	5.00	<1.00	1.00	<0.50
					<1.00	<5.00			
					<1.00	<5.00			
					<1.00	<5.00			
09/26							<1.00	8.00	
10/04							<1.00	2.00	
11/20							<1.00	0.00	
12/11	29.00	8.00	1.10	0.15	<1.00	12.00	<1.00	8.00	<0.10
					<1.00	10.00			
					<1.00	9.00			
					<1.00	5.00			
W44									
01/09	37.00	15.00	<1.00	0.21	3.00	22.00	18.00	19.00	<0.50
					<1.00	16.00			
					<1.00	17.00			
					<1.00	15.00			
02/13							15.00	0.00	
03/07							21.00	9.00	
04/24		16.00	<1.00	0.19	<1.00	14.00	18.00	0.00	<0.50
					<1.00	15.00			
					<1.00	17.00			
					<1.00	14.00			
05/30							14.00	0.00	
06/19							14.00	8.00	
07/19							18.00	1.00	

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W44									
08/07	23.00	18.00	<1.00	0.18	<1.00 <1.00 <1.00 <1.00	24.00 17.00 17.00 20.00	18.00	5.00	<0.50
09/21							21.00	0.00	
10/16							22.00	7.00	
11/19							22.00	0.00	
12/11	42.00	17.00	1.10	0.18	1.00 1.00 1.00 1.00	34.00 26.00 28.00 27.00	21.00	2.00	<0.10
W46									
03/06	18.00	9.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00	<5.00 <5.00 <5.00 <5.00	<1.00	6.00	<0.50
05/16		8.00	<1.00	0.12	1.00 <1.00 <1.00 1.00	6.00 5.00 <5.00 <5.00	<1.00	2.00	<0.50
08/16		9.00	<1.00	0.11	<1.00 1.00 <1.00 <1.00	<5.00 <5.00 <5.00 <5.00	<1.00	0.00	<0.50
10/17		9.00	<1.00	0.13	<1.00 <1.00 <1.00 <1.00	9.00 6.00 <5.00 <5.00	<1.00	2.00	<0.10
W47									
03/22							47.00	46.00	
05/17							41.00	149.00	
08/15							39.00	19.00	0.60
08/24									<2.50
10/25		181.00	2.90		12.00		42.00	80.00	<0.10
W48									
05/16		9.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00	6.00 <5.00 7.00 <5.00	<1.00	0.00	<0.50
W54									
05/31		6.00	<1.00	0.14	1.00 <1.00 <1.00 <1.00	<5.00 <5.00 <5.00 7.00	1.00	0.00	<0.50
08/16					<1.00	<5.00			

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W54									
08/17		7.00	<1.00	0.16	<1.00 <1.00 <1.00	<5.00 <5.00 <5.00	1.00	1.00	<0.50
10/16		5.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00	<5.00 <5.00 <5.00 <5.00	<1.00	3.00	<5.00
W57									
03/06	12.00	31.00	<1.00	0.15	1.00 1.00 1.00 1.00	35.00 35.00 38.00	8.00	355.00	<0.50
05/30		20.00	<1.00	0.13	<1.00 <1.00 <1.00 1.00	15.00 16.00 17.00 16.00	8.00	66.00	<0.50
08/30		24.00	<1.00	0.19	1.00 1.00 <1.00 1.00	10.00 9.00 9.00 9.00	4.00	316.00	<0.50
10/30		14.00	<1.00	0.14	3.00 2.00 2.00 2.00	16.00 19.00 18.00 18.00	4.00	154.00	<0.10
W58									
08/16		91.00	<1.00	2.10	1.00	<5.00	<1.00	109.00	<0.50
W62									
11/13	3.00	<5.00	<1.00	0.21	<1.00 <1.00 <1.00 <1.00	<5.00 <5.00 <5.00	<1.00	<25.00	<0.10
W63									
01/23	16.00	12.00	<1.00	0.14	<1.00 <1.00 <1.00 <1.00	<5.00 <5.00 34.00 31.00	<1.00	1.00	<0.50
04/03		6.00	<1.00	0.12	<1.00 <1.00 <1.00 <1.00	<5.00 7.00 <5.00 10.00	<1.00	0.00	<0.50
07/12		11.00	<1.00	0.13	<1.00 <1.00 <1.00 <1.00	13.00 <5.00 6.00 <5.00	<1.00	0.00	<0.50

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W63									
10/02		13.00	<1.00	0.13	<1.00 <1.00 <1.00 <1.00		<1.00	0.00	<0.10
W64									
01/25	22.00	32.00	1.70	0.30		<5.00	<1.00	11.00	
04/05							<1.00	0.00	<0.50
07/18		16.00	2.10	0.31	1.00 2.00 1.00 1.00	7.00 <5.00 5.00 <5.00	<1.00	15.00	<0.50
10/03		17.00	2.00	0.30	1.00 <1.00 <1.00 <1.00		<1.00	3.00	<0.10
W65									
02/02	11.00	10.00	<1.00	0.11	2.00 <1.00 <1.00 <1.00	<5.00 <5.00 <5.00 <5.00	<1.00	28.00	<0.50
04/03		10.00	<1.00	0.12	<1.00 <1.00 <1.00 <1.00	5.00 5.00 <5.00 9.00	<1.00	1.00	<0.50
07/17		9.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00	<5.00 <5.00 <5.00 <5.00	<1.00	0.00	<0.50
10/02		9.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00		<1.00	0.00	<0.10
W66									
01/18	27.00	25.00	7.90	0.11	<1.00 5.00 <1.00 <1.00	2132.00 2716.00 2805.00 2790.00	5900.00	2558.00	<0.50
02/22							2900.00	2378.00	
03/14							4900.00	2318.00	
04/10		10.00	7.50	0.11	<1.00 1.00 1.00 1.00	2404.00 2805.00 2629.00 2535.00	5900.00	2212.00	<0.50
05/17							4100.00	2091.00	
06/22							4200.00	2128.00	

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (µg/L)	TCE (µg/L)	⁹⁹ Tc (pCi/L)	PCB (µg/L)
W66									
07/25		11.00	6.80	0.10	<1.00 <1.00 <1.00 <1.00	1624.00 2002.00 2125.00 2150.00	3500.00	1658.00	<0.50
08/22		11.00	6.80	0.10	<1.00 <1.00 <1.00 <1.00	1724.00 1778.00 1828.00 2049.00	4700.00	2235.00	<0.50
09/20							1600.00	1184.00	
10/17		11.00	5.60	0.11	<1.00 <1.00 <1.00 <1.00	1565.00 1740.00 1757.00 1780.00	3900.00	1982.00	<0.10
11/09							<1.00	<25.00	
11/12							<1.00 <1.00 <1.00 <1.00	<25.00 <25.00 <25.00 <25.00	
11/13							2000.00	1289.00	
12/26							2200.00	1691.00	
W67									
02/01	10.00	9.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00	6.00 <5.00 <5.00 <5.00	<1.00	14.00	<0.50
04/02		9.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00	<5.00 <5.00 <5.00 <5.00	<1.00	2.00	<0.50
07/19		9.00	<1.00	0.11	1.00 1.00 1.00 1.00	<5.00 <5.00 <5.00 <5.00	<1.00	11.00	<0.50
10/02		9.00	<1.00	0.11	<1.00 <1.00 <1.00 <1.00		<1.00	0.00	<0.10
W68									
03/13	57.00	13.00	1.70	0.14	2.00 4.00 2.00 3.00	31.00 35.00 30.00 36.00	28.00	125.00	<0.50
04/03		14.00	1.90	0.14	<1.00 <1.00 <1.00 <1.00	33.00 28.00 31.00 27.00	29.00	95.00	<0.50

Table 4.7 (continued)

Date	Cl ⁻ (mg/L)	SO ₄ (mg/L)	NO ₃ (mg/L)	F ⁻ (mg/L)	TOC ^a (mg/L)	TOX ^b (μg/L)	TCE (μg/L)	⁹⁹ Tc (pCi/L)	PCB (μg/L)
W68									
07/11		13.00	1.40	0.16	<1.00 <1.00 <1.00 <1.00	13.00 8.00 15.00 14.00	12.00	102.00	<0.50
10/03		12.00	1.40	0.12	<1.00 <1.00 <1.00 <1.00		30.00	107.00	<0.10
W71									
03/13	97.00	8.00	<1.00	0.11	<1.00 1.00 2.00 5.00	28.00 37.00 26.00 36.00	6.00	20.00	<0.50
04/04		11.00	<1.00	0.12	1.20 1.20 1.00 <1.00	31.00 31.00 37.00 35.00	7.00	18.00	<0.50
07/11		8.00	1.20	0.11	2.00 2.00 2.00 1.00	21.00 36.00 25.00 30.00	3.00	2.00	<0.50
10/03		6.00	<1.00	0.10	1.00 1.00 1.00 1.00		3.00	1.00	<0.10

^aTotal organic carbon.^bTotal organic halogen.

Table 4.8. Quarterly effluent monitoring of metals at solid waste management units

Date	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
W16						
01/10	<0.050	0.380	0.870	<0.200	<0.050	0.400
05/22	<0.050	0.172	0.500	<0.200	<0.050	0.125
08/09	<0.050	0.301	0.965	<0.200	0.050	0.258
11/14	<0.050	0.095	<0.010	<0.200	<0.050	0.087
W17						
01/04	<0.050	0.640	0.140	<0.200	0.260	1.500
05/22						
08/29	0.148	0.316	1.900	<0.200	0.090	0.240
11/29	<0.050	0.639	0.326	<0.200	0.073	0.627
W18						
01/09	<0.050	0.140	7.540	<0.200	<0.050	0.060
05/16	<0.050	<0.010	7.700	<0.200	<0.050	0.009
08/21	<0.050	<0.010	7.540	<0.200	<0.050	<0.005
11/14	<0.050	<0.010	7.450	<0.200	<0.050	0.005
W19						
01/11	<0.050	0.800	0.220	<0.200	0.120	1.950
05/24						
08/23	<0.050	0.702	1.310	<0.200	0.066	0.898
10/04	<0.050	0.469	0.291	<0.200	<0.050	0.550
W20						
01/18	<0.050	0.100	18.950	<0.200	<0.050	0.080
04/19	0.077	0.092	10.560	<0.200	<0.050	0.065
11/01	<0.050	0.093	15.540	<0.200	<0.050	
W21						
01/24	<0.050	<0.010	0.770	<0.200	0.100	0.070
06/14	<0.050	<0.010	0.920	<0.200	0.080	0.049
08/30	<0.050	0.012	0.780	<0.200	0.060	0.072
10/23	<0.050	<0.010	1.160	<0.200	0.052	0.047
W22						
01/23	<0.050	<0.010	12.550	<0.200	<0.050	0.005
06/21	0.032	<0.010	10.350	<0.200	<0.050	0.010
08/21	<0.050	<0.010	10.000	<0.200	<0.050	<0.004
10/31	<0.050	<0.010	7.400	<0.200	<0.050	0.013
W23						
09/04	0.064	<0.010	5.700	<0.200	<0.050	68.350
W24						
09/05	<0.050	<0.010	1.142	<0.200	<0.050	20.480

Table 4.8 (continued)

Date	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
W26						
09/04	<0.050	0.014	1.230	<0.200	<0.050	15.020
W27						
09/05	<0.050	<0.010	5.170	<0.200	<0.050	53.750
W38						
04/11	<0.050	<0.010	0.164	<0.200	<0.050	0.006
08/01	<0.050	<0.010	0.134	<0.200	<0.050	0.005
11/08	<0.050	<0.010	0.137	<0.200	<0.050	<0.005
W39						
01/11	<0.050	<0.010	0.920	<0.200	<0.050	0.020
04/11	<0.050	<0.010	0.820	<0.200	<0.050	0.012
08/01	<0.050	<0.010	0.862	<0.200	<0.050	0.007
11/08	<0.050	<0.010	0.612	<0.200	<0.050	0.005
W40						
01/11	<0.050	<0.010	0.200	<0.200	<0.050	<0.005
04/23	<0.050	<0.010	0.240	<0.200	<0.050	<0.005
08/02	<0.050	<0.010	0.168	<0.200	<0.050	0.006
11/07	<0.050	<0.010	0.281	<0.200	<0.050	<0.005
W41						
04/19	<0.050	<0.010	1.230	<0.200	<0.050	0.006
08/02	<0.050	<0.010	0.387	<0.200	<0.050	<0.005
10/31	<0.050	<0.010	0.230	<0.200	<0.050	0.016
W42						
02/27	<0.050	0.020	1.760	<0.200	<0.050	0.020
04/24	<0.050	<0.010	1.680	<0.200	<0.050	0.008
08/08	<0.050	<0.010	0.959	<0.200	<0.050	0.009
W43						
02/28	<0.050	0.010	0.980	<0.200	<0.050	0.020
04/18	<0.050	<0.010	2.030	<0.200	<0.050	<0.005
08/08	<0.050	<0.010	0.188	<0.200	<0.050	0.006
12/11	0.104	<0.010	0.760	<0.200	0.062	<0.005
W44						
01/09	<0.050	<0.010	0.100	<0.200	<0.050	0.010
04/24	<0.050	<0.010	0.061	<0.200	<0.050	<0.005
08/07	<0.050	<0.010	0.139	<0.200	<0.050	0.026
12/11	<0.050	<0.010	0.194	<0.200	<0.050	0.009

