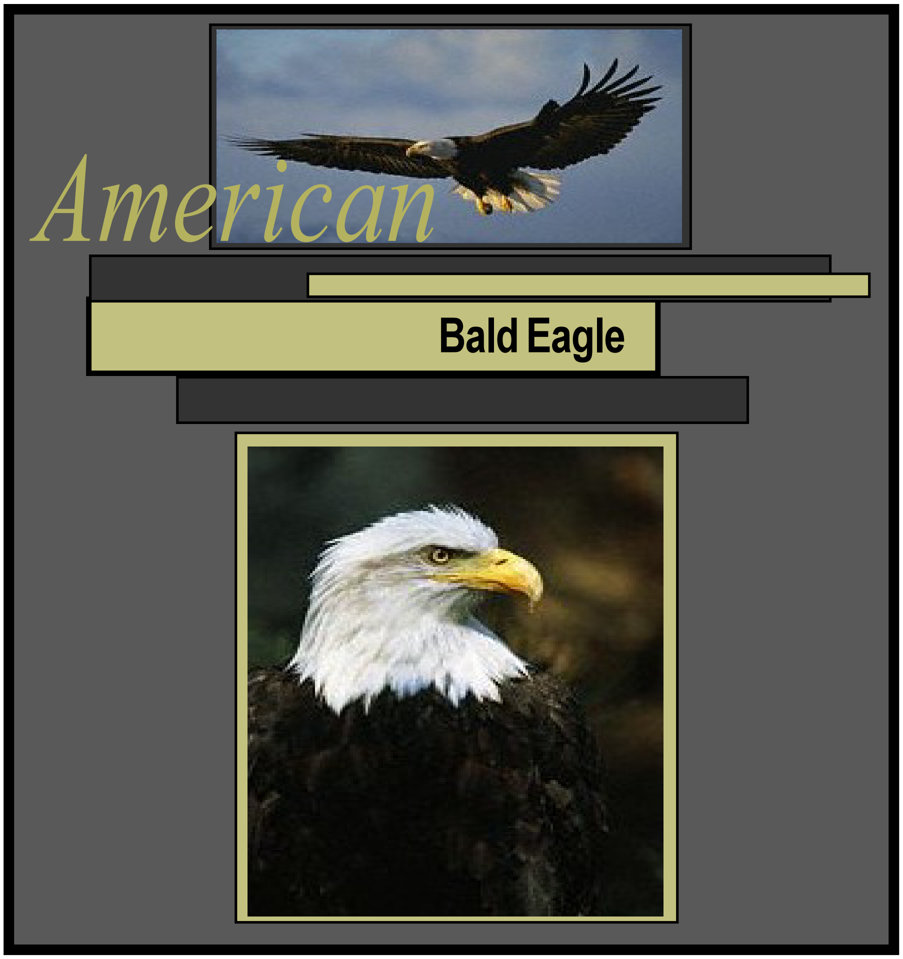
DOE/OR/07-2169/V1
Volume I

PADUCAH SITE

Annual Site Environmental Report



2003

Securing Our Future

Fractions and Multiples of Units

Multiple	Decimal Equivalent	Prefix	Symbol	Engineering Format
10^6	1,000,000	mega-	M	E+06
10^3	1,000	kilo-	k	E+03
10^2	100	hecto-	h	E+02
10	10	deka-	da	E+01
10^{-1}	0.1	deci-	d	E-01
10^{-2}	0.01	centi-	c	E-02
10^{-3}	0.001	milli-	m	E-03
10^{-6}	0.000001	micro-	µ	E-06
10^{-9}	0.000000001	nano-	n	E-09
10^{-12}	0.000000000001	pico-	p	E-12
10^{-15}	0.000000000000001	femto-	f	E-15
10^{-18}	0.000000000000000001	atto-	a	E-18

This report is intended to fulfill the requirements of U. S. Department of Energy (DOE) Order DOE O 231.1 Chg 2. The data and information contained in this report were collected in accordance with the Paducah Site Environmental Monitoring Plan (BJC 2002) approved by DOE. This report is not intended to provide the results of all sampling conducted at the Paducah Site. Additional data collected for other site purposes, such as environmental restoration remedial investigation reports and waste management characterization sampling, are presented in other documents that have been prepared in accordance with applicable DOE guidance and/or laws.

Units of Radiation Measure

Current System	Système International	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7 x 10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Conversions

Multiply	***by***	***to obtain***	***Multiply***	***by***	***to obtain***
in	2.54	centimeters	centimeters	0.394	in
ft	0.305	m	m	3.28	ft
mile	1.61	km	km	0.621	mile
lb	0.4538	kg	kg	2.205	lb
gal	3.785	L	L	0.264	gal
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
acres	0.40468	hectares	hectares	2.471	acres
dpm	0.45	pCi	pCi	2.22	dpm
pCi	10^{-6}	µCi	µCi	10^{6}	pCi
pCi/L (water)	10^{-9}	µCi/mL (water)	µCi/mL (water)	10^{9}	pCi/L (water)
pCi/m^3 (air)	10^{-12}	µCi/mL (air)	µCi/mL (air)	10^{12}	pCi/m^3 (air)

DOE/OR/07-2169/V1   Paducah Site   Annual Site Environmental Report for Calendar Year 2003

Paducah Annual Site Environmental Report 2003

DOE/OR/07-2169/V1

Paducah Site

Annual Site Environmental Report for Calendar Year 2003

November 2004

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

by
Bechtel Jacobs Company LLC
managing the

Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
Paducah, Kentucky 42001
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-03OR22980

Contents

Figures

Tables

Table **Page**

Acronyms and Abbreviations

ACO	Administrative Consent Order
AIP	KDEP Agreement in Principle
AOC	Area of Concern
ASER	Annual Site Environmental Report
ASTM	American Society of Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
Ba	Becquerel
BCHT™	Blended Chemical Heat Treatment™
Bi	Bismuth
BJC	Bechtel Jacobs Company LLC
^{14}C	Carbon-14
CAA	Clean Air Act
CAB	Paducah Citizens Advisory Board
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R.	Code of Federal Regulations
Ci	Curie
COE	U.S. Army Corps of Engineers
^{137}Cs	cesium-137
CSOU	comprehensive site-wide operable unit
CSTP	Conceptual Site Treatment Plan
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
D&D	decontamination and decommissioning
DCG	derived concentration guide
DMSA	DOE Material Storage Area
DNAPL	dense, nonaqueous-phase liquid
DOD	U.S. Department of Defense

DOE	U.S. Department of Energy
dps	disintegrations per second
DQO	data quality objective
DSA	Documented Safety Analysis
DSTP	Draft Site Treatment Plan
DUF_6	depleted uranium hexafluoride
EA	environmental assessment
EDD	electronic data deliverable
EDE	effective dose equivalent
EIC	DOE Environmental Information Center
EIS	environmental impact statement
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EQADMP	Environmental Services Quality Assurance and Data Management Plan
ERH	electrical resistance heating
FDA	Food and Drug Administration
FFA	Federal Facility Agreement
FFC Act	Federal Facility Compliance Act
FFCA	Federal Facility Compliance Agreement
FONSI	Finding of No Significant Impact
FS	feasibility study
ft	foot (feet)
ha	hectare(s)
HAP	hazardous air pollutant
HSWA	Hazardous and Solid Waste Amendments
ICRP	International Commission on Radiological Protection
IRA	interim remedial action
^{40}K	Potassium-40

K.A.R.	Kentucky Administrative Regulation
KCHS	Kentucky Cabinet for Health Services
KDAQ	Kentucky Division for Air Quality
KDEP	Kentucky Department for Environmental Protection
KDOW	Kentucky Division of Water
KDWM	Kentucky Division of Waste Management
kg	kilogram(s)
km	kilometer(s)
KOW	Kentucky Ordnance Works
KPDES	Kentucky Pollutant Discharge Elimination System
KRS	Kentucky Revised Statute
L	liter(s)
LRGA	Lower Regional Gravel Aquifer
m	meter(s)
MCL	maximum contaminant level
mHBI	modified Hilsenhoff Biotic Index
µg	microgram (s)
mg	milligrams (s)
mR	milliRoentgen (s)
mrem	millirem(s)
MSDS	material safety data sheet
mt	metric ton(s)
MW	monitoring well
^{24}Na	Sodium-24
NCP	National Contingency Plan
ND	non detect
NEPA	National Environmental Policy Act
NEPCS	Northeast Plume Containment System
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NOV	notice of violation

^{237}Np	neptunium-237
NPL	National Priorities List
NSDD	North-South Diversion Ditch
NTS	Nevada Test Site
NWPGS	Northwest Plume Groundwater System
OREIS	Oak Ridge Environmental Information System
OU	operable unit
PCB	polychlorinated biphenyl
pCi	picoCurie(s)
PEMS	Project Environmental Measurement Systems
PGDP	Paducah Gaseous Diffusion Plant
pH	hydrogen-ion concentration
PHA	public health assessment
ppb	parts per billion
ppm	part per million
PP/WM	Pollution Prevention/Waste Minimization
PSTP	Proposed Site Treatment Plan
^{239}Pu	plutonium-239
QA	Quality Assurance
QC	Quality Control
^{235}Ra	radium-235
rad	radiation absorbed dose
Rb	rubidium
RCRA	Resource Conservation and Recovery Act
Rd	Radon
RD/RAWP	Remedial Design/Remedial Action Work Plan
rem	Roentgen equivalent man
RFI	RCRA facility investigation
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	Record of Decision

SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Officer
SMO	Sample Management Office
SMP	Site Management Plan
SOW	statement of work
SPH	six-phase heating
^{90}Sr	strontium-90
Sv	sievert
SWMU	solid waste management unit
^{99}Tc	technetium-99
TCE	trichloroethylene (also called trichloroethene)
TCLP	Toxicity Characteristic Leaching Procedure
^{230}Th	thorium-230
^{234}Th	thorium-234
TLD	thermoluminescent dosimeter
TRE	Toxicity Reduction Evaluation
TSCA	Toxic Substances Control Act
TUc	chronic toxicity unit
^{234}U	uranium-234
^{235}U	uranium-235
^{238}U	uranium-238
UCRS	Upper Continental Recharge System
UE	uranium enrichment
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
U_3O_8	Triuranium octoxide
URGA	Upper Regional Gravel Aquifer
USEC	United States Enrichment Corporation
UST	underground storage tank
WAG	waste area group
WKWMA	West Kentucky Wildlife Management Area

Request for Comments

The U.S. Department of Energy (DOE) requires an annual site environmental report from each of the sites operating under its authority. This report presents the results from the various environmental monitoring programs and activities carried out during the year. This *Paducah Site Annual Site Environmental Report for Calendar Year 2003* was prepared to fulfill DOE requirements. This report is a public document, distributed to government regulators, business persons, special interest groups, and members of the public at large.

This report is based on thousands of environmental samples collected at or near the Paducah Site. Significant efforts were made to provide the data collected and details of the site environmental management programs in a clear and concise manner, while presenting summary information. The editors of this report encourage comments in order to better address the needs of our readers in future site environmental reports. Please send your comments to the following address:

U.S. Department of Energy

Portsmouth/Paducah Project Office

1017 Majestic Drive, Suite 200

Lexington, Kentucky 40513

1 Site Operation and Overview

Abstract

The Paducah Gaseous Diffusion Plant (PGDP), located in McCracken County, Kentucky, has been producing enriched uranium since 1952. In July 1993, the U.S. Department of Energy (DOE) leased the production areas of the site to the United States Enrichment Corporation (USEC), a private company. The DOE maintains responsibility for the environmental restoration, legacy waste management, non-leased facilities management, uranium hexafluoride (UF_6) cylinder management, and decontamination and decommissioning (D&D)/DOE Material Storage Area (DMSA) programs. The DOE also implements an environmental monitoring and management program to ensure protection of human health and the environment and compliance with all applicable regulatory requirements. This document summarizes calendar year (CY) 2003 environmental management (EM) activities, including effluent monitoring, environmental surveillance, and environmental compliance status. It also highlights significant site program efforts conducted by DOE and its contractors and subcontractors at the Paducah Site. ***This report does not include USEC environmental monitoring activities.***

Introduction

The DOE requires that environmental monitoring be conducted and documented for all of its facilities under the purview of DOE Order 231.1 Chg 2, *Environment, Safety and Health Reporting* (DOE 1996). Several other laws, regulations, and DOE directives require compliance with environmental standards. The purpose of this Annual Site Environmental Report (ASER) is to summarize CY 2003 environmental management activities at the Paducah Site, including effluent monitoring, environmental surveillance, and environmental compliance status, and to highlight significant site program efforts. Since April 1, 1998, Paducah Site programs have been coordinated by DOE's managing and integrating contractor, Bechtel Jacobs Company LLC (BJC). References in this report to the Paducah Site generally mean the property, programs, and facilities at or near PGDP for which DOE has ultimate responsibility.

Environmental monitoring consists of the following two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the direct measurement or the collection and analysis of samples of liquid and gaseous discharges to the environment. Environmental surveillance is the direct measurement or the collection and analysis of samples consisting of air, water, soil, biota, and other media. Environmental monitoring is performed to characterize and quantify contaminants, assess radiation exposure, demonstrate compliance with applicable standards and permit requirements, and detect and assess the effects , if any, on the local population and environment. Multiple samples are collected throughout the year and are analyzed for radioactivity, chemical content, and various physical attributes.

The overall goal for environmental management is to protect site personnel, the environment, and the Paducah Site's neighbors, and to maintain full compliance with all current environmental regulations. The current environmental strategy is to prevent

Significant Events 2003

- ☑ Completed the Six-Phase Heating (SPH) Treatability Study adjacent to the C-400 Building for cleanup of trichloroethene (TCE) of the groundwater contamination source.
- ☑ Continued operation of the Northwest and Northeast Plume groundwater treatment systems for cleanup of the plumes.
- ☑ Installed a sediment controls basin and excavated Section 2 of the North South Diversion Ditch (NSDD) to reduce the risk of exposure from contaminated soil, sediment, and surface water.
- ☑ Initiated removal of scrap metal, including Aluminum Ingots, from the PGDP Scrap Yards to remove contaminated scrap metal for disposal.
- ☑ Continued characterization and disposal of DMSA material (see Figure1.1).
- ☑ Shipped 1854 metric tons of low-level and hazardous waste off-site.
- ☑ Disposed of approximately 3800 tons of concrete crushate and 14 roll-off bins of wood debris at the on-site C-746-U Landfill.

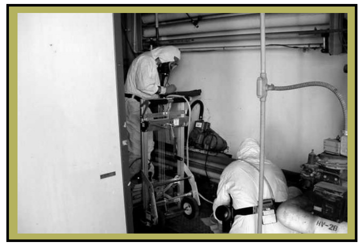


Figure 1.1 DMSA activities

Planned Events Beyond 2003

2004

- ☐ Complete Southwest Plume and C-746-S&T Landfills investigations to identify additional groundwater contamination sources.
- ☐ Initiate characterization of on-site surface water.
- ☐ Continue characterization of DMSA contents.
- ☐ Continue off-site shipment of mixed waste for treatment.
- ☐ Complete removal of contaminated soils from NSDD Section 1.
- ☐ Demolish C-410-A Hydrogen Tank.
- ☐ Continue scrap metal disposal.
- ☐ Complete plan with regulators for remediation for C-400 groundwater contamination.

2005

- ☐ Continue scrap metal disposal.
- ☐ Complete C-746-S&T Landfills site evaluation report.
- ☐ Complete on-site Surface Water Operable Unit investigation.
- ☐ Implement investigation work plan for burial grounds.
- ☐ Continue off-site shipment of mixed waste shipments for treatment.
- ☐ Complete remediation of C-400 groundwater contamination sources.

2006

- ☐ Complete scrap metal disposal.
- ☐ Complete DMSA characterization.
- ☐ Complete a plan with regulators for Southwest Plume groundwatr remediation.
- ☐ Implement remediation of contamination around the C-400 Building.

future compliance issues, to identify any current compliance issues, and to develop a system for resolution. The long-range goal of environmental management is to reduce exposures of the public, workers, and biota to harmful chemicals and radiation.

Background

Before World War II, the area now occupied by PGDP was used for agricultural purposes. Numerous small farms produced various grain crops and provided pasture for livestock. Early in the war, a 6526-hectare (ha) (16,126-acre) tract was assembled for construction of the Kentucky Ordnance Works (KOW), which was subsequently operated by the Atlas Powder Company until the end of the war. At that time, it was turned over to the Federal Farm Mortgage Corporation, and then to the General Services Administration.

In 1950, the U. S. Department of Defense (DOD) and DOE's predecessor, the Atomic Energy Commission, began efforts to expand fissionable material production capacity. As part of this effort, the National Security Resources Board was instructed to designate power areas within a strategically safe area of the United States. Eight government-owned sites were initially selected as candidate areas, one of which was the KOW site. In October 1950, as a result of joint recommendations from the DOD, Department of State, and the Atomic Energy Commission, President Truman directed the Atomic Energy Commission to further expand production of atomic weapons. One of the principle facets of this expansion program was the provision for a new gaseous diffusion plant. On October 18, 1950, the Atomic Energy Commission approved the Paducah Site for uranium enrichment operations and formally requested the Department of the Army to transfer the site from the General Services Administration to the Atomic Energy Commission.

Although construction of PGDP was not completed until 1954, production of enriched uranium began in 1952. The plant's mission, uranium enrichment, has continued unchanged, and the original facilities are still in operation, albeit with substantial upgrading and refurbishment. Of the 3062 ha (7566 acres) acquired by the Atomic Energy Commission in 1950, 551 ha (1361 acres) were subsequently transferred to the Tennessee Valley Authority (Shawnee Steam Plant site) and 1125 ha (2781 acres) were conveyed to the Commonwealth of Kentucky for wildlife conservation and for recreational purposes [West Kentucky Wildlife Management Area (WKWMA)]. DOE's current holdings at the Paducah Site total 1386 ha (3423 acres).

At Paducah's uranium enrichment plant, recycled uranium from nuclear reactors was introduced into the PGDP enrichment "cascade" in 1953 and continued through 1964. In 1964, cascade feed material was switched solely to virgin-mined uranium. Use of recycled uranium resumed in 1969 and continued through 1976. In 1976, the practice of recycling uranium feed material from nuclear reactors was halted and never resumed. During the recycling time periods, Paducah received approximately 90,000 metric tons (100,000 tons) of recycled uranium containing an estimated 328 grams of plutonium-239 (^{239}Pu), 18,400 grams of neptunium-237 (^{237}Np), and 661,000 grams of technetium-99 (^{99}Tc). The majority of the ^{239}Pu and ^{237}Np was separated out as waste during the initial chemical conversion to uranium hexafluoride ($UF_{6)}$. Concentrations of transuranics (e.g., ^{239}Pu and ^{237}Np) and ^{99}Tc are believed to have been deposited on internal surfaces of process equipment, and in waste products.

In October 1992, congressional passage of the National Energy Policy Act established USEC. Effective July 1, 1993, DOE leased the plant production operation facilities to USEC. Under the terms of the lease, USEC assumed responsibility for environmental compliance activities directly associated with uranium enrichment operations.

Under the lease agreement with USEC, DOE retained responsibility for the site Environmental Restoration Program; the Enrichment Facilities Program; and the Legacy Waste Management Program, including all waste inventories predating July 1, 1993, and wastes generated by subsequent DOE activities. The DOE is responsible for

Kentucky Pollutant Discharge Elimination System (KPDES) compliance at outfalls not leased to USEC. The DOE has also retained manager and co-operator status of facilities not leased to USEC. The DOE and USEC have negotiated the lease of specific plant site facilities, written memoranda of agreement to define their respective roles and responsibilities under the lease, and developed organizations and budgets to support their respective functions. The DOE is the owner, and Bechtel Jacobs Company LLC (BJC) with DOE are operators for Resource Conservation and Recovery Act (RCRA)-permitted facilities and are responsible for compliance with the RCRA permit.

Description of Site Locale

Location

The Paducah Site is located in a generally rural area of McCracken County, Kentucky. The center of PGDP is about 16 kilometers (km) (10 miles) west of Paducah, Kentucky, and 5 km (3 miles) south of the Ohio River (Figure 1.2 on the opposite page). The industrial portion of PGDP is situated within a fenced security area and constitutes about 303 ha (748 acres). Within this area, designated as secured industrial land use, are numerous active and inactive production buildings, offices, equipment and material storage areas, active and inactive waste management units, and other support facilities (Figure 1.3 is the C-400 building). The additional DOE-owned land at the Paducah Site is 1083 ha (2675 acres). Of this land, there is a 279 ha (689 acres) is a "buffer zone" that surrounds PGDP and it is designated as unsecured industrial land. There are no residences on DOE property at the Paducah Site. The DOE has also acquired approximately 54 ha (133 acres) in easements.

Three small communities are located within 5 km (3 miles) of the DOE property boundary at PGDP: Heath and Grahamville to the east, and Kevil to the southwest. The closest commercial airport is Barkley Regional Airport, approximately 8 km (5 miles) to the southeast. The population within an 80-km (50-mile) radius of PGDP is about 500,000, of which about 66,000 residents are located within a 16-km (10-mile) radius of PGDP (DOC 1994).

Climate

The Paducah Site is located in the humid continental zone where summers are warm ([uly averages 26°C (79°F)] and winters are moderately cold [January averages 1.7°C (35°F)]. Yearly precipitation averages about 125 centimeters (49 inches). The prevailing wind is from the south-southwest at approximately 16 km (10 miles) per hour.

Surface-Water Drainage

The Paducah Site is situated in the western part of the Ohio River basin. The confluence of the Ohio River with the Tennessee River is about 24 km (15 miles) upstream of the site, and the confluence of the Ohio River with the Mississippi River is about 56 km (35 miles) downstream. The plant is located on a local drainage divide; surface water from the east side of the plant flows east-northeast toward Little Bayou Creek and surface water from the west side of the plant flows west-northwest toward Bayou Creek (commonly referred to as "Big Bayou Creek"). Bayou Creek is a perennial stream that flows toward the Ohio River along a 14-km (9-mile) course. Little Bayou Creek is an intermittent stream that flows north toward the Ohio River along a 11-km (7-mile) course. The two creeks converge 5 km (3 miles) north of the plant before emptying into the Ohio River.

Flooding in the area is associated with Bayou Creek and Little Bayou Creek and the Ohio River. Maps of the calculated 100-year flood elevations show that all three drainage systems have 100-year floodplains located within the DOE boundary at PGDP. These 100-year floodplains range from approximately 340 to 380 feet (ft) above mean sea level. Plant elevations range from about 113 to 117 meters (m) (370 to 385 ft) above mean sea level (COE 1994).

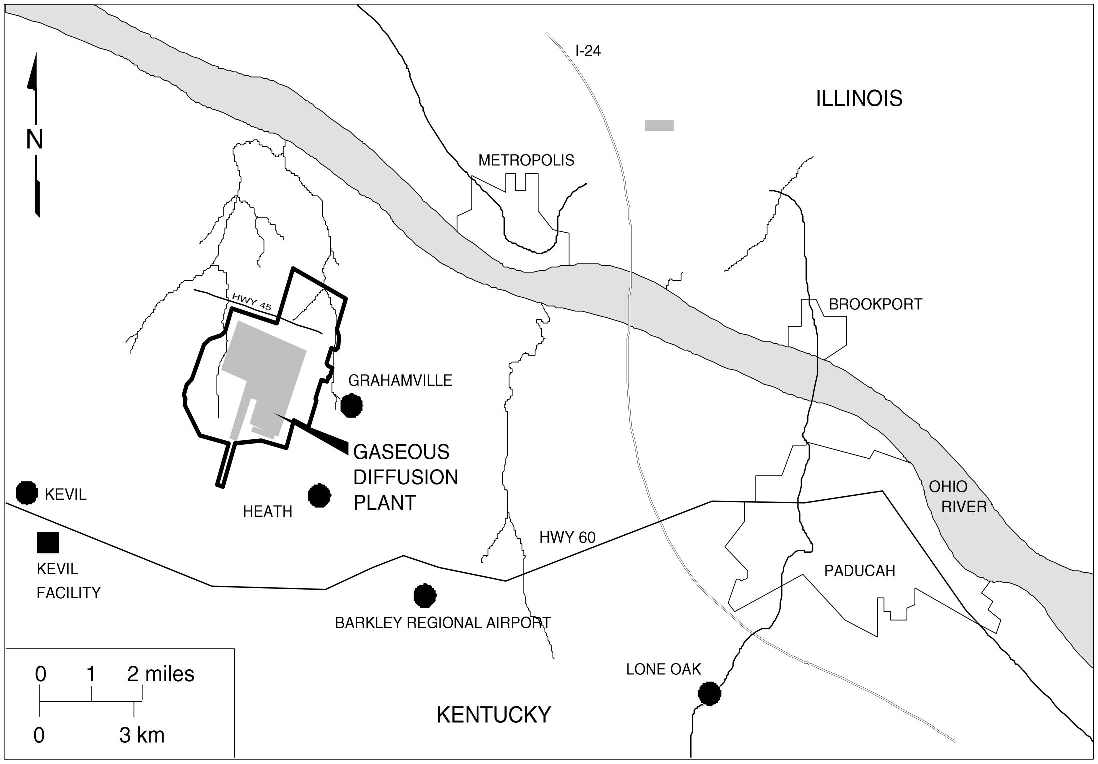


Figure 1.2 Location of the Paducah Site

Figure 1.3   East side of C-400 at the PGDP

Wetlands

More than 1100 separate wetlands, totaling over 648 ha (1600 acres), were found in a study area of about 4860 ha (12,000 acres) in and around the Paducah Site [U.S. Army Corps of Engineers (COE) 1994 and CDM 1994]. These wetlands have been classified into 16 cover types. More than 60 percent of the total wetland area is forested.

Soils and Hydrogeology

Soils of the area are predominantly silt loams that are poorly drained, acidic, and have little organic content. Of the six primary soil types associated with the Paducah Site, five commonly have the characteristics necessary to be considered prime farmland by the Natural Resources Conservation Service, formerly the Soil Conservation Service (Humphrey 1976).

The local groundwater flow system at the Paducah Site contains the following four major components (listed from shallowest to deepest): (1) the terrace gravels, (2) the Upper Continental Recharge System (UCRS), (3) the Regional Gravel Aquifer (RGA), and (4) the McNairy flow system.

The terrace gravels consist of shallow Pliocene gravel deposits in the southern portion of the plant site. These deposits usually lack sufficient thickness and saturation to constitute an aquifer, but may be an important source of groundwater recharge to the RGA.

The UCRS consists mainly of clay silt with interbedded sand and gravel in the upper continental deposits. The system is so named because of its characteristic recharge to the RGA.

The RGA consists of coarse-grained sediments at the base of the upper continental deposits, sand and gravel facies in the lower continental deposits, gravel and coarse sand portions of the upper McNairy that are directly adjacent to the lower continental deposits, and alluvium adjacent to the Ohio River. These deposits have an average thickness of 9 meters (m) (30 ft) and can be more than 21 m (70 ft) thick along an axis that trends east-west through the site. The RGA is the uppermost and primary aquifer, formerly used by private residences north of the Paducah Site.

The McNairy flow system is composed of interbedded and interlensing sand, silt accessory, and clay. Near PGDP, the McNairy Formation can be subdivided into three members: (1) an 18-m (60-ft)-thick sand-dominant lower member; (2) a 30- to 40-m (100- to 130-ft)-thick middle member, composed predominately of silty and clayey fine sand; and (3) a 9- to 15-m (30- to 50-ft)-thick upper member consisting of interbedded sands, silts, clays, and occasional gravel. Sand facies account for 40 to 50 percent of the total formation thickness of approximately 69 m (225 ft).

Groundwater flow originates south of the Paducah Site within eocene sands and the terrace gravels. Groundwater within the terrace gravels either discharges to local streams or recharges the RGA, although the flow regime of the terrace gravels is not fully understood. Groundwater flow through the UCRS is predominantly downward, also recharging the RGA. From the plant site, groundwater flows generally northward in the RGA toward the Ohio River, which is the local base level for the system.

Ecological Resources

Vegetation

Much of the Paducah Site has been impacted by human activity. Vegetation communities on the reservation are indicative of old field succession (e.g., grassy fields, field scrub-shrub, and upland mixed hardwoods). The open grassland areas, most of which are managed by WKWMA personnel, are periodically mowed or burned to maintain early successional vegetation, which is dominated by members of the compositae family and various grasses. Management practices on the WKWMA encourage re-establishment of once common native grasses such as eastern gama grass and indian grass. Other species commonly cultivated for wildlife forage are corn, millet, milo, and soybean (CH2M Hill 1992a).

Field scrub-shrub communities consist of sun-tolerant wooded species such as persimmon, maples, black locust, sumac, and oaks (CH2M Hill 1991a). The undergrowth may vary depending on the location of the woodlands. Wooded areas near maintained grasslands may have an undergrowth dominated by grasses.Other communities may contain a thick undergrowth of shrubs, including sumac, pokeweed, honeysuckle, blackberry, and grape.

Upland mixed hardwoods contain a variety of upland and transitional species. Dominant species include oaks, shagbark and shellbark hickory, and sugarberry (CH2M Hill 1991a). Undergrowth may vary from open, with limited vegetation for more mature stands of trees, to dense undergrowth similar to that described for a scrub-shrub community.

Wildlife

Wildlife species indigenous to hardwood forests, scrub-shrub, and open grassland communities are present at the Paducah Site. Grassy fields are frequented by rabbits, mice, songbirds, and a variety of other small mammals and birds. Redwing blackbirds, killdeer, cardinals, mourning doves, bobwhite quail, meadowlarks, warblers, sparrows, and red-tailed hawks have been observed in such areas. Scrub-shrub communities support a variety of wildlife including opossums, voles, moles, raccoons, gray squirrels, killdeer, bluejays, redwing blackbirds, bluebirds, cardinals, mourning doves, shrike, warblers, turkeys, and meadowlarks. Deer, squirrels, raccoons, turkeys, songbirds, and great horned owls are found within the mature woodlands of the DOE reservation (CH2M Hill 1991a). In addition, the Ohio River serves as a major flyway for migratory birds, which are occasionally seen on the Paducah Site (DOE 1995).

Amphibians and reptiles are common throughout the Paducah Site. Amphibians likely to inhabit the area include the American and Woodhouse toads. Reptiles include the eastern box turtle and several species of snakes. Also, fish populations in Bayou Creek and Little Bayou Creek are numerically dominated by various species of sunfish (DOE 1995).

Threatened and Endangered Species

A threatened and endangered species investigation identified federally listed, proposed, or candidate species potentially occurring at or near the Paducah Site (COE 1994). Updated information is obtained on a regular basis from federal and state sources. Currently, potential habitat for seven species of federal concern exists in the study area (Section 2, Table 2.3). Six of these species are listed as "endangered" under the Endangered Species Act of 1973 and one is listed as "threatened". Of note, significant potential summer habitat exists at the Paducah Site for the Indiana bat, a federally listed endangered species. However, neither the Indiana bat nor any other federally listed nor candidate species have been found on DOE property at the Paducah Site. Also, no property at the Paducah Site has been designated as "critical habitat" in accordance with the Endangered Species Act of 1973.

Cultural Resources

In a study area of about 4860 ha (12,000 acres) in and around the Paducah Site, there are 35 sites of cultural significance recorded with the State Historic Preservation Officer (SHPO) and several more unrecorded sites (COE 1994). Most of these sites are prehistoric and are located in the Ohio River floodplain. Six of the sites are on DOE property at PGDP. None of the sites are included in, or have been nominated to, the National Register of Historic Places, although some are potentially eligible. Additional discussion is included in Section 2.

Site Program Missions

The following two major programs are operated by DOE at the Paducah Site: (1) Environmental Management and (2) Uranium Programs. Environmental Restoration, Waste Management, and D&D are projects under the Environmental Management Program (Figure 1.4). The mission of the Environmental Restoration Program is to ensure that releases from past operations and stored waste at the Paducah Site are investigated and that appropriate remedial action is taken for protection to human health and the environment in accordance with the Federal Facility Agreement (FFA) (DOE 1998) and the October 2003 Agreed Order between DOE and the Kentucky Division of Waste Management (KDWM). The mission of the Waste Operations Program is to characterize and dispose of the legacy waste stored onsite in compliance with various Federal Facility Compliance Agreements (FFCAs), including DMSAs. The primary mission of the D&D program is to manage and characterize the areas and facilities in the programs and prepare materials or waste for disposition. The primary mission of the Uranium Program is to maintain safe, compliant storage of the DOE depleted UF_6 (DUF_6) inventory, pending final disposition of the material, and to manage facilities and grounds not leased to USEC. The environmental monitoring summarized in this report supports all four programs/projects.

Figure 1.4 Paducah Site programs/projects

2 Environmental Compliance

Abstract

The policy of DOE and its contractors and subcontractors at the Paducah Site is to conduct operations safely and minimize the impact of operations on the environment. Protection of the environment is considered a responsibility of paramount importance. The Paducah Site maintains an environmental compliance program aimed at meeting all applicable requirements and minimizing impacts. In 2003, DOE entered into two Agreed Orders with the Kentucky Department for Environmental Protection (KDEP) regarding DMSAs and listed waste issues and storage of DUF_6 cylinders.

Introduction

Local, state, and federal agencies, including DOE, are responsible for enforcing environmental regulations at the Paducah Site. Principle regulating agencies are the U.S. Environmental Protection Agency (EPA) Region 4 and the KDEP. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable laws and regulations.

The 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, the EPA has delegated regulatory authority to KDEP when the Kentucky program meets or exceeds EPA requirements. Where regulatory authority is not delegated, EPA Region 4 is responsible for reviewing and evaluating compliance with EPA regulations that pertain to the Paducah Site. Table 2.1 provides a summary of the Paducah Site environmental permits maintained by DOE in 2003. Figure 2.1 shows the major environmental laws and requirements applicable to the Paducah Site. Each is discussed in this section.

Table 2.1 Environmental permit and compliance agreement summary

Permit Type	Issued By	Expiration Date	Permit Number	Issued To
Water				
KPDES	KDOW	3/31/2003*	KY0004049	DOE
Solid Waste				
Residential Landfill (closed)	KDWM	11/1/2003*	073-00014	DOE
Inert Landfill (closed)	KDWM	6/11/2003*	073-00015	DOE
Solid Waste Contained Landfill (construction/operation)	KDWM	11/4/2006	073-00045	DOE
RCRA/Toxic Substances Control Act				
State Hazardous Waste Management Permit	KDWM	8/19/2001*	KY8890008982	DOE/BJC
Toxicity Characteristic Leaching Procedure, FFCA	EPA	NA	NA	DOE
Federal Facility Compliance Act Site Treatment Plan: Agreed Order	EPA	NA	NA	DOE
FFA	EPA KDWM	NA	NA	DOE
TSCA FFCA	EPA	NA	NA	DOE

NA – Not Applicable
KDOW – Kentucky Division of Water
KDWM – Kentucky Division of Waste Management

* New permits have been applied for.

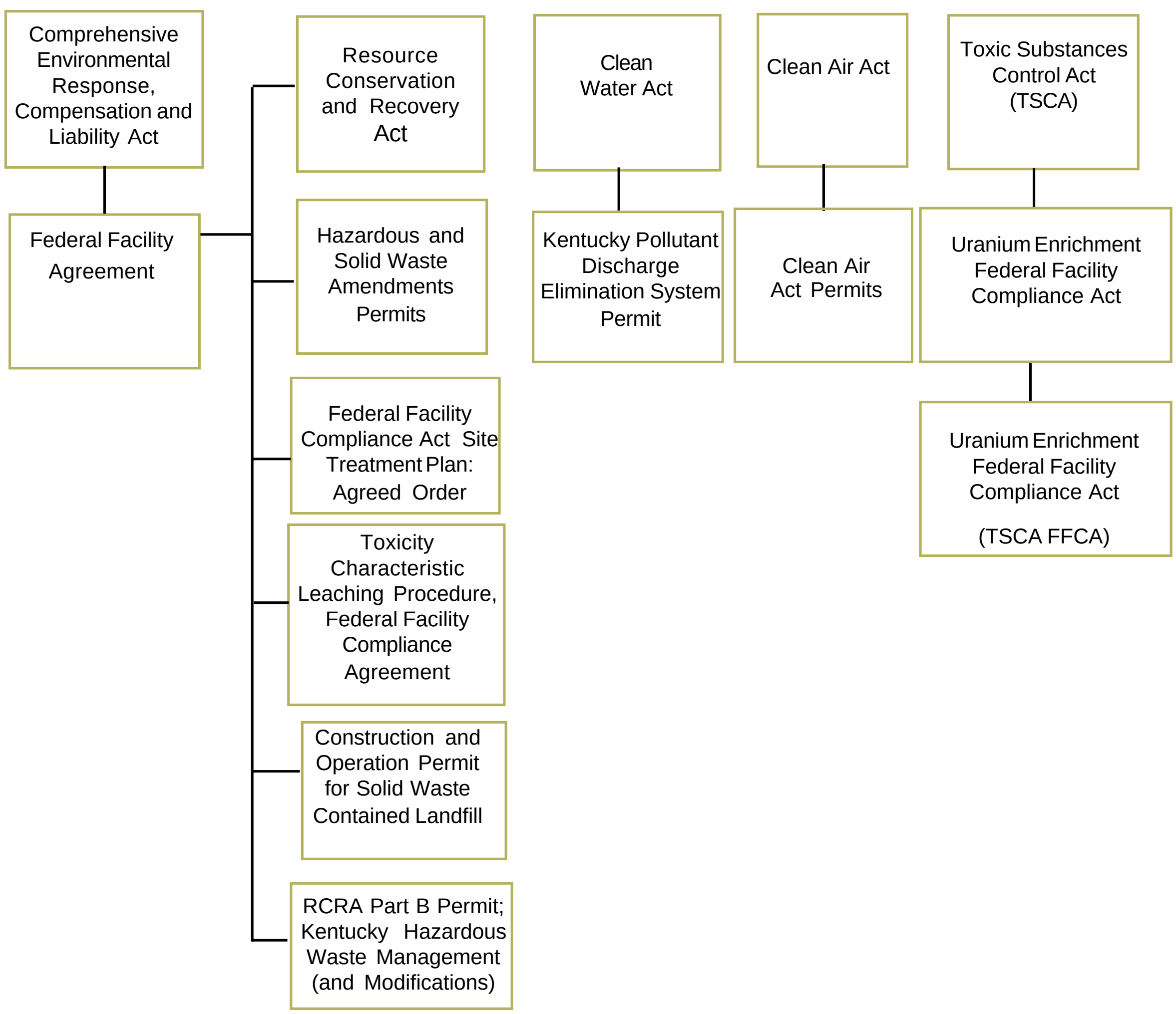


Figure 2.1 Regulatory drivers at the Paducah Site

Compliance Activities

Resource Conservation and Recovery Act

Regulatory standards for the identification, treatment, storage, and disposal of solid and hazardous waste are established by RCRA. Waste generators must follow specific requirements outlined in RCRA regulations for handling solid and hazardous wastes. Owners and operators of solid and hazardous waste treatment, storage, disposal, and recycling facilities are required to obtain operating and closure permits for waste treatment, storage, disposal, and recycling activities. The Paducah Site generates solid, hazardous waste, and mixed waste (i.e., hazardous waste mixed with radionuclides) and operates four permitted hazardous waste storage and treatment facilities.

Resource Conservation and Recovery Act Hazardous Waste Permit

Part A and Part B permit applications of RCRA for storage and treatment of hazardous wastes were initially submitted for the Paducah Site in the late 1980s. At that time, EPA had authorized the Commonwealth of Kentucky to exclusively administer the RCRA-based program for treatment, storage, and disposal units, but had not given the authorization to administer the 1984 Hazardous and Solid Waste Amendments (HSWA) provisions. Therefore, a permit application was submitted to EPA and the KDWM for treatment and storage of hazardous wastes.

On July 16, 1991, KDWM and EPA issued a 10-year RCRA permit (No. KY8890008982) to DOE as owner and operator and to DOE's prime contractor (currently BJC) as co-operator. This RCRA permit consisted of the following two individual permits: (1) a hazardous waste management permit administered by the Commonwealth of Kentucky and (2) a HSWA permit administered by EPA. The hazardous waste management permit contained regulatory provisions for treatment, storage, and disposal activities at PGDP, authorized under the RCRA-based program (pre-HSWA), as well as HSWA provisions. The HSWA permit addressed only the provisions of the HSWA, which include corrective actions for solid waste management units (SWMUs), air emissions, and the land disposal restrictions. In 1996, Kentucky received authorization to administer the HSWA provisions in lieu of EPA. Even though the state was authorized, EPA's portion of the RCRA permit remained in effect until April 19, 2001, and was then allowed to expire.

On February 21, 2001, DOE submitted a renewal application of the RCRA Permit to KDWM. On September 28, 2001, KDWM requested additional information. The DOE submitted a revised permit application in February 2002. DOE is awaiting the issuance of a new permit and continues to operate under the expired permit.

As part of the corrective action requirements, the RCRA permit's schedule of compliance requires DOE to develop and implement a RCRA facility investigation (RFI) work plan for SWMUs and areas of concern (AOCs). The DOE has submitted RFI work plans to the EPA and KDWM in accordance with the time frames specified in the schedule of compliance. These RFI work plans are described in further detail in the section on Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities.

Modifications to the Resource Conservation and Recovery Act Hazardous Waste Permit

Since issuance of the KDWM Hazardous Waste Management portion of the RCRA permit in 1991, 15 permit modifications have been approved. There were no modifications to this permit in 2003.

Resource Conservation and Recovery Act Hazardous Waste Facilities Closure Activities

In 2003, DOE submitted closure plans to KDWM for 18 DMSAs.

Resource Conservation and Recovery Act Notices of Violation

The DOE did not receive any notices of violation (NOVs) during 2003 from KDWM. However, DOE received two NOVs from the Missouri Department of Natural Resources dated January 24, 2003, and April 15, 2003. These NOVs alleged that DOE, as a registered hazardous waste generator in Missouri, was in violation of the Missouri Hazardous Waste Management Law for failure to submit the required annual registration fee for the period of January 1, 2003, through December 31, 2003, and the required manifest summary. Follow-up actions included withdrawing the Missouri registration and submitting the necessary paperwork to deactivate the registration. No further paperwork or fees were required. The DOE did not ship hazardous waste to Missouri in 2003.

2003 Agreed Orders with Commonwealth of Kentucky

On October 1, 2003, the Paducah Site entered into two Agreed Orders with KDWM. The Agreed Order (KNREPC File Numbers DWM-31434-042, DAQ-31740-030, and DOW-26141-042):

- Resolved all open Kentucky NOVs.
- Established health-based levels for listed waste contained in and no longer contaminated with determinations.
- Established regulatory deadlines for characterization of all DMSAs.
- Established a characterization process for legacy waste containers that may contain listed hazardous waste.
- Established RCRA closure requirements for hazardous waste storage units and DMSAs.

Under the Agreed Order, DOE paid a one million dollar penalty.

The Agreed Order (KNREPC File Number DWM-32434-030)

- Set the framework for managing the DUF_6 cylinders.

Land Disposal Restrictions

Hazardous waste is subject to land disposal restrictions and storage prohibitions that permit storage only for accumulation of sufficient quantities of hazardous waste to facilitate proper treatment, recycling, or disposal. Typically, hazardous wastes are not to be stored for more than one year. The Paducah Site generates mostly mixed waste, which is a combination of hazardous and radioactive waste. Nationally, there are limited opportunities for treatment and disposal of mixed waste. Therefore, the Paducah Site stores most of the mixed waste that is generated for longer than one year. If not for the radioactive constituents, this waste would not pose a compliance problem for the site because there would be treatment and disposal options readily available. On June 30, 1992, DOE entered into an FFCA with EPA Region 4 to regulate the treatment and storage of land-disposal restricted mixed waste at the Paducah Site. On April 13, 1998, EPA Region 4 released DOE from the FFCA, and allowed KDWM to regulate mixed waste under the Federal Facility Compliance Act (FFC Act).

Federal Facility Compliance Act

The FFC Act was enacted in October 1992. This act waived the immunity from fines and penalties that had existed for federal facilities for violations of hazardous waste management as defined by RCRA. As a result of the complex issues and problems associated with mixed chemical hazardous and radioactive waste (mixed waste), as well as the lack of treatment and disposal capacity, the FFC Act allowed a three-year extension for DOE facilities to prepare schedules and plans. These addressed how the facilities would manage their mixed waste in compliance with applicable RCRA regulations. The three-year waiver can be extended under the following conditions: (1) a mixed waste treatment plan and compliance schedule are approved by the appropriate agency, (2) an implementing order with that agency is signed, and (3) adherence to the plan and implementing order are maintained by the facility.

To facilitate compliance with the FFC Act and address the myriad of complex issues involved, the Paducah Site, along with 48 other DOE sites, began a four-phase approach. The first phase consisted of gathering required information and submitting to the EPA and state agencies an inventory of mixed wastes (mixed waste inventory report), including information pertaining to characterization and waste generation volumes.

The second phase of the approach involved the development of a Conceptual Site Treatment Plan (CSTP). The plan included investigation of the existing treatment capacity for facility wastes and, where there was no existing capacity, procurement of information on potential treatment technologies or options that could be employed to meet treatment requirements. The Paducah Site submitted the CSTP in October 1993.

The third phase of the approach expanded on the information in the CSTP to identify treatment options that are preferred both environmentally and economically. The information gathered by the ongoing waste characterization program and the technology evaluation and development program outlined in the CSTP formed the basis for the Draft Site Treatment Plan (DSTP), which was submitted to the regulators in August 1994.

The fourth phase of the approach combined the preferred treatment options from the DSTP with regulator and stakeholder comments and the overall DOE complex picture to formulate a Proposed Site Treatment Plan (PSTP). This PSTP was submitted to the regulators on April 3, 1995. Following review by both KDWM and other stakeholders, KDWM modified the PSTP and approved the modified version on October 5, 1995. The KDWM also issued an order to DOE that required DOE to comply with the approved Site Treatment Plan (STP). On November 2, 1995, DOE filed a petition for hearing that challenged portions of the STP and the order. The KDWM and DOE amended an Agreed Order that became effective September 10, 1997. The Paducah Site has complied since issuance.

Toxicity Characteristic Leaching Procedure Federal Facility Compliance Agreement

The Paducah Site has generated a significant volume of waste materials that are stored onsite. A large quantity of this waste was generated, characterized, and placed in storage before September 25, 1990. Prior to that, characterization required utilizing the Extraction Procedure for toxicity. On that date, a new regulation became effective replacing the Extraction Procedure for toxicity with the Toxicity Characteristic Leaching Procedure (TCLP). Because the accumulated wastes had not been characterized under the new toxicity characteristic regulations, DOE needed revised characterization data for these wastes using the new protocol.

On March 26, 1992, EPA Region 4 and DOE entered into a TCLP FFCA concerning the regulatory status of these wastes. The TCLP FFCA requires the Paducah Site to identify those solid wastes that are not being managed in RCRA storage areas and that have not been characterized under the TCLP test method. Additionally, the FFCA requires the Paducah Site to provide a schedule for TCLP characterization of the identified waste.

In response to the FFCA, the Paducah Site submitted an implementation plan that established a general framework for compliance with the requirements of the FFCA. The implementation plan established priorities for the characterization program and the nature of the data to be collected, and included a schedule for TCLP characterization of the identified waste. The primary characterization objective was the acquisition of sufficient data to safely handle the waste and provide for determination of its status under RCRA. Characterization of the waste with respect to polychlorinated biphenyls (PCBs) and radionuclide concentrations was the second objective. The final characterization objective was the collection of data related to treatment and/or disposal of the waste.

A three-phase program for accomplishing the goals of the plan was developed. Phase I activities consisted of data compilation and waste prioritization. Phase II involved identification of discrete waste streams and development of characterization plans. Phase III of the program included the development of sampling and analysis plans, field sampling, and data reporting. All three phases of the program have been completed. Characterization was completed by December 2000. The DOE continues to manage the program.

Solid Waste Management

The Paducah Site disposes a portion of its solid waste at its on-site contained landfill facility, C-746-U. Construction of the C-746-U Landfill began in 1995 and was completed in 1996. The operation permit was received from KDWM in November 1996. Disposal of waste at the landfill began in February 1997. The C-746-U Landfill operated from February 1997 through October 1999, and received approximately 16,000 tons (14,515 metric tons) of solid waste. In November 1999, waste acceptance activities at the C-746-U Landfill were suspended for all waste streams with the exception of wastes classified as no-rad-added (not contaminated with radioactivity). The DOE began preparation of an Environmental Assessment (EA) for the Implementation of the Authorized Limits Process for Waste Acceptance at the C-746-U Landfill, Paducah, Kentucky (DOE/EA-1414), in September 2000. Disposal operations other than no-rad-added waste packages were suspended while the EA was prepared. The DOE issued a Finding of No Significant Impact (FONSI) on August 6, 2002.

In late 2000, potential corrosion problems were discovered in the monitoring wells (MWs) surrounding the C-746-U Landfill. On August 10, 2001, KDWM issued a letter ordering DOE to cease the placement of waste in the landfill until such time as the MW network could be replaced. A long-term cover was installed as a result of the suspension of waste acceptance. In addition, KDWM required the completion of two sampling events, at an interval of no less than 30 days, prior to reopening the landfill. Activities were initiated to replace MWs at the landfill in late 2001 and completed in 2002. After completion of the EA in August 2002 and installation and sampling of the new MWs, the landfill resumed disposal operations in November 2002. From November 2002 through December 2002, 142 tons (129 metric tons) of waste were disposed. During 2003, the amount of waste disposed of in the landfill was 9151 tons (8302 metric tons).

In lieu of disposing of office waste at the C-746-U Landfill, office waste generated by DOE and its contractors at the plant site is taken offsite for disposal. Only office waste generated at the C-746-U Landfill was disposed at the landfill. Commercial Waste Incorporated in Mayfield, Kentucky, provides off-site disposal of the office waste. A site recycling program exists for office waste (see Section 3 for details).

The DOE received no NOVs during 2003 for the active C-746-U and inactive C-746-S & T Landfills. However, on November 12, 2002, KDWM issued NOVs for alleged disposal of RCRA-regulated wastes in the C-746-U Landfill and the inactive C-746-S Landfill. The KDWM approved a Sampling and Analysis Plan for the

C-746-U Landfill on February 21, 2003. On April 21, 2003, excavation and sampling of four waste streams with potential listed hazardous waste issues was initiated. The KDWM split samples with DOE and oversaw the effort. Analytical results were supplied to KDWM, along with a request for a contained-in determination. This means that when environmental media are generated and actively managed as wastes and the media have been contaminated with a listed waste, they must be managed as a hazardous waste until they are determined to no longer contain the listed waste. In October 2003, an Agreed Order was signed by DOE and KDWM (see previous discussion). The Agreed Order granted DOE's July 2003 contained-in request.

Underground Storage Tanks

Underground storage tank (UST) systems at the Paducah Site have been used to store petroleum products, such as gasoline, diesel fuel, and waste oil. These USTs are regulated under RCRA Subtitle I [40 Code of Federal Regulations (C.F.R.) Part 280] and Kentucky UST regulations [401 Kentucky Administrative Regulations (K.A.R.) Chapter 42], or are exempt from specific UST regulations.

The DOE is responsible for 16 of the 18 site USTs that have been reported to KDWM in accordance with regulatory notification requirements. Of DOE's 16 USTs, none are currently in use. Six were removed from the ground (including C-746-A1 in 2003), seven were filled in place with inert material, one (C-611-1) was "clean closed in place," and two were determined not to exist. Table 2.2 on the following page provides a current list of DOE USTs and their status.

At the end of 2003, one DOE UST (C-746-A1) had not met all regulatory requirements necessary to achieve permanent "clean" closure. Closure activities for this UST continued into 2004.

Comprehensive Environmental Response, Compensation, and Liability Act

The DOE and EPA Region 4 entered into an Administrative Consent Order (ACO) in August 1988 under Section 104 and 106 of CERCLA. The ACO was in response to the off-site groundwater contamination detected in July 1988.

On May 31, 1994, the Paducah Site was placed on the EPA National Priorities List (NPL), which is a list of sites across the nation designated by EPA as having the highest priority for site remediation. The EPA uses the Hazard Ranking System to determine which sites should be included on the NPL. A site is eligible for the NPL if it ranks 28.5 on the system; the Paducah Site ranked 56.9. Being placed on the NPL means DOE must follow the CERCLA cleanup requirements.

Section 120 of CERCLA requires federal facilities on the NPL to enter into an FFA, also referred to as an interagency agreement, with the appropriate regulatory agencies. The FFA, which was signed February 13, 1998, established a decision-making process for remediation of the Paducah Site, and coordinates CERCLA remedial action requirements with RCRA corrective action requirements specified in the RCRA permits. Upon signature of the FFA, the parties agreed to terminate the CERCLA ACO because those activities can be continued under the FFA. According to the FFA, DOE is required to submit an annual Site Management Plan (SMP) to EPA and KDEP. The plan summarizes the remediation work completed to date, outlines remedial priorities, and contains schedules for completing future work. The SMP is submitted to the regulators annually in November to update the enforceable milestones and to include any new strategic approaches.

The Agency for Toxic Substances and Disease Registry (ATSDR), based in Atlanta, Georgia, is part of the U.S. Public Health Service. As required by CERCLA, this agency conducts public health assessments (PHAs) of hazardous waste sites listed or proposed for lthe NPL. Representatives from the ATSDR made their initial site visit to Paducah in May

Table 2.2 Summary of USTs

UST	State ID	Date Installed	Operational Status	Regulatory Status
C-750-A	0001	1955	Removed from ground 3/91	Closure complete per KDWM letter of 3/25/99
C-750-B	0002	1955	Removed from ground 3/91	Closure complete per KDWM letter of 3/25/99
C-750-C	0003	1957 (Estimated)	Removed from ground 10/93	Clean closed under RCRA Subtitle C
C-750-D	0004	1957	Rinsed with TCE and emptied 6/79 filled with cement 10/97	Closure complete per KDWM letter of 11/23/99
C-746-A1	0005	1960	Emptied 9/88 filled with cement 10/97 removed from ground 4/03	Final closure awaits approval from KDWM
C-710-B	0006	1956 (Estimated)	Emptied 7/85 filled with cement 10/97	Closure complete per KDWM letter of 2/19/02
C-200-A	0007	1956 (Estimated)	Filled with grout in 1977	Closure complete per KDWM letter of 11/23/99
C-746-A2	0008	- -	Determined during Waste Area Grouping (WAG) 15 site investigation not to exist	Documented during Waste Area Group 15 site investigation not to exist
C-751-W	0009	1992	In use by USEC	In use by USEC
C-751-E	0010	1992	In use by USEC	In use by USEC
C-611-1	0011	1943 (Estimated)	Last used before 1975	Clean closed in place per KDWM letter of 12/6/96
C-611-3	0012	1953	Last used before 1975 filled with cement 9/97	Clean closed in place per KDWM letter of 12/6/96
C-611-2	0013	- -	Determined not to exist	No further action required per state correspondence of 12/6/96
C-611-4	0014	1943 (Estimated)	Last used before 1975 filled with sand	Clean closed in place per KDWM letter of 12/6/96
C-611-5	0015	Unknown	Filled with grout before 1975	Clean closed in place per KDWM letter of 12/6/96
C-200-B	0016	1967	Filled with concrete in 1981	Closure complete per KDWM letter of 2/19/02
C-745-K	0017	1951 (Estimated)	Removed from ground 2/02	Closure complete per KDWM letter of 12/4/02
C-746-K	0018	1951 (Estimated)	Removed from ground 4/02	Closure complete per KDWM letter of 12/4/02

1994 to assign a ranking to the site for priority in scheduling the health assessment. A "B" ranking was assigned to Paducah, which is the second highest priority. The ranking was based on groundwater contamination associated with the plant that had affected several off-site wells. The ATSDR is aware of the actions the site has taken since 1988 to address the risks from the potential use of contaminated water. In 1995, the ATSDR visited the Paducah Site to initiate a PHA. The PHA report was issued in May 2002. This document is available on the Internet at http://www.atsdr.cdc.gov/HAC/PHA/paducah2/pgd_toc.html.

Comprehensive Environmental Response, Compensation, and Liability Act Reportable Quantities

There were no spills of materials that exceeded a CERCLA-reportable quantity at the Paducah Site in 2003.

National Environmental Policy Act

An evaluation of the potential environmental impact of proposed federal activities is required by the National Environmental Policy Act (NEPA). In addition, an examination of alternatives to proposed actions is also required. Compliance with NEPA, as administered by DOE's NEPA Implementing Procedures (10 C.F.R. 1021) and the Council on Environmental Quality Regulations (40 C.F.R. 1500–1508), ensures that consideration is given to environmental values and factors in federal planning and decision making. In accordance with 10 C.F.R. 1021, the Paducah Site conducts NEPA reviews for proposed actions and determines if any proposal requires preparation of an environmental impact statement (EIS), an EA, or is categorically excluded (CX) from preparation of either an EIS or an EA. The Paducah Site maintains records of all NEPA reviews.

In 2003, DOE continued the preparation of an EIS for *Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility* (DOE/EIS-0359). The facility would convert the stored inventory of DUF_6 into a more stable uranium oxide for reuse or disposal. The DOE plans to complete the EIS in 2004.

The DOE completed an EA *Addendum for Disposition of Additional Waste at the Paducah Site* (DOE/EA-1339A). The FONSI was issued December 11, 2003. The EA addendum analyzed disposition of waste in addition to that analyzed in the original Waste Disposition EA (DOE/EA-1339, November 2002). The additional waste analyzed is primarily from DMSAs.

In addition, numerous minor activities were within the scope of the previously approved CXs for routine maintenance, small-scale facility modifications, and site characterization. The Paducah DOE Site Office and the DOE Oak Ridge Operations Office NEPA compliance officer approve and monitor the internal applications of previously approved CX determinations.

In accordance with the 1994 DOE Secretarial Policy Statement on NEPA, preparation of separate NEPA documents for environmental restoration activities conducted under CERCLA is no longer required. Instead, DOE CERCLA documents incorporate a consideration of environmental impacts resulting from the activity, or "NEPA values," to the extent practical. NEPA values are environmental issues that affect the quality of the human environment. Incorporation of NEPA values into CERCLA documents allows that the decision makers consider the potential effects of proposed actions on the human environment. Actions conducted under CERCLA are discussed in Section 3 of this report.

National Historic Preservation Act

The National Historic Preservation Act of 1966 (NHPA) is the primary law governing federal agencies' responsibility for identifying and protecting historic properties (cultural resources included in, or eligible for inclusion in, the National Register of Historic Places). There are currently no properties at the Paducah Site in the National Register of Historic Places, although there is a potential for eligible historic properties. Therefore, each proposed project is assessed, in conjunction with NEPA project reviews, to determine if there are any historic properties present and whether they may be affected. In making these determinations, DOE consults with the Kentucky SHPO as required by Section 106 of the NHPA.

In 2003, the Paducah Site proposed one project in which the SHPO was consulted. For D&D of the C-410 Project, a Cultural Resource Survey and National Register Assessment was prepared by a professional archeologist/ historian and provided to the SHPO. The SHPO provided correspondence indicating that regulatory requirements had been fulfilled for this project.

In accordance with 36 C.F.R. 800.13, DOE is in the process of developing an optional NHPA compliance strategy based on a programmatic agreement between DOE, the Advisory Council on

Historic Preservation, and the SHPO. The programmatic agreement provides for a more comprehensive cultural resources program and requires a survey to identify significant historical properties and development of a Cultural Resources Management Plan. In April 1997, a draft programmatic agreement was submitted to the SHPO for approval. In 2003, the SHPO approved the programmatic agreement and it was sent to the Advisory Council on Historic Preservation for final approval. The draft programmatic agreement was still in the process of being finalized at the end of 2003. Approval for implementation was anticipated in early 2004.

Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of endangered and threatened animals and plants. The act also serves to protect ecosystems on which such species depend. At the Paducah Site, proposed projects are reviewed, in conjunction with NEPA project reviews, to determine if activities have the potential to impact these species. If necessary, project-specific field surveys are performed to identify threatened and endangered species and their habitats, and mitigating measures are designed as needed. When appropriate, DOE initiates consultation with the U.S. Fish and Wildlife Service prior to implementing a proposed project.

Table 2.3 includes seven federally listed, proposed, or candidate species that have been identified as potentially occurring at or near the Paducah Site. Project NEPA reviews and associated

Table 2.3 Federally listed, proposed, and candidate species potentially occurring within the Paducah Site study area in 2003[a]

Common Name	Scientific Name	Endangered Species Act Status
Indiana Bat[b]	*Myotis sodalis*	Listed Endangered
Interior Least Tern	*Sterna antillarum athalassos*	Listed Endangered
Pink Mucket	*Lampsilis abrupta*	Listed Endangered
Ring Pink	*Obovaria retusa*	Listed Endangered
Orangefoot Pimpleback	*Plethobasus cooperianus*	Listed Endangered
Fat Pocketbook	*Potamilus capax*	Listed Endangered
Bald Eagle	*Haliaeetus leucocephalus*	Listed Threatened

[a] All of the above species are discussed in *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky, Volume III,* U. S. Army Corps of Engineers Nashville District, May 1994. Note that the study area encompasses 11,719 acres and extends to include the Ohio River, which is over three miles north of the DOE reservation. None of these species have been reported as sighted on the DOE reservation, although potential summer habitat exists there for the Indiana bat. No critical habitat for any of these species has been designated anywhere in the study area.

[b] Specimens of the Indiana bat were collected from WKWMA property in 1991 and 1999.

field surveys indicated that in 2003, DOE projects at the Paducah Site did not directly impact any of these seven species. Potential habitats of these species also were not significantly impacted.

Floodplain/Wetlands Environmental Review Requirements

Title 10 C.F.R., Part 1022, establishes procedures for compliance with Executive Order 11988, "Floodplain Management," and Executive Order 11990, "Protection of Wetlands." Activities, other than routine maintenance, proposed within 100-year floodplains or in wetlands first require that a notice of involvement be published in the Federal Register. A floodplain or wetlands assessment must then be prepared by DOE that evaluates potential impacts on the floodplains or wetlands and considers alternatives to avoid or lessen impacts. For floodplains, a floodplain statement of findings summarizing the floodplain assessment must be published in the Federal Register for public comment at least 15 days before beginning the project. Activities of DOE in "waters of the United States," which include wetlands, are likely to be subject to additional Clean Water Act (CWA) permit requirements administered by the COE and may require water quality certification from KDEP.

In 2003, no floodplain or wetlands assessments were prepared or approved. Also, no floodplain or wetlands notices of involvement were published in the Federal Register for the Paducah Site. In addition, DOE did not apply for any individual permits from COE or for any water quality certifications from the state. Some DOE projects were authorized through the COE nationwide permit program for activities involving waters of the United States.

The DOE activities did not result in significant impacts to floodplains or wetlands at the Paducah Site in 2003.

Clean Water Act

The CWA was established primarily through the passage of the Federal Water Pollution Control Act Amendments of 1972. The CWA established the following four major programs for control of water pollution: (1) a permit program regulating point-source discharges into waters of the United States, (2) a program to control and prevent spills of oil and hazardous substances, (3) a program to regulate discharges of dredge and fill materials into "waters of the United States," and (4) a program to provide financial assistance for construction of publicly owned sewage treatment works. The Paducah Site is primarily affected by the regulations for discharges of dredge and fill materials (see previous subsection on Floodplain/Wetlands Environmental Review Requirements) and for point-source discharges regulated under the KPDES Permit.

Kentucky Pollutant Discharge Elimination System Permits

The CWA applies to all non-radiological DOE discharges to waters of the United States. At the Paducah Site, the regulations are applied through issuance of a KPDES permit for effluent discharges to Bayou Creek and Little Bayou Creek. The Kentucky Division of Water (KDOW) issued KPDES Permit No. KY0004049 to the Paducah Site. This permit became effective April 1, 1998, and is enforced by KDOW. The KPDES Permit No. KY0004049 applies to the following four DOE outfalls: 001, 015, 017, and 019. The KPDES permit calls for chemical and biological monitoring as an indicator of discharge-related effects in the receiving streams. The permit technically expired at the end of March 2003, but by regulation, it is automatically extended until a new permit is obtained. A permit renewal application was submitted to KDOW in September 2002 and a minor revision to the application was submitted in May 2003. As of the end of 2003, KDOW had not approved the application; therefore, KPDES Permit No. KY0004049 remained in effect throughout 2003 and into 2004.

In correspondence dated March 17, 2003, from the Enforcement Branch of KDOW, an NOV was received for violations of Kentucky Revised Statute (KRS) 224, 401 K.A.R. 5:065 1(1). Specifically, Paducah KPDES Outfall 001 exceeded the permit limit for chronic toxicity in samples collected in October, November, and December 2002. These data were reported in the quarterly Discharge Monitoring Report submitted to KDOW in January 2003. A Toxicity Reduction Evaluation (TRE) Plan was prepared and submitted to KDOW on March 21, 2003; approved on April 14, 2003; and immediately implemented. Implementation has included monthly compliance monitoring for chronic toxicity at Outfall 001 and quarterly update reporting to KDOW. Additional failures for chronic toxicity occurred at Outfall 001 in January, June, August, September, and December 2003. No direct impacts on the receiving stream (Bayou Creek) have been noted. Efforts to identify the cause of the toxicity were ongoing at the end of 2003. No permit exceedences for other parameters occurred at Outfall 001 in 2003.

Outfall 017 failed for acute toxicity in the first quarter of 2003. A follow-up test was performed and passed. The first-quarter failure was investigated, but no cause was determined. Subsequent quarterly acute toxicity results for the remainder of 2003 passed. No further steps were required by the KPDES permit and implementing regulations. No permit exceedences for other parameters occurred at Outfall 017 in 2003.

No exceedences of effluent permit limits occurred at outfalls 015 or 019 in 2003.

Toxic Substances Control Act

In 1976, the Toxic Substances Control Act (TSCA) was enacted with a twofold purpose: (1) to ensure that information on the production, use, and environmental and health effects of chemical substances or mixtures are obtained by the EPA, and (2) to provide the means by which the EPA regulates chemical substances/mixtures.

Polychlorinated Biphenyls

The Paducah Site undertakes activities to comply with PCB regulations (40 C.F.R. 761) and the Uranium Enrichment (UE) FFCA promulgated under TSCA. The major activities performed in 2003 to ensure compliance included the following: maintaining compliant storage of PCB waste and PCB-contaminated wastewater, shipping PCB waste for treatment and disposal, treatment and discharge of PCB-contaminated wastewater, maintenance to the troughing system, and reporting and record keeping.

The UE TSCA FFCA between EPA and DOE was signed in February 1992. To meet the compliance goals at the Paducah Site, the UE TSCA FFCA is frequently revised and updated. Under this agreement, action plans have been developed and implemented for removal and disposal of large volumes of PCB material at the Paducah Site. Table 2.4 shows a summary of PCB items in service at the Paducah Site at the end of 2003.

Table 2.4 Summary of PCBs and PCB items in service at the end of 2003

Type	Number in Service	Volume (gal)	PCBs (kg)
PCB Transformers	66	95,256	277,152
PCB-Contaminated Transformers	9	2,299	0.95
PCB-Contaminated Electrical Equipment	7	2,094	1.13
PCB Capacitors	682	2,042*	12,528.6
PCB Open Systems	3	235	7.02

* assumed 540,000 parts per million (ppm) PCB, 13.5 lbs/gal

The annual PCB document, due July 1, provides details of facility activities associated with the management of PCB materials. The annual report provides details from the previous year on all PCB items that are in use, stored for reuse, generated as waste, stored for disposal, or shipped offsite for disposal. All Paducah Site UE TSCA FFCA milestones for 2003 were completed.

The facilities operated by USEC utilize equipment that contains PCB capacitors as well as transformers, electrical equipment, and other miscellaneous PCB equipment. Both radioactive and non-radioactive PCB wastes are stored onsite in storage units that meet TSCA and/or UE TSCA FFCA compliance requirements. Upon approval, nonradioactive PCBs are transported offsite to EPA-approved facilities for disposal.

Radioactive-contaminated PCB wastes are authorized by the UE TSCA FFCA for on-site storage at Paducah beyond two years. Technology for the treatment and/or disposal of radioactively contaminated PCB wastes is being evaluated.

Emergency Planning and Community Right-to-Know Act

Also referred to as Title III of the Superfund Amendments and Reauthorization Act, the Emergency Planning and Community Right-to-Know Act (EPCRA) requires reporting of emergency planning information, hazardous chemical inventories, and releases to the environment. Reports under EPCRA are submitted to federal, state, and local authorities. Executive Order 12856, signed in August 1993, subjects all federal agencies to EPCRA. The applicable requirements of EPCRA are contained in Sections 304, 311, 312, and 313.

- Section 304 requires reporting of off-site reportable quantity releases to state and local authorities. Reportable quantities for various chemical releases are defined in regulations implemented by EPA.

- Section 311 requires that either material safety data sheets (MSDSs), or lists of the hazardous chemicals for which an MSDS is required, be provided to state and local authorities for emergency planning purposes.

- Section 312 requires that a hazardous chemical inventory for chemicals stored at a site be submitted to state and local authorities for emergency planning.

- Section 313 requires annual reporting of releases of toxic chemicals to the EPA and the state.

The Paducah Site did not have any releases that were subject to Section 304 notification requirements during 2003. No Section 311 notifications were required in 2003. The Section 312 Tier II report of inventories for 2003 included UF_6, uranium tetrafluoride (UF_4), iron filings, activated carbon pellets, magnesium fluoride, and PCBs associated with DOE activities. The Paducah Site reported PCBs on the Section 313 report because DOE accepts legacy PCB material from USEC when disposal of electrical equipment is needed.

Clean Air Act

Authority for enforcing compliance with the Clean Air Act (CAA) and subsequent amendments resides with EPA Region 4 and the Kentucky Division for Air Quality (KDAQ). The Paducah Site maintains compliance with federal and state rules implementing the CAA and its amendments.

Clean Air Act Compliance Status

The Paducah Site had three air emission point sources in 2003. The Northwest Plume Groundwater System and the Northeast Plume Containment System are interim remedial actions (IRAs) under CERCLA addressing the containment of groundwater contamination at the Paducah Site. These separate facilities remove TCE contamination from the groundwater by air stripping. At the Northwest Plume Groundwater System, the TCE-laden groundwater passes through an air stripper to remove the TCE. The off-gas from the air stripper then passes through a carbon adsorption system to remove the TCE prior to atmosphere discharge. At the Northeast Plume Containment System, a cooling tower system acts as an air stripper for TCE.

The third project that had a point source was the SPH Treatability Study that removed TCE from the groundwater and soil (see Section 3 for additional information). The off-gas resulting from the treatment passed through activated carbon. The TCE was adsorbed on to the carbon and the spent carbon was returned to the vendor for regeneration.

Asbestos Program

Numerous facilities at the Paducah Site contain asbestos materials. Compliance programs for asbestos management include identification of asbestos materials, monitoring, abatement, and disposal. Procedures and program plans are maintained that delineate scope, roles, and responsibilities for maintaining compliance with EPA Region 4, Occupational Safety and Health Administration, and Kentucky regulatory requirements. Noncompliances with environmental protection standards were not identified in 2003.

