2013 Paducah Site

Annual Site Environmental Report: Student Summary

U.S. DEPARTMENT OF ENERGY PADUCAH GASEOUS DIFFUSION PLANT

2013 Annual Site Environmental Report (ASER): Student Summary

June 2016

Marshall County High School Ecology and Independent Study Students

Prepared by

Kentucky Research Consortium for Energy and Environment

for

United States Department of Energy Portsmouth/Paducah Project Office

Acknowledgment: This material is based upon work supported by the Department of Energy under Award Numbers DE-FG05-03OR23032 and DE-EM0004146

ACRONYMS

ACO	Administrative Consent Order
AO	Agreed Order
ASER	Annual Site Environmental Report
CAA	Clean Air Act
CAB	Paducah Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
CY	calendar year
D&D	decontamination and decommissioning
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
DUF6	depleted uranium hexaflouride
EA	environmental assessment
ED	effective dose
EDD	electronic data deliverable
EDE	effective dose equivalent
EIC	Environmental Information Center
EIS	environmental impact statement
EM	environmental management
EMP	Environmental Monitoring Plan
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERPP	Environmental Radiation Protection Program
FFA	Federal Facility Agreement
FFC Act	Federal Facilities Compliance Act
FFCA	Federal Facility Compliance Agreement
FR	Federal Register
FY	fiscal year
GHG	greenhouse gas
HAP	hazardous air pollutant
HPSB	high performance and sustainable buildings
KDEP	Kentucky Department for Environmental Protection
KDOW	Kentucky Division of Water
KDWM	Kentucky Division of Waste Management
KPDES	Kentucky Pollutant Discharge Elimination System
LATA Kentucky	Los Alamos Technical Associates Environmental Services of Kentucky
MCL	maximum contaminant level
MEI	maximally exposed individual
MW	monitoring well
NPL	National Priorities List
OREIS	Oak Ridge Environmental Information System
PEMS	Project Environmental Measurements System

PGDP	Paducah Gaseous Diffusion Plant
PPPO	U.S. DOE Portsmouth/Paducah Project Office
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
SOW	statement of work
SWMU	solid waste management unit
TLD	thermoluminescent dosimeter
UCRS	Upper Continental Recharge System
USEC	United States Enrichment Corporation
WKWMA	West Kentucky Wildlife Management Area

MESSAGE FROM THE DEPARTMENT OF ENERGY

The U.S. Department of Energy (DOE) was in period of great transition during 2013 with the shutdown of enrichment operations at the Paducah Gaseous Diffusion Plant (PGDP). With the shutdown of enrichment operations a new era began at the PGDP which includes the continued dismantling of the industrial facilities, planning for future dismantling of infrastructure and continued environmental management and monitoring. DOE continued to conduct comprehensive environmental monitoring at the PGDP site and nearby areas to ensure protection of human health and the environment. Environmental data collected during 2013 is summarized in an Annual Site Environmental Report. During the 2015-16 school year, Marshall County (Kentucky) High School Advanced Placement students participated in classroom and field activities related to the *PGDP 2013 Annual Site Environmental Report (ASER)*. The students compiled the results of their participation and understanding of information in the document *U.S. DEPARTMENT OF ENERGY PADUCAH GASEOUS PLANT 2013 ANNUAL SITE ENVIRONMENTAL REPORT (ASER): Student Summary*.

Environmental work at DOE's facilities is technically complex and challenging. The scale of the PGDP operations and historical impacts on the environment pose many technical challenges to DOE in its environmental management and cleanup. The Annual Student Summary Report remains important to DOE as a tool to explain to the public the comprehensive PGDP environmental monitoring and remediation programs. PGDP environmental data collected from soil, surface water, sediment, air, and groundwater during 2013 indicate that the site remains in compliance with regulatory and human health standards and is actively continuing and expanding the remediation of potential environmental contamination.

The PGDP site appreciates the work of the students and staff at Marshall County High School in the production of the 2013 Annual Site Environmental Report Student: *Student Summary* document. On behalf of the entire Department of Energy, we congratulate each of you for your effort, enthusiasm, and willingness to support DOE with this project. We hope that you enjoy reading the *PGDP 2013 Annual Site Environmental Report: Student Summary.*

Production Team:

Dr. Darrell Tualbee, UK Center for Applied Energy Research

Thomas Pinkerton, UK Center for Applied Energy Research

Alice Marksberry, UK Center for Applied Energy Research

Special Thanks to:

Tina Marshall, Marshall County High School Science Teacher

Dr. Steve Price, UK Dept. of Agriculture Assistant Professor

Dr. Richard Halbrook, SIU emeritus, Ecological Sciences

Tim Kreher, West Kentucky Wildlife Management Area Manager

Contents

Table of Figures

Table of Tables

EXECUTIVE SUMMARY

The purpose of the Paducah Gaseous Diffusion Plant (PGDP) Annual Site Environmental Report: Student Summary is to highlight significant site program efforts and summarize calendar year (CY) 2013 environmental management activities at the Paducah Site which included effluent monitoring, environmental surveillance, and environmental compliance status. Annually, the U.S. Department of Energy (DOE) implements programs to measure any impacts that its operations have on the environment and the public. Surveillance under these programs includes analyses of surface water, groundwater, sediment, ambient air, and direct radiation

DOE is a cabinet-level Department of the United States Government concerned with the country's policies regarding energy and power including the handling and safety of nuclear material. Research, development and use of nuclear materials has been extensive since World War II and DOE is now responsible for the management and cleanup of historical (legacy) environmental impacts at Paducah and other facilities across the country.

The PGDP located near the Ohio River west of the city of Paducah; the PGDP was one of the was one of the facilities tasked with a key step in the production of nuclear material. The PGDP processed uranium for Cold War weapons and nuclear power use from the early 1950's until 2013. The PGDP utilized heavy industrial processes to concentrate or "enrich" the concentration of the desired uranium-235 (U-235) isotope relative to its content in naturally occurring uranium. Enriched uranium from the PGDP was sent to other government facilities for further enrichment which made it suitable for use in nuclear weapons or reactor fuel.

The processes PGDP utilized to accomplish enrichment required extensive industrial facilities and extensive resources including chemicals, electricity, water and heat. The TVA Shawnee Steam Plant was built to provide enough electricity to power PGDP industrial processes. Several landfills were constructed to accommodate PGDP waste, and the PGDP operated its own water treatment system to provide fire system water, drinking water, and process cooling water.

Industrial operating practices typical of the 1950's, 1960's and early 1970's resulted in releases of chemicals and radionuclides to soil, sediment, surface water and groundwater at the PGDP. The solvent trichloroethylene (TCE) was used extensively to clean process equipment. TCE was spilled and leaked to soil which resulted in groundwater contamination. Two plumes of TCE-contaminated groundwater extend nearly three miles from the fenced industrial area toward the Ohio River. The radionuclide technetium-99 (Tc-99), in a form that is very soluble in water, was also released to groundwater plumes after being introduced to the PGDP in spent nuclear reactor tails sent to the PGDP for re-enrichment.

DOE actively implements and oversees programs that manage and decrease human and environmental risks from historical and current operations including impacts to local natural resources soil and sediment, air, and water. DOE's utilizes an Environmental Management System (EMS) at the PGDP to manage its monitoring, protection and cleanup of the environment. The EMS scores environmental management performance with a grading scale and PGDP received a score of green in 2013, which means that all standards of the EMS were met.

During 2013, 810 tons of waste from 10 different waste streams were emptied into the C-746-U Landfill along with demolition debris from the C-340 facility. During routine sampling, landfill monitoring identified a 15.2 percent increase in radiological contamination from 2012. The increase in radiological contamination did not exceed the standards established by DOE, however, the increase in radiological contamination will be monitored in 2014 to determine if there is a trend.

DOE is still conducting work at the PGDP to help with environmental cleanup. During 2013, 574 gallons of the solvent trichloroethene were extracted from contaminated source areas and the demolition of the C 340 facility was completed. During 2013, the depleted uranium hexafluoride (DUF6) conversion facility converted 8,199 metric tons of DUF6 to a more stable uranium oxide and hydrofluoric acid. The recycled hydrofluoric acid was sold to industry for re-use. Approximately 882,289 pounds of material were also recycled. Groundwater pump and treat containment systems for the largest two groundwater plumes at the site continued operation to contain and remove TCE and Tc-99 from groundwater.

PGDP groundwater programs continue to remediate contamination in off-site plumes through continued operation of groundwater pump and treat systems and remediation of on-site source areas. Sediment sampling results show that sediment contaminant concentrations are downward trending, and ambient air monitoring results indicate that airborne contaminants are not detected or are below permitted limits. The worst-case internal/external dose of radiation from PGDP that could possibly be received by the public was calculated through numerical modeling was 200 times lower than acceptable annual dose limits.

1.0 INTRODUCTION

The purpose of this Annual Site Environmental Report is to summarize CY 2013 environmental management activities at the Paducah Site, including effluent monitoring, environmental surveillance, and environmental compliance and to highlight significant site program efforts. DOE implements programs to measure any impacts that its operations have on the environment or the public and reports on those programs annually. Surveillance under DOE programs includes analyses of surface water, groundwater, sediment, ambient air, and direct radiation.

There are 2 types of environmental monitoring: effluent monitoring and environmental surveillance. Effluent monitoring is collecting and analyzing samples of liquid and gaseous discharges to the environment. Environmental Surveillance is collecting and analyzing samples of surrounding air, surface water, soil, groundwater, and sediment. In order to address and remediate environmental damage, both effluent monitoring and environmental surveillance are needed. Multiple samples are taken and tested for radioactivity, chemical constituents and physical properties.

The main goals of DOE's environmental management at the PGDP are to keep visitors, workers, communities, wildlife and the environment safe from exposure to and impacts from harmful chemicals and radiation related to the site. In July 1993, DOE leased the production areas of the site to the United States Enrichment Corporation (USEC). This report does not include USEC environmental monitoring activities related to the uranium enrichment process they operated during 2013. In 2013 there were three prime contractors performing environmental management work to support DOE: Swift & Staley Team, LATA Environmental Services of Kentucky and B&W Conversion Services.

1.1 SITE LOCATION

The PGDP was an active uranium enrichment plant located in McCracken County, Kentucky which ceased uranium enrichment production in May 2013 during the time period addressed by this report. The PGDP is a 3,556 acre DOE site, 10 miles from Paducah, and 3.5 miles from the Ohio River. Of the 3,556 acres 650 acres of industrial facilities are within a fenced security area ("plant") and 1,986 surrounding acres are licensed to the Commonwealth of Kentucky as part of the West Kentucky

Wildlife Management Area (WKWMA). The WKWMA is popular for deer hunting, waterfowl hunting, hunting-dog training and competition, horseback riding, fishing and general outdoor recreation.

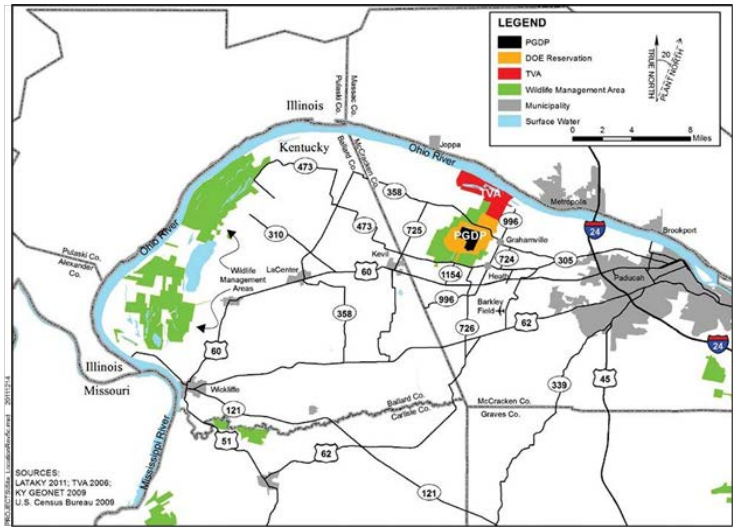

Figure 1.1. Location of the Paducah Site

1.2 GENERAL ENVIRONMENTAL SETTING

1.2.1 CLIMATE

The PGDP is located in a humid continental zone of the United States and averages yearly precipitation of about 49 inches. Winds average about 10 miles per hour and temperatures vary seasonally ranging from below freezing to more than 90 degrees Fahrenheit.

1.2.2 SURFACE WATER DRAINAGE

The PGDP is located approximately 3.5 miles south of the Ohio River in the lower Ohio River Basin. The Cumberland and Tennessee Rivers join the Ohio River approximately 15 miles upstream of the PGDP. The confluence of the Ohio and Mississippi Rivers is about 35 (river) miles downstream of the PGDP.

The PGDP DOE Reservation occupies portions of Bayou Creek and Little Bayou Creek watersheds. Surface water from the East side of the plant flows east-northeast into Little Bayou Creek. Surface water from the West side of the plant flows west-northwest into Bayou Creek. Bayou and Little Bayou Creeks converge 3 miles north of the plant before emptying into the Ohio River.

1.2.3 WETLANDS

More than 1,100 separate wetlands are found in the 12,000 acres around the PGDP. Sixty percent of the wetlands are forested wetlands. As part of activities associated with the 2013 PGDP Annual Site Environmental Report: Student Summary Project, MCHS students provided hands-on assistance to the University of Kentucky and the West Kentucky Wildlife Management area in the assessment and delineation of amphibian wetland habitat in the vicinity of the PGDP.

1.2.4 SOILS AND HYDROGEOLOGY

Naturally occurring soils in the vicinity of the PGDP are predominantly silty loam soils that are poorly drained, acidic, and have little organic content. The local groundwater flow system and aquifer

at the Paducah Site are described in Chapter 6

1.2.5 VEGETATION

Much of the vegetation in the vicinity of the PGDP has been impacted by human activity and is now old field succession. Open grassland areas are managed by WKWMA and are burned periodically to promote native species growth. Field scrub-shrub communities consist of sun tolerant wooded species. Upland mixed hardwood forests contain a variety of upland and transitional species.

1.2.6 WILDLIFE

Wildlife species present in the vicinity of the PGDP are indigenous to hardwood forest, scrub-shrub and open grassland communities. Many types of migratory waterfowl seasonally utilize the area surrounding the PGDP. Many types of sunfish and shiners inhabit the creeks and open water.

1.2.7 THREATENED AND ENDANGERED SPECIES

There is potential habitat for 13 species of federal concern at the Paducah Site. Eleven of those 13 species are on the endangered species list. None of the federally listed species have been found at the Paducah Site.