Table 4.8 (continued)

Date	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
W46						
03/06	<0.050	<0.010	5.500	<0.200	<0.050	0.010
05/16	<0.050	<0.010	7.600	<0.200	<0.050	0.026
08/16	<0.050	<0.010	8.110	<0.200	<0.050	0.006
10/17	<0.050	<0.010	9.310	<0.200	<0.050	0.011
W47						
03/22	0.121	0.055	285.000	<0.200	0.078	0.393
08/15						
08/24						
10/25	0.245	0.205	450.000	<0.200	0.180	0.058
W48						
05/16	<0.050	<0.010	8.550	<0.200	<0.050	0.023
W54						
05/31	<0.050	0.014	17.230	<0.200	<0.050	0.040
08/17	<0.050	<0.010	3.976	<0.200	<0.050	0.012
10/16	0.016	<0.010	4.553	<0.200	<0.050	0.006
W57						
03/06	<0.050	<0.010	35.650	<0.200	<0.050	0.060
05/30	<0.050	<0.010	20.060	<0.200	<0.050	0.014
08/30	<0.050	<0.010	21.780	<0.200	<0.050	0.046
10/30	<0.050	<0.010	11.100	<0.200	<0.050	0.031
W58						
08/16	<0.050	<0.010	4.386	<0.200	<0.050	0.013
W62						
11/13	<0.050	<0.010	5.950	<0.200	<0.050	0.006
W63						
01/23	0.070	<0.010	1.670	<0.200	0.110	<0.005
04/03	<0.050	<0.010	0.560	<0.200	0.104	0.005
07/12	0.095	<0.010	2.870	<0.200	0.138	0.016
10/02	<0.050	<0.010	0.348	<0.200	0.109	<0.005
W64						
01/25	0.050	<0.010	3.700	<0.200	0.130	0.020
07/18	<0.050	<0.010	0.602	<0.200	0.236	0.010
10/03	<0.050	<0.010	0.540	<0.200	0.110	<0.005

Table 4.8 (continued)

Date	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
W65						
02/02	<0.050	<0.010	0.040	<0.200	<0.050	0.020
04/03	<0.050	<0.010	0.048	<0.200	<0.050	0.021
07/17	<0.050	<0.010	0.156	<0.200	<0.050	0.008
10/02	<0.050	<0.010	0.033	<0.200	<0.050	0.050
W66						
01/18	<0.050	<0.010	0.020	<0.200	<0.050	0.005
04/10	<0.050	<0.010	0.360	<0.200	<0.050	0.060
07/25	<0.050	<0.010	0.043	<0.200	<0.050	<0.005
08/22	<0.050	<0.010	1.437	<0.200	0.185	<0.001
10/17	<0.050	<0.010	0.093	<0.200	<0.050	0.005
W67						
02/01	<0.050	<0.010	0.200	<0.200	0.060	<0.005
04/02	<0.050	<0.010	0.112	<0.200	0.060	0.005
07/19	<0.050	<0.010	0.126	<0.200	0.082	0.006
10/02	<0.050	<0.010	<0.010	<0.200	0.052	<0.005
W68						
03/13	<0.050	<0.010	0.185	<0.200	<0.050	0.030
04/03	<0.050	<0.010	0.081	<0.200	<0.050	0.032
07/11	<0.050	<0.010	0.166	<0.200	<0.050	0.042
10/03	<0.050	<0.010	0.020	<0.200	<0.050	0.027
W71						
03/13	0.115	<0.010	0.995	<0.200	0.094	0.011
04/04	<0.050	<0.010	0.325	<0.200	0.104	0.024
07/11	0.162	0.010	1.230	<0.200	0.195	0.033
10/03	0.108	<0.010	1.260	<0.200	0.112	0.014

Table 4.9. Quarterly effluent monitoring of radionuclide parameters at solid waste management units

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
W16					
01/10	<0.001	4.0	0.9	28.0	6.0
05/22	<0.001	22.4	15.3	24.0	24.0
08/09	<0.001	0.9	0.9	13.0	6.0
11/14	<0.001	5.3	0.2	28.0	3.0
W17					
01/04	0.014	9.0	3.2	20.0	19.0
05/22	0.010				
08/29	0.011	2.3	2.3	15.0	15.0
11/29	0.011	16.9	0.9	17.0	6.0
W18					
01/09	0.003	1.8	0.8	12.0	1.0
05/16	0.002	13.9	1.9	4.0	2.0
08/21	0.003	11.8	1.4	3.0	8.0
11/14	0.003	10.5	1.4	8.0	8.0
W19					
01/11	0.001	2.3	2.0	20.0	1.0
05/24	0.001	2.8	1.8	28.0	6.0
08/23	<0.001	10.0	1.1	9.0	4.0
10/04	<0.001	12.8	2.9	13.0	7.0
W20					
01/18	<0.001	5.3	0.7	29.0	7.0
04/19	<0.001	0.0	0.0	48.0	0.0
11/01	<0.001	0.0	1.1	101.0	5.0
W21					
01/24	<0.001	6.8	2.6	16.0	5.0
06/14	<0.001	21.7	1.1	8.6	5.0
08/30	<0.001	0.3	1.4	1.0	8.0
10/23	<0.001	8.1	1.6	5.0	5.0
W22					
01/23	<0.001	2.5	2.3	25.0	3.0
06/21	<0.001	2.5	3.3	37.0	4.0
08/21	<0.001	5.5	2.1	21.0	4.0
10/31	<0.001	1.1	6.3	50.0	4.0
W23					
09/04	0.001	0.6	3.4	1.0	14.0
W24					
09/05		1.0	4.4	1.0	13.0

Table 4.9 (continued)

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
W26					
09/04	0.019	0.6	2.7	1.0	9.0
W27					
09/05	<0.001	0.8	0.2	1.6	13.0
W38					
04/11	<0.001	1.3	1.6	15.0	4.0
08/01	<0.001	3.2	0.0	9.0	3.0
11/08	<0.001	2.1	0.0	29.0	9.0
W39					
01/11	<0.001	2.0	1.6	7.0	5.0
04/11	<0.001	3.5	1.1	10.0	1.0
08/01	<0.001	28.2	7.0	24.0	11.0
11/08	<0.001	8.6	0.7	1.0	6.0
W40					
01/11	<0.001	2.9	2.0	12.0	9.0
04/23	<0.001	0.9	0.0	4.0	1.0
08/02	<0.001	11.6	3.6	18.0	35.0
11/07	<0.001	1.9	5.6	20.0	3.0
W41					
04/19	<0.001	1.4	0.0	1.0	0.0
08/02	<0.001	12.2	3.6	24.0	6.0
10/31	<0.001	3.2	0.8	9.0	1.5
W42					
02/27	<0.001	0.9	1.8	18.0	3.0
04/24	<0.001	3.2	0.8	10.0	0.0
08/08	<0.001	2.4	0.6	4.0	9.0
W43					
02/28	<0.001	6.1	7.4	7.0	8.0
04/18	<0.001	0.0	0.0	10.0	1.0
08/08	<0.001	13.0	4.7	9.0	9.0
12/11	<0.001	3.4	0.1	5.0	4.0
W44					
01/09	<0.001	0.9	0.0	21.0	12.0
04/24	<0.001	0.1	0.8	11.0	0.0
08/07	<0.001	2.6	1.9	5.0	1.0
12/11	<0.001	8.2	0.2	1.0	0.0

Table 4.9 (continued)

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
W46					
03/06	<0.001	1.5	0.3	7.0	10.0
05/16	<0.001	2.9	1.9	2.0	0.0
08/16	0.006	2.1	4.7	3.0	12.0
10/17	0.001	5.2	1.1	2.0	9.0
W47					
10/25	0.067				
W48					
05/16	<0.001	2.2	7.2	4.0	14.0
W54					
05/31	<0.001	4.1	2.8	42.0	3.0
08/17	<0.001	1.1	1.7	3.0	5.0
10/16	0.001	8.5	2.3	6.0	2.0
W57					
03/06	0.053	11.8	0.5	110.0	55.0
05/30	0.020	10.5	0.1	154.0	1.0
08/30	0.027	0.9	0.0	2.0	5.0
10/30	0.021	0.4	5.6	113.0	15.0
W58					
08/16	12.000	1749.1	4.5	1265.0	25.0
W62					
11/13	<0.001	4.5	1.8	8.0	6.0
W63					
01/23	<0.001	1.9	2.3	19.0	11.0
04/03	<0.001	4.2	2.7	12.0	4.9
07/12	<0.001	2.4	0.9	10.9	9.0
10/02	0.002	1.8	1.6	8.0	6.0
W64					
01/25	0.006				
07/18	0.002	2.0	0.6	12.0	11.0
10/03	0.002	4.5	5.0	3.0	8.0

Table 4.9 (continued)

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
W65					
02/02	<0.001	2.6	0.5	14.0	5.0
04/03	<0.001	0.8	1.1	1.0	1.0
07/17	<0.001	10.0	6.2	14.0	3.0
10/02	<0.001	5.0	2.9	10.0	12.0
W66					
01/18	<0.001	1.5	4.1	1882.0	10.0
04/10	0.001	3.7	2.0	1484.0	10.0
07/25	<0.001	2.8	3.2	1389.0	1.0
08/22	<0.001	17.3	0.2	2037.0	0.0
10/17	0.001	31.8	16.0	1655.0	19.0
W67					
02/01	<0.001	1.2	2.3	6.0	17.0
04/02	<0.001	5.0	1.8	1.0	3.0
07/19	<0.001	1.3	1.1	5.4	7.0
10/02	<0.001	5.0	1.1	9.0	0.0
W68					
03/13	<0.001	1.3	0.9	85.0	2.0
04/03	<0.001	3.1	1.6	89.0	4.0
07/11	<0.001	2.8	0.7	28.0	8.0
10/03	<0.001	0.0	2.0	95.0	4.0
W71					
03/13	<0.001	3.7	2.5	1.0	11.7
04/04	<0.001	8.1	1.8	12.0	3.0
07/11	<0.001	1.6	1.7	1.0	5.0
10/03	<0.001	9.5	3.2	5.0	4.0

Table 4.10 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	Cl ⁻ (mg/L)	Cd (mg/L)	Cr (mg/L)	Mn (mg/L)	Se (mg/L)	PO ₄ (mg/L)	Am (pCi/L)	Co (pCi/L)
							W22							
01/23	6.6	152.0	58.2	18.85	7.00	18.55	41.0	<0.01	<0.01	3.740	<0.005	<2.00	9.10	0.30
06/21	6.1													
08/21	6.2						41.0							
10/31	6.1													
							W23							
09/04				23.00	12.12	21.68		<0.01		0.434	<0.005			0.20
							W24							
09/05				7.30	2.79	11.10		<0.01		0.072	<0.005			
							W26							
09/04				36.70	36.60	0.94		0.01		0.126	<0.005		5.20	1.40
							W27							
09/05	6.4	325.0	101.0	14.82	7.66	31.28	79.0	<0.01	<0.01	0.301	<0.005	<2.00	4.60	0.20
							W38							
04/11	6.3													
08/01	6.6						38.0							
11/08	6.3					41.74	37.0							
							W39							
01/11	6.5	494.0	243.0	44.70	22.20	60.25	35.0	<0.01	0.03	0.030	<0.005	<2.00	0.30	0.20
04/11	6.5													
08/01	6.4						33.0							
11/08	6.2					60.50	36.0							

Table 4.10 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	Cl ⁻ (mg/L)	Cd (mg/L)	Cr (mg/L)	Mn (mg/L)	Se (mg/L)	PO ₄ (mg/L)	Am (pCi/L)	Co (pCi/L)
02/02		142.0	68.6	14.35	6.35	12.60	11.0	<0.01	<0.01	0.010	<0.005	<2.00	1.30	0.20
02/13	6.4													
04/03	6.2													
07/17	6.1													
10/02	6.1													
01/18	6.1	225.0	46.0	27.75	9.10	17.70	27.0	<0.01	<0.01	0.005	<0.005	<2.00	9.80	1.80
04/10	6.4													
07/25	6.5													
08/22	6.3													0.10
10/17	6.3													
02/01	6.0	108.0	60.2	13.01	5.65	10.90	10.0	<0.01	<0.01	0.010	<0.005	<2.00	0.70	0.20
04/02	6.3													
07/19	6.0													
07/19	6.0													
10/02	6.1													
03/13	6.4	240.0	93.0	28.85	13.15	24.50	57.0	<0.01	<0.01	0.010	<0.005	<2.00	0.00	0.40
04/03	6.3													
07/11	6.4													
10/03	6.5													
03/13	5.9	291.0	101.0	27.40	11.91	49.75	97.0	<0.01	<0.01	0.012	<0.005	<2.00	0.60	0.10
04/04	6.0													
07/11	6.1													
10/03	5.8													

^aTotal dissolved solids.