Radionuclide National Emissions Standards for Hazardous Air Pollutants Program

Kentucky and EPA Region 4 regulate airborne emissions of radionuclides from DOE facilities under 40 CFR 61 Subpart H, the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. Potential radionuclide sources at the Paducah Site in 2003 resulted from scrap metal handling, the Northwest Plume Groundwater System, the NSDD removal project, the C-752-A waste treatment project, and fugitive source emissions. The fugitive source emissions include piles of contaminated scrap metal, roads, and building roofs. The DOE utilized ambient air monitoring data to verify insignificant levels of radionuclides in off-site ambient air. The Radiation/ Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services conducted ambient air monitoring during 2003. Ambient air data were collected at 11 sites surrounding the plant in order to measure radionuclides emitted from Paducah Site sources, including fugitive emissions. Results are discussed in Section 4.

Pollutants and Sources Subject to Regulation

Any stationary source emitting more than 10 tons/year of any hazardous air pollutant (HAP) or 25 tons/year of any combination of HAPs is considered a major source and is subject to regulation. EPA Region 4 must examine other sources for regulation under an “area source” program. The Paducah Site is not a major source by virtue of its individual or total HAP emissions.

Stratospheric Ozone Protection

The DOE refrigeration units contain less than 50 pounds of ozone-depleting substances; therefore, the only part of Title VI of the CAA that applies to the Paducah Site is the requirement to control refrigerants from leaking systems.

Clean Air Act NOVs

The KDAQ issued an NOV to DOE for failure to submit an annual compliance certification. This requirement applies to major air emission sources. However, because the Paducah Site is not a major air emission source, the database that the KDAQ maintains was corrected and the NOV was rescinded.

Kentucky/Department of Energy Agreement in Principle

The Kentucky/DOE Agreement in Principle (AIP) reflects the understanding and commitments between DOE and the Commonwealth of Kentucky regarding DOE's provision of technical and financial support to Kentucky for environmental oversight, surveillance, remediation, and emergency response activities. The goal of the AIP is to maintain an independent, impartial, and qualified assessment of the potential environmental impacts from present and future DOE activities at the Paducah Site. The AIP is intended to support non-regulatory activities whereas the FFA covers regulatory authority. The AIP includes a grant to support the Commonwealth of Kentucky in conducting independent monitoring and sampling, both onsite and offsite, and to provide support in a number of emergency response planning initiatives, including cooperative planning, conducting joint training exercises, and developing public information regarding preparedness activities.

Regulatory Inspections

Paducah Site environmental management programs are overseen by several organizations, both inside and outside the DOE complex. Each year, numerous appraisals, audits, and surveillances of various aspects of the environmental compliance program are conducted. Table 2.5 summarizes the state and federal regulatory inspections conducted in 2003.

Table 2.5 State and federal regulatory inspections at the Paducah Site in 2003

Date	Agency	Description
January	KDOW KDWM/EPA	Inspection of Water Line Extension RCRA Inspection
February	KDWM	C-746-U Landfill Inspection
March	none	none
April	KDWM	C-746-U Landfill Inspections (2)
May	KDOW KDWM	Outfall Inspection C-746-U Landfill Inspection
June	none	none
July	KDWM	DMSAs
August	KDWM	C-746-U Landfill Inspections (2)
September	KDAQ KDWM	Six-Phase Treatment System SWMUs
October	KDWM	C-746-U Landfill Inspection
November	none	none
December	KDOW KDWM	Outfall Inspection C-746-U Landfill Inspection

3 Environmental Program Information

Abstract

Environmental monitoring, environmental restoration, waste operations, facilities management, UF_6 cylinder management activities, and D&D/DMSA management occur at the Paducah Site. Several programs are conducted; therefore, they are presented in this section to inform the public.

Environmental Monitoring Program

The environmental monitoring program at the Paducah Site consists of effluent monitoring and environmental surveillance. Requirements for routine environmental monitoring programs were established to measure and monitor effluents from DOE operations and maintain surveillance on the effects of those operations on the environment and public health through measurement, monitoring, and calculation. This program is intended to demonstrate that DOE operations at the Paducah Site comply with DOE orders and applicable federal, state, and local regulations. The Environmental Monitoring Program is documented in the *Paducah Site Environmental Monitoring Plan* (BJC 2002) in accordance with DOE Order 5400.1, General Environmental Protection Program. The results of this program are discussed in detail in subsequent sections of this ASER.

Before the DOE/USEC transition (described in Section 1), The DOE's primary mission at the Paducah Site consisted of enriching uranium. However, since the transition on July 1, 1993, DOE's mission at the site has been focused on environmental restoration, DUF_6 cylinder management, waste management, and D&D/DMSA management. This change in mission also has changed the direction and emphasis of the environmental monitoring program. In November 1995, the site environmental monitoring plan was reissued to address DOE operations exclusively. The environmental monitoring plan is reviewed annually and updated at least every three years. The October 2002 version of the *Paducah Site Environmental Monitoring Plan* addresses the sampling events in 2003 that are reported in this ASER.

Environmental Restoration Program

The goal of the environmental restoration program is to ensure that releases from past operations and waste management activities are investigated and that appropriate remedial action is taken for the protection of human health and the environment. In May 1994, PGDP was added to EPA's NPL of hazardous waste sites that require the most cleanup. Two federal laws, RCRA and CERCLA, are the dominant regulatory drivers for environmental restoration activities at the Paducah Site. The RCRA sets the standards for managing hazardous waste and requires permits to be obtained for DOE facilities that treat, store, or dispose of hazardous waste and require assessment and cleanup of hazardous waste releases at SWMUs. The CERCLA addresses uncontrolled releases of hazardous substances and requires cleanup of inactive waste sites. As a result of being placed on the NPL and having RCRA permits, the DOE, EPA, and KDEP entered into an FFA in 1998. The FFA delineates the relationship between the active RCRA-regulated units and prescribes the requirements necessary to facilitate compliance with both laws.

The environmental restoration program supports remedial investigations (RIs) and environmental response actions, D&D of facilities no longer in use, projects designed to demonstrate or test advancements in remedial technologies, and other projects related to remedial action for the protection of human health and the environment.

Background

In July 1988, the Kentucky Radiation Control Branch, in conjunction with the Purchase District Health Department, sampled several residential groundwater wells north of the plant in response to concerns from a local citizen regarding the quality of water in a private well. Subsequent analyses of these samples revealed elevated gross beta levels indicative of possible radionuclide contamination. On August 9, 1988, these results were reported to the Paducah Site, which responded by sampling several private groundwater wells adjacent to the site on August 10, 1988. Upon analysis, some of the samples collected contained elevated levels of both TCE and ^{99}Tc. In response, DOE immediately instituted the following actions:

- provided a temporary alternate water supply to affected residences;
- sampled surrounding residential wells to assess the extent of contamination;
- began extension of a municipal water line to affected residences as a long-term source of water, and;
- began routine sampling of residential wells around the Paducah Site.

Following the initial response actions, DOE and EPA entered into an ACO in August 1988 under sections 104 and 106 of CERCLA. The major requirements of the ACO include monitoring of residential wells potentially affected by contamination, providing alternative drinking water supplies to residents with contaminated wells, and investigation of the nature and extent of off-site contamination.

Pursuant to the ACO, DOE continued routine sampling of residential wells and initiated a two-phase site investigation to identify the nature and extent of off-site contamination at the Paducah Site. Phase I of the site investigation, from summer 1989 to March 1991, evaluated the extent of off-site contamination through extensive groundwater monitoring and surface-water sampling. Results of these activities are reported in *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991b). Phase II of the site investigation, from November 1990 to October 1991, focused on identification and characterization of on-site sources contributing to off-site contamination, determined the level of risk to human health and the environment from exposure to contaminated media and biota, and developed an initial list of remedial alternatives. Results are reported in *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992a). Risks to human health and the environment from exposure to contamination originating at the Paducah Site were reported in *Results of the Public Health and Ecological Assessment, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992b). This report used data collected during the site investigation to quantitatively assess risks to human health and to qualitatively assess risks to the environment.

As part of the residential well sampling program that began when off-site contamination was discovered, DOE established a water policy. This policy states that in the event contamination originating from the Paducah Site is detected above plant-action levels, a response would be initiated by the Paducah Site. These levels established at the analytical laboratory detection limits of 25 picoCuries per liter (pCi/L) for ^{99}Tc and 1 part per billion (ppb) for TCE. Accordingly, residents would be notified immediately, as would state and EPA officials. Alternative water supplies would be provided through connection to the municipal water system, or in the event of a time lapse between discovery and the ability to complete connections, bottled water would be made available. The DOE pays installation cost of water systems and the monthly charges for water service to residents with contaminated wells.

The DOE modified this water policy in 1994 to include provisions to extend a municipal water line to the entire area potentially affected by groundwater contamination originating from the Paducah Site. All residents within the defined area, regardless of whether or not their wells were contaminated, were given the option to receive municipal water at DOE's expense. The DOE also provided municipal water to new residents and some new businesses. A five-year review of the water policy was issued in 1999.

The ACO activities identified two off-site groundwater contamination plumes, referred to as the Northwest and Northeast Plumes and identified several potential on-site source areas requiring additional investigation, and included the evaluation of alternatives and implementation of several interim activities. Upon signature of the FFA in February 1998, the FFA parties declared the ACO requirements satisfied and terminated the ACO because the remaining cleanup would be continued under the authority of the FFA. A series of RI/feasibility studies (FSs) were initiated under the FFA (e.g., Waste Area Groupings [WAGs] 1, 3, 6, 7, 22, 23, 27, and 28), including the ongoing evaluation of all major contaminant sources impacting groundwater and surface water. In accordance with the ACO and FFA, DOE actions have primarily focused on reducing potential risks associated with off-site contamination. Examples of the significant actions initiated and completed to date include the following (BJC 2004a):

- Imposed land-use controls (fencing and posting) to restrict public access to contaminated areas in certain outfall ditches and surface-water areas (1993).
- Extended municipal water lines as a permanent source of drinking water to affected residents to eliminate exposure to contaminated groundwater (1995).
- Constructed and implemented groundwater treatment systems for both the Northwest and Northeast Plumes to reduce contaminant migration (1995 and 1997, respectively).
- Constructed hard-piping to reroute surface runoff around highly contaminated portions of the NSDD to reduce potential migration of surface contamination (1995).
- Excavated soil with high concentrations of PCBs in on-site areas to reduce off-site migration and potential direct-contact risks to plant workers (1998).
- Removed and disposed of "drum mountain," which is a contaminated scrap pile potentially contributing to surface-water contamination to eliminate potential direct-

contact risks to plant workers and reduce off-site migration (2000).

- Applied *in situ* treatment of TCE-contaminated soil at the cylinder drop test site with innovative technology (i.e., the LASAGNA™ technology) to eliminate a potential source of groundwater contamination (2002).

- Removed petroleum-contaminated soil from SWMU 193 to eliminate a potential source of groundwater contamination (2002).

- Completed installation of a sediment control basin at Outfall 001 to control the potential migration of contamination during scrap removal, and initiated removal and disposal of approximately 54,000 tons of scrap metal to eliminate potential direct-contact risks to plant workers and a source of surface-water contamination (2002).

- Completed hard-piping and installation of a retention basin, and initiated excavation of the on-site portions of the NSDD, which will remove a source of potential direct-contact risk to plant workers and surface-water contamination (2003).

- Completed two key groundwater technology studies, including a successful treatability study to evaluate the effectiveness of the SPH technology for *in situ* treatment of dense, nonaqueous-phase liquid (DNAPL) at C-400 and a field demonstration to evaluate the technical constructability of a permeable treatment zone, which identified several installation concerns. (BJC 2004a)

Operable Units

The National Contingency Plan (NCP) states that owners of large, complex sites with multiple source areas, such as federal facilities, may choose to divide their sites into smaller areas for characterization and implementing response actions, as opposed to conducting a single site-wide comprehensive action. These discrete actions, referred to as operable units (OUs), may address a geographic portion of the site or specific site problems, or include a series of interim actions followed by final actions. The PGDP site cleanup strategy adopts this approach and includes a series of prioritized actions, ongoing site characterization activities to support future response action decisions, and D&D of the currently operating PGDP once it ceases operation, followed by a Comprehensive Sitewide Operable Unit (CSOU) evaluation. The timing and sequencing for implementation of these actions will be based on a combination of factors, including risk, compliance, and technical considerations associated with PGDP operations and other criteria, as outlined in Section XVIII.A of the FFA (BJC 2004a).

The OUs were established by developing a site conceptual risk model for each source area (SWMU/AOC). This process included a qualitative evaluation of contaminant types and concentration, release mechanisms, exposure pathways, points of exposure, and receptors based on current and reasonably foreseeable future land use. The source areas were initially grouped into the media-specific OUs as follows:

- Groundwater OU
- Surface-Water OU
- Soils OU
- Burial Grounds OU
- D&D OU
- CSOU

Sources and areas of contamination suspected of being primary risk contributors to off-site residents via the groundwater pathway were grouped under the Groundwater OU. Similarly, the Surface Water OU contains sources and areas of contamination posing the greatest risks to recreational users. The soils, D&D, and Burial Grounds OUs contain the sources posing the greatest risks to on-site industrial workers via direct contact. The objective of grouping the sources and areas of contamination into media-specific OUs is to provide a more comprehensive framework to assess site-wide risks, identify and prioritize response actions, and develop integrated cleanup solutions that will reduce risk across the primary exposure pathways.

To further support implementation of this strategy, the source areas and affected media within each OU were then subjected to a screening process using existing data and process knowledge to further segregate the source areas into various categories. These include areas for accelerated action, areas requiring additional characterization/risk evaluation, and areas in which investigation and/or remediation needs to be coordinated with D&D of the PGDP once it ceases operation. Criteria used to designate areas as warranting an accelerated action included the following:

- Actions necessary to prevent and/or mitigate human exposure to on- and/or off-site contamination posing near-term unacceptable risk,
- Actions necessary to ensure safe conditions for current industrial workers, and
- Actions providing the greatest opportunity for risk reduction.

The accelerated actions are designed to be focused with an emphasis on reducing threats associated with the major risk contributors for the primary exposure/migration pathways (e.g., groundwater, surface water, soil). Units not included as part of the currently planned accelerated actions will undergo additional investigation and/or risk evaluation to support future response action decisions. Certain investigation activities have been scoped to focus on characterizing specific site conditions/pathways. These include the Southwest Dissolved-Phase Plume/Sources Project and the Surface-Water Project (On-Site). Other investigations will be completed under the Site-Wide Soils OU. This OU will address the data gaps for the remaining units and will include a multimedia evaluation as appropriate (e.g., groundwater, surface water). The RI for the Site-Wide Soils OU will also evaluate the Northwest and Northeast Dissolved-Phase Groundwater Plumes and serve to identify hot-spot soil contamination that will be addressed through a removal action coordinated with the RI (BJC 2004a).

Areas included under the FFA that are associated with ongoing PGDP operations may have their investigation and/or remediation coordinated with cessation of PGDP operations. Units included under this category either are currently operating, are inactive but located within an operating facility, or have unique technical factors requiring consideration. An example of units that are currently operating are the electrical switchyards. Attempts to investigate and/or remediate the electrical switchyards while they are still operating could cause unacceptable safety hazards to workers, as well as increase the potential for disruption of PGDP operations. Other examples are units that receive ongoing wastewater discharges or are associated with contamination located beneath or within operating buildings, making it impractical for investigation and/or remediation until D&D of that specific facility. When those types of areas do not pose an immediate human health risk, the appropriate evaluation and/or remediation might need to be addressed as part of the eventual D&D of the currently operating PGDP after operations cease. Decisions for those areas will be made on a case-by-case basis in accordance with the FFA.

Groundwater is an example of an area that has unique technical factors that need special consideration in the sequencing and decision-making process. The cleanup strategy for groundwater contamination includes preventing human exposure to contaminated groundwater, addressing source areas posing off-site risks, and selecting and implementing final remedial actions for the dissolved-phase plumes. As part of executing this strategy, alternate drinking water has been provided to potentially affected residents to prevent human exposure, and groundwater treatment systems have been installed in both the Northwest and Northeast plumes to reduce further off-site migration. Additionally, source-reduction actions are currently being proposed for the C-400 area, which is the largest DNAPL source of off-site contamination. Also, and a site investigation for the Southwest Dissolved-Phase Plume/Sources will evaluate the need for additional groundwater actions for that plume before plant shutdown.

However, before a final decision for off-site dissolved-phase plumes can be reached, several technical factors must be considered, including the effectiveness of the DNAPL source actions at the C-400 area, whether additional DNAPL source areas exist beneath the operating PGDP, and the hydrogeologic effects that ceasing plant operations will have on groundwater flow directions. Each of these technical considerations, which will be further evaluated under the Site-Wide Soils OU, is essential to understanding remediation time frames and the fate/transport characteristics of the contaminants associated with the dissolved-phase plumes.

The scope of the D&D OU includes 17 currently inactive DOE facilities-those SWMUs and AOCs designated as being associated with plant operations as previously discussed, above and the currently operating PGDP. The 17 inactive DOE facilities are scheduled to undergo D&D before plant shutdown. The units associated with PGDP operations will be prioritized and sequenced with D&D of the PGDP.

The final CSOU evaluation will occur following completion of D&D of the PGDP after plant shutdown. As part of the final CSOU evaluation, the future land-use assumptions will be reassessed and modified, if necessary, to ensure consistency with the reasonably foreseeable land use, including any reuse initiatives that might be under consideration at that time. The scope of the final CSOU will include a site-wide baseline human health and ecological risk assessment to evaluate residual risks remaining and will identify any necessary additional actions to ensure long-term protectiveness (BJC 2004a).

The Agreed Order related to waste supports the option to defer final closure, post closure, and groundwater corrective actions for areas addressed under the Agreed Order to response actions selected and implemented as part of the appropriate OU under the FFA. Any such scope that is incorporated into Appendix B of the FFA will be included in future annual updates to the SMP. Similarly, any new D&D scope added to the FFA after plant shutdown will be added to Appendix B of the FFA and the SMP under future updates.

Site Priorities

The DOE uses a combination of factors to prioritize work being implemented under the EM program at PGDP. These include risk-based criteria, compliance with other programs, technical considerations associated with PGDP operations, mortgage reduction, and demonstrated progress toward completing the EM mission.

The risk prioritization criteria (Figure 3.1) incorporate the general program-management principles of the NCP, which emphasizes the use of accelerated actions to address imminent threats and reduce migration of off-site contamination. Consistent with those principles, the risk prioritization criteria described as follows are used as guidelines, in conjunction with the other previously mentioned factors, to prioritize response actions (BJC 2004a).

- **Mitigate immediate threats, both on and offsite.**
- **Reduce further migration of off-site contamination.**
- **Address sources contributing to off-site contamination.**
- **Address remaining sources contributing to on-site contamination.**
- **Perform D&D of the currently operating gaseous diffusion plant, units impacted by plant operations.**
- **Evaluate the final CSOU.**

Figure 3.1 Risk prioritization criteria

2003 Remedial Activities

Significant accomplishments for the environmental restoration program conducted in 2003 include the following:

- Completed the SPH Treatability Study adjacent to the C-400 Cleaning Building.
- Continued operation of the Northwest and Northeast Plume Groundwater treatment systems.
- Completed additional seismic investigation field work for the potential on-site disposal cell.
- Installed a sediment controls basin and excavated Section 2 of the NSDD.
- Continued characterization, removal, and disposal of scrap metal, including removal of all aluminum ingots.

Six-Phase Heating Treatability Study

The SPH Treatability Study began in 2002 with an objective to evaluate the performance of Electrical Resistance Heating (ERH) technology to remove TCE from the source area near the C-400 Building. The area around the C-400 Building is the primary source of TCE contamination in groundwater at PGDP. The project plan was documented in an approved treatability study work plan and engineering designs were also approved prior to beginning field implementation on April 5, 2002. Figure 3.2 depicts the installation of the system.

The primary objective of the SPH Treatability Study was to demonstrate the performance of ERH technology in the unsaturated and saturated soils of the UCRS and in the groundwater of the underlying RGA. The successful implementation of this technology demonstrated that ERH technology can effectively heat soil in the UCRS and groundwater in the RGA at the PGDP. Data produced during the SPH Treatability Study indicate that the system can successfully recover and treat the target contaminant vapors.

Six-phase heating is a type of ERH technology that uses a ring of six electrodes surrounding a central neutral electrode. The electrodes extend from a few

Figure 3.2 SPH Treatability Study

feet below the ground surface to the bottom of the RGA. Power is applied to the six electrodes, creating a flow of electricity to the neutral electrode. The natural resistance of the soil to the flow of electricity causes the soil to heat. As the soil heats past the boiling point of TCE, the TCE is vaporized. These vapors are captured by a soil vapor extraction system, which creates a vacuum to remove vapors from the soil. The extracted vapors are cooled to allow separation of TCE and any entrained water and condensing water vapor. This separation occurs because TCE has a lower boiling point (87ºC) than water. After removal of the water, the vapor effluent is passed through a series of granular activated carbon filters that adsorb the TCE.

The SPH system began active heating on February 14, 2003. The study was originally scheduled to operate for 130 days. However, a 45-day extension was implemented as a result of positive TCE extraction and the desire to increase temperatures at the base of the RGA. Active heating was discontinued on September 6, 2003, marking the end of the 45-day operational extension.

The removal of TCE in the groundwater of the RGA was assessed by a comparison of the baseline groundwater sample results to post- treatment groundwater sample results. The post- treatment gresults, when compared to the baseline groundwater sample results, indicated a 99 percent reduction in the TCE groundwater concentration. The removal of TCE in the soil was also assessed by a comparison of the baseline soil sample results to the post-treatment soil sample results. This comparison indicated an average TCE concentration reduction in soil of 98 percent. These results indicate that the TCE-removal efficiency goals were met as a result of the SPH Treatability Study.

Based on the results of the study, decision documents will be written to evaluate implementation of the ERH technology on a large-scale basis at PGDP.

Northwest Plume Groundwater System

The IRA of the Northwest Plume is documented in a ROD signed by DOE and EPA in July 1993. The KDEP also concurred with the ROD. The IRA resulted in the construction of the Northwest Plume Groundwater System (NWPGS). The NWPGS, which consists of two extraction well fields with two extraction wells each, transfer pipelines, and a fully enclosed treatment system. The NWPGS began operation on August 28, 1995. The interim action is designed to contain the migration of TCE and ^{99}Tc in the high-concentration portion of the Northwest Plume.

TCE is removed by an air-stripping process. The TCE is volatilized in a low-profile air stripper by a large volume of air that comes into contact with the contaminated groundwater during the treatment process. Activated carbon filtration beds are then used to remove the TCE from the off-gas generated by the air stripper before it is discharged to the atmosphere. ^{99}Tc is removed from the groundwater by an ion-exchange process.

The treatment system has extracted and treated approximately 847 million gallons of contaminated groundwater from startup through the end of 2003. The treatment system has exceeded the online goal of 85 percent since its startup in 1995. The NWPGS has consistently met the treatment goals documented in the ROD of 5 ppb TCE and 900 pCi/L of ^{99}Tc. The treated groundwater is released through KPDES-permitted Outfall 001. Radiological emissions from this facility are discussed in Section 4.

Northeast Plume Containment System

The IRA of the Northeast Plume was documented in a ROD signed by DOE and EPA in June 1995. The KDEP accepted the ROD with the issuance of Hazardous Waste Permit Modification 8, dated June 26, 1995. The IRA resulted in the construction of the Northeast Plume Containment System (NEPCS). The NEPCS consists of two extraction wells, an equalization tank, a transfer pump, a transfer pipeline, and instrumentation and controls. Characterization and construction activities were completed in December 1996. System startup and operational testing were conducted in February 1997, with the system beginning full operation at the end of February 1997.

System operation includes pumping groundwater contaminated with TCE from two extraction wells to the equalization tank. A transfer pump is used to pump the contaminated water from the equalization tank through a transfer pipeline (approximately 6000 linear feet) to the top of the C-637-2A or C-637-2B Cooling Tower. C-637-2A is the primary destination; however, if C-637-2A is off-line, flow is transferred to the C-637-2B tower. The cooling tower acts as an air stripper and removes the TCE from the groundwater as it moves through the tower.

Through 2003, approximately 538 million gallons of contaminated groundwater have been extracted and treated by the NEPCS. The system has been operational approximately 95 percent of the time since startup; with the exception of July through September 1999 when the facility was taken off-line due to cooling-tower maintenance.

CERCLA Waste Disposal Options

In March 2002, DOE completed a field investigation to evaluate seismic conditions at the Paducah Site for the siting of a potential on-site CERCLA waste disposal facility. The results were presented to EPA and KDWM in August 2002 in the *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2038&D1. In late 2002, plans for this activity were placed on hold; however, DOE re-opened consideration of this facility in 2003. The consideration includes completing elements of a seismic investigation and preparing an RI/FS to evaluate on-site and off-site disposal options. In 2003, the on-site and off-site Paleoliquifaction Study was completed, along with additional Direct Push Technology study samples. The existing seismic report will be updated and CERCLA documentation for the Seismic Report will be completed in 2004.

North- South Diversion Ditch

On August 21, 2002, the *Record of Decision for Interim Remedial Action at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-1948&D2) was approved by EPA and concurrence was received by the Commonwealth of Kentucky. The DOE signed the ROD on September 25, 2002. The portion of the NSDD addressed by the remedial action is comprised of sections 1 and 2 (i.e., SWMU 59). This portion of the NSDD is located inside the main security fence surrounding the industrialized portion of PGDP.

The remedial action objectives developed by the Project Team for sections of the NSDD located inside the security-fence area at PGDP and documented in the ROD are as follows:

- prevent future discharge of process water to the NSDD;
- reduce the risk to industrial workers and ecological receptors from exposure to contaminated surface soil, sediment, and surface water; and
- prevent future on-site runoff from being transported offsite (i.e., outside the existing security fence) via the NSDD.

The major components of the selected remedy include a two-phased approach. Phase I of the selected remedy includes the following components:

- Installation of piping (Figure 3.3) to route process discharges, which currently go to the NSDD, directly to the C-616 Water Treatment Facility;

- Installation of storm-water runoff controls in the NSDD downstream of section 2, prior to excavation of a surge basin during Phase I (existing culverts at the downgradient end of Section 2 will be plugged and filled with controlled low-strength material as an initial step in surge basin construction and existing sediment controls inside the security fence will remain in place to control runoff);
- Excavation of a surge basin to contain storm-water runoff until it can be treated through the C-616 facility; and
- Installation of a plug in the NSDD at the PGDP security fence, and in three other ditches within the watershed, to prevent discharge of storm-water runoff to sections of the NSDD outside the PGDP security fence.

Figure 3.3 NSDD piping

Phase II of the selected remedy includes the following components.

- Complete excavation of contaminated soils/sediments along sections 1 and 2 of the NSDD to achieve specified cleanup levels. Sections of the NSDD located inside the PGDP security-fence area (sections 1 and 2) will be excavated to remove contaminated soils/sediments, and a clay cover will be installed at the base of the excavation. The clay cover will provide an extra layer of protection in the elimination of the surface-exposure pathway.
- Appropriate staging and disposal of contaminated materials excavated during phases I and II. Nonhazardous waste generated as a result of the NSDD remedial action will be disposed of in the C-746-U Landfill.
- Restoration of sections 1 and 2 of the NSDD to grade with 2 ft of clay cover, approximately 2 ft of clean soil, and vegetation following completion of excavation activities. The clay cover will provide an extra layer of protection in the elimination of the surface-exposure pathway. If excavation achieves or exceeds the specified cleanup levels for sections 1 and 2, long-term maintenance of the clay cover would not be required. However, because the extent of contamination is not characterized fully and the remediation focuses on the ditch only, it is possible that some residual contamination would remain at depth. Any residual contamination would be addressed by the groundwater OU.

On September 26, 2002, DOE issued the Remedial Design/Remedial Action Work Plan (RD/RAWP) for the *North-South Diversion Ditch Piping and Pump Modifications at the Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-1967&D2.) The Commonwealth of Kentucky and EPA approved the RD/RAWP for the Piping and Pump Modifications on October 15, 2002. On October 21, 2002, field activities began on Phase I construction activities. The Phase I field activities were completed in 2003. Phase II construction activities began in 2003, with the completion of section 2 excavation. Disposal of staged waste from this excavation is being disposed at the C-746-U Landfill. Excavation section 1 and final disposal of excavation material for both sections 1 and 2 will be completed in 2004.

Scrap Metal Removal

The Paducah Site had approximately 54,000 tons of scrap metal in ten scrap yards, most of which are adjacent to each other, located in the northwestern portion of the plant's fenced area, most of which are located adjacent to each other. An Engineering Evaluation/Cost Analysis for S*crap Metal Disposition at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-1880&D2/R1), which analyzed alternatives for handling the scrap was approved by EPA and the Commonwealth of Kentucky in March 2001. The activities included in the removal action are to:

- construct staging areas to provide the scrap metal disposition with water, septic systems, electricity, and communications;
- control surface-water and sediment runoff by constructing a storm-water control basin;
- remove all of the scrap materials down to the level of surface soil;
- characterize, process, and package scrap materials to meet RCRA, TSCA, appropriate disposal facility waste acceptance criteria, and U.S. Department of Transportation shipping requirements; and
- transport and dispose of the materials removed.

During 2002, DOE completed construction of a storm-water control basin to support the removal action. In 2003, removal of scrap metal was initiated. The removal scope for the Scrap Metal project at Paducah consists of the following three major tasks:

- removal Action to dispose of the Northwest corner scrap yards;
- removal Action to dispose of the C-746-D Classified Scrap Metal Yard; and
- Operations and Maintenance of Scrap Metal infrastructure, including trailers and the C-613 storm-water collection basin that was constructed in 2002.

At the end of 2003, approximately 4100 tons of scrap had been removed from the Paducah Site. Figure 3.4 shows scrap metal being segregated and packaged for removal. Figure 3.5 shows scrap metal leaving the Paducah Site. This included 100 shipments of aluminum ingots completed on September 26, 2003, weighing 1969 tons. Figure 3.6 shows packaged ingots ready for shipment. The Post-construction Report for this Removal Action was be completed in early 2004. Fieldwork began September 2003 for removal of scrap from the C-746-D Classified Scrap Yard. In 2003, 137 containers were loaded for shipment and approximately 250 tons have been shipped. The C-613 basin that collects storm water from the northwest corner of the scrap yards is operating under normal conditions. The basin is routinely sampled, and then discharged to Outfall 001.

Waste Operations Program

The Paducah Site Waste Operations Program directs the safe treatment, storage, and disposal of waste generated before July 1, 1993 (i.e., legacy wastes), and waste from current DOE activities. The primary objective of the program is to ensure that waste materials do not migrate into the

Figure 3.4 Scrap metal removal project

Figure 3.5 Scrap metal leaving the Paducah Site

Figure 3.6 Aluminum ingots ready for shipment

environment. Waste managed under the program is divided into the following eight categories:

- *Low-level radioactive waste* -- radioactive waste not classified as high-level or transuranic and that does not contain any components regulated by RCRA or TSCA.
- *Hazardous waste* -- waste that contains one or more of the wastes listed as hazardous under RCRA or that exhibits one or more of the four RCRA hazardous characteristics: (1) ignitability, (2) corrosivity, (3) reactivity, and (4) toxicity.
- *Mixed waste* -- waste containing both hazardous and radioactive components. Mixed waste is subject to RCRA, which governs the hazardous components, and is subject to additional regulations that govern the radioactive components.
- *Transuranic waste* -- waste that contains more than 100 nanoCuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years.
- *PCB and PCB-contaminated waste* -- waste containing or contaminated with PCBs, a class of synthetic organic chemicals including 209 known isomers, each with 1 to 10 chlorine atoms on a biphenyl ring. Under TSCA regulations, PCB manufacturing was prohibited after 1978; however, continued use of PCBs is allowed, provided that the use does not pose a risk to human health or the environment. Disposal of all PCB materials is regulated.
- *Asbestos waste* -- asbestos-containing materials from renovation and demolition activities.
- *Solid* -- waste that is neither radioactive nor hazardous. Solid sanitary/industrial waste is basically refuse or industrial/ construction debris and is disposed in landfills.
- *PCB/Radioactive Waste* -- PCB waste or PCB items mixed with radioactive materials and managed as radioactive waste. PCB/radioactive/RCRA shall mean PCB/radioactive waste that may also be hazardous waste under RCRA.

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

Compliance for waste management activities involves meeting EPA and state regulations and DOE orders. In addition to compliance with these regulations, supplemental policies are enacted for management of radioactive, hazardous, PCB, PCB/radioactive, and mixed wastes. These policies include reducing the amount of wastes generated; characterizing and certifying waste before it is stored, processed, treated, or disposed; and pursuing volume reduction and use of on-site storage, when safe and cost-effective, until a final disposal option is identified. Table 3.1 summarizes the waste shipments during 2003. Figure 3.7 shows ash receivers (containers used to collect waste from C-410) staged for off-site shipment. In 2003, 9150 tons of waste were disposed in the on-site C-746-U Landfill.

Figure 3.7 Ash receivers ready for shipment

Site housekeeping activities were performed in 2003 to dispose of excess materials at the site. These activities included disposal of approximately 3800 tons on concrete crushate, disposal of 14 roll-off bins of wood debris to the C-746-U Landfill, and the closure of a 4000-gallon UST and appurtenances.

Pollution Prevention / Waste Minimization

The Pollution Prevention/Waste Minimization (PP/WM) Program at the Paducah Site provides guidance and objectives for minimizing waste generation. The program is set up to comply with regulations promulgated under RCRA and the Pollution Prevention Act, as well as applicable state and EPA rules, DOE orders, and Executive Orders.

Table 3.1 Waste shipments during 2003

- January – Shipped 5 metric tons of ash receivers and 206 metric tons aluminum ingots to the Nevada Test Site (NTS)
- February – Shipped 78 metric tons of remediation waste to Envirocare
- March – Shipped 275 metric tons of aluminum ingots to NTS
- April – Shipped 413 metric tons of aluminum ingots to NTS
- May – Shipped 71 metric tons of aluminum ingots to NTS
- May – Shipped 6 metric tons of waste to Envirocare
- August – Shipped 0.2 metric tons of waste to Chem Waste Management
- September – Shipped 692 metric tons of aluminum ingots to NTS
- September –Shipped 6 metric tons of treated ash receiver waste to Envirocare
- November – Shipped 10 metric tons of PCB mixed waste to the TSCA Incinerator
- December – Shipped 11 metric tons of PCB mixed waste to the TSCA Incinerator
- December – Shipped 8 metric tons of waste to Perma-Fix

The program strives to minimize waste using the following strategies:

- source reduction,
- segregation,
- reuse of materials,
- recycling, and
- procurement of recycled-content products.

The PP/WM Program has the following objectives:

- identify waste reduction opportunities,
- establish site-specific goals,
- establish employee awareness of PP/WM principles,
- integrate PP/WM technologies into ongoing projects,
- coordinate recycling programs,
- identify PP/WM responsibilities and resource requirements, and
- track and report results.

Recycling efforts in 2003 included 11.8 metric tons (mt) (26,000 pounds) of office paper; 0.52 mt (1100 pounds) of aluminum cans; 0.66 mt (1500 pounds) of telephone books; 0.39 mt (860 pounds) of printer and fax toner cartridges; 6.5 mt (14,320 pounds) of carbon used in the NWPGS; spent motor oil; used electrical equipment; and reuse of gravel generated from reconstruction of cylinder storage yards. Additional accomplishments of the PP/WM Program included continued use of micropurging techniques in groundwater sampling to reduce wastewater volume and transferring unused chemicals and materials to other programs for re-use. The recycling of rechargeable batteries and fluorescent light bulbs continues to reduce the volume of hazardous wastes generated at the site. The site also has converted to Philips Greens™ fluorescent bulbs that are not hazardous.

Depleted Uranium Hexafluoride Cylinder Program

DUF_6 is a product of the UE process. A solid at ambient temperatures, DUF_6 is stored in large metal cylinders. At the end of 2003, the Paducah Site managed an inventory of approximately 38,000 cylinders containing approximately 454,000 mt of UF_6 (most containing DUF_6) stored in outdoor facilities, commonly referred to as cylinder storage yards. Additional cylinders are added to the DOE inventory annually as a result of formal agreements with the USEC.

DUF_6 is stored as a crystalline solid at less than atmospheric pressure. When DUF_6 is exposed to moisture in the atmosphere, hydrogen fluoride and uranium reaction products form. The uranium by-products form a hard crystalline solid, which acts as a self-sealant within the storage cylinder. The hazard potential of DUF_6 is primarily chemical toxicity from any released hydrogen fluoride, rather than a radiological hazard.

The mission of the DUF_6 Cylinder Program is to safely store the DOE-owned DUF_6 inventory until its ultimate disposition. DOE has an active cylinder management program that includes cylinder and cylinder yard maintenance, routine inspections, cylinder yard construction and improvement, and other programmatic activities such as cylinder corrosion studies. The program maintains a cylinder inventory database, which serves as a systematic repository for all cylinder inspection data.

On April 15, 1999, DOE issued the *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, in response to the Defense Nuclear Facility Safety Board's request to analyze alternative chemical forms for the storage of DUF_6. As a result of this study, in 2002 DOE selected Uranium Disposition Services, LLC, to design, build, and operate facilities at Paducah, Kentucky, and Portsmouth, Ohio, that will convert the inventory of DUF_6 to triuranium octoxide

(U_3O_8), a more stable form of uranium that is suitable for disposal or reuse. In 2003, work was underway for the preliminary facility design. Construction is scheduled to start in July 2004, consistent with Public Law 107-206. DOE also entered into an Agreed Order in October 2003 with the Commonwealth of Kentucky that included a Cylinder Management Plan for continued activities associated with cylinder management at Paducah.

The Paducah DOE UF_6 Cylinder Storage Yards are categorized as a DOE Nonreactor Nuclear Category 2 facility. On December 18, 2003, a 10 C.F.R. 830-compliant Documented Safety Analysis (DSA) was submitted to DOE for approval. The DSA addresses all hazards (radiological and non radiological) and the controls necessary to provide adequate protection to the public, workers, and environment from these hazards.

Decontamination and Decommissioning/DOE Material Storage Areas

D&D is conducted for facilities and other structures contaminated with radiological and hazardous material. Facilities are accepted for D&D when they are no longer required to fulfill a site mission. Legacy contamination on the floors, walls, and ceiling of a structure and on equipment constitutes a potential for release to the environment, if not appropriately managed in the near term and ultimately removed. Two major facilities comprising approximately 46,450 m^2 (500,000 ft^2) have been accepted for D&D at PGDP. These facilities are the C-340 Metal Reduction Plant complex, where UF_6 was converted to uranium metal and hydrogen fluoride, and the C-410 Feed Plant complex, where uranium trioxide was converted to UF_6. Contaminants at these facilities include depleted uranium, natural uranium and transuranic radionuclides, UF_4, PCBs, asbestos, and lead paint. Fifteen additional inactive facilities are included in the D&D program at Paducah.

CERCLA documentation for removal of the C-410 Complex Infrastructure has been completed, as a non-time critical removal action. Additional documentation will be required for the C-410 building demolition and for the C-340 complex. Actual D&D of the C-410/C-420 complex has been initiated. D&D accomplishments in 2003 at the C-410/C-420 complex included the following:

- Completed sorting and repackaging of over 100 B-25 boxes of compactable wastes from the C-410 complex for offsite disposal.
- Completed isolation of steam, air, nitrogen, and steam condensate lines that enter the C-410 complex.
- Completed removal of support facilities around hydrofluoric acid tanks to prepare for disposition (See Figure 3.8).
- Completed removal of potentially fissile material in the C-410 complex.
- Developed DSA and initiated implementation process.

Figure 3.8 D&D of the C-410 Tank Farm included removal of piping, structures, and tanks

Activities performed during the year at the C-340 complex were limited to surveillance and maintenance of the structures to ensure containment of residual materials.

DMSAs are areas at PGDP containing material and equipment. They are undergoing a characterization process to comply with potential Nuclear Criticality Safety, RCRA, TSCA, and solid waste concerns. Originally included with the PGDP facilities leased to USEC, the DMSAs were returned to and accepted by DOE from USEC on December 31, 1996, to facilitate Nuclear Regulatory Commission certification of PGDP. The 160 DMSAs are located in non-leased areas inside buildings leased to USEC or are located in non-leased outdoor areas.

The Kentucky Natural Resources and Environmental Protection Cabinet filed an administrative complaint in October 2001 regarding the enforcement of NOVs alleging violations of Kentucky's delegated hazardous waste management program regulations. Most of these NOVs alleged the failure to characterize materials in DMSAs at PGDP or the unpermitted storage of hazardous waste in DMSAs. In October 2003, an Agreed Order between DOE and the Commonwealth of Kentucky was signed that resolved enforcement of the NOVs. The Agreed Order established regulatory deadlines for characterization and removal of DMSAs and also established RCRA closure requirements for DMSAs that are found to contain hazardous waste. As a result of the implementation of the order, the DMSA project status as of the end of 2003, characterization reports were completed on 38 DMSAs, field characterization was completed on 49 DMSAs, and field characterization was underway on 27 DMSAs. Fieldwork gives priority to DMSAs located outside or those that may contain hazardous waste. Lower priority DMSAs are addressed while sampling and analysis results from higher priority locations are prepared in order to achieve maximum efficiency in field operations. The characterization reports completed as of the end of 2003 determined that less than one-tenth of one percent by volume of the material and equipment characterized could be classified as hazardous waste. DOE notifies the Commonwealth of Kentucky when hazardous waste is identified during the DMSA project.

Public Awareness Program

A comprehensive community relations and public participation program on DOE activities exists at the Paducah Site. The purpose of the program is to provide the public with opportunities to become involved in decisions affecting environmental issues at the site. The program uses proactive public involvement to foster a spirit of openness and credibility among local citizens and various segments of the public.

Community/Educational Outreach

DOE and BJC Public Affairs supported several educational and community outreach activities during 2003. The DOE site manager spoke with civic groups, business leaders, and residents at pre-arranged events.

Citizens Advisory Board

The PGDP Citizens Advisory Board (CAB), a Site-Specific Advisory Board chartered by DOE under the Federal Advisory Committees Act, completed its seventh full year of operation in September 2003. During the year, the CAB held 11 regular board meetings and one retreat. The board also includes three task forces and three subcommittees, which meet as necessary.

The task forces review issues for:

- Groundwater and Surface Water,
- Waste Operations, and
- Long-Range Strategy and Stewardship.

The subcommittees handle topics concerning:

- Community Concerns,
- Nominations, Memberships, and
- Public Involvement.

All meetings are open to the public and all regular board meetings are publicly advertised.

In 2003, the CAB had 18 voting members, four ex-officio members, a deputy-designated federal official, and a federal coordinator. In August 2003, seven board members resigned. Because minimum of 12 members is required for the board to conduct business, a new member was appointed to the Board.

The Paducah CAB consists of individuals with diverse backgrounds and interests. It meets monthly to focus on early citizen participation in environmental cleanup priorities and related issues at the DOE facility. The Paducah CAB participates only in activities that are governed by DOE. Additional information concerning the Site-Specific Advisory Board may be obtained at www.oro.doe.gov/pgdpssab.

Environmental Information Center

The public has access to Administrative Records and programmatic documents at the DOE Environmental Information Center (EIC) in the Barkley Centre, 115 Memorial Drive, Paducah, Kentucky. The EIC is open Monday through Friday from 9 a.m. to 5 p.m. and by appointment. The phone number is (270) 554-6979.

Documents for public comment are also placed in the McCracken County Public Library (formerly the Paducah Public Library), 555 Washington Street, Paducah, Kentucky. The library is open Monday through Thursday from 9 a.m. to 9 p.m., Friday through Saturday from 9 a.m. to 6 p.m., and Sunday from 1 p.m. to 6 p.m.

The EIC, and other public web pages related to DOE work at the Paducah Site, can be accessed at www.bechteljacobs.com/p_eic/p_eic8.htm.

4 Radiological Effluent Monitoring

Abstract

Environmental Monitoring at the Paducah Site, as required by DOE Order 5400.1, consists of two components: (1) effluent monitoring and (2) environmental surveillance monitoring. Effluent monitoring is initiated to demonstrate compliance with one or more federal or state regulations. Radiological liquid effluent monitoring was performed at the four outfalls under the jurisdiction of DOE at the Paducah Site during 2003. Three of the four outfalls retained by DOE contain only rainfall runoff. A fourth outfall is a continuous-flow outfall. The outfalls were monitored for radionuclides historically present at the site. Surface-water runoff from landfills at the Paducah Site was also monitored. Concentrations of the radionuclides measured (uranium and ^{99}Tc) for DOE outfalls were within acceptable limits set by DOE and by state and federal standards. The DOE-operated point sources for radionuclides in airborne effluents during 2003 were the NWPGS, the Scrap Yards Removal Project, and the NSDD Excavation Project.

Introduction

Effluents are monitored for radionuclides known to be emitted or to have been present at the Paducah Site. Monitoring of radioactivity in liquid and airborne effluents is described fully in the *Paducah Site Environmental Monitoring Plan* (BJC 2002). Dose calculations are provided in Section 6.

Airborne Effluents

In accordance with the requirements of DOE Order 5400.1, effluent monitoring is to be conducted to meet *General Environmental Protection Program*, at all DOE sites. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, sets dose standards for members of the public at 10 millirem (mrem) per year from airborne releases and at 100 mrem per year through all exposure pathways resulting from routine DOE operations.

Radiological airborne releases from DOE facilities are also regulated by EPA and KDAQ under 40 C.F.R. 61, Subpart H, which covers radionuclide emissions, other than radon. This regulation was amended in 1989 to include specific sampling requirements for each emission point with the potential to emit radionuclides resulting in an effective dose equivalent of 0.1 mrem to the most affected off-site resident. When determining potential emissions, it is assumed that air pollution-abatement devices do not exist, but that the facility is otherwise operating normally.

Per 40 C.F.R. 61 Subpart H, DOE must report annual radionuclide emissions, covering emissions during the previous CY, by June 30 of each year, to the EPA via a NESHAP report. The EPA-approved methodologies for sampling and calculating must be used to address emissions. The DOE had four sources of airborne radionuclides in 2003. These sources were the NWPGS, the Scrap Yards Removal Project, C-746-A Waste Treatment, and the NSDD Excavation Project.

Northwest Plume Groundwater System

The CERCLA ROD, signed July 22, 1993, established the NWPGS. Although administrative requirements of environmental regulations do not apply to projects conducted under CERCLA, DOE has continued to supply all permit-related documentation to the regulators. The Operations and Maintenance Plan approved by EPA in March 1995 (and since revised), describes sampling and methodologies to be used at the NWPGS. The air emissions methodology is to sample the water stream influent and effluent to the air stripper. The difference in contaminant concentration is used to calculate air emissions. The analysis of the air stripper influent and effluent water provides a more accurate measurement of airborne discharges than actual stack measurements due to the low, practically immeasurable, radionuclide airborne effluents associated with the facility.

On August 28, 1995, DOE began operation of the NWPGS. The facility is located just outside of the northwest corner of the PGDP security area. The facility consists of an air stripper to remove volatile organics from water and an ion-exchange unit for the removal of ^{99}Tc. The air stripper is located upstream of the ion-exchange unit. The ^{99}Tc (radionuclide) concentration in the influent and effluent water of the air stripper and the quantity of the water passing through the air stripper were used to calculate total ^{99}Tc emissions from the facility in 2003. This is used to calculate dose rates associated with these operations.

Scrap Yards Removal Project

During 2003, construction was underway to complete roads and gravel pads, install administrative trailers, and clear vegetation around the area in preparation for the Scrap Metal Removal Project. In addition, some scrap metal was sampled and pallets were relocated to allow for the infrastructure activities. This project includes sorting and characterizing materials contained within the scrap yards. If possible, contamination will be reduced by cleaning. The scrap will then be packaged for shipment to a disposal facility. There are approximately 54,000 tons of scrap materials in the yards. Most of the metal is iron, nickel, or aluminum. The most common contaminant is uranium.

Based on emission factors, the amount of airborne radionuclides was less than EPA standards (Appendix E, Table 2 of 40 C.F.R. 61). Figure 4.1 shows the removal operation.

Figure 4.1 Scrap metal removal project

C-752-A Waste Treatment

During December 2003, 116 drums of PCB-containing acidic low-level liquid waste were treated on-site in the C-752-A enclosure. The treatment unit was comprised of a liquids transfer system, mixing tank and blades, reagent transfer system, and various process control and monitoring instruments. The acidic waste was neutralized to a hydrogen-ion concentration range between 4.0 and 9.0. The neutralized waste was containerized. The neutralized waste is planned for treatment in the TSCA Incinerator in Oak Ridge, Tennessee, in 2004

North-South Diversion Ditch Excavation and Scrap Yards Removal Project

During 2003, construction was underway to build a sedimentation basin in section 2 of NSDD. Contaminated soil from NSDD section 2 contaminated soils were also excavated for disposal. See Chapter 3 for more information. Removal of material from the Scrap Yards is described in Chapter 3.

Airborne Effluent Results

In 2003, releases to the atmosphere from the NWPGS were calculated to be 9.7 x 10^{-5} Curies of ^{99}Tc. The estimated emissions from the Scrap Metal Removal Project were 2.23 x 10^{-5} Curies. The estimated emissions from the waste treatment project were 4.09 x 10^{-11} Curies and 1.04 x 10^{-4} curies for the NSDD project. The calculated emissions were less than state and EPA standards (Appendix E, Table 2 of 40 C.F.R. 61). Dose to the public from airborne radionuclides is discussed in Section 6.

Liquid Effluents

The CWA for the Paducah Site is administered by KDOW through the KPDES Wastewater Discharge Permitting Program. The site-wide KPDES permit (KY0004049) became effective April 1, 1998, and expired March 31, 2003. A renewal permit application has been submitted to KDOW. This permit contains discharge limits based on water quality criteria for a zero-flow receiving stream.

In addition to nonradiological parameters on the KPDES permit, specific radionuclide analyses and indicator-gross-activity analyses are conducted on liquid effluent samples. Grab samples and composite samples at various frequencies are used to measure discharges.

The EPA safe-drinking-water limits for groundwater do not apply to Paducah Site surface water, as effluent ditches, Bayou Creek, and Little Bayou Creek are not drinking water supply sources for public or private use. However, DOE orders 5400.1 and 5400.5 establish effluent monitoring requirements to provide confidence that radiation exposure limits are not exceeded. Although no specific effluent limits for radiological parameters are included on the KPDES permit, DOE Order 5400.5 sets guidelines for allowable concentrations of radionuclides in various effluents and requires radiological monitoring to protect public health. This protection is achieved at the Paducah Site by meeting DOE Order 5400.5-derived concentration guidelines (DCGs), which are the concentrations of given radionuclides that would result in an effective dose equivalent of 100 mrem per year. The DCGs are based on the assumption that a member of the public has continuous, direct access to the liquid effluents. This conservative exposure scenario is very unlikely to exist. Because exposure is not continuous, this results in conservatively low concentrations for the DCGs. Further information on DCGs is provided in Appendix B.

For monitoring purposes, the Paducah Site uses estimates of DCG levels and outfall flow characteristics (rainfall dependent) to determine sampling frequencies. Neither continuous monitoring nor continuous sampling are required by DOE Order 5400.5. Uranium and ^{99}Tc are the primary radionuclides of concern. Analyses are also routinely performed for dissolved alpha, suspended alpha, dissolved beta, and suspended beta concentrations. The KPDES permit requires additional sampling (two events in five years) for priority pollutants at the DOE outfalls. This sampling was conducted in 2000 and 2002.

Other effluent monitoring is required by KDWM landfill permits 073-00014, 073-00015, and 073-00045 for the C-746-S, C-746-T, and C-746-U Landfills, respectively. Surface runoff is analyzed to determine if landfill constituents are being discharged into nearby receiving streams.

DOE Outfalls

The DOE was responsible for a total of four outfalls in 2003 (Figure 4.2 on the opposite page). Under KPDES permit number KY0004049, Outfall 001 is a continuous-flow outfall that received discharges from USEC's Phosphate Reduction Facility, a once-through cooling water system, and DOE's NWPGS. The DOE's NEPCS is treated through the C-637 cooling tower system at PGDP. The cooling tower basin water is then transferred to C-616 through a process known as blowdown. The water is transferred by an underground pipeline to C-616, a water treatment facility, and then ultimately discharges to Outfall 001. In addition, surface-water runoff from the northeast side of the plant is also collected in a sedimentation basin, and then discharged into Outfall 001. Outfall 015 receives surface-water runoff from the east-central sections of the plant. Outfall 017 receives surface-water runoff from the southeast section of the plant (primarily the cylinder storage yards). Outfall 019 receives surface-water runoff from C-746-U (DOE's operational landfill). Data are presented in Section 1, Tables 1.1 through 1.4 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II).

Landfill Surface Runoff

Surface runoff from the closed C-746-S Residential Landfill and the C-746-T Inert Landfill is monitored quarterly. Due to their close proximity, they are monitored as one landfill ("L" locations shown in Figure 4.2). Also, surface runoff is monitored from the Operating C-746-U Contained Landfill. Surface runoff from these landfills is monitored for gross alpha and gross beta concentrations. Grab samples are taken from the landfill runoff, the receiving ditch upstream of the runoff discharge point, and the receiving ditch downstream of the runoff discharge point. Sampling is performed to comply with KDWM permit requirements for landfill operations. Data are presented in Section 1, Tables 1.5 through 1.10 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II).

Liquid Effluent Monitoring Results

Tables 4.1 and 4.2 include the yearly minimum, maximum, and average concentrations of uranium and ^{99}Tc, respectively, at each outfall monitoring location. Each radionuclide is compared with the corresponding DCG and is presented as a percentage. The combined average concentrations at all outfalls were small percentages of the corresponding DCG. The average concentration of uranium being discharged to Outfall 015 was slightly above 7 percent of the DCG. The average concentration of uranium being discharged to Outfalls 001, 017, and 019 was less than 1 percent of the DCG. Outfall 015 received runoff from the uranium burial ground with small quantities of surface contamination from uranium compounds. Runoff from the burial ground is suspected as being responsible for the elevated uranium concentrations associated with Outfall 015. ^{99}Tc averages for 2003 for all four outfalls

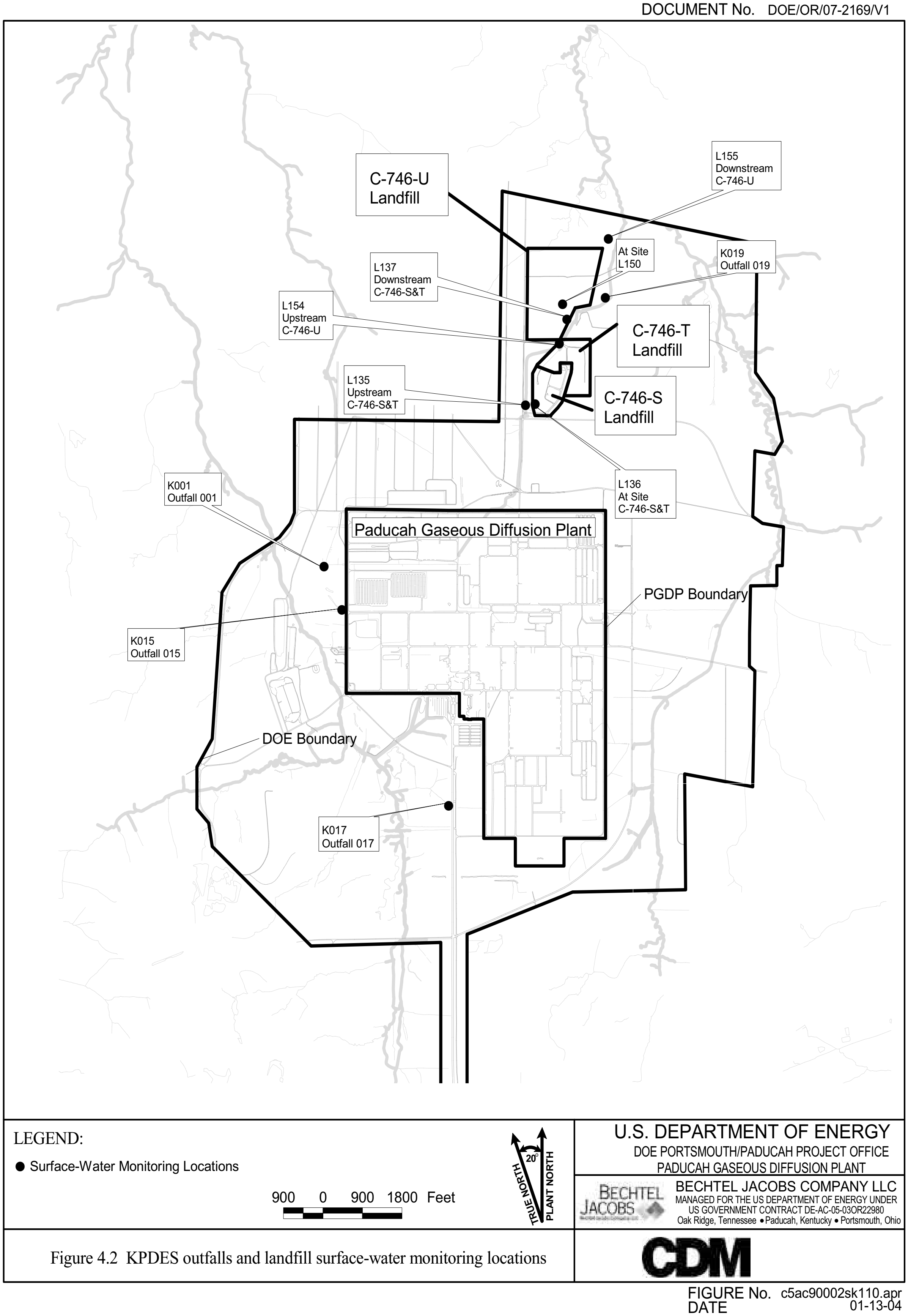


Figure 4.2 KPDES outfalls and landfill surface-water monitoring locations

Table 4.1 Total uranium concentration in DOE outfalls for 2003

Outfall	Number of Samples	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	Average (pCi/L)	% ^{235}U	% of DCG[a]
001	5	0.0014	0.014	0.0046	2.2	0.53[b]	0.36
015	4	0.013	0.19	0.099	44	0.33	7.3
017	4	<0.001	0.005	0.0028	1.7	0.60[b]	0.28
019	4	<0.001	<0.001	<0.001	0.7	0.76[c]	0.12

[a] DCG for uranium is 600 pCi/L.

[b] Insufficient uranium quantities to analyze for assay, assay based on past data.

[c] Insufficient uranium quantities to analyze for assay, natural uranium used as assay.

Table 4.2 Technetium-99 activity in DOE outfalls for 2003

Outfall	Number of Samples	Minimum (pCi/L)[a]	Maximum (pCi/L)[a]	Average (pCi/L)[a]	% of DCG[a]
001	5	1.04	23.4	6.82	0.00682
015	4	12.5	43.6	28.5	0.0285
017	4	-5.05	26.6	6.60	0.00660
019	4	-7.31	1.59	-2.02	-0.00202

[a] DCG for ^{99}Tc is 100,000 pCi/L.

were well below 0.1 percent of the DCG. Data for 2003 do not indicate a significant change in relation to DCG levels for any radionuclide compared to data for the past five years.

Figures 4.3 and 4.4 show the five-year summary of average concentrations of uranium and ^{99}Tc. Uranium concentrations for 2003 appear to be similar to those concentrations seen in 2002 and are lower than those seen in 1999 and 2001. ^{99}Tc activities for Outfalls 001 and 019 are lower than those seen in 2002. However, activity in Outfall 015 was higher and slightly higher in Outfall 017.

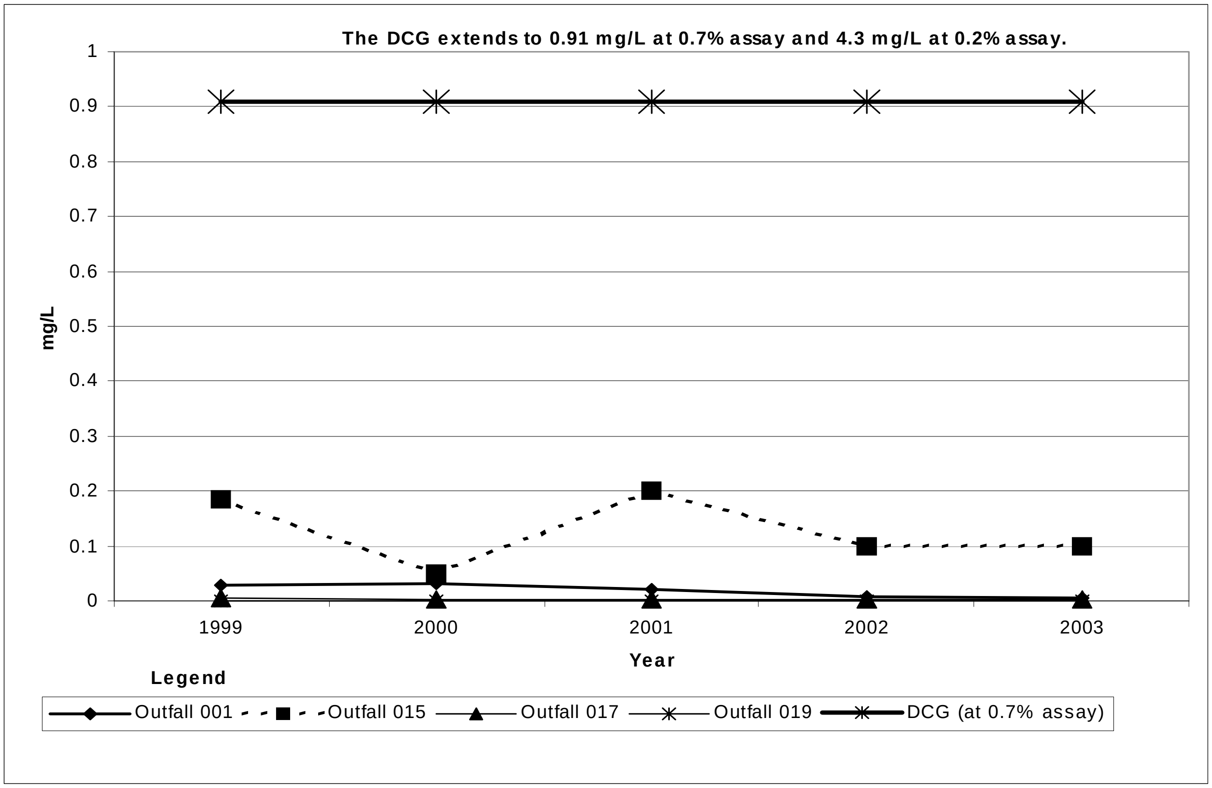


Figure 4.3 Uranium concentrations discharged to surface water, 1999-2003

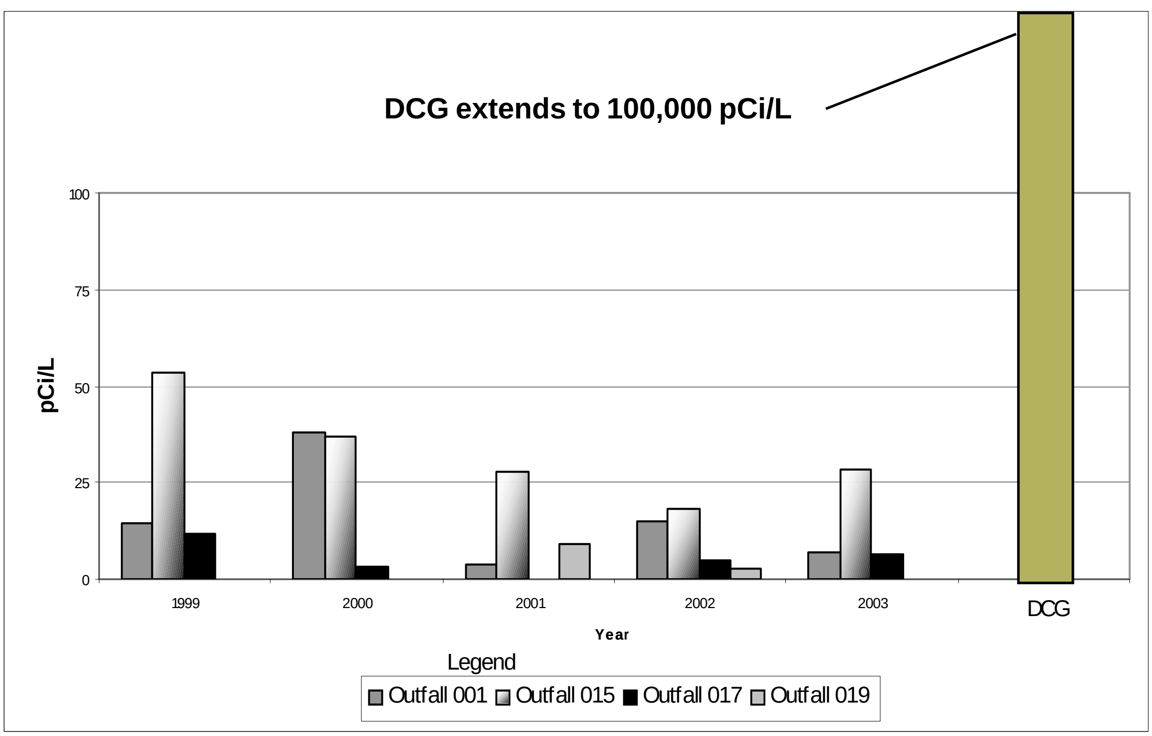


Figure 4.4 Technetium-99 activity discharged to surface water, 1999-2003

5 Radiological Environmental Surveillance

Abstract

The radiological environmental surveillance program assesses the effects of DOE activities on the surrounding population and environment. Surveillance includes analyses of surface water, groundwater, sediment, terrestrial wildlife, direct radiation, and ambient air. Surveillance results from 2003 indicate that radionuclide concentrations, in sampled media, were within applicable DOE standards.

Introduction

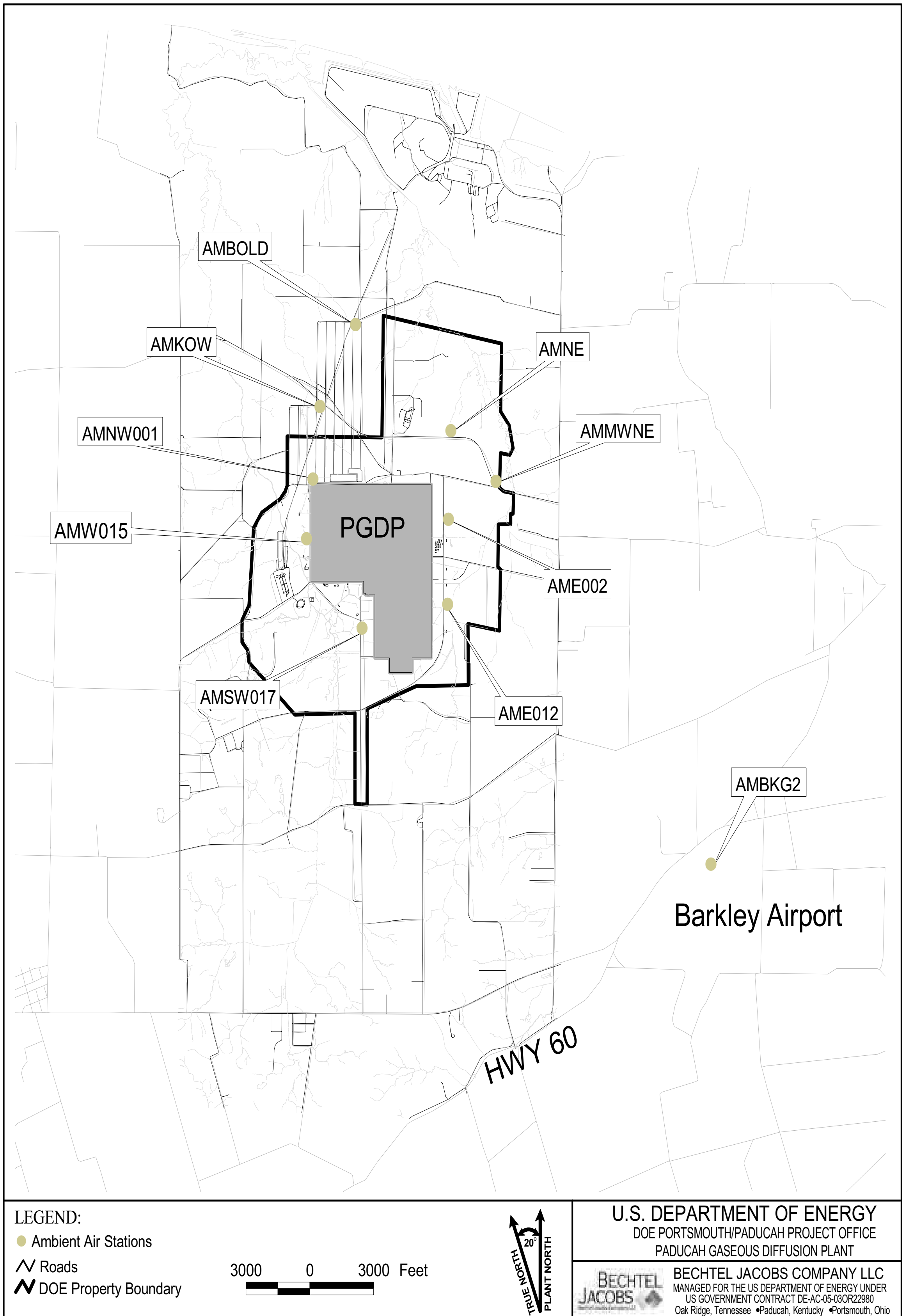
The Radiological Environmental Surveillance Program at the Paducah Site is based on DOE orders 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment.* These orders require that an environmental surveillance program be established at all DOE sites to monitor the radiological effects, if any, of DOE activities on the surrounding population and environment. Surveillance includes analyses of surface water, groundwater (Section 9), sediment, terrestrial wildlife, direct radiation, and ambient air.

Ambient Air

In accordance with the 1993 DOE/USEC agreement, USEC is responsible for the existing radionuclide airborne point-source discharges at PGDP, with the exception of DOE's NWPGS, the Scrap Metal Removal Project, and the NSDD Excavation Project. DOE monitors fugitive emission sources [using Kentucky Cabinet for Health Services (KCHS)-operated air monitors] including building roof tops, piles of contaminated scrap metal, roads, and concrete rubble piles. A potential fugitive or diffuse source of radionuclides could result from the decontamination of machinery and equipment used in remediation activities, such as well drilling. Machinery and equipment are washed with high-power sprayers to remove any contaminants from soil and groundwater. The concentrations of radionuclides on the equipment are so small that, under most circumstances, contamination cannot be distinguished from background.

The DOE utilized ambient-air-monitoring data to verify insignificant levels of radionuclides in off-site ambient air. Ambient air samples are collected at ten sites surrounding the plant (See Figure 5.1) in order to measure radionuclides emitted from Paducah Site sources, including

DOCUMENT No. DOE/OR/07-2169/V1



U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

BECHTEL JACOBS COMPANY LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER
US GOVERNMENT CONTRACT DE-AC-05-03OR22980
Oak Ridge, Tennessee •Paducah, Kentucky •Portsmouth, Ohio

Figure 5.1 Paducah Site ambient air monitoring stations

CDM

FIGURE No. c5ac90002sk124.apr
DATE 01-13-04

fugitive emissions. The Radiation/Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the KCHS conducted the ambient air monitoring during 2003. Based on 2003 results, plant-derived radionuclides were not detected by the Radiation Health and Toxic Agents Branch's air monitoring network. The monitoring results for 2003 are listed in Section 2, Table 2.1 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II). Based on these results, airborne radionuclides emitted from the Paducah Site (including both DOE and USEC emissions) were at or below background as measured by the ambient air monitors (KCHS 2004).