1.3 SITE MISSION

DOE created the Portsmouth/Paducah Project Office (PPPO) to provide leadership for environmental management activities at the Portsmouth, Ohio, and Paducah, Kentucky Gaseous Diffusion Plant.

The main goal of the PPPO is to accelerate the site cleanup, eliminate potential environmental threats, reduce DOE's footprint and reduce life-cycle site management costs. In order to achieve these goals there will be ongoing environmental remediation, waste management cleanup, decontamination and decommissioning as the plant shuts down and conversion of the depleted Uranium Hexafluoride.

1.4 PRIMARY OPERATIONS AND ACTIVITIES AT THE PADUCAH SITE

Two major programs are used to help DOE oversee the Paducah site, the environmental management (EM) and uranium programs. The EM program includes environmental restoration, waste disposition, and decontamination and decommissioning projects. The uranium program manages storage of the DUF6 and the operation of the PGDP DUF6 Conversion Facility. The Conversion Facility separates DUF6 to a stable oxide of uranium for disposal or re-use and hydrofluoric acid which is sold to industry for re-use.

The Environmental Restoration Project manages environmental investigations and responses to releases from past site operations and operates to ensure that human health and the environment are protected. A Federal Facilities Agreement between DOE, the U.S. Environmental Protection Agency (EPA), and Commonwealth of Kentucky is in place to help with the management and State and Federal environmental law compliance.

The Waste Management Program is in place to make sure that waste is disposed of properly in a manner protective of human health and the environment. The Decontamination and Decommissioning Project was put in place to eliminate unused facilities in a manner protective of human health and the environment.

1.5 DEMOGRAPHIC INFORMATION

The population of McCracken County, including the city of Paducah is approximately 66,000. Heath, Grahamville are the closest small communities to the PGDP.

2.0 Compliance Summary

The U.S EPA, Region 4, and the Kentucky Department for Environmental Protection (KDEP) are the principal regulating agencies that issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and generally oversee compliance with applicable laws and regulations. The EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards as directed and passed by states and the U.S Congress.

2.1 Environmental Restoration and Waste Management

2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

Both DOE and Region 4 entered into an Administrative Consent Order (ACO) in August 1988 under sections 104 and 106 of the Comprehensive Environmental Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The ACO was in response to off-site groundwater contamination detected at the Paducah site, July 1988.

On May 31, 1994 the PGDP was placed on the EPA's National Priorities List (NPL). The list identifies sites with the highest priority for site remediation. EPA used the Hazard Ranking System to determine sites that should be included on the NPL.

CERCLA Section 120 requires federal agencies responsible for a NPL site to enter into a Federal Facilities Agreement (FFA) with the EPA. The FFA, signed February 13, 1988, by DOE, EPA, and KDEP established a decision making program for remediation of the PGDP. The FFA coordinates CERCLA remedial action requirements with Resource Conservation and Recovery Act (RCRA) regulatory requirements that are the responsibility of the State. DOE, EPA, and KDEP agreed to terminate the CERCLA ACO and manage the PGDP under the FFA.

The FFA requires DOE to submit an annual Site Management Plan to the EPA and KDEP. The Plan summarizes pending remediation work, outlines remedial priorities, and contains schedules for completing future work. Site Management Plan milestone for 2013 are listed in Table 2.1.

2.1.2 Superfund Amendments and Reauthorization Act

CERCLA was amended in 1986 by the Superfund Amendments and Reauthorization Act which placed EPA's experience in administering the complex Superfund program into law, put increased focus on human health problems posed by hazardous waste sites and encouraged greater citizen participation in making decisions on how sites should be cleaned up.

2.1.3 Resource Conversation and Recovery Act

Regulatory standards for characterization, treatment, storage, and disposal of solid and hazardous wastes are established by RCRA. Owners and operators generating hazardous waste are required to obtain permits for the handling, treatment, storage and disposal of hazardous wastes. The PGDP generates solid, hazardous, and mixed waste, and operate three permitted hazardous waste storage and treatment facilities.

2.1.4 Resource Conservation and Recovery Act Hazardous Waste Permit

PGDP RCRA Part A and Part B permit applications for storage and treatment of hazardous wastes were submitted for the Paducah Site in the late 1980s. EPA authorized the Commonwealth of Kentucky to administer the RCRA-based program for treatment, storage, and disposal units, but had not given the authorization to administer 1984 Hazardous and Solid Waste Amendments provisions.

The current hazardous waste management facility permit was issued to DOE on September 30, 2004.

Table 2.1 CERCLA and FFA Significant Milestones for CY 2013

Milestone	Date Agreed	Date Completed
Burial Grounds Operable Unit (BGOU) Feasibility Study Report for Solid Waste Management Units (SWMUs) 5 and 6—D2/R3	2/15/2013	2/11/2013
Southwest Plume SWMU 1 (Soil Mixing) 90% Remedial Design Report—D1	2/16/2013	2/19/2013*
Soils Operable Unit Remedial Investigation Report—D2/R1	3/16/2013	2/7/2013
Northeast Plume Remediation Action Work Plan—D1	3/28/2013	3/28/2013
FFA Semiannual Progress Report—First Half of Fiscal Year (FY) 2013	4/30/2013	4/30/2013
BGOU Proposed Plan for SWMUs 5 and 6—D1	5/16/2013	5/2/2013
Southwest Plume SWMU 1 (Soil Mixing) 90% Remedial Design Report—D2	6/21/2013	6/21/2013
C-400 Operations and Maintenance Plan Phase IIa—D2	6/23/2013	6/19/2013
Southwest Plume Sources, SWMUs 211-A and 211-B Final Characterization Report—D1	6/26/2013	6/26/2013
Final Characterization Notification for SWMUs 211-A and 211-B	7/10/2013	7/10/2013
BGOU Proposed Plan for SWMUs 5 and 6—D2	7/17/2013	7/17/2013
Southwest Plume SWMU 1 (Soil Mixing) Remedial Action Work Plan—D1	7/21/2013	7/22/2013*
Northeast Plume Optimization Explanation of Significant Differences—D2	8/8/2013	8/5/2013
Northeast Plume Remediation Action Work Plan—D2	8/18/2013	8/19/2013*
Northeast Plume Operation and Maintenance Plan—D3/R4	8/25/2013	8/22/2013
CERCLA Five Year Remedy Review—D1	8/29/2013	8/29/2013
Southwest Plume SWMU 1 (Soil Mixing) 90% Remedial Design Report—D2/R1	9/22/2013	9/23/2013*
C-400 Steam Treatability Study Work Plan—D1	10/21/2013	10/18/2013
C-400 Remedial Action Work Plan for Phase IIa—D2/R3	10/24/2013	10/23/2013
FFA Semiannual Progress Report—Second Half of FY 2013	11/16/2013	11/14/2013
Site Management Plan for FY 2014—D1	12/6/2013	12/5/2013
Southwest Plume Sources, SWMUs 211-A and 211-B Final Characterization Report—D2	12/10/2013	12/10/2013
Southwest Plume SWMU 1 (Soil Mixing) Remedial Action Work Plan—D2	12/20/2013	12/19/2013
C-340 Removal Action Report—D1	12/31/2013	12/10/2013

*Date agreed to was a Saturday, Sunday, or holiday, so document was submitted the following business day, per the FFA.

2.1.5 Federal Facility Compliance Act - Site Treatment Plan

The Federal Facility Compliance Act was enacted in October 1992 and it waived immunity from fines and penalties that had existed for federal facilities for violations of RCRA hazardous waste management. The Act requires treatment plans for DOE mixed waste and requires the approval of treatment plans by the Commonwealth of Kentucky. DOE and KDEP signed an agreement for the treatment of PGDP's mixed waste in 1997.

2.1.6 National Environment Policy Act

An evaluation of the potential environmental impact of proposed federal activities is required by the National Environmental Policy Act. PGDP evaluates proposed non-CERCLA actions and determines if any proposal requires preparation of an Environmental Impact Statement (EIS), Environmental Assessment (EA), or receives an exclusion from preparation of an EIS or EA.

The PPPO began drafting an EA in 2012 to assess the environmental impacts associated with potential transfer of PGDP property to third parties for possible future economic development.

2.1.7 Toxic Substances Control Act

In 1976, the Toxic Substances Control Act was enacted to ensure that information on the production, use, environmental and health effects of chemical substances or mixtures is obtained by the EPA. The Act also identifies how the EPA can regulate chemical substances or mixtures.

2.1.8 Polychlorinated Biphenyls (PCBs)

The PGDP complies with PCB regulations under a Toxic Substances Control Act – Federal Facilities Compliance Agreement.

2.2 Radiation Protection

The Atomic Energy Act of 1954 provides authority to DOE for Radiation Protection of the Public and the Environment (DOE Order 458.1) and Radioactive Waste Management (DOE Order 435.1). Under these Orders DOE establishes the requirements for protection of the public and the environment against any undue risk from radiation associated with its activities handling and disposing of radioactive materials.

2.2.1 DOE Order 458.1, Radiation Protection of the Public and the Environment

DOE's site contractor implements an Environmental Radiation Protection Program (ERPP) to comply with DOE Order 458.1. The goals of the ERPP are to: 1) conduct radiological activities so that exposure to members of the public is maintained within the dose limits established by the Order; 2) control the radiological clearance of real and personal property; 3) ensure that potential radiation exposures to members of the public are As Low As Reasonably Achievable; 4) monitor routine and non-routine radiological releases and to access the radiation does to members of the public; and 5) provide protection of the environment from the effects of radiation and radioactive material.

2.2.2 DOE Order 435.1, Radioactive Waste Management

The PGDP manages low-level, high-level, and transuranic waste in compliance with DOE Order 435.1.

2.3 Air Quality and Protection

2.3.1 Clean Air Act

EPA Region 4 and/or the Kentucky Division for Air Quality have authority for enforcing compliance with the Clean Air Act and its amendments.

2.3.2. National Emission Standards for Hazardous Air Pollutants Program

The standards in this program address the release of radionuclides through air emissions regulated by Federal law and require the PGDP to operate under an EPA-approved release management plan.

2.4 Water Protection

2.4.1 Clean Water Act

The Clean Water Act was established through the Federal Water Pollution Control Act Amendments of 1972 which has four major programs: 1) regulating point-source discharges into waters of the United States; 2) controlling and preventing spills of oil and hazardous substances; 3) regulating discharges of dredge and fill materials into waters of the United States; and 4) providing financial

assistance for construction of publicly owned sewage treatment works. PGDP's discharges to surface water are regulated by the Commonwealth of Kentucky.

2.4.2 Kentucky Pollutant Discharge Elimination System (KPDES)

The Clean Water Act applies to all non-radiological DOE discharges to waters of the United States. The Kentucky Division of Water (KDOW) issues a KPDES permit to the PGDP. The permit requires monitoring of discharge-related effects in the receiving streams and adoption of Best Management Practices to minimize discharges that might impact a receiving stream's water quality.

Table 2.2 KPDES Non-compliances in CY 2013

Permit Type	Outfall	Parameter	Number of Permit Exceedances	Number of Samples Taken	Number of Compliant Samples	Percent Compliance	Month(s) of Exceedance(s)	Description/ Solution
KPDES	017	Zinc	1	27	26	96%	May	Corrective actions previously were implemented under the October 25, 2012, Agreed Order to ensure compliance with the permit requirements for zinc. No additional corrective actions are planned since the high zinc result for May is an outlier with no source or explanation and the levels for the following months were well below the permit limits.
KPDES	017	Chronic Toxicity	2	13	9	69%	May and July	The Toxicity Reduction Evaluation Plan revised in March 2013, and approved by KDOW on April 3, 2013, continues to be implemented to address toxicity issues.
KPDES	001	Total Residual Chlorine	5	59	54	92%	April, May, June, and July	A corrective action plan (CAP) to address total residual chlorine exceedances at Outfall 001 was submitted to KDOW. The CAP indicated discharges to KPDES Outfall 001 were influenced by natural algae growth in the plant ditches and lagoons and that the coloration due to the algae might be causing bias in the readings. A new instrument now is being used and does not indicate total residual chlorine in the outfall.

Six Notices of Violation related to the KPDES permit were issued to the PGDP in 2013 for exceeding water quality standards. Management practices implemented by the PGDP to address the toxicity remain in place. The toxicity exceedances in the fathead minnow tests were attributed to a pathogen unrelated to site activities. No penalties were assessed for the Notices of Violation.

2.4.3 Stormwater Management and the Energy Independence and Security Act of 2007

The PGDP implements energy and water audits to comply with the Energy Independence and

Security Act.

2.4.4 Safe Drinking Water Act

The PGDP withdraws water from the Ohio River which is treated for drinking water use in an on-site water treatment facility. The water treatment facilities are operated and managed by USEC in accordance with Safe Drinking Water Act regulations.

2.5 Additional Regulatory Compliance Requirements

2.5.1 Endangered Species Act

The Endangered Species Act of 1973 addresses the designation and protection of endangered and threatened animals, plants, and their ecosystems. Endangered species that may be present in the vicinity of the PGDP are listed in Table 2.3.

Table 2.3 Federally Listed, Proposed, and Candidate Species Potentially Occurring within the Paducah Site Study Area[A]

Group	Common Name	Scientific Name	Endangered Species Act Status
Mammals	Indiana Bat	*Myotis sodalis*	Endangered
	Northern Long-eared Bat	*Myotis septentrionalis*	Proposed
Mussels	Fanshell	*Cyprogenia stegaria*	Endangered
	Pink Mucket	*Lampsilis abrupta*	Endangered
	Ring Pink	*Obovaria retusa*	Endangered
	Orangefoot Pimpleback	*Plethobasus cooperianus*	Endangered
	Clubshell	*Pleurobema clava*	Endangered
	Rough Pigtoe	*Pleurobema plenum*	Endangered
	Fat Pocketbook	*Potamilus capax*	Endangered
	Spectaclecase	*Cumberlandia monodonta*	Endangered
	Sheepnose	*Plethobasus cyphyus*	Endangered
	Rabbitsfoot	*Quadrula c. cylindrical*	Threatened
Birds	Interior Least Tern	*Sterna antillarum athalassos*	Endangered

[a] All of the listed species are identified as an Endangered, Threatened, or Candidate Species known or with the potential to be located within McCracken County, Kentucky, by the U.S. Fish and Wildlife Service (November 2013).