5. BIOLOGICAL SAMPLING

Table 5.1. Metal concentrations (mg/kg) in deer meat and domestic beef

Metal	Reservation deer average (range)	Reference deer average (range)	Beef composite typical
Ca	21 (17–25)	23 (20–25)	80
Cu	1.4 (1.2–1.7)	1.2 (1.0–1.3)	0.69
Fe	32 (23–44)	33 (32–34)	18.4
Mg	260 (240–280)	250 (250–250)	180
Na	320 (230–390)	290 (270–300)	580
P	2,400 (2,300–2,500)	2,300 (2,300–2,300)	1,610
Zn	17 (12–22)	22 (19–24)	35.7

Table 5.2. Reference doses and metal intakes from ingesting one deer

Metal	Reference dose, RfD (mg/day)	Annualized reference dose, RfD (mg/year)	Estimated annual intake, PGDP deer (mg/year)	Estimated annual intake, reference (mg/year)
Ca	2.6	949	420 (337–522)	520 (470–570)
Cu			28 (20–39)	27 (23–31)
Fe			640 (354–864)	770 (760–780)
Mg			5,300 (4,309–6,161)	5,800 (5,700–5,900)
Na			6,400 (4,516–7,759)	6,600 (6,400–6,800)
P	14	5,110	48,000 (45,000–55,000)	54,000 (52,000–55,000)
Zn			340 (210–440)	500 (450–550)

6. SOIL AND SEDIMENT MONITORING

All information for this section is presented in Part 1.

7. POTENTIAL RADIATION DOSE TO THE PUBLIC

Table 7.1. 1990 annual dose estimation—worst case ingestion of groundwater

Radionuclide	Intake (exposure) values ^a				Dose values ^b	
	Concentration (pCi/L)	Ingestion rate (L/day)	Exposure frequency (days/year)	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^c (mrem/year)
⁹⁹ Tc	25.000	2.0	365	18250.00	1.30E-06	0.024

^aExposure values from EPA 600/8-89-043, "Exposure Factors Handbook," July 1989.^bDose factors from DOE/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1988.^cCommitted effective dose equivalent as committed (50-year) dose due to one year of exposure (mrem/year).

Table 7.2. 1990 annual dose estimation—worst case incidental ingestion of sediment in Little Bayou Creek

Radionuclide	Intake (exposure) values ^a				Dose values ^b	
	Concentration (pCi/g)	Ingestion rate (g/day)	Exposure frequency (days/year)	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^c (mrem/year)
²³⁴ U	3.370	0.8	213	574.25	2.60E-04	0.15
²³⁵ U	0.150	0.8	213	25.56	2.50E-04	0.01
²³⁸ U	12.100	0.8	213	2061.84	2.20E-04	0.47
⁹⁹ Tc	1.350	0.8	213	230.04	1.30E-06	0.00
²³⁷ Np	0.022	0.8	213	3.75	3.90E-03	0.01
²³⁹ Pu	0.014	0.8	213	2.39	4.30E-03	0.01
Total						0.65

^aExposure values from EPA 600/8-89-043, "Exposure Factors Handbook," July 1989.^bDose factors from DOE/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1988.^cCommitted effective dose equivalent as committed (50-year) dose due to one year of exposure (mrem/year).

Table 7.3. 1990 annual dose estimation—worst case incidental ingestion of sediment in Big Bayou Creek

Radionuclide	Intake (exposure) values ^a				Dose values ^b	
	Concentration (pCi/g)	Ingestion rate (g/day)	Exposure frequency (days/year)	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^c (mrem/year)
²³⁴ U	5.290	0.8	213	901.42	2.60E-04	0.23
²³⁵ U	0.240	0.8	213	4.09	2.50E-04	0.01
²³⁸ U	7.660	0.8	213	1305.26	2.30E-04	0.30
⁹⁹ Tc	9.270	0.8	213	1579.61	1.30E-06	0.00
²³⁷ Np	0.063	0.8	213	10.35	3.90E-03	0.04
²³⁹ Pu	0.024	0.8	213	4.09	4.30E-03	0.02
²³⁰ Th	0.170	0.8	213	28.97	5.30E-04	0.02
Total						0.62

^aExposure values from EPA 600/8-89-043, "Exposure Factors Handbook," July 1989.^bDose factors from DOE/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1988.^cCommitted effective dose equivalent as committed (50-year) dose due to one year of exposure (mrem/year).

Table 7.4. 1990 annual dose estimation—worst case ingestion of deer muscle

Radionuclide	Intake (exposure) values ^a				Dose values ^b	
	Concentration (pCi/g)	Ingestion rate (g/day)	Exposure frequency (days/year)	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^c (mrem/year)
²³⁴ U	0.021	227.0	178	848.53	2.60E-04	0.22

^aExposure values per C. Logsdon. Personal communication with R. D. Smith, November 27, 1990.^bDose factors from DOE/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1988.^cCommitted effective dose equivalent as committed (50-year) dose due to one year of exposure (mrem/year).

Table 7.5. 1990 annual dose estimation—worst case ingestion of foodcrops

Type	Nuclide	Intake (exposure) values ^a					Dose values ^b	
		Concentration (pCi/g)	Ingestion rate (g/day)	Exposure frequency (days/year)	Fraction ingested homegrown	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^c (mrem/year)
Cucumber	²³⁴ U	0.020	105.0	365	0.4	306.60	2.60E-04	0.080
Corn	²³⁴ U	0.032	213.0	365	0.4	1007.58	2.60E-04	0.262
Squash	²³⁴ U	0.009	287.0	365	0.4	377.12	2.60E-04	0.098
	⁹⁹ Tc	0.216	287.0	365	0.4	9050.83	1.30E-06	0.012
Peas	²³⁴ U	0.030	117.0	365	0.4	512.46	2.60E-04	0.133
Peppers	²³⁴ U	0.012	123.0	365	0.4	208.31	2.60E-04	0.054
Cabbage	²³⁴ U	0.010	102.0	365	0.4	153.39	2.60E-04	0.040
Tomatoes	²³⁴ U	0.030	123.0	365	0.4	538.74	2.60E-04	0.140
	²³⁵ U	0.017	123.0	365	0.4	296.31	2.50E-04	0.074
	²³⁸ U	0.011	123.0	365	0.4	197.54	2.30E-04	0.045
Beans	²³⁴ U	0.008	113.0	365	0.4	133.63	2.60E-04	0.035
Grapes	²³⁴ U	0.017	120.0	365	0.3	220.75	2.60E-04	0.057
Persimmons	²³⁴ U	0.032	164.0	365	0.3	581.84	2.60E-04	0.151
Total								1.180

^aExposure values from EPA 600/8-89-043, "Exposure Factors Handbook," July 1989.^bDose factors from DOE/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1988.^cCommitted effective dose equivalent as committed (50-year) dose due to one year of exposure (mrem/year).

Table 7.6. 1990 annual dose estimation—worst case direct radiation in Little Bayou Creek

Dose rate (mR/h)	Quality factor ^a (mrem/mR)	Exposure rate (h/trip)	Frequency ^b (trip/year)	Estimated dose (mrem/year)
0.039	1	0.5	213	4.15

^aQuality factor for converting gamma radiation from milliRoentgen to millirem.^bExposure frequency per C. Logsdon. Personal communication with M. G. Guhy, May 10, 1991.

8. SOLID WASTE MANAGEMENT PROGRAM

All information for this section is presented in Part 1.

9. SPECIAL STUDIES

All information for this section is presented in Part 1.

10. QUALITY ASSURANCE

Table 10.1. PGDP environmental analysis procedures for air

Parameter	Procedure	NIOSH or EPA method	Lowest concentration reported
Gross alpha, beta, air filters, radiochemistry	EC-2100	APHA 601, 602 ^a	Result obtained
Fluoride, air, SIE (µg/sample)	SA-F-2		5
Fluoride, stacks, SIE (mg/L)	SA-F-2		0.1 sample solution
Gamma-ray spectroscopy, air filters	R-26		Result obtained
Metals in air particulates, emission spectroscopy (µg/sample)	SC-35-2	NIOSH 7300 ^b	For 35 metals, mostly 1–10 each
Pu, air filters, radiochemistry	R-50	EPA-680/4-75-001	Result obtained
⁹⁹ Tc, air filters, radiochemistry	R-46		Result obtained
Th, alpha isotopes, radiochemistry	R-17		Result obtained
U, air filters, fluorometric (µg/sample)	EC-285		0.05
U isotopes, air filters, radiochemistry	I-4	EPA-680/4-75-001	Result obtained
U, stack gases, radiochemistry	I-4		Result obtained
U, stack samples, fluorometric (mg/L)	SA-U-8		0.001 sample solution

^aAPHA Methods, American Public Health Assoc., 1977.^bNIOSH Manual of Analytical Methods, Third Ed., U.S. Dept. of Health, Education, and Welfare, 1989.

Table 10.2. PGDP environmental analysis procedures for water

Parameter	Procedure	EPA method	Lowest concentration reported ^a
Alkalinity (CaCO ₃) (mg/L)	W-10	310.1	5
Gross alpha activity	R-4	900.0	Result obtained
Gross beta activity	R-4	900.0	Result obtained
²⁴¹ Am and ²⁴⁴ Cm	EC-1340		Result obtained
As and Se, furnace-AA			
As (mg/L)	SC-ENV-1	206.2	0.005
Se (mg/L)	SC-ENV-1	270.2	0.005
BOD (5-d) (mg/L)	W-20	405.1	5
COD, spectrophotometric method (mg/L)	W-40	Hach 8000	5
Anions, ion chromatograph ^b (mg/L)			
Chloride (mg/L)	W-50	300.0	2
Nitrate (N) (mg/L)	W-50	300.0	1
Sulfate (mg/L)	W-50	300.0	5
Phosphate (P) (mg/L)	W-50	300.0	2
Chlorine (total residual), amperometric (mg/L)	W-160	330.1	0.01
Chromium (VI), spectrophotometric (mg/L)	W-100	USGS ^c	0.01
Coliform bacteria (fecal) (col./100 mL)	W-80	909C Std. Mth. ^d	1
Coliform bacteria (total) (col./100 mL)	W-85	909A Std. Mth.	1
Color (color units)	SA-CLR-1	110.2	1
Conductance (specific) (µmho/cm)	SA-COND-1	120.1	0.5
Cyanide (total) (5-cm cell)	EC-1270	335.2	0.004
Fluoride (mg/L)	SA-F-5	340.2	0.1
Gamma-ray emitters	EC-1340		Result obtained
Hg (total) (mg/L)	SC-ENV-2	245.1	0.0002
²³⁷ Np	R-8		Result obtained
Nitrogen, ammonia, SIE (mg/L)	SA-NH3-2	350.3	0.2
Oil and grease, gravimetric (mg/L)	SA-O-G-1	413.1	5
Oil and grease, infrared (mg/L)	GA-9	413.2	2.0
pH, electrometric (mg/L)	W-110	150.1	Nearest 0.1 pH unit
Phosphorus (all forms) spectrophotometric (mg/L)	W-120	365.2	0.1
Pu isotopes	R-50		Result obtained
PCBs (µg/L)	OP-1	608	0.1 each Arochlor

Table 10.2 (continued)

Parameter	Procedure	EPA method	Lowest concentration reported ^a
Priority pollutants, organic (volatile, purgeable)	OP-3	624	
Trichloroethylene (µg/L)	OP-3	624	1
Acetone (µg/L)	OP-3	624	10
Isopropanol (µg/L)	OP-3	624	25
Benzene (µg/L)	OP-3	624	5
Toluene (µg/L)	OP-3	624	5
Ethylbenzene (µg/L)	OP-3	624	5
Total xylene (µg/L)	OP-3	624	5
1,2-Dichloroethane (µg/L)	OP-3	624	5
1,1,1-Trichloroethane (µg/L)	OP-3	624	5
Tetrachloroethene (µg/L)	OP-3	624	5
Trihalomethanes (µg/L)	OP-3	624	5
1,2-Dichloroethene (µg/L)	OP-3	624	5
Solids (dissolved) (mg/L)	W-140	160.1	10
Solids (total) (mg/L)	W-140	160.3	10
Solids (undissolved) (mg/L)	W-140	160.2	4
⁹⁹ Tc	R-46		Result obtained
Thorium isotopes	R-17		Result obtained
Total petroleum hydrocarbons (mg/L)	GA-28	418.1	0.1
Total organic carbon, combustion or oxidation	W-150	415.1	1
Turbidity (NTU)	W-170	180.1	0.05
Uranium (total), fluorometric (mg/L)	SA-U-8		1 × 10 ⁻³
Uranium isotopes	I-4		Result obtained
Uranium isotopic abundances	I-4		Result obtained

^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 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 meet the needs of the programs they support.