Meteorological Monitoring

DOE Order 5400.1 requires that DOE facilities collect representative meteorological data in support of environmental monitoring activities. This information is essential to characterize atmospheric transport and diffusion conditions in the vicinity of the Paducah Site.

Historic on-site meteorological data are used as input to calculate radiation dose to the public (Section 6). Additional meteorological data from Barkley Regional Airport are used by some groups for inputs into reporting. For example, the Environmental Restoration Program uses these data to correlate precipitation with groundwater flow.

Computer-aided atmospheric-dispersion modeling uses emission and meteorological data to determine the impacts of plant operations to the community. Modeling is used to simulate the transport of air contaminants and predict the effects of abnormal airborne emissions from a given source. In addition, a multitude of emergency scenarios can be developed to estimate the effects of unplanned releases to employees and population centers downwind of the source.

Surface Water

Paducah Site surface-water runoff is released through plant outfalls either in the west to Bayou Creek or to the east into Little Bayou Creek. Bayou Creek and Little Bayou Creek merge north of the site and discharge into the Ohio River. The net impact of the Paducah Site on surface waters can be evaluated by comparing data from samples collected upstream of the site with data from samples collected downstream of the site or from background waterways. Bayou Creek and Little Bayou Creek are considered to be waters of the Commonwealth of Kentucky and designated for all uses by the Commonwealth. However, because these creeks are not used as drinking water supplies, EPA safe-drinking-water standards do not apply. Radioactive effluents are managed in accordance with DOE Order 5400.5.

Table 5.1 shows the radiological analytical parameters analyzed under the quarterly surveillance surface-water sampling program. This table does not include the quarterly seep locations, which are upwellings of groundwater in the Little Bayou Creek bed. Similar to the groundwater sampling program, a shorter list of radiological analytical parameters, alpha activity, beta activity, and ^{99}Tc, are collected.

Figure 5.2 shows surveillance surface-water sampling and seep locations. Radiological sampling is conducted at upstream Bayou Creek (L1); downstream Bayou Creek (L5 and L6), downstream Little Bayou Creek (L11, L12, and L241); the convergence of both creeks (L8), upstream Ohio River (L29), downstream Ohio River (L30); downstream Ohio River at the confluence with the Mississippi River (L306), which is the closest public drinking water supply source downstream of the plant; and background stream Massac Creek (L64). Samples were also collected near the plant from Bayou Creek (C612, C616, K006, K016, and L291), Little Bayou Creek (K002, K011, L10, L55, L56, and L194) and at the C-746-K Landfill (C746K-5, C746KTB1, C746KTB2, and C746KUP). No sample point exists for upstream Little Bayou Creek, as the watershed is insufficient

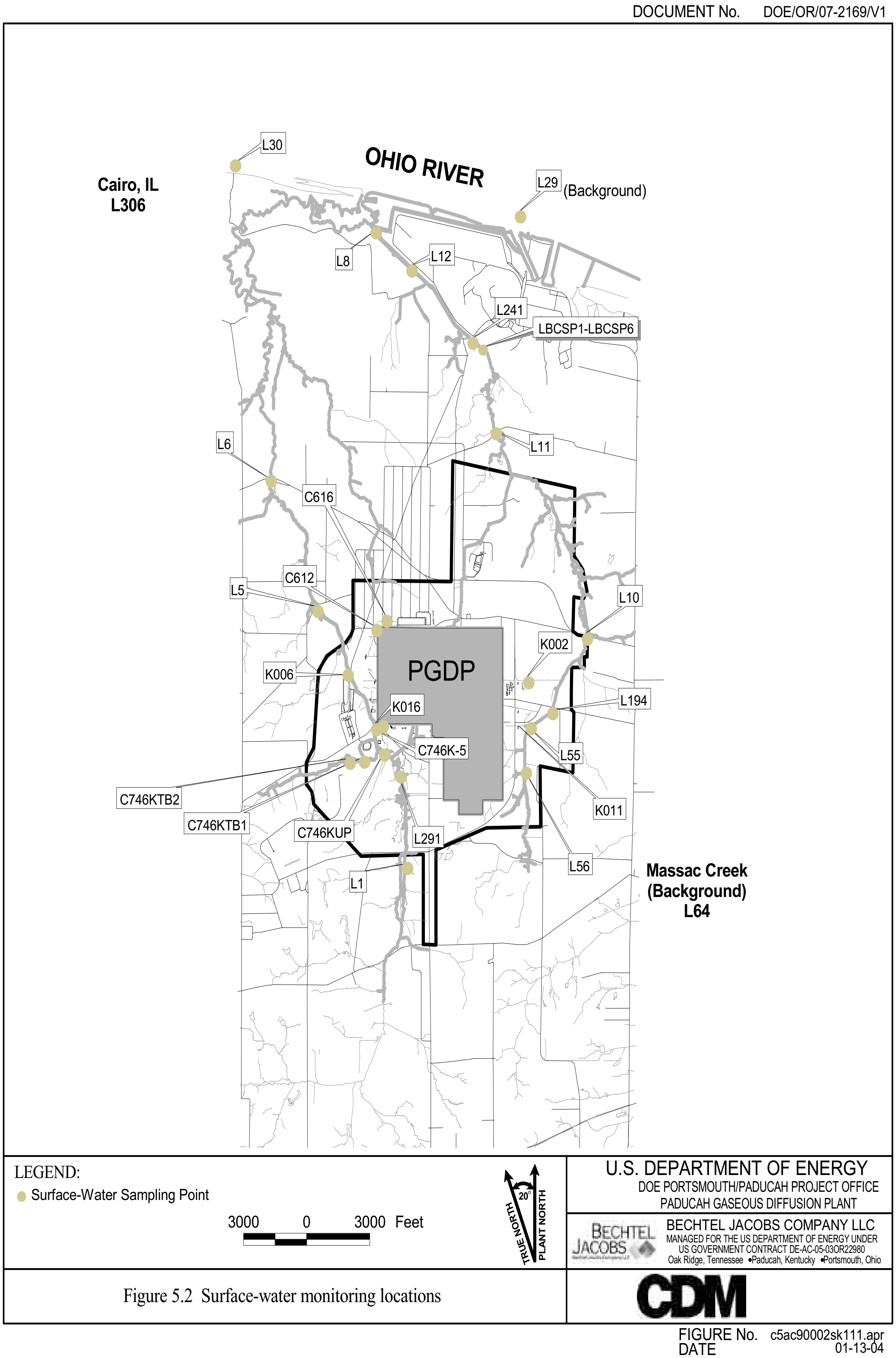


Figure 5.2 Surface-water monitoring locations

Table 5.1 Radiological parameters for surface-water samples

Parameter
Alpha Activity
Americium-241
Beta Activity
Cesium-134
Cesium-137
Cobalt-60
Dissolved Alpha
Dissolved Beta
Neptunium-237
Plutonium-238
Plutonium-239/240
Potassium-40
Suspended Alpha
Suspended Beta
Technetium-99
Thorium-228
Thorium-230
Thorium-232
Thorium-234
Uranium
Uranium-234
Uranium-235
Uranium-238

to develop adequate flow to monitor. Nearly all water in Little Bayou Creek is comprised of discharges from plant outfalls. Therefore, background water quality for Little Bayou Creek is based on L1 (upstream Bayou Creek). Sampling locations L29 and L64 are background waterways which are also used for comparison with data from Little Bayou Creek.

Locations in Little Bayou Creek (LBCSP1 through LBCSP6) were added to the surface-water sampling program in 2002. These locations, known as seeps, are upwellings of groundwater in the Little Bayou Creek bed. Six locations were chosen to sample each quarter to trend and observe changes in data. These seeps are located downstream of the plant site approximately halfway between the site and the Ohio River (Figure 5.2).

Surface-Water Surveillance Results

Table 5.2 provides the average concentrations of radionuclides upstream and downstream of plant effluents in Bayou Creek, downstream of plant effluents in Little Bayou Creek; at the C-746-K Landfill; upstream and downstream in the Ohio River and at the confluence of the Mississippi River (Cairo, Illinois); and at the background stream, Massac Creek. Comparisons of downstream data with upstream data and background waterways can be made to determine the influence of plant effluents on these waterways.

Radiological parameters were not found in significant concentrations at any sampled location in 2003 when compared to the DCGs. Concentrations of ^{99}Tc were elevated in downstream creek locations with the highest concentrations found downstream of plant effluents in Little Bayou Creek (Figure 5.2); however, these concentrations are well below the plant release criteria of 900 pCi/L. The level of radiological parameters seen at the C-746-K Landfill was similar to those found upstream of and near the plant site in Bayou Creek. The highest levels of thorium-234 (^{234}Th) were found upstream in the Ohio River, which is unaffected by plant operations. Based on the average of all analyses that were less than the analytical detection limit, Uranium-234 (^{234}U) was elevated at the L306 location in Cairo, Illinois. Again, concentrations of radionuclides in effluents at the Paducah Site were far below DCGs and do not pose a health risk. Appendix B provides the DCGs.

Table 5.3 provides the average concentrations of radiological parameters at the seep locations. Results indicate that higher levels of ^{99}Tc were seen at LBCSP5 than at other surface-water locations on Little Bayou Creek; however, these concentrations are well below the plant release criteria of 900 pCi/L and below the DCGs. Additional surface-water data are presented in tables 2.2 through 2.32 in Section 2 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II).

Table 5.2 Average radiological parameter concentrations for surface-water surveillance samples[a]

Parameter	DCG[b]	Upstream Bayou[1]	Bayou Near Site[2]	Downstream Bayou[3]	Little Bayou Near Site[4]	Downstream Little Bayou[5]	Creek Convergence[6]	C-746-K Landfill Area[7]	Upstream Ohio River[8]	Downstream Ohio River[9]	Massac Creek[10]	Cairo, IL[11]
Americium-241 (pCi/L)	30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cesium-134 (pCi/L)	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cesium-137 (pCi/L)	3,000	ND	0.27	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt-60 (pCi/L)	10,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Alpha (pCi/L)	--	1.75	1.13	3.51	**4.11**	2.19	-0.33	-0.32	-1.75	0.11	2.04	0.44
Dissolved Beta (pCi/L)	--	ND	12.25	10.44	7.63	**16.01**	ND	8.49	ND	ND	ND	ND
Neptunium-237 (pCi/L)	30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Plutonium-238 (pCi/L)	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Plutonium-239/240 (pCi/L)	30	ND	ND	ND	**0.01**	ND	ND	**0.01**	ND	ND	ND	ND
Potassium-40 (pCi/L)	7,000	40.18	-21.73	ND	-34.58	9.99	**91.53**	12.96	ND	ND	ND	ND
Suspended Alpha (pCi/L)	--	1.60	0.41	ND	**2.10**	1.48	ND	ND	ND	ND	ND	ND
Suspended Beta (pCi/L)	--	ND	2.02	**4.71**	ND	ND	ND	3.79	ND	ND	ND	ND
Technetium-99 (pCi/L)	100,000	7.17	9.12	11.02	10.24	**24.53**	ND	ND	ND	ND	ND	ND
Thorium-228 (pCi/L)	--	0.01	0.01	0.00	0.02	**0.07**	0.00	0.02	-0.04	0.01	0.00	-0.01
Thorium-230 (pCi/L)	300	ND	0.11	ND	0.11	**0.18**	ND	0.01	ND	ND	ND	ND
Thorium-232 (pCi/L)	--	ND	ND	ND	ND	**0.06**	ND	ND	ND	ND	ND	ND
Thorium-234 (pCi/L)	10,000	ND	52.51	ND	ND	ND	ND	ND	**134.48**	95.13	ND	ND
Uranium (pCi/L)	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Uranium-234 (pCi/L)	500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Uranium-235 (pCi/L)	600	ND	ND	ND	**4.61**	ND	ND	3.54	ND	ND	ND	ND
Uranium-235 (wt %)	--	c	c	0.47	0.26	0.30	c	**1.93**	c	c	c	c
Uranium-238 (pCi/L)	600	ND	0.51	2.02	2.79	1.13	0.78	**15.12**	ND	ND	ND	ND

a = Average concentration for the seep locations (LBCSP1 – LBCSP6) are found in Table 5.3.
b = DCG
c = Quantities of total uranium were found to be quite small or not detected; individual isotopes of uranium were not analyzed.
-- = DCGs for these radionuclides not provided.
ND=Not Detected
Bold values indicate the highest radionuclide concentrations for the parameter specified.

The following footnotes correspond with column titles in the above table. These are groupings of sample locations in the area described in the title.

1 = L1
2 = C612, C616, K006, L291
3 = L5, L6
4 = K002, K011, L10, L55, L56, L194
5 = L11, L12, L241
6 = L8
7 = C746K-5, C746KTB1, C746KTB2, C746KUP
8 = L29
9 = L30
10 = L64
11 = L306

Table 5.3 Average radiological concentrations for seep locations in Little Bayou Creek

Parameter	LBCSP1	LBCSP2	LBCSP3	LBCSP4	LBCSP5	LBCSP6
Alpha activity (pCi/L)	1.6	2.2	2	2.4	2.2	**3.1**
Beta activity (pCi/L)	7.9	15	25	23	**150**	150
Technetium-99 (pCi/L)	10	15	28	23	**180**	160

Bold values indicate the highest radionuclide concentrations for the parameter specified.

Sediment

Sediment is an important constituent of the aquatic environment. If a pollutant is a suspended solid or attached to suspended sediment, it can either settle to the bottom (thus creating the need for sediment sampling), be taken up by certain organisms, or become attached to plant surfaces. Pollutants transported by water can adsorb on suspended organic and inorganic solids or be assimilated by plants and animals. Suspended solids, dead biota, and excreta settle to the bottom and become part of the organic substrata that support the bottom-dwelling community of organisms. Sediments play a significant role in aquatic ecology by serving as a repository for radioactive or chemical substances that pass via bottom-feeding biota to the higher trophic levels.

Sediment Surveillance Program

As a result of DOE's retaining responsibility for historic environmental issues and problems, ditch sediments are sampled semiannually through a radiological environmental surveillance program. Table 5.4 shows the radiological analytical parameters. Sediment samples were taken from 16 locations (Figure 5.3).

Sediment Surveillance Results

Table 5.5 shows the upstream concentrations of radionuclides in the sediments compared with concentrations downstream of all DOE outfalls for 2003. Locations S27, S33, and S34 are downstream of plant effluents. Locations S20, S21, and S28 are considered reference, or background sites, and can be compared with downstream data. S20 and S21, located at Bayou Creek and Little Bayou Creek, respectively, are upstream of plant discharges, whereas S28 is located in a similar, off-site stream (Massac Creek) providing a regional reference site. S30, S1, S2, S31, S32, K001, C616, and C612 are located near the plant site and are below certain discharges of the plant, but not below all discharges (Figure 5.3).

In general, the location with the highest readings for most radionuclides is the NSDD (Table 5.5). Remediation activities are in progress. Access to this area is limited.

Uranium activity is elevated in Little Bayou Creek and Bayou Creek near the plant site and downstream. The levels are similar to those seen in 2001 and 2002. ^{99}Tc levels are elevated on Bayou Creek near the plant site, and also downstream on Little Bayou Creek. The downstream location on Little Bayou Creek (S34) corresponds with the seep sites mentioned previously.

Figure 5.4 shows uranium concentrations in sediment over the past five years. A small increase was seen in Bayou Creek at the plant site and Little Bayou Creek downstream of the plant, with a large increase in Little Bayou Creek near the plant site. New locations were added in 2001; therefore, no data are shown in Figure 5.4 for the new locations for years 1999 and 2000. New locations sampled near the plant site on both Bayou Creek and Little Bayou Creek indicate higher uranium amounts.

Figure 5.5 shows a decrease in ^{99}Tc activity in sediment in 2003 as compared to previous years. These locations correspond with locations downstream of the seep locations as previously noted. New locations are also shown as previously noted, therefore no data are shown in Figure 5.5 for the new locations for years 1999 and 2000. Other radionuclides, although present, are not significantly above background values. Additional sediment data are presented in tables 2.33 through 2.48 in Section 2 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II).

Table 5.4 Radiological parameters for sediment samples

Parameter
Alpha activity
Americium-241
Beta activity
Cesium-137
Cobalt-60
Neptunium-237
Plutonium-239/240
Potassium-40
Technetium-99
Thorium-230
Uranium-234
Uranium-235
Uranium-238

Table 5.5 Average[a] radiological parameter concentrations for sediment surveillance samples

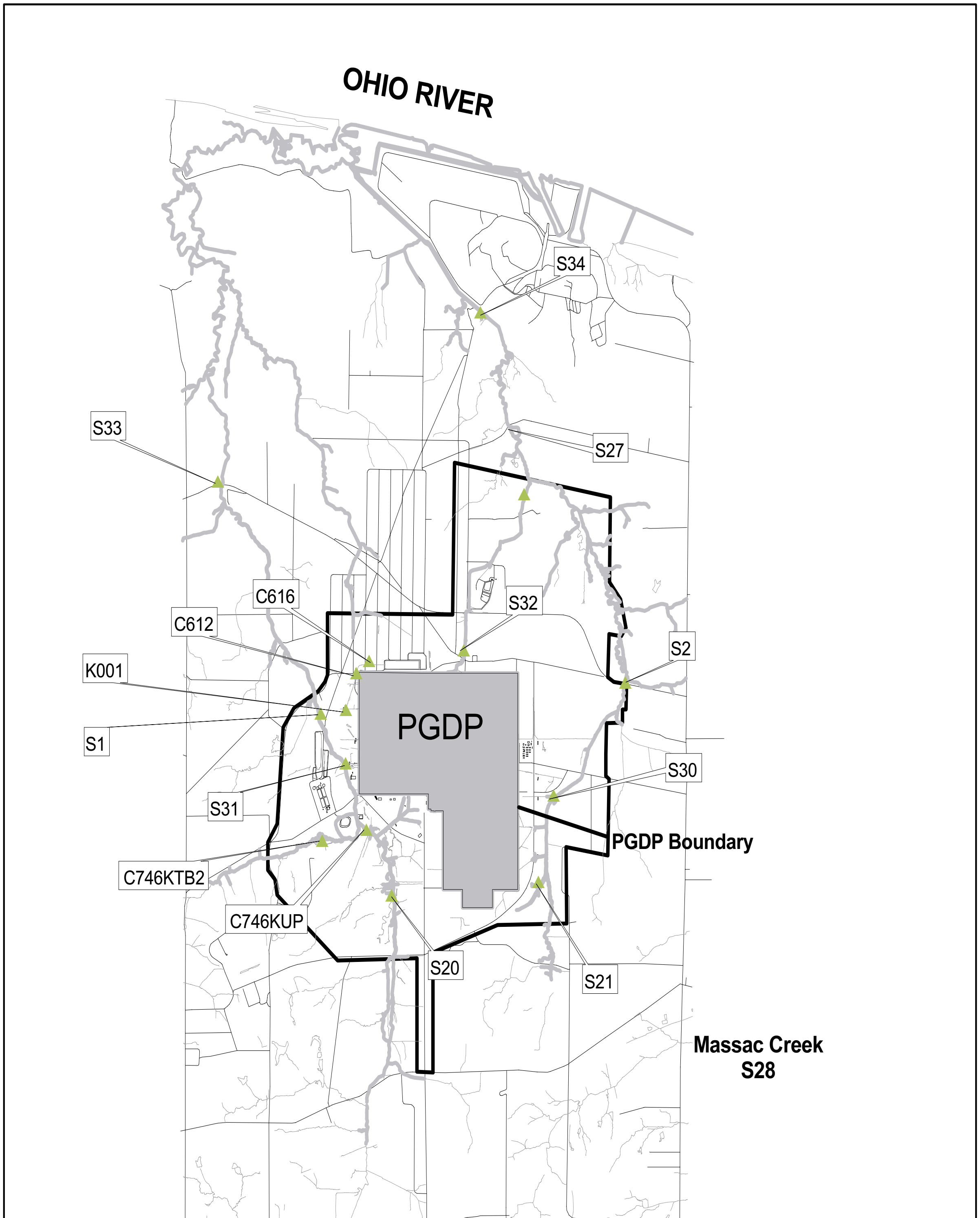
Parameter	Upstream Bayou[1]	Bayou Near Site[2]	Downstream Bayou[3]	Upstream Little Bayou[4]	Little Bayou Near Site[5]	Downstream Little Bayou[6]	C-746-K Area[7]	NSDD[8]	Massac Creek[9]
Alpha activity (pCi/g)	2	9.6	2.8	2.7	9.4	8.2	1.5	54	1.8
Americium-241 (pCi/g)	ND	ND	ND	ND	ND	ND	ND	0.48	ND
Beta activity (pCi/g)	1.5	24	3.1	2.9	20	9.8	0.98	66	1
Cesium-137 (pCi/g)	0.027	0.068	0.029	0.045	0.024	0.02	0.018	0.51	ND
Cobalt-60 (pCi/g)	ND	ND	ND	ND	ND	ND	ND	0.026	ND
Neptunium-237 (pCi/g)	ND	0.064	ND	ND	ND	ND	ND	0.57	ND
Plutonium-239/240 (pCi/g)	ND	0.056	0.0094	ND	ND	0.09	ND	1.8	ND
Potassium-40 (pCi/g)	2.7	4.9	3.2	5.7	2.6	2.4	1.9	6.5	2
Technetium-99 (pCi/g)	ND	5.7	0.26	ND	0.23	1.3	0.14	23	ND
Thorium-230 (pCi/g)	0.18	0.47	0.22	0.29	0.22	1.4	0.11	38	0.13
Uranium-234 (pCi/g)	b	2.4	0.41	b	0.76	0.67	b	2.3	b
Uranium-235 (pCi/g)	b	0.13	0.022	b	0.14	0.054	b	0.13	b
Uranium-235 (wt %)	b	0.61	0.57	b	0.18	0.29	b	0.54	b
Uranium-238 (pCi/g)	b	3.2	0.61	b	12	2.9	b	3.6	b

NSDD = North-South Diversion Ditch
ND = Not Detected
a = The average within each group of locations.
b = Quantities of total uranium were found to be quite small or not detected; individual isotopes of uranium were not analyzed.
Bold values indicate the highest radionuclide concentrations for the parameter specified.

The following footnotes correspond with column titles in the above table. These are groupings of sample locations in the area described in the title.

1 = S20
2 = C612, C616, K001, S1, S31
3 = S33
4 = S21
5 = S2, S30
6 = S27, S34
7 = C746KTB2, C746KUP
8 = S32
9 = S28

DOCUMENT No. DOE/OR/07-2169/V1



LEGEND:
▲ Sediment Sampling Point

2000 0 2000 4000 Feet

TRUE NORTH 20° PLANT NORTH

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

BECHTEL JACOBS COMPANY LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER
US GOVERNMENT CONTRACT DE-AC-05-03OR22980
Oak Ridge, Tennessee •Paducah, Kentucky •Portsmouth, Ohio

Figure 5.3 Sediment monitoring locations

CDM

FIGURE No. c5ac90002sk112apr
DATE 0-13-04

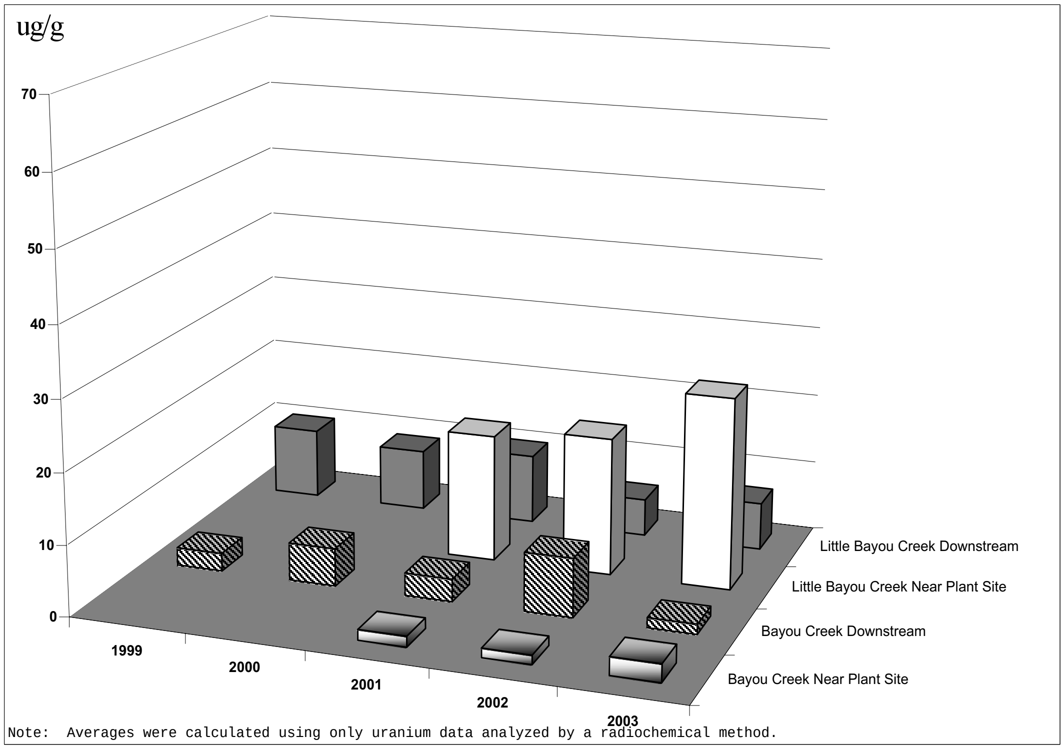


Figure 5.4 Five-year uranium concentration in sediment

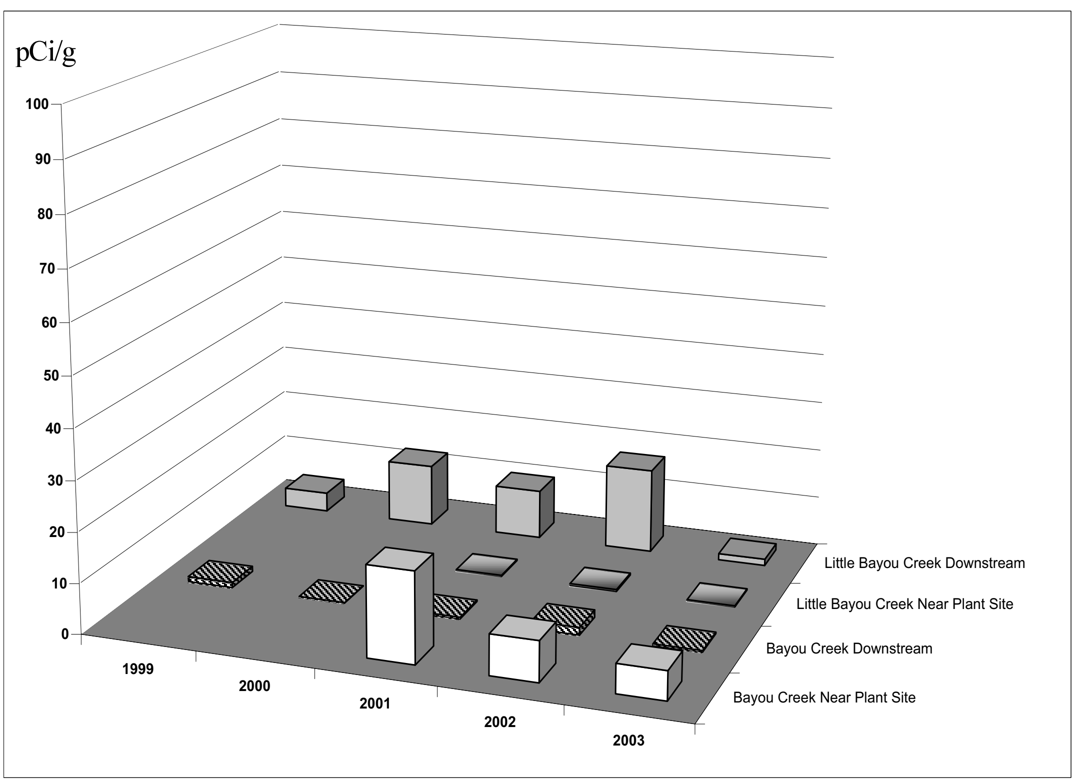


Figure 5.5 Five-year ^{99}Tc activity in sediment

Terrestrial Wildlife

Annual Deer Harvest

In 2003, a total of five deer were harvested in the WKWMA as part of DOE's ongoing effort to monitor the effects of the Paducah Site on the ecology of the surrounding area. No reference deer were collected in 2003; therefore, 2002 data were used for comparison. Liver, muscle, and bone samples were analyzed for several radionuclides [Cesium-137 (^{137}Cs), ^{237}Np, ^{239}Pu, ^{99}Tc, Thorium-230 (^{230}Th), ^{234}U, Uranium-235 (^{235}U), Uranium-238 (^{238}U), and Strontium-90 [^{90}Sr] (bone samples only)]. In addition, thyroid samples were analyzed for ^{99}Tc. Because the liver and muscle tissue are considered consumable by humans, these tissues can be evaluated for radiological risks (dose) if analyses reveal detectable levels above background, or levels found in reference deer. Bone and thyroid samples are used only as indicators of contamination.

Table 5.6 lists the radionuclides detected in deer tissue for 2003. In deer muscle, which is normally considered to be consumable by humans, concentrations of ^{230}Th were detected at low levels in WKWMA deer. In deer bone, ^{230}Th was found at or above detectable levels in WKWMA deer. In deer liver, ^{99}Tc, ^{230}Th, and ^{235}U were detected in WKWMA deer. No ^{99}Tc, ^{230}Th, and ^{235}U were detected in background deer. Dose assessments indicate that deer are acceptable for consumption and levels are consistent with previous years' data.

The thyroid and bone are not considered edible portions of deer, but rather as an indicator of the presence of target radionuclides. Specifically, ^{90}Sr accumulates in the bone and ^{99}Tc accumulates to some lesser degree in the thyroid. In 2003, all results were less than the analytical detection limit for ^{90}Sr in the bone and ^{99}Tc in the thyroid for both WKWMA deer and in 2002 for background deer from Stewart Island.

Additional deer data are presented in Tables 2.50 through 2.53 in Section 2 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II). Section 6 discusses dose calculations associated with eating deer from the WKWMA.

Table 5.6 Radiological parameters detected in deer tissue

Parameter[a] (pCi/L)	Deer 1	Deer 2	Deer 3	Deer 4	Deer 5	Deer (Background)[b]
Technetium-99 (Liver)	ND	ND	ND	0.314	ND	ND
Thorium-230 (Bone)	ND	0.195	0.0618	0.144	0.128	ND
Thorium-230 (Liver)	ND	0.149	0.153	0.107	ND	ND
Thorium-230 (Muscle)	0.088	0.140	0.158	ND	0.118	ND
Uranium-235 (Liver)	ND	ND	ND	0.0177	ND	ND

ND - Non Detect

[a] Other radionuclides were analyzed but not detected in any deer.

[b] Background deer were collected during 2002 from Stewart Island Habitat Restoration in Livingston County, Kentucky.

Direct Radiation

A primary concern of DOE's operations at the Paducah Site is direct external radiation exposure. External radiation exposure is defined as exposure attributed to radioactive sources outside the body (e.g., cosmic gamma radiation). Sources of external radiation exposure at the Paducah Site include the cylinder storage yards, the cascade system, and small sources such as instrument check locations. Cylinder storage yards have the largest potential for a dose to the public because of their proximity to the PGDP security fence.

The *Paducah Site Environmental Monitoring Plan* (BJC 2002) establishes DOE's program for monitoring external gamma radiation at areas accessible to members of the public. The External Radiation Exposure Monitoring Program has the following three objectives:

1) To establish the potential radiation dose received by a member of the public from direct exposure to DOE operations at the boundary of the DOE perimeter fence,

2) To establish the potential dose a member of the public may receive while visiting or passing through accessible portions of the DOE reservation, and

3) To calculate the radiation dose equivalent to the maximally exposed individual member of the public.

In 2003, monitoring consisted of quarterly placement, collection, and analysis of environmental thermoluminescent dosimeters (TLDs). These monitoring locations are shown in Figure 5.6. Monitoring results indicate that 10 of 46 locations were consistently above background levels (BJC 2004b). These locations were all at or near the PGDP security fence in the vicinity of UF_6 cylinder storage yards (Figure 5.6).

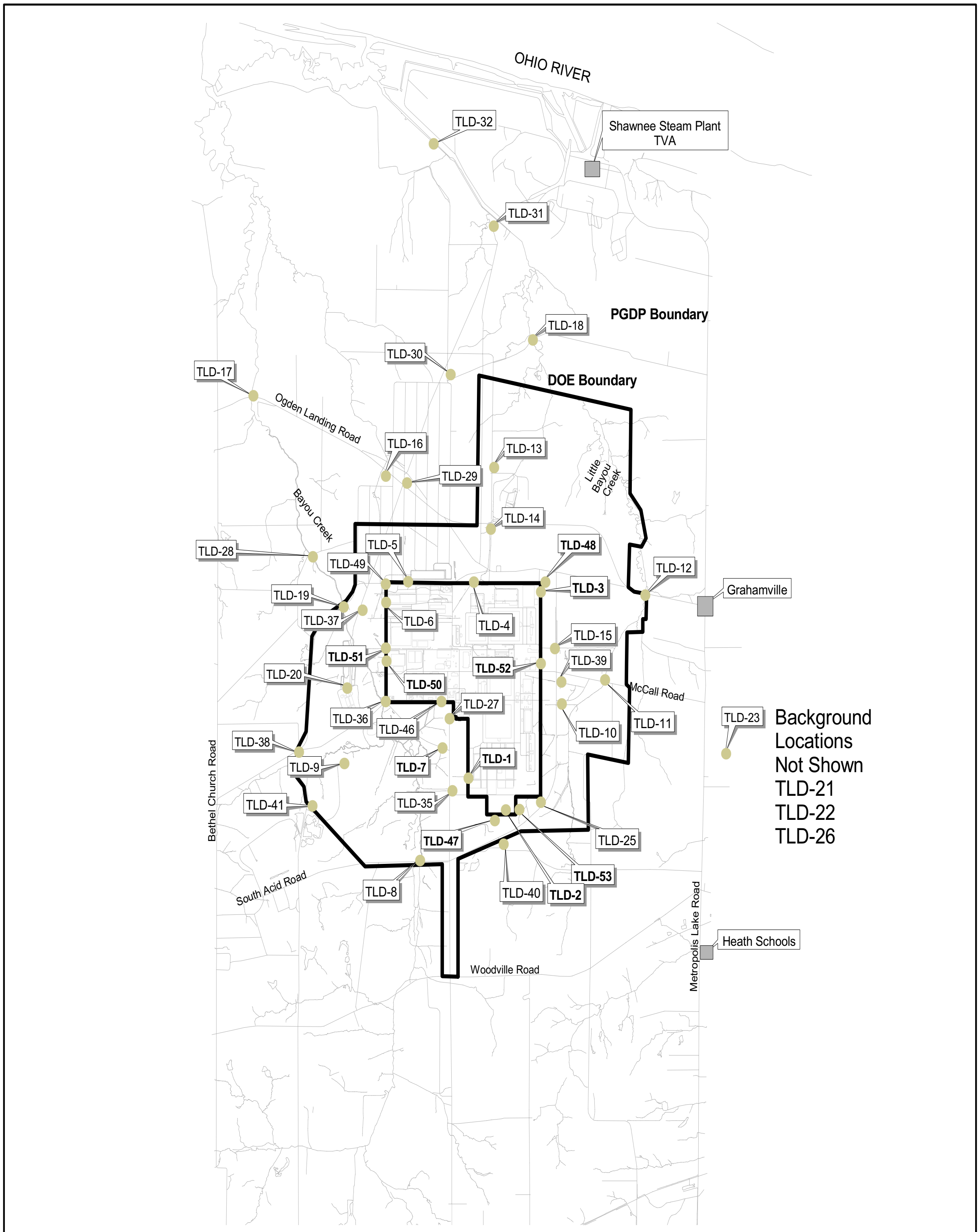
Annual dose rates for the background locations and the 10 locations above background were calculated. The mean annual background exposure was determined to be 98 milliRoentgen (mR), based on the analysis of TLDs placed away from DOE property. See the *Annual Report on External Gamma Radiation Monitoring for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (BJC/PAD-623). For each location, the mean background exposure was subtracted from the annualized total exposure to obtain a net annual exposure. The net annual exposure represents the total exposure at that location, for the entire CY 2003 attributed to the Paducah Site (Table 5.7). Exposure measured at these locations is assumed to result from DOE operations. Dose from direct radiation exposure to the maximally exposed individual member of the public from DOE operations is zero. Detailed information is discussed further in Section 6. Additional data are presented in Section 2, table 2.49 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II). Section 6 discusses dose calculations associated with direct radiation exposure.

Table 5.7 Net annual exposure from direct radiation attributed to the Paducah Site for 2003 (mR)

Location	TLD-1	TLD-2	TLD-3	TLD-7	TLD-47	TLD-48	TLD-50	TLD-51	TLD-52	TLD-53
total annual exposure	521	662	424	105	247	156	142	103	149	231
background[a]	98	98	98	98	98	98	98	98	98	98
net annual exposure	423	564	326	7	149	58	44	5	51	133

a based on the analysis of TLDs placed away from DOE property. See the *Annual Report on External Gamma Radiation Monitoring for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (BJC/PAD-623).

DOCUMENT No. DOE/OR/07-2169/V1



LEGEND:

● TLD Locations

2000 0 2000 Feet

TRUE NORTH 20° PLANT NORTH

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

BECHTEL JACOBS COMPANY LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER
US GOVERNMENT CONTRACT DE-AC-05-03OR22980
Oak Ridge, Tennessee •Paducah, Kentucky •Portsmouth, Ohio

Figure 5.6 TLD locations in the vicinity of PGDP

CDM

FIGURE No. c5ac90002sk113.apr
DATE 01-13-04

6 Dose

Abstract

For 2003, exposure pathways potentially contributing to dose were determined to include ingestion of surface water, ingestion of sediments, ingestion of deer meat, direct radiation, and atmospheric releases. The highest estimated dose a maximally exposed individual might have received from all combined DOE exposure pathways (worst-case scenario) was 1.52 mrem. This dose is less than 5 percent of the applicable federal standard of 100 mrem peryear.

Introduction

This section presents the calculated doses to individuals and the surrounding population from atmospheric and liquid releases from the Paducah Site, as well as direct radiation (sections 4 and 5). In addition, potential doses from special-case exposure scenarios, such as deer meat consumption, were calculated based upon deer sample analyses. Doses from naturally occurring sources are discussed in Appendix A.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, limits the dose to members of the public to less than 100 mrem per year total effective dose equivalent from all pathways resulting from operation of a DOE facility. Information on the demography and land use of the area surrounding the plant and identification of on-site sources have indicated radionuclides and exposure pathways of concern.

For the Phase I Remedial Action Site Investigation, a preliminary assessment of risk to the health of the public from contaminants at the Paducah Site was conducted. This study identified the following four primary pathways that each could contribute greater than 1 percent to the total off-site dose: (1) groundwater ingestion, (2) sediment ingestion, (3) wildlife ingestion, and (4) exposure to direct radiation. Since that preliminary assessment, groundwater wells that supplied drinking water in the downgradient direction from PGDP have been replaced with public drinking water, resulting in the loss of that pathway. Surface water is now considered to be the primary pathway for water ingestion. In addition, the NWPGS began operation in 1995, resulting in an airborne pathway that is now included in the dose calculations. In 2002, the Scrap Metal Removal Project also added to the airborne dose. Furthermore, in 1999, a drinking water pathway was added for consumption of surface water at the nearest public drinking water source (Ohio River at Cairo, Illinois).

To fully assess the potential dose to the public, a hypothetical group of extreme characteristics was used to postulate an upper limit to the dose of any real group. This is referred to as the worst-case scenario. The actual dose received is likely to be considerably less than the dose calculated.

Terminology and Internal Dose Factors

Most consequences associated with radionuclides released to the environment are caused by interactions between human tissue and various types of radiation emitted by the radionuclides. These interactions involve the transfer of energy from radiation to tissue, possibly resulting in tissue damage. Radiation may come from radionuclides outside the body or from radionuclides deposited inside the body (by inhalation, ingestion, and, in a few cases, absorption through the skin). Exposures to radiation from radionuclides outside the body are called external exposures; exposures to radiation from radionuclides inside the body are called internal exposures. This distinction is important because external exposure occurs only as long as a person is near the external radionuclide; simply leaving the area of the source will stop the exposure. Internal exposure continues as long as the radionuclide remains inside the body.

A number of specialized terms or quantities have been defined for characterizing exposures to radiation as defined in Appendix A. Because the damage associated with such exposures results primarily from the deposition of radiant energy in tissue, the units are defined in terms of the amount of incident-radiant energy absorbed by tissue and of the biological consequences of that absorbed energy. These terms or quantities include the following:

- *Committed effective dose equivalent (CEDE)* — the total internal dose (measured in mrem) received over a 50-year period resulting from the intake of radionuclides in a one-year period. The CEDE is the product of the annual intake (pCi) and the dose conversion factor for each radionuclide (mrem/pCi).

- *Effective dose equivalent* — includes the CEDE 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.

- *Total effective dose equivalent* — includes the sum of the effective dose equivalent (for external exposures) and the CEDE (for internal exposures). For purposes of compliance, dose equivalent to the whole body may be used as the effective dose equivalent for external exposures.

Internal dose factors for several radionuclides of interest at the Paducah Site are included in Appendix A.

Direct Radiation

In 2003, DOE conducted continuous monitoring for direct external radiation exposure (Section 5). Access to PGDP is limited due to the increased security boundary implemented in September 2001. The monitoring results indicate that, due to limited access of the public to radioactive source areas, the dose to the maximally exposed individual member of the public (i.e., the neighbor living closest to the PGDP security fence) from DOE operations did not vary statistically from background (i.e., essentially zero) (BJC 2004b).

For purposes of this ASER, an additional potential receptor was considered. In a conservative exposure scenario, this receptor is assumed to be exposed to the location at TLD-14 for 8.3 hours for the year. The 8.3 hours-per-year assumption is based on an individual driving past this location twice per day at 1 minute per trip, five days per week, 50 weeks per year. It is likely that actual exposure at this location is probably much less than assumed since any shielding from the receptor's vehicle is not considered. The closest location that would be accessible to the public in 2003 was TLD-14, which is near Harmony Cemetery located north of the plant security fence and south of Ogden Landing Road (Figure 5.6). This location resulted in external radiation exposures below background. Based on results from this location and other data obtained from all locations, the dose to the maximally exposed individual member of the public from DOE operations was zero.

Surface Water

The most common surface-water pathway for exposure is through drinking water containing radionuclides. Surface-water pathway dose was calculated for an individual assumed to consume water from the public drinking water supply at Cairo, Illinois. Cairo is the closest drinking water system (approximately 30 miles downstream) that uses water downstream of PGDP effluents. Typically, the average concentrations of radionuclides that were detected in Cairo are used to calculate the exposure resulting from consumption of surface water. In 2003, there were no radionuclides detected at the Cairo location. Therefore, the resulting net exposure to the maximally exposed receptor from the Paducah Site is 0.00 mrem.

Contaminated Sediment

Exposure to contaminated sediment in Bayou Creek and Little Bayou Creek could occur during fishing, hunting, or other recreational activities. Exposure is possible through incidental ingestion of contaminated sediment. The worst-case ingestion assumption is that an individual would splash around in one of the creeks every other day during the hunting season and ingest a small amount of sediment each visit (50 mg/day). A dose is then calculated based on the radionuclide concentrations and amount of exposure via ingestion. Massac Creek samples are assumed to be background and are subtracted from downstream-sample results to arrive at a dose associated with site releases. The downstream location with the maximum dose is assumed to represent the dose received from this pathway by the maximally exposed individual.

Doses are calculated for ingestion of sediments for both Bayou Creek and Little Bayou Creek. The worst-case dose was calculated to be at S32, the NSDD (Figure 5.3). The estimated worst-case dose above background from sediment ingestion was 0.018 mrem in 2003. Sediment sample locations are shown in Figure 5.4 in Section 5, page 10. Dose results are provided at the end of this section in Table 6.1.

Ingestion of Deer

The effect of an intake of a radionuclide by ingestion depends on the concentration of the radionuclide in food and drinking water and on the individual's consumption patterns. The estimated intake of a radionuclide is multiplied by the appropriate ingestion dose factor to provide the estimate of CEDE resulting from the intake.

Terrestrial wildlife, such as deer, can come into contact with contaminated soil, ingest plants that have taken up contaminants, or ingest contaminated water. Hunting is permitted in the WKWMA surrounding the Paducah Site, and the limit for deer harvest is two deer per person per season. Approximately 100 deer are harvested per year from WKWMA. The Paducah Site dose calculations assume that an individual kills two average-weight deer and consumes the edible portions of those deer during the year (approximately 100 pounds of meat and five pounds of liver). The dose is calculated for each deer sampled.

In 2003, five deer from the Paducah Site were sampled. No reference deer was collected in 2003; therefore, 2002 data were used for comparison. As a worst-case scenario for site dose contribution, it is assumed that a person kills and eats the two deer with the two highest dose estimates. The worst-case dose was calculated to be 1.5 mrem above background (Hampshire 2003). This value is used in the worst-case scenario calculations. This is less than the 4.2 mrem calculated in 2002.

Airborne Radionuclides

DOE's radionuclide airborne point-sources that contributed to the public dose in 2003 included four sources. These sources were the NWPGS, the Scrap Metal Removal Project, the NSDD excavation, and the C-752-A waste treatment activities. The four point-sources are discussed in Section 4. These point-sources were reviewed or monitored to determine the extent to which the general public could be exposed and to demonstrate compliance with EPA regulations that are based on International Commission on Radiological Protection (ICRP) publications (ICRP 1980).

The 50-year CEDE (internal) from DOE air sources to the maximally exposed individual, who under most circumstances is the person living closest to the plant in the predominant wind direction, is calculated each year. Environmental Protection Agency-supplied CAP-88 software was used to calculate the off-site dose from PGDP air emissions. CAP-88 provides a framework for developing dose and risk assessments for the purpose of demonstrating compliance with 40 C.F.R. 61.93(a). CAP-88 assesses both collective populations and maximally exposed individuals. The dose to the maximally exposed individual from DOE radioactive air emissions were calculated to be 1.8 x 10^{-5} mrem from the NWPGS; 1.6 x10^{-4} mrem from the C-746-P Scrap Metal Removal Project; 7.0 x 10^{-9} mrem from the C-746-D Scrap Metal Project; 6.0 x 10^{-4} mrem from the NSDD Excavation Project; and 7.0 x 10^{-10} mrem from the C-752-A waste treatment activities. If an individual was to receive the maximum dose from each of these sources, it would add up to approximately 0.000778 mrem, which is well below the 10 mrem limit of 40 C.F.R. Part 61, Subpart H.

Conclusions

Table 6.2 provides a summary of the dose for 2003 from the Paducah Site that could be received by a member of the public assuming worst-case exposure from all major pathways. The largest contributor to the calculated dose is from ingestion of deer meat. The groundwater pathway from DOE sources is assumed to contribute no dose to the population because all residents have been supplied with public water by DOE. The worst-case combined (internal and external) dose to an individual member of the public was calculated at 1.52 mrem. This level is well below the DOE annual dose limit of 100 mrem/year to members of the public and below the EPA limit of 10 mrem airborne dose to the public.

Estimates of radiation doses presented in this report were calculated using the dose factors provided by DOE and EPA guidance documents. These dose factors are based on ICRP Publication 30 (ICRP 1980). Figure 6.1 shows the potential (worst-case) annual dose as calculated for the past five years.

Table 6.1 Annual dose estimates for 2003 incidental ingestion of sediment from Bayou Creek and Little Bayou Creek

Location	Committed Effective Dose Equivalent (mrem)										Total (mrem)
	^{137}Cs	^{60}Co	^{237}Np	$^{239/240}$Pu	^{40}K	^{99}Tc	^{230}Th	^{234}U	^{235}U	^{238}U	
S1	5.0e-5	---	---	2.3e-3	2.4e-4	6.7e-6	1.3e-3	---	---	---	3.9e-3
S2	3.4e-6	---	---	---	2.4e-4	1.8e-6	5.1e-4	5.0e-4	7.8e-5	6.0e-3	7.3e-3
S20	7.2e-6	---	---	---	2.7e-4	---	5.1e-4	---	---	---	7.9e-4
S21	1.2e-5	---	---	---	5.7e-4	---	8.1e-4	---	---	---	1.4e-3
S27	5.0e-6	---	---	3.0e-3	1.4e-4	9.6e-6	4.8e-3	8.1e-4	6.8e-5	3.4e-3	1.2e-2
S28 (Background)	---	---	---	---	2.0e-4	---	3.7e-4	---	---	---	**5.7e-4**
S30	9.0e-6	---	---	---	2.8e-4	1.4e-6	7.6e-4	1.3e-3	2.4e-4	2.0e-2	2.3e-2
S31	6.1e-6	---	---	1.5e-3	2.7e-4	8.3e-6	1.9e-3	---	---	---	3.7e-3
S32 (Maximum)	1.4e-4	1.4e-6	1.2e-2	4.1e-2	6.5e-4	1.6e-4	1.1e-1	3.2e-3	1.6e-4	4.4e-3	**1.8e-1**
S33	7.7e-6	---	---	2.1e-4	3.2e-4	1.8e-6	6.2e-4	5.6e-4	2.9e-5	7.4e-4	2.5e-3
S34	5.6e-6	---	---	1.2e-3	3.3e-4	8.3e-6	3.1e-3	1.1e-3	8.2e-5	3.8e-3	9.6e-3
C612	1.9e-5	---	2.0e-3	7.1e-4	5.7e-4	9.6e-5	5.3e-4	3.2e-3	1.6e-4	4.0e-3	1.1e-2
C616	9.3e-6	---	2.3e-3	1.4e-3	7.3e-4	5.1e-5	1.7e-3	3.3e-3	1.7e-4	3.8e-3	1.3e-2
C746KTB2	4.2e-6	---	---	---	1.7e-4	1.1e-6	2.4e-4	---	---	---	4.2e-4
C746KUP	5.0e-6	---	---	---	2.1e-4	---	3.7e-4	---	---	---	5.9e-4
K001	9.3e-6	---	---	5.2e-4	5.3e-4	3.1e-5	1.0e-3	---	---	---	2.1e-3
	Net exposure from Paducah Site to maximally exposed individual (S32—S28) =										**1.8e-1**

--- non detect

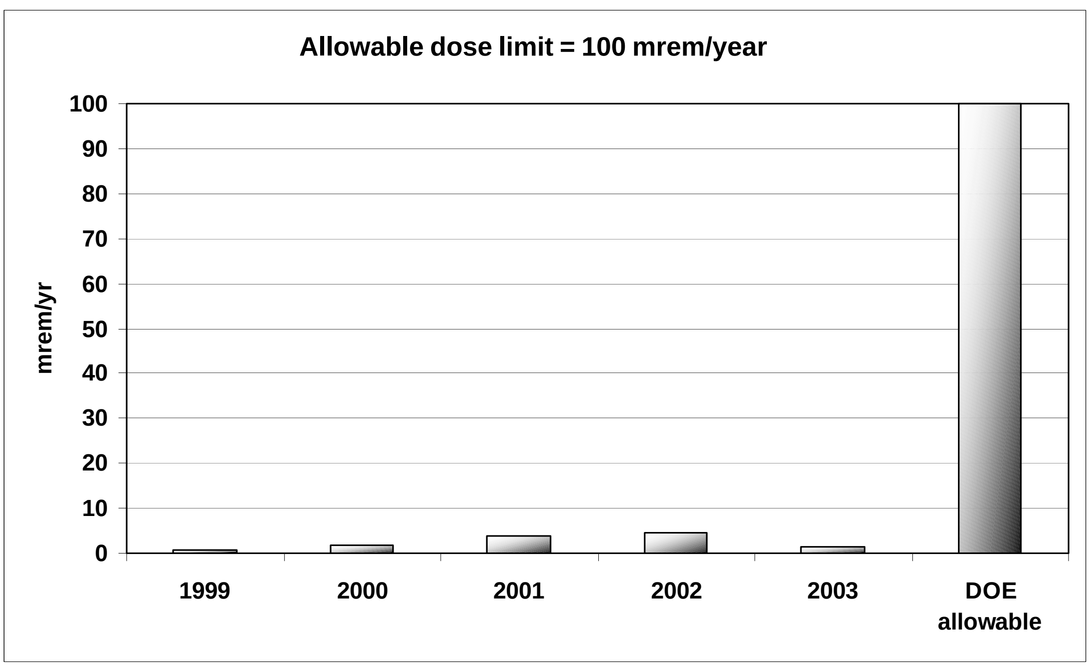


Figure 6.1 Potential radiological dose from DOE activities at the Paducah Site, 1999 through 2003

Table 6.2 Summary of potential radiological dose from the Paducah Site for 2003 (worst-case combined exposure pathways)

	Dose[a] (mrem/year)	Percent of total
Ingestion of surface water	0	0
Ingestion of sediments	0.018	0.01
Ingestion of deer meat	1.5	0.99
Direct radiation	0	0
Atmospheric releases[b]	3.78×10^{-4}	0
Total annual dose above background (all pathways)	**1.52**	**100**

[a] Maximum allowable exposure is 100 mrem/year (DOE Order 5400.5).
[b] DOE source emissions were from the NWPGS, the Scrap Metal Removal Project, the NSDD Excavation Project, and C-752-A waste treatment activities.

7 Nonradiological Effluent Monitoring

Abstract

In 2003, one KPDES outfall at the Paducah Site experienced exceedences for toxicity. Outfall 001 exceeded reportable KPDES effluent discharge permit limits for chronic toxicity. The DOE had three point sources and several fugitive sources for nonradiological air emissions. The combined emissions from these DOE sources were small; therefore, the Paducah Site is considered a minor source in accordance with the CAA.

Introduction

Responsibility for nearly all nonradioactive airborne emission sources at PGDP was turned over to USEC as a result of the 1993 lease agreement between USEC and DOE. Only a few fugitive sources, such as gravel roads, spoil piles (resulting from construction excavation), metal scrap pile windage, and three point sources remained the responsibility of DOE in 2003. The small amount of emissions from DOE sources results in CAA classification of the Paducah Site as a minor air emissions source.

Monitoring of nonradiological parameters in liquid effluents is summarized in the *Paducah Site Environmental Monitoring Plan* (BJC 2002) and is based on KPDES Permit KY0004049, and KDWM landfill permits 073-00014, 073-00015, and 073-00045. Effluents are monitored for nonradiological parameters listed on the permit governing the discharge.

Airborne Effluents

Airborne Effluent Applicable Regulations

The CAA at the Paducah Site is administered by KDAQ. The DOE has responsibility only for air emission sources under DOE program control; therefore, this report does not address emissions from the PGDP sources leased to USEC.

Airborne Effluent Monitoring Program

The point sources of air emissions other than radionuclides (Section 4) for the Paducah Site in 2003 were the NWPGS and the NEPCS. These systems, combined, removed 1288 pounds (0.64 tons) of TCE, which is a volatile organic compound and HAP, from 194,963,234 gallons of treated groundwater. These facilities remove TCE contamination from the groundwater by air stripping. At the NWPGS, TCE-laden air passes through activated carbon to remove TCE. The air stream is then released to the atmosphere where any remaining TCE naturally breaks down. The NEPCS uses the existing C-637-2A Cooling Tower at PGDP for stripping the TCE from groundwater.

The CAA defines volatile emissions as criteria pollutants. A minor source is limited to 100 tons per year of each criteria pollutant. If greater quantities of criteria pollutants are emitted, then the source is classified as a major source. A minor source has less stringent permit requirements because of the reduced potential for health effects from the smaller amount of emissions. The CAA also limits the emissions from a minor source of HAPs to 10 tons/year (9.07 metric tons) for each individual pollutant and 25 tons/year (22.68 metric tons) for all HAPs combined. TCE is classified as a HAP.

Liquid Effluents

Liquid Effluent Applicable Regulations

The CWA for the Paducah Site is administered by KDOW through the KPDES Wastewater Discharge Permitting Program. The site-wide KPDES permit (KY0004049) became effective April 1, 1998, and expired March 31, 2003. A renewal permit application has been submitted to KDOW. This permit contains discharge limits based on water quality criteria for a zero-flow receiving stream.

The KDWM specifies in landfill permits 073-00014, 073-00015, and 073-00045 that surface runoff be analyzed to ensure that landfill constituents are not discharging into nearby receiving streams.

Liquid Effluent Monitoring Program

The DOE conducts nonradiological effluent monitoring for outfalls under its jurisdiction (Section 4, Figure 4.2). Outfalls 001, 015, 017, and 019 were monitored for KPDES permit parameters. The specific sample collection, preservation, and analytical methods acceptable for the types of pollutants analyzed are listed in 40 C.F.R. 136. Preservation in the field is conducted per 40 C.F.R. 136, and chain-of-custody procedures are followed after collection and during transport to the analytical laboratory. The samples are then accepted by the laboratory and analyzed in accordance with 40 C.F.R. 136 procedures for the parameters required by the KPDES permit. The KPDES permit also intermittently requires additional sampling (two events in five years) for priority pollutants at the DOE outfalls. This sampling was conducted in 2000 and 2002.

Surface runoff from the closed C-746-S Residential Landfill, the closed C-746-T Inert Landfill, and the operating C-746-U Landfill was monitored quarterly. Grab samples were monitored for chemical oxygen demand, chloride, conductivity, dissolved oxygen, dissolved solids, flow rate, iron, pH, sodium, sulfate, suspended solids, temperature, total organic carbon, and total solids. The samples taken included landfill runoff, the receiving ditch upstream of the runoff discharge point, and the receiving ditch downstream of the runoff discharge point (Section 4, Figure 4.2). Sampling was performed to comply with the KDWM requirements for operation of the contained landfill.

Liquid Effluent Monitoring Results

Analytical results are reported to KDOW in monthly and quarterly discharge monitoring reports. Six exceedences of permit limits were reported in 2003 for DOE Outfall 001 (Table 7.1 and Section 2). Table 7.2 summarizes the maximum detected nonradiological analyses for samples collected as part of the required KPDES permit sampling. None of these detects resulted in KPDES permit violations.

Data for the KPDES samples and the surface runoff samples from the landfills are presented in Section 3, tables 3.1 through 3.4 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/OR/07-2169 Volume II).*

Table 7.1 KPDES permit exceedence summary for 2003

Location	Noncompliance Parameter	Species	Month Sampled	Result	KPDES Limit
Outfall 001	Chronic Toxicity	Fathead Minnows[1]	January	30.0 TUc	1.0 TUc
Outfall 001	Chronic Toxicity	Fathead Minnows	June	1.12 TUc	1.0 TUc
Outfall 001	Chronic Toxicity	Fathead Minnows	August	20.93 TUc	1.0 TUc
Outfall 001	Chronic Toxicity	Fathead Minnows	September	3.30 TUc	1.0 TUc
Outfall 001	Chronic Toxicity	Daphnids[2]	September	1.49 TUc	1.0 TUc
Outfall 001	Chronic Toxicity	Daphnids	December	1.57 TUc	1.0 TUc

1 – *Pimephales promelas* (fathead minnows)
2 – *Ceriodaphnia dubia* (water fleas)

Table 7.2 KPDES permit sampling routine nonradiological maximum detected analyses

Parameter	K001	K015	K017	K019
Cadmium (mg/L)	0.001	ND	ND	ND
Chlorine, Total Residual (mg/L)	0.08	0.03	0.03	0.11
Flow Rate (mgd)	9.8	1.3	36	0.8
Hardness - Total as CaCO3 (mg/L)	370	220	130	74
Iron (mg/L)	0.52	1.8	0.54	1.4
Nickel (mg/L)	0.01	ND	ND	ND
Oil and Grease (mg/L)	5.9	ND	ND	ND
Phosphorous (mg/L)	0.55	NR	NR	NR
Silver (mg/L)	0.002	ND	ND	ND
Suspended Solids (mg/L)	NR	NR	NR	ND
Trichloroethene (μg/L)	ND	NR	NR	NR
Uranium (mg/L)	0.014	0.19	0.005	ND
Zinc (mg/L)	ND	0.06	0.24	ND

ND - non detect
NR - not reported/collected

8 Nonradiological Environmental Surveillance

Abstract

The nonradiological environmental surveillance program at the Paducah Site assesses the effects of DOE operations on the site and the surrounding environment. Surveillance includes analyses of air, surface water, groundwater (Section 9), sediment, soil, vegetation, terrestrial wildlife, fish, and other aquatic life. Surveillance results for 2003 were similar to results reported in previous ASERs.

Introduction

Nonradiological surveillance at the Paducah Site involves the sampling and analysis of surface water, groundwater (see Section 9 for groundwater surveillance results), sediment, soil, terrestrial wildlife, fish, and other aquatic life. This section discusses the results of surveillance activities.

Ambient Air

As a result of the transfer of the production part of the plant to USEC in 1993, major air emission sources were transferred to USEC. Therefore, DOE does not conduct ambient air monitoring for nonradiological parameters at the Paducah Site.

Surface Water

Surface-water monitoring (except for biological monitoring) downstream of KPDES outfalls is not required by the KPDES permit. However, it is performed at the Paducah Site as part of the Environmental Surveillance Program. Figure 5.2 shows surveillance surface water sampling locations. Nonradiological sampling is conducted at upstream Bayou Creek (L1); downstream Bayou Creek (L5 and L6); downstream Little Bayou Creek (L12, L11, and L241); the convergence of both creeks (L8); upstream Ohio River (L29); downstream Ohio River (L30); downstream in the Ohio River at the confluence with the Mississippi River (L306); and background stream Massac Creek (L64). Locations were also collected near the plant on the Bayou Creek (C612, C616, K006, K016, and L291) and Little Bayou Creek (K002, L10, L55, L56, and L194). Samples were also collected near the C-746-K Landfill (C746KUP, C746KTB1, C746KTB2, and C-746K-

5). No sample point exists for upstream Little Bayou Creek, as the watershed is insufficient to develop adequate flow to monitor. Nearly all the water in Little Bayou Creek is comprised of discharges from the plant outfalls. Therefore, background water quality for Little Bayou Creek is based on L1 (upstream Bayou Creek). L29 and L64 are background waterways also used for comparison with data from Little Bayou Creek. Table 8.1 shows the analytical parameters that are analyzed on a quarterly or semiannual basis. Table 8.1 does not apply to the quarterly seep locations, which are upwellings of groundwater in the Little Bayou Creek bed. Similar to the groundwater sampling program, a different list of analytical parameters, presented in Table 8.2, is collected.

As described in Chapter 5, locations in Little Bayou Creek (LBCSP1 through LBCSP6) were added to the surface-water sampling program in 2002. These locations, known as seeps, are upwellings of groundwater in the Little Bayou Creek bed. Six locations were chosen to sample each quarter to trend and observe changes in data. These locations are located downstream of the plant site approximately halfway between the site and the Ohio River (Figure 5.2).

Surface Water Surveillance Results

Table 8.3 shows a water-chemistry comparison between upstream and downstream locations associated with the plant by presenting the maximum average concentrations of selected parameters. Similar to 2002, the only results of significance compared to background data were TCE results identified near the plant site and downstream of Little Bayou Creek at an average concentration of non detect and 36.25 µg/L, respectively.

Table 8.4 also presents the maximum average concentrations of selected parameters for the seep sampling locations. LBCSP5, one of the six Little Bayou Creek seep locations, had the highest maximum average for TCE at 232.5 µg/L.

There were no detections of surface-water PCBs in 2003. This is a decrease in PCB concentrations from 2002, which had PCB aroclors detected at low levels near the plant site on both Bayou Creek and Little Bayou Creek. Additionally, there were no detections of PCBs in surface water in 2001.

Additional data are presented in tables 4.1 through 4.31 of Section 4 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II).

Table 8.1 Nonradiological parameters for surface-water samples

Parameter
Chloride
Nitrate/Nitrite as Nitrogen
Sulfate
Alkalinity
Conductivity
Dissolved Oxygen
Flow Rate
pH
Temperature
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Phosphorous
Potassium
Selenium
Silver
Sodium
Thallium
Uranium
Vanadium
Zinc
PCB Aroclors
Polychlorinated biphenyl, Total
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloroethene
1,2-Dichloroethane
1,2-Dimethylbenzene
Benzene
Bromodichloromethane
Carbon tetrachloride
Chloroform
cis-1,2-Dichloroethene
Ethylbenzene
m,p-Xylene
Tetrachloroethene
Toluene
trans-1,2-Dichloroethene
Trichloroethene
Vinyl chloride
Ammonia
Cyanide
Hardness - Total as CaCO3
Suspended Solids

Table 8.2 Nonradiological parameters for surface-water seep-sampling locations

Parameter
Chloride
Sulfate
Alkalinity
Conductivity
Dissolved Oxygen
Flow Rate
pH
Temperature
Calcium
Magnesium
Manganese
Potassium
Sodium
Uranium
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloroethene
1,2-Dichloroethane
1,2-Dimethylbenzene
Benzene
Bromodichloromethane
Carbon tetrachloride
Chloroform
cis-1,2-Dichloroethene
Ethylbenzene
m,p-Xylene
Tetrachloroethene
Toluene
trans-1,2-Dichloroethene
Trichloroethene
Vinyl chloride

Table 8.3 Selected routine nonradiological surface-water surveillance results (maximum average concentrations)[a]

Parameter	Upstream Bayou[1]	Bayou Near Site[2]	Downstream Bayou[3]	Little Bayou Near Site[4]	Downstream Little Bayou[5]	Creek Convergence[6]	C-746-K Landfill Area[7]	Upstream Ohio River[8]	Downstream Ohio River[9]	Massac Creek[10]	Cairo, IL[11]
Aluminum (mg/L)	2.74	1.35	3.23	2.93	**4.86**	1.49	3.48	0.72	0.87	1.96	1.07
Ammonia (mg/L)	ND	0.285	0.24	0.36	ND	ND	**0.56**	ND	ND	ND	0.2
Barium (mg/L)	0.049	**0.125**	0.052	0.092	0.091	0.05	0.055	0.029	0.03	0.054	0.052
Calcium (mg/L)	12.4	**78.6**	37.3	24.1	27.3	25.4	15.2	24.6	24.6	11.7	43.6
Chloride (mg/L)	9.6	**121**	54.4	40.1	21.6	15.2	11.5	7.6	7.9	11.7	20.7
Cobalt (mg/L)	0.0013	0.0017	**0.0032**	0.0017	0.002	0.0011	0.002	ND	ND	0.001	0.0018
Copper (mg/L)	0.0078	0.0278	0.0121	0.0399	0.0226	0.0054	**0.0554**	0.0044	0.0044	0.0058	0.0065
Cyanide (mg/L)	ND	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND
Hardness-Total as CaCO3 (mg/L)	48	**254**	135	79	90.4	83.5	55	79.8	82.5	48	147
Iron (mg/L)	1.78	1.01	2.69	1.95	**2.81**	1.31	2.62	0.62	0.59	1.42	1.79
Lead (mg/L)	ND	ND	**0.00853**	ND	0.00738	ND	0.00559	ND	ND	ND	ND
Magnesium (mg/L)	3.39	**28.5**	11.4	6.16	5.55	4.84	3.59	4.79	4.97	3.11	11.4
Manganese (mg/L)	0.0815	0.0645	0.105	0.125	**0.331**	0.223	0.0773	0.0624	0.0767	0.206	0.122
Nickel (mg/L)	0.0058	0.0063	0.0053	0.006	**0.0158**	0.0069	0.0615	ND	0.0063	0.0031	0.0053
Nitrate/Nitrite as Nitrogen (mg/L)	0.54	**1.78**	1.18	0.56	0.95	0.72	0.48	0.49	0.49	0.64	1.33
PCB-1260 (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB-1268 (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphorous (mg/L)	0.18	**0.323**	0.185	0.297	0.252	0.188	0.263	0.14	0.142	0.11	0.207
Potassium (mg/L)	3.7	**21.4**	7.72	3.12	3.54	3.27	4.34	1.94	6.02	3.04	2.86
Suspended Solids (mg/L)	91	37	286	**1210**	60.7	44	218	26	28	37	65.8
Trichloroethene (ug/L)	2	1	ND	ND	**36.2**	3	1	ND	ND	ND	ND
Uranium (mg/L)	0.0014	0.0054	0.0109	**0.0176**	0.0045	0.0025	0.0016	0.0015	0.0015	0.0014	0.0015
Zinc (mg/L)	0.015	0.015	0.0825	0.0734	0.015	0.015	**0.118**	0.015	0.015	0.015	0.0203

a = The results presented in the table are the maximum average values for the locations within the area grouping.
Bold values indicate the highest concentrations for the parameter specified.
ND = Not Detected.

The following footnotes correspond with column titles in the above table. These are groupings of sample locations in the area described in the title.

1 = L1
2 = C612, C616, K006, L291
3 = L5, L6
4 = K002, K011, L10, L55, L56, L194
5 = L11, L12, L241
6 = L8
7 = C746K-5, C746KTB1, C746KTB2, C746KUP
8 = L29
9 = L30
10 = L64
11 = L306

Table 8.4 Selected routine nonradiological surface-water seep-sampling surveillance results (maximum average concentrations)[a]

Parameter	LBCSP1	LBCSP2	LBCSP3	LBCSP4	LBCSP5	LBCSP6
Calcium (mg/L)	25.1	27.6	25.5	**27.9**	25.9	23.9
Magnesium (mg/L)	8.9	**9.5**	8.9	9.2	8.4	8.4
Manganese (mg/L)	0.012	0.031	**0.061**	0.013	0.021	0.045
Potassium (mg/L)	1.96	1.77	1.64	1.82	**1.97**	1.45
Sodium (mg/L)	32	**32.9**	31.9	32.8	31.2	31.5
Sulfate (mg/L)	11.4	11	11.2	12.7	**20**	14.6
Trichloroethene (μg/L)	5.3	16.8	33.8	29.8	**232**	205

a = The results presented in the table are the maximum average values for each seep location.
Bold values indicate the highest concentrations for the parameter specified.

Sediment

Sediment is an important constituent of the aquatic environment. If a pollutant is a suspended solid or is attached to suspended sediment, it can settle to the bottom (thus creating the need for sediment sampling), be taken up by certain organisms, or become attached to plant surfaces. Pollutants transported by water can either adsorb on organic and inorganic solids or be assimilated by plants and animals. Suspended solids, dead biota, and excreta settle to the bottom and become part of the organic substrata that support the bottom-dwelling community of organisms. Sediments play a significant role in aquatic ecology by serving as a repository for radioactive or chemical substances that pass via bottom-feeding biota to the higher trophic levels.

Sediment Surveillance Program

Ditch sediments are sampled semiannually as part of a nonradiological environmental surveillance program. Sediment samples were taken from 16 locations in 2003 (Figure 5.3). Sediments were sampled for the parameters listed in Table 8.5.