2.5.2 National Historic Preservation Act

The National Historic Preservation Act of 1966 requires federal agencies to identify and protect historic properties eligible to be placed on the National Register of Historic Places. A Cultural Resources Management Plan identified an eligible historic district at the facility. The PGDP historic district encompasses the area of the process buildings; the switchyards; the C-100 Administration Building; cooling towers and pump houses; security facilities; water treatment facilities; storage tanks; and the support, maintenance, and warehouse buildings.

2.5.3 Migratory Bird Treaty Act

The U.S. Fish and Wildlife department and DOE updated a Memorandum of Understanding that requires further implementation of the Migratory Bird Treaty Act of 1918 under Executive Order 13186. Under the Act, DOE must take measures to minimize impacts to migratory birds in the course of site and environmental operations.

2.5.4 Asbestos Program

Facilities at the PGDP contain asbestos material that require compliance programs addressing identification, monitoring, abatement, and disposal of asbestos materials. The PGDP maintains

compliance with EPA, Occupational Safety and Health Administration, and Kentucky regulatory requirements regarding asbestos. During Decontamination and Decommissioning (D&D) of the C-340 Metals Plant, insulation containing asbestos was made accessible and abatement of that asbestos was performed at that time.

2.5.5 Pollutants and Sources Subject to Regulation

Any stationary source with the potential to emit more than 10 tons/year of any hazardous air pollutant (HAPs) or 25 tons/year of any combination of HAPs is subject to regulation. DUF6 has the potential to emit more than 10 tons of Hydrogen Fluoride per year but is managed to limit emissions to no more than 9 tons per year.

2.5.6 Stratospheric Ozone Protection

PGDP refrigeration units containing ozone-depleting substances are monitored for leaking to comply with Clean Air Act provisions.

2.5.7 Floodplain/Wetlands Environmental Review Requirements

DOE activities did not result in significant impacts to floodplains or wetlands in 2013.

2.5.8 Underground Storage Tanks Managed under RCRA Kentucky Regulations

Underground Storage Tank systems at the PGDP used to store petroleum products such as gasoline, diesel fuel, and waste oil are monitored by the site and the Kentucky Division of Waste Management**.**

2.5.9 Solid Waste Management

In May 2013, DOE submitted a revised Groundwater Assessment Report for the C-746-U Solid Waste Landfill at the Paducah Gaseous Diffusion Plant to address a Technical Notice of Deficiency issued by the Kentucky Division of Waste Management. The C-746-U Landfill required assessment after some constituents were found in vicinity groundwater monitoring wells. The source of contaminants was identified to be corrosion of the steel well casings which were replaced.

2.6 SUSTAINABILITY; LEADERSHIP IN ENVIRONMENT ENERGY AND ECONOMIC PERFORMANCE

2.6.1 Departmental Sustainability

The PGDP made a commitment to pursue the U.S Green Building Council's Leadership in Energy and Environmental Design to address requirements in DOE Order 436.1.

2.6.2 Federal Leadership in Environmental, Energy and Economic Performance

In 2013 the PGDP was not required to report its greenhouse gas emissions because they were lower than threshold criteria for reporting under Executive Order 13514.

2.7 Emergency Planning and Community Right to Know Act

The Emergency Planning and Community Right to Know Act requires reporting of emergency planning information, hazardous chemical inventories, and releases to the environment, including greenhouse gases. In 2013 the PGDP did not have any releases that required a Section 304 notification. The PGDP did report the locations and quantities of its stored chemicals to state and local governments. EPA and the states collect data on releases and transfers of specific toxic material. Table 2.4 lists the 2013 EPRCA reporting status for PGDP.

Table 2.4 Status of EPCRA Reporting

EPCRA Section	Description of Reporting	Status[a]
EPCRA Sec. 302–303	Planning Notification	No
EPCRA Sec. 304	Extremely Hazardous Substance Release Notification	No
EPCRA Sec. 311–312	Material Safety Data Sheet/Chemical Inventory	Yes
EPCRA Sec. 313	Toxic Release Inventory Reporting	Yes

[a] An entry of "yes," "no," or "not required" is sufficient for "Status."

2.8 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

2.8.1 Adapting to Climate Change

The PGDP Climate Change Adaptation Plan is an exploratory phase as the site dynamics change with USEC departing. Normal power usage, fleet exhaust, and process power make up the majority of GHG emitted, and efforts are concentrated in those areas.

2.9 Continuous Release Reporting

Section 103(a) of CERCLA requires that hazardous substance releases in excess of a reportable quantity be reported immediately to the National Response Center.

2.10 Unplanned Releases

There were no reportable unplanned environmental releases for DOE operations at PGDP in calendar year 2013.

2.11 Summary of Permits

A summary of DOE's required PGDP environmental permits is provided in Table 2.5.

Table 2.5 Permits Maintained by DOE for the Paducah Site for CY 2013

Permit Type	Issued By	Permit Number	Issued To
State Agency Interest ID# 3059			
Clean Water Act			
Kentucky Pollutant Discharge Elimination System	KDOW	KY0004049	DOE/LATA Kentucky/BWCS
Clean Air Act			
Conditional Major Operating Air Permit	KDEP	F-10-035R1	BWCS
RCRA—Solid Waste			
Residential Landfill (closed) Inert Landfill (closed) Solid Waste Contained Landfill (construction/operation)	KDWM KDWM KDWM	SW07300014 SW07300015 SW07300045	DOE/LATA Kentucky DOE/LATA Kentucky DOE/LATA Kentucky
RCRA—Hazardous Waste			
Hazardous Waste Facility Permit	KDWM	KY8-890-008-982	DOE/LATA Kentucky

3. Environmental Management System

The EMS integrates environmental protection, environmental compliance, pollution prevention, and continual improvement of environmental management into work planning and execution in order to protect the land, air, water, other natural or cultural resources potentially impacted by activities of DOE and its contractors. Environmental protection programs at the Paducah site utilize five core elements which are policy, planning, implementation and operation, checking, and management review. At the PGDP, DOE contractors are responsible for compliance with laws and regulations. In fiscal year 2013, EMS programs for conservation and protection of environmental resources resulted in a green scorecard that indicated standards for EMS implementation and operations had been met.

3.1 Environmental Operating Experience and Performance Measurement

DOE and site contractors conduct an environmental monitoring program for the PGDP which is described in the Environmental Monitoring Plan (EMP). The EMP identifies how effluent monitoring, environmental surveillance, and air monitoring around the plant will be conducted during the year. Los Alamos Technical Associates Kentucky (LATA KY) implements the environmental monitoring program and executes the activities contained in the PGDP EMP. The PGDP EMP can be found at:

http://www.latakentucky.com/PublicDocuments/EnvironmentalMonitoringPlanFY2013/

3.1.1 Site Sustainability Plan

A Site Sustainability Plan is implemented at the PGDP to ensure DOE carries out its missions in a manner that addresses national energy security and global environmental challenges. It also guides DOE in advancing sustainable, reliable, and efficient energy for the future and initiating cultural change to factor sustainability and greenhouse gas reductions into all management decisions. Additionally the plan ensures that DOE sets site sustainability goals pursuant to applicable laws, regulations, executive orders, sustainability initiatives, and related performance scorecards. Table 3.1 summarizes FY 2013 sustainability related goals.

3.1.2 Waste Minimization/Pollution Prevention

The PGDP Waste Minimization/Pollution Prevention Program provides guidance and objectives for minimizing waste generation at the site. The program complies with RCRA requirements, the Pollution Prevention Act, as well as Commonwealth of Kentucky and U.S. Environmental Protection Agency rules, DOE orders, Executive Orders, and the Site Treatment Plan. PGDP site wastes are minimized using source reduction, segregation, reuse of materials, recycling, and procurement of recycled-content products.

3.1.3 Depleted Uranium Hexaflouride Cylinder Program

DOE is converting the PGDP's inventory of depleted uranium hexafluoride (DUF6) to tri-uranium octa-oxide, which is a more stable form of uranium that is suitable for disposal or reuse. Uranium Disposition Services operates facilities at Paducah, Kentucky and Portsmouth, Ohio to convert and recycle DOE's DUF6.

Table 3.1 DOE Goal Summary

DOE Goal	Site Performance Status	Site Planned Actions
GHG Reduction and Comprehensive GHG Inventory		
28% Scope 1 and 2 GHG reductions by FY 2020 from a FY 2008 baseline (related goals).	6.1% below FY 2008 baseline, strong progress toward "28% below baseline."	The Paducah Site is below the FY 2008 baseline for this goal for the second year in a row; continued vigilance with electrical consumption and fleet fuel consumption will be required to maintain and meet performance status.
13% Scope 3 GHG reduction by FY 2020 from the FY 2008 baseline.	21.7% reduction from FY 2008, exceeding 13% required reduction.	Personnel reduction has helped the site meet this goal.
Building, Energy Savings Performance Contracts Initiative Schedule, and Regional and Local Planning		
30% energy intensity reduction by FY 2015 from the FY 2003 baseline.	123.9% up from the 2003 baseline.	Energy consumption has decreased, however not to 2003 levels. The site has lost much of the gross square feet calculated in the original baseline due to the D&D operations. Small operational energy initiatives are acted upon as they arise; however, nothing large scale is planned.
EISA Section 432 energy and water evaluations.	100%	The Remediation and Infrastructure contractors performed 100% of the required EISA evaluations.
Individual buildings or processes metering for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015).	81% of electricity. 100% of natural gas (met). 0% of water [not applicable (N/A)]. Steam and chilled water (N/A).	The FY 2011 Metering Assessment details the metered consumption and steps required to achieve this goal. Natural gas already is metered, and steam is not being used by DOE contractors.
Cool roofs (when economical) for roof replacements unless project already has Critical Decision-2 approval. New roofs must have thermal resistance of at least R-30.	Work in progress.	Many facilities at the Paducah Site are trailers. Placement of cool roofs on trailers is uneconomical. A cool roof upgrade is being assessed for one of the buildings at the Paducah Site, C-103, because the life cycle for the building will require a replacement. The remaining facilities are being evaluated, but may not have the surface square footage or effective lifespan to achieve a return on investment.
15% of existing buildings larger than 5,000 gross ft^2 to be compliant with the five guiding principles of HPSB by FY 2015.	Initiated as life cycle allows.	The site is scheduled for D&D and investment in building upgrades is not fiscally responsible. As maintenance is performed at the C-103 Building, which is a building that has a continued, useful life, the HPSB standards are given consideration.
All new construction and major renovations greater than 5,000 gross ft^2 must comply with the guiding principles.	The Site currently has no projects planned that fit the requirements.	No new construction is planned for the Paducah Site; however, any upgrades to existing facilities are made with the HPSB principles in mind.

DOE Goal	Site Performance Status	Site Planned Actions
Fleet Management		
10% annual increase in fleet alternative fuel consumption by FY 2015 relative to the FY 2005 baseline.	41.3% increase from last year.	In FY 2005 there was no E85 present at the site, making the baseline 0. This year, the site was up 41.3% from FY 2012. The performance status should remain stable if fleet size/makeup does not change.
2% annual reduction in fleet petroleum consumption by FY 2020 relative to the FY 2005 baseline.	2,662% over FY 2005 baseline.	The recent fleet reduction plan and fuel saving practices have had a continued significant impact on the petroleum consumption. Historical data provided in the Consolidated Energy Data Report shows the Paducah Site having very low petroleum consumption in FY 2005. It will be extremely difficult to meet this goal with the return of the USEC fleet to DOE being a possibility.
100% of light-duty vehicle purchases must consist of alternative fuel vehicles (AFVs) by FY 2015 and thereafter.	AFVs currently make up 38%. Hybrid electric vehicles make up 25%.	The site has requested that General Services Administration send more AFVs/hybrids as other vehicles leave the site.
Reduce fleet inventory of non-mission critical vehicles by 35% by FY 2013 relative to a FY 2005 baseline.	Goal has been met.	The reduction in vehicle usage and total fleet numbers was completed in FY 2011.
Water Use Efficiency and Management		
26% potable water intensity reduction by FY 2020 from a FY 2007 baseline.	Goal is met.	To meet the standard, the contractors have installed low-flow systems and ceased all landscape watering. This site estimates this goal has been met.
20% water consumption reduction of industrial, landscaping, and agricultural (ILA) by FY 2020 from the FY 2010 baseline.	N/A	FY 2010 baseline is 0. The site still is not consuming water for ILA purposes; thus, there is no reduction to record.
Pollution Prevention and Waste Reduction		
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, by FY 2015.	Currently diverting 50.4%.	Estimates show the site at 50.4% diversion rate; the site intends to use best practices and innovation to continue to decrease municipal landfill waste.
Divert at least 50% of construction and demolition materials and debris by FY 2015.	Currently diverting 8.8%.	Noncontaminated waste is recycled and reused when applicable. The site historically recycles a large amount of D&D waste when it is not contaminated. This year, a portion of the old Waterworks Bridge abutment was recycled.
Sustainable Acquisition		
Procurements meet requirements by including necessary provisions and clauses.	Goal is met.	Environmentally Preferred Purchasing Program allows the subcontractors to monitor all purchase orders and make additions to the list for new products.

DOE Goal	Site Performance Status	Site Planned Actions
Electronic Stewardship and Data Centers		
All data centers are metered to measure monthly power usage effectiveness (PUE) of 100% by FY 2015.	N/A	The Paducah Site does not have any data centers.
Maximum annual weighted average PUE of 1.4 by FY 2015.	N/A	The Paducah Site does not have any data centers in which to monitor PUE.
Electronic Stewardship—100% of eligible personal computers, laptops, and monitors with power management actively implemented and in use by FY 2012.	Goal is met.	Power management is actively implemented on all computers.
Renewable Energy		
20% of annual electricity consumption from renewable sources by FY 2020.	Presently at 109.5% from renewable energy sources purchased.	PPPO purchases renewable energy certificates for the Paducah and Portsmouth sites. This year 7,500 MWh was purchased.
Climate Change Adaption		
Climate Change Adaption—Address DOE Climate Adaption Plan goals.		The initiatives being taken at the Paducah Site for climate change adaptation are the same as the sustainability goals. This includes reduction in fleet and fuel usage; overall electrical and water consumption decrease; and recycling for all waste and excess inventory.

3.1.4 Environmental Restoration, Waste Disposition, and D&D

In 2013, PGDP completed D&D of C-340 Metals Plant and installation of an electrical resistance heating system near the C-400 Cleaning Building to remove TCE from the subsurface. The site also made progress on the decontamination and decommissioning of the C-410 Feed Plant by stabilizing more than 9,000 feet of UF6 piping, removing and neutralizing more than a ton of residual UF6, removing asbestos wiring, and removing and packaging 20 UF6 cold traps weighing more than 10,000 pounds each.