^bApproved for drinking water only (reagent water).

^cU.S. Geological Survey, "Methods for Analysis of Inorganic Substances in Water and Fluvial Sediment," Open-File Report 78-679; N. W. Skougstad et al., "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," Chapter A1, in *Techniques of Water-Resources Investigation*, Book 5, U.S. Geological Survey, 1979.

^dAll references to Standard Methods for the 16th Edition, 1985.

Table 10.3. PGDP atomic absorption and ICP environmental analysis procedures for water (lowest concentration reported)^a

Element	PGDP SC-ENV-1 ^b EPA 200 series graphite furnace AA (mg/L)	PGDP SC-ENV-4 ^b and SC-ICP-OP ^b EPA 200.7 ICP (mg/L)
Ag		0.03
Al		0.1
As	0.005	0.1
Ba		0.005
Ca		0.01
Cd		0.01
Cr		0.05
Cu		0.01
Fe		0.01
K		2.0
Li		0.02
Mg		0.002
Mn		0.005
Mo		0.05
Na		0.04
Ni		0.05
Pb		0.2
Se	0.005	0.2
Zn		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 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.

^bKY/L-176 "Technical Procedures," Vols. I and II, March 1, 1991.

Table 10.4. PGDP environmental analysis procedures for biota

Parameter	Procedure ^a	EPA method	Lowest concentration reported (mg/kg)
Fluoride in vegetation	EC-4100		3
Gamma-ray spectrometry of vegetation	EC-1340		Result obtained
U (total and isotopic) in vegetation	I-4		Result obtained

^aKY/L-176, "Technical Procedures," Vols. I and II, March 1, 1991.

Table 10.5. PGDP environmental analysis procedures for soil and sediment

Parameter	Procedure ^{a,b}	EPA method ^{c,d}	Lowest concentration reported (mg/kg)
Hg (total), flameless AA	SC-ENV-2	245.5	0.2
Np, direct gamma spectrum	R-15 EC-3300		Result obtained
²³⁷ Np, radiochemical	R-17 EC-3305		Result obtained
Pu, radiochemical	R-50 EC-3360		Result obtained
PCBs, gas chromatographic	OP-2	RCRA-8080	0.1
Priority pollutants organic (volatile purgeables)	OP-3	RCRA-8240	
Trichloroethene	OP-3	RCRA-8240	1
Benzene	OP-3	RCRA-8240	1
Toluene	OP-3	RCRA-8240	1
Ethylbenzene	OP-3	RCRA-8240	1
Xylenes (total)	OP-3	RCRA-8240	1
1,1,1-Trichloroethane	OP-3	RCRA-8240	1
Tetrachloroethene	OP-3	RCRA-8240	1
⁹⁹ Tc, radiochemical	R-46		Result obtained
Th (alpha-emitting) isotopes, radiochemical	R-17		Result obtained
Total petroleum hydrocarbons	GA-28	418.1	0.1
1,2,4-Trichlorobenzene	GA-28	RCRA-8120	0.1
U (total), fluorometric	EC-3700		0.5
U (total and isotopic), isotope dilution mass spectrometric	I-4		Result obtained
U isotopes, radiochemical	I-4		Result obtained
Aluminum	SC-ENV-5 & SC-ICP-OP	200.7	6.0
Arsenic	SC-ENV-5	200 series	0.5
Barium	SC-ENV-5 & SC-ICP-OP	200.7	0.04
Beryllium	SC-ENV-5 & SC-ICP-OP	200.7	0.1
Cadmium	SC-ENV-5 & SC-ICP-OP	200.7	0.6
Calcium	SC-ENV-5 & SC-ICP-OP	200.7	2.0
Chromium	SC-ENV-5 & SC-ICP-OP	200.7	0.4
Cobalt	SC-ENV-5 & SC-ICP-OP	200.7	0.4
Copper	SC-ENV-5 & SC-ICP-OP	200.7	0.2
Iron	SC-ENV-5 & SC-ICP-OP	200.7	1.0
Lead	SC-ENV-5 & SC-ICP-OP	200.7	4.0
Magnesium	SC-ENV-5 & SC-ICP-OP	200.7	0.1
Manganese	SC-ENV-5 & SC-ICP-OP	200.7	0.1
Molybdenum	SC-ENV-5 & SC-ICP-OP	200.7	1.6
Nickel	SC-ENV-5 & SC-ICP-OP	200.7	0.8
Potassium	SC-ENV-5 & SC-ICP-OP	200.7	10.0
Selenium	SC-ENV-1	200 series	0.5
Silver	SC-ENV-5 & SC-ICP-OP	200.7	0.6
Sodium	SC-ENV-5 & SC-ICP-OP	200.7	1.0
Vanadium	SC-ENV-5 & SC-ICP-OP	200.7	0.6
Zinc	SC-ENV-5 & SC-ICP-OP	200.7	0.4

^aEC designation refers to procedures in "Environmental and Effluent Analysis Manual," Martin Marietta Energy Systems, September 19, 1989.

^bOther designations in this column refer to "Technical Procedures," KY/L-176 Vols. I and II, Paducah Gaseous Diffusion Plant.

^cProcedures with RCRA designations refer to U.S. Environmental Protection Agency Dec. 1987, "Test Methods for Evaluating Solid Waste," SW-846.

^dRemainder of procedures from U.S. Environmental Protection Agency March 1983, "Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020.

Table 10.6. PGDP analysis procedures for off-site well waters

Parameter	Procedure ^{a,b}	EPA method ^{c,d}	Lowest concentration reported
Gross alpha activity	EC-1010	900.0	Report result obtained
Gross beta activity	EC-1010	900.0	Report result obtained
Benzene (µg/L)	OP-3	RCRA-8240	5
1,2-Dichloroethane (µg/L)	OP-3	RCRA-8240	5
Ethylbenzene (µg/L)	OP-3	RCRA-8240	5
PCBs (µg/L)	OP-1	RCRA-8080	0.1
Total petroleum			
Hydrocarbons (mg/L)	GA-28	418.1	0.1
Toluene (µg/L)	OP-3	RCRA-8240	1
1,1,1-Trichloroethane (µg/L)	OP-3	RCRA-8240	5
Trichloroethylene (µg/L)	OP-3	RCRA 8240	1
⁹⁹ Tc (pCi/L)	R-46		25

^aEC designation refers to procedures in "Environmental and Effluent Analysis Manual," Martin Marietta Energy Systems, September 19, 1989.

^bOther designations in this column refer to "Technical Procedures," KY/L-176 Vols. I and II, Paducah Gaseous Diffusion Plant.

^cProcedures with RCRA designations refer to U.S. Environmental Protection Agency Dec. 1987, "Test Methods for Evaluating Solid Waste," SW-846.

^dRemainder of procedures from U.S. Environmental Protection Agency March 1983, "Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020.

Table 10.7. PGDP analysis procedures for field measurements

Parameter	Procedure	EPA method	Lowest concentration reported
pH	ES-14	150.1	0.1 ^a
Dissolved oxygen (mg/L)	ES-14	360.1	0.1
Temperature	ES-14	170.1	0.1 ^b
Total residual chlorine (mg/L)	ES-16	330.5	0.01
Depth (ft)	ES-2	NA	0.01

^aNearest pH unit.

^bNearest degree F.

**Table 10.8. 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)	1.03 ± 0.01	2.67 ± 1.27	220	18
<i>Thermal ionization mass spectrometer</i>					
Uranium	10–20 mg/L (T)	1.206 ± 0.165	20.64 ± 16.50	17	56
Assay (wt % ²³⁵ U)	0.0–1.00 (T)	1.002 ± 0.037	0.17 ± 3.71	17	15

^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 10.9. 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 trichlorophenol, in water (RCRA 9020)	100	100.9 ± 2.19	29	12	100.9
	100	100.8 ± 1.22	107	12	100.8
<i>Polychlorinated biphenyls (µg/L)</i>					
PCB, spike recovery, in water (EPA 608)	40.0	34.7 ± 30.9	3	149	86.8
PCB, spike recovery, in groundwater (RCRA 8080)	40.0	38.2 ± 5.44	11	47	95.5
	50.0	41.7 ± 14.2	4	68	83.4
	0.096	0.081 ± 0.013	4	32	84.3
<i>Trichloroethylene (µg/L)</i>					
TCE, spike recovery, in groundwater (RCRA 8240)	5.0	4.66 ± 0.08	150	21	93.2
TCE, spike recovery, in water (EPA 624)	5.0	4.62 ± 0.28	22	28	92.4

^aLimit of error of the 95% confidence level.

**Table 10.10. PGDP Environmental Protection Agency Performance Evaluation
Report DMR-QA Study Number 010**

Parameter	Reported value	True ^a value	Acceptable limits	Warning limits	Performance ^b evaluation
<i>Trace metals (µg/L)</i>					
Aluminum	1190	1200	949–1440	1010–1380	Acceptable
Chromium	52.0	50.0	37.2–61.0	40.2–58.0	Acceptable
Copper	80.0	85.0	72.9–94.5	75.6–91.8	Acceptable
Iron	648.0	650	559–737	581–715	Acceptable
Nickel	209.0	200	172–227	179–220	Acceptable
Zinc	970.0	900	783–1000	810–976	Acceptable
<i>Miscellaneous parameters (mg/L)^c</i>					
pH (units)	5.9	6.00	5.86–6.12	5.89–6.09	Acceptable
Total suspended solids	69.0	73.0	61.3–78.0	63.3–75.9	Acceptable
Oil and grease	17.8	18.0	10.6–23.2	12.2–21.7	Acceptable
Total residual chlorine	1.50	1.50	0.896–1.82	1.02–1.70	Acceptable
<i>Demand (mg/L)</i>					
COD	75	76.2	58.3–93.6	62.7–89.2	Acceptable
5-day BOD	59	50.9	29.1–72.8	34.5–67.4	Acceptable