Table 8.5 Semiannual nonradiological parameters for sediment samples

Parameter
Grain Size Diameter
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Uranium
Vanadium
Zinc
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
PCB-1268
Polychlorinated biphenyl
Moisture
Total Organic Carbon

Sediment Surveillance Results

Table 8.6 shows the maximum average values for locations within the area group for specific parameters. Parameters were selected to include those that were detected. The results of detected parameters are compared to determine the difference between upstream (or background) and downstream concentrations. Aluminum, barium, calcium, chromium, cobalt, iron, magnesium, manganese, potassium, and vanadium were detected at all sites. The highest level of metals was seen at Bayou Creek near the plant site. Consistent with levels seen in 2002, chromium was identified in the NSDD at 32.25 mg/kg and near the plant site on Little Bayou Creek at 46.4 mg/kg (highest level). Arsenic was found upstream in Little Bayou Creek and near the plant site. Zinc was found at all locations; however the highest level was found in the NSDD. Generally, contaminants are more abundant near the plant site and decrease in areas downstream of the plant site.

PCBs were found in the NSDD, Little Bayou Creek and Bayou Creek near the plant site, with the highest level seen in Little Bayou Creek. PCB-1254 and PCB-1260 were the most abundant aroclors.

Additional sediment data are presented in tables 4.32 through 4.47 of Section 4 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II).

Table 8.6 Selected routine nonradiological sediment surveillance results (average concentrations)[a]

Parameter	Upstream Bayou[1]	Bayou Near Site[2]	Downstream Bayou[3]	Upstream Little Bayou[4]	Little Bayou Near Site[5]	Downstream Little Bayou[6]	C-746-K Area[7]	NSDD[8]	Massac Creek[9]
Aluminum (mg/kg)	4260	**7740**	2860	5180	4500	2060	4950	5330	1860
Arsenic (mg/kg)	ND	ND	ND	**8.16**	6.8	ND	ND	ND	ND
Barium (mg/kg)	37.7	**92.7**	27.8	58.9	55.1	22.2	39.5	46	22
Beryllium (mg/kg)	ND	**0.662**	ND	ND	0.507	ND	0.51	ND	ND
Calcium (mg/kg)	635	**4260**	448	888	1030	411	799	1700	272
Chromium (mg/kg)	9.16	23.5	7.6	12.4	**46.4**	25.9	10.7	32.2	4.13
Cobalt (mg/kg)	4.72	4.31	3.15	**4.97**	4.79	3.37	3.49	3.5	3.7
Copper (mg/kg)	5.32	20	ND	ND	5.84	7.9	6.5	**26.3**	ND
Iron (mg/kg)	8380	**12000**	5060	8300	8580	4080	7240	8440	4060
Magnesium (mg/kg)	404	**1070**	282	600	432	212	490	723	211
Manganese (mg/kg)	235	128	124	**266**	222	91.7	157	118	146
Mercury (mg/kg)	ND	**0.21**	ND	ND	ND	ND	ND	ND	ND
Nickel (mg/kg)	ND	8.8	ND	ND	ND	ND	5.99	**15.5**	ND
PCB-1254 (µg/kg)	ND	ND	ND	ND	**370**	ND	ND	265	ND
PCB-1260 (µg/kg)	ND	100	ND	ND	**395**	ND	ND	160	ND
Potassium (mg/kg)	303	**739**	190	314	271	145	402	423	187
Selenium (mg/kg)	ND	20.3	ND	ND	ND	ND	ND	**21**	ND
Sodium (mg/kg)	ND	**202**	ND	ND	183	ND	ND	ND	ND
Uranium (mg/kg)	ND	**121**	33.5	ND	66.2	50	ND	33.5	ND
Vanadium (mg/kg)	16.6	**25.7**	10.9	16.1	18	7.93	15.9	14.4	7.34
Zinc (mg/kg)	23.6	50.1	ND	27.1	39.5	26.5	24.3	**52**	ND

NSDD = North-South Diversion Ditch
a = The results presented in the table are the maximum average values for the locations within the area grouping.
Bold values indicate the highest concentrations for the parameter specified.

The following footnotes correspond with column titles in the above table. These are groupings of sample locations in the area described in the title.
1 = S20
2 = C612, C616, K001, S1, S31
3 = S33
4 = S21
5 = S2, S30
6 = S27, S34
7 = C746KTB2, C746KUP
8 = S32
9 = S28

Soil

The major source of soil contamination is from air pathways. Because DOE no longer controls any major air emission sources, routine soil surveillance is not performed. However, surface soil contamination is being addressed by the Surface Soils OU (see Environmental Restoration Program in Section 3).

Vegetation

Because DOE no longer operates any major air emission sources, routine vegetation surveillance activities are not performed.

Terrestrial Wildlife

Annual Deer Harvest

The deer population in the WKWMA is sampled annually to determine levels of radionuclides (Section 5), PCBs, and inorganic elements that might be attributed to past plant practices. There were five deer harvested from the WKWMA and one deer harvested in 2002 from the Stewart Island Habitat Restoration in Livingston County, Kentucky, to serve as a reference sample.

PCBs tend to accumulate in fat tissue. PCB-1268 was present in deer from the Paducah Site, while PCB-1260 was detected in the background deer. Table 8.7 shows the PCB results. All measurable PCBs were well below the Food and Drug Administration (FDA) standard of 3 parts per million (ppm) for red meat.

A risk assessment was conducted using the concentrations of PCBs found in deer, assuming 20 percent fat content and that a hunter would eat the two deer with the highest levels of PCBs found. The risk assessment concluded that the risk to the hunter who eats 100 pounds of the two worst-case deer (50 pounds/deer) would have an average increased cancer risk of 0.000012, or approximately 12 chances of cancer development per one million people who eat the deer (Hampshire 2003).

A comparison of the metals detected in the 2003 deer with the 2002 deer shows essentially no change. Arsenic and lead are the only metals, which were not detected in 2003. Beryllium and chromium were found in 2003 and not found in 2002; however, both were present in the 2001 data set. Mercury was identified at low levels in both 2002 and 2003. Most metal results are comparable between the background and site deer, for example, the average cadmium result in kidney is 1.2 mg/kg and the result in the background deer is 2.14 mg/kg.

Additional deer data are presented in tables 4.48 through 4.51 of Section 4 of the *Environmental Monitoring Results Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2169 Volume II).

Table 8.7 Summary of PCB detections in deer for 2003[a]

Parameter	Deer 1	Deer 2	Deer 3	Deer 4	Deer 5	Background Deer[b]
PCB-1260 (µg/kg)	ND	ND	ND	ND	ND	33.7
PCB-1268 (µg/kg)	ND	37.4	39.9	33.6	39.1	ND

[Result] = Detected at the result indicated.
µg/kg = part per billion (ppb)
ND = Non Detect
[a] Other PCB aroclors were analyzed but not detected in any deer.
[b] Background deer were collected during 2002 from Stewart Island Habitat Restoration in Livingston County, Kentucky.

Fish and Other Aquatic Life

Watershed (biological) monitoring was conducted, as required, by DOE Order 5400.1 and KPDES Permit KY0004049. The KPDES permit also requires toxicity monitoring of one continuous outfall and of three intermediate outfalls on a quarterly basis. Watershed or biological monitoring of Bayou Creek and Little Bayou Creek has been conducted since 1987.

The objectives of the Watershed Monitoring Program are as follows:

- determine whether discharges from the Paducah Site and its associated SWMUs are adversely affecting instream fauna;
- assess the ecological health of Bayou Creek and Little Bayou Creek;
- assess the degree to which abatement actions ecologically benefit Bayou Creek and Little Bayou Creek;
- provide guidance for remediation;
- provide an evaluation of changes in potential human health concerns; and
- provide data that could be used to assess the impact of inadvertent spills or fish kills.

The 2003 sampling effort was conducted in accordance with the *Bayou Creek and Little Bayou Creek Watershed Monitoring Plan*. The plan is required by the KPDES permit. In January and February 2003, the U.S. Fish and Wildlife Service and the KDOW, respectively, requested additional changes to the watershed monitoring plan. The plan was revised in April 2003 to include the following changes:

- Fish bioaccumulation sampling will not be performed in 2003, but fish will be sampled for PCBs and metals, including mercury, in even years of sampling to avoid elimination of population by sampling (this will begin in CY 2004).
- The targeted species for the bioaccumulation samples at Bayou Creek will be changed from spotted bass to creek chubs and green sunfish.
- Sampling location UTM 6.9 will be deleted and a location on the West Fork of Massac Creek will be added. The West Fork of Massac Creek will be considered a reference site.
- Sampling location BM 7.6 was eliminated as a sampling site since a new reference site is being added at the West Fork of Massac Creek.
- Sampling location BM 5.55 will be moved downstream to BM 4.6.

Sampling for fish community and benthic macroinvertebrates at LUM 5.0 will be discontinued. These tests will be added to LUM 2.7 on Little Bayou Creek.

Study Area and Methods

As specified according to *Big Bayou Creek and Little Bayou Creek Revised Watershed Monitoring Program, April 2003*, the fish and benthic macroinvertebrate communities were sampled in June 2003 at eight locations, including locations in Massac Creek and in the West Fork of Massac Creek, both which serve as sources of background fish (MAM 8.6 and WFM 0.5, respectively). Figure 8.1 shows the eight locations, with the exception of MAM 8.6 and WFM 0.5 which are located offsite.

Benthic macroinvertebrate samples were collected with a Surber square-foot bottom sampler from appropriate locations within a designated riffle at each site. Samplers selected sampling locations within the reaches of the stream. Samples were processed in a laboratory following EPA methods. Organisms were identified to the lowest practical taxon and enumerated. Instream and riparian habitat and water quality were assessed at each site following standard procedures outlined by the EPA. An analysis of the data includes general descriptive and parametric

DOCUMENT No. DOE/OR/07-2169/V1

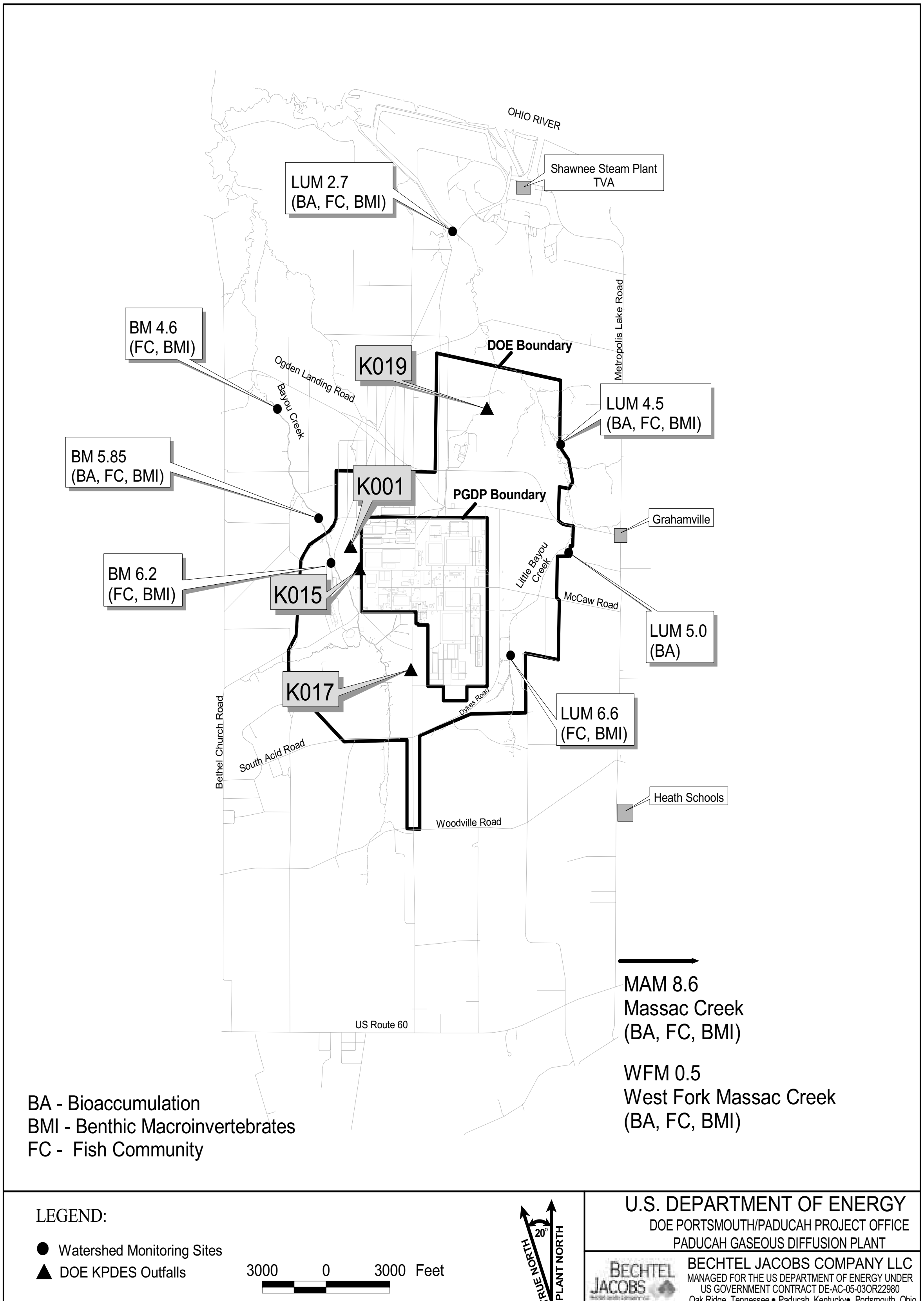


Figure 8.1 Biological monitoring locations

FIGURE No. c5ac90002sk114.apr
DATE 01-13-04

statistics to evaluate trends in temporal and spatial changes that could be associated with abatement activities or remedial actions. Metrics of the benthic macroinvertebrate community, such as total density; total taxonomic richness; taxonomic richness of the pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera; percent community similarity index; and dominants in common are included in the analysis of the data. The Modified Hilsenhoff Biotic Index (mHBI) was used to evaluate the water quality of the sample locations.

Quantitative samplings of the fish communities in the PGDP area were conducted by electrofishing. Block nets defined the sample reaches (eight to 120 m [26 to 394 feet]) of each site sampled. A three-pass depletion method was used in collecting the samples. Data from these samples were used to estimate species' richness, population size (numbers and biomass per unit area), and annual production. All fish sampling locations overlap locations used in the benthic macroinvertebrate community task. All field sampling was conducted according to Standard Operating Procedures.

The frequency for the bioaccumulation monitoring task has been changed to every two years and monitoring was not conducted in 2003.

Watershed Monitoring

Results of watershed monitoring are reported annually. Reports for 2003 monitoring include the *Watershed Monitoring Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky KPDES Permit No. KY0004049* BJC/PAD-613 (BJC 2004c). Additional analysis of the data can be seen in this report. The report conclusions, which meet the objectives of the Watershed Monitoring Program, are presented as follows.

Mean density for benthic macroinvertebrate samples was compared for three sites: MAM 8.6, BM 6.2, and LUM 4.5, between the years of 1999 through 2003. These sites were chosen for comparison because they were the only sites that have been sampled for the entire time period. Densities fluctuated for all three sites over the five-year period; however, populations at Massac Creek displayed a wider range of densities over the same period of time. This is possibly due to the shifting substrate at this site, which can result in a less stable habitat for macroinvertebrate populations to reestablish from one year to the next. A marked increase in mean density is seen at BM 6.2 for 2003; this is due to increased numbers of Diptera.

The higher values, mHBI which resulted in lower water quality ratings in 2003, are a result of higher numbers of tolerant Diptera taxa. The inclusion of taxa collected in multi-habitat samples provided a more complete picture of the taxa assemblage at these sites. This also affected the mHBI values because of the addition of more tolerant taxa such as Odonata (dragonflies and damselflies) and Coleoptera (beetles). This lower trend in water quality ratings was seen at all sites during 2003. It is difficult to assign a cause for the shift in taxa composition, but collecting macroinvertebrates at the same time each year and at the same locations would give comparable data over several years.

Quantitative samplings of the fish communities in the PGDP area were conducted to assess the ecological health of Bayou Creek and Little Bayou Creek and to determine whether discharges from the Paducah Site are adversely affecting the watershed. Data from these samples were used to estimate species richness, population size (numbers and biomass per unit area), and annual production. All fish sampling locations overlap locations used in the benthic macroinvertebrate community task. All fish observed in 2003 were found to be in good health. Fish communities examined in 2003 do show some changes in density, biomass, total numbers, and species richness. However, the changes noted are not indicative of contaminant impacts. The changes in the community are more aligned with ecological impacts such as, and primarily, recent high-water events and unstable substrates (BJC 2004c).

The PCB concentrations in fish from Little Bayou Creek, Bayou Creek, West Fork of Massac Creek, and Massac Creek were not determined in 2003. These concentrations have previously been detected in fish tissue from Bayou Creek and Little Bayou Creek. PCBs have varied over the past five years and have consistently been elevated above the background level. All mean PCB concentrations of sites sampled in 2002 were under 0.2 µg/g (ppm). The FDA Action limit for fish is 2 ppm. Sampling for PCBs and metals is planned for the summer of 2004.

9 Groundwater

Abstract

The primary objectives of groundwater monitoring at the Paducah Site are to detect contamination and provide the basis for groundwater quality assessments if contamination is detected. Monitoring includes the exit pathways at the perimeter of the plant and off-site water and monitoring wells. Primary off-site contaminants continue to be TCE, an industrial degreasing solvent, and ^{99}Tc, a fission by-product. Evidence suggests the presence of TCE as a DNAPL in groundwater beneath the site.

Introduction

Monitoring and protection of groundwater resources at the Paducah Site are required by federal and state regulations and by DOE orders. Federal groundwater regulations generally are enacted and enforced by EPA. The Paducah Site lies within EPA Region 4 jurisdiction which encompasses the southeastern United States and maintains headquarters in Atlanta, Georgia. Many state groundwater regulations are enacted and enforced by KDWM located in Frankfort, Kentucky. A KDWM field office for western Kentucky is located in Paducah.

When off-site contamination from the Paducah Site was discovered in 1988, the EPA Region 4 and DOE entered into an ACO. DOE provided an alternate water supply to affected residences. Under CERCLA, DOE is also required to determine the nature and extent of off-site contamination through sampling of potentially affected wells and a comprehensive site investigation.

A CERCLA/ACO site investigation, completed in 1991, determined off-site contaminants in the RGA to be TCE, used as an industrial degreasing solvent (discontinued use in 1993), and ^{99}Tc, a fission by-product contained in nuclear power reactor returns that were brought on-site several years ago for re-enrichment of ^{235}U. Such reactor returns are no longer used in the enrichment process; however, since the system is closed, ^{99}Tc is still present in the system. Known or potential sources of TCE and ^{99}Tc include former test areas and other facilities, spills, leaks, buried waste, and leachate derived from contaminated scrap metal.

Investigations of the on-site source areas of TCE at the Paducah Site are ongoing. The main source of TCE contamination in the groundwater is near the C-400 Cleaning Building. A common degreasing agent, TCE may act as a DNAPL due to its low solubility and higher density relative to water. DNAPLs either sink to the bottom of aquifers or come to rest on a less-permeable layer within an aquifer, forming pools. These DNAPL pools form a continuous source for the dissolved-phase contamination (plumes) that are migrating off-site toward the Ohio River

(Figure 9.1). Pools of DNAPL are extremely difficult to clean due to low solubility in water and the inability to find them in groundwater. Currently, only the highest concentrations of dissolved TCE are controlled by pump-and-treat systems (in Northwest and Northeast plumes) at Paducah. The pump-and-treat system installed northwest of the plant also controls the highest concentrations of dissolved ^{99}Tc that would otherwise migrate offsite. Continued groundwater monitoring serves to identify the extent of contamination, predict the possible fate of the contaminants, and determine the movement of groundwater near the plant. This year's (CY 2003) plume map (Figure 9.1) continues the basic interpretation presented in the plume maps for CY 2002. Revisions for CY 2003 reflect the following: (1) decreasing TCE trends in MWs along the core of the Northeast Plume and over a large area to the west of the Northeast Plume well field, (2) extension of >25 pCi/L ^{99}Tc east of PGDP toward the Northeast Plume well field, (3) eastward migration of the Northwest Plume in the area of the north well field, and (4) re-interpretation of the extent of a core of ^{99}Tc contamination located to the east of the primary core of the Northwest Plume (BJC 2004d).

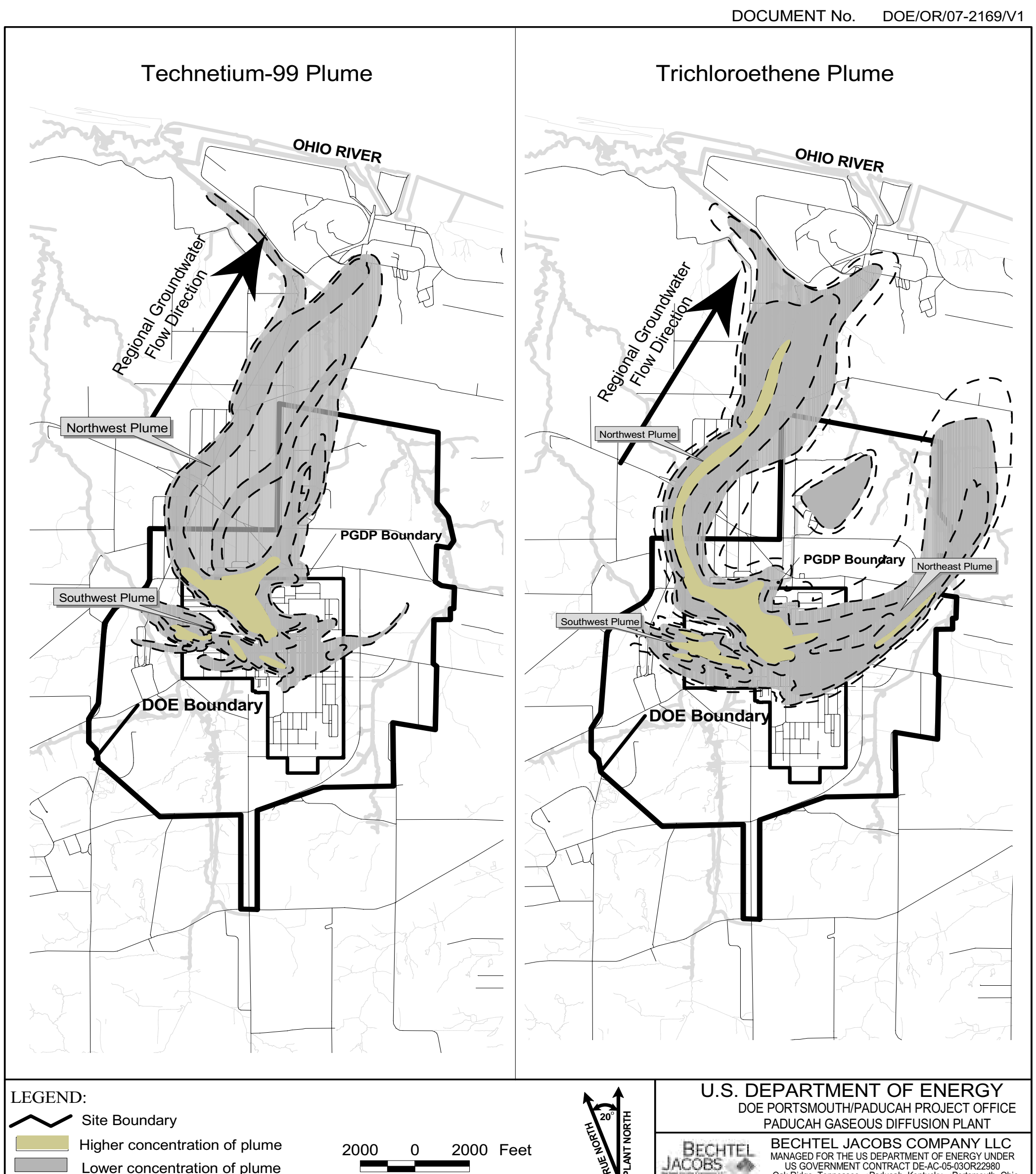


Figure 9.1 Off-site extent of groundwater plumes

FIGURE No. c5ac90002sk095.apr
DATE 01-13-04

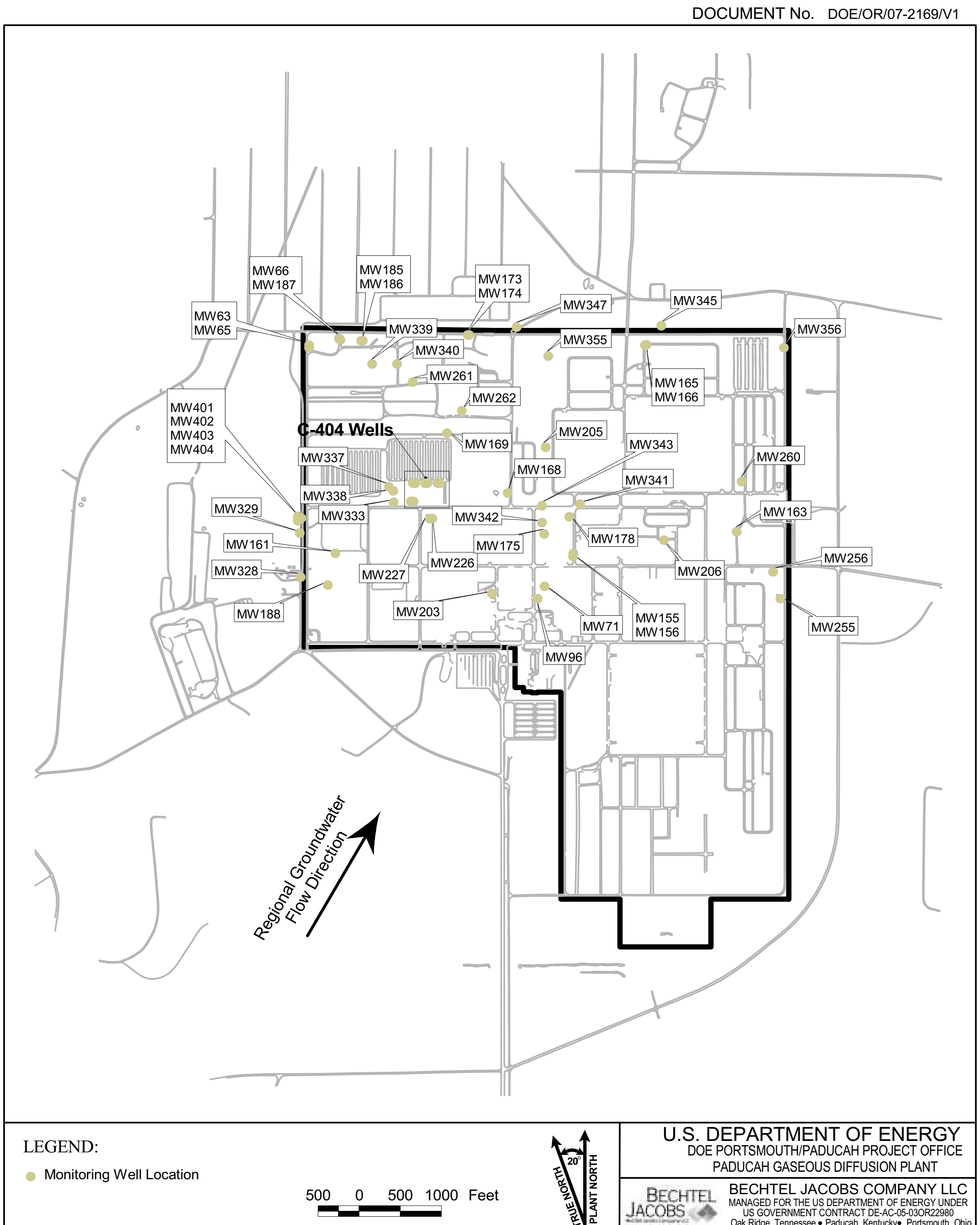


Figure 9.2 Wells sampled inside the perimeter fence

CDM
FIGURE No. c5ac90002sk099.apr
DATE 01-13-04

Groundwater monitoring at Paducah complies with one or more federal or state regulations and permit conditions and includes perimeter exit pathway monitoring and off-site water well monitoring (see Groundwater Monitoring Program). Figures 9.2 and 9.3 show the locations of all wells sampled during 2003.

Groundwater Hydrology

When rain falls to the ground, some of it flows along the surface as streams or lakes, some of it is used by plants, some evaporates and returns to the atmosphere, and some sinks into

DOCUMENT No. DOE/OR/07-2169/V1

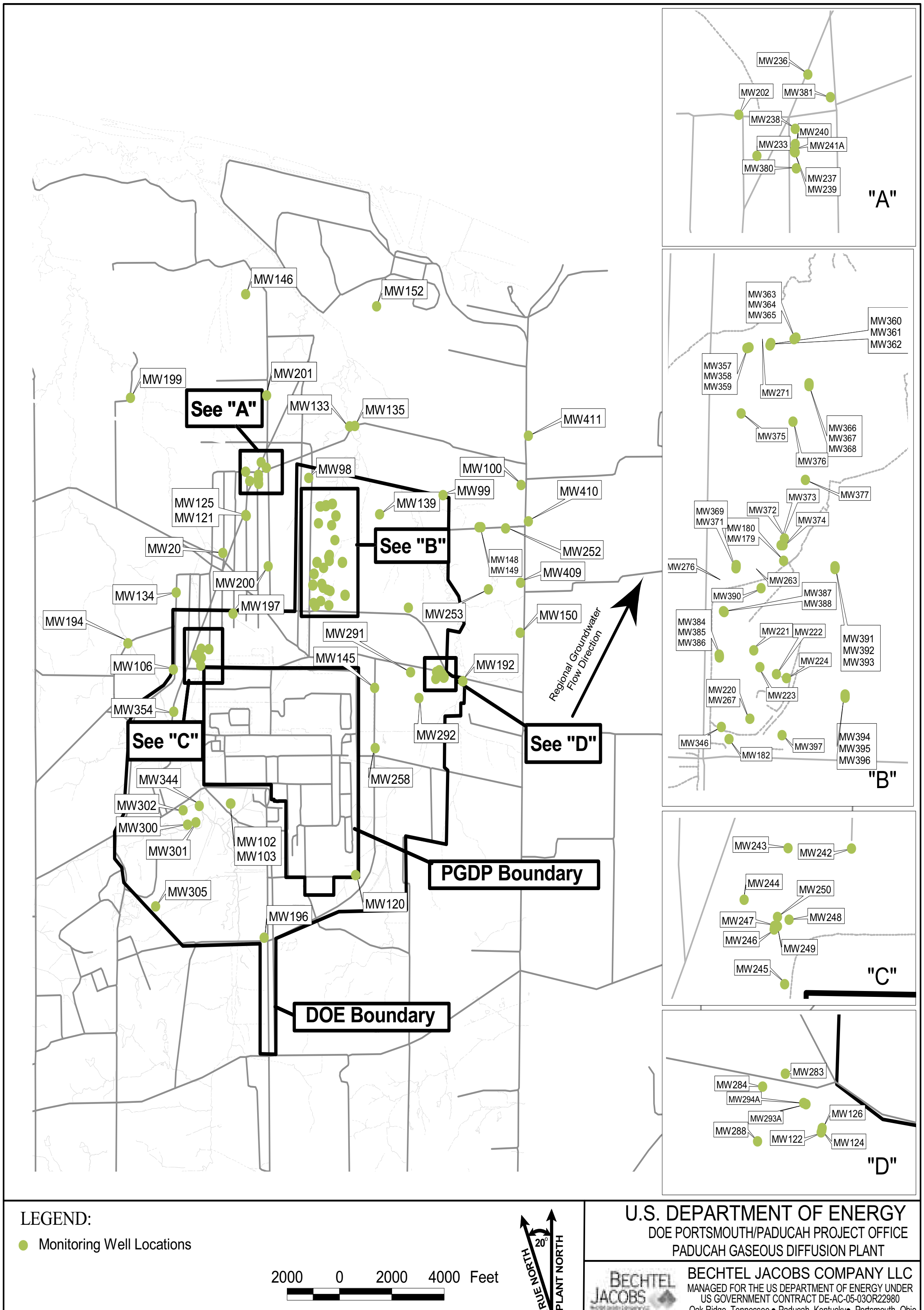


Figure 9.3 Wells sampled in the vicinity of the Paducah Site

FIGURE No. c5ac90002sk100.apr
DATE 01-13-04

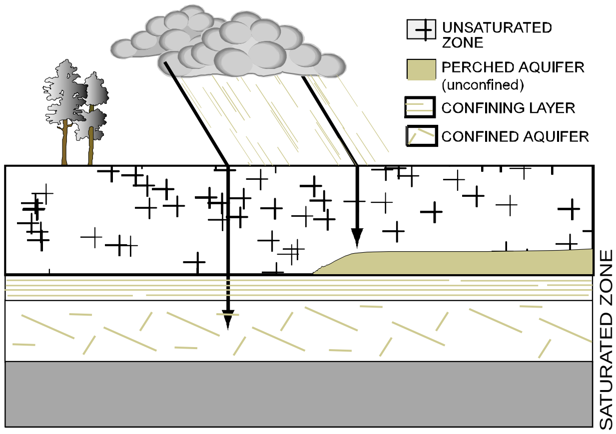


Figure 9.4 Typical path for rainwater accumulation as groundwater

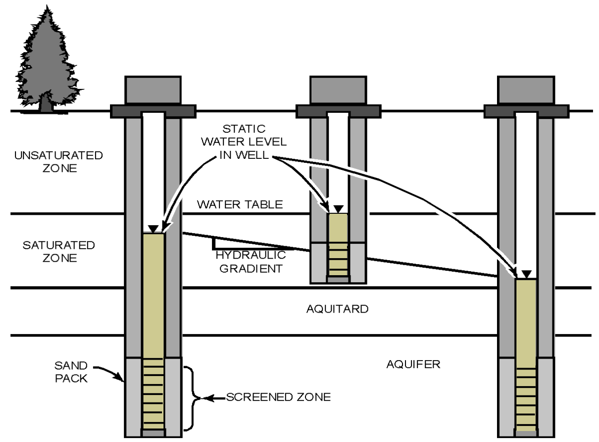


Figure 9.5 MW construction showing relationship between screened zone and water level in wells where limited flow in the aquifer is to the right

the ground. The water that sinks into the ground moves into the spaces between the particles of soil and sand, infiltrating porous soil and rock. Groundwater is the water that is found underground in cracks and spaces in soil, sand, and rock. Groundwater is stored in, and moves slowly through, an aquifer, which is a source of useable water. Aquifers typically consist of layers of gravel, sand, sandstone, or fractured rock. The speed at which groundwater flows through the surface depends on the size of the spaces in the soil or rock and how well the spaces are connected. Hydraulic conductivity, is the physical property that describes the ease with which water can move through the pore spaces and fractures in soil, gravel, sand, and rock.

The area in the subsurface where water fills these pore spaces is called the saturated zone (Figure 9.4). The top of the saturated zone is the water table, which is the boundary between the unsaturated and saturated zones. This boundary usually, but not always, gently mirrors the surface topography and is higher than natural exits such as springs, swamps, and beds of streams and rivers. Groundwater can be brought to the surface naturally, either through discharge as a spring or as flow into lakes and streams, or it can be extracted through a well drilled into the aquifer. A well is a pipe/screen assembly in the ground that fills with groundwater, which can then be brought to the surface using a pump.

Groundwater movement is determined by differences in the energy associated with the groundwater's elevation in a specific location to the elevation of other nearby groundwater. This is called hydraulic head. Hydraulic head is considered to be the total energy in any water mass resulting from three components: pressure, velocity, and elevation. Water will rise in a well casing in response to the pressure of the water surrounding the well's screened zone. The depth to water in the well is measured and the elevation calculated to determine the hydraulic head of the water in the monitored zone (Figure 9.5). The hydraulic gradient measures the difference in hydraulic head over a specified distance. By comparing the water levels in adjacent wells screened in the same zone, a horizontal hydraulic gradient can be determined and the lateral direction of groundwater flow can be predicted. Only wells screened in the same zones are considered when determining the horizontal gradient. Wells screened above and below an aquitard (a geologic unit which inhibits groundwater flow) can also have different hydraulic heads, thus defining a vertical gradient. If the water levels in deeper wells are lower than those in shallower wells, vertical flow is primarily downward.

Groundwater aquifers are one of the primary pathways by which potentially hazardous substances can spread through the environment. Substances placed in the soil may migrate downward due to gravity or be dissolved in rainwater, which moves them downward through the unsaturated zone into the aquifer. The contaminated water then flows laterally downgradient toward the discharge point. MWs are used extensively at the Paducah Site to assess the effect of plant operations on groundwater quality. Wells positioned to sample groundwater flowing away from a site are called downgradient wells, and wells placed to sample groundwater before it flows under a site are called upgradient wells. Any contamination of the downgradient wells that is not present in the upgradient wells at a site may be determined to be a result of that site. Wells can be drilled to various depths in the saturated zone and be screened to monitor the recharge area above the aquifer, different horizons within the aquifer, or water-bearing zones below the aquifer. Vertical and horizontal groundwater flow directions are determined by the permeability and continuity of geologic strata, in addition to hydraulic head. To effectively monitor the movement of groundwater and any hazardous constituents it may contain, hydrogeologists at the Paducah Site have undertaken many detailed studies of the geology of strata beneath the site.

Geologic and Hydrogeologic Setting

The Paducah Site, located in the Jackson Purchase region of western Kentucky, lies within the northern tip of the Mississippi Embayment portion of the Gulf Coastal Plain Province (Figure 9.6). The Mississippi embayment is a large sedimentary trough oriented nearly north-south that received sediments during the Cretaceous and Tertiary geologic time periods.

Figure 9.6 The Mississippi embayment aquifer system (source: USGS Web site, http://sr6capp.er.usgs.gov/aquiferBasics/ext_embay.html)

During the Cretaceous Period, sediments were deposited in a coastal marine environment, creating the McNairy/Clayton Formation. For the most part, the McNairy/Clayton Formation is sandy at the bottom and silty at the top. However, variations in the geologic make-up of the McNairy/Clayton Formation do occur and lenses of clay, and at least one fairly continuous string of gravel, are present within the formation.

The Clayton Formation overlies the McNairy. The Clayton Formation was deposited during the early Paleocene geologic epoch in an environment so similar to that of the McNairy that the Clayton and upper portion of the McNairy are indistinguishable in lithologic samples. Later in the Paleocene, the Porters Creek Clay was deposited in marine and brackish water environments in a sea that occupied most of the Mississippi Embayment. The McNairy/Clayton and the Porters Creek Clay formations dip 9 to 10.5 m [30 to 35 ft] per mile to the south-southwest.

The next feature in the geologic history at the Paducah Site is a Pleistocene-age river valley, occupying approximately the same position as the present-day Ohio and Tennessee River valleys. In forming the valley, braided stream channels of the ancestral Tennessee River, and possibly several "feeder" streams, eroded any sediments deposited after the Paleocene Porters Creek Clay and before the Pleistocene. The river system also eroded portions of the Porters Creek Clay and the McNairy Formation and cut a prominent terrace in the Porters Creek Clay at the south end of the plant. The sediments deposited on this erosional surface are termed continental deposits. The lower portion of the continental deposits consists of approximately 9 m (30 ft) of stream gravel and sand.

Over time, sediments from the retreating glaciers dammed the river valley, causing the formation of a lake. Silts and clays with thin zones of sand and occasional gravel were deposited in the lake, forming the upper portion of the continental deposits. These deposits range from approximately 1.5 to 17 m (5 to 55 ft) thick.

Finally, loess, a wind-blown silt, overlies the continental deposits throughout the site. Thickness of loess deposits varies from approximately 1.5 to 8 m (5 to 25 ft), averaging 4.6 m (15 ft).

The local groundwater flow system at the Paducah Site contains the following four major components (from shallowest to deepest): (1) the terrace gravels, (2) UCRS, (3) RGA, and (4) the McNairy flow system. The Rubble Zone is the formation underlying the McNairy. The terrace gravels consist of shallow Pliocene gravel deposits in the southern portion of the plant site. These deposits usually lack sufficient thickness and saturation to constitute an aquifer, but may be an important source of groundwater recharge to the RGA.

The UCRS consists mainly of clay silt with interbedded sand and gravel in the upper continental deposits. The system is so named because of its characteristic recharge to the RGA.

The RGA consists of coarse-grained sediments at the base of the upper continental deposits, sand and gravel facies in the lower continental deposits, gravel and coarse sand portions of the upper McNairy that are directly adjacent to the lower continental deposits, and alluvium adjacent to the Ohio River. These deposits have an average thickness of 9 m (30 ft) and can be more than 21 m (70 ft) thick along an axis that trends east-west through the site. The RGA is the uppermost and primary aquifer, formerly used by private residences north of the Paducah Site.

The McNairy flow system consists of interbedded and interlensing sand, silt, and clay of the McNairy Formation. Sand facies account for 40 to 50 percent of the total formation thickness of approximately 69 m (225 ft).

Uses of Groundwater in the Vicinity

The WKWMA and some lightly populated farmlands are in the immediate vicinity of the Paducah Site. Homes are sparsely located along rural roads in the vicinity of the site. Two communities, Grahamville and Heath, lie within 3.2 km (2 miles) east of the plant.

Both groundwater and surface water (Cairo, Illinois only) sources have been used for water supply to residents and industries in the plant area. Wells in the area are screened at depths ranging from 4.6 to 75 m (15 to 245 ft). The majority of these wells are believed to be screened in the RGA. The Paducah Site continues to provide municipal water to all residents within the area of groundwater contamination from the site. These residents' out-of-service wells are utilized by DOE for sampling as a result of written agreements. Residential wells that are no longer sampled have been capped and locked.

Groundwater Monitoring Program

The primary objectives of groundwater monitoring at the Paducah Site are early detection of any contamination resulting from past and/or present land disposal of wastes and provision of the basis for developing groundwater quality assessments, if contamination is detected. Additional objectives outlined in DOE Orders 5400.1, *General Environmental Protection Program* and 450.1, *Environmental Protection Program*, require that groundwater monitoring at all DOE facilities "...determine and document the effects of operations on groundwater quality and quantity." The DOE orders require groundwater monitoring to be conducted onsite and in the vicinity of DOE facilities to accomplish the following:

- 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.

These objectives are outlined in the following three documents related to groundwater monitoring: (1) *Paducah Gaseous Diffusion Plant Groundwater Protection Program Management Plan* (BJC 2003), (2) *Groundwater Protection Plan* (BJC 2001), (3) and the *Paducah Site Environmental Monitoring Plan* (BJC 2002). Scheduled sampling continues for more than 170 MWs and residential wells in accordance with DOE orders and federal, state, and local requirements. Well sampling is included in several different monitoring programs, which are described as follows.

Resource Conservation and Recovery Act Permit Monitoring Programs

Presently, the only hazardous waste facility at the Paducah Site that requires groundwater monitoring is the C-404 Landfill (Figure 9.7). The C-404 Low-Level Radioactive Waste Burial Ground was used for the disposal of uranium-contaminated solid wastes until 1986 when it was determined that, of the wastes disposed there, gold dissolver precipitate was considered a hazardous waste under RCRA. The landfill was covered with a RCRA-compliant clay cap and was certified "closed" as a hazardous waste landfill in 1987. The landfill is now monitored under post-closure monitoring requirements. According to the Kentucky C-404 Post-Closure Permit, 14 wells (MWs 84–95, 226, and 227) monitor groundwater quality of the UCRS (four wells) and the underlying RGA (ten wells)

DOCUMENT No. DOE/OR/07-2169/V1

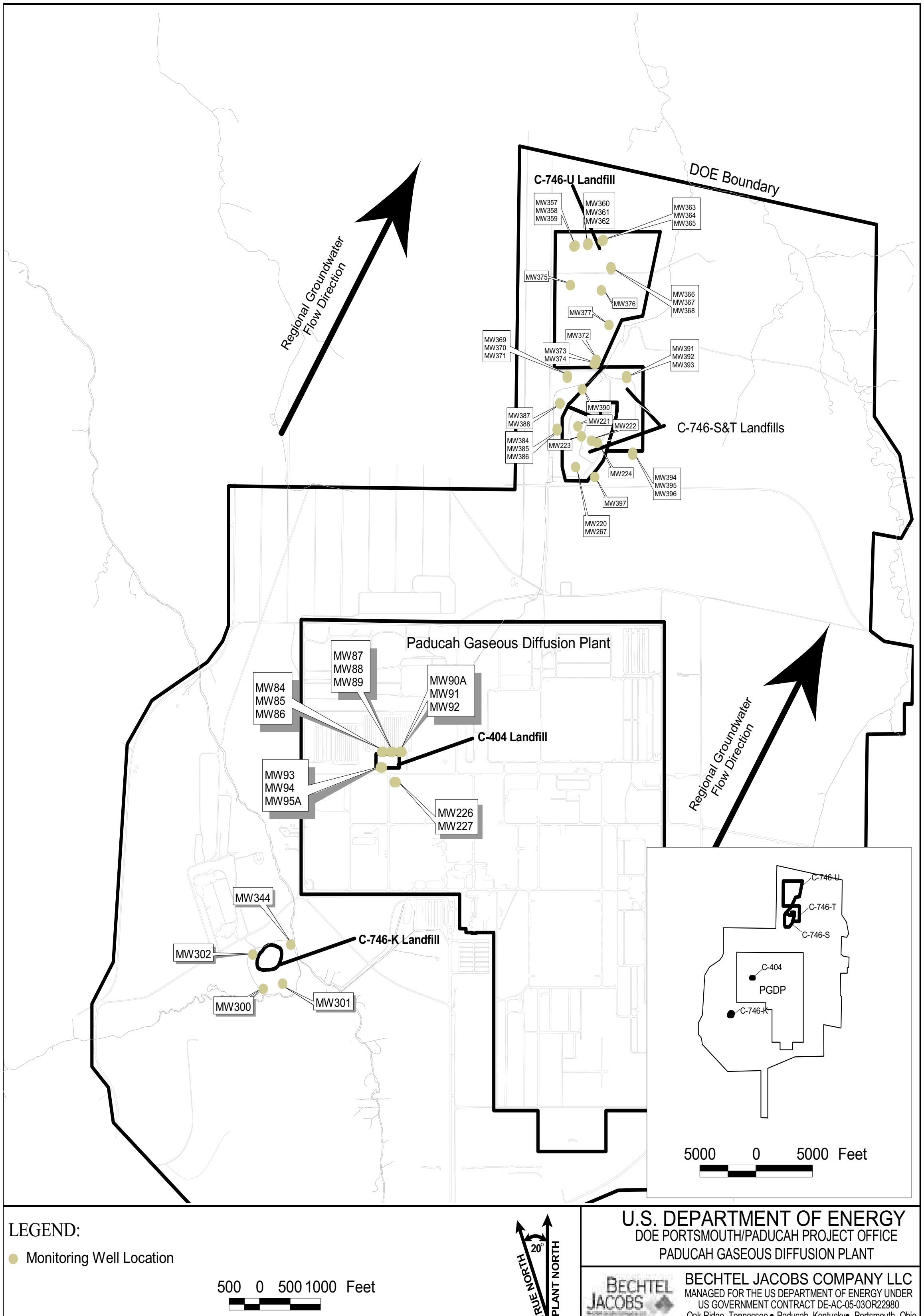


Figure 9.7 Monitoring well locations near the landfills

CDM

FIGURE No. c5ac90002sk096.apr
DATE 01-13-04

during the required post-closure monitoring on a semiannual basis.

During 2003, MWs at the C-404 Landfill were sampled and analyzed for total and dissolved chromium, arsenic, cadmium, lead, mercury, selenium, and uranium. Also monitored are TCE, and ^{99}Tc. TCE exceeded the Maximum Contaminant Level (MCL) in four upgradient RGA wells and two downgradient RGA wells. Total chromium also exceeded MCLs in three upgradient RGA wells. Results are reported to KDWM semiannually. A summary of the detected maximum results for each of the wells is provided in Table 9.1. Parameters with no detections are not listed.

State Solid Waste Disposal Regulations

Post-closure groundwater monitoring continues for the C-746-S Residential Landfill. The landfill stopped receiving solid waste before July 1, 1995, and was certified closed on October 31, 1995, by an independent engineering firm. The groundwater monitoring system for the C-746-S Residential Landfill also encompasses the C-746-T Inert Landfill, which was certified closed in November 1992. The C-746-T Inert Landfill has fulfilled its two years of post closure environmental monitoring and maintenance requirements and is awaiting final closure approval from KDWM.

The groundwater monitoring system for C-746-S and C-746-T consists of upgradient, sidegradient, and downgradient wells (Figure 9.7). The monitoring system is designed to monitor the UCRS, the upper portion of the RGA (URGA), and lower portion of the RGA (LRGA).

The MWs at C-746-S and C-746-T are sampled quarterly and in accordance with 401 K.A.R. 48:300. The analytes are dictated by a KDWM-approved solid waste landfill permit modification. Evaluation of the groundwater monitoring data collected at the C-746-S and C-746-T landfills requires immediate reporting to KDWM of results exceeding Kentucky MCLs (401 K.A.R. 47:030 Section 6) and statistical analysis of the results for constituents that do not have an MCL.

During 2003, lead exceeded contaminant levels in the lower RGA downgradient wells. Beta activity exceeded contaminant levels in upgradient, sidegradient, and downgradient wells. Turbidity contaminant-level exceedences were seen in upgradient, sidegradient, and downgradient wells, and TCE and PCB levels exceeded contaminant levels in some upgradient and downgradient wells. KDWM was notified of the exceedences, as required by the permit. Results were reported to KDWM on a quarterly basis. A summary of the maximum results for upgradient, sidegradient, and downgradient wells in each of the monitored portions of the groundwater system is provided in Table 9.2.

Table 9.1 Summary of maximum groundwater results from the RGA at C-404 Landfill

	Upgradient Wells				Downgradient Wells							
Parameter	MW 226	MW 227	MW 93	MW 95A	MW 84	MW 86	MW 87	MW 89	MW 90A	MW92	Criteria Reference	
Chromium, Total (mg/L)	**0.20**	**0.24**	ND	ND	ND	ND	ND	ND	ND	ND	0.1	MCL
Technetium-99 (pCi/L)	134	22	ND	ND	ND	ND	ND	ND	ND	ND	900	MCL
Trichloroethene (µg/L)	**230**	**26**	**120**	**60**	**87**	**60**	**8**	ND	ND	ND	5	MCL

ND - non detect

MCL - Maximum Contaminant Level

Bold - exceeds criteria

^{99}Tc - MCL of 900 pCi/L is calculated based on 4 mrem for beta emitters

Table 9.2 Summary of maximum groundwater results at C-746-S&T Landfills

		Lower RGA MWs			UCRS MWs			Upper RGA MWs			Criteria Reference	
	Parameter	Up-gradient	Side-gradient	Down-gradient	Up-gradient	Side-gradient	Down-gradient	Up-gradient	Side-gradient	Down-gradient		
Anion	Bromide	ND	ND	ND	ND	2.8	1.7	ND	ND	ND		
(mg/L)	Chloride	46	34	64	28	320	110	49	80	63		
	Fluoride	0.33	0.55	0.21	0.22	0.32	0.46	1	0.4	0.32		
	Nitrate as Nitrogen	2	1.7	2	ND	ND	ND	2	ND	1.5	10	MCL
	Sulfate	16	22	13	ND	23	24	27	26	15		
Metal	Aluminum	ND	0.79	0.74	ND	6	0.5	5.6	ND	0.43		
(mg/L)	Arsenic	ND	ND	ND	ND	ND	ND	ND	0.025	ND	0.05	MCL
	Barium	0.29	0.22	0.27	0.11	0.56	0.29	2.2	0.4	0.6	2	MCL
	Cadmium	ND	ND	ND	ND	ND	ND	0.0011	ND	ND	0.005	MCL
	Calcium	26	36	40	24	78	50	35	39	34		
	Chromium	ND	ND	0.075	ND	ND	ND	0.075	ND	0.039	0.1	MCL
	Cobalt	ND	ND	0.0015	ND	0.029	0.0044	0.57	ND	0.16		
	Iron	8.6	2.8	1.3	8.3	11	12	26	17	4.3		
	Lead	ND	ND	**0.017**	ND	0.0083	0.013	0.015	ND	0.011	0.015	
	Magnesium	11	10	18	6.5	31	20	15	14	15		
	Manganese	1.7	0.046	0.63	0.11	0.5	1.1	36	2.8	2.5		
	Mercury	ND	ND	ND	ND	ND	ND	0.0003	ND	ND	0.002	MCL
	Molybdenum	ND	0.0021	0.0061	ND	0.0042	0.0027	0.03	ND	0.011		
	Nickel	0.0057	ND	0.029	ND	0.15	0.0057	0.74	ND	0.74		
	Potassium	2	1.7	2	0.55	1.2	1.4	7.9	1.6	30		
	Selenium	0.0072	0.0061	0.01	ND	0.018	0.012	0.008	0.0061	0.0076	0.05	MCL
	Silver	ND	ND	ND	ND	ND	ND	0.0021	ND	ND	0.05	
	Sodium	64	34	54	170	130	130	74	130	58		
	Uranium	ND	ND	ND	ND	ND	ND	0.0013	ND	ND	0.02	MCL
	Zinc	ND	ND	ND	ND	ND	ND	0.067	ND	0.039		
Dissolved Metal	Barium, Dissolved	0.26	0.18	0.28	0.11	0.57	0.28	**2.1**	0.35	0.52	2	MCL
(mg/L)	Chromium, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	0.021	0.10	MCL
	Uranium, Dissolved	ND	ND	ND	ND	ND	ND	0.0012	ND	ND	0.02	MCL
PHYSC	Dissolved Solids (mg/L)	300	270	290	620	770	530	440	480	290		
PCBs	PCB-1016	ND	ND	ND	ND	ND	ND	1.2	ND	ND		
(µg/L)	PCB-1242	ND	ND	ND	ND	ND	ND	7.9	ND	0.78		
	Polychlorinated biphenyl	ND	ND	ND	ND	ND	ND	**7.9**	ND	**0.78**	0.5	MCL
Rads	Alpha activity	6.8	4.1	ND	ND	9.6	ND	9	ND	5.7	15	MCL
(pCi/L)	Beta activity	**58**	**120**	10	**250**	**83**	ND	**90**	**75**	45	50	MCL
	Strontium-90	ND	ND	ND	ND	ND	ND	ND	11	ND		
	Technetium-99	66	140	21	ND	120	16	170	76	26	900	MCL
	Thorium-234	ND	260	550	ND	1000	670	4500	ND	ND		
VOC	Acetone	ND	ND	10	82	ND	11	14	ND	14		
(µg/L)	Trichloroethene	**10**	ND	**14**	ND	2	ND	**13**	2	**20**	5	MCL
Wetchem	Chemical Oxygen Demand (mg/L)	ND	ND	ND	250	ND	ND	56	39	ND		
	Iodide (mg/L)	ND	ND	ND	ND	ND	2.7	2.7		ND		
	Total Organic Carbon (mg/L)	9.4	1.7	3.6	88	6.7	9.1	26	10	3.3		
	Total Organic Halides (ug/L)	140	12	51	670	77	120	45	260	43		
	Turbidity (NTU)	**18**	**7.7**	**28**	**35**	**100**	**98**	**240**	**28**	**17**	5	MCL

MCL - Maximum Contaminant Level

Bold - exceeds criteria

ND - non detect

VOC - volatile organic compound

The C-746-U Contained Landfill, a solid waste landfill at the Paducah Site, was completed in 1996 and operation was initiated in 1997. Solid waste regulations require groundwater monitoring of the landfill. Monitoring wells were installed in clusters of three. The three well clusters had wells in the UCRS, URGA, and LRGA (Figure 9.7).

Evaluation of the groundwater monitoring data collected for permitted wells at the C-746-U Landfill included immediate reporting to KDWM of results exceeding Kentucky MCLs (401 K.A.R. 47:030, Section 6) and statistical analysis of the results for constituents that do not have an MCL. During 2003, beryllium exceeded contaminant levels in some sidegradient wells. Turbidity exceeded contaminant levels in upgradient, sidegradient, and downgradient wells. PCB levels exceeded contaminant levels in some upgradient, sidegradient, and downgradient wells. TCE exceeded contaminant levels in some upgradient and downgradient wells. KDWM was notified of the exceedences and results were reported to KDWM on a quarterly basis. A summary of the maximum results for upgradient, sidegradient, and downgradient wells in each of the monitored portions of the groundwater system is provided in Table 9.3.

C-746-K Sanitary Landfill Groundwater Monitoring

The C-746-K Sanitary Landfill was used at PGDP between 1951 and 1981 primarily for the disposal of fly ash. Post-closure groundwater monitoring continues for the C-746-K Landfill on a quarterly basis. The UCRS and RGA are not present at the C-746-K site. Wells at the landfill are installed to monitor groundwater in the terrace gravels (Figure 9.7). A summary of the maximum results for each of the wells is provided in Table 9.4. Degradation compounds and TCE, at concentrations above their respective regulatory criterion, were identified in wells around the C-746-K site. Beryllium, lead, and beta activity were also found above regulatory criteria.

Residential (Federal Facility Agreement) Monitoring

The FFA requires sampling of residential wells potentially affected by the contaminant plume (DOE 1998). Currently, only three residential wells (R2, R294, and R302) are sampled monthly. Eighteen other residential wells are monitored semiannually as required by the FFA. All residential wells that are sampled monthly were analyzed for alpha and beta activity, TCE, and ^{99}Tc. As stated previously, the hydrologic unit in which residential wells are screened is uncertain; however, most are believed to be RGA wells. Table 9.5 provides a summary of the maximum detected results for the residential well monthly monitoring program. The 18 residential wells, sampled semiannually, showed no detections of TCE or ^{99}Tc. Three wells showed alpha activity and eight wells showed beta activity. These results are not listed in Table 9.5.

For one residential well, R424, DOE has provided the residents with a carbon filtering system to allow them to have safe drinking water. These filters are replaced semiannually and sampled before and after filter replacement. The groundwater in the well contains TCE above levels established by the EPA Safe Drinking Water Act (SDWA); however, its location makes it highly improbable that the contaminants migrated from the Paducah Site. All residents were notified by mail of the results.

Environmental Surveillance Monitoring

Environmental surveillance monitoring is defined as perimeter-exit-pathway (off-site exposure) monitoring and off-site water well monitoring. Environmental surveillance monitoring is conducted in support of DOE orders and other laws and regulations as addressed in the *Paducah Site Environmental Monitoring Plan* (BJC 2002). Specific wells monitored for environmental surveillance are as follows:

Table 9.3 Summary of maximum groundwater results at C-746-U Landfill

		Lower RGA MWs			UCRS MWs			Upper RGA MWs			Criteria Reference	
	Parameter	Up-gradient	Side-gradient	Down-gradient	Up-gradient	Side-gradient	Down-gradient	Up-gradient	Side-gradient	Down-gradient		
Anion	Bromide	ND	ND	ND	ND	ND	2.1	ND	ND	ND		
(mg/L)	Chloride	41	32	54	22	16	200	30	39	56		
	Fluoride	0.3	0.32	0.28	0.35	1.3	0.33	0.34	0.91	0.26	4	MCL
	Nitrate as Nitrogen	1.1	ND	ND	2.9	ND	ND	ND	ND	ND	10	MCL
	Sulfate	110	23	190	320	110	5.6	100	34	88		
Metal	Aluminum	1.8	0.25	0.61	18	2.7	20	8.2	3.3	2.3		
(mg/L)	Arsenic	ND	0.013	0.015	ND	ND	ND	0.012	ND	0.014	0.05	MCL
	Barium	0.55	0.49	0.32	0.2	0.064	0.24	0.41	0.96	0.42	2	MCL
	Beryllium	ND	ND	ND	ND	ND	ND	ND	**0.005**	ND	0.004	MCL
	Boron	ND	ND	1.3	ND	ND	ND	0.43	ND	0.6		
	Cadmium	0.0034	0.0015	ND	0.0031	0.0017	ND	ND	0.0051	ND	0.005	MCL
	Calcium	42	61	65	50	50	61	39	61	47		
	Cobalt	0.22	0.094	0.14	0.13	0.056	0.0016	0.29	0.86	0.069		
	Iron	19	57	16	36	7.2	14	34	44	18		
	Lead	ND	ND	ND	0.01	ND	0.006	0.0094	0.0055	ND	0.015	
	Magnesium	18	21	27	19	16	16	17	20	18		
	Manganese	15	5	2.5	3.4	0.57	0.68	18	24	0.83		
	Mercury	ND	ND	ND	ND	0.0002	ND	ND	ND	ND	0.002	MCL
	Molybdenum	0.0011	ND	ND	0.0091	0.005	0.0024	0.0015	0.0039	0.001		
	Nickel	0.073	ND	0.026	0.0065	ND	0.0079	0.027	ND	0.019		
	Potassium	2.6	4	2.9	2	1	2.8	2.5	2.9	2.1		
	Selenium	0.0074	ND	ND	ND	ND	0.01	0.0061	ND	0.0074	0.05	MCL
	Sodium	54	51	62	300	100	330	98	110	68		
	Uranium	ND	ND	0.0041	0.0059	ND	0.011	ND	0.0013	ND	0.02	MCL
	Zinc	ND	ND	0.023	0.099	0.093	0.038	ND	ND	ND		
Dissolved Metal	Barium, Dissolved	0.5	0.51	0.29	0.15	0.073	0.22	0.34	0.72	0.35	2	MCL
(mg/L)	Uranium, Dissolved	ND	ND	ND	0.0045	ND	0.0041	ND	0.0015	ND	0.02	MCL
PHYSC	Dissolved Solids	320	610	490	3800	910	1100	590	1200	350		
PCBs	PCB-1016	0.44	ND	0.19	ND	ND	ND	ND	ND	0.6		
(µg/L)	PCB-1242	0.3	ND	0.19	1.3	1.5	ND	0.43	0.79	1.1		
	Polychlorinated Biphenyls	0.44	ND	0.19	**1.3**	**1.5**	ND	0.43	**0.79**	**1.1**	0.5	MCL
Rads	Alpha activity	14	14	6.9	ND	ND	8.5	ND	ND	6.6	15	MCL
(pCi/L)	Beta activity	41	32	34	6.9	ND	6.6	33	40	22	50	MCL
	Radium	ND	1	ND	ND	ND	ND	ND	ND	ND		
	Radium-226	0.4	0.87	0.52	0.18	ND	0.81	1	1	0.35	20	
	Strontium-90	ND	7.6	ND	12	ND	ND	ND	ND	ND		
	Technetium-99	50	39	46	21	ND	ND	55	17	37	900	MCL
VOC	Acetone	890	23	11	8900	3000	430	1900	20	5800		
(µg/L)	Carbon disulfide	7	ND	ND	5	ND	ND	5	6	ND		
	Chloroform	ND	ND	ND	ND	5	ND	ND	ND	ND		
	Iodomethane	ND	ND	ND	120	ND	ND	ND	ND	ND		
	Trichloroethene	ND	ND	**18**	**9**	ND	ND	ND	1	**6**	5	MCL
Wetchem	Chemical Oxygen Demand (mg/L)	37	ND	ND	400	1400	210	140	830	ND		
	Iodide	ND	3.2	ND	3.4	5.7	ND	ND	2.7	ND		
	Total Organic Carbon (mg/L)	9.7	120	3.9	110	730	64	52	320	9		
	Total Organic Halides (µg/L)	19	42	72	1200	69	540	79	530	180		
	Turbidity (NTU)	**53**	**12**	**19**	**68**	**10**	**360**	**180**	**200**	**40**	5	MCL

MCL - Kentucky Maximum Contaminant Level
ND - non detected
Bold - exceeds criteria

Table 9.4 Summary of maximum groundwater results at C-746-K Landfill

	Parameter	MW300	MW301	MW302	MW344	Criteria Reference	
Anion (mg/L)	Chloride	20	20	11	27		
	Sulfate	2900	1600	160	200		
Metal (mg/L)	Aluminum	22	4.6	0.64	22		
	Arsenic	ND	ND	ND	0.011	0.05	MCL
	Barium	0.029	0.055	0.085	0.21	2	MCL
	Beryllium	**0.017**	ND	ND	ND	0.004	MCL
	Cadmium	0.0021	ND	ND	ND	0.005	MCL
	Calcium	440	500	54	100		
	Iron	500	260	5.8	35		
	Lead	**0.019**	ND	ND	0.011	0.015	SDWA
	Magnesium	130	72	34	29		
	Manganese	27	17	1.9	6.2		
	Nickel	0.2	0.0091	0.028	0.057		
	Potassium	21	35	0.34	5		
	Sodium	84	43	100	77		
	Uranium	0.0017	0.0023	ND	ND	0.02	MCL
Metals (pCi/L)	Barium, Dissolved	0.018	0.027	0.077	0.14	2	MCL
Dissolved	Beryllium, Dissolved	**0.016**	ND	ND	ND	0.004	MCL
	Uranium, Dissolved	0.0015	0.0026	ND	ND	0.02	MCL
Rads (pCi/L)	Beta activity	**54**	50	43	ND	50	MCL
	Technetium-99	ND	ND	16	20	900	MCL
	Uranium-238	1.6	2	ND	ND		
VOC (µg/L)	1,1-Dichloroethane	100	ND	ND	ND		
	1,1-Dichloroethene	**180**	ND	ND	ND	7	MCL
	cis-1,2-Dichloroethene	1700	37	ND	ND		
	Trichloroethene	**58**	ND	ND	ND	5	MCL
	Vinyl Chloride	**53**	2	ND	ND	2	MCL

SDWA - Safe Drinking Water Act

MCL - Kentucky Maximum Contaminant Level

ND - non detect

Bold - Exceeds Criteria

Table 9.5 Summary of maximum groundwater results from residential monthly monitoring

Well Number	Alpha activity pCi/L	Beta activity pCi/L	^{99}Tc pCi/L	TCE µg/L
R2	3.8	**63**	69	**230**
R294	2.9	4.8	18	2
R302	7.6	12	20	ND
	MCL=15	MCL=50	MCL=900	MCL=5

ND - non detect

MCL - Kentucky Maximum Contaminant Level

Bold - Exceeds Criteria

• *Semiannual Monitoring Program* - UCRS MWs 96, 149, 166, 174, 192, 180, 186, 182, and 187; RGA MWs 20, 63, 65, 71, 98, 99, 100, 106, 125, 134, 135, 139, 146, 148, 152, 155, 156, 161, 163, 165, 168, 169, 173, 175, 178, 185, 188, 191, 193, 197, 200, 201, 202, 203, 205, 206, 252, 253, 260, 261, 262, 328, 329, 333, 337, 338, 339, 340, 341, 342, 343, 354, 355, 409, 410, and 411; McNairy MW 133 and 356; Rubble Zone MWs 345, 346, 347;

• *Annual Background Monitoring Program* - Terrace Gravels MW196; Eocene Sand MW305; RGA MWs 103, 150, 194, and 199; McNairy MWs 102, 120, 121, and 122;

• *Natural Attenuation Monitoring Program* - RGA MWs 20, 99, 100, 125, 134, 152, 161, 163, 188, 193, 201, 206, 260, 328, 329, 409, 410, and 411; and

• *Annual Radiological Monitoring Program* - MWs 100, 102, 103, 106, 120, 121, 122, 125, 133, 134, 135, 139, 146, 148, 149, 150, 152, 155, 156, 161, 163, 165, 166, 168, 169, 173, 174, 175, 178, 180, 182, 185, 186, 187, 188, 191, 192, 193, 194, 196, 197, 199, 20, 200, 201, 202, 203, 205, 206, 252, 253, 260, 261, 262, 300, 301, 302, 305, 328, 329, 333, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 354, 355, 356, 401 Port 4, 402 Port 5, 403 Port 4, 404 Port 5, 409, 410, 411, 63, 65, 66, 71, 96, 98, and 99.

During 2003, surveillance wells were sampled for volatile organic compounds, metals, radionuclides, alpha and beta activity, carbonaceous biochemical oxygen demand, hardness, and suspended solids. Table 9.6 provides a summary of the maximum detected results for each hydrogeologic unit sampled for the surveillance program. The maximum TCE value reported (from routine monitoring program wells) in the RGA is 190,000 micrograms per liter (µg/L) from MW 156. The well is located at the southeast corner of C-400. This level of TCE is consistent with levels shown at this well in the past. TCE was also detected in the McNairy at 29 µg/L in MW 356. One other well completed in the McNairy (MW 99) showed a TCE detection (18 µg/L).

During 2003, ^{99}Tc activities in the RGA (9050 pCi/L-MW 343) exceeded maximum contaminant levels. Maximum ^{99}Tc activities of 18 pCi/L (MW 133) recorded in the McNairy during 2003 did not exceed MCLs.

Three wells, MW 345, MW 346, and MW 347, have been installed, penetrating the Rubble Zone, which is the formation underlying the McNairy. Uranium was detected in all three wells in 2003 with the highest measurement of 0.0057 mg/L. Thorium-234 was detected in two wells at 644 and 290 pCi/L. No TCE or ^{99}Tc detections were observed in 2003.

MW Rehabilitation

In late 2002, DOE initiated a MW rehabilitation program to enhance the effectiveness of the MWs at the Paducah Site. Well rehabilitation activities were completed in 2003 for a total of 89 wells. The rehabilitation process utilized Blended Chemical Heat Treatment (BCHT™) as either preventive maintenance or full rehabilitation depending on the severity of biofouling in the well. The BCHT™ method consists of three phases designed to remove the accumulated biofilm and blocking materials from the well screen, well bore, and surrounding aquifer. The shock phase uses heated chemicals, which are jetted into the screen and allowed to remain overnight. The disrupt phase continuously applies heated chemicals via jetting. The removal of bio film and blocking material redevelops the MW using surging and airlift pumping techniques. Figure 9.8 shows the MW rehabilitation equipment utilized during this project.