3.1.5 Emergency Management

For emergency management purposes, the PGDP has an Emergency Response Organization. This includes a crisis manager, an Emergency Operations Center cadre, an incident commander, the Emergency Squad, and the Joint Public Information Center. The PGDP has a fully staffed fire department, protective force officers and a medical facility.

On Sunday, November 17, 2013, a tornado struck the plant. Wind speeds were upwards of 115 mph and, when damage was confirmed, the plant shift superintendent declared an emergency and activated the Emergency Response Organization. A staff of 60 responded. There were no injuries and everything functioned properly. Damage included the exterior of one of the four enrichment process buildings, adjacent cooling towers, and an electrical switchyard.

Figure 3.1 Cooling Tower Damage from the 2013 tornado.

3.2 Awards and Recognition

3.2.1 Public Awareness, Community Relations and Public Participation

A comprehensive PGDP Community Relations and Public Participation Program exists to provide the public with opportunities to become involved in decisions affecting environmental issues at the site. Community/Educational Outreach includes the PGDP Citizens Advisory Board which is a group of community members who provide DOE input on site environmental and re-use issues, the PGDP Environmental Information Center which catalogues and provides access to PGDP Administrative Record and environmental documents, DOE sponsorship of a science bowl for area high school students, and sponsorship of the Marshall County High School ASER Student Summary Program.

4. ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

4.1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

DOE conducts routine operations at the PGDP that result in releases of radioactive material to the atmosphere. Those releases potentially expose the community to radiation above background levels. Because of this, DOE monitors surface water, ground water, sediment, direct radiation, and air in order to minimize the amount of radiation the public is being exposed to due to its processing and handling of radioactive material. With the use of environmental monitoring, surveillance data, and release data the PGDP is able to calculate the estimated annual dose. Individuals in the U.S. receive an average annual dose of approximately 620 mrem from many different sources as shown in figure 4.1 below.

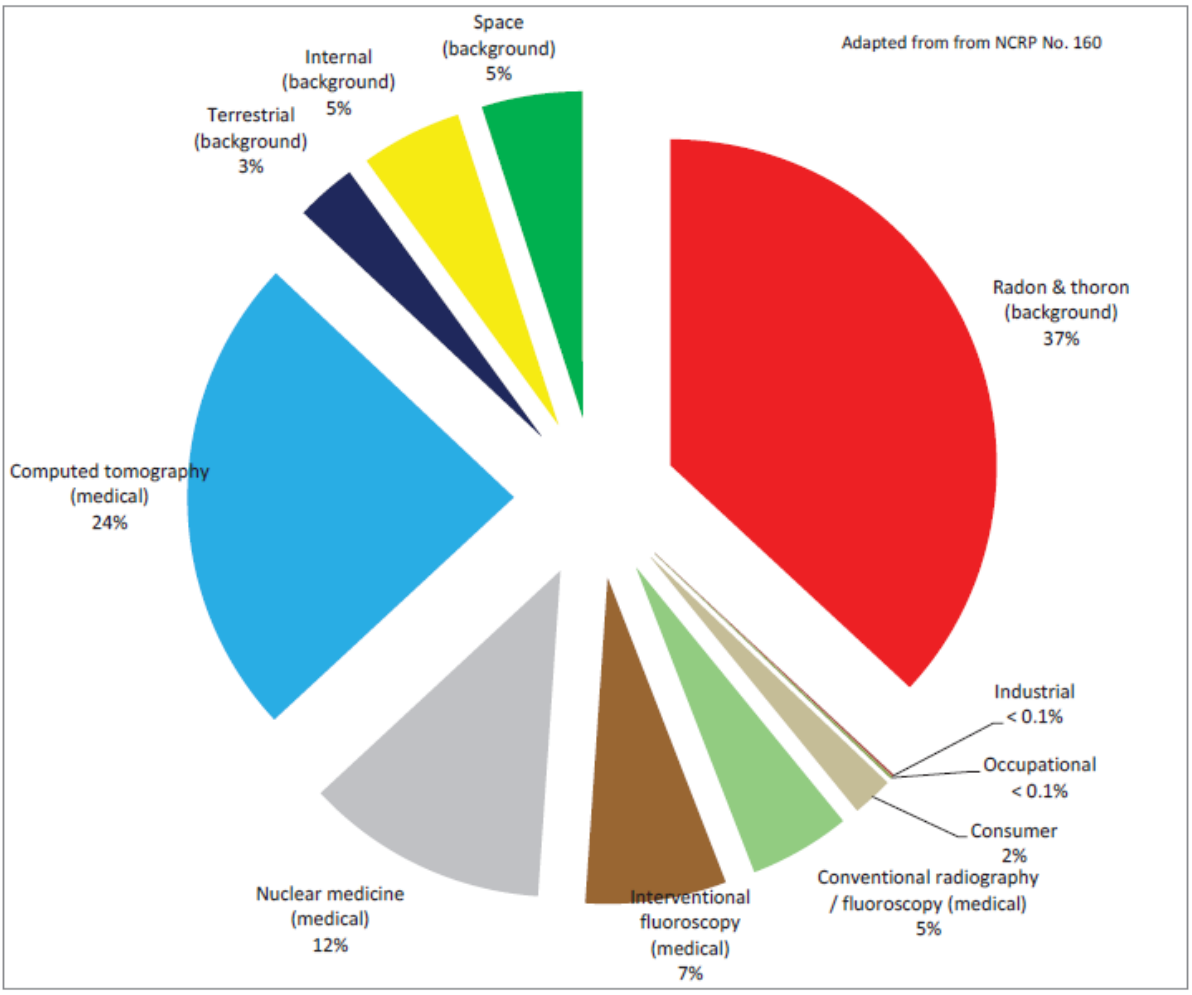

Figure 4.1 Sources of Radiation

4.1.1 What is Dose?

Dose is the amount of energy absorbed by the human body as a result of radiation released by a radioactive source. Dose is measured in units of roentgen equivalent man (rem). Exposure to radiation from radionuclides outside the body is called "external exposure", while radiation

exposure from radioactive material within the body is known as “internal exposure”. Internal exposure continues as long as the radiation source is inside of the body and continuing to emit radiation. Internal and external exposures to radioactive material can result in a dose.

People are routinely exposed to natural and man-made sources of ionizing radiation as shown in Figure 3. To confirm that doses to the public are below established limits, PGDP calculates annual dose estimates using effluent release data, direct radiation monitoring data and environmental monitoring data combined with relevant site specific data such as exposure pathways, meteorologic conditions and population habits and characteristics.

An exposure pathway consists of a route for released radioactive material to be transported by an environmental medium from a radioactive material source to an ecological or human receptor. Routine operations at PGDP release incidental radioactive materials into the environment through atmospheric and liquid discharges. Releases potentially result in radiation dose to members of the public and the environment. Radioactive materials present at PGDP are the result of processing uranium-bearing material and recycled uranium-bearing material into uranium with an enriched (higher) percentage of the isotope uranium-235 relative to the percentage of uranium-235 in naturally occurring uranium.

The following radionuclides are present at the PGDP as part of the uranium enrichment process:

1. Uranium-234 (245,000 year half-life)
2. Uranium-235 (704,000,000 year half-life
3. Uranium-238 (4,470,000,000 year half-life)
4. Thorium-230 (75,400 year half-life)
5. Plutonium-238 (87.7 year half-life)
6. Plutonium-239 (24,100 year half-life)
7. Neptunium-237 (2,140,000 year half-life)
8. Americium-241 (432 year half-life)
9. Cesium-137 (30.2 year half-life)
10. Technetium-99 (211,000 year half-life)

The principal pathways by which individuals could potentially be exposed to radioactive materials include:

1. Inhalation of gases and particulates
2. Ingestion of vegetables, crops, milk, fish, venison, other game
3. Ingestion of surface water and groundwater
4. Skin absorption from contact
5. External exposure radiation emitted from radioactive material

In order to estimate the amount of radiation potentially received by individuals, DOE conducts exposure assessments. Exposure assessments are calculated or “modeled” exposures using exposure pathways and radionuclides applicable to the PGDP site. (Figure 4.2).

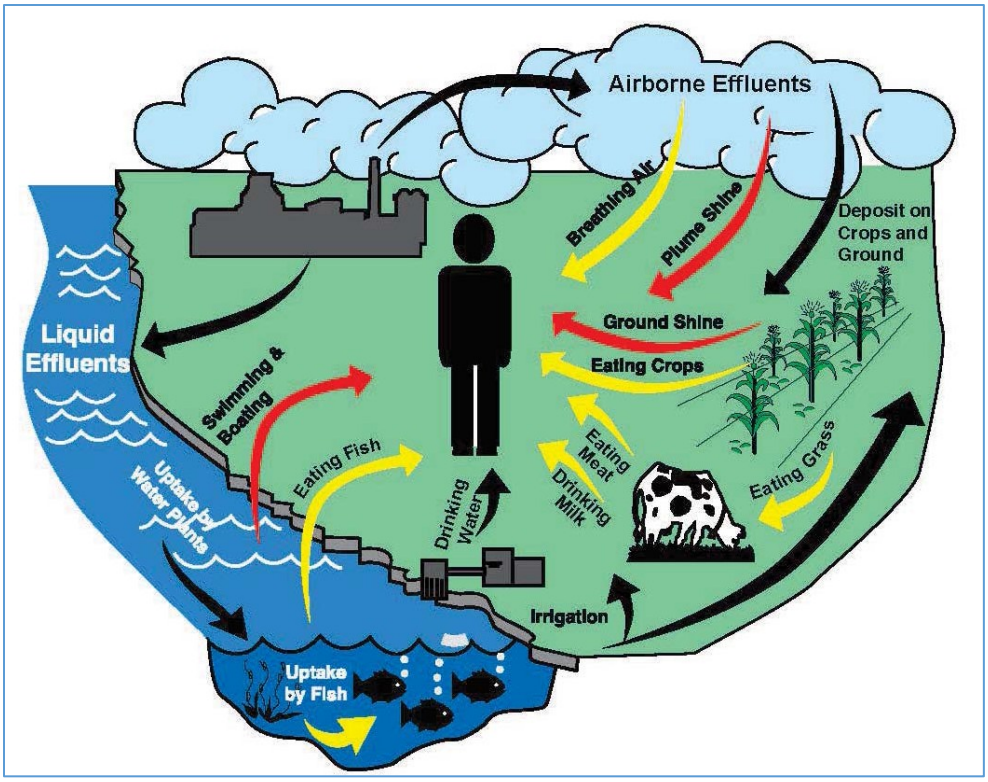

Figure 4.2 Radiation exposure pathways.

4.1.2 Dose Assessment Methodology

Measurements of radionuclide concentrations in liquids and air released from the PGDP are modeled to estimate the maximum exposure to an individual in a year. For determining compliance with public dose limits, PGDP calculates the potential off-site doses from PGDP releases of radioactive materials on the population living within a 50-mile radius of PGDP.

The maximally exposed individual (MEI) is a hypothetical resident who has the greatest probability of being affected by a radiological release. The MEI for PGDP is established based on assumptions that characterize an individual who lives outside the PGDP site at the location where the highest concentration of radionuclides in air have been modeled, consumes milk, meat, and vegetables produced at that location; spends time on or near Bayou or Little Bayou Creek, hunts on the wildlife reservation and consumes hunted wildlife. The PGDP MEI does not drink groundwater because all persons downgradient of the PGDP are provided water from the local public water supply system.

Additional assumptions related to the MEI are that surface water is not used for irrigation of crops because surface water is not used agriculturally in the vicinity of the PGDP. Little Bayou Creek is an ephemeral stream and does not support aquatic life for consumption and few game fish are found in Bayou Creek so fish ingestion is not considered.

Dose from ingestion of surface water is calculated at the nearest public withdrawal location in Cairo Illinois. Dose from sediment ingestion and incidental contact with surface water is based on assumptions for recreational use of the Bayou and Little Bayou Creeks on the reservation. Dose associated with airborne releases are calculated for the hypothetical MEI located at the nearest plant neighbor.

4.1.3 Air Monitoring and Estimated Dose from Airborne Effluents

DOE operations may result in airborne releases from various sources including CERCLA remedial actions and fugitive emissions. Airborne radionuclide sources at the PGDP evaluated were considered to be the Northwest Plume Treatment Facility, the Northeast Plume Treatment Facility Cooling Tower, the Northeast Plume Treatment System Alternate Treatment Unit, the DUF_6 Conversion Facility, fugitive dust source emissions, and miscellaneous sources. Activities that could generate fugitive emissions include transport and disposal of waste, demolition of contaminated facilities such as the C-340 Building (demolished in 2013), decontamination of contaminated equipment, and most environmental remediation activities. Ambient air monitoring, which monitors fugitive emissions from all DOE and USEC Paducah operations is conducted using eight continuous air monitors located around the PGDP reservation. Data from a background location also is collected. Table 4.1 identifies PGDP facilities and their radionuclide releases to air.

Airborne radionuclide emissions are regulated by EPA under the Clean Air Act to be a maximum of 10 mrem effective dose equivalent (EDE) to any member of the public in any year. Airborne radioactive materials released in 2013 from stacks and diffuse sources on the PGDP are shown in Tables 4.1 to 4.3 and the EDE to the MEI was calculated to be 0.03 mrem which is much less than the 10 mrem Clean Air Act effective dose equivalent standard.

Table 4.1 PGDP Radionuclide Atmospheric Releases for CY 2013 (in Curies)

Nuclide	Northwest Plume Treatment Facility	Northeast Plume Treatment Facility Cooling Tower	Northeast Plume Treatment System Alternate Treatment Unit	DUF_6 Conversion Facility	Total DOE Emissions	Total Site Emissions*
U-234	0	0	--	1.57E-07	1.57E-07	5.46E-03
U-235	0	0	--	7.19E-09	7.19E-09	1.90E-04
U-238	0	0	--	3.85E-07	3.85E-07	2.54E-03
Tc-99	1.27E-04	2.26E-06	1.28E-06	--	1.31E-04	4.60E-03
Th-230	0	0	--	--	--	5.84E-06
Th-231	0	0	--	2.80E-08	2.80E-08	2.80E-08
Th-234	0	0	--	2.56E-06	2.56E-06	2.56E-06
Np-237	0	0	--	--	--	6.18E-04
Pu-239	0	0	--	--	--	1.34E-06
Pa-234m	0	0	--	2.56E-06	2.56E-06	2.56E-06
Total Curies/Year	**1.27E-04**	**2.26E-06**	**1.28E-06**	**5.70E-06**	**1.36E-04**	**1.34E-02**

*The total site emissions reflect both USEC and DOE emissions; however, the source-specific columns show only DOE emissions. USEC emissions included in the calculated total DOE emissions, but are not discussed in this ASER.