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

^bPerformance evaluation by EPA. 0–1.96 standard deviation for acceptable; 1.97–2.58 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 10.11. January 1990 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	1	50.4	54.18	53.04	0.638	Acceptable
CaCO ₃	2	78.6	80.51	78.67	0.016	Acceptable
(mg/L)						
Aluminum	1	36	29.3	32.6	0.474	Acceptable
(μg/L)	2	258	263.5	278.6	0.510	Acceptable
Ammonia as N	1	0.78	0.86	0.83	0.412	Acceptable
(mg/L)	2	2.4	2.46	2.37	0.036	Acceptable
Arsenic	1	35	33.7	33.4	0.272	Acceptable
(μg/L)	2	393	413.8	395.2	0.022	Acceptable
Barium	1	342	362.3	363.0	0.972	Acceptable
(μg/L)	2	1510	1564.8	1586.0	0.580	Acceptable
Beryllium	1	46	47.8	47.2	0.366	Acceptable
(μg/L)	2	149	138.3	138.5	0.888	Acceptable
BOD	1	135	100.80	105.06	1.449	Acceptable
(mg/L)	2	21	13.77	15.04	1.487	Acceptable
Cadmium	1	97	92.1	92.5	0.793	Acceptable
(μg/L)	2	198	186.2	187.0	0.945	Acceptable
Calcium	1	9.0	9.57	9.37	0.729	Acceptable
(mg/L)	2	4.55	4.87	4.85	0.749	Acceptable
Chloride	1	75.8	75.88	76.04	0.081	Acceptable
(mg/L)	2	97.1	97.17	98.14	0.215	Acceptable
Chromium	1	28	29.2	29.9	0.372	Acceptable
(μg/L)	2	244	250.0	252.7	0.374	Acceptable
COD	1	145	162.30	158.54	1.047	Acceptable
(mg/L)	2	25	22.17	23.08	0.268	Acceptable
Conductivity	1	440	479.9	418.72	0.506	Acceptable
(μmho/cm)	2	563	617.8	543.36	0.499	Acceptable
Copper	1	25	28.4	29.0	0.859	Acceptable
(μg/L)	2	132	141.2	143.1	1.113	Acceptable
Fluoride	1	4.10	4.12	4.14	0.152	Acceptable
(mg/L)	2	7.10	7.12	7.19	0.163	Acceptable
Hexavalent	1	0.05	0.05	0.04	0.138	Acceptable
chromium	2	0.11	0.12	0.12	0.955	Acceptable
(mg/L)						
Iron	1	34	36.5	39.4	0.544	Acceptable
(μg/L)	2	468	499.3	505.6	0.989	Acceptable
Lead	1	118	122.7	122.3	0.211	Acceptable
(μg/L)	2	285	284.6	285.4	0.015	Acceptable
Magnesium	1	5.50	5.38	5.35	0.402	Acceptable
(mg/L)	2	10.26	10.10	10.10	0.231	Acceptable
Manganese	1	77	78.6	76.9	0.009	Acceptable
(μg/L)	2	179	181.5	181.9	0.239	Acceptable
Mercury	1	1.4	1.7	1.6	1.136	Acceptable
(μg/L)	2	2.9	3.2	3.3	0.765	Acceptable
Nickel	1	28	25.6	26.8	0.252	Acceptable
(μg/L)	2	164	159.9	164.0	0.002	Acceptable
Nitrate as N	1	0.72	0.69	0.66	0.545	Acceptable
(mg/L)	2	1.7	1.61	1.40	0.571	Acceptable
Oil and grease	1	9.6	10.03	9.10	0.140	Acceptable
(mg/L)	2	38.6	40.13	33.04	0.579	Acceptable

Table 10.11 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
pH	1	6.8	6.39	6.66	0.595	Acceptable
(units)	2	6.6	6.19	6.44	0.653	Acceptable
Potassium	1	16.08	17.16	16.56	0.303	Acceptable
(mg/L)	2	11.51	12.74	12.11	0.271	Acceptable
Selenium	1	14	15.8	17.4	0.890	Acceptable
(µg/L)	2	73	86.6	90.1	0.733	Acceptable
Silver	1	56	58.8	57.6	0.280	Acceptable
(µg/L)	2	102	108.7	108.6	0.848	Acceptable
Sodium	1	56.72	58.41	56.87	0.033	Acceptable
(mg/L)	2	83.12	85.12	82.69	0.054	Acceptable
Sulfate	1	31.4	32.77	32.14	0.217	Acceptable
(mg/L)	2	35.9	36.67	36.65	0.185	Acceptable
TDS ^{b,c}	1	134	107.5	104.61	0.769	Acceptable
(mg/L)	2	291	274.1	102.32	0.446	Acceptable
TOC ^d	1	76	61.09	61.47	2.097	Warning
(mg/L)	2	9	8.35	8.64	0.211	Acceptable
Thallium	1	18	24.3	23.5	1.696	Acceptable
(µg/L)	2	200	250.0	249.1	1.518	Acceptable
Total hardness as CaCO ₃	1	45.6	46.07	45.62	0.005	Acceptable
(mg/L)	2	55.5	53.74	53.99	0.391	Acceptable
Total organic halides	1	29.0	33.8	47.4	0.469	Acceptable
(µg/L)	2	183.0	152.9	133.6	0.698	Acceptable
Total residual chlorine	1	0.59	0.60	0.58	0.134	Acceptable
(mg/L)	2	1.6	1.42	1.40	0.986	Acceptable
TSS ^{e,c}	1	70	79.1	88.8 ^c	0.041	Acceptable
(mg/L)	2	189	221.7	91.8 ^c	0.817	Acceptable
Trichloroethane	1	16.0	19.0	18.4	0.988	Acceptable
(µg/L)	2	54.0	65.0	60.0	0.841	Acceptable
Uranium	1	156.0	160.2	167.6	1.060	Acceptable
(µg/L)	2	1380	1401.4	1456.0	0.683	Acceptable
Vanadium	1	109	130.0	130.4	1.662	Acceptable
(µg/L)	2	1240	1345.0	1365.5	1.292	Acceptable
Zinc	1	56.0	53.9	55.1	0.092	Acceptable
(µg/L)	2	149	148.1	146.4	0.164	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.97–2.58 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 10.12. March 1990 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	46.6	46.6	45.5	0.546	Acceptable
	2	64.0	62.6	61.5	1.241	Acceptable
Aluminum (μg/L)	1	54	52.7	55.4	0.099	Acceptable
	2	193	193.2	205.9	0.397	Acceptable
Ammonia as N (mg/L)	1	0.39	0.37	0.40	0.179	Acceptable
	2	2.5	2.42	2.45	0.184	Acceptable
Arsenic (μg/L)	1	88	79.4	78.5	1.412	Acceptable
	2	160	179.6	181.1	1.442	Acceptable
Barium (μg/L)	1	359	362.3	350.7	0.293	Acceptable
	2	2192	2235.5	2164.2	0.156	Acceptable
Beryllium (μg/L)	1	39	42.8	40.6	0.247	Acceptable
	2	129	135.7	131.1	0.148	Acceptable
BOD (mg/L)	1	234.0	214.0	193.4	1.024	Acceptable
	2	43.0	40.2	36.0	0.730	Acceptable
Cadmium (μg/L)	1	19	15.7	15.5	1.355	Acceptable
	2	116	107.8	110.0	0.666	Acceptable
Calcium (mg/L)	1	10.8	10.9	10.7	0.144	Acceptable
	2	8.7	8.9	8.8	0.050	Acceptable
Chloride (mg/L)	1	47.0	47.2	47.8	0.300	Acceptable
	2	48.0	48.2	48.8	0.303	Acceptable
Chromium (μg/L)	1	49	47.9	48.9	0.012	Acceptable
	2	136	135.4	134.9	0.058	Acceptable
COD (mg/L)	1	285.0	344.5	308.0	0.410	Acceptable
	2	56.0	64.7	55.7	0.016	Acceptable
Conductivity (μmho/cm)	1	283.0	307.7	282.2	0.054	Acceptable
	2	321.0	352.8	316.3	0.293	Acceptable
Copper (μg/L)	1	84	85.3	84.8	0.157	Acceptable
	2	180	183.3	181.5	0.110	Acceptable
Fluoride (mg/L)	1	1.8	1.79	1.78	0.186	Acceptable
	2	6.1	6.06	6.02	0.270	Acceptable
Hexavalent chromium (mg/L)	1	0.03	0.033	0.031	0.126	Acceptable
	2	0.13	0.125	0.125	0.722	Acceptable
Iron (μg/L)	1	35	34.9	36.6	0.233	Acceptable
	2	220	230.2	231.0	0.871	Acceptable
Lead (μg/L)	1	27.0	24.5	25.3	0.458	Acceptable
	2	428	402.4	389.2	0.667	Acceptable
Magnesium (mg/L)	1	4.91	4.62	4.6 ²	0.965	Acceptable
	2	7.14	6.81	6.54	0.675	Acceptable
Manganese (μg/L)	1	63	60.5	58.4	0.944	Acceptable
	2	166	163.3	161.7	0.506	Acceptable
Mercury (μg/L)	1	1.8	1.80	1.75	0.133	Acceptable
	2	2.3	2.1	2.47	0.224	Acceptable
Nickel (μg/L)	1	57	57.3	55.6	0.153	Acceptable
	2	186	188.7	187.0	0.054	Acceptable
Nitrate as N (mg/L)	1	0.67	0.62	0.61	1.047	Acceptable
	2	1.40	1.33	1.31	0.770	Acceptable
Oil and grease (mg/L)	1	10.9	11.1	10.0	0.269	Acceptable
	2	29.1	30.4	27.2	0.373	Acceptable
Orthophosphate as P (mg/L)	1	0.36	0.36	0.36	0.090	Acceptable
	2	2.50	2.36	2.38	0.351	Acceptable

Table 10.12 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
pH	1	7.9	7.84	7.91	0.020	Acceptable
(units)	2	7.8	7.73	7.79	0.021	Acceptable
Potassium	1	14.45	13.19	12.88	1.239	Acceptable
(mg/L)	2	7.589	6.78	6.74	1.333	Acceptable
Selenium	1	17	14.7	15.2	0.938	Acceptable
(µg/L)	2	76	70.2	69.2	0.780	Acceptable
Silver	1	38	34.3	34.2	0.660	Acceptable
(µg/L)	2	274	243.4	245.1	1.298	Acceptable
Sodium	1	29.42	28.61	28.38	0.627	Acceptable
(mg/L)	2	41.49	40.59	40.58	0.376	Acceptable
Sulfate	1	12	12.3	12.1	0.069	Acceptable
(mg/L)	2	16	16.6	16.5	0.313	Acceptable
TDS ^{b,c}	1	204.0	189.3	0.45	0.415	Acceptable
(mg/L)	2	504.0	507.1	0.59	0.138	Acceptable
TOC ^d	1	119.0	129.7	130.1	1.295	Acceptable
(mg/L)	2	25.0	24.3	24.5	0.312	Acceptable
Thallium	1	125	128.9	130.9	0.280	Acceptable
(µg/L)	2	350	386.2	379.5	0.552	Acceptable
Toluene	1	46	47.2	42.9	0.34	Acceptable
(µg/L)	2	82	83.9	84.6	0.29	Acceptable
Total hardness as CaCO ₃	1	45.3	46.36	45.38	0.028	Acceptable
(mg/L)	2	48.7	50.37	49.29	0.129	Acceptable
Total organic halides	1	24	18.1	19.4	1.157	Acceptable
(µg/L)	2	278	329.7	293.2	0.561	Acceptable
Total residual chlorine	1	0.1	0.135	0.137	0.515	Acceptable
(mg/L)	2	2.15	2.41	2.23	0.177	Acceptable
TSS ^{e,f}	1	29.0	31.0	7.79	0.177	Acceptable
(mg/L)	2	278.0	331.7	4.98	1.523	Acceptable
1,1,1-trichloroethane	1	22	21.0	20.1	0.514	Acceptable
(µg/L)	2	63	59.7	60.2	0.377	Acceptable
Uranium	1	82	80.1	88.3	0.492	Acceptable
(µg/L)	2	280	300.3	342.5	1.133	Acceptable
Vanadium	1	76	90.0	88.2	0.786	Acceptable
(µg/L)	2	1026	1087.9	1067.1	0.382	Acceptable
Zinc	1	58	51.2	51.0	1.324	Acceptable
(µg/L)	2	140	135.0	134.7	0.622	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.97–2.58 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 10.13. May 1990 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	47.5	51.7	51.3	1.143	Acceptable
	2	38.3	36.3	36.7	0.480	Acceptable
Aluminum (μg/L)	1	65	60.0	61.1	0.282	Acceptable
	2	174	170.0	171.5	0.107	Acceptable
Ammonia as N (mg/L)	1	0.27	0.262	0.253	0.298	Acceptable
	2	1.9	1.92	1.96	0.299	Acceptable
Arsenic (μg/L)	1	32	27.8	27.3	1.397	Acceptable
	2	425	394.0	389.6	1.087	Acceptable
Barium (μg/L)	1	345	333.3	331.8	0.884	Acceptable
	2	1890	1810.7	1853.3	0.227	Acceptable
Beryllium (μg/L)	1	21	20.1	19.8	0.718	Acceptable
	2	129	120.6	117.7	1.735	Acceptable
BOD (mg/L)	1	190	204.4	189.3	0.019	Acceptable
	2	16	16.2	16.3	0.073	Acceptable
Cadmium (μg/L)	1	47	42.1	42.2	1.24	Acceptable
	2	239	210.3	215.0	2.225	Warning
Calcium (mg/L)	1	9.35	9.33	9.32	0.059	Acceptable
	2	27.84	29.39	28.59	0.405	Acceptable
Chloride (mg/L)	1	49.8	50.0	50.1	0.152	Acceptable
	2	101.3	104.7	101.5	0.033	Acceptable
Chromium (μg/L)	1	40.0	37.0	37.6	0.440	Acceptable
	2	247	235.0	238.4	0.481	Acceptable
COD (mg/L)	1	300	329.1	309.2	0.225	Acceptable
	2	31	26.0	26.8	0.658	Acceptable
Conductivity (μmho/cm)	1	302	327	302.9	0.047	Acceptable
	2	505	550.6	501.2	0.147	Acceptable
Copper (μg/L)	1	99	94.8	94.8	0.874	Acceptable
	2	280	269.3	264.6	0.563	Acceptable
Fluoride (mg/L)	1	1.2	1.20	1.19	0.109	Acceptable
	2	6.1	6.02	6.08	0.065	Acceptable
Hexavalent chromium (mg/L)	1	0.02	0.022	0.022	0.339	Acceptable
	2	0.43	0.435	0.421	0.271	Acceptable
Iron (μg/L)	1	36	34.9	35.4	0.163	Acceptable
	2	253	244.2	254.0	0.053	Acceptable
Lead (μg/L)	1	73	70.5	70.7	0.256	Acceptable
	2	288	265.0	263.6	0.935	Acceptable
Magnesium (mg/L)	1	3.95	3.67	3.66	1.333	Acceptable
	2	11.52	11.01	10.80	1.221	Acceptable
Manganese (μg/L)	1	64	60.5	60.3	0.551	Acceptable
	2	476	453.7	455.8	0.834	Acceptable
Mercury (μg/L)	1	2	1.4	1.4	2.298	Warning
	2	5	4.0	3.8	1.904	Acceptable
Nickel (μg/L)	1	38	34.4	35.9	0.321	Acceptable
	2	144	137.5	136.3	0.655	Acceptable
Nitrate as N (mg/L)	1	0.24	0.20	0.19	1.078	Acceptable
	2	1.9	1.80	1.80	1.023	Acceptable
Oil and grease (mg/L)	1	16.8	17.9	14.0	0.575	Acceptable
	2	29.8	31.8	29.3	0.083	Acceptable
Orthophosphate as P (mg/L)	1	0.42	0.40	0.39	0.866	Acceptable
	2	3.5	3.61	3.56	0.194	Acceptable