Figure 9.8 MW rehabilitation equipment

Table 9.6 Summary of maximum groundwater results from environmental surveillance monitoring

	Parameter	Eocene	McNairy	RGA	Rubble Zone	Terrace Gravel	UCRS	Criteria	Reference
Anion (mg/L)	Chloride	ND	45	110	ND	ND	63		
	Nitrate as Nitrogen	ND	1.2	4.8	ND	ND	3.7	10	MCL
	Sulfate	ND	9.4	53	ND	ND	140		
Metal (mg/L)	Aluminum	ND	ND	0.61	ND	ND	ND		
	Barium	ND	0.21	0.44	ND	ND	0.86	2	MCL
	Beryllium	ND	ND	ND	ND	ND	**0.0053**	0.004	MCL
	Cadmium	ND	ND	0.0028	ND	ND	0.0026	0.005	MCL
	Calcium	ND	27	34	ND	ND	49		
	Chromium	ND	0.022	**2.5**	ND	ND	**1.1**	0.1	MCL
	Cobalt	ND	0.02	0.21	ND	ND	0.27		
	Copper	ND	ND	0.033	ND	ND	0.044		
	Iron	ND	0.57	18	ND	ND	48		
	Lead	ND	ND	0.0056	ND	ND	**0.02**	0.015	
	Magnesium	ND	11	14	ND	ND	19		
	Manganese	ND	0.18	9.1	ND	ND	26		
	Molybdenum	ND	0.0053	0.06	ND	ND	0.0071		
	Nickel	ND	0.0091	1.9	ND	ND	0.92		
	Phosphorous	ND	ND	0.32	ND	ND	ND		
	Potassium	ND	1.2	9.2	ND	ND	6.4		
	Selenium	ND	ND	0.014	ND	ND	0.0073	0.05	MCL
	Total Metals	ND	ND	21	ND	ND	ND		
	Uranium	0.0023	0.0016	0.0062	0.0057	ND	**0.17**	0.02	MCL
Rads (pCi/L)	Alpha activity	14	ND	**50**	7	ND	**92**	15	MCL
	Beta activity	ND	12	**5800**	11	29	**590**	50	MCL
	Dissolved Alpha	ND	ND	**74**	ND	ND	**62**	15	MCL
	Dissolved Beta	ND	ND	**4200**	ND	ND	**570**	50	MCL
	Potassium-40	ND	ND	340	ND	ND	380		
	Suspended Alpha	7.6	ND	5.6	ND	ND	ND	15	MCL
	Suspended Beta	ND	ND	23	ND	ND	ND	50	MCL
	Technetium-99	18	18	**9000**	ND	ND	820	900	MCL
	Thorium-230	ND	ND	0.76	ND	ND	1.6		
	Thorium-232	ND	ND	0.16	ND	ND	0.26		
	Thorium-234	ND	ND	1100	640	ND	1100		
	Uranium-235	ND	ND	0.7	ND	ND	0.54		
	Uranium-238	2	ND	5.5	ND	ND	160		
VOC (µg/L)	1,1-Dichloroethane	ND	ND	17	ND	ND	ND		
	1,1-Dichloroethene	ND	ND	**30**	ND	ND	**10**	7	MCL
	Carbon tetrachloride	ND	ND	170	ND	ND	ND	5	MCL
	cis-1,2-Dichloroethene	ND	ND	**360**	ND	ND	**490**		
	Trichloroethene	ND	**29**	**190000**	ND	ND	**16000**	5	MCL
	Vinyl chloride	ND	ND	**720**	ND	ND	ND	2	MCL
Wetchem (mg/L)	Chromium, hexavalent	ND	ND	0.02	ND	ND	ND	0.1	MCL
	Hardness - Total as CaCO3	ND	ND	180	ND	ND	ND		
	Suspended Solids	ND	ND	76	ND	ND	ND		
	Total Organic Compounds	ND	13	48	ND	ND	190		

MCL - Kentucky Maximum Contaminant Level
ND - not detect
Bold - exceeds criteria

Environmental Restoration Activities

Northwest Plume Monitoring

The site continued operations of the NWPGS. This action, which started operation in 1995, is to contain off-site migration of the high-concentration section of the Northwest Plume. This was the first phase of the high-concentration portion of remedial action for groundwater at the Paducah Site. Two extraction wells near a source of the Northwest Plume and two additional extraction wells farther north, near the centroid of the plume, were installed. Each set of extraction wells is surrounded by an MW network (Figure 9.9). The network is used for monitoring groundwater quality and water levels to determine the effectiveness of the interim action.

Trends in TCE for 2003 were similar to those of 2002. The 2003 maps continue to document a division in the north end of the Northwest Plume. Both TCE and ^{99}Tc detections in the seeps of Little Bayou Creek suggest that a core of contaminant flow migrates downstream along the creek in the area of Tennessee Valley Authority Shawnee Steam Plant's settling ponds. The most notable change in the 2003 maps is the interpretation that the core of the Northwest Plume has migrated to the east of the north well field in both the middle and lower RGA.

The 2003 ^{99}Tc maps for the Northwest Plume depict three cores of contamination migrating from the north side of PGDP. A significant change is the interpretation of the source of that resulted in ^{99}Tc in MW 152 near the Shawnee Steam Plant. The MW 152 ^{99}Tc contamination is attributed to the main core of the Northwest Plume (BJC 2004d).

Summaries of the program's monitoring results are listed in tables 9.7 and 9.8. The data for this program are reported in the FFA Semiannual Progress Report.

Northeast Plume Monitoring

EPA approved an Interim ROD for treatment of the Northeast Plume in June of 1995. Implementation of the ROD was completed in 1996 and operation began in 1997, which consisted of construction of two extraction wells, several MWs (Figure 9.10) with piezometers, and facilities required to transfer the TCE-contaminated water to the C-637 Cooling Tower for treatment. Groundwater quality and water-level information obtained from the piezometers and MWs are used to evaluate the effectiveness of the remedial action. The upgradient MWs are used to detect possible ^{99}Tc contamination within the high-concentration area of the plume before it reaches the extraction wells.

Within the Northeast Plume, TCE trends supported showing that a large area of the Northeast Plume, located west of the Northeast Plume well field, had responded to the pump-and-treat system with significantly reduced contaminant levels. In the LRGA, sharply declining TCE trends in MW 255 and MW 258 indicated that the area of higher concentration has migrated northeastward. Meanwhile, the TCE values for MW 99 in 2003 continue to indicate that the tip of the Northeast Plume is migrating northwestward in the middle RGA. Contaminant levels generally are less than 25 pCi/L offsite and are only greater than 100 pCi/L at a few discrete locations. One significant change was required for the CY 2003 map. The continuing rise in ^{99}Tc levels well MW 256 and consistent detection in MW 292 during 2003 indicated that a discrete core of ^{99}Tc had migrated approximately 0.5 miles outside the security-fenced area along the trend of the Northeast Plume (BJC 2004d).

A summary of the program's monitoring results is listed in Table 9.9. The data for this program are reported in the FFA Semiannual Progress Report.

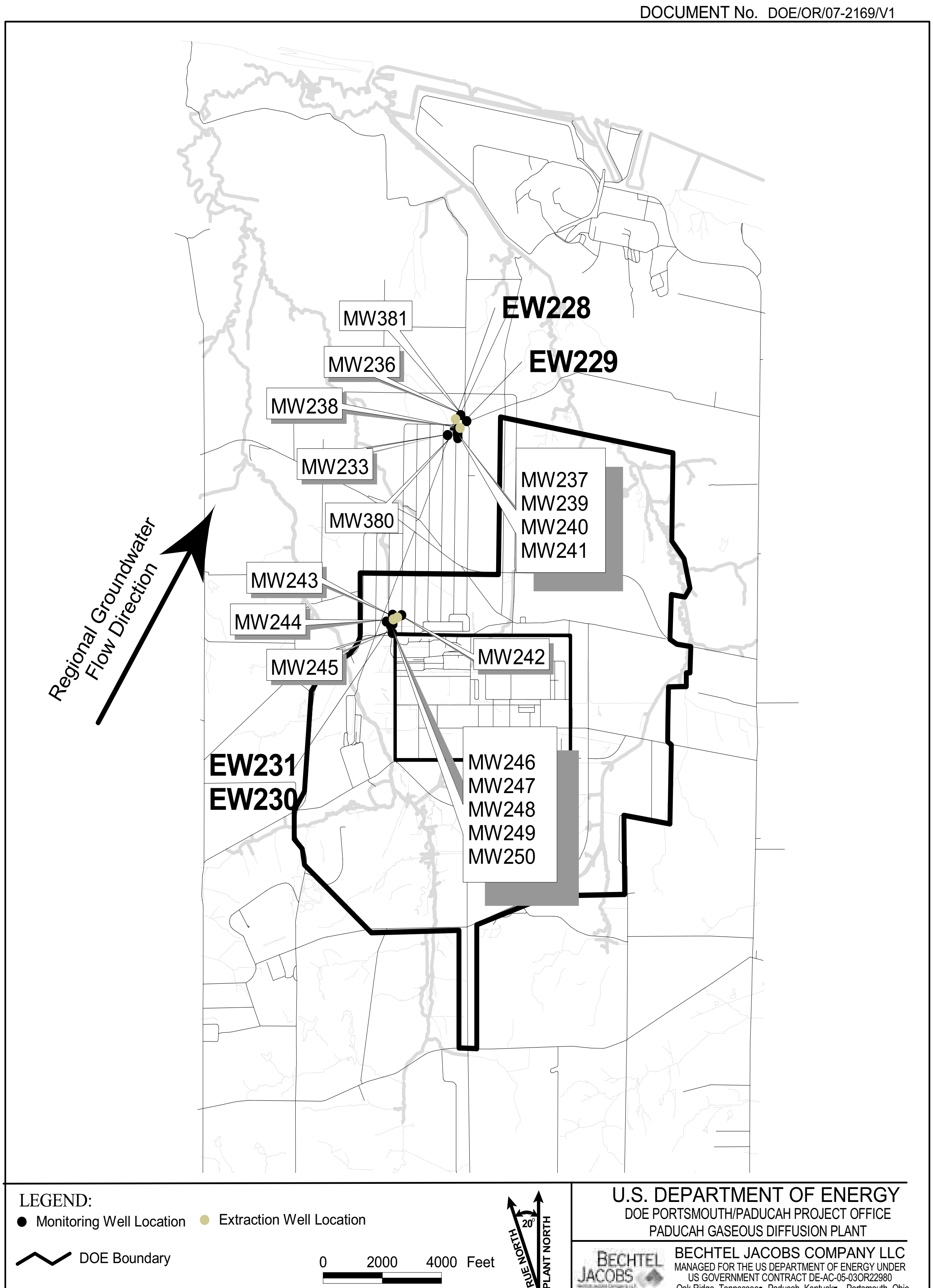


Figure 9.9 Northwest plume monitoring wells

FIGURE No. c5ac90002sk097.apr
DATE 01-13-04

Table 9.7 Summary of maximum groundwater results from the Northwest Plume north field groundwater monitoring

	Analysis	MW 233	MW 236	MW 237	MW 238	MW 239	MW 240	MW 241A	MW 380	MW 381	Criteria	Reference
Anions (mg/L)	Chloride	29	26	3.2	26	22	27	27	26	36		
	Fluoride	0.17	0.16	0.61	0.15	0.33	0.17	0.15	0.15	0.15	4	MCL
	Nitrate as Nitrogen	2	1.7	ND	1.8	ND	1.6	1.6	1.8	1.9	10	MCL
	Sulfate	14	23	55	19	17	15	16	22	22		
Field (mg/L)	Turbidity (NTU)	**16**	**10**	**130**	**65**	**68**	**64**	**16**	**9.4**	**8.1**	5	MCL
Metals (mg/L)	Aluminum	0.22	0.22	11	1.2	0.74	0.25	ND	0.37	ND		
	Barium	0.26	0.17	0.23	0.15	0.029	0.25	0.14	0.17	0.18	2	MCL
	Beryllium	ND	ND	ND	ND	0.0011	ND	ND	ND	ND	.004	MCL
	Calcium	23	24	42	23	25	22	22	25	28		
	Cobalt	0.0071	0.0028	0.061	0.0015	0.0037	0.0023	ND	0.001	ND		
	Iron	0.22	0.55	11	2.8	25	0.64	0.23	0.35	0.24		
	Lead	ND	ND	ND	0.0058	0.0056	ND	0.006	0.0057	ND	.015	
	Magnesium	9.3	9.5	14	9	8.1	8.6	8.7	9.7	11		
	Manganese	2.7	0.83	0.45	0.14	0.83	1	0.0072	0.5	0.21		
	Molybdenum	ND	0.0027	0.0012	ND	ND	ND	ND	ND	ND		
	Nickel	0.039	ND	0.053	ND	0.0068	ND	ND	ND	ND		
	Potassium	1.5	1.4	0.97	1.4	8	1.4	1.5	1.5	1.7		
	Silver	ND	ND	0.0016	ND	ND	ND	ND	ND	ND	0.05	
	Sodium	34	32	110	30	65	30	33	32	36		
	Zinc	ND	ND	ND	ND	0.044	ND	ND	0.025	ND		
Metals Dissolved(mg/L)	Aluminum, Dissolved	ND	ND	1.8	ND	ND	ND	ND	ND	ND		
	Barium, Dissolved	0.26	0.17	0.22	0.14	0.028	0.23	0.14	0.16	0.17	2	MCL
	Calcium, Dissolved	23	24	33	22	24	22	22	25	29		
	Cobalt, Dissolved	0.007	0.003	0.073	ND	0.0035	0.002	ND	ND	ND		
	Iron, Dissolved	ND	ND	8.9	ND	23	ND	ND	ND	ND		
	Magnesium, Dissolved	9	9.2	11	8.6	8.1	8.5	8.6	9.5	10		
	Manganese, Dissolved	2.9	0.82	0.38	0.098	0.78	0.97	ND	0.48	0.19		
	Molybdenum, Dissolved	ND	0.0032	ND	ND	ND	ND	ND	ND	ND		
	Nickel, Dissolved	0.039	ND	ND	ND	0.006	ND	ND	ND	ND		
	Potassium, Dissolved	1.4	1.3	0.52	1.2	7.9	1.3	1.3	1.2	1.6		
	Sodium, Dissolved	34	33	93	30	75	31	33	32	39		
Physc (pCi/L)	Dissolved Solids	160	170	320	140	140	160	160	170	200		
Rads (pCi/L)	Alpha activity	ND	5.3	ND	6	ND	ND	ND	ND	ND	15	MCL
	Beta activity	11	**190**	ND	**93**	13	18	12	**180**	**240**	50	MCL
	Technetium-99	22	220	ND	110	ND	22	24	240	330	900	MCL
VOC (µg/L)	Trichloroethene	**11**	**490**	ND	**270**	ND	**37**	**25**	**570**	**690**	5	MCL
Wetchem (mg/L)	Alkalinity	86	84	130	81	32	100	84	84	90		
	Silica	15	14	94	15	46	14	13	14	14		
	Total Organic Carbon (mg/L)	1	1.4	18	1	1.8	ND	5.1	1.7	ND		

MCL - Kentucky Maximum Contaminant Level
ND - non detect
Bold - exceeds criteria

Table 9.8 Summary of maximum groundwater results from the Northwest Plume south field groundwater monitoring

	Parameter	MW 242	MW 243	MW 244	MW 245	MW 246	MW 247	MW 248	MW 249	MW 250	Criteria	Reference
Anion (mg/L)	Chloride	65	56	32	17	2.9	8.1	53	20	28		
	Fluoride	0.18	0.13	0.15	0.28	0.41	0.17	0.14	0.18	0.16	4	MCL
	Nitrate as Nitrogen	ND	1.5	1.3	ND	ND	ND	3	ND	1	10	MCL
	Sulfate	7.3	11	12	8.9	92	11	10	9.2	13		
Metal (mg/L)	Aluminum	6.4	0.86	ND	45	4.3	7.3	0.96	3	0.33		
	Barium	0.58	0.15	0.15	1.5	0.049	0.11	0.18	0.25	0.099	2	MCL
	Cadmium	ND	ND	ND	0.0022	ND	ND	ND	ND	ND	.005	MCL
	Calcium	32	30	22	85	23	23	25	23	22		
	Cobalt	0.038	0.0046	0.0021	0.33	ND	ND	0.0013	0.0046	ND		
	Iron	35	4.2	0.17	55	2.7	34	1.3	5.3	0.51		
	Lead	ND	ND	ND	0.013	ND	ND	ND	ND	ND	.015	
	Magnesium	12	11	8.3	30	8.6	13	11	8.7	8.4		
	Manganese	6.5	0.51	0.37	40	0.019	1	0.79	3.7	0.022		
	Molybdenum	0.0056	0.0047	0.0046	0.0028	ND	0.002	ND	ND	ND		
	Nickel	0.059	0.015	ND	0.14	ND	0.013	0.0068	0.0092	ND		
	Potassium	1.8	1.1	1.1	7.7	0.57	5.9	1.1	1.4	1.1		
	Sodium	28	30	32	98	83	33	30	31	32		
Dissolved Metal (mg/L)	Zinc	ND	ND	0.11	ND	ND	0.1	ND	ND	ND		
	Aluminum, Dissolved	ND	ND	ND	3.9	ND	0.23	ND	ND	ND		
	Barium, Dissolved	0.55	0.14	0.13	1.1	0.04	0.1	0.17	0.23	0.09	2	MCL
	Calcium, Dissolved	32	29	21	78	22	24	26	23	22		
	Cobalt, Dissolved	0.031	0.0033	0.002	0.31	ND	ND	0.0013	0.0047	ND		
	Iron, Dissolved	31	3.3	ND	30	ND	34	ND	2.2	ND		
	Magnesium, Dissolved	12	11	8.3	26	8.8	13	11	8.7	8.7		
	Manganese, Dissolved	6.2	0.51	0.36	38	0.015	0.98	0.82	3.6	0.02		
	Molybdenum, Dissolved	0.0039	0.0057	0.0053	ND	ND	ND	ND	ND	ND		
	Nickel, Dissolved	0.052	0.015	ND	ND	ND	ND	0.006	0.0083	ND		
	Potassium, Dissolved	1	1	1.1	3.9	ND	6.1	0.99	1.3	1		
	Sodium, Dissolved	29	29	32	93	87	36	31	36	33		
	Zinc, Dissolved	ND	ND	0.11	ND	ND	ND	ND	ND	ND		
PHYSC (pCi/L)	Dissolved Solids	260	220	150	560	260	210	210	130	170		
RADS (pCi/L)	Alpha activity	6.2	ND	ND	ND	ND	8.2	**19**	4.7	ND	15	MCL
	Beta activity	**110**	**310**	38	48	ND	12	**690**	27	29	50	MCL
	Radon	ND	ND	ND	250	**1100**	ND	240	ND	ND	300	MCL
	Technetium-99	130	360	46	42	ND	29	**910**	43	43	900	MCL
VOC (µg/L)	cis-1,2-Dichloroethene	32	ND	ND	ND	ND	ND	ND	ND	ND		
	Trichloroethene	**110**	**900**	**6**	**150**	ND	ND	**4600**	**110**	**26**	5	MCL
	Vinyl Chloride	**4**	ND	ND	ND	ND	ND	ND	ND	ND	2	MCL
WETCHEM	Alkalinity (mg/L)	89	64	93	87	140	64	71	69	88		
	Silica (mg/L)	22	17	20	82	28	56	15	19	16		
	Turbidity (NTU)	**86**	**21**	**16**	**950**	**59**	**87**	**30**	**40**	**16**	5	MCL
	Total Organic Carbon	5	ND	ND	92	ND	22	ND	ND	ND		

MCL - Kentucky Maximum Contaminant Level
ND - Non detect
Bold - Exceeds criteria

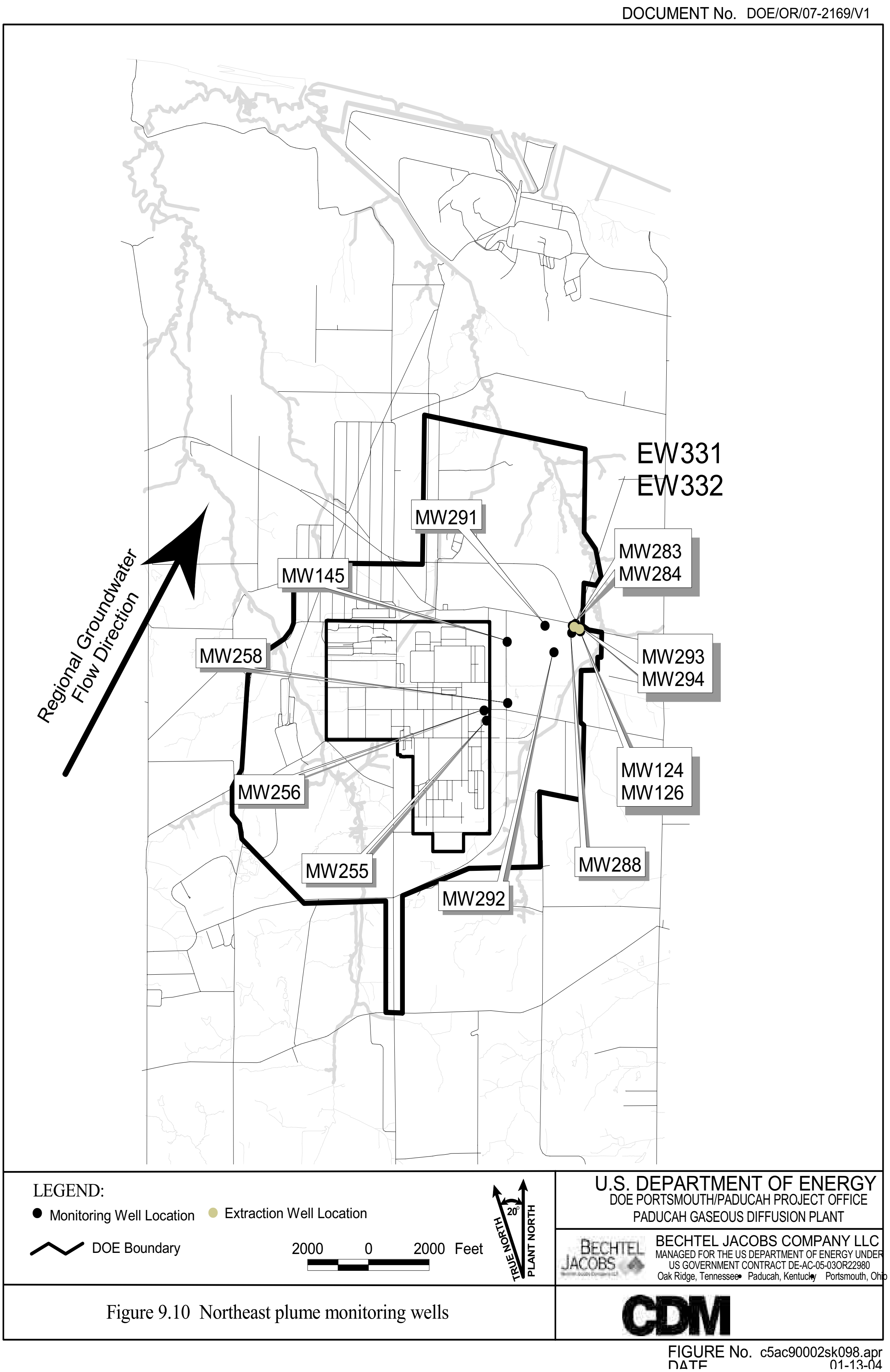


Figure 9.10 Northeast plume monitoring wells

Table 9.9 Summary of maximum groundwater results from the Northeast Plume groundwater monitoring

	Parameter	MW 124	MW 126	MW 145	MW 255	MW 256	MW 258	MW 283	MW 284	MW 288	MW 291	MW 292	MW 293A	MW 294A	Criteria Reference	
Anion	Chloride	49	54	100	56	53	54	73	71	69	56	62	56	53		
(mg/L)	Fluoride	0.22	0.18	0.2	0.37	0.24	0.26	0.14	0.14	0.16	0.17	0.18	0.2	0.16	4	MCL
	Nitrate as Nitrogen	3	1.4	ND	ND	ND	1.3	1.2	1.2	1.2	1.2	1.4	2.4	3.7	10	MCL
	Sulfate	22	11	96	16	29	24	8.1	5.9	17	8.9	16	13	11		
Metal	Aluminum	2	ND	0.78	19	1.2	2.7	ND	ND	ND	ND	ND	0.31	0.55		
(mg/L)	Barium	0.19	0.19	0.072	**2.2**	0.19	0.14	0.29	0.28	0.26	0.2	0.22	0.22	0.24	2	MCL
	Beryllium	ND	ND	ND	0.0011	ND	ND	ND	ND	ND	ND	ND	ND	ND	.004	MCL
	Calcium	21	22	47	30	27	23	26	26	29	20	31	27	22		
	Chromium	0.029	ND	0.056	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	MCL
	Cobalt	0.012	0.0021	ND	0.24	0.022	0.0027	ND	ND	ND	0.0033	ND	0.0051	0.0013		
	Iron	2.3	0.27	0.35	20	0.72	1.4	0.12	0.11	ND	0.3	ND	0.2	0.38		
	Lead	ND	ND	ND	0.0085	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.015	
	Magnesium	8.8	8.6	19	13	11	9.5	11	10	12	7.9	12	8.8	8.7		
	Manganese	1.5	0.042	0.042	35	1.3	0.062	0.021	ND	ND	0.074	0.0088	0.36	0.071		
	Molybdenum	ND	ND	ND	0.0075	0.0019	ND	0.0019	0.0014	0.0012	0.0013	0.0053	ND	ND		
	Nickel	0.013	ND	0.0075	0.11	0.0073	ND	ND	ND	ND	ND	ND	0.0084	ND		
	Potassium	1.8	1.4	5.1	3.3	2.9	1.9	1.4	1.6	1.7	1.3	2	1.9	2.1		
	Selenium	ND	0.011	ND	ND	0.0053	0.008	0.0066	0.0087	0.011	0.0072	0.011	0.012	0.013	0.05	MCL
	Sodium	47	45	62	80	59	58	34	35	46	37	59	41	41		
	Uranium	ND	ND	ND	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.02	MCL
Dissolved Metal	Barium, Dissolved	0.18	0.19	0.063	0.18	0.16	0.12	0.29	0.27	0.25	0.21	0.22	0.22	0.23	2	MCL
(mg/L)	Calcium, Dissolved	22	23	48	29	27	23	28	27	30	20	29	27	22		
	Cobalt, Dissolved	0.013	0.0021	ND	0.23	0.022	0.0028	ND	ND	ND	0.0027	ND	0.0051	ND		
	Iron, Dissolved	0.22	ND	ND	2.1	ND	ND	ND	ND	ND	ND	ND	ND	ND		
	Magnesium, Dissolved	9	8.9	19	12	10	9.2	12	11	12	8.1	11	8.8	8.7		
	Manganese, Dissolved	1.6	0.046	0.045	37	1.3	0.061	0.023	ND	ND	0.083	0.0099	0.35	0.066		
	Molybdenum, Dissolved	ND	ND	ND	0.0057	0.002	ND	ND	ND	ND	0.0013	0.0065	ND	ND		
	Nickel, Dissolved	0.012	ND	ND	0.087	0.0061	ND	ND	ND	ND	ND	ND	0.0081	ND		
	Potassium, Dissolved	1.6	1.4	5.3	1.6	3.1	1.7	1.5	1.6	1.8	1.4	1.8	2	2		
	Selenium, Dissolved	ND	0.0088	ND	ND	ND	0.007	0.0053	0.0057	0.0073	0.005	0.0086	0.0083	0.011	0.05	MCL
	Sodium, Dissolved	45	43	67	83	64	60	36	35	46	37	52	41	39		
	Uranium, Dissolved	ND	ND	ND	0.0017	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.02	MCL
PHYSC	Dissolved Solids	230	220	430	520	300	270	260	230	260	210	260	230	240		
Rads	Alpha activity	ND	ND	ND	9.5	6.1	ND	ND	ND	ND	3.5	ND	4	ND	15	MCL
(pCi/L)	Beta activity	ND	6.9	22	ND	**110**	11	9	6.5	24	ND	18	ND	ND	50	MCL
	Technetium-99	ND	ND	29	19	130	ND	18	16	50	26	35	ND	ND	900	MCL
VOC	1,1-Dichloroethene	ND	ND	ND	ND	**93**	ND	ND	ND	ND	ND	ND	ND	ND	7	MCL
(µg/L)	cis-1,2-Dichloroethene	ND	ND	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
	Trichloroethene	**160**	3	**75**	**520**	**420**	**640**	**150**	**150**	**470**	**150**	**550**	**480**	**810**	5	MCL
Wetchem	Alkalinity (mg/L)	91	86	130	280	160	150	89	81	100	73	120	88	69		
	Silica (mg/L)	9	11	13	13	12	14	11	12	11	10	11	13	11		
	Turbidity (NTU)	**110**	**120**	**44**	**470**	**28**	**98**	**18**	**28**	**60**	**50**	**36**	**5.8**	**70**	5	MCL
	Total Organic Carbon (mg/L)	ND	ND	1.3	30	ND	ND	ND	ND	ND	ND	ND	ND	ND		

MCL - Kentucky Maximum Contaminant Level
ND - non detect
Bold - exceeds criteria

Groundwater Monitoring Results

The primary objectives of groundwater monitoring at the Paducah Site are being met by the monitoring programs. Contamination has been detected in groundwater offsite. Through the monitoring program, in conjunction with RIs, a footprint of the groundwater contamination has been mapped and is annually updated. The program continues to expand each year to further delineate the boundaries of the footprint over time and to identify source locations for contaminants. Monitoring wells upgradient and downgradient from individual underground waste disposal facilities are sampled and analyzed for contaminants of concern. Contaminants identified by the monitoring program are evaluated by technical assessment and statistical analysis as required by permit, legal agreements, and other standard environmental practices to determine if the source of the contaminants could be from the disposal site being monitored. Beta activity, TCE, and ^{99}Tc are found in the off-site and on-site contamination plumes. Groundwater monitoring results from all sampling efforts conducted by the Paducah Site are compiled in the Paducah Oak Ridge Environmental Information System (OREIS) database. A complete listing of analytical results is available upon request from the BJC Public Affairs Department.

A more detailed interpretation of the TCE and ^{99}Tc groundwater contamination and plumes within the RGA is available from the DOE EIC in *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2003 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (BJC 2004d). However, Figure 9.1 shows offsite groundwater plumes.

10 Quality Assurance

Abstract

The Paducah Site maintains a Quality Assurance/Quality Control (QA/QC) Program to verify the integrity of data generated within the Environmental Monitoring Program. Monitoring and sampling organizations at Paducah select sampling methods, instruments, locations, schedules, and other sampling and monitoring criteria based on applicable guidelines from various established authorities.

Introduction

The Paducah Site maintains a QA/QC Program to verify the integrity of data generated within the Environmental Monitoring Program. Each aspect of the monitoring program, from sample collection to data reporting, must address quality requirements and assessment standards. Requirements and guidelines for the QA/QC Program at the Paducah Site are established by DOE Order 414.1, *Quality Assurance*; state and federal regulations; and documentation from the EPA, the American National Standards Institute, the American Society of Mechanical Engineers, the American Society of Testing and Materials (ASTM), and the American Society for Quality Control. The QA/QC Program specifies organizational and programmatic elements to control equipment, design, documents, data, nonconformances, and records. Emphasis is placed on planning, implementing, and assessing activities. These Program requirements are specified in project and subcontract documents to ensure that requirements are included in project-specific QA plans and other planning documents.

The *Environmental Services Subcontract Quality Assurance and Data Management Plan (EQADMP)* defines the relationship of each element of the Environmental Monitoring Program to key quality and data management requirements. Training requirements, sample custody, procedures, instrument calibration and maintenance, and data review are a few of the subjects discussed in the EQADMP. In 2003, a variety of functions were performed for the Environmental Monitoring Program, such as conducting surveillances, reporting problems, reviewing data, reviewing procedures, and revising the EQADMP.

Field Sampling Quality Control

Data Quality Objectives and Sample Planning

From the point of conception of any sampling program, data quality objectives (DQOs) play an important role. The number of samples, location of sampling sites, sampling methods, sampling schedules, and coordination of sampling and analytical resources to meet critical completion times are part of a DQO process and are documented in the *Paducah Site Environmental Monitoring Plan* (BJC 2002).

Each sampling location and sample collected is assigned a unique identification number, which consists of an alpha numeric sequence. Each segment of the sequence is used to designate information concerning the location from which a sample is collected. In order to progress from planning to implementing the DQOs, an analytical statement of work (SOW) for the analytical laboratory is generated from a system within the Paducah Integrated Data System. From this system, the Project Environmental Measurements System (PEMS), an electronic database used for managing and streamlining field-generated and laboratory-generated data, is populated with sample identification numbers, sampling locations, sampling methods, analytical parameters, analytical methods, and sample container and preservative requirements. This information is used to produce sample bottle labels and chain-of-custody forms for each sampling event.

Field Measurements

Field measurements for the groundwater and surface water monitoring program are collected in the field and include water level measurements, pH, conductivity, flow rate, turbidity, temperature, dissolved oxygen, total residual chlorine, and barometric pressure. Environmental conditions, such as ambient temperature and weather, are also recorded. Field measurements are collected and either downloaded electronically, recorded on appropriate field forms, or recorded in logbooks, and input into PEMS.

Sampling Procedures

Samples are collected using media-specific procedures, which are written according to EPA-approved sampling methods. Sample media consist of surface water, groundwater, sediment, and biota, such as fish and deer. Sample information recorded during a sampling event consists of the following: sample identification number, station (or location), date collected, time collected, person who performed the sampling, etc. This information is documented in a logbook and on a chain-of-custody form and sample container label, and input directly into PEMS on a weekly or other appropriate basis. Chain-of-custody forms are maintained from the point of sampling, and samples are properly protected until they are placed in the custody of an analytical laboratory.

Field Quality Control Samples

The QC program for both groundwater and environmental monitoring activities specifies a minimum target rate of 5 percent, or one per 20 environmental samples, for field QC samples. Table 10.1 shows the types of field QC samples collected and analyzed. Analytical results of field QC samples are evaluated to determine if the sampling event had any affect on the sample results.

Analytical Laboratory Quality Control

Analytical Procedures

When available and appropriate for the sample matrix, EPA-approved SW-846 methods are used for sample analysis. When SW-846 methods are not available, other nationally recognized methods, such as those developed by DOE and ASTM, are used. Analytical methods are

Table 10.1 Types of QC samples

Field QC Samples	Laboratory QC Samples
Field blanks[a]	Laboratory duplicates
Field duplicates	Reagent blanks
Trip blanks[a]	Matrix spikes[b]
Equipment rinseates	Matrix spike duplicates
	Surrogates
	Performance evaluations
	Laboratory control samples

a Blanks – samples of deionized water used to assess potential contamination from a source other than the media being sampled.

b Spikes – samples that have been mixed with a known quantity of a chemical to measure instrument effectiveness during the analysis process.

identified in an analytical SOW. Using guidance from EPA, laboratories document the steps in handling, analysis, and approval of results. Chain-of-custody procedures are followed until a sample is analyzed.

Laboratory Quality Control Samples

Laboratory QC samples are prepared and analyzed as required by the analytical methods used. Typical laboratory QC samples are identified in Table 10.1. If acceptance criteria are not met for the QC samples, then appropriate action, as denoted by the analytical method, is taken or the analytical data are appropriately qualified.

Independent Quality Control

The Paducah Site is directed by DOE and EPA requirements to participate in independent QC programs. The site also participates in voluntary independent programs to improve analytical QC. These programs generate data that are readily recognizable as objective measures, allowing participating laboratories and government agencies a periodic review of their performance. Results that exceed acceptable limits are investigated and documented according to formal procedures. Although participation in certain programs is mandated, the degree of participation is voluntary so that each laboratory can select parameters of particular interest to that facility. These programs are conducted by EPA, DOE, and commercial laboratories.

Laboratory Audits/Sample Management Office

Laboratory audits are performed periodically by the BJC Oak Ridge Sample Management Office (SMO) to ensure that the laboratory is in compliance with regulations, procedures, and the contract between the laboratory and the SMO. Findings are documented and addressed by the audited laboratory through corrective actions.

Data Management

Project Environmental Management System

The data generated from sampling events are stored in PEMS, a consolidated site data system for tracking and managing data. The system is used to manage field-generated data; import laboratory-generated data; input data qualifiers identified during the data review process; and transfer data to the Paducah OREIS for reporting. PEMS uses a variety of references and code lists to ensure consistency and standardization of the data.

Paducah OREIS

Paducah OREIS is the database used to consolidate data generated by the Environmental Management Program. Data consolidation consists of the activities necessary to prepare the evaluated data for the users. The PEMS files containing the assessed data are transferred from PEMS to Paducah OREIS for future use. The data manager is responsible for notifying project team and other data users of the data availability. Data used in reports distributed to external agencies (e.g., the quarterly landfill reports, the ASER, and the biological monitoring program reports) are obtained from Paducah OREIS and have been through the data review process.

Electronic Data Deliverables

A "results only" Electronic Data Deliverable (EDD) is requested for all samples analyzed by each laboratory. The results and qualifier information from the EDD are checked in addition to the format of all fields provided. Discrepancies are immediately reported to the laboratory so corrections can be made or new EDDs can be issued. Approximately 10 percent of the EDDs are randomly checked to verify that the laboratory continues to provide adequate EDDs.

Data Packages

A "forms only" Level III data package is requested from the laboratory when data validation is to be performed on a specific sampling event or media. All data packages received from the fixed-base laboratory are tracked, reviewed, and maintained in a secure environment. The following information is tracked: sample delivery group number; date received; number of samples; sample analyses; receipt of the EDD, if applicable; and comments. The contents of the data package and the chain-of-custody forms are compared and discrepancies are identified. Discrepancies are immediately reported to the laboratory and data validators. All data packages are forwarded to the PGDP Environmental Management and Enrichment Facilities Document Management Center for permanent storage.

Laboratory Contractual Screening

Laboratory contractual screening is the process of evaluating a set of data against the requirements specified in the analytical SOW to ensure that all requested information is received. The contractual screening includes, but is not limited to, the chain-of-custody form, number of samples, analytes requested, total number of analyses, method used, QC samples analyzed, EDDs, units, holding times, and reporting limits achieved. The contractual screening is conducted electronically upon receipt of data from the analytical laboratory. Any exception to the SOW is identified and documented.

Data Verification, Validation, and Assessment

Data verification is the process for comparing a data set against a set standard or contractual requirement. Verification is performed electronically, manually, or by a combination of both. Data verification includes contractual screening and other criteria specific to the data. Data are flagged as necessary. Verification qualifiers are stored in PEMS and transferred with the data to Paducah OREIS.

Data validation is the process performed by a qualified individual for a data set, independent from sampling, laboratory, project management, or other decision-making personnel. Data validation evaluates the laboratory adherence to analytical method requirements. Validation qualifiers are stored in PEMS and transferred with the data to Paducah OREIS. Data from routine sampling events are validated programmatically at a frequency of 5 percent of the total data packages. Each of the selected data packages, which make up 5 percent of the total number of data packages, is validated 100 percent.

Data assessment is the process for assuring that the type, quality, and quantity of data are appropriate for their intended use. It allows for the determination that a decision (or estimate) can be made with the desired level of confidence, given the quality of the data set. Data assessment follows data verification and data validation (if applicable) and must be performed at a rate of 100 percent to ensure data are useable. The data assessment is conducted by trained technical personnel in conjunction with other project team members. Assessment qualifiers are stored in PEMS and transferred with the data to Paducah OREIS. Data are made available for reporting from Paducah OREIS upon completion of the data assessment, and associated documentation is filed with the project files.

The EPA and KDOW require, as part of their QA program, a laboratory QA study. Each laboratory performing analyses to demonstrate KPDES permit compliance are required to participate. Two laboratories and one sampling organization participated in the study in 2003. Final results for the DMR QA study were “acceptable.” These results were provided to KDOW and EPA as required.

References

BJC 2004a. *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1849&D2R1, Bechtel Jacobs Company LLC, Paducah, KY.

BJC 2004b. *Annual Report on External Gamma Radiation Monitoring for Calendar Year 2003 for the Paducah Gaseous Diffusion Plant*, BJC/PAD-623, Bechtel Jacobs Company LLC, Paducah, KY.

BJC 2004c. *Watershed Monitoring Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-613, Bechtel Jacobs Company LLC, Paducah, KY.

BJC 2004d. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifier for Calendar Year 2003 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-169/R3, Bechtel Jacobs Company LLC, Paducah, KY.

BJC 2003. *Groundwater Protection Management Program for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-497, Bechtel Jacobs Company LLC, Paducah, KY.

BJC 2002. *Paducah Site Environmental Monitoring Plan*, BJC/PAD-285/R1, Bechtel Jacobs Company LLC, Paducah, KY.

BJC 2001. *Groundwater Protection Plan*, Bechtel Jacobs Company LLC, Paducah Gaseous Diffusion Plant, Paducah, KY.

CDM 1994. *Investigation of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant*, 7916-003-FR-BBRY, CDM Federal Services, Inc., Paducah, KY.

CH2M Hill 1992a. *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/SUB/13B-97777C P-03/1991/1, CH2M Hill, Paducah, Kentucky.

CH2M Hill 1992b. *Results of the Public Health and Ecological Assessment, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/SUB/13B-97777C P-03/1991/1, CH2M Hill, Paducah, Kentucky.

CH2M Hill 199la. *Results of the Public Health and Ecological Assessment, Phase II at the Paducah Gaseous Diffusion Plant* (Draft), KY/SUB/13B-97777C P-03/1991/1, CH2M Hill, Paducah, KY.

CH2M Hill 1991b. *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/ER-4, CH2M Hill, Paducah, KY.

COE 1994. *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky*, Five Volumes, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

DOC 1994. *County Business Patterns 1992*, Economics and Statistics Administration, Bureau of the Census, U.S. Department of Commerce.

DOE 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant,* DOE/OR/07-1707, EPA Region IV, U.S. Department of Energy, and Kentucky Natural Resources and Environmental Protection Cabinet.

DOE 1996. *Environment, Safety and Health Reporting*, DOE Order 231.1 Chg 2, Office of Environment, Safety and Health, U.S. Department of Energy, Washington, DC.

DOE 1995. *Environmental Assessment for the Construction, Operation, and Closure of the Solid Waste Landfill at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/EA-1046, U.S. Department of Energy, Oak Ridge, TN.

Hampshire 2003. Electronic mail message from G.J. Hampshire to J. D. Young, dated November 26, 2003, "Deer doses."

Humphrey 1976. *Soil Survey of Ballard and McCracken Counties*, U. S. Department of Agriculture, Soil Conservation Service, in cooperation with the Kentucky Agriculture Experiment Station.

ICRP 1980. *Annals of the ICRP, Parts I and II, Limits for Intakes of Radionuclides by Workers,* International Commission on Radiological Protection Publication 30, Elmsford, NY.

KCHS 2004. Correspondence from E. Scott (Radiation Health and Toxic Agents Branch) to D. R. Guminski, "Year 2003 Air Monitoring Data."

Glossary

absorption – The process by which the number and energy of particles or photons entering a body of matter is reduced by interaction with the matter.

adsorption – The accumulation of gases, liquids, or solutes on the surface of a solid or liquid.

activity – See radioactivity.

air stripping – The process of bubbling air through water to remove volatile organic compounds from the water.

alpha particle – A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air – The atmosphere around people, plants, and structures.

analyte – A constituent or parameter being analyzed.

analytical detection limit – The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

aquifer – A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquitard – A geologic unit that inhibits the flow of water.

assimilate – To take up or absorb.

atom – Smallest particle of an element capable of entering into a chemical reaction.

beta particle – A negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

biota – The animal and plant life of a particular region considered as a total ecological entity.

CERCLA-reportable release – A release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

chain-of-custody form – A form that documents sample collection, transport, analysis, and disposal.

closure – Formal shutdown of a hazardous waste management facility under Resource Conservation and Recovery Act requirements.

compliance – Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

concentration – The amount of a substance contained in a unit volume or mass of a sample.

conductivity – A measure of a material's capacity to convey an electric current. For water, this property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

confluence – The point at which two or more streams meet; the point where a tributary joins the main stream.

congener – Any particular member of a class of chemical substances. A specific congener is denoted by a unique chemical structure.

contained landfill – A solid waste site or facility that accepts disposal of solid waste. The technical requirements for contained landfills are found in 401 K.A.R. 47:080, 48:050, and 48:070 to 48:090.

contamination – Deposition of unwanted material on the surfaces of dissolved into structures, areas, objects, or personnel.

cosmic radiation – Ionizing radiation with very high energies that originates outside the earth's atmosphere. Cosmic radiation is one contributor to natural background radiation.

Curie (Ci) – A unit of radioactivity. One Curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the Curie are commonly used:

- **kiloCurie (kCi)** – 10^3 Ci, one thousand curies; 3.7×10^{13} disintegrations per second.
- **milliCurie (mCi)** – 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.
- **microCurie (µCi)** – 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.
- **picoCurie (pCi)** – 10^{-12} Ci, one-trillionth of a curie; 3.7×10^{-2} disintegrations per second.

daughter – A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive – The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide or into a different energy state of the same radionuclide.

dense, nonaqueous-phase liquid (DNAPL) – The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethylene and trichloroethylene.

derived concentration guide (DCG) – The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and the lens of the eye. The guidelines for radionuclides in air and water are given in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

disintegration, nuclear – A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dose – The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

- **absorbed dose** – The quantity of radiation energy absorbed by an organ divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 Gy).
- **dose equivalent** – The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 Sv).
- **committed dose equivalent** – The calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).
- **committed effective dose equivalent** – The sum of the committed dose equivalents to various tissues in the body, each

multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

- **effective dose equivalent** – The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.
- **collective dose equivalent/collective effective dose equivalent** – The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

downgradient – In the direction of decreasing hydrostatic head.

downgradient well – A well that is installed hydraulically downgradient of a site and that may be capable of detecting migration of contaminants from a site.

drinking water standards (DWS) – Federal primary drinking water standards, both proposed and final, as set forth by the EPA in 40 C.F.R. 141 and 40 C.F.R. 143.

effluent – A liquid or gaseous waste discharge to the environment.

effluent monitoring – The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures to members of the public, and demonstrating compliance with applicable standards.

Environmental Restoration – A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities (decontamination and decommissioning) contaminated with waste as a result of nuclear-related activities.

exposure (radiation) – The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation received at a person's workplace. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation – Exposure to ionizing radiation when the radiation source is located outside the body.

fauna – The population of animals in a given area, environment, formation, or time span.

flora – The population of plants in a given area, environment, formation, or time span.

formation – A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

gamma ray – High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to X-rays except for the source of the emission.

Gaussian puff/plume model – A computer-simulated atmospheric dispersion of a release using a Gaussian (normal) statistical distribution to determine concentrations in air.

grab sample – A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface-water samples (also called dip samples).

groundwater, unconfined – Water that is in direct contact with the atmosphere through open spaces in permeable material.

half-life, radiological – The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

hardness – The amount of calcium carbonate dissolved in water, usually expressed as part of calcium carbonate per million parts of water.

hydrogeology – Hydraulic aspects of site geology.

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

in situ – In its original place; field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

internal dose factor – A factor used to convert intakes of radionuclides to dose equivalents.

internal radiation – Occurs when natural radionuclides enter the body by ingestion of foods or liquids or by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion – An atom or compound that carries an electrical charge.

irradiation – Exposure to radiation.

isotopes – Forms of an element having the same number of protons but differing numbers of neutrons in their nuclei.

- **long-lived isotope** – A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).

- **short-lived isotope** – A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

lower limit of detection – The smallest concentration or amount of analyte that can be reliably detected in a sample at a 95 percent confidence level.

maximally exposed individual – A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

migration – The transfer or movement of a material through air, soil, or groundwater.

milliroentgen (mR) – A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable concentration – The smallest amount or concentration of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

monitoring – Process whereby the quantity and quality of factors that can affect the environment or human health are measured periodically to regulate and control potential impacts.

mrem – The dose equivalent that is one-thousandth of a rem.

natural radiation – Radiation from cosmic and other naturally occurring radionuclide (such as radon) sources in the environment.

nuclide – An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

outfall – The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

part per billion (ppb) – A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or mg/mL.

part per million (ppm) – A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L.

pathogen – A disease-producing agent; usually refers to living organisms.

person-rem – Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

pH – A measure of the hydrogen-ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 6, neutral solutions have a pH equal to 7, and basic solutions have a pH greater than 7.

piezometer – An instrument used to measure the hydraulic potential of groundwater at a given point; also, a well designed for this purpose.

polychlorinated biphenyl (PCB) - Any chemical substance that is limited to the biphenyl molecule and that has been chlorinated to varying degrees.

polynuclear aromatic hydrocarbon (PAH) – Any organic compound composed of more than one benzene ring.

process water – Water used within a system process.

purge – To remove water before sampling, generally by pumping or bailing.

quality assurance (QA) – Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC) – The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

quality factor – The factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. A quality factor is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad – An acronym for Radiation Absorbed Dose. The rad is a basic unit of absorbed radiation dose. (This is being replaced by the "gray," which is equivalent to 100 rad.)

radiation detection instruments – Devices that detect and record the characteristics of ionizing radiation.

radioactivity – The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

radioisotopes – Radioactive isotopes.

radionuclide – An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reference material – A material or substance with one or more properties that is sufficiently well established and used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

release – Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem – The unit of dose equivalent (absorbed dose in rads multiplied by the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

remediation – The correction of a problem. See Environmental Restoration.

Resource Conservation and Recovery Act (RCRA) – Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

RFI Program – RCRA Facility Investigation Program; EPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

roentgen – A unit of exposure from X-rays or gamma rays. One roentgen equals 2.58 x 10^4 coulombs per kilogram of air.

screen zone – In well construction, the section of a formation that contains the screen, or perforated pipe, that allows water to enter the well.

semivolatile organic analyte (SVOA) – Any organic compound with a high boiling point which will volatilize upon heating.

sievert (Sv) – The SI (International System of Units) unit of dose equivalent; 1 Sv = 100 rem.

slurry – A suspension of solid particles (sludge) in water.

source – A point or object from which radiation or contamination emanates.

specific conductance – The ability of water to conduct electricity; this ability varies in proportion to the amount of ionized minerals in the water.

stable – Not radioactive or not easily decomposed or otherwise modified chemically.

storm-water runoff – Surface streams that appear after precipitation.

strata – Beds, layers, or zones of rocks.

substrate – The substance, base, surface, or medium in which an organism lives and grows.

surface water – All water on the surface of the earth, as distinguished from groundwater.

suspended solids – Mixture of fine, nonsettling particles of any solid within a liquid or gas.

terrestrial radiation – Ionizing radiation emitted from radioactive materials, primarily ^{40}K, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

thermoluminescent dosimeter (TLD) – A device used to measure external gamma radiation.

total activity – The total quantity of radioactive decay particles that are emitted from a sample.

total solids – The sum of total dissolved solids and suspended solids.

total suspended particulates – Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transuranic element (TRU) – An element above uranium in the Periodic Table, that is, with an atomic number greater than 92. All 11 TRUs are produced artificially and are radioactive. They are neptunium, plutonium, americium, curium, berkelium, californium, einsteinium, fermium, mendelevium, nobelium, and lawrencium.

troughing system – A collection and containment system designed to collect leaks of oil that have been contaminated with PCBs.

turbidity – A measure of the concentration of sediment or suspended particles in solution.

upgradient – In the direction of increasing hydrostatic head.

vadose zone – Soil zone located above the water table.

volatile organic compound (VOC) – Any organic compound which has a low boiling point and readily volatilizes into air (e.g., trichloroethane, tetrachloroethylene, and trichloroethylene).

watershed – The region draining into a river, river system, or body of water.

wetland – A lowland area, such as a marsh or swamp, inundated or saturated by surface or groundwater sufficiently to support hydrophytic vegetation typically adapted to life in saturated soils.

Appendix A: Radiation

This appendix gives basic information about radiation. This information is intended to be a basis for understanding normal radiation dose from sources unassociated with the Paducah Site. People are constantly exposed to radiation. For example, radon in air; potassium in food and water; and uranium, thorium, and radium in the earth's crust are all sources of radiation. The following discussion describes important aspects of radiation, including atoms and isotopes; types, sources, and pathways of radiation; radiation measurement; and dose information.

ATOMS AND ISOTOPES

All matter is made up of **atoms**. The atom is thought to consist of a dense central nucleus surrounded by a cloud of electrons. The nucleus is composed of protons and neutrons. **Table A.1** summarizes the basic components of an atom. In an electrically neutral atom, the number of protons equals the number of electrons. Atoms can lose or gain electrons through ionization. The number of protons in the nucleus determines an element's atomic number, or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the number of neutrons may vary among atoms of the same element. The number of neutrons and protons determines the atomic weight of the atom.

Atoms of the same element with a different number of neutrons are called **isotopes**. Isotopes have the same chemical properties but different atomic weights. **Figure A.1** depicts isotopes of the element hydrogen. Uranium, which has 92 protons, is another example of an element that has isotopes. All isotopes of uranium have 92 protons. However, each uranium isotope has a different number of neutrons. ^{234}U has 92 protons and 142 neutrons; ^{235}U has 92 protons and 143 neutrons; and ^{238}U has 92 protons and 146 neutrons.

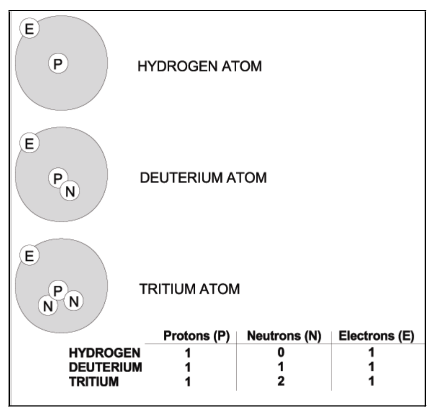


Figure A.1 Isotopes of the element hydrogen.

Table A.1 Summary of the basic parts of an atom.

Particle	Location	Charge	Comments
Protons	Nucleus	+ positive	The number of protons determines the element. If the number of protons changes, the element changes.
Neutrons	Nucleus	No charge	Atoms of the same element have the same number of protons, but can have a different number of neutrons. This is called an isotope.
Electrons	Orbit nucleus	– negative	This negative charge is equal in magnitude to the proton's positive charge.

Source: Bechtel Jacobs Company, LLC. *Radiological Worker I and II Academics Training*, Student Handbook, revision 2.

BASIC INFORMATION ABOUT RADIATION

Radioactivity was discovered in 1896 by the French physicist Antoine Henri Becquerel when he observed that the element, uranium, can blacken a photographic plate, even when separated from the plate by glass or black paper. In 1898, the French chemists Marie Curie and Pierre Curie concluded that radioactivity is a phenomenon associated with atoms, independent of their physical or chemical state. The Curies measured the heat associated with the decay of radium and established that 1 g (0.035 oz) of radium gives off about 100 cal of energy every hour. This release of energy continues hour after hour and year after year, whereas the complete combustion of a gram of coal results in the production of a total of only about 8000 cal of energy. Radioactivity attracted the attention of scientists throughout the world, following these early discoveries. In the ensuing decades, many aspects of the phenomenon were thoroughly investigated ("Radioactivity" 2002, Appendix A references).

Radiation is energy in the form of waves or particles moving through space. Radiation occurs because unstable atoms give off excess energy to become stable. **Ionization** is the process of removing electrons from neutral atoms. NOTE: Ionization should not be confused with radiation. Ionization is a result of the interaction of radiation with an atom, and is what allows the radiation to be detected. **Ionizing radiation** is energy (particles or rays) emitted from radioactive atoms that can cause ionization. Ionizing radiation is capable of displacing electrons and changing the chemical state of matter and subsequently causing biological damage. Therefore, ionizing radiation is potentially harmful to human health. Examples of ionizing radiation include alpha, beta, and gamma radiation. **Non-ionizing radiation** bounces off or passes through matter without displacing electrons. Non-ionizing radiation does not have enough energy to ionize an atom. It is unclear whether non-ionizing radiation is harmful to human health. Examples include visible light, radar waves, microwaves, and radio waves. **Radioactivity** is the process of unstable, or radioactive, atoms becoming stable by emitting radiant energy. Radioactivity that occurs over a period of time is called **radioactive decay**. The discovery that radium decays to produce radon proved conclusively that radioactive decay is accompanied by a change in the chemical nature of the decaying element. A **disintegration** is a single atom undergoing radioactive decay. **Radioactive half-life** is the time it takes for one-half of the radioactive atoms present to decay (Bechtel Jacobs Company, LLC., Appendix A references).

TYPES, SOURCES, AND PATHWAYS OF RADIATION

Visible light, heat, radio waves, and alpha particles are examples of radiation. When people feel warmth from the sunlight, they are actually absorbing the radiant energy emitted by the sun. Electromagnetic radiation is radiation in the form of electromagnetic waves; examples include gamma rays, ultraviolet light, and radio waves. Particulate radiation is radiation in the form of particles; examples include alpha and beta particles. The spectrum of particle and electromagnetic radiations ranges from the extremely short wavelengths of cosmic rays and electrons to very long radio waves that are hundreds of kilometers in length. **Figure A.2** shows the difference between a longer wavelength and a shorter wavelength. **Figure A.3** illustrates the wavelengths of several types of radiation along with an example of something that is approximately the same dimension in length.

The Radiation's ability to penetrate material is an important consideration in protecting human health. Adequate shielding decreases the power of radiation by absorbing part or all of it. **Figure A.4** shows the different penetrating power of alpha, beta, and gamma rays. Alpha rays are stopped by the thickness of a few sheets of paper or a rubber glove. A few centimeters of wood or a thin sheet of copper stops beta rays. Gamma rays and X-rays require thick shielding of a heavy material, such as iron, lead, or concrete ("Radiation" 2002, Appendix A references).

Radiation is everywhere. Most occurs naturally, but a small percentage is from human-made sources. Naturally occurring radiation is identical to the radiation resulting from human-made sources.

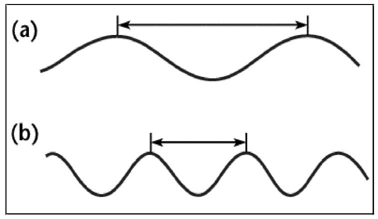


Figure A.2 Comparison between longer (a) and shorter (b) wavelengths[a].

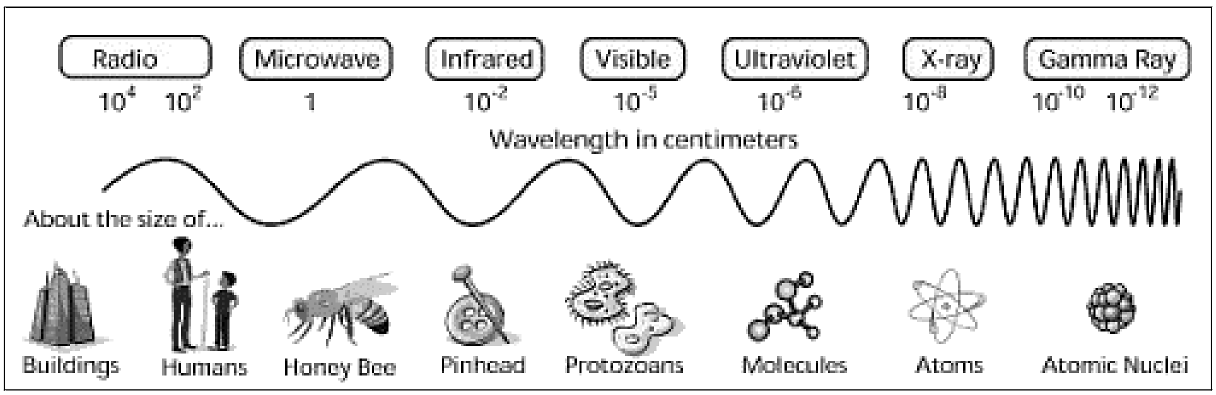


Figure A.3 The approximate wavelengths of the various regions of the electromagnetic spectrum and an example of something that is approximately the same size[b].

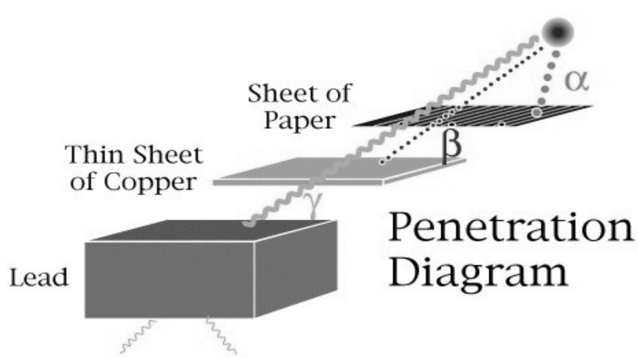


Figure A.4 The penetrating potential of the trhee types of ionizing radiation: alpha, beta, and gamma[c].

[a] ("Electromagnetic…" 2002, Appendix A references)
[b] ("Exploring …" 2002, Appendix A references)
[c] ("Experiment…" 2002, Appendix A references)

Naturally occurring radiation is known as **background radiation**. In fact, this naturally occurring radiation is the major source of radiation in the environment. People have little control over the amount of background radiation to which they are exposed. Background radiation remains relatively constant over time. The amount of background radiation present in the environment today is much the same as it was hundreds of years ago. Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Depending on its origin, background radiation is categorized as cosmic, terrestrial, or internal. **Cosmic radiation** comes from the sun and outer space and is made up of energetically charged particles from that continuously hit the earth's atmosphere. Because the atmosphere provides some shielding against cosmic radiation, the intensity of cosmic radiation increases with altitude above sea level. Therefore, a person in Denver, Colorado, is exposed to more cosmic radiation than a person in Paducah, Kentucky. **Terrestrial radiation** refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn); radon progeny, the relatively short-lived decay products of radium-235 (^{235}Ra); potassium (^{40}K); isotopes of thorium (Th); and isotopes of uranium (U) are the elements responsible for most terrestrial radiation. **Internal radiation** is radiation that is inside the body and is in close contact with body tissue. Internal radiation can deposit large amounts of energy in a small amount of tissue. Radioactive material in the environment enters the body through the air people breathe, the food they eat, and even through an open wound. Natural radionuclides in the body include isotopes of U, Th, Ra, Rn, Pu, bismuth (Bi), and lead in the ^{238}U and ^{212}Th decay series. In addition, the body contains isotopes of sodium-24 (^{24}Na), ^{40}K, rubidium (Rb), and carbon-14 (^{14}C). Most of our internal exposure comes from ^{40}K.

In addition to background radiation, there are human-made sources of radiation to which most people are exposed. Examples include consumer products, medical sources, and other sources. Some **consumer products** are sources of radiation. In some of these products, such as smoke detectors and airport X-ray baggage inspection systems, the radiation is essential to the performance of the device. In other products, such as televisions and tobacco products, the radiation occurs incidentally to the product function. **Medical sources** of radiation account for the majority of the exposure people receive from human-made radiation. Radiation is an important tool of diagnostic medicine and treatment. Exposure is deliberate and directly beneficial to the patients exposed. Generally, diagnostic or therapeutic medical exposures result from X-ray beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Radiation and radioactive materials are also used in a wide variety of pharmaceuticals and in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves. Nuclear medical examinations and treatment involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body. **Other sources** of radiation include fallout from atmospheric atomic weapons tests; emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; emissions from mineral extraction facilities; and transportation of radioactive materials. Atmospheric testing of atomic weapons has been suspended. About one-half of 1% of the United States population performs work in which radiation in some form is present.

Radiation and radioactive material in the environment can reach people through many routes. Potential routes for radiation are referred to as **pathways**. Several radiation pathways are shown in **Figure A.5**. For example, radioactive material in the air could fall on a pasture. Cows could then eat the grass, and the radioactive material on the grass would show up in the cow's milk. People drinking the milk would thus be exposed to this radiation. Or, people could simply inhale the radioactive material in the air. The same events could occur with radioactive material in water. Fish living in the water would be exposed. People eating the fish would then be exposed to the radiation in the fish. Or, people swimming in the water would be exposed.

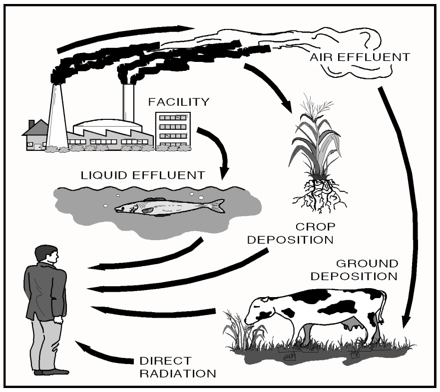


Figure A.5 Possible radiation pathways.

MEASURING RADIATION

To determine the possible effects of radiation on the environment and the health of people, the radiation must be measured. More precisely, its potential to cause damage must be determined. When measuring the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or **activity**. The rate of decay varies widely among the various radioisotopes. For that reason, 1 g of one radioactive substance may contain the same amount of activity as several tons of another substance. Activity is measured by the number of disintegrations a radioactive material undergoes in a certain period of time. In the United States, activity is expressed in a unit of measure known as a **curie (Ci)**. In the international system of units, activity is expressed in a unit of measure known as a **Becquerel (Bq)**. One disintegration per second (dps) equals one Becquerel (Bq).

One curie equals:

- 37,000,000,000 atom disintegrations per second (3.7×10^{10} dps).
- 37,000,000,000 Becquerels (3.7×10^{10} Bq)
- 1,000,000 microcuries (1×10^{6} µCi)

DOSE INFORMATION

The total amount of energy absorbed per unit mass as a result of exposure to radiation is expressed in a unit of measure known as a **radiation absorbed dose (rad)**. In the international system of units, 100 rad = 1 gray. However, in terms of human health, it is the effect of the absorbed energy that is important because some forms of radiation are more harmful than others. The unit, rad, does not take into account the potential effects that different types of radiation have on the body. The measure of potential biological damage caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a **Roentgen equivalent man (rem)**. One rem of any type of radiation has the same total damaging effect and pertains to the human body. Dose is expressed in millirems (mrem), because a rem represents a fairly large dose. One millirem is equal to 1/1000 rem. The International System of Units uses the **Sievert (Sv)**, 100 rem = 1 Sievert (Sv), 100 mrem = 1 millisievert (mSv).

Many terms are used to report **dose**, as listed in **Table A.2**. Several factors are taken into account, including the amount of radiation absorbed, the organ absorbing the radiation, and the effect of the radiation over a 50-year period. The term "dose," in this report, includes the committed effective dose equivalent (EDE) and the effective dose equivalent attributable to penetrating radiation from sources external to the body.

Determining dose is an involved process using complex mathematical equations based on several factors, including the type of radiation, the rate of exposure, weather conditions, and typical diet. Basically, radiant energy is generated from radioactive decay, or activity. People absorb some of the energy to which they are exposed. This absorbed energy is calculated as part of an individual's dose. Whether radiation is natural or human made, its effects on people are the same.

A comparison of some dose levels is presented in **Table A.3**. Included is an example of the type of exposure that may cause such a dose or the special significance of such a dose. This information is intended to help the reader become familiar with the type of doses individuals may receive. The average annual dose received by residents of the United States from cosmic radiation is about 27 mrem (0.27 mSv) (NCRP 1987). The average annual dose from cosmic radiation received by residents in the Paducah area is about 45 mrem (0.45 mSv). The average annual dose received from terrestrial gamma radiation in the United States is about 28 mrem (0.28 mSv). The terrestrial dose varies geographically across the country (NCRP 1987); typical reported values are 16 mrem (0.16 mSv) at the Atlantic and Gulf coastal plains and 63 mrem (0.63 mSv) at the eastern slopes of the Rocky Mountains. In the Paducah area, background levels of radionuclides in soils are within typical levels indicating that the dose received from terrestrial gamma radiation is within the range of typical reported values (DOE 1997). The major contributors to the annual dose equivalent for internal radionuclides are the short-lived decay products of radon, mostly Rn-222. They contribute an average dose of about 200 mrem (2.00 mSv) per year. This dose estimate is based on an average radon concentration of about 1 pCi/L (0.037 Bq/L) (NCRP 1987). The average dose from other internal radionuclides is about 39 mrem (0.39 mSv) per year, most of which can be attributed to the naturally occurring isotope of potassium, K-40. The concentration of radioactive potassium in human tissues is similar in all parts of the world. **Table A.4** presents the internal dose factors for an adult. The United States average annual dose received by an individual from consumer products is about 10 mrem (0.10 mSv) (NCRP 1987). The dose from medical sources include nuclear medicine examinations, which involve the internal administration of radiopharmaceuticals, and generally account for the largest portion of the dose received from human-made sources. However, the radionuclides used in specific tests are not distributed uniformly throughout the body. In these cases, comparisons are made using the concept of EDE, which relates exposure of organs or body parts to one effective whole-body dose. The average annual EDE from medical examinations is 53 mrem (0.53 mSv), including 39 mrem (0.39 mSv) for diagnostic X- rays and 14mrem (0.14mSv) for nuclear medicine procedures (NCRP 1989). The actual doses received by individuals who complete such medical exams are much higher than these values, but not everyone receives such exams each year (NCRP 1989). The dose from other sources include small doses received by individuals that occur as a result of radioactive fallout from atmospheric atomic weapons tests, emissions of radioactive materials

Table A.2 Dose terminology.

Term	Description
absorbed dose	quantity of radiation energy absorbed by an organ divided by an organ's mass
dose equivalent	absorbed dose to an organ multiplied by a quality factor
effective dose equivalent	single weighted sum of combined dose equivalents received by all organs
committed dose equivalent	effective dose equivalent to an organ over a 50-year period following intake
committed effective dose equivalent	total effective dose equivalent to all organs in the human body over a 50-year period following intake
collective effective dose equivalent	sum of effective dose equivalents of all members of a given population
quality factor	a modifying factor used to adjust for the effect of the type of radiation, for example, alpha particles or gamma rays, on tissue
weighting factor	tissue-specific modifying factor representing the fraction of the total health risk from uniform, whole-body exposure

from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to the average dose to an individual (NCRP 1987). A comprehensive EPA report of 1984 projected the average occupational dose to monitored radiation workers in medicine, industry, the nuclear fuel cycle, government, and miscellaneous industries to be 105 mrem (1.05 mSv) per year for 1985, down slightly from 110 mrem (1.10 mSv) per year in 1980 (EPA 1984).

Table A.3 Comparison and description of various dose levels

Dose level	Description
1 mrem (0.01 mSv)	Approximate daily dose from natural background radiation, including radon.
2.5 mrem (0.025 mSv)	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles.
10 mrem (0.10 mSv)	Annual exposure limit, set by the EPA for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants and uranium mines and mills .
45 mrem (0.45 mSv)	Average yearly dose from cosmic radiation received by people in the Paducah area.
46 mrem (0.46 mSv)	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear power plant accident.
66 mrem (0.66 mSv)	Average yearly dose to people in the United States from human-made sources.
100 mrem (1.00 mSv)	Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker.
110 mrem (1.10 mSv)	Average occupational dose received by U.S. commercial radiation workers in 1980.
244 mrem (2.44 mSv)	Average dose from an upper gastrointestinal diagnostic X-ray series.
300 mrem (3.00 mSv)	Average yearly dose to people in the United States from all sources of natural background radiation.
1-5 rem (0.01-0.05 Sv)	EPA protective action guidelines state that public officials should take emergency action when the dose to a member of the public from a nuclear accident will likely reach this range.
5 rem (0.05 Sv)	Annual limit for occupational exposure of radiation workers set by NRC and DOE.
10 rem (0. 10 Sv)	The BEIR V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer, caused by the radiation, of 0.8% (BEIR 1990).
25 rem (0.25 Sv)	EPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency.
75 rem (0.75 Sv)	EPA guideline for maximum dose to emergency workers volunteering for lifesaving work.
50-600 rem (0.50-6.00 Sv)	Doses in this range received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people would die within 60 days.

Adapted from *Savannah River Site Environmental Report for 1993, Summary Pamphlet,* WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.

Table A.4 Internal dose factors for an adult.

Isotope	Half-life (years)	Intake[a] (mrem/pCi)			
		Inhalation (soluble)	Inhalation (slightly soluble)	Inhalation (insoluble)	Ingestion
^{237}Np	2,100,000	NA	0.49	NA	0.0039
^{239}Pu	24,000	NA	0.51	0.33	0.0043
^{99}Tc	210,000	0.00000084	0.0000075	0.12	0.0000013
^{230}Th	75,000	NA	0.32	0.26	0.00053
^{234}U	240,000	0.0027	0.0071	0.13	0.00026
^{235}U	710,000,000	0.0025	0.0067	0.12	0.00025
^{238}U	4,500,000,000	0.0024	0.0062	0.12	0.00023

[a] Source: U.S. DOE. July 1988. *Internal Dose Conversion Factors for Calculations of Dose to the Public*, DOE/EH-0071.
NA = not available in the above-referenced document

Appendix A References

Bechtel Jacobs Company, LLC. *Radiological Worker I and II Academics Training*, Student Handbook, revision 2.