Table 4.2 Dose Calculations for Airborne Releases

Emission Sources	Dose to the Maximum Exposed Individual for Each Source (mrem)	Dose to the Maximum Exposed Individual for the Plant (mrem)
DOE Emission Sources		
Northwest Plume Treatment Facility	2.5E-05	2.5E-05
Northeast Plume Treatment Facility Cooling Tower	1.7E-07	1.3E-07
Northeast Plume Treatment Facility Alternate Treatment Unit	1.9E-07	8.9E-08
DUF_6 Conversion Facility	2.5E-07	1.7E-07
Total from DOE Sources		**2.5E-05**
Total from USEC Sources*		**3.0E-02**
Total from All Sources		**3.0E-02**

*USEC sources included in the calculated total DOE emissions, but are not discussed in this ASER.

Table 4.3 Calculated Radiation Doses from Airborne Releases

	Effective Dose to MEI (mrem)	Percent of Standard (%)	Collective Effective Dose (person-rem)
PGDP	3.0E-02	0.3	0.2

4.1.4 Liquid Discharge Monitoring and Estimated Dose from Liquid Effluent

4.1.4.1 Surface water

Radioactive contaminants released to water may be in dissolved or suspended form, deposited in sediment, deposited on ground or vegetation by flooding or irrigation, absorbed into plants and animals, or may infiltrate to the groundwater.

Surface water leaving PGDP includes rainfall runoff from cylinder yards and landfills and effluent from site processes. Surface water discharges from PGDP flow into Bayou and Little Bayou Creeks and then flow into the Ohio River.

The derived concentration standard for an isotope is the concentration of the isotope in drinking water that is calculated (derived) to result in an annual dose of 100 mrem to a person if a person's entire annual drinking water intake contained the radioactive isotope. Each isotope has its own derived concentration standard that is specific to the isotopes radiation type, radioactive energy, and half-life.

The derived concentration standards for PGDP surface water are very conservative because they assume consumption of surface water in the vicinity of the PGDP and surface water is not used as a drinking water source at or in the vicinity of the PGDP.

For radiological environmental surveillance monitoring, surface water was sampled quarterly at four locations and one background location. A location near the closest public water withdrawal location, Cairo, Illinois was also sampled. No threshold limits were exceeded in 2013.

In addition to surface water sampling locations above, samples are taken at five PGDP outfalls. Table 4.4 lists the outfall, types of effluents discharged at the outfall, and type of flow. Isotopic

analyses are not performed if the alpha and beta activity levels are below established thresholds. If a threshold is not exceeded at a location, then the dose calculated will be less than 0.09 mrem/yr. and is assumed to pose minimal risk to the public or the environment. Table 4.5 summarizes the isotopic detections of radionuclides at surface water sampling locations.

Table 4.4 KPDES Outfall Information

Outfall	Types of Liquid Effluent	Type of Flow
K001	USEC's C-616 Liquid Pollution Abatement Facility DOE NWPGS and NEPCS DOE's waste management activities, including routinely generated C-404 treated leachate, C-733 and C-612-A sump water, and other waste management activities DOE's discharge operations at the Northwest Storm Water Collection Basin (also referred to as the C-613 Sedimentation Basin) C-613 Sedimentation Basin	Continuous
K015	Surface water runoff from the east-central sections of the plant	Intermittent
K017	Surface water runoff from the southeast section of the plant (primarily the cylinder storage yards)	Continuous
K019	Surface water runoff from C-746-U (DOE's operational nonhazardous, solid waste landfill)	Intermittent
K020	Treated leachate from the C-746-S and C-746-U Landfills	Intermittent

Table 4.5 Ranges of Detected Radionuclides in 2013 Surface Water

Isotope	Range
Potassium-40 (pCi/L)	24.9–101
Technetium-99 (pCi/L)	15.3–49.9
Uranium-234 (pCi/L)	0.443–83.5*
Uranium-235 (pCi/L)	0.0513–10.5*
Uranium-238 (pCi/L)	0.541–642*

*Maximum results are from radiological monitoring locations near K020.

4.1.4.2 Drinking water

Surface water in the vicinity of the PGDP is not used as a drinking water source but it does discharge into the Ohio River which is used as a public drinking water source 30 miles downstream of the PGDP at Cairo, Illinois at the confluence of the Ohio and Mississippi Rivers. The average concentrations of radionuclides at Cairo were used to calculate the dose to the MEI resulting from consumption of surface water. The radionuclides in Cairo surface water are assumed to come from PGDP in this calculation because radionuclides were not detected in background samples.

In 2013, three Cairo surface water samples were collected and analyzed for radionuclides. Radiological results were non-detect for two of the three samples. Tc-99 was detected in one sample with an activity of 15.3 pCi/L. The detection was well below the derived concentration standard of 44,000 pCi/L for ingestion of water. The drinking water dose calculation used the average activities of the three Cairo water samples. The MEI was assumed to consume all of their water at the public drinking water supply average activity at 8 glasses/day for 365 days a year. The MEI's maximum annual dose for 2013 was calculated to be 0.012 mrem which is significantly less than the 100 mrem/yr limit.

4.1.4.3 Incidental ingestion of surface water

Dose to the hypothetical MEI is calculated based on incidental ingestion of water due to wading or swimming in Bayou Creek, Little Bayou Creek and their tributaries for 45 days a year, 2.6 hours a day, and 0.05 liters per hour. The highest monthly surface water results from the various sampling locations were utilized to calculate the dose to the MEI from incidental ingestion of surface water and was calculated to be 0.32 mrem/year.

4.1.4.4 Landfill leachate

During CY 2013, 810 tons of waste from 10 different waste streams was disposed of in the C-746-U Landfill. The waste included building demolition debris from the C-340 facility, soils, personal protective equipment, scrap metal, investigation derived wastes, and other various items. Contaminated material may be disposed of if it is below acceptable levels. DOE reviews and authorizes disposal of each waste stream that possesses residual radioactivity to ensure accurate inventory control is maintained. During routine sampling of the leachate during the summer of 2013, an increase in radiological contaminants was noted. These levels were 15.2% above the 2012 discharge concentrations based on the time-weighted averages for 2013, but did not exceed the DCS. Subsequent sampling in 2014 has shown a reduction in contaminant concentrations.

4.1.4.5 Groundwater

Groundwater wells that supplied drinking water downgradient from PGDP have been replaced with public drinking water so that groundwater as water source is no longer a reasonable route for exposure for the MEI. Consumption of groundwater is not considered in the calculation of cumulative dose to the surrounding population.

4.1.5 Sediment Monitoring and Estimated Dose

Sediment is an important constituent of the aquatic environment. If a radionuclide is a suspended solid or is attached to suspended sediment, it can settle to the bottom, be taken up by certain organisms, or become attached to plant surfaces. Suspended organic and inorganic solids can be assimilated by plants and animals and enter the aquatic food chain. Suspended solids, dead biota, and excreta settle to the bottom and become part of the organic material that supports bottom-dwelling organisms providing an additional way for radionuclides to enter the food chain.

4.1.5.1 Sediment Surveillance Program

Historically, the maximum annual radiological dose to a member of the public from sediment exposure was less than 0.4 mrem, which is significantly less than the 100 mrem annual dose allowed.

Sediment sampling for radiological and nonradiological constituents at the Paducah Site was done in June 2013. Sampling locations have been selected to facilitate the site-specific radiation exposure pathway analysis and to provide an indication of the accumulation of undissolved radionuclides in the aquatic environment (Figure 4.5). Locations were chosen to represent areas of public access, introduction of plant effluents to the environment, any unplanned release, and verification of the effectiveness of PGDP effluent monitoring.

During CY 2013, an unplanned release occurred due to heavy rains during the demolition of

Building C-340. Sediment sampling following the heavy rains was performed in August 2013 at three locations: L194, S2, and S28 (Figure 4.5). Location S2 was sampled before the heavy rains.

Sediment analytical results for radioactive contaminants are summarized in Table 4.6. CY 2013 sediment sample uranium concentrations (activities) were above background in Little Bayou Creek and Bayou Creek near and downstream of the plant site. The radiological results for CY 2013 are similar to those measured during CY 2008–2010 and activities were near background activities with the exception of locations S1, S2 and S27.

Location S1 is immediately downstream of PGDP discharges to Bayou Creek on DOE property. Little Bayou Creek location S2 is downgradient of PGDP discharges from the east side of the industrial area. Little Bayou Creek location S27 is downstream of the east-side discharges and the North-South Diversion ditch confluence with Little Bayou Creek.

Locations S1 and S27 historically exhibit the highest concentrations of analyzed radionuclides. Location S1, exhibited elevated Tc-99 activity. C-340 building demolition was completed in 2013 which was reflected in the S2 sample results which were lower after the unplanned release than before the unplanned release.

Table 4.6 Radiological Activities for Sediment Sampling[a]

Parameter	S1[b]	S1[b] (duplicate)	S2[b]	S2[c]	S20[b]	S27[b]	S33[b]	S34[b]	L194[c]	S28[c]
Alpha activity	8.64	12.7	13.5	not analyzed	2.95	21.6	3.35	3.45	not analyzed	not analyzed
Beta activity	20.4	25.4	16.5	not analyzed	3.75	106	4.14	2.78	not analyzed	not analyzed
Cesium-137	0.0519	0.0329	0.0275[d]	0.0266	0.026	0.044	0.0782	0.0156[d]	0.0319	0.009[d]
Neptunium-237	0.126	0.142	0.000[d]	0.000[d]	0.000[d]	0.434	0.000[d]	0.0108[d]	0.000[d]	0.004[d]
Plutonium-238	0.00251[d]	0.00338[d]	0.00443[d]	0.000[d]	0.00308[d]	0.0177[d]	0.0033[d]	0.00267[d]	0.000[d]	0.000[d]
Plutonium-239/240	0.0209[d]	0.0264[d]	0.00619[d]	0.000[d]	0.00179[d]	0.496	0.0167[d]	0.102	0.000[d]	0.000[d]
Potassium-40	5.85	5.07	6.67	5.79	2.62	4.63	4.46	3.21	7.15	4.43
Technetium-99	20	26.7	0.0632[d]	0.000[d]	0.000[d]	5.7	0.139[d]	0.737	0.00941[d]	1.8
Thorium-228	0.62	0.792	0.919	0.633	0.646	0.768	0.548	0.581	0.759	0.504
Thorium-230	0.799	1.01	0.948	0.724	0.604	5.36	0.703	1.4	1.38	1.03
Thorium-232	0.618	0.776	0.878	0.759	0.598	0.712	0.545	0.582	0.88	0.584
Thorium-234	9.23	4.85	7.74	6.47	0.763[d]	3.39	1.81	2.04	6.58	0.646
Total Uranium	7.61	9.57	7.46	7.32	0.777	13.5	2.73	2.53	4.91	0.613[d]
Uranium-234	2.7	3.21	0.959	1.01	0.358	4.56	1.12	0.749	0.975	0.291
Uranium-235	0.174	0.227	0.101	0.0856	0.0329	0.287	0.06	0.0467	0.0987	0.00869[d]
Uranium-238	4.73	6.13	6.4	6.22	0.387	8.65	1.55	1.73	3.83	0.314

[a] Units are in pCi/g.
[b] Sampling conducted before the unplanned release.
[c] Sampling conducted after the unplanned release.
[d] Result reported at concentrations less than the laboratory's reporting limit.
Note: Consistent with Nuclear Regulatory Commission guidance, 0.000 pCi/g is presented for results reported as less than zero.

4.1.5.2 Sediment Dose

Areas with sediment that contains elevated radionuclide levels within the DOE property boundaries are access controlled for protection of the public. For the hypothetical MEI, exposure to contaminated sediment in Bayou Creek and Little Bayou Creek could occur during hunting or other recreational activities and is possible through incidental ingestion of contaminated sediment. The worst-case ingestion assumption consists of an adult individual wading at a creek location every other day during the hunting season (104 days/year) and ingesting a small amount of sediment during each visit (100 mg/day). The dose is calculated based

on the radionuclide activity and the amount of exposure via ingestion.

Doses are calculated for ingestion of sediments for both Bayou Creek and Little Bayou Creek using the radiological results for sediment surveillance samples for CY 2013 (Table 4.7). The worst-case annual dose (including background) was calculated to be at location S27 (0.15 mrem); although this is an unlikely scenario because the area currently is posted for contamination control. A comparison of sediment sampling data is provided in Table 4.6. Dose above background from sediment was 0.077 mrem at downstream Little Bayou but was comparable to the dose calculated for the sediment background location Massac Creek which is outside of PGDP related watersheds and several miles east of Little Bayou Creek . This exposure pathway is the major contributor to the dose received by the MEI but much less than the

Table 4.7 Average Annual Dose Estimates for CY 2013 Incidental Ingestion of Sediment

	Committed Effective Dose Equivalent (mrem)—Sediment Ingestion									
Location	**Cs-137**	**Np-237**	**Pu-238**	**Pu-239/ Pu-240**	**Tc-99**	**Th-230**	**U-234**	**U-235**	**U-238**	**Total (mrem)**
Upstream Bayou[1]	4.21E-03	0.00E+00	2.14E-05	1.38E-05	0.00E+00	7.60E-04	2.28E-04	1.20E-03	4.07E-03	1.05E-02
Bayou Near Site[2]	2.66E-03	8.27E-03	0.00E+00	1.68E-04	2.14E-04	3.78E-04	1.65E-03	6.12E-03	5.31E-02	7.25E-02
Downstream Bayou[3]	8.46E-03	0.00E+00	1.53E-06	1.15E-04	1.28E-06	1.25E-04	4.85E-04	9.89E-04	1.22E-02	2.24E-02
Little Bayou near Site[4,d]	4.32E-04	0.00E+00	0.00E+00	2.10E-06	2.22E-07	5.20E-04	3.97E-04	2.27E-03	5.36E-02	5.73E-02
Downstream Little Bayou[5,d]	6.16E-04	1.37E-02	4.93E-05	2.29E-03	2.95E-05	3.49E-03	1.46E-03	4.89E-03	5.06E-02	7.71E-02
Massac Creek[6]	0.00E+00	2.47E-04	0.00E+00	0.00E+00	1.65E-05	5.36E-04	0.00E+00	0.00E+00	0.00E+00	7.99E-04
Net Exposure from Paducah Site to maximally exposed individual [a,b,c,d] (Downstream Little Bayou) =										**7.71E-02**