Table 10.13 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
pH	1	5.1	4.86	5.19	0.435	Acceptable
(units)	2	5.9	5.45	5.78	0.704	Acceptable
Potassium	1	18.09	18.27	18.22	0.087	Acceptable
(mg/L)	2	5.26	5.43	5.46	0.389	Acceptable
Selenium	1	39	36.7	36.3	0.414	Acceptable
(µg/L)	2	81	65.2	64.9	1.421	Acceptable
Silver	1	24	22.0	22.2	0.506	Acceptable
(µg/L)	2	174	173.9	177.0	0.200	Acceptable
Sodium	1	34.27	32.65	32.13	0.823	Acceptable
(mg/L)	2	46.22	44.88	44.16	0.513	Acceptable
Sulfate	1	10.1	10.3	10.2	0.064	Acceptable
(mg/L)	2	37.0	37.9	35.7	0.184	Acceptable
Tetrachloroethane	1	24	26.1	23.1	0.290	Acceptable
(µg/L)	2	80	83.5	76.2	0.296	Acceptable
TDS ^b	1	154	151.8	101.4 ^c	0.221	Acceptable
(mg/L)	2	521	532.4	97.8 ^c	0.006	Acceptable
TOC ^d	1	125.0	123.9	123.1	0.176	Acceptable
(mg/L)	2	10.3	9.8	10.4	0.076	Acceptable
Thallium	1	45	48.6	56.0	0.638	Acceptable
(µg/L)	2	645	648.7	589.9	0.566	Acceptable
Toluene	1	18	19.0	17.5	0.175	Acceptable
(µg/L)	2	84	84.7	77.1	0.507	Acceptable
Total organic halides	1	24	29.3	26.7	0.516	Acceptable
(µg/L)	2	190	220.0	204.1	0.352	Acceptable
Total residual chlorine	1	0.44	0.48	0.48	0.336	Acceptable
(mg/L)	2	2.6	2.60	2.47	0.576	Acceptable
TSS ^e	1	47	59.3	92.2 ^c	1.515	Acceptable
(mg/L)	2	138	162.4	94.3 ^c	1.340	Acceptable
Uranium	1	59	60.1	62.5	0.856	Acceptable
(µg/L)	2	1010	1001.0	979.2	0.375	Acceptable
Vanadium	1	41	50.0	49.6	1.920	Acceptable
(µg/L)	2	1418	1348.8	1357.7	0.783	Acceptable
Zinc	1	28	24.2	26.2	0.398	Acceptable
(µg/L)	2	244	220.0	222.4	1.557	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.97–2.58 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 10.14. July 1990 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	60.1	60.11	57.45	0.739	Acceptable
	2	61.1	61.78	59.89	0.396	Acceptable
Aluminum (μg/L)	1	36	40.0	46.1	0.721	Acceptable
	2	274	280.1	281.0	0.250	Acceptable
Ammonia as N (mg/L)	1	0.72	0.669	0.646	0.481	Acceptable
	2	2.0	2.01	1.98	0.099	Acceptable
Arsenic (μg/L)	1	36.7	43.68	42.40	0.924	Acceptable
	2	207.5	236.40	230.36	0.719	Acceptable
Barium (μg/L)	1	362	362.3	366.0	0.116	Acceptable
	2	1140	1117.7	1133.6	0.071	Acceptable
Benzene (μg/L)	1	15	17.6	17.5	1.130	Acceptable
	2	60	65.0	66.3	0.878	Acceptable
Beryllium (μg/L)	1	24	22.6	21.4	1.240	Acceptable
	2	123	110.5	106.8	1.797	Acceptable
BOD (mg/L)	1	143	130.5	127.1	0.657	Acceptable
	2	42	40.1	37.5	0.584	Acceptable
Cadmium (μg/L)	1	15	14.7	14.8	0.084	Acceptable
	2	228	210.3	210.6	1.190	Acceptable
Calcium (mg/L)	1	12.21	12.33	12.52	0.246	Acceptable
	2	23.63	23.96	24.15	0.390	Acceptable
Chloride (mg/L)	1	58	56.9	56.8	0.496	Acceptable
	2	99	97.2	95.8	0.434	Acceptable
Chlorobenzene (μg/L)	1	38	42.8	41.7	0.878	Acceptable
	2	58	64.5	63.9	1.008	Acceptable
Chromium (μg/L)	1	32	32.6	33.6	0.257	Acceptable
	2	121	119.6	119.5	0.177	Acceptable
COD (mg/L)	1	210	210.1	204.3	0.323	Acceptable
	2	62	64.6	59.2	0.344	Acceptable
Conductivity (μmho/cm)	1	355	385.9	346.6	0.365	Acceptable
	2	486	530.6	477.8	0.268	Acceptable
Copper (μg/L)	1	90	94.8	92.2	0.390	Acceptable
	2	152	154.7	154.5	0.242	Acceptable
Ethyl benzene (μg/L)	1	6	7.1	6.7	0.724	Acceptable
	2	87	95.1	93.2	0.727	Acceptable
Fluoride (mg/L)	1	3.3	3.31	3.26	0.149	Acceptable
	2	9.5	9.27	9.12	0.421	Acceptable
Hexavalent chromium (mg/L)	1	0.010	0.017	0.016	1.879	Acceptable
	2	0.36	0.361	0.363	0.176	Acceptable
Iron (μg/L)	1	47	55.8	55.8	0.910	Acceptable
	2	533	523.2	523.0	0.274	Acceptable
Lead (μg/L)	1	32	31.7	31.8	0.038	Acceptable
	2	303	292.4	293.2	0.380	Acceptable
Magnesium (mg/L)	1	3.8	3.56	3.62	0.889	Acceptable
	2	11.5	10.73	10.78	0.766	Acceptable
Manganese (μg/L)	1	63	60.5	59.7	0.753	Acceptable
	2	169	163.3	160.9	0.991	Acceptable
Mercury (μg/L)	1	1.6	1.60	1.57	0.154	Acceptable
	2	2.7	2.74	2.87	0.406	Acceptable
Nickel (μg/L)	1	30	31.8	31.7	0.321	Acceptable
	2	153	147.1	147.0	0.452	Acceptable

Table 10.14 (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	1.1	0.86	0.85	2.097	Warning
	2	1.6	1.32	1.34	1.739	Acceptable
Oil and grease (mg/L)	1	5.3	5.32	6.04	0.330	Acceptable
	2	44.2	47.9	40.6	0.436	Acceptable
Orthophosphate as P (mg/L)	1			Unreported		
	2	1.2	1.12	1.09	1.226	Acceptable
pH (units)	1	8.9	8.92	8.70	0.590	Acceptable
	2	9.2	9.13	8.91	0.903	Acceptable
Potassium (mg/L)	1	17.26	16.03	16.19	0.954	Acceptable
	2	8.04	7.43	7.56	0.642	Acceptable
Selenium (μg/L)	1	18.5	18.3	18.4	0.028	Acceptable
	2	143.7	145.3	143.1	0.027	Acceptable
Silver (μg/L)	1	13	17.2	17.6	1.892	Acceptable
	2	171	173.9	174.4	0.376	Acceptable
Sodium (mg/L)	1	44.84	42.07	43.00	0.781	Acceptable
	2	50.72	47.87	48.25	1.137	Acceptable
Sulfate (mg/L)	1	17	17.3	17.0	0.004	Acceptable
	2	18	18.8	18.5	0.262	Acceptable
Tetrachloroethane (μg/L)	1	7	8.2	7.6	0.480	Acceptable
	2	92	108.8	103.0	0.057	Acceptable
TDS ^{b,c} (mg/L)	1	119	120.4	101.9	0.141	Acceptable
	2	299	296.7	100.4	0.044	Acceptable
TOC ^d (mg/L)	1	84	79.1	78.5	0.879	Acceptable
	2	27	24.3	24.5	0.987	Acceptable
Thallium (μg/L)	1	47	48.6	48.6	0.184	Acceptable
	2	385	386.2	368.0	0.425	Acceptable
Toluene (μg/L)	1	10	11.4	10.9	0.627	Acceptable
	2	54	61.2	60.0	0.991	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	44	45.4	45.2	0.244	Acceptable
	2	102.6	104.0	102.8	0.064	Acceptable
Total organic halides (μg/L)	1	40	40.7	39.2	0.194	Acceptable
	2	166	176.1	156.1	0.754	Acceptable
Total residual chlorine (mg/L)	1	0.12	0.13	0.12	0.121	Acceptable
	2	2.3	2.27	2.11	0.557	Acceptable
TSS ^{e,c} (mg/L)	1	66	71.0	92.9 ^c	0.106	Acceptable
	2	195	214.0	94.4 ^c	0.501	Acceptable
Uranium (μg/L)	1	128	120.1	121.4	0.927	Acceptable
	2	1300	1301.3	1337.4	0.348	Acceptable
Vanadium (μg/L)	1	265	287.5	279.9	0.545	Acceptable
	2	1040	1107.9	1107.8	0.792	Acceptable
Zinc (μg/L)	1	47	48.5	48.9	0.371	Acceptable
	2	233	225.0	225.6	0.459	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.97–2.58 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 10.15. September 1990 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	52.4	52.49	52.70	0.068	Acceptable
	2	66.9	65.20	64.34	0.589	Acceptable
Aluminum (μg/L)	1	79	60.0	66.5	0.597	Acceptable
	2	387	400.1	354.8	0.268	Acceptable
Ammonia as N (mg/L)	1	0.53	0.58	0.59	0.495	Acceptable
	2	1.9	2.05	2.07	0.783	Acceptable
Arsenic (μg/L)	1	46.5	39.71	40.32	0.783	Acceptable
	2	232.5	183.9	185.9	1.848	Acceptable
Barium (μg/L)	1	704	724.6	722.4	0.283	Acceptable
	2	1251	1283.8	1271.5	0.265	Acceptable
Benzene (μg/L)	1	28	26.6	27.4	0.104	Acceptable
	2	58	52.6	57.5	0.046	Acceptable
Beryllium (μg/L)	1	22	20.0	20.3	0.622	Acceptable
	2	240	234.5	225.5	0.904	Acceptable
BOD (mg/L)	1	229	221.4	200.7	0.482	Acceptable
	2	41	41.1	37.7	0.372	Acceptable
Cadmium (μg/L)	1	51	49.1	49.1	0.469	Acceptable
	2	143	136.0	136.3	0.712	Acceptable
Calcium (mg/L)	1	19.02	20.21	21.28	0.439	Acceptable
	2	28.23	30.41	30.28	0.916	Acceptable
Carbon tetrachloride (μg/L)	1	32	29.5	30.4	0.152	Acceptable
	2	107	88.8	90.6	0.913	Acceptable
Chloride (mg/L)	1	86	89.4	89.0	0.588	Acceptable
	2	129	128.3	128.5	0.070	Acceptable
Chlorobenzene (μg/L)	1	19	21.0	19.5	0.222	Acceptable
	2	60	62.4	62.6	0.257	Acceptable
Chloroform (μg/L)	1	14	14.4	14.4	0.149	Acceptable
	2	148	132.2	129.6	0.676	Acceptable
Chromium (μg/L)	1	60	61.70	60.96	0.113	Acceptable
	2	118	122.0	119.0	0.072	Acceptable
COD (mg/L)	1	333	356.5	338.3	0.240	Acceptable
	2	60	66.1	62.4	0.197	Acceptable
Conductivity (μmho/cm)	1	483	529.3	480.0	0.110	Acceptable
	2	652	719.9	638.0	0.302	Acceptable
Copper (μg/L)	1	40	31.6	32.1	1.557	Acceptable
	2	140	133.7	132.7	0.585	Acceptable
Ethyl benzene (μg/L)	1	12	13.6	13.3	0.431	Acceptable
	2	64	68.5	70.7	0.617	Acceptable
Fluoride (mg/L)	1	2.2	2.26	2.20	0.025	Acceptable
	2	6.0	6.07	6.06	0.177	Acceptable
Hexavalent chromium (mg/L)	1	0.07	0.058	0.058	2.476	Warning
	2	0.30	0.30	0.30	0.004	Acceptable
Iron (μg/L)	1	129	126.4	125.7	0.150	Acceptable
	2	373	390.6	390.4	0.557	Acceptable
Lead (μg/L)	1	34	37.6	37.1	0.588	Acceptable
	2	263	293.6	266.0	0.131	Acceptable
Magnesium (mg/L)	1	6.50	6.58	6.71	0.203	Acceptable
	2	8.94	8.98	8.96	0.017	Acceptable
Manganese (μg/L)	1	38	36.3	26.6	0.341	Acceptable
	2	199	201.6	194.8	0.301	Acceptable
Mercury (μg/L)	1	2	1.4	1.4	2.138	Warning
	2	5.2	4.49	4.04	1.261	Acceptable