"Electromagnetic Radiation." Accessed May 15, 2002.
http://www.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec.html

"Experiment #4:Penetrating Power" Accessed May 16, 2002.
http://www.lbl.gov/abc/experiments/Experiment4.html

"Exploring other Wavelengths," Imagine the Universe, NASA website. Accessed May 15, 2002.
http://imagine.gsfc.nasa.gov/docs/science/answers_l2/new_wavelengths.html

NCRP 1987. "Ionizing Radiation Exposure of the Population of the United States," *NCRP Report No. 93,* National Council on Radiation Protection and Measurements, Washington, D.C.

NCRP 1989. "Exposure of the U.S. Population from Diagnostic Medical Radiation," *NCRP Report No. 100,* National Council on Radiation Protection and Measurements, Bethesda Md.

"Radiation," Microsoft® Encarta® Online Encyclopedia 2002.
http://encarta.msn.com © 1997-2002 Microsoft Corporation. All Rights Reserved

"Radioactivity," Microsoft® Encarta® Online Encyclopedia 2002.
http://encarta.msn.com © 1997-2002 Microsoft Corporation.

"Regions of the Electromagnetic Spectrum," Imagine the Universe, NASA website. Accessed May 14, 2002.
http://imagine.gsfc.nasa.gov/docs/science/know_l1/spectrum_chart.html

Savannah River Site Environmental Report for 1993, Summary Pamphlet, WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.

U.S. Department of Energy. *Internal Dose Conversion Factors for Calculations of Dose to the Public*, DOE/EH-0071.

Appendix B: Radionuclide and Chemical Nomenclature

Table B.1 Half-life and DCG for selected radionuclides

Radionuclide	Symbol	Half-life	Ingested Water DCG (µCi/ml)
Americium-241	^{241}Am	432 years	3 E - 08
Bismuth-210	^{210}Bi	5.01 days	2 E - 05
Cesium-137	^{137}Cs	30.2 years	3 E - 06
Cobalt-60	^{60}Co	5.3 years	1 E - 05
Lead-206	^{206}Pb	Stable	None
Lead-210	^{210}Pb	21 years	3 E - 08
Lead-214	^{214}Pb	26.8 minutes	2 E - 04
Neptunium-237	^{237}Np	2,140,000 years	3 E - 08
Plutonium-239	^{239}Pu	24,110 years	3 E - 08
Polonium-210	^{210}Po	138.9 days	8 E - 08
Polonium-214	^{214}Po	164 microseconds	None
Polonium-218	^{218}Po	3.05 minutes	None
Potassium-40	^{40}K	1,260,000,000 years	7 E - 06
Protactinium-234m	^{234m}Pa	1. 17 minutes	None
Radium-226	^{226}Ra	1,602 years	1 E - 07
Radon-222	^{222}Rn	3.821 days	None
Technetium-99	^{99}Tc	212,000 years	1 E - 04
Thorium-230	^{230}Th	80,000 years	3 E - 07
Thorium-231	^{231}Th	25.5 hours	1 E - 04
Thorium-234	^{234}Th	24.1 days	1 E - 05
Uranium-234	^{234}U	247,000 years	5 E - 07
Uranium-235	^{235}U	710,000,000 years	6 E - 07
Uranium-236	^{236}U	23,900,000 years	5 E - 07
Uranium-238	^{238}U	4,510,000,000 years	6 E - 07

Derived Concentration Guide (DCG) is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem. DCGs do not consider decay products when the parent radionuclide is the cause of the exposure.

Table B.2 Nomenclature for elements and chemical compounds

Constituent	Symbol	Constituent	Symbol
Aluminum	Al	Manganese	Mn
Ammonia	NH_3	Mercury	Hg
Antimony	Sb	Nickel	Ni
Arsenic	As	Nitrate	NO_3^-
Barium	Ba	Nitrite	NO_2^-
Beryllium	Be	Nitrogen	N
Cadmium	Cd	Oxygen	O
Calcium	Ca	Ozone	O_3
Calcium carbonate	$CaCO_3$	Phosphate	PO_4^{3-}
Carbon	C	Phosphorus	P
Chlorine	Cl	Potassium	K
Chromium	Cr	Radium	Ra
Chromium, hexavalent	Cr^{6+}	Radon	Rn
Cobalt	Co	Selenium	Se
Copper	Cu	Silver	Ag
Fluorine	F	Sodium	Na
Hydrogen fluoride	HF	Sulfate	SO_4^{2-}
Iron	Fe	Sulfur dioxide	SO_2
Lead	Pb	Thorium	Th
Lithium	Li	Uranium	U
Magnesium	Mg	Zinc	Zn

BJC/PAD-611/V2
Volume II

Environmental Monitoring Results, Annual Site Environmental Report for Calendar Year 2003, Paducah Gaseous Diffusion Plant, Paducah, Kentucky

BJC/PAD-611/V2
Volume II

Environmental Monitoring Results, Annual Site Environmental Report, Calendar Year 2003 Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—September 2004

Prepared by
CDM Federal Services Inc.,
under subcontract 23900-SC-RM056F

Prepared for the
U. S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
East Tennessee Technology Park
Oak Ridge Y-12 Plant   Oak Ridge National Laboratory
Paducah Gaseous Diffusion Plant   Portsmouth Gaseous Diffusion Plant
under contract DE-AC05-03OR22980
for the
UNITED STATES DEPARTMENT OF ENERGY

List of Tables

Notes:

1. “ND” means the parameter was not detected. Detection limits are available in the Paducah OREIS database. The count detects column represents the number of times the contaminant was detected when sampled during the year.

2. Monitoring programs often include measurement of extremely low concentrations of radionuclides, below the detection limit of the counting instruments. Less-than-detectable data will produce numerical measurements with values below the detection limit and sometimes negative values. All of the actual values, including those that are negative, are included in the statistical analyses in accordance with DOE’s *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991).

3. For non-radiological data, average values are calculated using the actual result values from the OREIS database. Where analytical result values were below the detection level, half of the detection limit was used to calculate average concentration. For radiological data, the average concentration was calculated by using the actual result given for both detectable and non-detectable results.

4. Reference Criteria for Sections 1 and 2 are used for comparison of results to Derived Concentration Guide (DCG) levels or site action limits that have been defined by the Environmental Programs.

5. The following data volume includes monitoring results for surface water, sediment, air, and animal tissue. Groundwater results are not presented in this data volume because more significant detail and data tables are presented in the Annual Site Environmental Report, Volume I.

1. RADIOLOGICAL EFFLUENT DATA

KPDES Radiological Data

Table 1.1 Radiological Effluent Data for Outfall 001

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Dissolved Alpha	pCi/L	-2.7	4.4	1.1	0	5		
Dissolved Beta	pCi/L	23	42	30	5	5		
Suspended Alpha	pCi/L	0.47	3.1	1.9	0	5		
Suspended Beta	pCi/L	-2.1	2.9	0.46	0	5		
Technetium-99	pCi/L	1	23	6.8	1	5	ActionLimit	900

Table 1.2 Radiological Effluent Data for Outfall 015

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	54	54	54	1	1		
Beta activity	pCi/L	67	67	67	1	1		
Dissolved Alpha	pCi/L	2.8	170	54	3	4		
Dissolved Beta	pCi/L	23	230	78	4	4		
Suspended Alpha	pCi/L	-1.1	13	4.2	1	4		
Suspended Beta	pCi/L	3.1	52	22	3	4		
Technetium-99	pCi/L	12	44	28	3	4	ActionLimit	900

Table 1.3 Radiological Effluent Data for Outfall 017

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	1.6	1.6	1.6	0	1		
Beta activity	pCi/L	11	11	11	1	1		
Dissolved Alpha	pCi/L	-2.3	9.6	2.9	1	4		
Dissolved Beta	pCi/L	-0.3	28	13	2	4		
Suspended Alpha	pCi/L	-0.28	2.5	1.3	0	4		
Suspended Beta	pCi/L	-4.4	2.7	0.068	0	4		
Technetium-99	pCi/L	-5	27	6.6	1	4	ActionLimit	900

Table 1.4 Radiological Effluent Data for Outfall 019

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Dissolved Alpha	pCi/L	-4	0.96	-1.9	0	4		
Dissolved Beta	pCi/L	-3.8	1.9	0.39	0	4		
Suspended Alpha	pCi/L	-2.3	2.1	-1.2	0	4		
Suspended Beta	pCi/L	-7.1	5.2	0.53	0	4		
Technetium-99	pCi/L	-7.3	1.6	-2	0	4	ActionLimit	900

Surface Water Radiological Data

Table 1.5 Radiological Effluent Data for Landfill Surface Water Location L135

Upstream of the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	3.1	6.4	4.5	4	5		
Beta activity	pCi/L	13	54	25	5	5		

Table 1.6 Radiological Effluent Data for Landfill Surface Water Location L136

At the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	-0.011	2.2	1.1	0	5		
Beta activity	pCi/L	4.9	11	7.3	3	5		

Table 1.7 Radiological Effluent Data for Landfill Surface Water Location L137

Downstream of the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	0.18	2.6	1.6	1	4		
Beta activity	pCi/L	12	31	20	4	4		

Table 1.8 Radiological Effluent Data for Landfill Surface Water Location L150

At the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	1.1	4.7	2.1	1	4		
Beta activity	pCi/L	5.3	10	7.2	3	4		

Table 1.9 Radiological Effluent Data for Landfill Surface Water Location L154

Upstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	-0.57	5.2	2.8	4	6		
Beta activity	pCi/L	8.5	40	18	6	6		

Table 1.10 Radiological Effluent Data for Landfill Surface Water Location L155

Downstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	1.4	8	5.1	3	4		
Beta activity	pCi/L	4.6	12	8.8	3	4		

2. RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE DATA

Ambient Air Data

Table 2.1 Kentucky Radiation Health and Toxics Branch Air Monitoring

	AMSW017	AMW015	AMNW001	AMNE	AME002	AME012	AMBKG2	AMBOLD	AMKOW	AMMWNE
Nuclide	**Ci/m3**	**Ci/m3**	**Ci/m3**	**Ci/m3**	**Ci/m3**	**Ci/m3**	**Ci/m3**	**Ci/m3**	**Ci/m3**	**Ci/m3**
Quarter 1										
Americium-241	4.643E-16	1.654E-16	2.607E-16	1.871E-16	1.053E-16	4.528E-16	4.304E-16	4.854E-16	1.182E-16	3.338E-16
Neptunium-237	9.001E-17	9.934E-17	-3.063E-16	2.849E-16	-3.603E-17	-2.157E-16	-5.733E-17	-3.738E-17	1.285E-16	1.739E-16
Technetium-99	1.4697E-16	4.847E-17	-1.89E-17	7.571E-18	1.623E-16	-1.893E-17	2.45E-16	2.79786E-16	1.47447E-16	-6.8087E-17
Uranium-238	2.043E-16	2.129E-16	2.81E-16	2.77E-16	2.395E-16	2.349E-16	2.162E-16	2.437E-16	2.691E-16	2.462E-16
Sum of ratios	0.35	0.20	-0.08	0.37	0.06	0.09	0.21	0.26	0.20	0.35
Quarter 2										
Americium-241	-3.227E-16	1.662E-16	3.059E-16	3.903E-17	2.091E-16	-6.499E-17	-2.623E-16	-3.103E-16	2.816E-16	4.485E-17
Neptunium-237	-9.723E-17	-8.362E-17	5.321E-16	-1.855E-16	-2.928E-16	6.259E-17	-1.942E-17	1.316E-16	7.338E-17	1.916E-16
Technetium-99	2.999E-16	1.806E-16	-3.184E-17	6.523E-16	5.894E-16	3.473E-17	5.465E-16	2.0148E-16	8.95936E-17	3.87585E-16
U-238	3.275E-16	2.758E-16	2.386E-16	3.629E-16	3.796E-16	3.805E-16	2.671E-16	2.607E-16	2.537E-16	2.98E-16
Sum of ratios	-0.21	0.05	0.63	-0.09	-0.08	0.06	-0.12	-0.02	0.24	0.22
Quarter 3										
Americium-241	-6.527E-16	4.022E-16	2.013E-16	2.964E-16	-8.615E-17	-1.128E-16	3.604E-17	-1.026E-15	1.858E-16	2.499E-16
Neptunium-237	-3.027E-16	-2.673E-16	-8.687E-17	-2.42E-16	-2.592E-16	-2.862E-16	3.477E-16	3.022E-16	-1.044E-16	2.202E-16
Technetium-99	-1.873E-16	2.444E-16	3.096E-16	1.175E-16	2.071E-16	2.076E-16	-2.693E-16	-2.3771E-16	1.77334E-16	3.69882E-16
Uranium-238	2.344E-16	2.704E-16	3.416E-16	3.338E-16	2.831E-16	2.679E-16	1.89E-16	3.353E-16	2.432E-16	2.654E-16
Sum of ratios	-0.57	0.02	0.08	0.00	-0.23	-0.26	0.33	-0.25	0.04	0.35
Quarter 4										
Americium-241		6.355E-18	1.504E-16	1.562E-16	-8.347E-16	-1.196E-16	-8.038E-16	3.509E-16	-1.812E-16	1.762E-16
Neptunium-237	2.536E-16	9.254E-17	-5.46E-16	-5.108E-17	-1.707E-17	3.603E-17	1.576E-16	-2.607E-16	-1.232E-16	-1.463E-16
Technetium-99	2.9216E-17	9.464E-16	8.543E-16	3.033E-16	-7.345E-18	2.802E-16	-2.998E-16	5.028E-16	2.258E-16	2.814E-16
Uranium-238	1.854E-16	1.61E-16	1.977E-16	2.033E-16	1.949E-16	1.674E-16	1.888E-16	1.761E-16	2.651E-16	1.505E-16
Sum of ratios	0.23	0.11	-0.35	0.07	-0.43	-0.01	-0.27	-0.01	-0.16	-0.01

*Sum of Ratios: The ratio of the measured concentration to the allowable concentration is added for all radionuclides for each quarter for each location. A value of less than one indicates regulatory compliance.

Surface Water Radiological Data

Table 2.2 Radiological Monitoring Data for Surface Water Location L1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-10	12	-1.2	0	4	10%DCG	3
Cesium-134	pCi/L	-12	-0.67	-6.6	0	4		
Cesium-137	pCi/L	-5.8	0.71	-1.1	0	4	10%DCG	300
Cobalt-60	pCi/L	-2.4	1.6	0.29	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	0.024	3.1	1.8	0	4		
Dissolved Beta	pCi/L	0.32	9	3.9	0	4		
Neptunium-237	pCi/L	-0.95	-0.039	-0.42	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.098	0.14	-0.019	0	4		
Plutonium-239/240	pCi/L	-0.017	0.051	0.006	0	4	10%DCG	3
Potassium-40	pCi/L	-94	200	40	1	4		
Suspended Alpha	pCi/L	-2.5	6.5	1.6	1	4		
Suspended Beta	pCi/L	-5.9	7.3	2.7	0	4		
Technetium-99	pCi/L	2.8	16	7.2	1	4	ActionLimit	900
Thorium-228	pCi/L	-0.0013	0.021	0.012	0	4		
Thorium-230	pCi/L	-0.045	0.18	0.051	0	4	10%DCG	30
Thorium-232	pCi/L	-0.016	0.044	0.007	0	4		
Thorium-234	pCi/L	-120	78	-8.8	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	3	10%DCG	60

Surface Water Radiological Data

Table 2.3 Radiological Monitoring Data for Surface Water Location L5

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-7.4	21	1.6	0	4	10%DCG	3
Cesium-134	pCi/L	-16	-0.74	-7.2	0	4		
Cesium-137	pCi/L	-0.91	7.5	2.1	0	4	10%DCG	300
Cobalt-60	pCi/L	-3	8.9	1.5	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-3	6.6	2.4	0	4		
Dissolved Beta	pCi/L	8.2	19	11	1	4		
Neptunium-237	pCi/L	-0.73	0.037	-0.36	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.056	0.039	-0.018	0	4		
Plutonium-239/240	pCi/L	-0.043	0.051	0.014	0	4	10%DCG	3
Potassium-40	pCi/L	-81	130	7.1	0	4		
Suspended Alpha	pCi/L	-4.6	6.4	-0.8	0	4		
Suspended Beta	pCi/L	-0.54	15	7.2	2	4		
Technetium-99	pCi/L	1.1	22	14	3	4	ActionLimit	900
Thorium-228	pCi/L	-0.0099	0.031	0.013	0	4		
Thorium-230	pCi/L	-0.084	0.49	0.11	0	4	10%DCG	30
Thorium-232	pCi/L	-0.027	0.022	-0.0049	0	4		
Thorium-234	pCi/L	-35	110	11	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.52	6.1	3.2	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.4 Radiological Monitoring Data for Surface Water Location L6

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-5.7	6.5	1.7	0	4	10%DCG	3
Cesium-134	pCi/L	-18	0.033	-5.3	0	4		
Cesium-137	pCi/L	-6.3	-0.54	-3.4	0	4	10%DCG	300
Cobalt-60	pCi/L	-1.8	9.4	3.3	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	3	7	4.6	0	4		
Dissolved Beta	pCi/L	4.5	14	9.8	2	4		
Neptunium-237	pCi/L	-0.62	0.074	-0.36	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.13	0.019	-0.041	0	4		
Plutonium-239/240	pCi/L	-0.045	-0.0033	-0.019	0	4	10%DCG	3
Potassium-40	pCi/L	-120	180	-17	0	4		
Suspended Alpha	pCi/L	-2.7	4	0.42	0	4		
Suspended Beta	pCi/L	0.27	2.9	2.2	0	4		
Technetium-99	pCi/L	-3.4	20	7.8	1	4	ActionLimit	900
Thorium-228	pCi/L	-0.058	0.0041	-0.016	0	4		
Thorium-230	pCi/L	-0.1	0.0092	-0.037	0	4	10%DCG	30
Thorium-232	pCi/L	-0.049	0.011	-0.019	0	4		
Thorium-234	pCi/L	-69	-30	-44	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.48	1.2	0.84	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.5 Radiological Monitoring Data for Surface Water Location C612

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-32	0.019	-13	0	4	10%DCG	3
Cesium-134	pCi/L	-15	-0.23	-8.2	0	4		
Cesium-137	pCi/L	-1.9	7.8	1.9	0	4	10%DCG	300
Cobalt-60	pCi/L	-7.4	3.4	-0.76	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-3.6	4.1	0.27	0	4		
Dissolved Beta	pCi/L	-0.31	17	9.3	2	4		
Neptunium-237	pCi/L	-0.62	0.018	-0.34	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.032	0.078	0.012	0	4		
Plutonium-239/240	pCi/L	-0.0088	0.016	0.0071	0	4	10%DCG	3
Potassium-40	pCi/L	-180	150	-29	0	4		
Suspended Alpha	pCi/L	-1.7	7.1	1.2	1	4		
Suspended Beta	pCi/L	-4.1	9.8	3.5	1	4		
Technetium-99	pCi/L	11	27	20	3	4	ActionLimit	900
Thorium-228	pCi/L	0.00086	0.02	0.0087	0	4		
Thorium-230	pCi/L	-0.014	0.18	0.061	0	4	10%DCG	30
Thorium-232	pCi/L	-0.025	0.026	-0.000097	0	4		
Thorium-234	pCi/L	-180	320	24	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	3	10%DCG	60

Surface Water Radiological Data

Table 2.6 Radiological Monitoring Data for Surface Water Location C616

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-5.9	40	10	0	4	10%DCG	3
Cesium-134	pCi/L	-16	-0.47	-9.8	0	4		
Cesium-137	pCi/L	-8.9	4.4	-2.4	0	4	10%DCG	300
Cobalt-60	pCi/L	-4.3	7.2	0.45	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-7.8	4	-0.39	0	4		
Dissolved Beta	pCi/L	24	55	35	4	4		
Neptunium-237	pCi/L	-0.68	-0.19	-0.42	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.093	0.049	-0.028	0	4		
Plutonium-239/240	pCi/L	-0.045	0.037	-0.0027	0	4	10%DCG	3
Potassium-40	pCi/L	-150	210	30	1	4		
Suspended Alpha	pCi/L	-0.65	3.8	0.9	1	4		
Suspended Beta	pCi/L	1.1	2.8	2	0	4		
Technetium-99	pCi/L	0	18	7.1	1	4	ActionLimit	900
Thorium-228	pCi/L	-0.013	0.068	0.034	0	4		
Thorium-230	pCi/L	-0.0079	0.14	0.08	0	4	10%DCG	30
Thorium-232	pCi/L	-0.046	0.14	0.029	0	4		
Thorium-234	pCi/L	-0.24	480	200	1	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	1.4	0.92	2	3	10%DCG	60

Surface Water Radiological Data

Table 2.7 Radiological Monitoring Data for Surface Water Location K006

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-29	-0.00068	-13	0	4	10%DCG	3
Cesium-134	pCi/L	-18	0.8	-8.8	0	4		
Cesium-137	pCi/L	-0.15	2.9	1	0	4	10%DCG	300
Cobalt-60	pCi/L	-7.2	3.4	-0.55	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-3.8	3.9	0.76	0	4		
Dissolved Beta	pCi/L	0.31	6.8	4.4	0	4		
Neptunium-237	pCi/L	-0.7	-0.17	-0.42	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.12	0.07	-0.052	0	4		
Plutonium-239/240	pCi/L	-0.0067	0.041	0.019	0	4	10%DCG	3
Potassium-40	pCi/L	-180	6.9	-75	0	4		
Suspended Alpha	pCi/L	-4.4	2.6	0.056	0	4		
Suspended Beta	pCi/L	-4.4	5.5	1.5	0	4		
Technetium-99	pCi/L	-1.7	8.4	3	0	4	ActionLimit	900
Thorium-228	pCi/L	-0.027	0.023	0.0024	0	4		
Thorium-230	pCi/L	0.028	0.56	0.21	1	4	10%DCG	30
Thorium-232	pCi/L	-0.013	0.062	0.012	0	4		
Thorium-234	pCi/L	-120	16	-30	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	3	10%DCG	60

Surface Water Radiological Data

Table 2.8 Radiological Monitoring Data for Surface Water Location K016

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-20	11	-6.6	0	4	10%DCG	3
Cesium-134	pCi/L	-5.2	0.71	-2.2	0	4		
Cesium-137	pCi/L	-6.9	0.23	-1.6	0	4	10%DCG	300
Cobalt-60	pCi/L	0.39	8.3	3.5	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-0.8	6.8	2.6	1	4		
Dissolved Beta	pCi/L	5.6	13	10	2	4		
Neptunium-237	pCi/L	-0.78	-0.29	-0.46	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.062	0.14	0.023	0	4		
Plutonium-239/240	pCi/L	-0.0099	0.023	0.012	0	4	10%DCG	3
Potassium-40	pCi/L	-33	160	46	1	4		
Suspended Alpha	pCi/L	-1.6	0.99	-0.26	0	4		
Suspended Beta	pCi/L	0.88	5.5	3	0	4		
Technetium-99	pCi/L	7.3	18	11	1	4	ActionLimit	900
Thorium-228	pCi/L	-0.01	0.057	0.015	0	4		
Thorium-230	pCi/L	-0.0005	0.64	0.21	1	4	10%DCG	30
Thorium-232	pCi/L	-0.0089	0.042	0.015	0	4		
Thorium-234	pCi/L	-130	190	15	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.51	0.75	0.64	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.9 Radiological Monitoring Data for Surface Water Location L291

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	2		
Americium-241	pCi/L	-31	10	-7.4	0	5	10%DCG	3
Cesium-134	pCi/L	-16	0.23	-4.9	0	5		
Cesium-137	pCi/L	-7.5	16	2	1	5	10%DCG	300
Cobalt-60	pCi/L	-6.9	6.1	-0.3	0	5	10%DCG	1000
Dissolved Alpha	pCi/L	-0.27	5.5	2.1	0	5		
Dissolved Beta	pCi/L	1.7	5.6	4	0	5		
Neptunium-237	pCi/L	-0.59	0.26	-0.24	0	5	10%DCG	3
Plutonium-238	pCi/L	-0.12	0.029	-0.052	0	5		
Plutonium-239/240	pCi/L	-0.026	0.042	0.0086	0	5	10%DCG	3
Potassium-40	pCi/L	-96	-45	-69	0	5		
Suspended Alpha	pCi/L	-2.6	4.2	0.23	0	5		
Suspended Beta	pCi/L	-2.4	3.6	0.46	0	5		
Technetium-99	pCi/L	-2.8	9.9	5	0	5	ActionLimit	900
Thorium-228	pCi/L	-0.022	0.0088	-0.0063	0	5		
Thorium-230	pCi/L	-0.17	0.27	0.014	0	5	10%DCG	30
Thorium-232	pCi/L	-0.018	0.053	0.018	0	5		
Thorium-234	pCi/L	-93	330	54	0	5		
Uranium	pCi/L	40	40	40	0	2	10%DCG	60
Uranium-234	pCi/L	30	40	32	0	4	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	4	10%DCG	60

Surface Water Radiological Data

Table 2.10 Radiological Monitoring Data for Surface Water Location K002

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-32	34	6.7	0	4	10%DCG	3
Cesium-134	pCi/L	-8.2	-1.2	-4.7	0	4		
Cesium-137	pCi/L	-4.2	1.7	-0.92	0	4	10%DCG	300
Cobalt-60	pCi/L	-3.2	5.1	0.65	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-1.6	4	0.67	0	4		
Dissolved Beta	pCi/L	4.2	8.8	6.9	0	4		
Neptunium-237	pCi/L	-0.57	0.056	-0.37	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.098	0.059	-0.019	0	4		
Plutonium-239/240	pCi/L	-0.025	0.038	0.0042	0	4	10%DCG	3
Potassium-40	pCi/L	-65	48	-2.9	0	4		
Suspended Alpha	pCi/L	0.45	4	1.7	0	4		
Suspended Beta	pCi/L	1.2	5.8	4.3	0	4		
Technetium-99	pCi/L	6.9	32	16	2	4	ActionLimit	900
Thorium-228	pCi/L	-0.01	0.052	0.024	0	4		
Thorium-230	pCi/L	0.0085	0.2	0.094	0	4	10%DCG	30
Thorium-232	pCi/L	-0.046	0.02	-0.011	0	4		
Thorium-234	pCi/L	-66	38	-11	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.71	1.4	1.1	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.11 Radiological Monitoring Data for Surface Water Location L10

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-3.2	11	2.7	0	4	10%DCG	3
Cesium-134	pCi/L	-14	-0.66	-6.3	0	4		
Cesium-137	pCi/L	-6	1.2	-3	0	4	10%DCG	300
Cobalt-60	pCi/L	-3.1	2.4	0.46	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-2.5	12	6	3	4		
Dissolved Beta	pCi/L	2	16	8.3	1	4		
Neptunium-237	pCi/L	-0.72	0.13	-0.22	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.11	0.046	-0.052	0	4		
Plutonium-239/240	pCi/L	-0.041	0.071	0.022	0	4	10%DCG	3
Potassium-40	pCi/L	-230	20	-110	0	4		
Suspended Alpha	pCi/L	-0.63	5.3	2.8	1	4		
Suspended Beta	pCi/L	-0.29	3.2	2	0	4		
Technetium-99	pCi/L	2.8	13	8.5	0	4	ActionLimit	900
Thorium-228	pCi/L	0.0013	0.039	0.025	0	4		
Thorium-230	pCi/L	-0.056	0.34	0.18	1	4	10%DCG	30
Thorium-232	pCi/L	-0.0025	0.097	0.027	0	4		
Thorium-234	pCi/L	-99	380	100	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	2.7	3.2	3	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.12 Radiological Monitoring Data for Surface Water Location L194

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-25	-0.099	-16	0	4	10%DCG	3
Cesium-134	pCi/L	-18	0.56	-8.4	0	4		
Cesium-137	pCi/L	-3.3	7.4	2	0	4	10%DCG	300
Cobalt-60	pCi/L	-4.3	15	3.8	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	1.9	10	6.7	2	4		
Dissolved Beta	pCi/L	1.4	26	11	1	4		
Neptunium-237	pCi/L	-0.79	0.018	-0.26	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.017	0.025	-0.0032	0	4		
Plutonium-239/240	pCi/L	-0.03	0.13	0.032	1	4	10%DCG	3
Potassium-40	pCi/L	-210	47	-75	0	4		
Suspended Alpha	pCi/L	-2	5.6	2.4	1	4		
Suspended Beta	pCi/L	-1.8	5.9	2.1	0	4		
Technetium-99	pCi/L	-15	29	12	2	4	ActionLimit	900
Thorium-228	pCi/L	-0.019	0.037	0.0033	0	4		
Thorium-230	pCi/L	-0.06	0.26	0.14	1	4	10%DCG	30
Thorium-232	pCi/L	-0.0097	0.027	0.0014	0	4		
Thorium-234	pCi/L	-120	310	48	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	2.2	15	6.4	0	3	10%DCG	60
Uranium-238	pCi/L	2.3	11	5.7	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.13 Radiological Monitoring Data for Surface Water Location L55

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-4	9.5	3.6	0	4	10%DCG	3
Cesium-134	pCi/L	-12	1.5	-4.1	0	4		
Cesium-137	pCi/L	-4.6	0.73	-1.9	0	4	10%DCG	300
Cobalt-60	pCi/L	-6.6	2	-1.3	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-0.66	9	4.6	2	4		
Dissolved Beta	pCi/L	3.5	11	6.5	0	4		
Neptunium-237	pCi/L	-0.54	#VALUE!	-0.33	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.16	0.023	-0.055	0	4		
Plutonium-239/240	pCi/L	-0.055	0.037	-0.017	0	4	10%DCG	3
Potassium-40	pCi/L	-89	21	-54	0	4		
Suspended Alpha	pCi/L	-0.66	5.1	1.6	1	4		
Suspended Beta	pCi/L	-3.8	2	-0.86	0	4		
Technetium-99	pCi/L	-7.8	10	4.5	0	4	ActionLimit	900
Thorium-228	pCi/L	-0.019	0.018	0.0058	0	4		
Thorium-230	pCi/L	-0.13	0.72	0.12	1	4	10%DCG	30
Thorium-232	pCi/L	-0.015	0.031	0.0017	0	4		
Thorium-234	pCi/L	-60	320	42	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	2.2	32	12	1	3	10%DCG	60
Uranium-238	pCi/L	0	8.2	3.5	3	4	10%DCG	60

Surface Water Radiological Data

Table 2.14 Radiological Monitoring Data for Surface Water Location L56

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-0.13	20	11	0	4	10%DCG	3
Cesium-134	pCi/L	-12	7.5	-2.4	0	4		
Cesium-137	pCi/L	-6.9	-0.76	-3.3	0	4	10%DCG	300
Cobalt-60	pCi/L	-2.4	14	2.9	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	0.21	7.4	2.6	1	4		
Dissolved Beta	pCi/L	-1.4	14	5.7	1	4		
Neptunium-237	pCi/L	-0.87	-0.018	-0.32	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.049	0.13	0.046	0	4		
Plutonium-239/240	pCi/L	-0.048	0.033	-0.00026	0	4	10%DCG	3
Potassium-40	pCi/L	-110	190	71	2	4		
Suspended Alpha	pCi/L	-0.12	3.8	2	0	4		
Suspended Beta	pCi/L	0	10	3.9	0	4		
Technetium-99	pCi/L	5.8	15	9.7	0	4	ActionLimit	900
Thorium-228	pCi/L	-0.0058	0.12	0.05	0	4		
Thorium-230	pCi/L	-0.13	0.27	0.038	0	4	10%DCG	30
Thorium-232	pCi/L	-0.036	0.1	0.0079	0	4		
Thorium-234	pCi/L	-50	58	0.2	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.55	0.42	1	3	10%DCG	60

Surface Water Radiological Data

Table 2.15 Radiological Monitoring Data for Surface Water Location L11

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-24	7.9	-8.4	0	4	10%DCG	3
Cesium-134	pCi/L	-16	-0.62	-11	0	4		
Cesium-137	pCi/L	-5	5.7	1.3	0	4	10%DCG	300
Cobalt-60	pCi/L	-0.12	2	1	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-1.8	5.1	2	1	4		
Dissolved Beta	pCi/L	3.1	13	7.7	1	4		
Neptunium-237	pCi/L	-0.74	0.35	-0.29	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.12	0.029	-0.047	0	4		
Plutonium-239/240	pCi/L	-0.024	0.045	0.016	0	4	10%DCG	3
Potassium-40	pCi/L	-110	150	-0.98	0	4		
Suspended Alpha	pCi/L	-0.97	2.3	0.79	0	4		
Suspended Beta	pCi/L	-1.6	8.9	3.3	0	4		
Technetium-99	pCi/L	2.2	17	12	1	4	ActionLimit	900
Thorium-228	pCi/L	-0.0047	0.17	0.055	0	4		
Thorium-230	pCi/L	-0.058	0.81	0.24	1	4	10%DCG	30
Thorium-232	pCi/L	-0.044	0.18	0.031	0	4		
Thorium-234	pCi/L	-140	130	-15	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.86	2.1	1.4	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.16 Radiological Monitoring Data for Surface Water Location L12

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	2		
Americium-241	pCi/L	-36	15	-4.7	0	5	10%DCG	3
Cesium-134	pCi/L	-22	0.1	-5	0	5		
Cesium-137	pCi/L	-1.7	1.9	0.15	0	5	10%DCG	300
Cobalt-60	pCi/L	-2.8	0.84	-0.35	0	5	10%DCG	1000
Dissolved Alpha	pCi/L	-0.48	3.6	1.6	0	5		
Dissolved Beta	pCi/L	5.6	36	16	3	5		
Neptunium-237	pCi/L	-0.62	-0.21	-0.39	0	5	10%DCG	3
Plutonium-238	pCi/L	-0.063	0.13	0.015	0	5		
Plutonium-239/240	pCi/L	-0.055	0.0061	-0.016	0	5	10%DCG	3
Potassium-40	pCi/L	-270	230	19	1	5		
Suspended Alpha	pCi/L	-0.66	6.8	2.6	2	5		
Suspended Beta	pCi/L	-5.1	1.5	-1.2	0	5		
Technetium-99	pCi/L	11	32	21	3	5	ActionLimit	900
Thorium-228	pCi/L	-0.022	0.27	0.099	2	5		
Thorium-230	pCi/L	-0.09	0.62	0.24	1	5	10%DCG	30
Thorium-232	pCi/L	-0.013	0.23	0.086	1	5		
Thorium-234	pCi/L	-94	84	5.1	0	5		
Uranium	pCi/L	40	40	40	0	2	10%DCG	60
Uranium-234	pCi/L	30	40	32	0	4	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.44	1.3	0.99	4	4	10%DCG	60

Surface Water Radiological Data

Table 2.17 Radiological Monitoring Data for Surface Water Location L241

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-33	2.5	-8.1	0	4	10%DCG	3
Cesium-134	pCi/L	-8.7	-0.62	-3.4	0	4		
Cesium-137	pCi/L	-0.15	4.7	1.9	0	4	10%DCG	300
Cobalt-60	pCi/L	-4.5	11	3.6	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	1	7.8	3	1	4		
Dissolved Beta	pCi/L	3.7	38	24	3	4		
Neptunium-237	pCi/L	-0.71	0.085	-0.38	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.24	-0.068	-0.13	0	4		
Plutonium-239/240	pCi/L	-0.041	0.02	-0.00093	0	4	10%DCG	3
Potassium-40	pCi/L	-170	360	9.8	1	4		
Suspended Alpha	pCi/L	-1.1	2.7	0.73	0	4		
Suspended Beta	pCi/L	-5	10	-0.41	0	4		
Technetium-99	pCi/L	15	63	41	4	4	ActionLimit	900
Thorium-228	pCi/L	-0.029	0.24	0.046	1	4		
Thorium-230	pCi/L	-0.11	0.4	0.054	0	4	10%DCG	30
Thorium-232	pCi/L	0.0079	0.2	0.065	1	4		
Thorium-234	pCi/L	-33	300	75	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.63	1.3	1	3	3	10%DCG	60

Surface Water Radiological Data

Table 2.18 Radiological Monitoring Data for Surface Water Location C746K-5

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-23	1.3	-9.8	0	5	10%DCG	3
Cesium-134	pCi/L	-10	1.4	-4.3	0	5		
Cesium-137	pCi/L	-5.2	8.6	0.1	0	5	10%DCG	300
Cobalt-60	pCi/L	-2.5	2.5	-0.056	0	5	10%DCG	1000
Dissolved Alpha	pCi/L	-5.4	4	0.67	0	5		
Dissolved Beta	pCi/L	1.6	13	6.6	1	5		
Neptunium-237	pCi/L	-0.87	-0.15	-0.42	0	5	10%DCG	3
Plutonium-238	pCi/L	-0.044	0.1	0.023	0	5		
Plutonium-239/240	pCi/L	-0.0067	0.035	0.014	0	5	10%DCG	3
Potassium-40	pCi/L	-28	160	34	1	5		
Suspended Alpha	pCi/L	-3.3	3.2	0.49	0	5		
Suspended Beta	pCi/L	-5	15	4.4	1	5		
Technetium-99	pCi/L	0	9	6	0	5	ActionLimit	900
Thorium-228	pCi/L	-0.01	0.045	0.0079	0	5		
Thorium-230	pCi/L	-0.15	0.000053	-0.061	0	5	10%DCG	30
Thorium-232	pCi/L	-0.042	0.031	0.0053	0	5		
Thorium-234	pCi/L	-88	150	26	0	5		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	32	0	4	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.6	0	4	10%DCG	60
Uranium-238	pCi/L	0.35	0.54	0.4	1	4	10%DCG	60

Surface Water Radiological Data

Table 2.19 Radiological Monitoring Data for Surface Water Location C746KTB1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-17	13	-3.5	0	4	10%DCG	3
Cesium-134	pCi/L	-4.5	1.7	-0.83	0	4		
Cesium-137	pCi/L	-2.5	8.9	2.6	0	4	10%DCG	300
Cobalt-60	pCi/L	-5.2	10	2.6	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-2.6	5.3	0.076	0	4		
Dissolved Beta	pCi/L	5.8	17	11	2	4		
Neptunium-237	pCi/L	-0.69	#VALUE!	-0.29	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.13	0.031	-0.055	0	4		
Plutonium-239/240	pCi/L	-0.063	0.055	0.014	0	4	10%DCG	3
Potassium-40	pCi/L	-86	4.7	-28	0	4		
Suspended Alpha	pCi/L	-4.4	2	-1.1	0	4		
Suspended Beta	pCi/L	0	6.3	3.7	0	4		
Technetium-99	pCi/L	-14	13	5.4	0	4	ActionLimit	900
Thorium-228	pCi/L	0.00068	0.07	0.026	0	4		
Thorium-230	pCi/L	-0.13	0.31	0.054	0	4	10%DCG	30
Thorium-232	pCi/L	-0.018	0.087	0.018	0	4		
Thorium-234	pCi/L	-84	140	26	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	3	10%DCG	60

Surface Water Radiological Data

Table 2.20 Radiological Monitoring Data for Surface Water Location C746KTB2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-36	14	-2.1	0	4	10%DCG	3
Cesium-134	pCi/L	-5.1	-0.011	-1.8	0	4		
Cesium-137	pCi/L	-5.8	1.6	-0.37	0	4	10%DCG	300
Cobalt-60	pCi/L	-0.84	3.5	0.47	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-4.2	-0.18	-2.3	0	4		
Dissolved Beta	pCi/L	2.9	13	8.1	2	4		
Neptunium-237	pCi/L	-0.57	-0.22	-0.36	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.054	0.055	0.01	0	4		
Plutonium-239/240	pCi/L	-0.052	0.13	0.03	1	4	10%DCG	3
Potassium-40	pCi/L	-120	140	23	0	4		
Suspended Alpha	pCi/L	-2.1	3.6	0.44	0	4		
Suspended Beta	pCi/L	1.2	5.7	3.1	0	4		
Technetium-99	pCi/L	4	8.3	5.8	0	4	ActionLimit	900
Thorium-228	pCi/L	-0.01	0.087	0.032	0	4		
Thorium-230	pCi/L	-0.17	0.44	0.084	1	4	10%DCG	30
Thorium-232	pCi/L	0.012	0.062	0.03	0	4		
Thorium-234	pCi/L	-96	270	53	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	3	10%DCG	60

Surface Water Radiological Data

Table 2.21 Radiological Monitoring Data for Surface Water Location C746KUP

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-20	20	-4.7	0	4	10%DCG	3
Cesium-134	pCi/L	-17	0.63	-8.2	0	4		
Cesium-137	pCi/L	-2.5	1.8	0.22	0	4	10%DCG	300
Cobalt-60	pCi/L	-5.8	3	-0.0047	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-5	3	0.0017	0	4		
Dissolved Beta	pCi/L	1.3	15	8.6	2	4		
Neptunium-237	pCi/L	-0.85	-0.15	-0.44	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.1	0.014	-0.021	0	4		
Plutonium-239/240	pCi/L	-0.037	0.043	-0.00076	0	4	10%DCG	3
Potassium-40	pCi/L	-78	110	17	0	4		
Suspended Alpha	pCi/L	-3.2	4.3	0.83	0	4		
Suspended Beta	pCi/L	-1.2	13	3.7	1	4		
Technetium-99	pCi/L	0	10	5.7	0	4	ActionLimit	900
Thorium-228	pCi/L	0.00041	0.061	0.019	0	4		
Thorium-230	pCi/L	-0.12	0.16	-0.0041	0	4	10%DCG	30
Thorium-232	pCi/L	0.0042	0.026	0.017	0	4		
Thorium-234	pCi/L	-16	280	160	0	4		
Uranium	pCi/L	40	760	400	0	2	10%DCG	60
Uranium-234	pCi/L	30	530	160	0	4	10%DCG	50
Uranium-235	pCi/L	2.2	26	10	1	3	10%DCG	60
Uranium-238	pCi/L	0.35	210	52	0	4	10%DCG	60

Surface Water Radiological Data

Table 2.22 Radiological Monitoring Data for Surface Water Location L8

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-7.7	11	2.1	0	4	10%DCG	3
Cesium-134	pCi/L	-16	-0.58	-5.9	0	4		
Cesium-137	pCi/L	0.071	1.7	0.85	0	4	10%DCG	300
Cobalt-60	pCi/L	-1.8	3.3	1.1	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-2.7	1.5	-0.33	0	4		
Dissolved Beta	pCi/L	5.5	10	8.2	0	4		
Neptunium-237	pCi/L	-0.7	0.17	-0.25	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.16	0.061	-0.042	0	4		
Plutonium-239/240	pCi/L	-0.037	0.023	-0.0055	0	4	10%DCG	3
Potassium-40	pCi/L	-94	240	92	1	4		
Suspended Alpha	pCi/L	-4	2.1	-1.2	0	4		
Suspended Beta	pCi/L	-3.6	5.4	2.3	0	4		
Technetium-99	pCi/L	0.76	9.7	4	0	4	ActionLimit	900
Thorium-228	pCi/L	-0.027	0.021	-0.0014	0	4		
Thorium-230	pCi/L	-0.18	-0.0063	-0.071	0	4	10%DCG	30
Thorium-232	pCi/L	-0.024	0.0091	-0.0079	0	4		
Thorium-234	pCi/L	-22	83	33	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	50	38	0	4	10%DCG	50
Uranium-235	pCi/L	2.2	2.2	2.2	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	1.2	0.78	3	4	10%DCG	60

Surface Water Radiological Data

Table 2.23 Radiological Monitoring Data for Surface Water Location L29

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-11	1	-2.9	0	4	10%DCG	3
Cesium-134	pCi/L	-15	-0.35	-10	0	4		
Cesium-137	pCi/L	-4.2	0.94	-2.7	0	4	10%DCG	300
Cobalt-60	pCi/L	-2.1	2.6	0.24	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-4.3	-0.45	-1.7	0	4		
Dissolved Beta	pCi/L	-2.6	7.3	3.7	0	4		
Neptunium-237	pCi/L	-0.72	-0.13	-0.4	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.093	0.045	-0.025	0	4		
Plutonium-239/240	pCi/L	-0.058	-0.003	-0.029	0	4	10%DCG	3
Potassium-40	pCi/L	-120	120	-35	0	4		
Suspended Alpha	pCi/L	-3.4	1.6	-1.2	0	4		
Suspended Beta	pCi/L	2.2	4.5	3.4	0	4		
Technetium-99	pCi/L	-2.7	5.5	1.8	0	4	ActionLimit	900
Thorium-228	pCi/L	-0.042	-0.026	-0.037	0	4		
Thorium-230	pCi/L	-0.12	-0.029	-0.058	0	4	10%DCG	30
Thorium-232	pCi/L	-0.0096	0.026	0.0091	0	4		
Thorium-234	pCi/L	-63	270	130	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	50	38	0	4	10%DCG	50
Uranium-235	pCi/L	2.2	2.2	2.2	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	4	10%DCG	60

Surface Water Radiological Data

Table 2.24 Radiological Monitoring Data for Surface Water Location L30

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-4	3.7	-1	0	4	10%DCG	3
Cesium-134	pCi/L	-14	-0.89	-7.2	0	4		
Cesium-137	pCi/L	-1.2	6.2	1.9	0	4	10%DCG	300
Cobalt-60	pCi/L	-4.4	11	2.5	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-1.5	3.6	0.11	0	4		
Dissolved Beta	pCi/L	-0.28	7.4	3.8	0	4		
Neptunium-237	pCi/L	-0.72	-0.17	-0.48	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.15	0.051	-0.048	0	4		
Plutonium-239/240	pCi/L	-0.033	0.01	-0.01	0	4	10%DCG	3
Potassium-40	pCi/L	-120	180	22	0	4		
Suspended Alpha	pCi/L	-2	5.6	0.39	0	4		
Suspended Beta	pCi/L	0	7.4	2.7	0	4		
Technetium-99	pCi/L	-4.9	12	3.4	0	4	ActionLimit	900
Thorium-228	pCi/L	-0.011	0.014	0.0052	0	4		
Thorium-230	pCi/L	-0.16	0.028	-0.056	0	4	10%DCG	30
Thorium-232	pCi/L	-0.026	0.026	0.00025	0	4		
Thorium-234	pCi/L	-59	350	95	1	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	50	38	0	4	10%DCG	50
Uranium-235	pCi/L	2.2	2.2	2.2	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	4	10%DCG	60

Surface Water Radiological Data

Table 2.25 Radiological Monitoring Data for Surface Water Location L306

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-27	26	-4.4	0	6	10%DCG	3
Cesium-134	pCi/L	-17	-0.51	-9.9	0	6		
Cesium-137	pCi/L	-9.4	4.5	-0.17	0	6	10%DCG	300
Cobalt-60	pCi/L	-2.6	6.8	2.2	0	6	10%DCG	1000
Dissolved Alpha	pCi/L	-1.2	3.3	0.44	0	6		
Dissolved Beta	pCi/L	2.6	8.7	5	0	6		
Neptunium-237	pCi/L	-0.7	0.17	-0.29	0	6	10%DCG	3
Plutonium-238	pCi/L	-0.085	0.045	-0.014	0	6		
Plutonium-239/240	pCi/L	-0.032	0.066	-0.0083	0	6	10%DCG	3
Potassium-40	pCi/L	-170	140	-35	0	6		
Suspended Alpha	pCi/L	-1.4	4.1	1.1	0	6		
Suspended Beta	pCi/L	-0.54	7.1	4.4	0	6		
Technetium-99	pCi/L	-2.4	5.1	1.7	0	6	ActionLimit	900
Thorium-228	pCi/L	-0.055	0.045	-0.0079	0	6		
Thorium-230	pCi/L	-0.14	0.043	-0.066	0	6	10%DCG	30
Thorium-232	pCi/L	-0.025	0.018	-0.01	0	6		
Thorium-234	pCi/L	-39	210	78	0	6		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	50	42	0	6	10%DCG	50
Uranium-235	pCi/L	2.2	2.2	2.2	0	5	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	6	10%DCG	60

Surface Water Radiological Data

Table 2.26 Radiological Monitoring Data for Surface Water Location L64

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Activity of U-235	pCi/L	2.2	2.2	2.2	0	1		
Americium-241	pCi/L	-11	12	-0.75	0	4	10%DCG	3
Cesium-134	pCi/L	-21	-0.96	-12	0	4		
Cesium-137	pCi/L	-3.7	-0.56	-2.4	0	4	10%DCG	300
Cobalt-60	pCi/L	-2.8	5.4	0.59	0	4	10%DCG	1000
Dissolved Alpha	pCi/L	-0.83	3.7	2	0	4		
Dissolved Beta	pCi/L	1.8	9.1	6	0	4		
Neptunium-237	pCi/L	-0.93	0.13	-0.27	0	4	10%DCG	3
Plutonium-238	pCi/L	-0.18	0.03	-0.076	0	4		
Plutonium-239/240	pCi/L	-0.033	0.051	-0.00054	0	4	10%DCG	3
Potassium-40	pCi/L	-97	99	13	0	4		
Suspended Alpha	pCi/L	-1.1	6.8	2.5	1	4		
Suspended Beta	pCi/L	0.59	4.1	2.7	0	4		
Technetium-99	pCi/L	0	21	8	1	4	ActionLimit	900
Thorium-228	pCi/L	-0.037	0.055	-0.0036	0	4		
Thorium-230	pCi/L	-0.093	0.3	0.061	0	4	10%DCG	30
Thorium-232	pCi/L	0.0034	0.05	0.026	0	4		
Thorium-234	pCi/L	-47	68	0.15	0	4		
Uranium	pCi/L	40	40	40	0	1	10%DCG	60
Uranium-234	pCi/L	30	40	33	0	3	10%DCG	50
Uranium-235	pCi/L	0	2.2	1.5	0	3	10%DCG	60
Uranium-238	pCi/L	0.35	0.35	0.35	0	3	10%DCG	60

Table 2.27 Radiological Monitoring Data for Surface Water Seep Location LBCSP1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	-0.87	3.4	1.6	0	4		
Beta activity	pCi/L	1.9	11	7.9	3	4		
Technetium-99	pCi/L	0	24	10	1	4	ActionLimit	900

Table 2.28 Radiological Monitoring Data for Surface Water Seep Location LBCSP2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	0.28	3.5	2.2	1	4		
Beta activity	pCi/L	9.6	20	15	4	4		
Technetium-99	pCi/L	0.65	26	15	2	4	ActionLimit	900

Surface Water Radiological Data

Table 2.29 Radiological Monitoring Data for Surface Water Seep Location LBCSP3

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	-0.03	4.1	2	0	4		
Beta activity	pCi/L	18	32	25	4	4		
Technetium-99	pCi/L	18	40	28	4	4	ActionLimit	900

Table 2.30 Radiological Monitoring Data for Surface Water Seep Location LBCSP4

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	-2.5	4.7	2.4	1	4		
Beta activity	pCi/L	21	28	23	4	4		
Technetium-99	pCi/L	8.4	34	23	3	4	ActionLimit	900

Table 2.31 Radiological Monitoring Data for Surface Water Seep Location LBCSP5

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	-1.1	4.7	2.2	1	4		
Beta activity	pCi/L	130	180	150	4	4		
Technetium-99	pCi/L	160	200	180	4	4	ActionLimit	900

Table 2.32 Radiological Monitoring Data for Surface Water Seep Location LBCSP6

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/L	-2.8	6.5	3.2	2	4		
Beta activity	pCi/L	140	150	150	4	4		
Technetium-99	pCi/L	160	170	160	4	4	ActionLimit	900

Sediment Radiological Data

Table 2.33 Radiological Data for Sediment Location S20

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	1.2	2.8	2	2	2		
Americium-241	pCi/g	-0.012	-0.0078	-0.0098	0	2		
Beta activity	pCi/g	1.3	1.6	1.5	2	2		
Cesium-137	pCi/g	0.0094	0.045	0.027	1	2		
Cobalt-60	pCi/g	-0.0019	0.00094	-0.00049	0	2		
Neptunium-237	pCi/g	-0.0012	0.0038	0.0013	0	2		
Plutonium-239/240	pCi/g	0.0015	0.0023	0.0019	0	2		
Potassium-40	pCi/g	1.6	3.9	2.7	2	2		
Technetium-99	pCi/g	0	0.038	0.019	0	2		
Thorium-230	pCi/g	0.18	0.18	0.18	2	2		

Table 2.34 Radiological Data for Sediment Location C612

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	9.4	15	12	2	2		
Americium-241	pCi/g	-0.032	-0.031	-0.031	0	2		
Beta activity	pCi/g	18	58	38	2	2		
Cesium-137	pCi/g	0.043	0.098	0.071	2	2		
Cobalt-60	pCi/g	-0.013	-0.005	-0.0089	0	2		
Neptunium-237	pCi/g	0.075	0.12	0.098	2	2		
Plutonium-239/240	pCi/g	0.031	0.032	0.031	2	2		
Potassium-40	pCi/g	5.1	6.3	5.7	2	2		
Technetium-99	pCi/g	3.1	24	14	2	2		
Thorium-230	pCi/g	0.0035	0.38	0.19	2	2		
Uranium-234	pCi/g	2.3	2.3	2.3	1	1		
Uranium-235	pCi/g	0.12	0.12	0.12	1	1		
Uranium-238	pCi/g	3.3	3.3	3.3	1	1		

Sediment Radiological Data

Table 2.35 Radiological Data for Sediment Location C616

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	7.6	15	12	3	3		
Americium-241	pCi/g	0.0086	0.037	0.027	0	3		
Beta activity	pCi/g	22	56	39	3	3		
Cesium-137	pCi/g	0.025	0.041	0.035	3	3		
Cobalt-60	pCi/g	-0.016	0.0037	-0.0043	0	3		
Neptunium-237	pCi/g	0.071	0.17	0.11	1	3		
Plutonium-239/240	pCi/g	0.049	0.083	0.06	3	3		
Potassium-40	pCi/g	7.1	7.3	7.2	3	3		
Technetium-99	pCi/g	3.8	11	7.4	3	3		
Thorium-230	pCi/g	0.53	0.7	0.59	3	3		
Uranium-234	pCi/g	2.4	2.4	2.4	1	1		
Uranium-235	pCi/g	0.13	0.13	0.13	1	1		
Uranium-238	pCi/g	3.1	3.1	3.1	1	1		

Table 2.36 Radiological Data for Sediment Location K001

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	6.1	7.2	6.6	2	2		
Americium-241	pCi/g	-0.0096	0.028	0.009	0	2		
Beta activity	pCi/g	15	18	16	2	2		
Cesium-137	pCi/g	0.035	0.035	0.035	2	2		
Cobalt-60	pCi/g	0.0033	0.0052	0.0043	0	2		
Neptunium-237	pCi/g	0.047	0.056	0.051	0	2		
Plutonium-239/240	pCi/g	0.022	0.023	0.023	2	2		
Potassium-40	pCi/g	4.6	6	5.3	2	2		
Technetium-99	pCi/g	4	5	4.5	2	2		
Thorium-230	pCi/g	0.31	0.42	0.37	2	2		

Table 2.37 Radiological Data for Sediment Location S1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	4.9	6.8	5.8	2	2		
Americium-241	pCi/g	0.019	0.02	0.019	0	2		
Beta activity	pCi/g	6.2	7.6	6.9	2	2		
Cesium-137	pCi/g	0.18	0.21	0.19	2	2		
Cobalt-60	pCi/g	-0.0041	0.0012	-0.0014	0	2		
Neptunium-237	pCi/g	0.029	0.031	0.03	0	2		
Plutonium-239/240	pCi/g	0.089	0.11	0.099	2	2		
Potassium-40	pCi/g	2.3	2.4	2.4	2	2		
Technetium-99	pCi/g	0.91	1	0.97	2	2		
Thorium-230	pCi/g	0.44	0.52	0.48	2	2		

Sediment Radiological Data

Table 2.38 Radiological Data for Sediment Location S31

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	3.5	16	9.7	2	2		
Americium-241	pCi/g	0.011	0.036	0.024	0	2		
Beta activity	pCi/g	4.3	18	11	2	2		
Cesium-137	pCi/g	0.0035	0.042	0.023	1	2		
Cobalt-60	pCi/g	-0.0043	-0.0032	-0.0038	0	2		
Neptunium-237	pCi/g	-0.0016	0.034	0.016	0	2		
Plutonium-239/240	pCi/g	0.047	0.083	0.065	2	2		
Potassium-40	pCi/g	2.6	2.8	2.7	2	2		
Technetium-99	pCi/g	0.56	1.9	1.2	2	2		
Thorium-230	pCi/g	0.48	0.88	0.68	2	2		

Table 2.39 Radiological Data for Sediment Location S33

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	2.7	2.9	2.8	2	2		
Americium-241	pCi/g	0.011	0.015	0.013	0	2		
Beta activity	pCi/g	2.6	3.5	3.1	2	2		
Cesium-137	pCi/g	0.025	0.033	0.029	2	2		
Cobalt-60	pCi/g	0.00068	0.0019	0.0013	0	2		
Neptunium-237	pCi/g	-0.013	0.018	0.0024	0	2		
Plutonium-239/240	pCi/g	0.0035	0.015	0.0094	1	2		
Potassium-40	pCi/g	2.9	3.5	3.2	2	2		
Technetium-99	pCi/g	0.23	0.3	0.26	2	2		
Thorium-230	pCi/g	0.16	0.28	0.22	2	2		
Uranium-234	pCi/g	0.41	0.41	0.41	1	1		
Uranium-235	pCi/g	0.022	0.022	0.022	1	1		
Uranium-238	pCi/g	0.61	0.61	0.61	1	1		

Table 2.40 Radiological Data for Sediment Location S21

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	2.6	2.9	2.7	2	2		
Americium-241	pCi/g	-0.04	-0.019	-0.029	0	2		
Beta activity	pCi/g	2.6	3.3	2.9	2	2		
Cesium-137	pCi/g	-0.0086	0.098	0.045	1	2		
Cobalt-60	pCi/g	-0.0058	0.0024	-0.0017	0	2		
Neptunium-237	pCi/g	-0.027	-0.011	-0.019	0	2		
Plutonium-239/240	pCi/g	0.00068	0.0044	0.0026	0	2		
Potassium-40	pCi/g	3.2	8.2	5.7	2	2		
Technetium-99	pCi/g	0.032	0.043	0.038	0	2		
Thorium-230	pCi/g	0.23	0.36	0.29	2	2		

Sediment Radiological Data

Table 2.41 Radiological Data for Sediment Location S2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	5.7	5.9	5.8	2	2		
Americium-241	pCi/g	0.029	0.051	0.04	0	2		
Beta activity	pCi/g	7.9	13	10	2	2		
Cesium-137	pCi/g	0.012	0.015	0.013	1	2		
Cobalt-60	pCi/g	-0.0037	-0.00024	-0.002	0	2		
Neptunium-237	pCi/g	-0.0085	0.0067	-0.00092	0	2		
Plutonium-239/240	pCi/g	-0.0012	0.00028	-0.00046	0	2		
Potassium-40	pCi/g	2.3	2.6	2.4	2	2		
Technetium-99	pCi/g	0.12	0.41	0.26	1	2		
Thorium-230	pCi/g	0.15	0.21	0.18	2	2		
Uranium-234	pCi/g	0.36	0.36	0.36	1	1		
Uranium-235	pCi/g	0.059	0.059	0.059	1	1		
Uranium-238	pCi/g	4.9	4.9	4.9	1	1		

Table 2.42 Radiological Data for Sediment Location S30

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	8.1	18	13	2	2		
Americium-241	pCi/g	-0.0067	0.03	0.012	0	2		
Beta activity	pCi/g	12	49	30	2	2		
Cesium-137	pCi/g	0.014	0.053	0.034	1	2		
Cobalt-60	pCi/g	-0.0083	0.00021	-0.004	0	2		
Neptunium-237	pCi/g	-0.015	0.013	-0.001	0	2		
Plutonium-239/240	pCi/g	-0.00015	0.0064	0.0031	0	2		
Potassium-40	pCi/g	2.7	3	2.8	2	2		
Technetium-99	pCi/g	0.18	0.22	0.2	2	2		
Thorium-230	pCi/g	0.21	0.32	0.27	2	2		
Uranium-234	pCi/g	0.37	1.6	0.96	2	2		
Uranium-235	pCi/g	0.066	0.3	0.18	2	2		
Uranium-238	pCi/g	5.5	26	16	2	2		

Sediment Radiological Data

Table 2.43 Radiological Data for Sediment Location S27

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	4.1	13	8.6	2	2		
Americium-241	pCi/g	-0.015	0.029	0.007	0	2		
Beta activity	pCi/g	6.7	19	13	2	2		
Cesium-137	pCi/g	0.01	0.027	0.019	1	2		
Cobalt-60	pCi/g	0.0018	0.0046	0.0032	0	2		
Neptunium-237	pCi/g	0.014	0.025	0.019	0	2		
Plutonium-239/240	pCi/g	0.046	0.21	0.13	2	2		
Potassium-40	pCi/g	1.4	1.5	1.4	2	2		
Technetium-99	pCi/g	0.71	2	1.4	2	2		
Thorium-230	pCi/g	0.83	2.5	1.7	2	2		
Uranium-234	pCi/g	0.34	0.85	0.59	2	2		
Uranium-235	pCi/g	0.033	0.068	0.051	2	2		
Uranium-238	pCi/g	2.1	3.5	2.8	2	2		

Table 2.44 Radiological Data for Sediment Location S34

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	3.9	12	7.9	2	2		
Americium-241	pCi/g	0.0036	0.026	0.015	0	2		
Beta activity	pCi/g	4.2	9.2	6.7	2	2		
Cesium-137	pCi/g	0.01	0.031	0.021	1	2		
Cobalt-60	pCi/g	-0.00013	0.016	0.0078	0	2		
Neptunium-237	pCi/g	0.0068	0.032	0.019	0	2		
Plutonium-239/240	pCi/g	0.03	0.075	0.053	2	2		
Potassium-40	pCi/g	3.2	3.4	3.3	2	2		
Technetium-99	pCi/g	1.1	1.3	1.2	2	2		
Thorium-230	pCi/g	0.72	1.5	1.1	2	2		
Uranium-234	pCi/g	0.83	0.83	0.83	1	1		
Uranium-235	pCi/g	0.062	0.062	0.062	1	1		
Uranium-238	pCi/g	3.1	3.1	3.1	1	1		

Sediment Radiological Data

Table 2.45 Radiological Data for Sediment Location C746KTB2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	0.18	1.1	0.62	1	2		
Americium-241	pCi/g	-0.019	-0.013	-0.016	0	2		
Beta activity	pCi/g	0.63	0.77	0.7	0	2		
Cesium-137	pCi/g	0.01	0.022	0.016	1	2		
Cobalt-60	pCi/g	-0.00083	0.0061	0.0026	0	2		
Neptunium-237	pCi/g	-0.0073	0.00055	-0.0034	0	2		
Plutonium-239/240	pCi/g	0.00057	0.0023	0.0015	0	2		
Potassium-40	pCi/g	0.96	2.4	1.7	2	2		
Technetium-99	pCi/g	0.12	0.21	0.16	1	2		
Thorium-230	pCi/g	0.081	0.087	0.084	2	2		

Table 2.46 Radiological Data for Sediment Location C746KUP

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	1.5	2.7	2	3	3		
Americium-241	pCi/g	-0.014	0.016	0.0034	0	3		
Beta activity	pCi/g	1	1.3	1.2	2	3		
Cesium-137	pCi/g	0.016	0.024	0.019	3	3		
Cobalt-60	pCi/g	-0.0034	0.0058	0.00057	0	3		
Neptunium-237	pCi/g	-0.012	0.0072	-0.0013	0	3		
Plutonium-239/240	pCi/g	-0.00087	0.0024	0.001	0	3		
Potassium-40	pCi/g	2	2.3	2.1	3	3		
Technetium-99	pCi/g	0.1	0.13	0.12	0	3		
Thorium-230	pCi/g	0.1	0.16	0.13	3	3		

Table 2.47 Radiological Data for Sediment Location S32

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	49	60	54	2	2		
Americium-241	pCi/g	0.46	0.5	0.48	2	2		
Beta activity	pCi/g	47	86	66	2	2		
Cesium-137	pCi/g	0.46	0.55	0.51	2	2		
Cobalt-60	pCi/g	-0.0025	0.054	0.026	1	2		
Neptunium-237	pCi/g	0.42	0.73	0.57	1	2		
Plutonium-239/240	pCi/g	1.6	1.9	1.8	2	2		
Potassium-40	pCi/g	6.2	6.7	6.5	2	2		
Technetium-99	pCi/g	18	27	23	2	2		
Thorium-230	pCi/g	35	40	38	2	2		
Uranium-234	pCi/g	2.3	2.3	2.3	1	1		
Uranium-235	pCi/g	0.12	0.12	0.12	1	1		
Uranium-238	pCi/g	3.6	3.6	3.6	1	1		

Sediment Radiological Data

Table 2.48 Radiological Data for Sediment Location S28

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Alpha activity	pCi/g	1.5	2.1	1.8	2	2		
Americium-241	pCi/g	-0.022	0.012	-0.0046	0	2		
Beta activity	pCi/g	0.85	1.2	1	1	2		
Cesium-137	pCi/g	-0.0052	0.0071	0.00096	0	2		
Cobalt-60	pCi/g	0.00073	0.0019	0.0013	0	2		
Neptunium-237	pCi/g	-0.000046	0.0079	0.0039	0	2		
Plutonium-239/240	pCi/g	-0.0022	0.0032	0.00048	0	2		
Potassium-40	pCi/g	1.7	2.3	2	2	2		
Technetium-99	pCi/g	0.032	0.033	0.032	0	2		
Thorium-230	pCi/g	0.1	0.15	0.13	2	2		

Direct Gamma Radiation (TLD) Data

Table 2.49 Radiological Exposure Due to Gamma Radiation (mrem)

Location	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annualized[1]
TLD-1	120	155	130	128	522
TLD-2	180	200	160	137	662
TLD-3	130	170	100	33	424
TLD-4	26	26	26	18	95
TLD-5	27	27	24	18	94
TLD-6	24	23	22	16	83
TLD-7	28	30	28	21	105
TLD-8	21	21	21	14	76
TLD-9	24	24	22	16	85
TLD-10	23	24	23	16	84
TLD-11	24	26	23	17	88
TLD-12	23	25	22	16	84
TLD-13	27	28.5	27	19	99
TLD-14	23	24	22	16	83
TLD-15	22	23	21	15	79
TLD-16	27	29	26	19	99
TLD-17	23	23	20	15	79
TLD-18	23	23	22	15	82
TLD-19	23	23	22		91
TLD-20	26	26	25	17	92
TLD-25	27	29	25.5	18	97
TLD-27	26	25	24	18	91
TLD-28	25	25	25		100
TLD-29	22	24	22	15	81
TLD-30	25	25	24	17	89
TLD-31	28		28		117
TLD-32	9	28	28	20	84
TLD-35	23	24	24	16	85
TLD-36	22	22	20	15	77
TLD-37	21	22	21	14	77
TLD-38	22	23	22	15	80
TLD-39	21	22	21	14	76
TLD-40	28			19	88
TLD-41		23	22		91
TLD-46	23	24	22	16	84
TLD-47	64	74	67	47	247
TLD-48	41	60	37	21	156
TLD-49	25	25	23	17	89
TLD-50	39	42	36	28	142
TLD-51	29	30	26	20	103
TLD-52	32	41	47	31	149
TLD-53	58	70	62	46	231
TLD-21	27	32	27	19	103
TLD-22	29	28	26	19	100
TLD-23	27	29	25	18	97
TLD-26	25	27	24	16	91

[1]Note: Annualized results represent a summation of the quarters adjusted to ensure that there is a correlation between the results and 1 year (365 days). TLDs may not have been collected on the last day of each quarter so this accounts for varying number of days.