[a] Maximum allowable exposure is 100 mrem/year for all contributing pathways and 25 mrem/year from one source (DOE Order 458.1).
[b] Radionuclide dose from S20 is considered background and has been subtracted from PGDP-related doses. If location dose is less than background dose the dose is specified as 0.00E+0 mrem.
[c] Dose calculated as ratio of listed dose for Adult Recreator in Table A.8 in *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE 2013b), which includes the ingestion, inhalation, and external gamma pathways.
[d] When more than one sample is present at the listed location, the doses of each sample are averaged.
The following footnotes correspond with row titles in this table. These are groupings of sample locations in the area described in the title and are shown on Figure 4.5.
1 = S20 (Background) 3 = S33 5 = S27, S34
2 = S1 4 = S2, L194 6 = S28

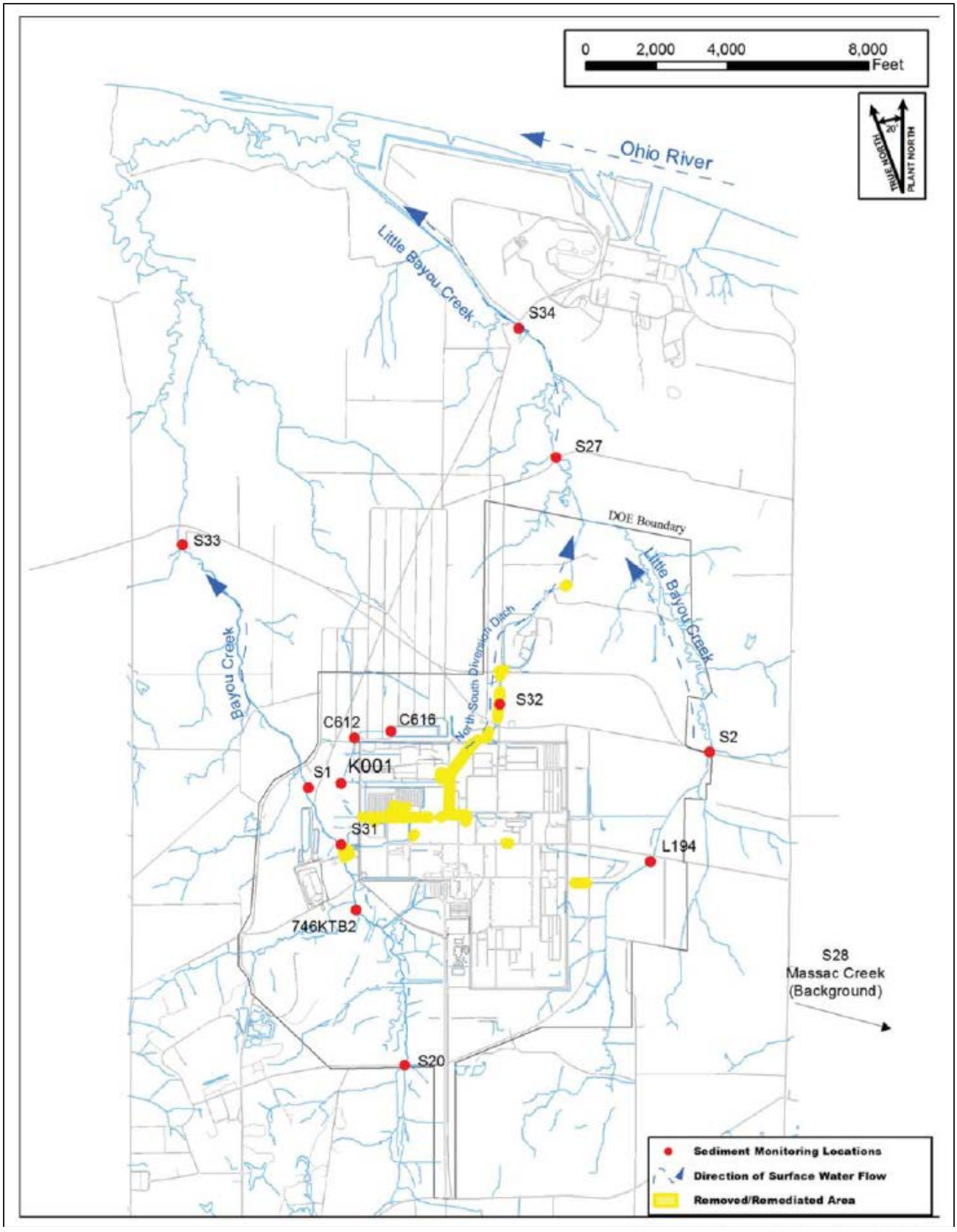

Figure 4.3 Sediment Monitoring Locations

4.1.6 Terrestrial Environment Monitoring and Estimated Dose

Woodlands, meadows, and cultivated fields dominate the rural landscape around the DOE Reservation. Immediately adjacent to the DOE Reservation is the WKWMA, which is used by a hunters, trappers, and anglers. Hunting and trapping activities may include such wildlife as rabbit, deer, quail, raccoon, squirrel, dove, turkey, waterfowl, and beaver. The Kentucky Department of Fish and Wildlife Resources sponsors field hunting trials for dogs within the WKWMA.

Wildlife and animal products, including meat, eggs, and milk, may become contaminated through animal ingestion of contaminated water, sediment, other animals, or through direct contact with contaminated areas. Ingestion of these products can lead to public dose.

4.1.7 Wildlife

Deer monitoring has been eliminated from the Paducah Site monitoring program based on extensive review of data sets from 20 years of deer harvesting.

4.1.8 Direct Radiation Monitoring and Estimated Dose

4.1.8.1 Direct radiation surveillance

External radiation exposure is defined as exposure to radioactive sources outside the body. DOE conducts a routine external gamma and neutron radiation monitoring program to provide data on external radiation exposure from DOE operations. Sources of external radiation exposure at the Paducah Site include the cylinder storage yards, the operations inside the buildings, and small items such as instrument calibration sources. Cylinder storage yards have the largest potential for a dose to the public because of their proximity to the PGDP security fence. Thermoluminescent dosimeters (TLDs) are placed at locations where the individuals might be exposed to radiation from PGDP sources and many TLD locations are

The primary factor in selecting the monitoring locations is the potential for a member of the public to be exposed to external radiation.

In 2013, direct radiation was monitored by quarterly placement, collection, and analysis of environmental TLDs. These monitoring locations are shown in Figure 4.6. Monitoring results indicate that 16 of 52 locations were consistently above background levels. Most of these locations were at or near the PGDP security fence in the vicinity of UF_6 cylinder storage yards in areas that until recently were not accessible to members of the public.

4.1.8.2 Direct radiation dose

PGDP security protocols do not allow the public near the security fence. The external radiation doses measured by TLDs in areas accessible to the public were not statistically above background; therefore, the ED potentially received by a member of the public passing through accessible portions of the DOE Reservation are not statistically above background and, for the purposes of this report, are considered to be negligible. In 2013, TLD-14 and TLD-40 represented the closest locations that would be accessible to the public. TLD-14 is near Harmony Cemetery, located north of the plant security fence and south of Ogden Landing Road. Measurements at

this location indicated external radiation doses statistically equivalent to the background radiation level. In 2013, TLD-40 located on the DOE Reservation boundary with the DOE-leased WKWMA area off of Dyke Road indicated external radiation dose measured to be at background levels. The MEI at the private residences also was calculated to be at background levels. Based on the results of the gamma and neutron radiation dose measurements made during CY 2013, the ED to the MEI member of the public from DOE operations was below the applicable DOE limit of 100 mrem within a year.

4.1.8.3 Cumulative dose survey

This section presents the calculated radiological doses to individuals and the surrounding population from atmospheric and liquid releases from the Paducah Site, as well as from direct radiation. Table 4.8 provides a summary of the radiological dose for 2013 from the Paducah Site that could be received by a member of the public assuming worst-case exposure from all relevant pathways. The largest contributor to the calculated dose is from incidental ingestion of surface water. The groundwater pathway from DOE sources is assumed to contribute no dose to the population, because DOE has supplied all downgradient residents with public water. The worst-case combined (internal and external) dose to an individual member of the public was calculated at 0.44 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.

Table 4.8 Summary of Potential Radiological Dose to the MEI from the Paducah Site for CY 2013[a]

Pathway	Dose to Maximally Exposed Individual[b] (mrem/year)	Percent of Total	Percent of DOE 100 mrem/yr Limit
Incidental ingestion of surface water	0.32	73	0.32
Ingestion of drinking water (Cairo, Illinois)	0.012	2.7	0.012
Incidental ingestion of sediments	0.077	18	0.077
Direct radiation	0.00	0.00	0.00
Atmospheric releases[c,d]	0.03	6.8	0.03
Ingestion of groundwater[e]	not applicable	not applicable	not applicable
Total annual dose above background (all relevant pathways)[a]	**0.44**	**100**	**0.44**

[a] Pathways defined in previous sections.
[b] Maximum allowable exposure from all sources is 100 mrem/year (DOE Order 458.1).
[c] DOE source emissions were from NWPGS, NEPCS, DUF_6 conversion activities and includes USEC emissions.
[d] Doses associated with atmospheric releases also include ingestion pathways considered in the AirDose EPA food chain modeling routines.
[e] Groundwater is not a viable pathway for the MEI due to DOE providing public water to downgradient residents.

The cumulative dose to members of the public residing within 50 miles of the PGDP is summed over exposure pathways. The annual cumulative population dose is 6.22 person-rem. Table 4.9 provides a summary of the population dose calculations.

4.1.9 Biota Monitoring and Estimated Dose

Radionuclides from natural and man-made sources are found in PGDP water, sediment, and soils. Those radionuclides may bioaccumulate in animals from eating contaminated feed, drinking contaminated water, and breathing contaminated air and may accumulate in fish when they eat contaminated foods and equilibrate with surrounding contaminated waters and sediment. Because plant and animal populations residing in or near these media or taking food

or water from these media may be exposed to a greater extent than humans.

Table 4.9 Summary of Potential Radiological Dose to the Population within 50 Miles of the Paducah Site for CY 2013[a]

Pathway	Population Dose (person-rem/year)	Percent of Total
Incidental ingestion of surface water[c]	not applicable	not applicable
Ingestion of drinking water (Cairo, Ill)	6.2	99.7
Incidental ingestion of sediments	not applicable	not applicable
Direct radiation	0.00	0
Atmospheric releases[b,e]	0.02	0.3
Ingestion of groundwater[d]	not applicable	not applicable
Total annual dose above background (all relevant pathways)[a]	**6.22**	**100**

[a] Pathways defined in previous sections.
[b] DOE source emissions were from NWPGS, NEPCS, DUF_6 conversion activities and includes USEC emissions.
[c] Incidental ingestion of surface water and sediment within plant creeks and ditches is not applicable for calculation of collective dose to residents who reside within 50 miles of PGDP.
[d] Groundwater is not a viable pathway for the calculation of collective dose due to DOE providing public water to downgradient residents.
[e] Doses associated with atmospheric releases also include ingestion pathways considered in the AirDose EPA food chain modeling routines.

Measured concentrations and bioconcentration factors associated with radionuclides of concern at the PGDP in animals and fish are low so routine site-specific pathway assessments, to include biota sampling are not performed.

Table 4.10 summarizes the radiological dose to aquatic and terrestrial biota for Bayou Creek. Table 4.11 summarizes the radiological dose to aquatic and terrestrial biota for Little Bayou Creek. The sum of fractions for each assessment was less than 1.0, indicating that the applicable concentration guidelines were not exceeded for aquatic and terrestrial biota.

Table 4.10 Bayou Creek 2013 Evaluation of Dose to Aquatic and Terrestrial Biota

Aquatic Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	1.05E+03	0.00E+00	0.0519	4.93E+04	1.05E-06
K-40	101	2.90E+03	3.48E-02	5.85	5.80E+04	1.01E-04
Np-237	0	6.85E+01	0.00E+00	0.126	7.86E+04	1.60E-06
Tc-99	0	2.47E+06	0.00E+00	20	4.69E+05	4.26E-05
Th-228	0	3.74E+02	0.00E+00	0.62	1.64E+04	3.77E-05
Th-230	0	2.57E+03	0.00E+00	0.799	2.74E+06	2.92E-07
Th-232	0	3.04E+02	0.00E+00	0.618	3.29E+06	1.88E-07
Th-234	0	2.67E+05	0.00E+00	9.23	4.33E+04	2.13E-04
U-234	0.882	2.02E+02	4.37E-03	2.7	3.08E+06	8.77E-07
U-235	0.0513	2.17E+02	2.36E-04	0.174	1.05E+05	1.66E-06
U-238	1.63	2.23E+02	7.30E-03	4.73	4.28E+04	1.10E-04
Summed	-	-	**4.67E-02**	-	-	**5.11E-04**

Riparian Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	4.26E+01	0.00E+00	0.0519	3.12E+03	1.66E-05
K-40	101	2.50E+02	4.04E-01	5.85	4.43E+03	1.32E-03
Np-237	0	1.16E+04	0.00E+00	0.126	7.63E+03	1.65E-05
Tc-99	0	6.67E+05	0.00E+00	20	4.22E+04	4.73E-04
Th-228	0	2.04E+03	0.00E+00	0.62	8.05E+02	7.70E-04
Th-230	0	1.39E+04	0.00E+00	0.799	1.04E+04	7.66E-05
Th-232	0	1.68E+03	0.00E+00	0.618	1.30E+03	4.76E-04
Th-234	0	3.81E+06	0.00E+00	9.23	4.33E+03	2.13E-03
U-234	0.882	6.83E+02	1.29E-03	2.7	5.27E+03	5.13E-04
U-235	0.0513	7.36E+02	6.97E-05	0.174	3.73E+03	4.67E-05
U-238	1.63	7.56E+02	2.16E-03	4.73	2.49E+03	1.90E-03
Summed	-	-	**4.08E-01**	-	-	**7.74E-03**

Table 4.11 Little Bayou Creek 2013 Evaluation of Dose to Aquatic and Terrestrial Biota