Table 10.15 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	No. of standard deviations from the mean	Performance ^a evaluation
Nickel	1	60	50.9	49.6	1.511	Acceptable
(µg/L)	2	186	179.1	179.4	0.507	Acceptable
Nitrate as N	1	Unreported				
(mg/L)	2	1.38	1.26	1.24	1.357	Acceptable
Oil and grease	1	11.9	12.0	10.4	0.342	Acceptable
(mg/L)	2	32.4	35.0	31.3	0.143	Acceptable
Orthophosphate as P (mg/L)	1	Unreported				
	2	4.76	4.49	4.16	0.836	Acceptable
pH	1	4.6	4.27	4.52	0.336	Acceptable
(units)	2	7.9	7.50	7.62	0.714	Acceptable
Potassium	1	12.94	13.15	13.45	0.340	Acceptable
(mg/L)	2	14.63	15.01	14.98	0.315	Acceptable
Selenium	1	21.5	20.37	19.53	0.577	Acceptable
(µg/L)	2	162.5	150.35	145.09	0.709	Acceptable
Silver	1	47	49.0	48.4	0.329	Acceptable
(µg/L)	2	140	144.9	144.6	0.392	Acceptable
Sodium	1	58.53	55.59	55.57	0.777	Acceptable
(mg/L)	2	77.19	73.76	73.49	0.776	Acceptable
Sulfate	1	34	35.2	34.2	0.054	Acceptable
(mg/L)	2	46	44.4	43.1	0.679	Acceptable
Tetrachloroethane	1	11	13.5	12.2	0.427	Acceptable
(µg/L)	2	74	78.1	74.1	0.009	Acceptable
TDS ^{b,c}	1	126	150.2	102.9	1.072	Acceptable
(mg/L)	2	267	276.1	101.0	0.648	Acceptable
TOC ^d	1	147	134.2	140.4	0.457	Acceptable
(mg/L)	2	26	24.9	26.3	0.089	Acceptable
Thallium	1	91	98.5	92.5	0.060	Acceptable
(µg/L)	2	305	343.2	339.3	0.453	Acceptable
Total hardness as CaCO ₃	1	77	77.6	76.5	0.115	Acceptable
(mg/L)	2	112	112.9	112.2	0.034	Acceptable
Total organic halides	1	45	30.4	33.4	1.850	Acceptable
(µg/L)	2	164	150.1	137.5	1.667	Acceptable
Total residual chlorine	1	0.45	0.529	0.492	0.416	Acceptable
(mg/L)	2	1.97	2.115	1.982	0.064	Acceptable
TSS ^{e,f}	1	63	70.9	90.6	0.168	Acceptable
(mg/L)	2	193	219.5	93.2	0.729	Acceptable
1,1,1-trichloroethane	1	11	11.2	11.6	0.207	Acceptable
(µg/L)	2	81	72.4	76.3	0.217	Acceptable
Uranium	1	100	100.1	106.6	0.594	Acceptable
(µg/L)	2	620	600.6	638.5	0.480	Acceptable
Vanadium	1	246	261.9	268.9	0.437	Acceptable
(µg/L)	2	1090	1066.2	1100.3	0.138	Acceptable
Zinc	1	66	59.3	58.9	1.311	Acceptable
(µg/L)	2	166	163.3	164.3	0.133	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.97–2.58 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 10.16. November 1990 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	39.05	39.60	0.210	Acceptable
	2	53.4	54.19	53.79	0.095	Acceptable
Aluminum (μg/L)	1	70.7	66.87	70.15	0.033	Acceptable
	2	320.4	315.25	326.41	0.168	Acceptable
Ammonia as N (mg/L)	1	0.29	0.283	0.292	0.038	Acceptable
	2	2.4	2.52	2.56	0.504	Acceptable
Antimony (μg/L)	1	90.9	208.2	173.52	1.430	Acceptable
	2	427.5	684.73	614.61	1.503	Acceptable
Arsenic (μg/L)	1	33.5	31.76	30.47	0.662	Acceptable
	2	316	323.1	287.5	0.351	Acceptable
Barium (μg/L)	1	428.5	434.7	423.4	0.177	Acceptable
	2	1967.3	1999.1	1981.4	0.120	Acceptable
Beryllium (μg/L)	1	38.7	37.69	36.21	0.804	Acceptable
	2	220.4	208.54	203.37	1.14	Acceptable
BOD (mg/L)	1	232	208.4	197.1	0.740	Acceptable
	2	44	37.6	36.0	1.043	Acceptable
Cadmium (μg/L)	1	31	28.6	29.8	0.181	Acceptable
	2	122.4	119.28	120.96	0.122	Acceptable
Calcium (mg/L)	1	7.33	7.554	7.682	0.536	Acceptable
	2	24.2	25.51	25.17	0.594	Acceptable
Carbon tetrachloride (μg/L)	1	10	10.8	10.4	0.328	Acceptable
	2	111	105.2	109.0	0.133	Acceptable
Chloride (mg/L)	1	56	56.5	55.8	0.073	Acceptable
	2	121	121.0	118.6	0.433	Acceptable
Chlorobenzene (μg/L)	1	7	7.6	7.3	0.369	Acceptable
	2	73	74.3	74.2	0.168	Acceptable
Chromium (μg/L)	1	38.8	41.97	41.67	0.354	Acceptable
	2	157.8	157.37	155.32	0.100	Acceptable
COD (mg/L)	1	335	335.4	319.2	0.720	Acceptable
	2	58	60.6	53.9	0.256	Acceptable
Cobalt (μg/L)	1	139.3	142.78	142.12	0.397	Acceptable
	2	403.4	410.17	408.32	0.234	Acceptable
Conductivity (μmho/cm)	1	313	338.5	315.0	0.114	Acceptable
	2	576	633.2	567.4	0.198	Acceptable
Copper (μg/L)	1	22	22.1	23.4	0.338	Acceptable
	2	107.7	114.59	119.11	1.097	Acceptable
Fluoride (mg/L)	1	2.3	2.34	2.37	0.287	Acceptable
	2	5.7	5.72	5.78	0.198	Acceptable
Iron (μg/L)	1	102.6	94.80	95.85	0.599	Acceptable
	2	362.7	346.62	345.95	0.567	Acceptable
Lead (μg/L)	1	74.5	88.08	87.78	1.069	Acceptable
	2	233.5	233.31	233.53	0.001	Acceptable
Magnesium (mg/L)	1	6.11	5.90	5.92	0.356	Acceptable
	2	11.7	11.44	11.38	0.285	Acceptable
Manganese (μg/L)	1	49.7	48.39	47.16	0.526	Acceptable
	2	111.8	108.88	110.40	0.168	Acceptable
Mercury (μg/L)	1	1.85	1.90	1.73	0.347	Acceptable
	2	3.7	3.74	3.68	0.055	Acceptable
Molybdenum (μg/L)	1	35.4	74.41	62.35	1.128	Acceptable
	2	169.5	252.99	233.43	2.305	Warning
Nickel (μg/L)	1	74.3	73.82	70.60	0.364	Acceptable
	2	141.3	137.52	138.00	0.173	Acceptable

Table 10.16 (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		Unreported			
	2	3.4	1.53	1.53	11.546	Not acceptable
Oil and grease (mg/L)	1	6.9	7.44	7.55	0.183	Acceptable
	2	29	31.0	27.5	0.202	Acceptable
Orthophosphate as P (mg/L)	1		Unreported			
	2	9.6	4.66	4.56	6.758	Not acceptable
pH (units)	1	6.6	6.22	6.12	1.540	Acceptable
	2	7.9	7.98	7.72	0.739	Acceptable
Potassium (mg/L)	1	11.3	11.9	11.6	0.344	Acceptable
	2	16.5	17.3	16.9	0.344	Acceptable
Selenium (µg/L)	1	15.6	12.22	12.57	1.623	Acceptable
	2	165	155.4	146.8	0.703	Acceptable
Silver (µg/L)	1	64.5	61.24	61.04	0.704	Acceptable
	2	389	382.2	380.6	0.273	Acceptable
Sodium (mg/L)	1	38.2	36.50	36.34	0.579	Acceptable
	2	58.3	56.57	55.05	0.789	Acceptable
Sulfate (mg/L)	1	17	18.5	18.1	0.784	Acceptable
	2	28	30.0	29.6	0.578	Acceptable
TDS ^{b,c} (mg/L)	1	187	195.2	102.27	0.319	Acceptable
	2	217	225.8	100.76	0.860	Acceptable
TOC ^d (mg/L)	1	128	126.3	124.0	0.273	Acceptable
	2	22	22.8	22.6	0.273	Acceptable
Thallium (µg/L)	1	143.9	157.55	147.33	0.154	Acceptable
	2	284.3	334.66	324.08	1.003	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	43.6	43.17	43.44	0.047	Acceptable
	2	109.4	110.80	109.07	0.065	Acceptable
Total organic halides (µg/L)	1	31	21.9	22.5	2.389	Warning
	2	320	351.2	312.7	0.131	Acceptable
Total residual chlorine (mg/L)	1	0.35	0.392	0.368	0.218	Acceptable
	2	4.9	5.23	4.62	0.307	Acceptable
TSS ^{e,f} (mg/L)	1	49	55.3	90.23	0.175	Acceptable
	2	119	135.0	94.34	0.957	Acceptable
1,1,1-trichloroethane (µg/L)	1	17	17.6	17.5	0.188	Acceptable
	2	55	55.9	59.4	0.498	Acceptable
1,1,2-trichloroethane (µg/L)	1	31	32.9	33.2	0.558	Acceptable
	2	87	85.7	89.2	0.193	Acceptable
Uranium (µg/L)	1	110	120.1	115.7	0.483	Acceptable
	2	900	1001.0	939.5	0.825	Acceptable
Vanadium (µg/L)	1	75.6	110.21	106.17	1.746	Acceptable
	2	1686.6	1691.6	1695.5	0.081	Acceptable
Zinc (µg/L)	1	56.4	53.9	55.2	0.137	Acceptable
	2	173.5	174.97	177.79	0.209	Acceptable