Deer Radiological Data

Table 2.50 Radiological Analysis of Deer Bone Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Neptunium-237	pCi/g	-0.018	0.013	-0.00019	0	6		
Plutonium-239/240	pCi/g	-0.015	0.0092	-0.00086	0	6		
Technetium-99	pCi/g	-0.4	0.27	-0.1	0	6		
Thorium-230	pCi/g	0.047	0.2	0.11	4	6		
Uranium-234	pCi/g	-0.031	0.038	0.0022	0	6		
Uranium-235	pCi/g	-0.011	0.01	0.0008	0	6		
Uranium-238	pCi/g	0.0000042	0.012	0.0027	0	6		

Table 2.51 Radiological Analysis of Deer Thyroid Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Technetium-99	pCi/g	-0.93	1.2	0.19	0	5		

Table 2.52 Radiological Analysis of Deer Muscle Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Neptunium-237	pCi/g	-0.0095	-0.0032	-0.0065	0	6		
Plutonium-239/240	pCi/g	-0.0072	0.019	0.0034	0	6		
Technetium-99	pCi/g	-0.14	0.0056	-0.067	0	6		
Thorium-230	pCi/g	0.06	0.16	0.11	5	6		
Uranium-234	pCi/g	0.000021	0.011	0.0054	0	6		
Uranium-235	pCi/g	-0.0039	).0000038	-0.00064	0	6		
Uranium-238	pCi/g	-0.0031	0.012	0.004	0	6		

Table 2.53 Radiological Analysis of Deer Liver Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Reference Criteria	Reference Value
Neptunium-237	pCi/g	-0.047	-0.0037	-0.021	0	6		
Plutonium-239/240	pCi/g	-0.0066	0.0038	-0.0011	0	6		
Technetium-99	pCi/g	-0.11	0.31	-0.0075	1	6		
Thorium-230	pCi/g	0.033	0.15	0.088	3	6		
Uranium-234	pCi/g	-0.0089	0.0058	-0.0044	0	6		
Uranium-235	pCi/g	-0.0034	0.018	0.0035	1	6		
Uranium-238	pCi/g	-0.003	0.011	0.0028	0	6		

3. NON-RADIOLOGICAL EFFLUENT DATA

KPDES Outfall Non-Radiological Data

Table 3.1 Non-Radiological Effluent Data for Outfall 001

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Antimony	mg/L	ND	ND	ND	0	5
Arsenic	mg/L	ND	ND	ND	0	5
Beryllium	mg/L	ND	ND	ND	0	5
Cadmium	mg/L	ND	0.001	0.0006	1	5
Chlorine, Total Residual	mg/L	0.03	0.08	0.033	100	100
Chromium	mg/L	ND	ND	ND	0	5
Conductivity	umho/cm	110	1500	970	100	100
Copper	mg/L	ND	0.02	0.0067	1	5
Dissolved Oxygen	mg/L	5.7	13	8.8	100	100
Flow Rate	mgd	0.7	9.8	2.4	100	100
Hardness - Total as CaCO3	mg/L	160	370	240	14	14
Iron	mg/L	ND	0.52	0.29	3	5
Lead	mg/L	ND	ND	ND	0	5
Mercury	mg/L	ND	ND	ND	0	5
Nickel	mg/L	ND	0.01	0.005	2	5
Oil and Grease	mg/L	ND	5.9	2.6	1	52
PCB-1016	ug/L	ND	ND	ND	0	14
PCB-1221	ug/L	ND	ND	ND	0	14
PCB-1232	ug/L	ND	ND	ND	0	14
PCB-1242	ug/L	ND	ND	ND	0	14
PCB-1248	ug/L	ND	ND	ND	0	14
PCB-1254	ug/L	ND	ND	ND	0	14
PCB-1260	ug/L	ND	ND	ND	0	14
PCB-1268	ug/L	ND	ND	ND	0	14
pH	Std Unit	7	8.7	7.6	100	100
Phosphorous	mg/L	0.07	0.55	0.23	52	52
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	14
Selenium	mg/L	ND	ND	ND	0	5
Silver	mg/L	ND	0.002	0.0007	1	5
Temperature	deg F	43	88	65	100	100
Thallium	mg/L	ND	ND	ND	0	5
Total Metals	mg/L	ND	ND	ND	0	5
Trichloroethene	ug/L	ND	ND	ND	0	14
Uranium	mg/L	0.0014	0.014	0.0046	5	5
Zinc	mg/L	ND	ND	ND	0	5

KPDES Outfall Non-Radiological Data

Table 3.2 Non-Radiological Effluent Data for Outfall 015

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Chlorine, Total Residual	mg/L	0.03	0.03	0.03	11	11
Chromium	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	250	800	450	18	18
Copper	mg/L	ND	0.02	0.0076	1	4
Dissolved Oxygen	mg/L	6.6	11	9.1	18	18
Flow Rate	mgd	0.0029	1.3	0.38	18	18
Hardness - Total as CaCO3	mg/L	100	220	170	11	11
Iron	mg/L	0.6	1.8	1.2	4	4
Lead	mg/L	ND	ND	ND	0	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Oil and Grease	mg/L	ND	ND	ND	0	11
PCB-1016	ug/L	ND	ND	ND	0	11
PCB-1221	ug/L	ND	ND	ND	0	11
PCB-1232	ug/L	ND	ND	ND	0	11
PCB-1242	ug/L	ND	ND	ND	0	11
PCB-1248	ug/L	ND	ND	ND	0	11
PCB-1254	ug/L	ND	ND	ND	0	11
PCB-1260	ug/L	ND	ND	ND	0	11
PCB-1268	ug/L	ND	ND	ND	0	11
pH	Std Unit	6.8	7.8	7.5	18	18
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	11
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Temperature	deg F	40	77	58	18	18
Thallium	mg/L	ND	ND	ND	0	4
Total Metals	mg/L	ND	ND	ND	0	4
Uranium	mg/L	0.013	0.19	0.099	4	4
Zinc	mg/L	ND	0.06	0.02	1	4

KPDES Outfall Non-Radiological Data

Table 3.3 Non-Radiological Effluent Data for Outfall 017

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Chlorine, Total Residual	mg/L	0.03	0.03	0.03	11	11
Chromium	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	55	470	200	22	22
Copper	mg/L	ND	0.02	0.0071	1	4
Dissolved Oxygen	mg/L	6.3	10	8.6	22	22
Flow Rate	mgd	0.062	36	4.6	22	22
Hardness - Total as CaCO3	mg/L	28	130	67	13	13
Iron	mg/L	ND	0.54	0.32	3	4
Lead	mg/L	ND	ND	ND	0	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Oil and Grease	mg/L	ND	ND	ND	0	13
PCB-1016	ug/L	ND	ND	ND	0	13
PCB-1221	ug/L	ND	ND	ND	0	13
PCB-1232	ug/L	ND	ND	ND	0	13
PCB-1242	ug/L	ND	ND	ND	0	13
PCB-1248	ug/L	ND	ND	ND	0	13
PCB-1254	ug/L	ND	ND	ND	0	13
PCB-1260	ug/L	ND	ND	ND	0	13
PCB-1268	ug/L	ND	ND	ND	0	13
pH	Std Unit	7.4	8	7.6	22	22
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	13
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Temperature	deg F	43	80	60	22	22
Thallium	mg/L	ND	ND	ND	0	4
Total Metals	mg/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.005	0.0027	3	4
Zinc	mg/L	ND	0.24	0.12	3	4

KPDES Outfall Non-Radiological Data

Table 3.4 Non-Radiological Effluent Data for Outfall 019

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Chlorine, Total Residual	mg/L	0.03	0.11	0.052	12	12
Chromium	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	150	160	160	12	12
Copper	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	8.2	10	8.8	12	12
Flow Rate	mgd	0.15	0.8	0.64	12	12
Hardness - Total as CaCO3	mg/L	66	74	68	4	4
Iron	mg/L	0.33	1.4	0.7	4	4
Lead	mg/L	ND	ND	ND	0	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Oil and Grease	mg/L	ND	ND	ND	0	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	8	8.5	8.2	12	12
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Suspended Solids	mg/L	ND	ND	ND	0	4
Temperature	deg F	43	73	64	12	12
Thallium	mg/L	ND	ND	ND	0	4
Total Metals	mg/L	ND	ND	ND	0	4
Uranium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 3.5 Non-Radiological Effluent Data for Landfill Surface Water Location L135

Upstream of the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Chemical Oxygen Demand (COD)	mg/L	ND	53	38	3	5
Chloride	mg/L	ND	3.2	2.5	4	5
Conductivity	umho/cm	100	190	140	5	5
Dissolved Oxygen	mg/L	6.3	10	8.1	5	5
Dissolved Solids	mg/L	110	140	130	5	5
Flow Rate	mgd	0.3	1.1	0.48	5	5
Iron	mg/L	0.53	2.8	1.7	5	5
pH	Std Unit	6.7	7.4	7.1	5	5
Sodium	mg/L	2.8	5.1	3.9	5	5
Sulfate	mg/L	5.8	17	9.3	5	5
Suspended Solids	mg/L	ND	ND	ND	0	5
Temperature	deg F	41	76	59	5	5
Total Organic Carbon (TOC)	mg/L	8	16	13	5	5
Total Solids	mg/L	140	160	150	5	5
Uranium	mg/L	0.0044	0.01	0.0067	5	5

Table 3.6 Non-Radiological Effluent Data for Landfill Surface Water Location L136

At the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Chemical Oxygen Demand (COD)	mg/L	ND	61	30	2	5
Chloride	mg/L	ND	14	3.9	2	5
Conductivity	umho/cm	180	530	280	5	5
Dissolved Oxygen	mg/L	5.4	13	8.5	5	5
Dissolved Solids	mg/L	140	400	200	5	5
Flow Rate	mgd	0.19	4.1	1.7	5	5
Iron	mg/L	0.36	1.4	0.69	5	5
pH	Std Unit	7	7.9	7.5	5	5
Sodium	mg/L	0.003	19	5.4	5	5
Sulfate	mg/L	13	130	39	5	5
Suspended Solids	mg/L	ND	47	23	1	5
Temperature	deg F	36	77	58	5	5
Total Organic Carbon (TOC)	mg/L	4.3	22	11	5	5
Total Solids	mg/L	160	430	230	5	5
Uranium	mg/L	0.0015	0.0058	0.0031	5	5

Surface Water Non-Radiological Data

Table 3.7 Non-Radiological Effluent Data for Landfill Surface Water Location L137

Downstream of the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Chemical Oxygen Demand (COD)	mg/L	ND	53	40	3	4
Chloride	mg/L	ND	3	2.1	3	4
Conductivity	umho/cm	87	150	130	4	4
Dissolved Oxygen	mg/L	6.6	11	9.2	4	4
Dissolved Solids	mg/L	110	210	140	4	4
Flow Rate	mgd	0.4	2.7	1.2	4	4
Iron	mg/L	0.59	3.2	1.9	4	4
pH	Std Unit	6.7	7.2	7.1	4	4
Sodium	mg/L	1.8	4.1	3.2	4	4
Sulfate	mg/L	5.7	18	11	4	4
Suspended Solids	mg/L	ND	74	37	2	4
Temperature	deg F	41	77	59	4	4
Total Organic Carbon (TOC)	mg/L	10	17	15	4	4
Total Solids	mg/L	150	420	230	4	4
Uranium	mg/L	0.0018	0.0076	0.0038	4	4

Table 3.8 Non-Radiological Effluent Data for Landfill Surface Water Location L150

At the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Chemical Oxygen Demand (COD)	mg/L	ND	45	24	1	4
Chloride	mg/L	ND	4.4	1.8	1	4
Conductivity	umho/cm	110	310	200	4	4
Dissolved Oxygen	mg/L	7.6	12	9.3	4	4
Dissolved Solids	mg/L	86	220	170	4	4
Flow Rate	mgd	0.05	0.66	0.37	4	4
Iron	mg/L	2.3	4.6	3.7	4	4
pH	Std Unit	7.5	7.6	7.5	4	4
Sodium	mg/L	0.0013	4.6	1.9	4	4
Sulfate	mg/L	7.9	34	18	4	4
Suspended Solids	mg/L	ND	86	50	2	4
Temperature	deg F	40	77	59	4	4
Total Organic Carbon (TOC)	mg/L	6.6	15	8.9	4	4
Total Solids	mg/L	190	240	220	4	4
Uranium	mg/L	ND	0.0015	0.0012	3	4

Surface Water Non-Radiological Data

Table 3.9 Non-Radiological Effluent Data for Landfill Surface Water Location L154

Upstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Chemical Oxygen Demand (COD)	mg/L	ND	53	42	5	6
Chloride	mg/L	ND	2.6	1.9	4	6
Conductivity	umho/cm	84	160	130	6	6
Dissolved Oxygen	mg/L	6.2	11	9	6	6
Dissolved Solids	mg/L	120	140	130	6	6
Flow Rate	mgd	0.2	1.6	0.99	6	6
Iron	mg/L	0.73	3	2.1	6	6
pH	Std Unit	6.6	7.4	7	6	6
Sodium	mg/L	0.0032	4.3	2.5	6	6
Sulfate	mg/L	5.4	15	10	6	6
Suspended Solids	mg/L	ND	40	24	2	6
Temperature	deg F	41	77	59	6	6
Total Organic Carbon (TOC)	mg/L	8.8	18	16	6	6
Total Solids	mg/L	130	260	170	6	6
Uranium	mg/L	0.0015	0.0061	0.003	6	6

Table 3.10 Non-Radiological Effluent Data for Landfill Surface Water Location L155

Downstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Chemical Oxygen Demand (COD)	mg/L	ND	46	25	1	4
Chloride	mg/L	4.2	20	8.3	4	4
Conductivity	umho/cm	89	290	150	4	4
Dissolved Oxygen	mg/L	6.8	11	8.5	4	4
Dissolved Solids	mg/L	110	240	140	4	4
Flow Rate	mgd	12	41	25	4	4
Iron	mg/L	1.7	4.4	3.3	4	4
pH	Std Unit	6.4	7.3	7	4	4
Sodium	mg/L	0.0044	22	8.5	4	4
Sulfate	mg/L	7.8	52	21	4	4
Suspended Solids	mg/L	ND	140	92	3	4
Temperature	deg F	42	76	60	4	4
Total Organic Carbon (TOC)	mg/L	7.4	14	9.2	4	4
Total Solids	mg/L	140	430	250	4	4
Uranium	mg/L	0.0037	0.0083	0.0059	4	4

4. NON-RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE DATA

Surface Water Non-Radiological Data

Table 4.1 Non-Radiological Monitoring Data for Surface Water Location L1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	20	33	26	4	4
Aluminum	mg/L	ND	5.2	2.1	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.038	0.055	0.049	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	7.4	15	12	4	4
Chloride	mg/L	6.4	16	9.6	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.0013	0.00069	1	4
Conductivity	umho/cm	84	280	170	4	4
Copper	mg/L	ND	0.02	0.0057	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	7.9	12	10	4	4
Flow Rate	mgd	0.07	140	36	4	4
Hardness - Total as CaCO3	mg/L	37	55	48	4	4
Iron	mg/L	ND	3.3	1.4	3	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2	5.2	3.4	4	4
Manganese	mg/L	0.031	0.11	0.081	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.01	0.0039	1	4
Nitrate/Nitrite as Nitrogen	mg/L	ND	0.72	0.42	3	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.1	8.2	7.8	4	4
Phosphorous	mg/L	0.08	0.33	0.18	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2.3	6.6	3.7	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	6.8	34	15	4	4
Suspended Solids	mg/L	ND	91	31	1	4
Temperature	deg F	38	80	56	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	2	0.87	1	4
Uranium	mg/L	ND	ND	ND	0	7

Surface Water Non-Radiological Data

Table 4.1 Non-Radiological Monitoring Data for Surface Water Location L1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.2 Non-Radiological Monitoring Data for Surface Water Location L5

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	25	30	27	4	4
Aluminum	mg/L	ND	8.4	2.5	3	4
Ammonia	mg/L	ND	0.24	0.14	1	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.03	0.097	0.052	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	18	48	30	4	4
Chloride	mg/L	21	61	46	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.0032	0.0012	1	4
Conductivity	umho/cm	300	740	470	4	4
Copper	mg/L	ND	0.022	0.0097	3	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	7.7	12	9.4	4	4
Flow Rate	mgd	1	130	44	4	4
Hardness - Total as CaCO3	mg/L	60	200	120	4	4
Iron	mg/L	ND	6.7	2	3	4
Lead	mg/L	ND	0.0085	0.004	1	4
Magnesium	mg/L	3.4	17	9	4	4
Manganese	mg/L	0.036	0.28	0.1	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.01	0.0038	1	4
Nitrate/Nitrite as Nitrogen	mg/L	0.35	1.9	0.94	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.2	8.4	7.5	4	4
Phosphorous	mg/L	0.14	0.28	0.18	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2.9	11	6	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	20	62	42	4	4
Suspended Solids	mg/L	ND	290	80	1	4
Temperature	deg F	38	83	60	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.019	0.0097	6	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.3 Non-Radiological Monitoring Data for Surface Water Location L6

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	21	34	29	4	4
Aluminum	mg/L	ND	4.5	1.4	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.037	0.065	0.05	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	19	54	37	4	4
Chloride	mg/L	46	59	54	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.0012	0.00068	1	4
Conductivity	umho/cm	310	710	540	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	3.5	12	8.5	4	4
Flow Rate	mgd	1	180	49	4	4
Hardness - Total as CaCO3	mg/L	63	180	140	4	4
Iron	mg/L	ND	3.1	0.97	2	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	4	17	11	4	4
Manganese	mg/L	0.081	0.12	0.094	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.58	1.8	1.2	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.4	8.4	7.7	4	4
Phosphorous	mg/L	0.12	0.18	0.14	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	3.1	11	7.7	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	42	62	51	4	4
Suspended Solids	mg/L	ND	160	47	1	4
Temperature	deg F	38	82	58	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.005	0.0027	4	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.4 Non-Radiological Monitoring Data for Surface Water Location C616

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	22	40	28	4	4
Aluminum	mg/L	ND	0.25	0.14	1	4
Ammonia	mg/L	ND	0.3	0.19	2	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.021	0.03	0.026	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	65	90	79	4	4
Chloride	mg/L	89	150	120	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.002	0.0011	2	4
Conductivity	umho/cm	940	1500	1200	4	4
Copper	mg/L	ND	0.024	0.01	3	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.4	11	8.2	4	4
Flow Rate	mgd	1.6	8.9	4.2	4	4
Hardness - Total as CaCO3	mg/L	60	390	250	4	4
Iron	mg/L	ND	0.33	0.2	2	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	21	37	29	4	4
Manganese	mg/L	0.034	0.057	0.044	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.01	0.006	3	4
Nitrate/Nitrite as Nitrogen	mg/L	0.56	2.8	1.8	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.9	7.9	7.4	4	4
Phosphorous	mg/L	0.23	0.47	0.32	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	18	24	21	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	78	160	120	4	4
Suspended Solids	mg/L	ND	ND	ND	0	4
Temperature	deg F	51	86	69	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.01	0.0035	3	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.5 Non-Radiological Monitoring Data for Surface Water Location C612

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	32	73	56	4	4
Aluminum	mg/L	ND	ND	ND	0	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.11	0.14	0.12	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	21	26	24	4	4
Chloride	mg/L	34	39	36	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	320	350	330	4	4
Copper	mg/L	ND	0.028	0.0088	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.9	9.6	8.3	4	4
Hardness - Total as CaCO3	mg/L	93	120	100	4	4
Iron	mg/L	ND	ND	ND	0	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	9	11	10	4	4
Manganese	mg/L	ND	ND	ND	0	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.69	2.3	1.8	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.5	8.2	8	4	4
Phosphorous	mg/L	ND	0.05	0.031	1	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.1	1.2	1.2	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	25	36	31	4	4
Suspended Solids	mg/L	ND	ND	ND	0	4
Temperature	deg F	55	68	61	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	1	0.75	2	4
Uranium	mg/L	ND	0.005	0.0017	1	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.6 Non-Radiological Monitoring Data for Surface Water Location K006

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	35	50	40	4	4
Aluminum	mg/L	0.28	0.78	0.46	4	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.0093	0.028	0.021	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	14	24	18	4	4
Chloride	mg/L	9.5	14	11	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	180	230	200	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.5	13	9.9	4	4
Flow Rate	mgd	0.6	2.2	1.3	4	4
Hardness - Total as CaCO3	mg/L	56	95	75	4	4
Iron	mg/L	0.44	0.84	0.62	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	4.7	8.1	7	4	4
Manganese	mg/L	0.016	0.043	0.032	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	ND	0.54	0.23	3	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.4	7.6	7.5	4	4
Phosphorous	mg/L	0.05	0.08	0.07	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.7	2.1	2	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	13	17	14	4	4
Suspended Solids	mg/L	ND	ND	ND	0	4
Temperature	deg F	40	86	64	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.005	0.0015	1	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.7 Non-Radiological Monitoring Data for Surface Water Location K016

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	0.86	50	29	3	3
Aluminum	mg/L	ND	0.83	0.5	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.029	0.054	0.04	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	26	44	35	4	4
Chloride	mg/L	10	350	98	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	210	1300	590	3	3
Copper	mg/L	ND	0.022	0.0098	3	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	4.8	11	7.4	3	3
Flow Rate	mgd	0.19	2	1.1	2	2
Hardness - Total as CaCO3	mg/L	76	130	100	4	4
Iron	mg/L	ND	0.49	0.33	3	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.9	4.6	4	4	4
Manganese	mg/L	0.0067	0.011	0.0083	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.26	1	0.55	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.5	7.6	7.6	3	3
Phosphorous	mg/L	0.07	0.27	0.18	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	0.82	2.9	2	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	12	230	67	4	4
Suspended Solids	mg/L	ND	ND	ND	0	4
Temperature	deg F	39	77	62	3	3
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.005	0.0026	4	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.8 Non-Radiological Monitoring Data for Surface Water Location L291

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	23	40	30	5	5
Aluminum	mg/L	0.22	2.4	1.3	5	5
Ammonia	mg/L	ND	ND	ND	0	5
Antimony	mg/L	ND	ND	ND	0	5
Arsenic	mg/L	ND	ND	ND	0	5
Barium	mg/L	0.045	0.055	0.05	5	5
Beryllium	mg/L	ND	ND	ND	0	5
Cadmium	mg/L	ND	ND	ND	0	5
Calcium	mg/L	11	19	16	5	5
Chloride	mg/L	5.6	13	8.5	5	5
Chromium	mg/L	ND	ND	ND	0	5
Cobalt	mg/L	ND	ND	ND	0	5
Conductivity	umho/cm	130	250	170	5	5
Copper	mg/L	ND	0.02	0.0047	1	5
Cyanide	mg/L	ND	ND	ND	0	5
Dissolved Oxygen	mg/L	4.7	12	9.4	5	5
Flow Rate	mgd	0.05	32	6.9	5	5
Hardness - Total as CaCO3	mg/L	47	61	55	5	5
Iron	mg/L	0.23	1.6	1	5	5
Lead	mg/L	ND	ND	ND	0	5
Magnesium	mg/L	2.8	3.8	3.3	5	5
Manganese	mg/L	0.038	0.083	0.064	5	5
Mercury	mg/L	ND	ND	ND	0	5
Nickel	mg/L	ND	ND	ND	0	5
Nitrate/Nitrite as Nitrogen	mg/L	0.18	0.57	0.43	5	5
PCB-1016	ug/L	ND	ND	ND	0	5
PCB-1221	ug/L	ND	ND	ND	0	5
PCB-1232	ug/L	ND	ND	ND	0	5
PCB-1242	ug/L	ND	ND	ND	0	5
PCB-1248	ug/L	ND	ND	ND	0	5
PCB-1254	ug/L	ND	ND	ND	0	5
PCB-1260	ug/L	ND	ND	ND	0	5
PCB-1268	ug/L	ND	ND	ND	0	5
pH	Std Unit	7	8.2	7.6	5	5
Phosphorous	mg/L	0.05	0.34	0.18	5	5
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	5
Potassium	mg/L	2.4	6.4	4.2	5	5
Selenium	mg/L	ND	ND	ND	0	5
Silver	mg/L	ND	ND	ND	0	5
Sodium	mg/L	7.6	30	13	5	5
Suspended Solids	mg/L	ND	37	15	1	5
Temperature	deg F	40	76	53	5	5
Thallium	mg/L	ND	ND	ND	0	5
Trichloroethene	ug/L	ND	ND	ND	0	5
Uranium	mg/L	ND	0.005	0.0015	1	9
Vanadium	mg/L	ND	ND	ND	0	5
Zinc	mg/L	ND	ND	ND	0	5

Surface Water Non-Radiological Data

Table 4.9 Non-Radiological Monitoring Data for Surface Water Location K002

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	30	50	42	3	3
Aluminum	mg/L	0.27	1.9	0.88	4	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.019	0.046	0.033	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	15	32	24	4	4
Chloride	mg/L	5.5	120	35	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	130	530	300	3	3
Copper	mg/L	ND	0.02	0.006	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.1	12	8.8	3	3
Flow Rate	mgd	0.58	3.4	1.9	3	3
Hardness - Total as CaCO3	mg/L	53	93	76	4	4
Iron	mg/L	0.25	1.3	0.66	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	1.9	4.6	3.2	4	4
Manganese	mg/L	0.0082	0.023	0.016	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.36	0.54	0.44	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.4	7.9	7.7	3	3
Phosphorous	mg/L	0.17	0.28	0.2	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.5	3.2	2.3	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	5.8	78	26	4	4
Suspended Solids	mg/L	ND	ND	ND	0	4
Temperature	deg F	42	80	63	3	3
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.0096	0.0037	4	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	0.06	0.018	1	4

Surface Water Non-Radiological Data

Table 4.10 Non-Radiological Monitoring Data for Surface Water Location L10

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	20	50	32	4	4
Aluminum	mg/L	0.34	5.2	2.4	4	4
Ammonia	mg/L	ND	0.36	0.17	1	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.053	0.066	0.059	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	11	29	19	4	4
Chloride	mg/L	6.1	26	17	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	140	330	220	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	5.4	13	9.2	4	4
Flow Rate	mgd	0.83	12	4.5	4	4
Hardness - Total as CaCO3	mg/L	38	90	64	4	4
Iron	mg/L	0.35	2.9	1.5	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.8	6	4.2	4	4
Manganese	mg/L	0.034	0.1	0.061	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.3	0.89	0.56	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.3	8.4	7.6	4	4
Phosphorous	mg/L	0.1	0.38	0.2	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2.2	4.8	3.1	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	6.7	33	20	4	4
Suspended Solids	mg/L	ND	24	14	1	4
Temperature	deg F	38	78	58	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	0.0059	0.01	0.0086	7	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	0.06	0.02	1	4

Surface Water Non-Radiological Data

Table 4.11 Non-Radiological Monitoring Data for Surface Water Location L194

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	27	50	36	4	4
Aluminum	mg/L	ND	3.1	1.4	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.037	0.057	0.044	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	20	25	23	4	4
Chloride	mg/L	13	27	20	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	240	330	290	4	4
Copper	mg/L	ND	0.02	0.005	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	5.9	12	8.6	4	4
Flow Rate	mgd	0.72	4.7	2.6	3	3
Hardness - Total as CaCO3	mg/L	65	90	79	4	4
Iron	mg/L	0.24	1.7	0.96	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	4.3	6	5.1	4	4
Manganese	mg/L	0.019	0.041	0.033	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.22	0.79	0.54	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.7	8.1	7.3	4	4
Phosphorous	mg/L	0.13	0.2	0.16	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2.3	2.9	2.6	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	18	35	26	4	4
Suspended Solids	mg/L	ND	28	14	1	4
Temperature	deg F	43	83	64	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	0.0067	0.036	0.018	7	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.12 Non-Radiological Monitoring Data for Surface Water Location L55

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	25	37	30	4	4
Aluminum	mg/L	ND	3.9	2.1	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.059	0.12	0.078	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	12	37	23	4	4
Chloride	mg/L	6.9	41	22	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	160	470	340	4	4
Copper	mg/L	ND	0.04	0.012	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.9	13	10	4	4
Flow Rate	mgd	0.24	8.1	2.6	4	4
Hardness - Total as CaCO3	mg/L	41	120	79	4	4
Iron	mg/L	0.26	2.3	1.4	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.9	8.1	5	4	4
Manganese	mg/L	0.035	0.096	0.067	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.17	0.69	0.39	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.9	8.2	7.5	4	4
Phosphorous	mg/L	0.05	0.46	0.18	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.4	6.1	2.9	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	6.5	55	25	4	4
Suspended Solids	mg/L	ND	2400	610	2	4
Temperature	deg F	37	84	58	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.026	0.013	6	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	0.073	0.026	1	4

Surface Water Non-Radiological Data

Table 4.13 Non-Radiological Monitoring Data for Surface Water Location L56

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	30	110	61	4	4
Aluminum	mg/L	0.32	7.7	2.9	4	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.054	0.12	0.092	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	10	28	19	4	4
Chloride	mg/L	6.1	59	40	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.0017	0.00079	1	4
Conductivity	umho/cm	150	500	360	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	7.5	12	9.8	4	4
Flow Rate	mgd	0.1	38	9.7	4	4
Hardness - Total as CaCO3	mg/L	56	90	78	4	4
Iron	mg/L	0.28	4.8	1.9	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.7	10	6.2	4	4
Manganese	mg/L	0.052	0.23	0.13	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.01	0.004	1	4
Nitrate/Nitrite as Nitrogen	mg/L	0.22	0.74	0.46	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7	8.2	7.4	4	4
Phosphorous	mg/L	ND	0.42	0.23	3	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	0.92	4	2.1	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	5.2	63	38	4	4
Suspended Solids	mg/L	ND	300	82	1	4
Temperature	deg F	36	75	55	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.005	0.0015	1	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.14 Non-Radiological Monitoring Data for Surface Water Location L11

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	20	35	26	4	4
Aluminum	mg/L	ND	6.7	3.1	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.041	0.067	0.055	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	8.7	18	13	4	4
Chloride	mg/L	4.4	22	13	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.0011	0.00065	1	4
Conductivity	umho/cm	110	280	170	4	4
Copper	mg/L	ND	0.023	0.0075	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	7	12	9	4	4
Flow Rate	mgd	1.4	21	9.6	4	4
Hardness - Total as CaCO3	mg/L	37	65	52	4	4
Iron	mg/L	0.33	3.5	1.9	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.5	5.6	3.7	4	4
Manganese	mg/L	0.04	0.12	0.079	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.016	0.0064	1	4
Nitrate/Nitrite as Nitrogen	mg/L	0.2	0.44	0.28	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.9	8.2	7.4	4	4
Phosphorous	mg/L	0.13	0.43	0.21	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2	4.9	3.1	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	3.9	23	13	4	4
Suspended Solids	mg/L	ND	41	24	2	4
Temperature	deg F	39	79	59	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.0063	0.0039	5	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.15 Non-Radiological Monitoring Data for Surface Water Location L12

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	20	40	29	4	4
Aluminum	mg/L	ND	9.8	3.9	4	5
Ammonia	mg/L	ND	ND	ND	0	5
Antimony	mg/L	ND	ND	ND	0	5
Arsenic	mg/L	ND	ND	ND	0	5
Barium	mg/L	0.066	0.099	0.081	5	5
Beryllium	mg/L	ND	ND	ND	0	5
Cadmium	mg/L	ND	ND	ND	0	5
Calcium	mg/L	12	43	27	5	5
Chloride	mg/L	4.4	24	15	5	5
Chromium	mg/L	ND	ND	ND	0	5
Cobalt	mg/L	ND	0.0028	0.0017	4	5
Conductivity	umho/cm	130	380	260	5	5
Copper	mg/L	ND	ND	ND	0	5
Cyanide	mg/L	ND	ND	ND	0	5
Dissolved Oxygen	mg/L	7.1	11	9.6	5	5
Flow Rate	mgd	0.26	64	28	5	5
Hardness - Total as CaCO3	mg/L	51	130	90	5	5
Iron	mg/L	ND	4.8	2.3	4	5
Lead	mg/L	ND	0.0081	0.0045	2	5
Magnesium	mg/L	3.2	6.8	5	5	5
Manganese	mg/L	0.17	0.72	0.33	5	5
Mercury	mg/L	ND	ND	ND	0	5
Nickel	mg/L	ND	ND	ND	0	5
Nitrate/Nitrite as Nitrogen	mg/L	0.35	1.7	0.82	5	5
PCB-1016	ug/L	ND	ND	ND	0	5
PCB-1221	ug/L	ND	ND	ND	0	5
PCB-1232	ug/L	ND	ND	ND	0	5
PCB-1242	ug/L	ND	ND	ND	0	5
PCB-1248	ug/L	ND	ND	ND	0	5
PCB-1254	ug/L	ND	ND	ND	0	5
PCB-1260	ug/L	ND	ND	ND	0	5
PCB-1268	ug/L	ND	ND	ND	0	5
pH	Std Unit	6.9	7.9	7.4	5	5
Phosphorous	mg/L	0.09	0.47	0.25	5	5
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	5
Potassium	mg/L	2.4	5	3.5	5	5
Selenium	mg/L	ND	ND	ND	0	5
Silver	mg/L	ND	ND	ND	0	5
Sodium	mg/L	4	26	15	5	5
Suspended Solids	mg/L	ND	88	40	3	5
Temperature	deg F	49	74	59	5	5
Thallium	mg/L	ND	ND	ND	0	5
Trichloroethene	ug/L	ND	10	4.7	4	5
Uranium	mg/L	ND	0.005	0.003	5	9
Vanadium	mg/L	ND	ND	ND	0	5
Zinc	mg/L	ND	ND	ND	0	5

Surface Water Non-Radiological Data

Table 4.16 Non-Radiological Monitoring Data for Surface Water Location L241

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	14	40	30	3	3
Aluminum	mg/L	0.25	7.8	2.2	4	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.076	0.12	0.091	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	10	27	20	4	4
Chloride	mg/L	4.5	30	22	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.0014	0.00072	1	4
Conductivity	umho/cm	170	330	260	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	0.02	0.013	1	4
Dissolved Oxygen	mg/L	7.7	11	9.7	4	4
Flow Rate	mgd	0.23	13	6	4	4
Hardness - Total as CaCO3	mg/L	48	89	72	4	4
Iron	mg/L	0.32	4.2	1.5	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.8	7.1	5.5	4	4
Manganese	mg/L	0.017	0.18	0.11	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.27	2.2	0.95	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.6	8	7.1	4	4
Phosphorous	mg/L	ND	0.49	0.17	3	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2	5.2	2.9	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	3.7	34	22	4	4
Suspended Solids	mg/L	ND	58	22	1	4
Temperature	deg F	48	73	61	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	2	68	36	4	4
Uranium	mg/L	ND	0.007	0.0033	4	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.17 Non-Radiological Monitoring Data for Surface Water Location C746K-5

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	20	50	35	5	5
Aluminum	mg/L	ND	7.2	2.1	3	5
Ammonia	mg/L	ND	ND	ND	0	5
Antimony	mg/L	ND	ND	ND	0	5
Arsenic	mg/L	ND	ND	ND	0	5
Barium	mg/L	0.031	0.073	0.048	5	5
Beryllium	mg/L	ND	ND	ND	0	5
Cadmium	mg/L	ND	ND	ND	0	5
Calcium	mg/L	7.1	18	15	5	5
Chloride	mg/L	6	16	12	5	5
Chromium	mg/L	ND	ND	ND	0	5
Cobalt	mg/L	ND	0.002	0.00081	1	5
Conductivity	umho/cm	89	270	190	5	5
Copper	mg/L	ND	0.02	0.0045	1	5
Cyanide	mg/L	ND	ND	ND	0	5
Dissolved Oxygen	mg/L	6.6	13	8.5	5	5
Flow Rate	mgd	0.65	200	48	5	5
Hardness - Total as CaCO3	mg/L	33	64	54	5	5
Iron	mg/L	ND	5.2	1.6	3	5
Lead	mg/L	ND	0.0056	0.0031	1	5
Magnesium	mg/L	2	4.8	3.6	5	5
Manganese	mg/L	0.03	0.18	0.077	5	5
Mercury	mg/L	ND	ND	ND	0	5
Nickel	mg/L	ND	0.01	0.0036	1	5
Nitrate/Nitrite as Nitrogen	mg/L	ND	0.35	0.18	2	5
PCB-1016	ug/L	ND	ND	ND	0	5
PCB-1221	ug/L	ND	ND	ND	0	5
PCB-1232	ug/L	ND	ND	ND	0	5
PCB-1242	ug/L	ND	ND	ND	0	5
PCB-1248	ug/L	ND	ND	ND	0	5
PCB-1254	ug/L	ND	ND	ND	0	5
PCB-1260	ug/L	ND	ND	ND	0	5
PCB-1268	ug/L	ND	ND	ND	0	5
pH	Std Unit	7	7.5	7.3	5	5
Phosphorous	mg/L	0.06	0.29	0.15	5	5
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	5
Potassium	mg/L	2.3	6	3.3	5	5
Selenium	mg/L	ND	ND	ND	0	5
Silver	mg/L	ND	ND	ND	0	5
Sodium	mg/L	7.4	24	14	5	5
Suspended Solids	mg/L	ND	220	53	1	5
Temperature	deg F	37	76	62	5	5
Thallium	mg/L	ND	ND	ND	0	5
Trichloroethene	ug/L	ND	ND	ND	0	5
Uranium	mg/L	ND	0.005	0.0016	2	9
Vanadium	mg/L	ND	ND	ND	0	5
Zinc	mg/L	ND	ND	ND	0	5

Surface Water Non-Radiological Data

Table 4.18 Non-Radiological Monitoring Data for Surface Water Location C746KTB1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	20	35	28	4	4
Aluminum	mg/L	0.71	3.9	2.7	4	4
Ammonia	mg/L	ND	0.56	0.21	1	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.045	0.069	0.055	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	8.3	11	9.8	4	4
Chloride	mg/L	5.2	7.6	6.3	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	91	130	120	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.5	12	10	4	4
Flow Rate	mgd	0.15	7.5	2.5	4	4
Hardness - Total as CaCO3	mg/L	36	55	44	4	4
Iron	mg/L	0.63	2.7	1.8	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.4	2.9	2.6	4	4
Manganese	mg/L	0.037	0.094	0.057	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.29	0.65	0.43	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.6	7.2	6.9	4	4
Phosphorous	mg/L	0.05	0.53	0.26	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.8	7.1	4.3	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	6	9.8	7.9	4	4
Suspended Solids	mg/L	ND	38	17	1	4
Temperature	deg F	40	74	57	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	0.005	0.0014	1	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.19 Non-Radiological Monitoring Data for Surface Water Location C746KTB2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	20	40	29	4	4
Aluminum	mg/L	0.9	3.4	2.3	4	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.048	0.059	0.053	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	8.3	12	10	4	4
Chloride	mg/L	3.8	5.9	5.2	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	89	140	120	4	4
Copper	mg/L	ND	0.02	0.0053	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.5	12	8.5	4	4
Flow Rate	mgd	1.4	13	5.4	4	4
Hardness - Total as CaCO3	mg/L	35	51	42	4	4
Iron	mg/L	0.94	2.1	1.6	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.1	3.1	2.5	4	4
Manganese	mg/L	0.036	0.084	0.062	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.21	0.4	0.32	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.9	7.1	7	4	4
Phosphorous	mg/L	0.06	0.39	0.23	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.7	7.1	4.3	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	6.3	7.1	6.7	4	4
Suspended Solids	mg/L	ND	30	19	2	4
Temperature	deg F	40	74	57	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	ND	ND	0	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.20 Non-Radiological Monitoring Data for Surface Water Location C746KUP

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	28	37	32	4	4
Aluminum	mg/L	ND	2.3	1.2	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.038	0.054	0.046	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	11	17	15	4	4
Chloride	mg/L	5.9	15	10	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	120	280	180	4	4
Copper	mg/L	ND	0.055	0.018	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	7.3	12	9.4	4	4
Flow Rate	mgd	0.18	19	7.7	4	4
Hardness - Total as CaCO3	mg/L	43	66	55	4	4
Iron	mg/L	ND	1.3	0.84	3	4
Lead	mg/L	ND	0.0051	0.0031	1	4
Magnesium	mg/L	2.8	4.6	3.5	4	4
Manganese	mg/L	0.041	0.07	0.053	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.061	0.018	1	4
Nitrate/Nitrite as Nitrogen	mg/L	ND	0.65	0.37	3	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7	7.6	7.3	4	4
Phosphorous	mg/L	0.08	0.32	0.16	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2.4	7.9	4.2	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	7.4	31	14	4	4
Suspended Solids	mg/L	ND	ND	ND	0	4
Temperature	deg F	40	80	60	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	1	0.62	1	4
Uranium	mg/L	ND	ND	ND	0	8
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	0.12	0.042	1	4

Surface Water Non-Radiological Data

Table 4.21 Non-Radiological Monitoring Data for Surface Water Location L8

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	16	50	37	4	4
Aluminum	mg/L	0.24	4.3	1.5	4	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.03	0.063	0.05	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	11	33	25	4	4
Chloride	mg/L	5.8	31	15	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.0011	0.0008	2	4
Conductivity	umho/cm	130	390	240	4	4
Copper	mg/L	ND	0.02	0.0051	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.4	12	9.1	4	4
Flow Rate	mgd	33	33	33	1	1
Hardness - Total as CaCO3	mg/L	42	120	84	4	4
Iron	mg/L	0.67	3	1.3	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.5	7.2	4.8	4	4
Manganese	mg/L	0.061	0.42	0.22	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.01	0.0042	1	4
Nitrate/Nitrite as Nitrogen	mg/L	0.54	1.1	0.72	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.7	7.4	7.1	4	4
Phosphorous	mg/L	0.09	0.41	0.19	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2.2	4.5	3.3	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	4.3	29	14	4	4
Suspended Solids	mg/L	ND	54	29	2	4
Temperature	deg F	46	73	61	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	3	1.1	1	4
Uranium	mg/L	ND	0.005	0.0023	3	8
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.22 Non-Radiological Monitoring Data for Surface Water Location L29

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	35	50	40	4	4
Aluminum	mg/L	ND	0.95	0.56	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.025	0.031	0.029	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	23	26	25	4	4
Chloride	mg/L	5.6	9.4	7.5	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	170	210	190	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	7.3	12	9.8	4	4
Hardness - Total as CaCO3	mg/L	75	83	80	4	4
Iron	mg/L	0.26	1.1	0.62	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	4.2	5.6	4.8	4	4
Manganese	mg/L	0.035	0.074	0.062	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.3	0.58	0.48	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.4	8	7.7	4	4
Phosphorous	mg/L	0.11	0.2	0.14	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.6	2.1	1.9	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	4.5	7.5	6.3	4	4
Suspended Solids	mg/L	ND	28	22	3	4
Temperature	deg F	44	85	62	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	ND	ND	0	8
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.23 Non-Radiological Monitoring Data for Surface Water Location L30

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	32	50	40	4	4
Aluminum	mg/L	ND	1.2	0.49	2	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.026	0.032	0.03	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	23	27	25	4	4
Chloride	mg/L	5.7	9.6	7.9	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	ND	ND	0	4
Conductivity	umho/cm	180	210	200	4	4
Copper	mg/L	ND	ND	ND	0	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.9	12	9.7	4	4
Hardness - Total as CaCO3	mg/L	80	85	82	4	4
Iron	mg/L	0.37	1	0.59	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	4.5	5.7	5	4	4
Manganese	mg/L	0.039	0.11	0.077	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	0.01	0.0041	1	4
Nitrate/Nitrite as Nitrogen	mg/L	0.31	0.6	0.49	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	7.4	8.1	7.7	4	4
Phosphorous	mg/L	0.11	0.21	0.14	4	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	1.5	18	6	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	4.8	7.6	6.4	4	4
Suspended Solids	mg/L	ND	32	24	3	4
Temperature	deg F	46	86	63	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	ND	ND	0	8
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.24 Non-Radiological Monitoring Data for Surface Water Location L306

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	45	70	58	6	6
Aluminum	mg/L	0.31	1.7	1.1	6	6
Ammonia	mg/L	ND	0.2	0.12	1	6
Antimony	mg/L	ND	ND	ND	0	6
Arsenic	mg/L	ND	ND	ND	0	6
Barium	mg/L	0.046	0.059	0.052	6	6
Beryllium	mg/L	ND	ND	ND	0	6
Cadmium	mg/L	ND	ND	ND	0	6
Calcium	mg/L	41	46	44	6	6
Chloride	mg/L	14	29	21	6	6
Chromium	mg/L	ND	ND	ND	0	6
Cobalt	mg/L	ND	0.002	0.0012	3	6
Conductivity	umho/cm	330	370	350	6	6
Copper	mg/L	ND	0.02	0.0057	1	6
Cyanide	mg/L	ND	ND	ND	0	6
Dissolved Oxygen	mg/L	7.7	13	9.7	6	6
Hardness - Total as CaCO3	mg/L	140	160	150	6	6
Iron	mg/L	0.98	3.3	1.8	6	6
Lead	mg/L	ND	ND	ND	0	6
Magnesium	mg/L	11	12	11	6	6
Manganese	mg/L	0.063	0.19	0.12	6	6
Mercury	mg/L	ND	ND	ND	0	6
Nickel	mg/L	ND	0.01	0.0038	1	6
Nitrate/Nitrite as Nitrogen	mg/L	0.75	1.8	1.3	6	6
PCB-1016	ug/L	ND	ND	ND	0	6
PCB-1221	ug/L	ND	ND	ND	0	6
PCB-1232	ug/L	ND	ND	ND	0	6
PCB-1242	ug/L	ND	ND	ND	0	6
PCB-1248	ug/L	ND	ND	ND	0	6
PCB-1254	ug/L	ND	ND	ND	0	6
PCB-1260	ug/L	ND	ND	ND	0	6
PCB-1268	ug/L	ND	ND	ND	0	6
pH	Std Unit	7.6	8.2	7.8	6	6
Phosphorous	mg/L	0.13	0.32	0.21	6	6
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	6
Potassium	mg/L	2.4	3.3	2.9	6	6
Selenium	mg/L	ND	ND	ND	0	6
Silver	mg/L	ND	ND	ND	0	6
Sodium	mg/L	11	19	15	6	6
Suspended Solids	mg/L	29	110	66	6	6
Temperature	deg F	41	85	58	6	6
Thallium	mg/L	ND	ND	ND	0	6
Trichloroethene	ug/L	ND	ND	ND	0	6
Uranium	mg/L	ND	ND	ND	0	12
Vanadium	mg/L	ND	ND	ND	0	6
Zinc	mg/L	ND	0.06	0.018	1	6

Surface Water Non-Radiological Data

Table 4.25 Non-Radiological Monitoring Data for Surface Water Location L64

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Alkalinity	mg/L	18	35	28	4	4
Aluminum	mg/L	ND	2.9	1.5	3	4
Ammonia	mg/L	ND	ND	ND	0	4
Antimony	mg/L	ND	ND	ND	0	4
Arsenic	mg/L	ND	ND	ND	0	4
Barium	mg/L	0.039	0.065	0.054	4	4
Beryllium	mg/L	ND	ND	ND	0	4
Cadmium	mg/L	ND	ND	ND	0	4
Calcium	mg/L	10	14	12	4	4
Chloride	mg/L	10	14	12	4	4
Chromium	mg/L	ND	ND	ND	0	4
Cobalt	mg/L	ND	0.001	0.00063	1	4
Conductivity	umho/cm	130	150	140	4	4
Copper	mg/L	ND	0.02	0.0052	1	4
Cyanide	mg/L	ND	ND	ND	0	4
Dissolved Oxygen	mg/L	6.3	12	9.5	4	4
Flow Rate	mgd	0.84	51	15	4	4
Hardness - Total as CaCO3	mg/L	40	53	48	4	4
Iron	mg/L	0.84	2	1.4	4	4
Lead	mg/L	ND	ND	ND	0	4
Magnesium	mg/L	2.5	3.4	3.1	4	4
Manganese	mg/L	0.11	0.29	0.21	4	4
Mercury	mg/L	ND	ND	ND	0	4
Nickel	mg/L	ND	ND	ND	0	4
Nitrate/Nitrite as Nitrogen	mg/L	0.12	1.1	0.64	4	4
PCB-1016	ug/L	ND	ND	ND	0	4
PCB-1221	ug/L	ND	ND	ND	0	4
PCB-1232	ug/L	ND	ND	ND	0	4
PCB-1242	ug/L	ND	ND	ND	0	4
PCB-1248	ug/L	ND	ND	ND	0	4
PCB-1254	ug/L	ND	ND	ND	0	4
PCB-1260	ug/L	ND	ND	ND	0	4
PCB-1268	ug/L	ND	ND	ND	0	4
pH	Std Unit	6.9	8.2	7.2	4	4
Phosphorous	mg/L	ND	0.16	0.089	3	4
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4
Potassium	mg/L	2.3	4.9	3	4	4
Selenium	mg/L	ND	ND	ND	0	4
Silver	mg/L	ND	ND	ND	0	4
Sodium	mg/L	6.9	13	9.7	4	4
Suspended Solids	mg/L	ND	37	17	1	4
Temperature	deg F	40	78	57	4	4
Thallium	mg/L	ND	ND	ND	0	4
Trichloroethene	ug/L	ND	ND	ND	0	4
Uranium	mg/L	ND	ND	ND	0	7
Vanadium	mg/L	ND	ND	ND	0	4
Zinc	mg/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.26 Non-Radiological Monitoring Data for Surface Water Seep Location LBCSP1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
1,1,1-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1,2-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethene	ug/L	ND	ND	ND	0	4
1,2-Dichloroethane	ug/L	ND	ND	ND	0	4
1,2-Dimethylbenzene	ug/L	ND	ND	ND	0	4
Alkalinity	mg/L	35	70	51	4	4
Benzene	ug/L	ND	ND	ND	0	4
Bromodichloromethane	ug/L	ND	ND	ND	0	4
Calcium	mg/L	24	27	25	4	4
Carbon tetrachloride	ug/L	ND	ND	ND	0	4
Chloride	mg/L	34	36	35	4	4
Chloroform	ug/L	ND	ND	ND	0	4
cis-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Conductivity	umho/cm	330	360	340	4	4
Dissolved Oxygen	mg/L	3.9	6.7	5.1	4	4
Ethylbenzene	ug/L	ND	ND	ND	0	4
Flow Rate	mgd	0.0002	0.04	0.014	3	3
m,p-Xylene	ug/L	ND	ND	ND	0	4
Magnesium	mg/L	7.5	11	8.9	4	4
Manganese	mg/L	ND	0.019	0.0098	3	4
pH	Std Unit	5.9	6.6	6.3	4	4
Potassium	mg/L	1.8	2.1	2	4	4
Sodium	mg/L	28	36	32	4	4
Sulfate	mg/L	11	12	11	4	4
Temperature	deg F	55	64	58	4	4
Tetrachloroethene	ug/L	ND	ND	ND	0	4
Toluene	ug/L	ND	ND	ND	0	4
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Trichloroethene	ug/L	4	6	5.2	4	4
Uranium	mg/L	ND	ND	ND	0	4
Vinyl chloride	ug/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.27 Non-Radiological Monitoring Data for Surface Water Seep Location LBCSP2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
1,1,1-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1,2-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethene	ug/L	ND	ND	ND	0	4
1,2-Dichloroethane	ug/L	ND	ND	ND	0	4
1,2-Dimethylbenzene	ug/L	ND	ND	ND	0	4
Alkalinity	mg/L	35	75	55	4	4
Benzene	ug/L	ND	ND	ND	0	4
Bromodichloromethane	ug/L	ND	ND	ND	0	4
Calcium	mg/L	26	30	28	4	4
Carbon tetrachloride	ug/L	ND	ND	ND	0	4
Chloride	mg/L	38	40	39	4	4
Chloroform	ug/L	ND	ND	ND	0	4
cis-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Conductivity	umho/cm	350	370	360	4	4
Dissolved Oxygen	mg/L	3.9	570	150	4	4
Ethylbenzene	ug/L	ND	ND	ND	0	4
Flow Rate	mgd	0.0007	0.0024	0.0015	2	2
m,p-Xylene	ug/L	ND	ND	ND	0	4
Magnesium	mg/L	8.4	10	9.5	4	4
Manganese	mg/L	ND	0.035	0.017	2	4
pH	Std Unit	6.1	6.5	6.3	4	4
Potassium	mg/L	1.7	1.8	1.8	4	4
Sodium	mg/L	30	37	33	4	4
Sulfate	mg/L	11	11	11	4	4
Temperature	deg F	54	61	58	4	4
Tetrachloroethene	ug/L	ND	ND	ND	0	4
Toluene	ug/L	ND	ND	ND	0	4
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Trichloroethene	ug/L	11	21	17	4	4
Uranium	mg/L	ND	ND	ND	0	4
Vinyl chloride	ug/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.28 Non-Radiological Monitoring Data for Surface Water Seep Location LBCSP3

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
1,1,1-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1,2-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethene	ug/L	ND	ND	ND	0	4
1,2-Dichloroethane	ug/L	ND	ND	ND	0	4
1,2-Dimethylbenzene	ug/L	ND	ND	ND	0	4
Alkalinity	mg/L	40	72	56	4	4
Benzene	ug/L	ND	ND	ND	0	4
Bromodichloromethane	ug/L	ND	ND	ND	0	4
Calcium	mg/L	24	28	26	4	4
Carbon tetrachloride	ug/L	ND	ND	ND	0	4
Chloride	mg/L	37	40	39	4	4
Chloroform	ug/L	ND	ND	ND	0	4
cis-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Conductivity	umho/cm	340	370	360	4	4
Dissolved Oxygen	mg/L	4.1	5.7	4.7	4	4
Ethylbenzene	ug/L	ND	ND	ND	0	4
Flow Rate	mgd	0.004	0.17	0.068	3	3
m,p-Xylene	ug/L	ND	ND	ND	0	4
Magnesium	mg/L	8	9.8	8.9	4	4
Manganese	mg/L	ND	0.06	0.017	1	4
pH	Std Unit	6	6.5	6.2	4	4
Potassium	mg/L	1.5	1.8	1.6	4	4
Sodium	mg/L	29	35	32	4	4
Sulfate	mg/L	11	11	11	4	4
Temperature	deg F	54	60	57	4	4
Tetrachloroethene	ug/L	ND	ND	ND	0	4
Toluene	ug/L	ND	ND	ND	0	4
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Trichloroethene	ug/L	29	38	34	4	4
Uranium	mg/L	ND	ND	ND	0	4
Vinyl chloride	ug/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.29 Non-Radiological Monitoring Data for Surface Water Seep Location LBCSP4

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
1,1,1-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1,2-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethene	ug/L	ND	ND	ND	0	4
1,2-Dichloroethane	ug/L	ND	ND	ND	0	4
1,2-Dimethylbenzene	ug/L	ND	ND	ND	0	4
Alkalinity	mg/L	45	70	64	4	4
Benzene	ug/L	ND	ND	ND	0	4
Bromodichloromethane	ug/L	ND	ND	ND	0	4
Calcium	mg/L	26	30	28	4	4
Carbon tetrachloride	ug/L	ND	ND	ND	0	4
Chloride	mg/L	40	41	40	4	4
Chloroform	ug/L	ND	ND	ND	0	4
cis-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Conductivity	umho/cm	370	380	370	4	4
Dissolved Oxygen	mg/L	4	4.6	4.4	4	4
Ethylbenzene	ug/L	ND	ND	ND	0	4
Flow Rate	mgd	0.17	0.74	0.46	2	2
m,p-Xylene	ug/L	ND	ND	ND	0	4
Magnesium	mg/L	8.4	10	9.2	4	4
Manganese	mg/L	ND	0.018	0.01	3	4
pH	Std Unit	6	6.6	6.3	4	4
Potassium	mg/L	1.6	2	1.8	4	4
Sodium	mg/L	29	36	33	4	4
Sulfate	mg/L	12	13	13	4	4
Temperature	deg F	56	58	57	4	4
Tetrachloroethene	ug/L	ND	ND	ND	0	4
Toluene	ug/L	ND	ND	ND	0	4
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Trichloroethene	ug/L	26	36	30	4	4
Uranium	mg/L	ND	ND	ND	0	4
Vinyl chloride	ug/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.30 Non-Radiological Monitoring Data for Surface Water Seep Location LBCSP5

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
1,1,1-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1,2-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethene	ug/L	ND	ND	ND	0	4
1,2-Dichloroethane	ug/L	ND	ND	ND	0	4
1,2-Dimethylbenzene	ug/L	ND	ND	ND	0	4
Alkalinity	mg/L	40	70	54	4	4
Benzene	ug/L	ND	ND	ND	0	4
Bromodichloromethane	ug/L	ND	ND	ND	0	4
Calcium	mg/L	22	29	26	4	4
Carbon tetrachloride	ug/L	ND	ND	ND	0	4
Chloride	mg/L	26	35	31	4	4
Chloroform	ug/L	ND	ND	ND	0	4
cis-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Conductivity	umho/cm	330	360	340	4	4
Dissolved Oxygen	mg/L	4	5	4.5	4	4
Ethylbenzene	ug/L	ND	ND	ND	0	4
Flow Rate	mgd	0.000089	0.012	0.004	4	4
m,p-Xylene	ug/L	ND	ND	ND	0	4
Magnesium	mg/L	6.6	11	8.4	4	4
Manganese	mg/L	ND	0.044	0.016	3	4
pH	Std Unit	6.1	6.5	6.3	4	4
Potassium	mg/L	1.8	2.3	2	4	4
Sodium	mg/L	27	35	31	4	4
Sulfate	mg/L	16	29	20	4	4
Temperature	deg F	55	59	58	4	4
Tetrachloroethene	ug/L	ND	ND	ND	0	4
Toluene	ug/L	ND	ND	ND	0	4
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Trichloroethene	ug/L	170	340	230	4	4
Uranium	mg/L	ND	ND	ND	0	4
Vinyl chloride	ug/L	ND	ND	ND	0	4

Surface Water Non-Radiological Data

Table 4.31 Non-Radiological Monitoring Data for Surface Water Seep Location LBCSP6

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
1,1,1-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1,2-Trichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethane	ug/L	ND	ND	ND	0	4
1,1-Dichloroethene	ug/L	ND	ND	ND	0	4
1,2-Dichloroethane	ug/L	ND	ND	ND	0	4
1,2-Dimethylbenzene	ug/L	ND	ND	ND	0	4
Alkalinity	mg/L	30	67	46	4	4
Benzene	ug/L	ND	ND	ND	0	4
Bromodichloromethane	ug/L	ND	ND	ND	0	4
Calcium	mg/L	21	27	24	4	4
Carbon tetrachloride	ug/L	ND	ND	ND	0	4
Chloride	mg/L	30	35	33	4	4
Chloroform	ug/L	ND	ND	ND	0	4
cis-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Conductivity	umho/cm	300	320	320	4	4
Dissolved Oxygen	mg/L	4	4.2	4.1	4	4
Ethylbenzene	ug/L	ND	ND	ND	0	4
Flow Rate	mgd	0.0008	0.003	0.0019	2	2
m,p-Xylene	ug/L	ND	ND	ND	0	4
Magnesium	mg/L	6.9	10	8.4	4	4
Manganese	mg/L	ND	0.069	0.034	3	4
pH	Std Unit	6	6.4	6.2	4	4
Potassium	mg/L	1.2	1.8	1.4	4	4
Sodium	mg/L	29	38	31	4	4
Sulfate	mg/L	14	15	15	4	4
Temperature	deg F	52	60	57	4	4
Tetrachloroethene	ug/L	ND	ND	ND	0	4
Toluene	ug/L	ND	ND	ND	0	4
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	0	4
Trichloroethene	ug/L	170	230	200	4	4
Uranium	mg/L	ND	ND	ND	0	4
Vinyl chloride	ug/L	ND	ND	ND	0	4

Sediment Non-Radiological Data

Table 4.32 Non-Radiological Data for Sediment Location S20

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	2800	5700	4300	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	33	42	38	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	250	1000	630	2	2
Chromium	mg/kg	8.3	10	9.2	2	2
Cobalt	mg/kg	4.2	5.2	4.7	2	2
Copper	mg/kg	ND	5.3	3.9	1	2
Grain Size Diameter	%	12	22	17	2	2
Iron	mg/kg	8300	8500	8400	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	260	550	400	2	2
Manganese	mg/kg	120	350	230	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	30	35	32	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	180	430	300	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	1600	6600	4100	2	2
Uranium	mg/kg	ND	ND	ND	0	4
Vanadium	mg/kg	16	17	17	2	2
Zinc	mg/kg	ND	24	17	1	2

Sediment Non-Radiological Data

Table 4.33 Non-Radiological Data for Sediment Location C612

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	2700	4100	3400	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	19	47	33	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	210	1800	990	2	2
Chromium	mg/kg	6.2	32	19	2	2
Cobalt	mg/kg	ND	4.3	2.8	1	2
Copper	mg/kg	ND	18	10	1	2
Grain Size Diameter	%	35	44	40	2	2
Iron	mg/kg	4300	6700	5500	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	200	730	460	2	2
Manganese	mg/kg	51	120	83	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	58	110	82	2	2
Nickel	mg/kg	ND	6.6	4.5	1	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	190	350	270	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	200	150	1	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	3800	12000	7900	2	2
Uranium	mg/kg	ND	100	28	1	4
Vanadium	mg/kg	10	15	12	2	2
Zinc	mg/kg	ND	42	26	1	2

Sediment Non-Radiological Data

Table 4.34 Non-Radiological Data for Sediment Location C616

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	6300	10000	7700	3	3
Antimony	mg/kg	ND	ND	ND	0	3
Arsenic	mg/kg	ND	ND	ND	0	3
Barium	mg/kg	88	100	93	3	3
Beryllium	mg/kg	ND	0.82	0.52	2	3
Cadmium	mg/kg	ND	ND	ND	0	3
Calcium	mg/kg	1200	1600	1400	3	3
Chromium	mg/kg	19	27	24	3	3
Cobalt	mg/kg	3.8	4.1	3.9	3	3
Copper	mg/kg	11	12	12	3	3
Grain Size Diameter	%	33	34	34	3	3
Iron	mg/kg	9000	13000	10000	3	3
Lead	mg/kg	ND	ND	ND	0	3
Magnesium	mg/kg	800	1400	1100	3	3
Manganese	mg/kg	100	150	130	3	3
Mercury	mg/kg	ND	ND	ND	0	3
Moisture	%	45	67	59	3	3
Nickel	mg/kg	5.7	10	8.5	3	3
PCB-1016	ug/kg	ND	ND	ND	0	3
PCB-1221	ug/kg	ND	ND	ND	0	3
PCB-1232	ug/kg	ND	ND	ND	0	3
PCB-1242	ug/kg	ND	ND	ND	0	3
PCB-1248	ug/kg	ND	ND	ND	0	3
PCB-1254	ug/kg	ND	ND	ND	0	3
PCB-1260	ug/kg	ND	ND	ND	0	3
PCB-1268	ug/kg	ND	ND	ND	0	3
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	3
Potassium	mg/kg	500	1100	740	3	3
Selenium	mg/kg	ND	ND	ND	0	3
Silver	mg/kg	ND	ND	ND	0	3
Sodium	mg/kg	200	210	200	3	3
Thallium	mg/kg	ND	ND	ND	0	3
Total Organic Carbon (TOC)	mg/kg	4000	5500	4600	3	3
Uranium	mg/kg	ND	100	27	1	6
Vanadium	mg/kg	14	27	19	3	3
Zinc	mg/kg	29	38	34	3	3

Sediment Non-Radiological Data

Table 4.35 Non-Radiological Data for Sediment Location K001

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	3000	4400	3700	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	32	43	38	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	1500	1500	1500	2	2
Chromium	mg/kg	11	12	12	2	2
Cobalt	mg/kg	3.4	3.6	3.5	2	2
Copper	mg/kg	8.8	18	13	2	2
Grain Size Diameter	%	51	64	58	2	2
Iron	mg/kg	5100	5600	5300	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	580	830	710	2	2
Manganese	mg/kg	47	50	48	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	81	81	81	2	2
Nickel	mg/kg	ND	5.6	4	1	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	300	430	360	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	200	140	1	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	5700	8300	7000	2	2
Uranium	mg/kg	ND	ND	ND	0	4
Vanadium	mg/kg	8.7	11	9.6	2	2
Zinc	mg/kg	37	39	38	2	2

Sediment Non-Radiological Data

Table 4.36 Non-Radiological Data for Sediment Location S1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	2300	5300	3800	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	23	40	32	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	460	690	580	2	2
Chromium	mg/kg	10	19	15	2	2
Cobalt	mg/kg	2.6	4.1	3.3	2	2
Copper	mg/kg	ND	11	6.7	1	2
Grain Size Diameter	%	20	22	21	2	2
Iron	mg/kg	5800	10000	8000	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	230	420	320	2	2
Manganese	mg/kg	88	130	110	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	40	47	43	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	130	260	200	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	3600	15000	9300	2	2
Uranium	mg/kg	ND	ND	ND	0	4
Vanadium	mg/kg	9.8	17	14	2	2
Zinc	mg/kg	22	32	27	2	2

Sediment Non-Radiological Data

Table 4.37 Non-Radiological Data for Sediment Location S31

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	5300	9000	7200	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	33	39	36	2	2
Beryllium	mg/kg	0.5	0.64	0.57	2	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	1300	7200	4300	2	2
Chromium	mg/kg	13	29	21	2	2
Cobalt	mg/kg	3.1	3.9	3.5	2	2
Copper	mg/kg	ND	20	11	1	2
Grain Size Diameter	%	21	26	23	2	2
Iron	mg/kg	10000	14000	12000	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	520	680	600	2	2
Manganese	mg/kg	100	150	130	2	2
Mercury	mg/kg	ND	0.21	0.15	1	2
Moisture	%	32	78	55	2	2
Nickel	mg/kg	ND	8.8	5.7	1	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	100	75	1	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	100	75	1	2
Potassium	mg/kg	270	350	310	2	2
Selenium	mg/kg	ND	20	15	1	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	2700	12000	7400	2	2
Uranium	mg/kg	ND	120	43	1	4
Vanadium	mg/kg	18	34	26	2	2
Zinc	mg/kg	22	78	50	2	2

Sediment Non-Radiological Data

Table 4.38 Non-Radiological Data for Sediment Location S33

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	2600	3100	2900	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	26	29	28	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	360	540	450	2	2
Chromium	mg/kg	7.1	8.1	7.6	2	2
Cobalt	mg/kg	ND	3.1	2.2	1	2
Copper	mg/kg	ND	ND	ND	0	2
Grain Size Diameter	%	28	38	33	2	2
Iron	mg/kg	4400	5800	5100	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	260	300	280	2	2
Manganese	mg/kg	97	150	120	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	36	38	37	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	180	200	190	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	2300	3200	2800	2	2
Uranium	mg/kg	ND	100	26	1	4
Vanadium	mg/kg	9.4	12	11	2	2
Zinc	mg/kg	ND	ND	ND	0	2

Sediment Non-Radiological Data

Table 4.39 Non-Radiological Data for Sediment Location S21

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	2900	7400	5200	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	8.2	5.3	1	2
Barium	mg/kg	52	65	59	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	880	900	890	2	2
Chromium	mg/kg	9.1	16	12	2	2
Cobalt	mg/kg	4.6	5.4	5	2	2
Copper	mg/kg	ND	ND	ND	0	2
Grain Size Diameter	%	21	37	29	2	2
Iron	mg/kg	7900	8600	8300	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	400	800	600	2	2
Manganese	mg/kg	190	340	270	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	41	49	45	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	110	520	310	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	2200	4400	3300	2	2
Uranium	mg/kg	ND	ND	ND	0	4
Vanadium	mg/kg	15	18	16	2	2
Zinc	mg/kg	ND	27	19	1	2

Sediment Non-Radiological Data

Table 4.40 Non-Radiological Data for Sediment Location S2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	3000	5900	4500	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	33	42	37	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	920	1100	1000	2	2
Chromium	mg/kg	22	27	25	2	2
Cobalt	mg/kg	3.4	5.5	4.5	2	2
Copper	mg/kg	ND	5.8	4.2	1	2
Grain Size Diameter	%	20	22	21	2	2
Iron	mg/kg	6800	7800	7300	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	330	470	400	2	2
Manganese	mg/kg	180	270	220	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	31	41	36	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	110	110	110	2	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	110	170	140	2	2
Potassium	mg/kg	160	390	270	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	2200	4800	3500	2	2
Uranium	mg/kg	ND	100	29	1	4
Vanadium	mg/kg	13	18	16	2	2
Zinc	mg/kg	31	34	33	2	2

Sediment Non-Radiological Data

Table 4.41 Non-Radiological Data for Sediment Location S30

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	4000	5000	4500	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	6.8	4.7	1	2
Barium	mg/kg	52	59	55	2	2
Beryllium	mg/kg	ND	0.51	0.38	1	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	730	850	790	2	2
Chromium	mg/kg	20	72	46	2	2
Cobalt	mg/kg	4.7	4.9	4.8	2	2
Copper	mg/kg	ND	ND	ND	0	2
Grain Size Diameter	%	28	35	32	2	2
Iron	mg/kg	5600	12000	8600	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	360	500	430	2	2
Manganese	mg/kg	59	130	93	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	37	37	37	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	280	460	370	2	2
PCB-1260	ug/kg	380	410	400	2	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	660	870	760	2	2
Potassium	mg/kg	170	220	190	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	200	140	1	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	2200	4600	3400	2	2
Uranium	mg/kg	ND	110	62	3	4
Vanadium	mg/kg	16	20	18	2	2
Zinc	mg/kg	30	49	39	2	2

Sediment Non-Radiological Data

Table 4.42 Non-Radiological Data for Sediment Location S27

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	1400	2600	2000	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	15	30	22	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	270	550	410	2	2
Chromium	mg/kg	16	36	26	2	2
Cobalt	mg/kg	ND	3.4	2.3	1	2
Copper	mg/kg	ND	7.9	5.2	1	2
Grain Size Diameter	%	22	24	23	2	2
Iron	mg/kg	2700	4300	3500	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	120	300	210	2	2
Manganese	mg/kg	59	120	92	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	32	40	36	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	ND	140	98	1	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	1100	2100	1600	2	2
Uranium	mg/kg	ND	100	29	2	4
Vanadium	mg/kg	6.4	9.5	7.9	2	2
Zinc	mg/kg	ND	26	18	1	2

Sediment Non-Radiological Data

Table 4.43 Non-Radiological Data for Sediment Location S34

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	1800	2300	2100	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	17	26	22	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	260	480	370	2	2
Chromium	mg/kg	11	16	14	2	2
Cobalt	mg/kg	2.5	2.6	2.6	2	2
Copper	mg/kg	ND	ND	ND	0	2
Grain Size Diameter	%	21	30	26	2	2
Iron	mg/kg	3900	4300	4100	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	150	260	200	2	2
Manganese	mg/kg	80	87	84	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	36	42	39	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	120	150	140	2	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	2000	6400	4200	2	2
Uranium	mg/kg	ND	100	27	1	4
Vanadium	mg/kg	6.6	8.1	7.3	2	2
Zinc	mg/kg	ND	ND	ND	0	2

Sediment Non-Radiological Data

Table 4.44 Non-Radiological Data for Sediment Location C746KTB2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	1400	3300	2400	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	11	29	20	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	200	420	310	2	2
Chromium	mg/kg	7.3	8.4	7.9	2	2
Cobalt	mg/kg	ND	3.3	2.3	1	2
Copper	mg/kg	ND	ND	ND	0	2
Grain Size Diameter	%	4.6	18	11	2	2
Iron	mg/kg	4000	6300	5200	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	110	300	200	2	2
Manganese	mg/kg	75	200	140	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	35	58	47	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	ND	200	130	1	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	1900	6800	4400	2	2
Uranium	mg/kg	ND	ND	ND	0	4
Vanadium	mg/kg	10	14	12	2	2
Zinc	mg/kg	ND	ND	ND	0	2

Sediment Non-Radiological Data

Table 4.45 Non-Radiological Data for Sediment Location C746KUP

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	2900	9000	5000	3	3
Antimony	mg/kg	ND	ND	ND	0	3
Arsenic	mg/kg	ND	ND	ND	0	3
Barium	mg/kg	28	61	39	3	3
Beryllium	mg/kg	ND	0.51	0.34	1	3
Cadmium	mg/kg	ND	ND	ND	0	3
Calcium	mg/kg	510	1300	800	3	3
Chromium	mg/kg	6.7	16	11	3	3
Cobalt	mg/kg	3.1	3.7	3.5	3	3
Copper	mg/kg	ND	6.5	3.8	1	3
Grain Size Diameter	%	17	20	19	3	3
Iron	mg/kg	5700	9000	7200	3	3
Lead	mg/kg	ND	ND	ND	0	3
Magnesium	mg/kg	270	920	490	3	3
Manganese	mg/kg	81	200	160	3	3
Mercury	mg/kg	ND	ND	ND	0	3
Moisture	%	30	35	33	3	3
Nickel	mg/kg	ND	6	3.7	1	3
PCB-1016	ug/kg	ND	ND	ND	0	3
PCB-1221	ug/kg	ND	ND	ND	0	3
PCB-1232	ug/kg	ND	ND	ND	0	3
PCB-1242	ug/kg	ND	ND	ND	0	3
PCB-1248	ug/kg	ND	ND	ND	0	3
PCB-1254	ug/kg	ND	ND	ND	0	3
PCB-1260	ug/kg	ND	ND	ND	0	3
PCB-1268	ug/kg	ND	ND	ND	0	3
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	3
Potassium	mg/kg	180	830	400	3	3
Selenium	mg/kg	ND	ND	ND	0	3
Silver	mg/kg	ND	ND	ND	0	3
Sodium	mg/kg	ND	ND	ND	0	3
Thallium	mg/kg	ND	ND	ND	0	3
Total Organic Carbon (TOC)	mg/kg	1400	2400	2000	3	3
Uranium	mg/kg	ND	ND	ND	0	6
Vanadium	mg/kg	12	23	16	3	3
Zinc	mg/kg	ND	25	20	2	3

Sediment Non-Radiological Data

Table 4.46 Non-Radiological Data for Sediment Location S32

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	4000	6600	5300	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	42	50	46	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	1600	1800	1700	2	2
Chromium	mg/kg	26	39	32	2	2
Cobalt	mg/kg	2.6	4.4	3.5	2	2
Copper	mg/kg	24	29	26	2	2
Grain Size Diameter	%	38	42	40	2	2
Iron	mg/kg	5500	11000	8400	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	650	800	720	2	2
Manganese	mg/kg	78	160	120	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	65	67	66	2	2
Nickel	mg/kg	15	16	16	2	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	210	320	260	2	2
PCB-1260	ug/kg	130	190	160	2	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	340	510	420	2	2
Potassium	mg/kg	360	490	420	2	2
Selenium	mg/kg	ND	21	16	1	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	3400	12000	7700	2	2
Uranium	mg/kg	ND	100	28	1	4
Vanadium	mg/kg	9.1	20	14	2	2
Zinc	mg/kg	50	54	52	2	2

Sediment Non-Radiological Data

Table 4.47 Non-Radiological Data for Sediment Location S28

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	960	2800	1900	2	2
Antimony	mg/kg	ND	ND	ND	0	2
Arsenic	mg/kg	ND	ND	ND	0	2
Barium	mg/kg	12	32	22	2	2
Beryllium	mg/kg	ND	ND	ND	0	2
Cadmium	mg/kg	ND	ND	ND	0	2
Calcium	mg/kg	200	350	270	2	2
Chromium	mg/kg	2.8	5.4	4.1	2	2
Cobalt	mg/kg	ND	3.7	2.5	1	2
Copper	mg/kg	ND	ND	ND	0	2
Grain Size Diameter	%	14	24	19	2	2
Iron	mg/kg	3000	5200	4100	2	2
Lead	mg/kg	ND	ND	ND	0	2
Magnesium	mg/kg	120	300	210	2	2
Manganese	mg/kg	130	160	150	2	2
Mercury	mg/kg	ND	ND	ND	0	2
Moisture	%	32	32	32	2	2
Nickel	mg/kg	ND	ND	ND	0	2
PCB-1016	ug/kg	ND	ND	ND	0	2
PCB-1221	ug/kg	ND	ND	ND	0	2
PCB-1232	ug/kg	ND	ND	ND	0	2
PCB-1242	ug/kg	ND	ND	ND	0	2
PCB-1248	ug/kg	ND	ND	ND	0	2
PCB-1254	ug/kg	ND	ND	ND	0	2
PCB-1260	ug/kg	ND	ND	ND	0	2
PCB-1268	ug/kg	ND	ND	ND	0	2
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2
Potassium	mg/kg	ND	190	120	1	2
Selenium	mg/kg	ND	ND	ND	0	2
Silver	mg/kg	ND	ND	ND	0	2
Sodium	mg/kg	ND	ND	ND	0	2
Thallium	mg/kg	ND	ND	ND	0	2
Total Organic Carbon (TOC)	mg/kg	1200	5600	3400	2	2
Uranium	mg/kg	ND	ND	ND	0	4
Vanadium	mg/kg	4.8	9.9	7.3	2	2
Zinc	mg/kg	ND	ND	ND	0	2

Deer Non-Radiological Data

Table 4.48 Non-Radiological Analysis of Deer Liver Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	ND	6.7	3.5	5	6
Antimony	mg/kg	ND	ND	ND	0	6
Arsenic	mg/kg	ND	ND	ND	0	6
Barium	mg/kg	0.032	0.25	0.1	6	6
Beryllium	mg/kg	ND	ND	ND	0	6
Cadmium	mg/kg	0.093	0.21	0.15	6	6
Chromium	mg/kg	1.9	3.1	2.6	6	6
Cobalt	mg/kg	0.12	0.21	0.15	6	6
Copper	mg/kg	34	91	66	6	6
Iron	mg/kg	57	82	71	6	6
Lead	mg/kg	ND	ND	ND	0	6
Lipids	%	3.5	6.4	5.1	6	6
Manganese	mg/kg	3.5	6.6	5.1	6	6
Mercury	mg/kg	ND	ND	ND	0	6
Nickel	mg/kg	ND	ND	ND	0	6
PCB-1016	ug/kg	ND	ND	ND	0	6
PCB-1221	ug/kg	ND	ND	ND	0	6
PCB-1232	ug/kg	ND	ND	ND	0	6
PCB-1242	ug/kg	ND	ND	ND	0	6
PCB-1248	ug/kg	ND	ND	ND	0	6
PCB-1254	ug/kg	ND	ND	ND	0	6
PCB-1260	ug/kg	ND	ND	ND	0	6
PCB-1268	ug/kg	ND	ND	ND	0	6
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	6
Selenium	mg/kg	ND	0.87	0.32	2	6
Silver	mg/kg	ND	ND	ND	0	6
Thallium	mg/kg	ND	0.6	0.33	1	6
Vanadium	mg/kg	ND	ND	ND	0	6
Zinc	mg/kg	22	45	35	6	6

Deer Non-Radiological Data

Table 4.49 Non-Radiological Analysis of Deer Muscle Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	1.2	8.7	3.1	6	6
Antimony	mg/kg	ND	ND	ND	0	6
Arsenic	mg/kg	ND	ND	ND	0	6
Barium	mg/kg	ND	0.14	0.062	5	6
Beryllium	mg/kg	ND	0.018	0.0091	1	6
Cadmium	mg/kg	ND	ND	ND	0	6
Chromium	mg/kg	1.6	2.1	1.9	6	6
Cobalt	mg/kg	ND	ND	ND	0	6
Copper	mg/kg	1.4	2.1	1.6	6	6
Iron	mg/kg	32	46	41	6	6
Lead	mg/kg	ND	ND	ND	0	6
Manganese	mg/kg	0.13	0.27	0.2	6	6
Mercury	mg/kg	ND	ND	ND	0	6
Nickel	mg/kg	ND	ND	ND	0	6
Selenium	mg/kg	ND	ND	ND	0	6
Silver	mg/kg	ND	ND	ND	0	6
Thallium	mg/kg	ND	ND	ND	0	6
Vanadium	mg/kg	ND	0.12	0.05	1	6
Zinc	mg/kg	17	29	24	6	6

Table 4.50 Non-Radiological Analysis of Deer Kidney Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Aluminum	mg/kg	ND	1.9	1.5	5	6
Antimony	mg/kg	ND	1.1	0.62	1	6
Arsenic	mg/kg	ND	ND	ND	0	6
Barium	mg/kg	0.35	0.68	0.47	6	6
Beryllium	mg/kg	ND	ND	ND	0	6
Cadmium	mg/kg	0.16	1.9	1.3	6	6
Chromium	mg/kg	1.5	2	1.7	6	6
Cobalt	mg/kg	ND	0.12	0.08	3	6
Copper	mg/kg	3.5	4.2	3.8	6	6
Iron	mg/kg	31	70	48	6	6
Lead	mg/kg	ND	ND	ND	0	6
Manganese	mg/kg	1.4	1.7	1.5	6	6
Mercury	mg/kg	ND	0.088	0.057	5	6
Nickel	mg/kg	ND	0.28	0.16	2	6
Selenium	mg/kg	0.39	0.65	0.51	6	6
Silver	mg/kg	ND	0.16	0.073	1	6
Thallium	mg/kg	ND	ND	ND	0	6
Vanadium	mg/kg	ND	ND	ND	0	6
Zinc	mg/kg	21	24	22	6	6

Deer Non-Radiological Data

Table 4.51 Non-Radiological Analysis of Deer Fat Tissue for 2003

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples
Lipids	%	41	91	70	12	12
PCB-1016	ug/kg	ND	ND	ND	0	12
PCB-1221	ug/kg	ND	ND	ND	0	12
PCB-1232	ug/kg	ND	ND	ND	0	12
PCB-1242	ug/kg	ND	ND	ND	0	12
PCB-1248	ug/kg	ND	ND	ND	0	12
PCB-1254	ug/kg	ND	ND	ND	0	12
PCB-1260	ug/kg	ND	ND	ND	0	12
PCB-1268	ug/kg	ND	40	28	10	12
Polychlorinated biphenyl	ug/kg	ND	40	28	10	12

Preface

This report summarizes the information found in the Paducah Annual Site Environmental Report (ASER) for 2003, DOE/OR/07-2169/V1. The United States Department of Energy (DOE) requires an annual report to be prepared that presents the results from various environmental monitoring programs and activities carried out during the year. This report summary is written so that it can be easily understood and can educate the reader about the mission, goals, and activities of DOE at Paducah. This is a brief summary of calendar year 2003 activities. These activities include environmental monitoring, contamination cleanup, accomplishments, and general information. This report also includes and discusses data contained in the 2003 Paducah ASER. The data presented in this summary are a subset of the data included in the Paducah ASER volumes I and II.