Aquatic Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	1.05E+03	0.00E+00	0.044	4.93E+04	8.93E-07
K-40	0	2.90E+03	0.00E+00	4.63	5.80E+04	7.98E-05
Np-237	0	6.85E+01	0.00E+00	0.434	7.86E+04	5.52E-06
Pu-239	0	1.87E+02	0.00E+00	0.496	7.04E+06	7.05E-08
Tc-99	0	2.47E+06	0.00E+00	5.7	4.69E+05	1.21E-05
Th-228	0	3.74E+02	0.00E+00	0.768	1.64E+04	4.67E-05
Th-230	0	2.57E+03	0.00E+00	5.36	2.74E+06	1.96E-06
Th-232	0	3.04E+02	0.00E+00	0.712	3.29E+06	2.17E-07
Th-234	0	2.67E+05	0.00E+00	3.39	4.33E+04	7.84E-05
U-234	0	2.02E+02	0.00E+00	4.56	3.08E+06	1.48E-06
U-235	0	2.17E+02	0.00E+00	0.287	1.05E+05	2.74E-06
U-238	10.8	2.23E+02	4.84E-02	8.65	4.28E+04	2.02E-04
Summed	-	-	**4.84E-02**	-	-	**4.32E-04**
Riparian Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	4.26E+01	0.00E+00	0.044	3.12E+03	1.41E-05
K-40	0	2.50E+02	0.00E+00	4.63	4.43E+03	1.04E-03
Np-237	0	1.16E+04	0.00E+00	0.434	7.63E+03	5.69E-05
Pu-239	0	6.22E+02	0.00E+00	0.496	5.86E+03	8.46E-05
Tc-99	0	6.67E+05	0.00E+00	5.7	4.22E+04	1.35E-04
Th-228	0	2.04E+03	0.00E+00	0.768	8.05E+02	9.54E-04
Th-230	0	1.39E+04	0.00E+00	5.36	1.04E+04	5.14E-04
Th-232	0	1.68E+03	0.00E+00	0.712	1.30E+03	5.48E-04
Th-234	0	3.81E+06	0.00E+00	3.39	4.33E+03	7.84E-04
U-234	0	6.83E+02	0.00E+00	4.56	5.27E+03	8.66E-04
U-235	0	7.36E+02	0.00E+00	0.287	3.73E+03	7.70E-05
U-238	10.8	7.56E+02	1.43E-02	8.65	2.49E+03	3.48E-03
Summed	-	-	**1.43E-02**	-	-	**8.55E-03**

4.2 CLEARANCE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

Property potentially containing residual radioactive material is not cleared from PGDP unless the property does not to contain residual radioactive material or the property monitored to determine that any residual radioactive materials concentrations are within acceptable limits. DOE sets authorized limits for the release of property. Each DOE contractor establishes property clearance requirement procedures.

In 2013, LATA Kentucky assessed and authorized 115 releases of non-real property. Several property releases supported reuse and recycling efforts. Multiple radiological surveys were performed to measure and assess the radiological status of the property prior to release. Items released included heavy equipment, vehicles, containers, tanks, monitoring equipment, activated carbon, batteries, recovered Freon, transformers, light ballasts, unused chemicals, and mobile offices. Items with potential volumetric contamination were assessed and compared to background to support release.

In 2013 *B&W Conversion Services, LLC* continued off-site shipment of hydrofluoric acid produced by the DUF_6 Conversion Facility, which converts DUF_6 into uranium oxide and

hydrofluoric acid. Each shipment must meet the release limit of less than 3 pCi/mL of total uranium activity. During 2013, 1,318,813 gal of hydrofluoric acid were shipped off-site, and the total uranium activity of each shipment was < 1.06 pCi/mL.

In addition to off-site releases, DOE also placed some 810 tons of waste with residual radioactive contamination into the on-site C-746-U Landfill during 2013. Waste streams disposed of within the C-746-U Landfill included building demolition debris, scrap metal, soil, personal protective clothing, investigation derived wastes, and concrete. Table 4.12 provides a summary of Authorized Limit disposals at the C-746-U Landfill and the cumulative totals since Authorized Limit inception in May 2003.

Table 4.12 C-746-U Landfill Authorized Limit Disposals at C-746-U Landfill

Cumulative Activity from 2013 Disposals		Total Activity from Disposals 5/21/03 to 12/31/13			
Isotope	Activity (Curies)	Isotope	Activity (Curies)	Inventory Limit (Curies)	Percent Utilized
Am-241	0.000086974	Am-241	0.00616688	79	0.01%
Cs-137	0.000062775	Cs-137	0.01013736	43	0.02%
Np-237	0.000078427	Np-237	0.01141782	12	0.10%
Pu-238	0.000043004	Pu-238	0.00186785	88	0.00%
Pu-239/240	0.000086858	Pu-239/240	0.01376221	162	0.01%
Tc-99	0.005990041	Tc-99	1.01231318	117	0.87%
Th-228	0.000307886	Th-228	0.33676058	9	3.74%
Th-230	0.000475479	Th-230	0.58066208	230	0.25%
Th-232	0.000336776	Th-232	0.00055218	9	0.01%
U-234	0.003997262	U-234	0.00421266	360	0.00%
U-235	0.000247034	U-235	0.00046244	15	0.00%
U-238	0.008818624	U-238	0.00903403	360	0.00%

Waste Streams Disposed of (2013)	10	Waste Streams Disposed of (2003–2013)	250
Mass Disposed of (2013)	810 tons	Mass Disposed (2003–2013)	121,000 tons
		Volume of Current Cells	386,169 yd^3
		Remaining Cell Volume	68,680 yd^3

4.3 UNPLANNED RADIOLOGICAL RELEASES

During the winter and spring of 2013, an unplanned radiological release occurred as a result of high amounts of rainfall onto the C-340 demolition project. The C-340 facility was used to produce uranium tetrafluoride and uranium metal. Demolition activities using heavy equipment to disassemble and downsize the building structure and internal components. Uranium residues from piles of demolition debris located on the C-340 footprint were mobilized by multiple rain events in the spring and summer. Uranium was detected at increased levels in Outfalls 010 and 011 which receive runoff from the C-340 area. Upon notification of the uranium results, the demolition project undertook corrective actions in an attempt to further mitigate the release by increasing the use of sediment controls, fixatives, and improved housekeeping.

The impacts of the unplanned release on the dose received by the MEI and biota have been discussed in previous sections. Outfalls 010 and 011 drain to Little Bayou Creek. Little Bayou Creek is not a source of drinking water; dose to the MEI was calculated assuming only incidental ingestion during recreational activities. Further, Little Bayou Creek is posted and controlled in accordance with 10 *CFR* 835, which further limits public access. Due to these considerations, the resultant dose to the MEI from incidental surface water ingestion was found to be insignificant at 0.32 mrem/y.

5.0 Environmental Nonradiological Program Information

PGDP environmental monitoring addresses releases of radioactive and non-radioactive materials to the air, surface water, groundwater, sediment and soil. Non-radioactive materials are addressed as part of nonradiological monitoring.

5.1 Air Monitoring

Steam plant emissions are the largest monitored nonradiological point source at the site and monitoring of the steam plant emissions was conducted by USEC during plant operations. The only DOE point source that required monitoring is the DUF6 conversion Facility which during 2013 released approximately 61.7 lb of HF.

5.2 Surface Water Monitoring

Surface runoff is analyzed to ensure that site landfills are not releasing constituents to nearby streams. Monitoring results are summarized in Tables 5.1 and 5.2 and additional records are available through the PEGASIS web site, http://padgis.latakentucky.com/padgis.

5.3 Sediment Monitoring

During 2013, PCBs were detected in sediment at concentrations ranging from 110 µg/kg to 2,250 µg/kg. Sediment monitoring locations are shown in Figure 4.5. The no action level for PCBs is 284 µg/kg for the teen recreational user and the action level is 28,400µg/kg (DOE 2013b, *Methods for Conducting Risk Assessments and Risk Evaluations at the PGDP)*. Evaluation of sediment concentration results will be continued in future years for locations where the no action level was exceeded but the concentration was less than the action level. Additional monitoring results are available through the PEGASIS Website at http://padgis.latakentucky.com/padgis.

5.4 Biota Monitoring

Due to the extensive watershed monitoring of Bayou Creek and Little Bayou Creek since 1987 biological monitoring is no longer required.

5.4.1 Aquatic Life

Chronic and acute toxicity sampling are still conducted under KPDES permit guidelines. Warning signs remain along Bayou and Little Bayou Creeks to warn the public about possible risks posed by recreational contact with these waters, stream sediments and fish caught in the creeks.

Table 5.1 Surface Water Monitoring Summary

Program	Number of Locations
Effluent Watershed Monitoring Program	
C-746-S and C-746-T Landfill Surface Water *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00224 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00357 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00374	3*
C-746-U Landfill Surface Water *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00320 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00356 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00375	3*
KPDES Monthly Discharge Monitoring Reports	5
C-613 Northwest Storm Water Control Facility Reported to KDWM via electronic mail	1
Environmental Surveillance Watershed Monitoring Program	
Surface Water	19
Seep	1

*One location is listed for both C-746-S and C-746-T and for C-746-U.

Table 5.2 Ranges of Detected Analytes in 2013 Surface Water Samples

Analyte	Range
Anions	
Chloride (mg/L)	2.3–35
Nitrate as Nitrogen (mg/L)	1.7–2.6
Sulfate (mg/L)	4–46
Wetchemistry Parameters	
Carbonaceous Biochemical Oxygen Demand (mg/L)	5–9
Chemical Oxygen Demand (mg/L)	26–76
Dissolved Solids (mg/L)	40–1970
Hardness—Total as $CaCO_3$ (mg/L)	16–560
Suspended Solids (mg/L)	8–492
Total Organic Carbon (mg/L)	1.3–24.8
Total Organic Halides (µg/L)	7.4–97
Total Solids (mg/L)	104–762
Semivolatile Organic Compounds	
Benz(a)anthracene (µg/L)	0.0025–0.009
Benzo(k)fluoranthene (µg/L)	0.006–0.0069
Volatile Organic Compounds	
Trichloroethene (µg/L)	1.7–41
Pesticides/PCBs	
Heptachlor (µg/L)	0.0088–0.0088
PCB-1248 (µg/L)	0.16–0.69
PCB-1254 (µg/L)	0.13–0.13
PCB-1260 (µg/L)	0.06–0.07
Polychlorinated biphenyl (µg/L)	0.26–0.69
Metals	
Arsenic (mg/L)	0.00106–0.00481
Barium (mg/L)	0.0118–0.131
Iron (mg/L)	0.0094–5.9
Lead (mg/L)	0.00282–0.00282
Nickel (mg/L)	0.00584–0.00933
Phosphorous (mg/L)	0.09–0.76
Selenium (mg/L)	0.00545–0.021
Sodium (mg/L)	0.971–8.57
Uranium (mg/L)	0.00101–1.74
Zinc (mg/L)	0.0207–2.81

5.5 Groundwater Monitoring

DOE Orders, Federal and Commonwealth of Kentucky regulations require groundwater monitoring and protection. Groundwater is not used for onsite purposes and DOE provides an alternate treated water supply to residence in areas where groundwater contamination has been identified or could possibly occur in the future. See Chapter 6 for additional information regarding groundwater monitoring.

6.0 GROUNDWATER PROTECTION PROGRAM

DOE, the U.S. EPA, and the Commonwealth of Kentucky require the PGDP to monitor and protect the groundwater resources at the PGDP. Since groundwater contamination related to the PGDP was discovered offsite in 1988, DOE and regulatory agencies have completed many groundwater investigation projects to identify the nature and extent of site-related groundwater contamination and to identify the sources of groundwater contamination. Based on investigations a number of actions have been completed and others are ongoing to stop releases of contamination to groundwater and decrease the extent and concentrations of contaminated groundwater.

Protecting groundwater from future contamination and cleanup of contaminated groundwater are primary concerns for environmental cleanup activities at the PGDP site.

6.0.1 Groundwater Protection and Monitoring Background

The Results of the Site Investigation Phase 1 determined the primary off-site contaminants in Regional Gravel Aquifer groundwater to be trichloroethylene (TCE) and technetium-99 (Tc-99) (see Section 6.1).

TCE was first widely produced in the 1920's to extract vegetable oils from plants. But it's most popular use is as a metal degreaser. TCE was used extensively as an industrial degreasing solvent at the PGDP until 1993. The extent of TCE groundwater contamination is shown on Figure 6.1.

Two areas of TCE groundwater contamination, referred to as the Northeast and Northwest Plumes, extend for more than two miles beyond the PGDP industrial site. One smaller area of TCE groundwater contamination, the Southwest Plume is located on the DOE industrial site and a smaller area of TCE groundwater contamination occurs north of the DOE industrial site at a landfill complex. Tc-99 is found in groundwater associated with the Northwest Plume, Southwest Plume and near-site portions of the Northeast Plume.

Tc-99 is a nuclear fission by-product contained in used nuclear power reactor fuel rod material that, until 1976, was brought to the PGDP for re-enrichment of its U-235 component. Tc-99 is still present in environmental media and waste. The chemical form of Tc-99 found at the PGDP is very soluble in water which contributes to its identification as a primary PGDP groundwater contaminant in site investigations. Potential sources for the Tc-99 include former test areas, spills, leaks, buried waste, and leachate taken from contaminated scrap metal.

Site environmental investigations indicate that the main source of TCE contamination in groundwater is near the C-400 Cleaning Building where TCE was delivered in railcars, stored and used in large quantities for cleaning process equipment. TCE has a low solubility in water and a higher density than water which allows it to sink through the subsurface where it may form pools on less permeable layers of the subsurface or where it may remain trapped in smaller amounts between grains of sand, gravel, silt and clay. Pooled and trapped TCE slowly dissolves

in groundwater which makes treatment difficult because the TCE source can be deep within the aquifer.

The Environmental Surveillance Groundwater Monitoring Program is reviewed each year and modified as appropriate to continue to delineate the boundaries of the contaminant plumes over time. A summary of detected analytes in 2013 are shown in Table 6.2 (Ranges of Detected Analytes in 2013 Monitoring Well Groundwater Samples).