^aPerformance evaluation made by using EPA criteria, 0–1.96 standard deviations for acceptable; 1.97–2.58 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 10.17. January 1990 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	0.0437	0.0443	0.0386–0.0501	Acceptable	373
	2	0.0617	0.0591	0.0519–0.0665	Acceptable	373
	3	0.0200	0.0201	0.0169–0.0233	Acceptable	373
	4	0.0320	0.0328	0.0293–0.0364	Acceptable	373
Cadmium (total mg)	1	0.0084	0.0089	0.0078–0.0100	Acceptable	372
	2	0.0121	0.0118	0.0106–0.0132	Acceptable	372
	3	0.0157	0.0157	0.0142–0.0174	Acceptable	372
	4	0.0094	0.0099	0.0091–0.0109	Acceptable	372
Zinc (total mg)	1	0.1354	0.1457	0.1230–0.1685	Acceptable	369
	2	0.1052	0.1043	0.0897–0.1190	Acceptable	369
	3	0.0828	0.0847	0.0733–0.0962	Acceptable	369
	4	0.1593	0.1704	0.1478–0.1932	Acceptable	369
Asbestos (fibers/mm ²)	1	616.0	763.4	426.0–1198.5	Acceptable	1237
	2	497.0	503.5	255.7–834.6	Acceptable	1237
	3	122.0	158.5	73.5–275.8	Acceptable	1237
	4	366.0	383.5	193.5–637.5	Acceptable	1237

^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 10.18. April 1990 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	0.0236	0.0241	0.0206–0.0276	Acceptable	384
	2	0.0422	0.0419	0.0370–0.0469	Acceptable	384
	3	0.0588	0.0575	0.0508–0.0642	Acceptable	384
	4	0.0357	0.0361	0.0318–0.0403	Acceptable	384
Cadmium (total mg)	1	0.0149	0.0150	0.0135–0.0165	Acceptable	381
	2	0.0082	0.0080	0.0073–0.0089	Acceptable	381
	3	0.0123	0.0119	0.0107–0.0133	Acceptable	381
	4	0.0100	0.0100	0.0089–0.0113	Acceptable	381
Zinc (total mg)	1	0.2161	0.2153	0.1917–0.2390	Acceptable	377
	2	0.1897	0.1842	0.1637–0.2049	Acceptable	377
	3	0.1317	0.1275	0.1119–0.1432	Acceptable	377
	4	0.1002	0.1009	0.0840–0.1179	Acceptable	377
Asbestos (fibers/mm ²)	1	193.0	217.8	37.1–548.9	Acceptable	1273
	2	85.0	147.1	15.6–412.9	Acceptable	1273
	3	213.0	246.8	42.3–612.0	Acceptable	1273
	4	232.0	459.6	169.3–892.2	Acceptable	1273

^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 10.19. July 1990 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	0.0668	0.0642	0.0543–0.0741	Acceptable	390
	2	0.0282	0.0268	0.0227–0.0310	Acceptable	390
	3	0.0892	0.0843	0.0731–0.0955	Acceptable	390
	4	0.0512	0.0483	0.0414–0.0552	Acceptable	390
Cadmium (total mg)	1	0.0091	0.1071	0.0922–0.1220	Acceptable	386
	2	0.0119	0.1297	0.1134–0.1459	Acceptable	386
	3	0.0200	0.2185	0.1880–0.2491	Acceptable	386
	4	0.0128	0.1751	0.1512–0.1990	Acceptable	386
Zinc (total mg)	1	0.1066	0.1071	0.0922–0.1220	Acceptable	382
	2	0.1288	0.1297	0.1134–0.1459	Acceptable	382
	3	0.2224	0.2185	0.1880–0.2491	Acceptable	382
	4	0.1851	0.1751	0.1512–0.1990	Acceptable	382
Asbestos (fibers/mm ²)	1	448	369.3	194.7–599.5	Acceptable	1304
	2	628	573.2	201.4–1135.2	Acceptable	1304
	3	1058	783.1	435.7–1231.5	Acceptable	1304
	4	318	224.8	104.8–390.1	Acceptable	1304

^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 10.20. October 1990 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
Cadmium (total mg)	1	0.0074	0.0072	0.0062–0.0082	Acceptable	383
	2	0.0100	0.0107	0.0090–0.0123	Acceptable	383
	3	0.0120	0.0111	0.0094–0.0126	Acceptable	383
	4	0.0196	0.0185	0.0157–0.0213	Acceptable	383
Chromium (total mg)	1	0.0862	0.0894	0.0743–0.1046	Acceptable	378
	2	0.0488	0.0528	0.0437–0.0618	Acceptable	378
	3	0.0100	0.1015	0.0828–0.1200	Outlier	378
	4	0.1922	0.1947	0.1578–0.2315	Acceptable	378
Lead (total mg)	1	0.0528	0.0717	0.0639–0.0795	Outlier	355
	2	0.0260	0.0265	0.0225–0.0304	Acceptable	355
	3	0.0418	0.0392	0.0339–0.0445	Acceptable	355
	4	0.0635	0.0598	0.0519–0.0676	Acceptable	355
Asbestos (fibers/mm ²)	1	79	173.3	55.9–355.4	Acceptable	1321
	2	162	361.6	111.9–753.8	Acceptable	1321
	3	220	521.3	221.3–948	Outlier	1321
	4	329	554.4	253.9–970.8	Acceptable	1321

^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 10.21. March 1, 1990, 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	0.514E+02	0.558E+02	1.09	Acceptable
¹⁴⁴ Ce	0.312E+02	0.290E+02	0.93	Acceptable
⁵⁷ Co	0.650E+01	0.638E+01	0.98	Acceptable
⁶⁰ Co	0.940E+02	0.892E+01	0.95	Acceptable
¹³⁷ Cs	0.204E+02	0.188E+02	0.92	Acceptable
¹⁴⁴ Ce	0.312E+02	0.290E+02	0.93	Acceptable
¹³⁴ Cs	0.182E+02	0.132E+02	0.73	Marginal
⁵⁴ Mn	0.960E+01	0.954E+02	0.99	Acceptable
<i>Soil (pCi/g)</i>				
⁴⁰ K	0.608E+03	0.620E+03	1.02	Acceptable
¹³⁷ Cs	0.175E+05	0.202E+05	1.15	Acceptable
<i>Water (pCi/mL)</i>				
¹³⁴ Cs	0.462E+03	0.321E+03	0.69	Marginal
⁵⁷ Co	0.198E+03	0.176E+03	0.89	Acceptable
⁵⁴ Mn	0.103E+03	0.950E+02	0.92	Acceptable
⁶⁰ Co	0.206E+03	0.163E+03	0.79	Marginal
¹³⁷ Cs	0.198E+03	0.163E+03	0.82	Acceptable
¹⁴⁴ Ce	0.403E+03	0.355E+03	0.88	Acceptable
U (μg/mL)	0.788E-01	0.690E-01	0.88	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.

Table 10.22. September 1990, 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>				
⁵⁴ Mn	0.333E+02	0.332E+02	1.00	Acceptable
⁵⁷ Co	0.114E+02	0.118E+02	1.04	Acceptable
⁶⁰ Co	0.254E+02	0.241E+02	0.95	Acceptable
¹³⁷ Cs	0.157E+02	0.164E+02	1.04	Acceptable
²³⁹ Pu	0.510E-01	0.450E-01	0.88	Acceptable
¹³⁴ Cs	0.163E+02	0.170E+02	1.04	Acceptable
<i>Soil (pCi/g)</i>				
⁴⁰ K	0.513E+03	0.454E+03	0.88	Acceptable
¹³⁷ Cs	0.196E+03	0.203E+03	1.04	Acceptable
<i>Water (pCi/mL)</i>				
U (μg/mL)	0.189E-01	0.220E-01	1.16	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.
- 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., Lauth, J. R., and Short, T. M. December 1989. *Biological Monitoring Program for the Paducah Gaseous Diffusion Plant, Three-Year Report* (draft). University of Kentucky, Lexington.
- CDM Federal Programs Corporation 1991. *Paducah Gaseous Diffusion Plant Remedial Investigation of the Underground Storage Tanks in the Vicinity of the C-750 Garage Facility, Draft Workplan and Sampling and Analysis Plan*, Fairfax, Va.
- 40 CFR Pt. 60 Appendix A Method A, "Visual Determination of the Opacity of Emissions From Stationary Sources."
- 40 CFR 136.3 "Environmental Protection Agency Regulations on Test Procedures for the Analysis of Pollutants," 1987.
- CH2M Hill 1990. *Draft Results of the Site Investigation Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Ky.*, KY/ER-4, Martin Marietta Energy Systems.
- 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.
- Douthitt, J. W. 1990. *Paducah Gaseous Diffusion Plant Groundwater Protection Program Management Plan*, KY/ER-2, Martin Marietta Energy Systems.
- 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.
- Forstrom, J. M., Early, T. O., and Douthitt, J. W. 1991. *Groundwater Surveillance Plan for the Paducah Gaseous Diffusion Plant*, in press.
- Geotrans, Inc. 1990. *Numerical Modeling of Groundwater Flow at the Paducah Gaseous Diffusion Plant, Phase I and II*.
- Hoffman, F. O., et al., 1984. *Preliminary Screening of Contaminants in Sediments*, ORNL/TM-9370, Union Carbide Corp. Nuclear Div., Oak Ridge Natl. Lab.

- 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 July 1988. *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071.
- 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 June 15, 1989. *DOE Manual*, "Radiological Effluent Monitoring and Environmental Surveillance," DOE Order 5400.XY.
- 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*.
- U.S. Environmental Protection Agency (EPA) July 1989. *Exposure Factors Handbook*, EPA/600/8-89/043.
- 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 CY 1990. Radiological chemical releases for CY 1990 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 EPA's toxic substance list. Currently, more than 300 specific chemicals and 20 chemical categories must be reviewed and possibly reported under SARA Sect. 313. If any of these chemicals was 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 1990, 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." 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 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 EPA and the Kentucky Department of Environmental Protection no

later than July 1, 1991. The information for this appendix was generated in March and April; 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 1990 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	3,750/1,700	Cooling tower system	Material balance
	Water: Big Bayou Creek	17/8	C-616 chromium reduction facility	Monitoring
	Water: Little Bayou Creek	41/19	Cooling tower system,	Monitoring
	Land: to C-616 sludge lagoon	10,600/4,800	C-616 chromium reduction facility sludge	Monitoring
Trichloro-ethylene	Air: point source	62,000/28,000	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	1,070/480	Cooling tower system	Engineering calculations
Chlorine	Air: fugitive emissions	9,100/4,100	Cooling tower system	Engineering calculations
	Water: Big Bayou Creek	430/190	C-615 sewage treatment plant	Monitoring
	Water: Little Bayou Creek	28/13	Once-through cooling water	Monitoring
Freon 114	Air: fugitive emissions	350,000/158,000	Process cooling	Engineering calculations

Paducah Gaseous Diffusion Plant 1990 chemical release information

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	12,900/5,800	C-310 stack emissions	Engineering calculations/continuous stack sampling
Nitric acid	Air: point source	2/1	C-400 storage tank	Engineering calculations
Nitrogen	Air: fugitive emissions	1,600,000/726,000	General plant cooling	Material balance
Ammonia	Air: fugitive emissions	525/240	Blueprint machines	Material balance
Freon 11	Air: fugitive emissions	2,400/1,080	Air-conditioning systems	Material balance
Freon 22	Air: fugitive emissions	1,100/500	Air-conditioning systems	Material balance
Freon 113	Air: fugitive emissions	3,000/1,400	C-360 flush solution for sample cool-down	Material balance
<i>Steam plant emissions</i>				
Sulfur dioxide ^b	Air: stack emissions	620,000/280,000	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	20,000/9,000	Fossil fuels combustion	Emission factors

^aQuantity calculated as chromium; chemical compound is sodium bichromate.

^bU.S. Environmental Protection Agency October 1986. *Compilation of Air Pollutant Emission Factors*, Vol. 1 (Suppl. A).

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