You are encouraged to comment on the content of this summary, as well as make suggestions for future documents. Please send your comments and suggestions to:

United States Department of Energy
Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513

Contents

DOE Planning and Management

The Paducah Gaseous Diffusion Plant (PGDP) reached its 50th anniversary of operation in October 2002 as is the only operating uranium enrichment plant in the United States. With a half century of production behind it, the plant faces significant environmental cleanup challenges. The PGDP is situated on a 3556-acre parcel of DOE-owned property in Western Kentucky, approximately 10 miles west of the city of Paducah and 3 miles south of the Ohio River. The primary gaseous diffusion plant operations associated with the enrichment process are located on 748 acres within the plant security fence. Of the remaining acreage comprising the DOE-owned property (outside the main security fence), 1986 acres are leased to the Kentucky Department for Fish and Wildlife Resources, as part of the West Kentucky Wildlife Management Area, and the remaining land (822 acres) is relegated as a buffer zone around the secure area.

The area surrounding PGDP is predominantly rural. Immediately adjacent to PGDP is a wildlife area that is used by hunters and fishers. The remaining area is lightly populated with randomly located residences and farms, with some private residences located immediately adjacent to the DOE property boundary and the wildlife area. The small communities of Grahamville and Heath are located approximately 1.5 to 2 miles east of the plant. Metropolis, Illinois, is located north of PGDP across the Ohio River. The PGDP is in an area of abundant surface water and groundwater resources. Bordering the east and west sides of the secure area are Little Bayou Creek and Bayou Creek, respectively. Little Bayou Creek originates in the adjacent wildlife area, and Bayou Creek originates about 2.5 miles south of PGDP. Both creeks flow north toward the Ohio River, which is about 3 miles north of PGDP. Water discharged from PGDP constitutes the majority of normal flow in Bayou Creek and Little Bayou Creek. The discharges are regulated by the Commonwealth of Kentucky.

Currently, the United States Enrichment Corporation (USEC) operates uranium enrichment at PGDP. This corporation was established on October 24, 1992, by the enactment of the Energy Policy Act of 1992. The charter of USEC under this act is to provide profitable and competitive uranium enrichment services. The USEC has leased the uranium enrichment production facilities from DOE since July 1, 1993, but DOE has retained the non-leased facilities and is responsible for the decontamination and decommissioning and cleanup for environmental conditions that existed before July 1, 1993.

In 2003, DOE and the Commonwealth of Kentucky signed a Letter of Intent to document a commitment to promote accelerated cleanup at PGDP, develop integrated planning and funding requests, meet commitments under the Paducah Federal Facility Agreement, and settle all identified outstanding enforcement and compliance issues through an Agreed Order. The Letter of Intent documented the desire to move forward to share a vision to accomplish the agreed-upon scope by a mutually acceptable date, with a goal to achieve accelerated completion. The DOE agreed to take all necessary steps to accelerate risk reduction and to apply as large a percentage as possible of the Paducah Site's budget to accelerated cleanup as a continuing and ongoing process. "Risk reduction" to human health and the environment would be considered an important factor in setting priorities and cleanup strategies. A preference would be for cleanup strategies that reduce site-wide long-term stewardship requirements and costs. The DOE and the Commonwealth of Kentucky agreed to seek United States Environmental Protection Agency (EPA) agreement and cooperation with response to implementing these approaches as well.

Significant Events at Paducah in 2003

- ☑ Completed the Six-Phase Heating Treatability Study adjacent to the C-400 Building for cleanup of trichloroethene (TCE) of the groundwater contamination source.
- ☑ Continued operation of the Northwest and Northeast Plume groundwater treatment systems for cleanup of the plumes.
- ☑ Installed a sediment controls basin and excavated Section 2 of the contaminated North South Diversion Ditch to reduce the risk of exposure from contaminated soil, sediment, and surface water.
- ☑ Initiated removal of scrap metal, including aluminum ingots, from the PGDP Scrap Yards to remove contaminated scrap metal for disposal.
- ☑ Continued characterization and disposal of the contents in DOE Material Storage Area (see photo).
- ☑ Shipped 1854 metric tons of low-level and hazardous waste off-site.
- ☑ Disposed of approximately 3800 tons of concrete crushate and 14 roll-off bins of wood debris in the on-site landfill.

DMSA activities

Planned Events Beyond 2003

2004

- ☐ Complete Southwest Plume and C-746-S&T Landfills investigations to identify additional groundwater contamination sources.
- ☐ Initiate characterization of on-site surface water.
- ☐ Continue characterization of DOE Material Storage Area contents.
- ☐ Continue off-site shipment of mixed waste for treatment.
- ☐ Complete removal of contaminated soils from North South Diversion Ditch Section 1.
- ☐ Demolish a hydrogen tank.
- ☐ Continue scrap metal disposal.
- ☐ Complete plan with regulators for remediation for C-400 groundwater contamination.

2005

- ☐ Continue scrap metal disposal.
- ☐ Complete C-746-S&T Landfills site evaluation report.
- ☐ Complete on-site Surface Water Operable Unit investigation.
- ☐ Implement investigation work plan for burial grounds.
- ☐ Continue off-site shipment of mixed waste for treatment.
- ☐ Complete remediation of C-400 groundwater contamination sources.

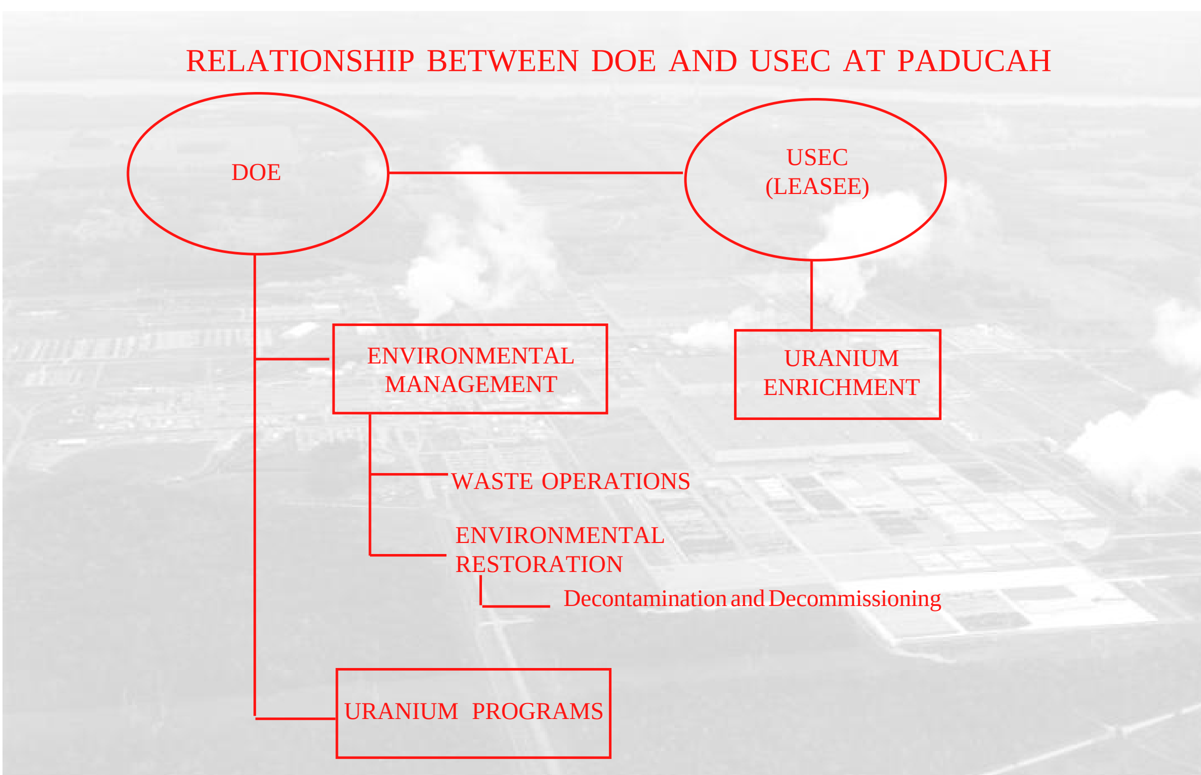
2006

- ☐ Complete scrap metal disposal.
- ☐ Complete Department of Energy Material Storage Area characterization.
- ☐ Complete a plan with regulators for Southwest Plume groundwater remediation.
- ☐ Implement remediation of contamination around the C-400 Building.

Program Missions

The following two major programs are operated by DOE at the Paducah Site: (1) Environmental Management and (2) Uranium Programs. Environmental Restoration, Waste Operations, and decontamination and decommissioning are projects under the Environmental Management Program. The program/project missions are described below.

Program/Project	Mission
Environmental Restoration	Ensure that releases from past activities at the Paducah Site are investigated, and that appropriate remedial action is taken for protection of human health and the environment.
Waste Operations	Characterize and dispose of the legacy waste stored onsite in compliance with various agreements between DOE and the regulatory agencies (including waste in DOE Material Storage Areas).
Decontamination and Decommissioning	A subset of the Environmental Restoration and Waste Management projects that will disposition surplus facilities and prepare materials or waste for disposal.
Uranium Programs	Maintain safe, compliant storage of the DOE depleted uranium hexafluoride inventory, pending final disposal of the material, and manage facilities and grounds not leased to USEC. Design, contruct, and operate a facility to convert depleted uranium hexafluoride to uranium oxide and aqueous hydrogen fluoride.



Environmental Compliance

The DOE is required to implement environmental regulations that are required by the Commonwealth of Kentucky and USEPA. These regulations have been established to limit exposure to levels of hazardous wastes and chemicals that may be detrimental to human health and the environment. These regulations are commonly referred to as environmental compliance and those applicable to the DOE-owned site are summarized as follows.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

RCRA is a law that governs the management of hazardous waste. The PGDP received a RCRA permit to manage hazardous waste on August 19, 1991. The permit must be renewed every ten years. The DOE submitted a hazardous waste permit renewal application to the Kentucky Division of Waste Management on February 21, 2001. On September 28, 2001, Kentucky Division of Waste Management requested additional information. A revised permit application was submitted in February 2002. DOE is awaiting issuance of a new permit and continues to operate under the expired permit.

The DOE did not receive any notices of violation during 2003 from Kentucky or EPA regulators. However, DOE received two notices of violation from the Missouri Department of Natural Resources, dated January 24, 2003, and April 15, 2003. These notices alleged that DOE, as a registered hazardous waste generator in Missouri, was in violation of the Missouri Hazardous Waste Management Law for failure to submit the required annual registration fee for calendar year 2003, and the required manifest summary. Follow-up actions included withdrawing the Missouri registration and submitting the necessary paperwork to deactivate registration. No further paperwork or fees were required, because DOE did not ship hazardous waste to Missouri.

In 2003, DOE submitted closure plans to Kentucky regulators for 18 DMSAs. Fourteen were inside buildings and four were outside. These closure plans were reviewed and accepted by the regulators and the storage areas were complete.

On October 1, 2003, the DOE entered into two Agreed Orders with the Kentucky Division of Waste Management. The Agreed Order (KNREPC File Numbers DWM-31434-042, DAQ-31740-030, and DOW-26141-042) relates to hazardous waste management and included the following actions:

- Resolved all open Kentucky notices of violation.
- Established health-based levels for waste contained in determinations.
- Provided waste criteria for the C-746-U Landfill.
- Established regulatory deadlines for characterization of all Department of Energy Material Storage Areas.
- Established a characterization process for legacy waste containers that may contain RCRA hazardous waste.
- Established RCRA closure requirements for hazardous waste storage units and Department of Energy Material Storage Areas.
- Established penalties for non-compliant waste storage.

The DOE will pay one million dollars in four installments of $250,000 for penalties related to hazardous waste violations issued by Kentucky regulators.

The second Agreed Order (KNREPC File Number DWM-32434-030) relates to depleted uranium hexafluoride cylinder mangement and documented the following action:

- Set the framework for managing cylinders of depleted uranium hexafluoride.

SOLID WASTE

The DOE disposes of a portion of its solid waste units in on-site landfill C-746-U. During 2003, 9151 tons of waste were disposed in the landfill. In lieu of disposing of office waste at the C-746-U Landfill, office waste generated by DOE and its contractors at the plant site is taken offsite for disposal. Only office waste generated at the C-746-U Landfill was disposed in the landfill.

The DOE received no notices of violation during 2003 for the active C-746-U and inactive C-746-S and C-746-T Landfills. However, late in calendar year 2002, Kentucky regulators issued violations for alleged disposal of RCRA-regulated wastes in the C-746-U Landfill and the inactive C-746-S Landfill. On April 21, 2003, an approved sampling plan was initiated to sample four potentially hazardous waste streams in the C-746-U Landfill. Kentucky regulators also collected samples and observed DOE's sampling efforts. Analytical results were supplied to Kentucky regulators and the violations resulted in the October 2003 Agreed Order signed by DOE and the Commonwealth of Kentucky.

UNDERGROUND STORAGE TANKS

In April 2002, a previously unknown underground storage tank was discovered during refurbishment of cylinder storage yard C-745-K. Kentucky regulators were notified of the discovery. The UST was removed and clean-closure for the site was obtained. The DOE is responsible for 16 of the 18 underground storage tanks that have been reported to Kentucky regulators, as required. The USEC is responsible for the other two underground storage tanks. Of DOE's 16 underground storage tanks, none are currently in use.

NATIONAL ENVIRONMENTAL POLICY ACT

The DOE completed an Environmental Assessment Addendum for Disposition of Additional Waste to the original Waste Disposition Environmental Assessment at the Paducah Site. The addendum was prepared primarily for wastes from DOE material storage areas. A finding of "No Significant Impacts" relative to the additional wastes was issued by DOE on December 11, 2003.

Additionally, as required in the National Environmental Policy Act, DOE is preparing an Environmental Impact Statement for "Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility." The facility would convert the stored inventory of depleted uranium hexafluoride into a more stable uranium oxide for reuse or disposal. The DOE plans to complete the Environmental Impact Statement in 2004. In addition, minor activities were performed in 2003 that were previously approved for routine maintenance, small-scale facility modifications, and site characterization.

CLEAN AIR ACT COMPLIANCE STATUS

The Paducah Site had three air emission point sources in 2003. The Northwest Plume Groundwater System and the Northeast Plume Containment System are interim remedial actions under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), addressing the containment of groundwater contamination. These separate facilities remove TCE contamination from the groundwater by air stripping. At the Northwest Plume Groundwater System, the TCE-laden groundwater passes through an air stripper to remove the TCE. The off-gas from the air stripper then passes through an activated carbon system to remove the TCE prior to atmosphere discharge. The Northeast Plume Containment System extracts TCE-contaminated groundwater and pumps it to a cooling tower system that acts as an air stripper and removes TCE from the groundwater.

The third project that had a point-source was the subsurface heating treatability study that removed TCE from the groundwater and soil near the C-400 building. The TCE was vaporized underground and extracted using a vacuum. The TCE vapor passed through activated carbon where the TCE was adsorbed on the carbon.

Kentucky and EPA Region 4 regulate airborne radionuclide emissions from DOE facilities under 40 Code of Federal Regulations 61 Subpart H, the National Emission Standards for Hazardous Air Pollutants regulations. Potential radionuclide sources at the Paducah Site in 2003 resulted from scrap metal handling, the Northwest Plume Groundwater System, the North-South Diversion Ditch removal project, the C-752-A waste treatment project, and fugitive-source emissions. The fugitive-source emissions include piles of contaminated scrap metal, roads, and building roofs. The DOE utilized ambient air-monitoring data collected by the Radiation/Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services. This was done to verify insignificant levels of radionuclides in off-site ambient air. Ambient-air data were collected at 11 sites surrounding the plant.

KENTUCKY POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMITS

The DOE received a notice of violation dated March 17, 2003, from the Enforcement Branch of the Kentucky Division of Water. Specifically, Paducah Outfall 001 exceeded the permit limit for toxicity in samples collected in October, November, and December 2002. A Toxicity Reduction Evaluation Plan was prepared and submitted to the Division of Water on March 21, 2003, for review and approval. The plan was approved April 14, 2003, and immediately implemented. The plan has included monthly collecting toxicity samples at Outfall 001 and submitting quarterly update reports to the Division of Water. Additional failures for toxicity occurred at Outfall 001 in January, June, August, September, and December 2003. No direct impacts on the receiving stream (Bayou Creek) have been noted. Efforts to identify the cause of the toxicity were ongoing at the end of 2003.

Outfall 017 failed for toxicity in the first quarter of calendar year 2003. A follow-up test was performed and passed. The first-quarter failure was investigated, but no cause was determined. Subsequent quarterly toxicity results for the remainder of 2003 passed. No further steps were required by the permit.

Waste Removal

The primary objective of waste operations is to ensure that wastes do not migrate into the environment. Requirements for meeting waste management regulatory objectives are varied and complex because of the variety of waste streams generated by DOE activities. The goal, however, is to comply with current regulations while planning cleanup actions that will also comply with future regulations. The DOE off-site waste shipments in 2003, totaling 1781.2 metric tons, are summarized in the following table.

Waste shipments during 2003

- January – Shipped 5 metric tons of ash receivers to Nevada Test Site
- January – Shipped 206 metric tons aluminum ingots to Nevada Test Site
- February – Shipped 78 metric tons of remediation waste to Envirocare, Utah
- March – Shipped 275 metric tons of aluminum ingots to Nevada Test Site
- April – Shipped 413 metric tons of aluminum ingots to Nevada Test Site
- May – Shipped 71 metric tons of aluminum ingots to Nevada Test Site
- May – Shipped 6 metric tons of waste to Envirocare, Utah
- August – Shipped 0.2 metric tons of waste to Chem Waste Management
- September – Shipped 692 metric tons of aluminum ingots to Nevada Test Site
- September –Shipped 6 metric tons of treated ash receiver waste to Envirocare, Utah
- November – Shipped 10 metric tons of polychlorinated biphenyls mixed waste to the Toxic Substances Control Act Incinerator in Oak Ridge, Tennessee
- December – Shipped 11 metric tons of polychlorinated biphenyls mixed waste to the Toxic Substances Control Act Incinerator in Oak Ridge, Tennessee
- December – Shipped 8 metric tons of waste to Perma-Fix

WASTE MINIMIZATION/POLLUTION PREVENTION

Waste Minimization and Pollution Prevention are efforts employed at PGDP to reduce the amount of waste generated and eliminate pollution from DOE-funded activities. Waste Minimization and Pollution Prevention efforts are primarily implemented through recycling and reuse of materials and waste reduction techniques. Recycling efforts in 2003 are summarized in following table.

Recycling efforts in 2003

- 11.8 metric tons of office paper
- 0.52 metric tons of aluminum cans
- 0.66 metric tons of telephone books
- 0.39 metric tons of printer and fax toner cartridges
- 6.5 metric tons of carbon used in the Northwest Plume Groundwater Treatment Facility
- spent motor oil
- used electrical equipment
- reuse of gravel generated from reconstruction of cylinder storage yards

Additional accomplishments of the Waste Minimization/Pollution Prevention Program included continued use of micropurging techniques in groundwater sampling to reduce wastewater volume and the transfer of unused chemicals and materials to other programs for re-use. The recycling of rechargeable batteries and fluorescent light bulbs continues to reduce the volume of hazardous wastes generated at the site. DOE has also converted to fluorescent bulbs that are not hazardous.

Decontamination and Decommissioning

Decontamination and Decommissioning is conducted on facilities and other structures contaminated with radiological and hazardous material when they are no longer required to fulfill a site mission. Legacy contamination on the floors, walls, and ceiling of a structure and on equipment constitutes a potential for release to the environment if not appropriately managed. Two major facilities comprising approximately 46,450 m^2 (500,000 ft^2) have been categorized for decontamination and decommissioning at PGDP. These facilities are the C-340 Metal Reduction Plant complex, where uranium hexafluoride was converted to uranium metal and hydrogen fluoride; and the C-410 Feed Plant complex, where uranium trioxide was converted to uranium tetrafluoride. Contaminants at these facilities include depleted uranium, natural uranium and transuranic radionuclides, uranium tetrafluoride, polychlorinated biphenyls, asbestos, and lead paint. Fifteen less significant inactive facilities are included in the decontamination and decommissioning program at Paducah.

CERCLA regulatory documentation regarding the C-410 complex infrastructure has been completed and classified, as a non-time-critical removal action. Additional documentation will be required for the C-410 building demolition and for the C-340 complex. Actual decontamination and decommissioning of the C-410 complex has been initiated.

Decontamination and Decommissioning accomplishments in 2003 at the C-410 complex included the following:

- Completed sorting and repackaging over 100 boxes of compactable wastes for off-site disposal.
- Completed isolation of steam, air, nitrogen, and steam condensate lines.
- Completed removal of support facilities around hydrofluoric acid tanks to prepare for disposition (see photo).
- Completed removal of potentially fissile material in the C-410 complex.

C-410 Tank Farm decontamination and decommissioning included removal of piping, structures, and tanks

Additional Waste Removal

DOE MATERIAL STORAGE AREAS

DOE Material Storage Areas are material and equipment storage areas at PGDP that are undergoing a characterization process to comply with potential nuclear criticality safety, regulatory, and solid waste requirements. Originally included with the PGDP facilities leased to USEC, DOE accepted the return of the areas from USEC on December 31, 1996, to facilitate Nuclear Regulatory Commission certification of PGDP. The 160 areas are now non-leased areas located inside buildings leased to USEC or in designated outside areas.

The Kentucky Natural Resources and Environmental Protection Cabinet filed an administrative complaint in October 2001, alleging violations of Kentucky's delegated hazardous waste management program regulations. Most of these violations alleged the failure to characterize materials in DOE Material Storage Areas at PGDP, or the unpermitted storage of hazardous waste. In October 2003, an Agreed Order between DOE and the Commonwealth of Kentucky that resolved the violationswas signed. The Agreed Order established regulatory deadlines for characterization and removal of material storage areas and also established RCRA closure requirements for hazardous waste. As a result of the Agreed Order implementation, as of the end of 2003, characterization reports were completed on 38 of the areas, field characterization was completed on 49 of the areas, and field characterization was underway on 27 of the areas. Material storage areas located outside or those that may contain hazardous waste are given priority. The characterization reports completed as of the end of 2003 determined that less than one-tenth of one percent by volume of the material and equipment characterized could be classified as hazardous waste. DOE notifies the Commonwealth of Kentucky when hazardous waste is identified.

TOXIC SUBSTANCES CONTROL ACT

The Uranium Enrichment Toxic Substances Control Act Federal Facility Compliance Agreement between EPA and DOE was signed February 1992. To meet the compliance goals at the Paducah Site, the agreement is frequently revised and updated. Under this agreement, action plans have been developed and implemented for removal and disposal of polychlorinated biphenyl material at the Paducah Site. All Paducah Site Uranium Enrichment Toxic Substances Control Act Federal Facility Compliance Agreement milestones for 2003 were completed.

Environmental Restoration

Environmental restoration includes the activities and tasks required by state and federal regulations that must be implemented to clean up the Paducah site. The levels to which the site needs to be cleaned must be mutually agreed upon by DOE and the regulatory agencies.

The National Contingency Plan states that owners of large, complex sites with multiple source areas, such as federal facilities, may choose to divide their sites into smaller areas for characterization and implementing response actions, as opposed to conducting a single site-wide comprehensive action. These discrete actions, referred to as operable units, may address a geographic portion of the site, specific site problems, or include a series of interim actions followed by final actions. The PGDP site cleanup strategy adopts this approach and includes a series of prioritized actions, ongoing site characterization activities, to support future response action decisions, and decontamination and decommissioning of the currently operating PGDP. Once the plant ceases operation, a Comprehensive Sitewide Operable Unit evaluation will be conducted. The operable units were established by developing a site-conceptual risk model for each source area (Solid Waste Management Unit/Area of Concern). This process included a qualitative evaluation of contaminant types and concentration, release mechanisms, exposure pathways, points of exposure, and receptors based on current and reasonably foreseeable land use.

Sources and areas of contamination suspected as primary risk contributors to off-site residents from groundwater were grouped under the Groundwater operable unit. Similarly, the Surface Water operable unit contains sources and areas of contamination posing the greatest risks to recreational users. The Soils, Decontamination and Decommissioning, and Burial Grounds operable units contain sources posing the greatest risks to on-site industrial workers. The objective of grouping the sources and areas of contamination into media-specific operable units is to provide a complete approach to assess site-wide risks, identify and prioritize response actions, and develop integrated cleanup solutions that will reduce risk.

The DOE uses a combination of factors to prioritize work being implemented under the Environmental Management program at PGDP. These include risk-based criteria, compliance with other programs, technical considerations associated with PGDP operations, mortgage reduction, and demonstrated progress toward completing the environmental management mission. The risk-prioritization criteria (see table) incorporate the general program-management principles of the National Contingency Plan, which emphasizes the use of accelerated actions to address imminent threats and reduce migration of off-site contamination.

Risk Prioritization Criteria.

- **Mitigate immediate threats, both on- and off-site.**
- **Reduce further migration of off-site contamination.**
- **Address sources contributing to off-site contamination.**
- **Address remaining sources contributing to on-site contamination.**
- **Perform decontamination and decommissioning of non-operating gaseous diffusion plant**
- **Evaluate the final Comprehensive Sitewide Operable Unit.**

2003 REMEDIAL ACTIVITIES

Accomplishments

- Completed the six-phase heating treatability study adjacent to the C-400 Cleaning Building.
- Continued operation of the Northwest and Northeast Plume Groundwater treatment systems.
- Completed additional seismic investigation fieldwork for the potential on-site disposal cell.
- Installed a sediment controls basin and excavated Section 2 of the North-South Diversion Ditch.
- Continued characterization, removal, and disposal of scrap metal, including removal of all aluminum ingots.

Aluminum ingots ready for shipment

Six phase heating treatability study

Scrap metal removal project

Uranium Programs

The mission of the Uranium Programs is to maintain safe, compliant storage of the DOE depleted uranium hexafluoride inventory, pending final disposal of the material, and manage facilities and grounds not leased to USEC. The mission is also to design, construct, and operate a facility to convert depleted uranium hexafluoride to uranium oxide and aqueous hydrogen fluoride. The management activities associated with depleted uranium hexafluoride cylinders are described as follows.

DEPLETED URANIUM HEXAFLOURIDE CYLINDER MANAGEMENT

Depleted uranium hexaflouride is a product of the uranium enrichment process. A solid, at ambient temperatures, depleted uranium hexaflouride is stored in large metal cylinders. At the end of 2003, the Paducah Site managed an inventory of approximately 38,000 cylinders containing approximately 454,000 metric tons of uranium hexaflouride (most containing depleted uranium hexaflouride) stored in outdoor facilities, commonly referred to as cylinder storage yards. Additional cylinders are added to the DOE inventory annually as a result of formal agreements with USEC.

Depleted uranium hexaflouride is stored as a crystalline solid at less than atmospheric pressure. When depleted uranium hexaflouride is exposed to the atmosphere, hydrogen fluoride and uranium-reaction products form. The hazard potential of depleted uranium hexaflouride is primarily chemical toxicity from any released hydrogen fluoride, rather than a radiological hazard.

The DOE has an active Cylinder Management program that includes cylinder and cylinder-yard maintenance, routine inspections, cylinder-yard construction and improvement, and other programmatic activities, such as cylinder corrosion studies. A cylinder inventory database is maintained, which serves as a systematic repository for all cylinder inspection data.

On April 15, 1999, DOE issued the *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, in response to the Defense Nuclear Facilities Safety Board's request to analyze alternative chemical forms for the storage of depleted uranium hexaflouride. As a result of this study, in 2002, DOE selected Uranium Disposition Services, LLC, to design, build, and operate facilities at Paducah, Kentucky and Portsmouth, Ohio. These facilities will convert the inventory of depleted uranium hexaflouride to triuranium octoxide, a more stable form of uranium that is suitable for disposal or reuse. Preliminary design activities were initiated in 2003. Public Law 107-206 requires groundbreaking by July 31, 2004. The DOE also entered into an Agreed Order in October 2003 with the Commonwealth of Kentucky that included a Cylinder Management Plan for continued activities associated with cylinder management at Paducah.

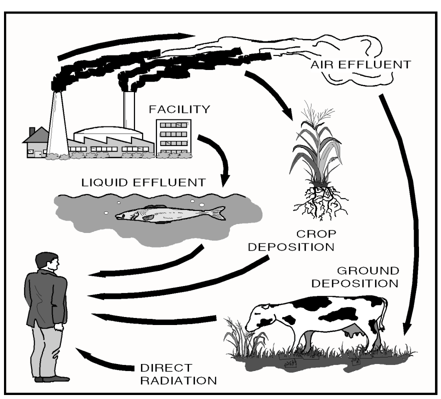
The Paducah DOE cylinder storage yards are categorized as a DOE Nonreactor Nuclear Category 2 facility. On December 18, 2003, a required safety analysis was submitted to DOE for approval. The safety analysis addressed hazards (radiological and nonradiological) and the controls necessary to provide adequate protection to the public, workers, and environment.

Radiation - What Is It?

It comes from outer space, the ground, the food we eat, and even from within our own bodies. Radiation is all around us and has been present since the birth of this planet. Naturally occurring radioactive materials were discovered in 1896. Less than 50 years later, physicist Enrico Fermi split the atom, producing the first sustainable nuclear chain reaction. Today, both man-made and natural radiation are part of our lives. We use radioactive materials for beneficial purposes, such as generating electricity and diagnosing and treating medical problems. For example, more than 200 million X-rays are performed in America every year. Over 80 percent of our exposure to radiation comes from natural sources. Our own bodies, which contain the radioactive element potassium, account for 11 percent of our total exposure. Consumer products make up another three percent of our exposure to radiation. The average annual radiation exposure for a person living in the United States is 360 millirem.

Though radiation offers many benefits, exposure to it can also threaten our health and the quality of our environment. We cannot eliminate radiation from our environment. We can, however, reduce our risks by controlling our exposure to it. Radiation can cause cancer if the exposure is great enough. In this respect, it is similar to many hazardous chemicals found in the environment that can cause cancer. It may cause other adverse health effects, including genetic defects in the children of exposed parents or mental retardation in the children of mothers exposed during pregnancy. However, the risk of developing cancer due to radiation exposure is much higher than the risk of these other effects. Much of our knowledge about the risks from radiation is based on studies of over 100,000 survivors of the atomic bombs at Hiroshima and Nagasaki, Japan. In these studies that have continued over the last 50 years, scientists have been able to observe the effects of a wide range of radiation doses, including doses comparable to an average person's lifetime dose from naturally occurring background radiation (about 20,000 millirem). We have learned many things from these studies. The most important are as follows:

- The higher the radiation dose a person receives, the greater the chance of developing cancer.
- It is the chance of cancer occurring, not the kind or severity of cancer, that increases as the radiation dose increases.
- Most cancers do not appear until many years after the radiation dose is received (typically 10 to 40 years).

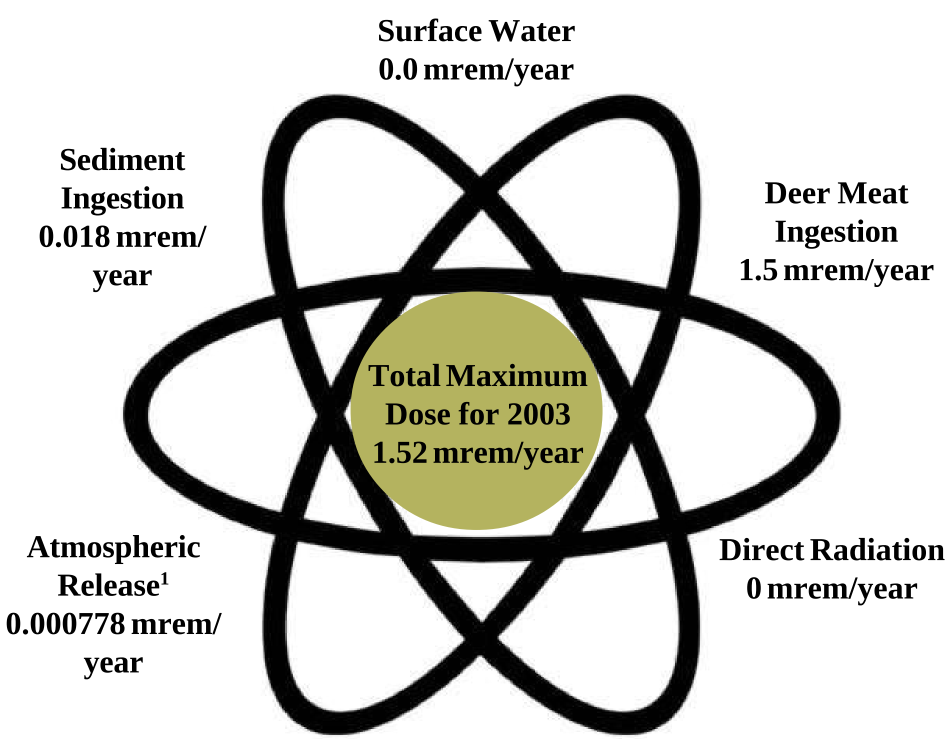


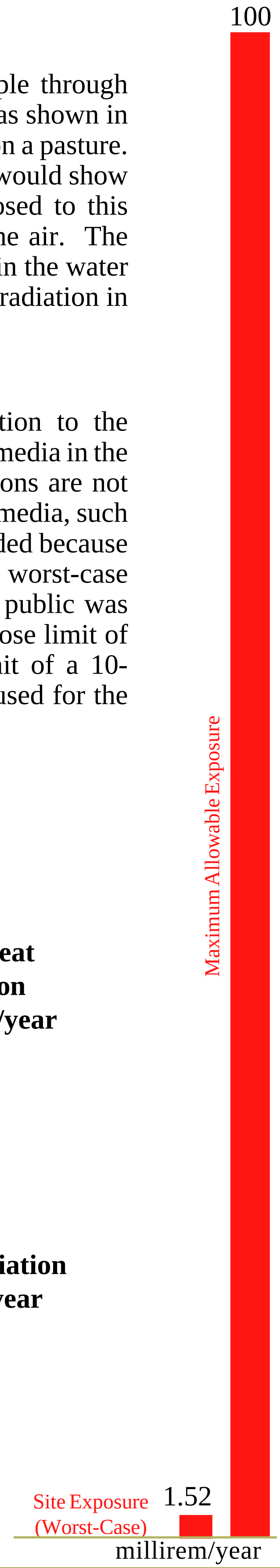
Possible radiation pathways

2003 Paducah Site Radiation Dose

Radiation and radioactive material in the environment can reach people through many routes. Potential routes for radiation are referred to as pathways, as shown in the figure below. For example, radioactive material in the air could fall on a pasture. Cows could then eat the grass, and the radioactive material on the grass would show up in the cow's milk. People drinking the milk would thus be exposed to this radiation. Or, people could simply inhale the radioactive material in the air. The same events could occur with radioactive material in water. Fish living in the water would be exposed. People eating the fish would then be exposed to the radiation in the fish, or people swimming in the water would be exposed.

The figure to the right shows DOE's maximum potential contribution to the radiation dose that a person could receive from being exposed to various media in the environment around the Paducah Site (potential USEC dose contributions are not included) for 2003. The dose is calculated based on 2003 monitoring of media, such as air, surface water, sediment, and deer meat. Groundwater is not included because residents living near the site are not drinking the groundwater. The worst-case combined (internal and external) dose to an individual member of the public was calculated at 1.52 millirem. This level is well below the DOE annual dose limit of 100 millirem/year to members of the public and below the EPA limit of a 10-millirem airborne dose to the public. The dose chart shows all media used for the calculation.





[1]DOE source emissions were from the Northwest Plume, Scrap Metal Removal, C-752-A waste treatment, and North-South Diversion Ditch excavation.

Environmental Monitoring

The DOE performs environmental monitoring at the Paducah Site to comply with applicable laws and regulations, to identify trends, and to raise environmental awareness. Effluent monitoring and environmental surveillance monitoring are two ways environmental monitoring are performed. Effluent monitoring (required by environmental regulations) is performed by collecting and analyzing samples of discharges from the plant into the air and water. Surveillance monitoring (performed by DOE to evaluate its impacts on the environment) is performed by collecting and analyzing samples of environmental media to measure the concentration of contaminants. The information obtained from effluent discharge monitoring is used to determine the effects on the environment of the DOE facilities operations.

Watershed sampling

WHAT ENVIRONMENTAL MEDIA ARE SAMPLED?

Routine sampling is performed on several different media, including air, groundwater, sediment, surface water, fish, and deer. When a need for non-routine sampling is identified, other types of samples may be collected under special one-time studies. In 2003, approximately 1100 samples were collected. The different media are discussed in the text on the following pages, providing some detail of what is sampled, the results of sampling during 2003, and the relative effect on the radiation dose calculation. In most cases, contaminants that are specific to the plant site are discussed in detail, such as uranium, technetium-99, TCE, and polychlorinated biphenyls.

Air and Direct Radiation Monitoring

AIR AND RADIOLOGICAL MONITORING RESULTS

The DOE monitors specific sources of contamination, such as systems emitting radionuclides. The Radiation/Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services, through a grant funded by DOE, monitors ambient air for radionuclides. Thermoluminescent dosimeters (radiation measuring devices) are used to monitor the dose that may be received from radioactivity at, or near, the plant site.

The DOE had four sources of airborne radionuclides in 2003. These sources were the Northwest Plume Groundwater System, the Scrap Metal Removal Project, the C-752-A waste treatment project, and the North-South Diversion Ditch Excavation. The amount of radionuclides emitted were calculated or determined based on sampling data and emission factors. Based on the radionuclide results, the radiation dose from these projects to the maximally exposed individual through emissions to the air was calculated to be ***approximately 0.000778 millirem/year in 2003***. The DOE sources of air discharges for contaminants other than radionuclides were the Northwest Plume Groundwater System and the Northeast Plume Groundwater System. Combined, these systems removed 1288 pounds (0.64 tons) of TCE from the groundwater through the use of air-stripping processes.

The DOE utilized ambient-air-monitoring data to verify insignificant levels of radionuclides in off-site ambient air. Ambient-air data were collected at ten sites surrounding the plant in order to measure radionuclides emitted from Paducah Site sources, including fugitive emissions. Results indicated that radionuclides emitted in the air emissions were at, or below, background at the sampling locations. The radiation dose to the maximally exposed individual member of the public (the neighbor living closest to the PGDP security fence) from the DOE operations did not vary statistically from background and was essentially zero.

On a quarterly basis, environmental thermoluminescent dosimeters were placed at 46 locations in and around PGDP or at background locations. Monitoring results indicate that nine locations were consistently above background levels. These nine locations were all at or near the PGDP security fence in the vicinity of uranium hexaflouride cylinder storage yards. For purposes of this ASER Summary, an additional potential receptor was considered. In a very conservative exposure scenario, this receptor is assumed to be exposed to the closest location that would be accessible to the public in 2003. This location is near Harmony Cemetery, located north of the plant security fence and south of Ogden Landing Road. This location resulted in external radiation exposures below background. This means that the dose was effectively zero.

Surface Water and Sediment Monitoring

NONRADIOLOGICAL PARAMETERS IN SURFACE WATER

None of the detected nonradiological analytes in samples collected as part of the required permit sampling at the four DOE outfalls were in excess in of permit limits. Six exceedences of permit limits for toxicity were reported in 2003 for DOE Outfall 001.

Similar to 2002, the only results of significance compared to background data at surface water locations in Bayou Creek and Little Bayou Creek were TCE results identified downstream of Little Bayou Creek at an average concentration of 36.25 µg/L. The highest maximum average concentration of TCE for the seep sampling locations at Little Bayou Creek was at 232.5 µg/L.

There were no detections of polychlorinated biphenyls in surface water in 2003. This is a decrease in polychlorinated biphenyl concentrations from 2002, which had polychlorinated biphenyls detected at low levels near the plant site on both Bayou Creek and Little Bayou Creek. Additionally, there were no detections of polychlorinated biphenyls in surface water in 2001.

NONRADIOLOGICAL PARAMETERS IN SEDIMENT

Aluminum, barium, calcium, chromium, cobalt, iron, magnesium, manganese, potassium, and vanadium were detected at sediment sampling locations in Bayou Creek and Little Bayou Creek. The highest level of metals was seen at Bayou Creek near the plant site. Consistent with levels seen in 2002, chromium was identified in the North-South Diversion Ditch at 32.25 mg/kg and near the plant site on Little Bayou Creek at 46.4 mg/kg (highest level). Arsenic was found in Bayou Creek and Little Bayou Creek near the plant site. Zinc was found at all locations; however, the highest level was found in the North-South Diversion Ditch.

In 2003, polychlorinated biphenyls were found in the North-South Diversion Ditch, Bayou Creek, and Little Bayou Creek sediments near the plant site, with the highest level seen in Little Bayou Creek.

RADIONUCLIDES IN SURFACE WATER

the PGDP effluents are monitored at DOE outfalls under the Kentucky permit for radionuclides known to be emitted or to have been present at the Paducah Site. Uranium and technetium-99 are compared with the corresponding derived concentration guide and are presented as a percentage. The derived concentration guide is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 millirem. The combined average concentrations at all outfalls were small percentages when compared to the derived concentration guide values.

The average concentration of uranium being discharged to Outfall 015 was slightly above seven percent of the derived concentration guide. The average concentration of uranium being discharged to Outfalls 001, 017, and 019 was less than one percent of the derived concentration guide. Outfall 015 received runoff from the uranium burial ground with small quantities of surface contamination from uranium compounds. Runoff from the burial ground is suspected as being responsible for the elevated uranium concentrations associated with Outfall 015. Technetium-99 averages for 2003 for all four outfalls were well below 0.1 percent of the derived concentration guide. Data for 2003 do not indicate a significant change in relation to derived concentration guide levels for any radionuclide compared to data for the past five years.

Uranium concentrations for 2003 appear to be similar to those concentrations seen in 2002 and are lower than those seen in 1999 and 2001. Technetium-99 concentrations for Outfalls 001 and 019 are lower than those seen in 2002. However, concentrations in Outfall 015 for 2003 were higher, and slightly higher in Outfall 017.

Radiological parameters at surface water locations sampled upstream and downstream of PGDP effluents in Bayou Creek; downstream of effluents in Little Bayou Creek and at the C-746-K Landfill; and upstream and downstream in the Ohio River and at the confluence of the Mississippi River and at the background stream, Massac Creek, were not found in significant concentrations at any sampled location in 2003 when compared to the derived concentration guides. Concentrations of technetium-99 were elevated in downstream creek locations with the highest concentrations found downstream of plant effluents in Little Bayou Creek. However, these concentrations are well below the plant release criteria for technetium-99 of 900 pCi/L. The level of radiological parameters seen at the C-746-K Landfill was similar to those found upstream of and near the plant site in Bayou Creek. The highest levels of thorium-234 were found upstream in the Ohio River, which is unaffected by plant operations. Again, concentrations of radionuclides in effluents at the Paducah Site were far below derived concentration guides and do not pose a health risk.

The average concentrations of radiological parameters at the Little Bayou Creek seep locations are shown in the following table. Results indicate higher levels of technetium-99 were measured at LBCSP5 than at other surface water locations on Little Bayou Creek; however, these concentrations are well below the plant release criteria of 900 pCi/L and below the derived concentration guide.

Average radiological concentrations for seep locations in Little Bayou Creek

Parameter	LBCSP1	LBCSP2	LBCSP3	LBCSP4	LBCSP5	LBCSP6
Alpha activity (pCi/L)	1.6	2.2	2	2.4	2.2	**3.1**
Beta activity (pCi/L)	7.9	15	25	23	**150**	150
Technetium-99 (pCi/L)	10	15	28	23	**180**	160

[**Bold**] values indicate the highest radionuclide concentrations for the parameter specified.

Surface-water-pathway dose was calculated for an individual assumed to consume water from the public drinking water supply at Cairo, Illinois. Cairo is the closest drinking water system that uses water downstream where PGDP discharges water into the Ohio River. In 2003, there were no radionuclides detected at the Cairo, Illinois, location. ***The net exposure to the maximally exposed receptor from the Paducah Site based on theoretical assumptions was 0.0 millirem.***

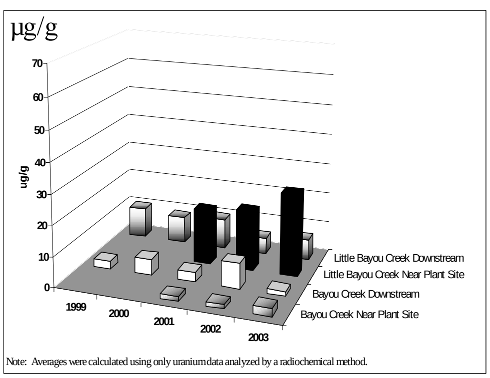
Surface Water and Sediment Monitoring (Cont.)

RADIONUCLIDES IN SEDIMENT

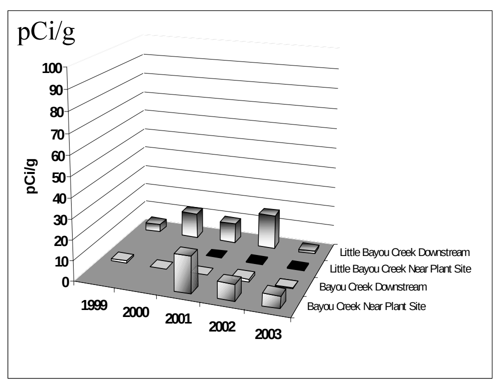
The highest concentrations of radiological parameters at sediment locations sampled in the North-South Diversion Ditch, Bayou Creek, Little Bayou Creek, and at the Massac Creek background stream, were found in the North-South Diversion Ditch. Remediation activities are underway at the North-South Diversion Ditch due to the potential risk, and access to this area is limited. ***The estimated worst-case dose above background from sediment ingestion at this location was 0.018 millirem.***

Uranium activity is elevated in Bayou Creek and Little Bayou Creek near the plant site and downstream. The levels are similar to those seen in 2001 and 2002. Technetium-99 levels are elevated on Bayou Creek near the plant site, and also downstream on Little Bayou Creek.

The figure below shows uranium concentrations in sediment over the past five years. A small increase was seen in the uranium concentrations in sediment in Bayou Creek at the plant site and Little Bayou Creek downstream of the plant, with a large increase in Little Bayou Creek near the plant site. Locations sampled near the plant site on both Bayou and Little Bayou creeks indicate higher amounts of uranium. The figure below shows a decrease in technetium-99 concentrations in sediment in 2003 as compared to previous years. Other radionuclides, although present, are not significantly above background values.



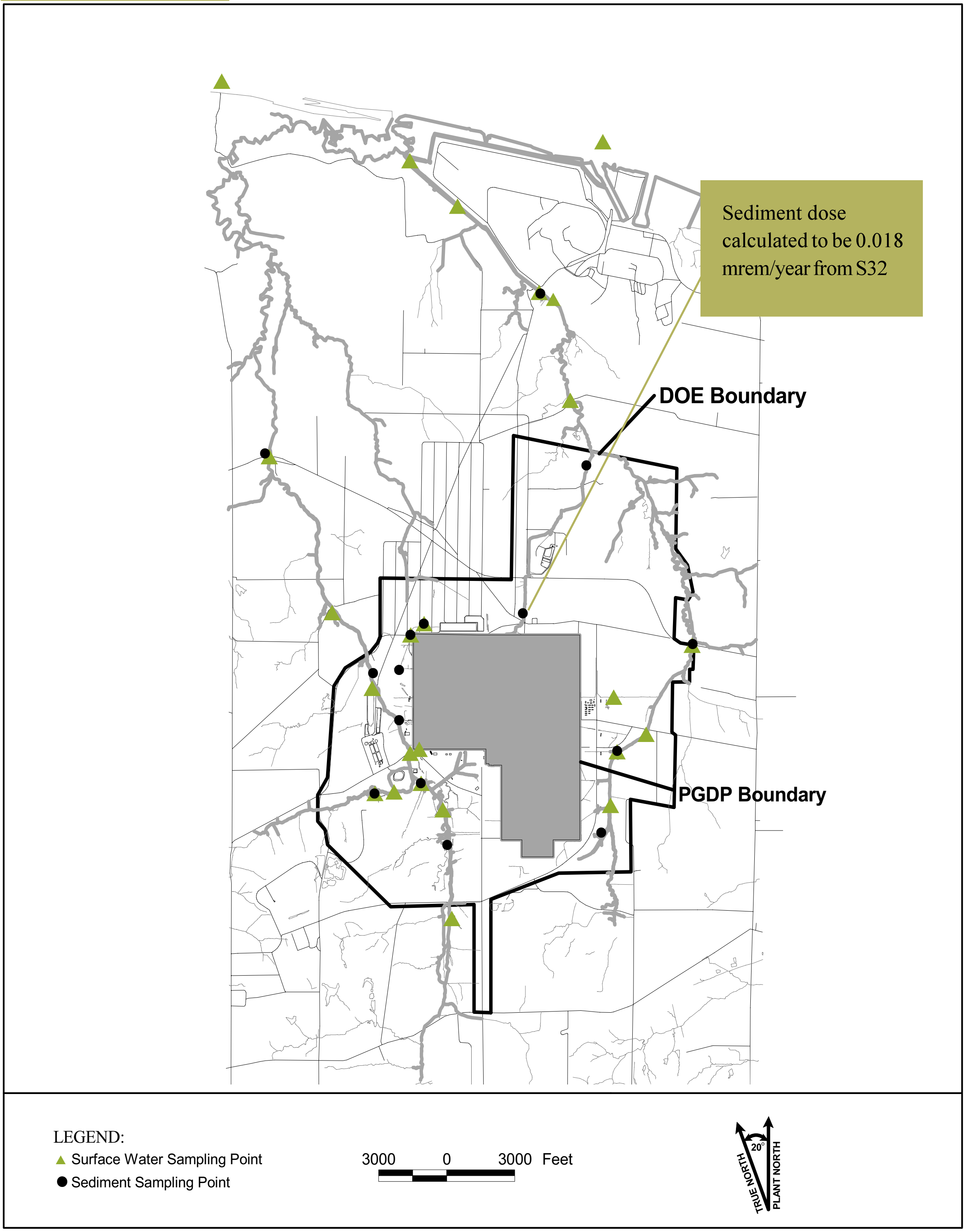
Five-year uranium concentration in sediment



Five-year technetium-99 activity in sediment

Surface Water and Sediment Monitoring

Surface Water dose calculated to be 0.0 mrem/year from L306 located at Cairo, Illinois.



Biological Monitoring

DEER SAMPLING

In 2003, a total of five deer were harvested around the plant as part of DOE's ongoing effort to monitor the effects of the Paducah Site on the ecology of the surrounding area. No reference deer were collected in 2003; therefore, 2002 data were used for comparison. Liver, muscle, and bone samples were analyzed for several radionuclides [cesium-137, neptunium-237, plutonium-239, technetium-99, thorium-230, uranium-234, uranium-235, uranium-238, and strontium-90 (bone samples only)]. In addition, thyroid samples were analyzed for technetium-99. Because the liver and muscle tissue are considered consumable by humans, these tissues can be evaluated for radiological risks (dose). Bone and thyroid samples are used only as indicators of contamination.

The following table lists the radionuclides detected in deer tissue for 2003. In deer muscle, which is normally considered consumable by humans, concentrations of thorium-230 were detected at low levels in deer. In deer bone, thorium-230 was found at or above detectable levels in deer from this area. In deer liver, technetium-99, thorium-230, and uranium-235 were detected in deer from this area. No technetium-99, thorium-230, and uranium-235 were detected in background deer. Dose assessments indicate that deer are acceptable for consumption, and levels are consistent with previous years' data.

The thyroid and bone are not considered edible portions of deer, but are analyzed for the presence of target radionuclides. Specifically, strontium-90 accumulates in the bone and technetium-99 accumulates to some lesser degree in the thyroid. In 2003, all results were non-detect for strontium-90 in the bone and technetium-99 in the thyroid for the deer harvested, and for background deer from Stewart Island taken in 2002. Stewart Island in Livingston County is well away from PGDP and provides a good background reference sample.

As a worst-case scenario for site dose contribution, it is assumed that a person harvests and eats the two deer with the two highest dose estimates. The worst-case dose was calculated to be 1.5 millirem above background. This value is used in the worst-case scenario calculations. This is lower than the 4.2 millirem calculated in 2002 and very similar to results from the past five years.

Radiological parameters detected in deer tissue.

RADS (pCi/g)	Parameter[a]	Deer 1	Deer 2	Deer 3	Deer 4	Deer 5	Deer (Background)[b]
	Technetium-99 (Liver)	ND	ND	ND	0.314	ND	ND
	Thorium-230 (Bone)	ND	0.195	0.0618	0.144	0.128	ND
	Thorium-230 (Liver)	ND	0.149	0.153	0.107	ND	ND
	Thorium-230 (Muscle)	0.088	0.140	0.158	ND	0.118	ND
	Uranium-235 (Liver)	ND	ND	ND	0.0177	ND	ND

ND - Non Detect

[a] Other radionuclides were analyzed but not detected in any deer.

[b] Background deer were collected during 2002 from Stewart Island Habitat Restoration in Livingston County, Kentucky.

Polychlorinated biphenyls tend to accumulate in fat tissue. Polychlorinated biphenyl-1268 was present in deer from the Paducah Site, while polychlorinated biphenyl-1260 was detected in the background deer. The following table shows the polychlorinated biphenyl results. All measurable polychlorinated biphenyls were well below the Food and Drug Administration standard of 3 parts per million (mg/kg) for red meat.

A comparison of the metals detected between the 2003 and the 2002 deer shows essentially no change. Arsenic and lead are the only metal, that were not detected in 2003. Beryllium and chromium were found in 2003 and not found in 2002; however, both were present in the 2001 data set. Mercury was identified at low levels in both 2002 and 2003. Most metal results are comparable between the background and site deer. For example, the average cadmium result in kidney from PGDP deer is 1.2 mg/kg and the result in the background deer is 2.14 mg/kg.

Summary of PCB detections in deer for 2003[a]

Parameter	Deer 1	Deer 2	Deer 3	Deer 4	Deer 5	Background Deer [b]
Polychlorinated biphenyl-1260 (µg/kg)	ND	ND	ND	ND	ND	33.7
Polychlorinated biphenyl -1268 (µg/kg)	ND	37.4	39.9	33.6	39.1	ND

[Result] — Detected at the result indicated.
µg/kg — part per billion (ppb)
ND — Non Detect
[a] Other polychlorinated biphenyl aroclors were analyzed but not detected in any deer.
[b] Background deer were collected during 2002 from Stewart Island Habitat Restoration in Livingston County, Kentucky.

WATERSHED MONITORING

Watershed (biological) monitoring was conducted in accordance with Federal and State requirements. Sampling was conducted in June 2003 at eight locations, including locations in Massac Creek and in the West Fork of Massac Creek, both of which serve as background fish sources. The frequency for the bioaccumulation monitoring task has been changed to every two years, and monitoring was not conducted in 2003.

Quantitative samplings of the fish communities in the PGDP area were conducted. Data from these samples were used to estimate species richness, population size (numbers and biomass per unit area), and annual production. All fish community locations overlap locations used in the benthic macroinvertebrate community task. The macroinvertebrate task studies small organisms located in the creek bed. All fish observed in 2003 were found to be in good health. Fish communities examined in 2003 do show some changes in density, biomass, total numbers, and species richness. However, the changes noted are not indicative of contaminant impacts. The changes in the community are more aligned with ecological impacts such as, and primarily, recent high-water events and unstable substrates.

Groundwater Monitoring

Monitoring and protection of groundwater resources at the Paducah Site are required by federal and state regulations and by DOE orders. Federal groundwater regulations generally are enacted and enforced by EPA. When off-site groundwater contamination from the Paducah Site was discovered in 1988, the EPA Region 4 and DOE entered into an Administrative Consent Order. The DOE provided an alternate water supply to affected residents. Under CERCLA, DOE is also required to determine the nature and extent of off-site contamination through sampling of potentially affected wells and a comprehensive site investigation.

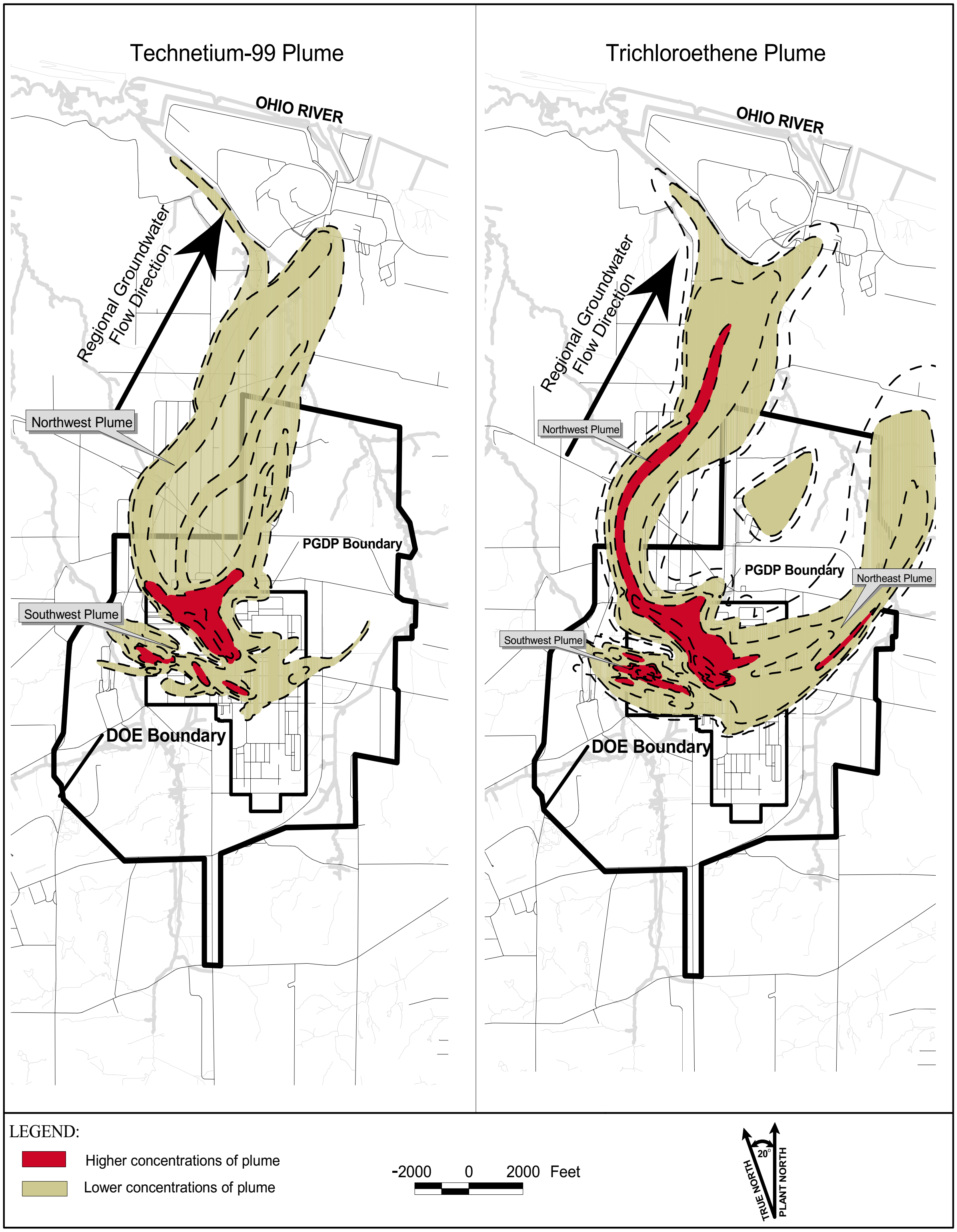
Investigations of the on-site source areas of TCE at the Paducah Site are ongoing. A common degreasing agent, TCE is a dense nonaqueous phase liquid with typically low solubility in water. These types of liquids either sink to the bottom of aquifers or come to rest on a less-permeable layer within an aquifer, forming pools. Dense nonaqueous phase liquid pools form a continuous source for dissolved-phase contamination (plumes) that are migrating offsite toward the Ohio River. Pools of dense nonaqueous phase liquids are extremely difficult to clean up. The Six-Phase Heating Treatability Study was completed in 2003, with the objective to evaluate the performance of the Six-Phase Heating technology to remove TCE from the source area near the C-400 building. The area around the C-400 building is the primary source of TCE contamination in groundwater at the PGDP. In addition, DOE continued two pump-and-treat systems at Paducah to treat TCE contamination. The pump-and-treat system installed northwest of the plant also treats the highest concentrations of dissolved technetium-99 in the groundwater.

In addition to the groundwater activities described in the previous paragraph, groundwater monitoring continued to identify the extent of contamination, predict the possible fate of the contaminants, and determine the movement of groundwater near the plant. Currently, there are three plumes identified. The 2003 plume map (next page) continues the basic interpretation presented in the plume maps for 2002. Revisions for 2003 reflect the following: (1) decreasing TCE trends in monitoring wells along the core of the Northeast Plume and over a large area to the west of the Northeast Plume well field, (2) extension of >25 pCi/L technetium-99 east of PGDP toward the Northeast Plume well field, (3) eastward migration of the Northwest Plume in the area of the north well field, and (4) re-interpretation of the extent of a core of technetium-99 contamination located to the east of the primary core of the Northwest Plume.

In late 2002, DOE initiated a monitoring well rehabilitation program to enhance the effectiveness of the monitoring wells at the Paducah Site. Well rehabilitation activities were completed in 2003 for a total of 89 wells. The rehabilitation process utilized Blended Chemical Heat Treatment as either preventive maintenance or full rehabilitation depending on the severity of biofouling (build up of biological mass) in the well. The treatment method consisted of three phases designed to remove the accumulated biofilm and blocking materials from the well screen, well bore, and surrounding aquifer.

Well rehabilitation project

Paducah Site Groundwater Plumes



Public Involvement and Information

DOE Environmental Information Center. The public has access to Administrative Records and programmatic documents at the DOE Environmental Information Center located at the Barkley Centre, 115 Memorial Drive, Paducah, Kentucky. It is open Monday through Friday from 9 a.m. to 5 p.m. The telephone number is (270) 554-6979. Information on the Environmental Information Center can be found at http://www.bechteljacobs.com/p_eic.shtml.

Citizens Advisory Board. In 2003, the Paducah Citizens Advisory Board had 18 voting members, four ex-officio members, a deputy-designated federal official, and a federal coordinator. In August 2003, seven Board members resigned. Because a minimum of twelve members is required for the board to conduct business, a new member was appointed. The Paducah Citizens Advisory Board consists of individuals with diverse backgrounds and interests. It meets monthly to focus on early citizen participation in environmental cleanup priorities and related issues at the DOE facility. The Paducah board participates only in activities that are governed by DOE. Information on the board can be found at http://www.oro.doe.gov/pgdpssab. The office phone number is (270) 554-3004.

ADDITIONAL INFORMATION

Additional information concerning DOE activities at PGDP can be found on the Internet at:

Website	Link To
http://www.oro.doe.gov/Paducah	DOE Paducah
http://www.energy.gov	DOE
http://www.bechteljacobs.com	Bechtel Jacobs Company
http://www.epa.gov/region4/	EPA Region 4
http://publichealth.state.ky.us	Kentucky Radiation Health and Toxic Agents Control Branch
http://www.waste.ky.gov/	Kentucky Department for Environmental Protection, Waste Management Branch
http://www.kdfwr.state.ky.us	Kentucky Department of Fish Wildlife Resources

ADDITIONAL READING

These documents are available at the DOE Environmental Information Center:

Ionizing Radiation Exposure of the Population of the United States, NCRP Report No. 93, National Council on Radiation Protection and Measurements, Washington, DC.

Paducah Site Annual Site Environmental Report for Calendar Year 2003, DOE/OR/07-2169/V1 and VII, Department of Energy, Lexington, KY.

Paducah Site Environmental Monitoring Plan, BJC/PAD-285/R1, Bechtel Jacobs Company LLC, Paducah, KY.

Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2003 at the Paducah Gaseous Diffusion Plant, Paducah Kentucky, BJC/PAD-169/R4, Bechtel Jacobs Company LLC, Paducah, KY.