6.1. Geology and Hydrogeology of the PGDP

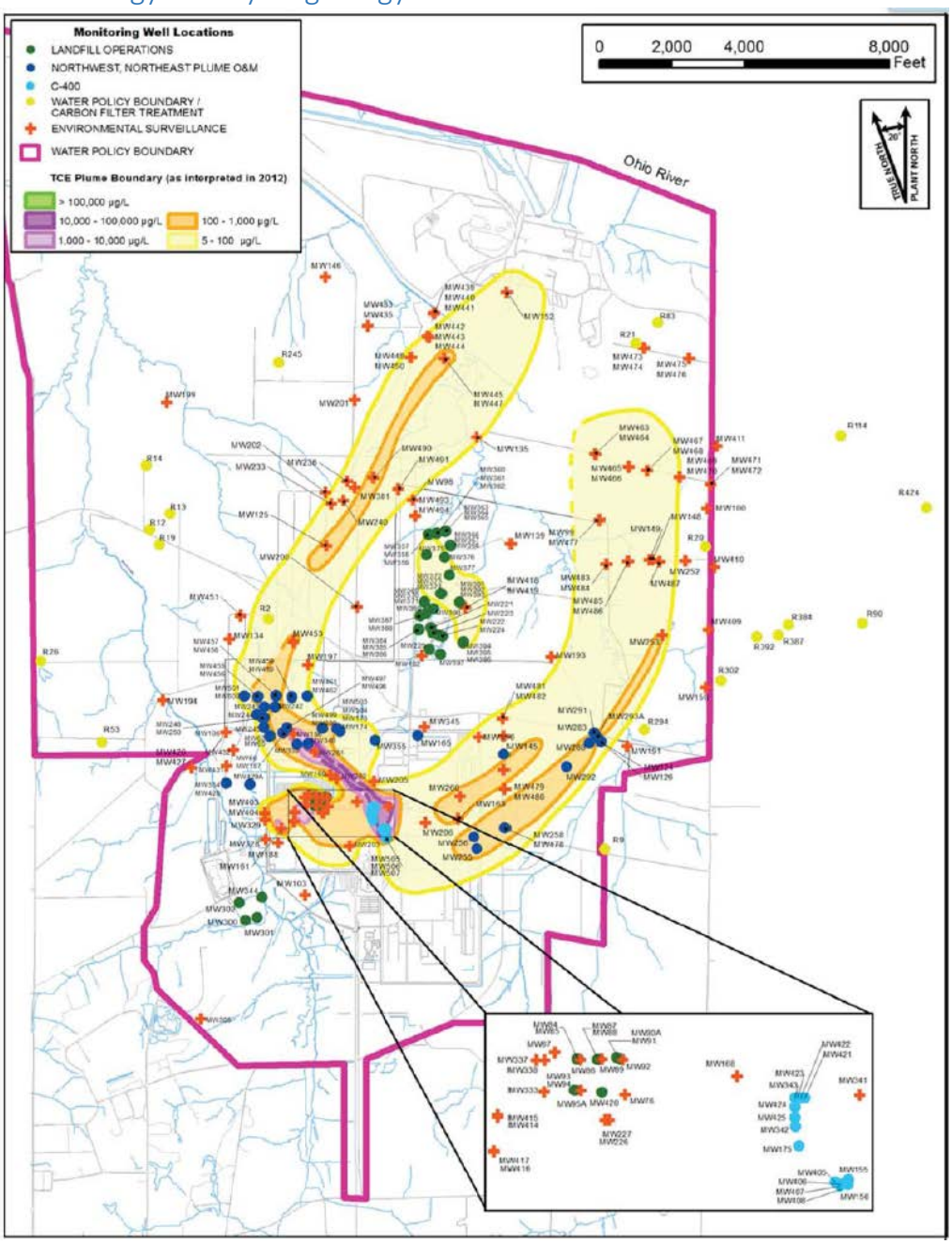

Figure 6.1. PGDP 2012 TCE Groundwater Plumes and Groundwater Monitoring Wells Sampled in CY 2013

Paducah is part of the Mississippian Embayment of the Gulf Coastal Plain Province, an area where the ancient Gulf of Mexico extended northward from its present position to southern Illinois. In the subsurface of the Province thick sand, silt and clay deposits overlie bedrock. Bedrock occurs at depths from hundreds to thousands of feet below ground surface.

Infiltrating precipitation and surface water recharge the local aquifer which is identified as the Regional Gravel Aquifer (RGA) beneath the PGDP. RGA groundwater discharges to local streams and wetlands or it may ultimately discharge to the Ohio River. The components of the groundwater flow system at the PGDP are illustrated in Figure 7.

Additional information regarding the geology and hydrogeology of PGDP can be found in the *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (available at http://paducaheic.com/Search.aspx?accession=I-02500-0030) (MMES, 1992).

6.2 Groundwater Usage

Surrounding the PGDP are lightly populated farmlands, the West Kentucky Wildlife Management Area and rural homes. The communities of Grahamville and Heath are located within 2 miles of the PGDP.

Historically, RGA groundwater was the main source of drinking water for local residents and the main source of water for industrial and agricultural use in the vicinity of the PGDP. In areas where groundwater is known to be contaminated or is suspected of becoming contaminated in the near future, DOE provides water from the West McCracken County Water District and pays the water bills for residences, businesses and farms. Residential and agricultural wells in the vicinity of the PGDP have been capped and locked except for those that are used by DOE as part of its groundwater monitoring system.

Groundwater monitoring provides early detection of any contamination resulting from land disposal and release of wastes and provides data that can be used if contamination is detected. Table 6.1 shows the monitoring and reporting locations for each of the programs that requires groundwater monitoring.

Groundwater monitoring is used to detect the nature and extent of contamination and to determine the movement of groundwater and contamination near the PGDP. Monitoring data is used to make decisions for the removal or containment of contamination. Fig 6.2 shows monitoring wells that were sampled in 2013. Figure 6.2 also shows the 2012 TCE plume map that is revised every two years. Figure 6.3 shows maps of the Northwest Plume from 2000 to 2012 and shows how the plume is decreasing over the years.

Groundwater monitoring at the PGDP addresses general environmental surveillance, current and inactive landfills, groundwater contaminant plume pump-and-treat operations, the C-400 Cleaning Building, and area residential wells.

The PGDP groundwater plume maps are revised every two years to provide a basis for timely planning and cleanup. Procedures have been put in place to clean up the Northwest and Northeast Plume, the C-400 building and the Southwest Plume. Figure 6.3 shows the location of the groundwater plumes and groundwater pump and treat facilities. Table 6.3 summarizes the gallons of TCE that have been removed from extracted groundwater.

Groundwater monitoring at several Landfill Wells, showed that they exceeded the maximum contaminant level. The beta activity and TCE in the wells were sourced from upgradient of the

landfill and associated with the migration of historical plumes. A summary is shown in Table 6.4

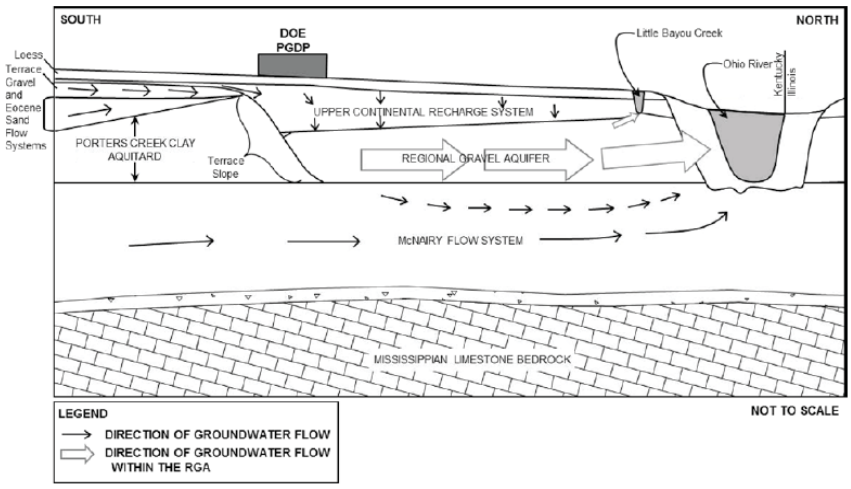

Figure 6.2. Paducah Site Groundwater Flow System

Table 6.1 Summary of Groundwater Monitoring at the PGDP

Program	Number of Wells				
	Terrace Gravel[a]	RGA	UCRS	Rubble Zone	Total
Groundwater Monitoring Program for Landfill Operations					
C-746-S and C-746-T Landfill Wells *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00224 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00357 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00374	0	18	5	0	23[b]
C-746-U Landfill Wells *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00320 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00356 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00375	0	13	8	0	21
C-404 Landfill Wells (required by permit) Semiannual C-404 Groundwater Monitoring Reports: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00223 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00358	0	5	4	0	9
C-404 Landfill Wells (noncommitted)	0	11	0	0	11[c]
C-746-K Landfill Wells Semiannual FFA Progress Reports: http://paducaheic.com/Search.aspx?accession=env 1.A-00527	4	0	0	0	4
Northeast Plume Operations and Maintenance Program Semiannual FFA Progress Reports (see above for links)					
Semiannual Wells	0	11	0	0	11[d]
Quarterly Wells	0	5	0	0	5
Northwest Plume Operations and Maintenance Program Semiannual FFA Progress Reports (see above for links)					
Semiannual Wells	0	33	0	0	33
C-400 Monitoring Wells Semiannual FFA Progress Reports (see above for links)					
Semiannual Wells	0	8	0	0	8
Quarterly Wells	0	9	0	0	9
Water Policy Boundary Monitoring Program ASER					
Northwestern Wells	0	22	0	0	22
Northeastern Wells	0	11	0	0	11

Carbon Filter Treatment System ASER	0	1	0	0	1
Environmental Surveillance Groundwater Monitoring Program ASER					
Biennial Wells	1	96	4	0	101
Annual Wells	0	26	1	1	28[d]
Geochemical Environmental Surveillance	0	39	0	0	39[e]

[a] Includes Eocene Sands.

[b] The total number of wells where sampling is required by the permit associated with the C-746-S&T Landfills is 25; however, 2 of these wells are required by the permit only for water level measurement. The total number of analytically measured wells, therefore, is 23.

[c] The total number of wells associated with the C-404 Landfill noncommitted wells is 11; however, these wells also are included in the Environmental Surveillance Groundwater Monitoring Program.

[d] Three wells were revised mid-CY 2013 from sampling under the Environmental Surveillance Program to the Northeast Plume Operations and Maintenance Program. At the end of CY 2013, the number of total wells under the Northeast Plume Operations and Maintenance Program was 14 and the Environmental Surveillance Groundwater Monitoring Annual Wells was 25.

[e] The total number of wells associated with the Geochemical Environmental Surveillance monitoring is 39; however, these wells also are monitored in other programs.

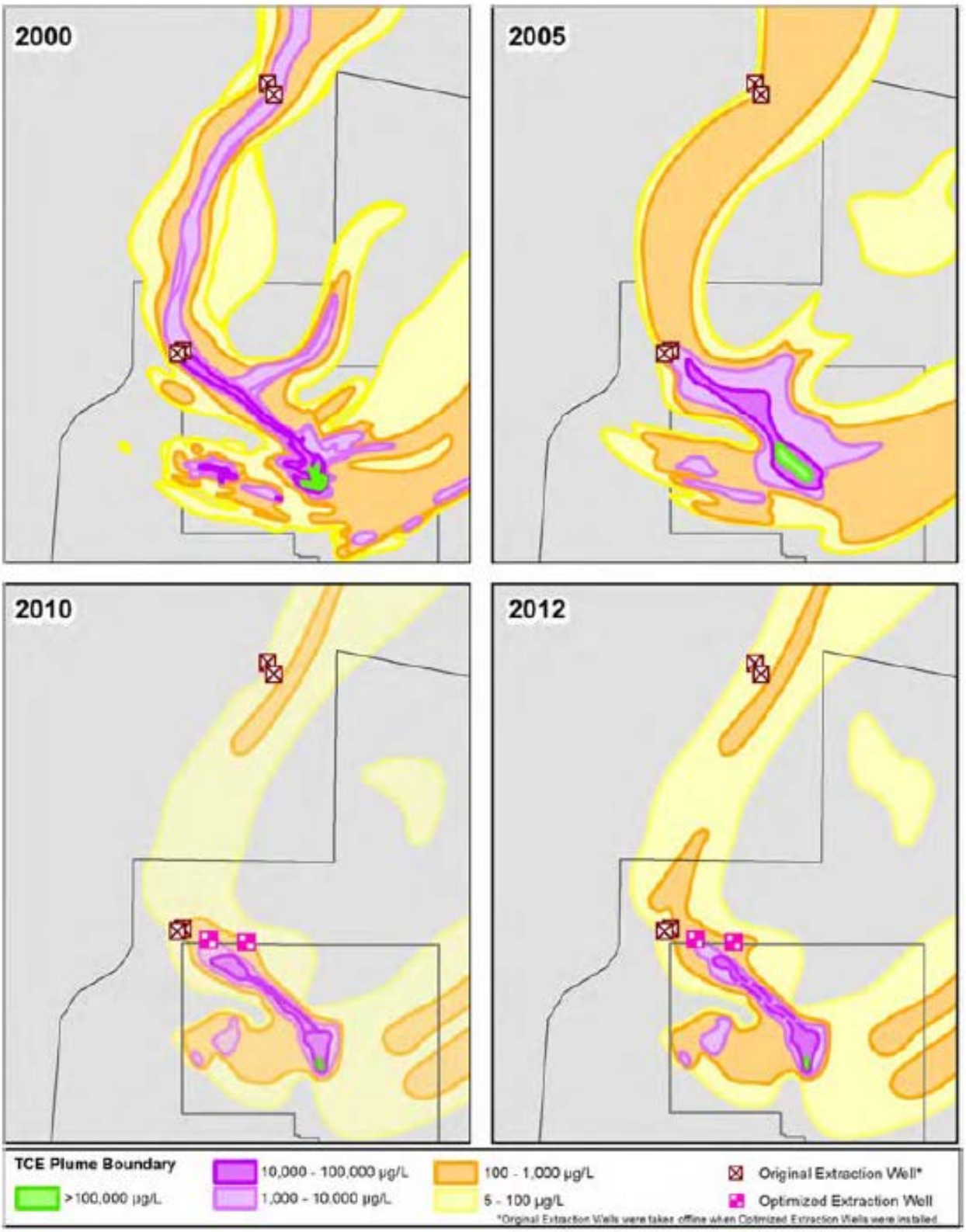

Figure 6.3. PGDP Northwest Plume Groundwater TCE Concentrations 2000 - 2012

Agreements have been put in place to clean up the Northwest Plume, the Northeast Plume, the

C-400 Cleaning Building source area, and sources to the Southwest Plume. These documents can be found in the PGDP Environmental Information Center. Table 6.3 lists the cumulative TCE removed through these projects. The locations of the Northwest and Northeast Plume Pump and Treat Systems are shown in Figure 6.2. The graphs shown in Figures 6.4 and 6.5 illustrate the cumulative TCE removed by the NWPGS and the NEPCS.

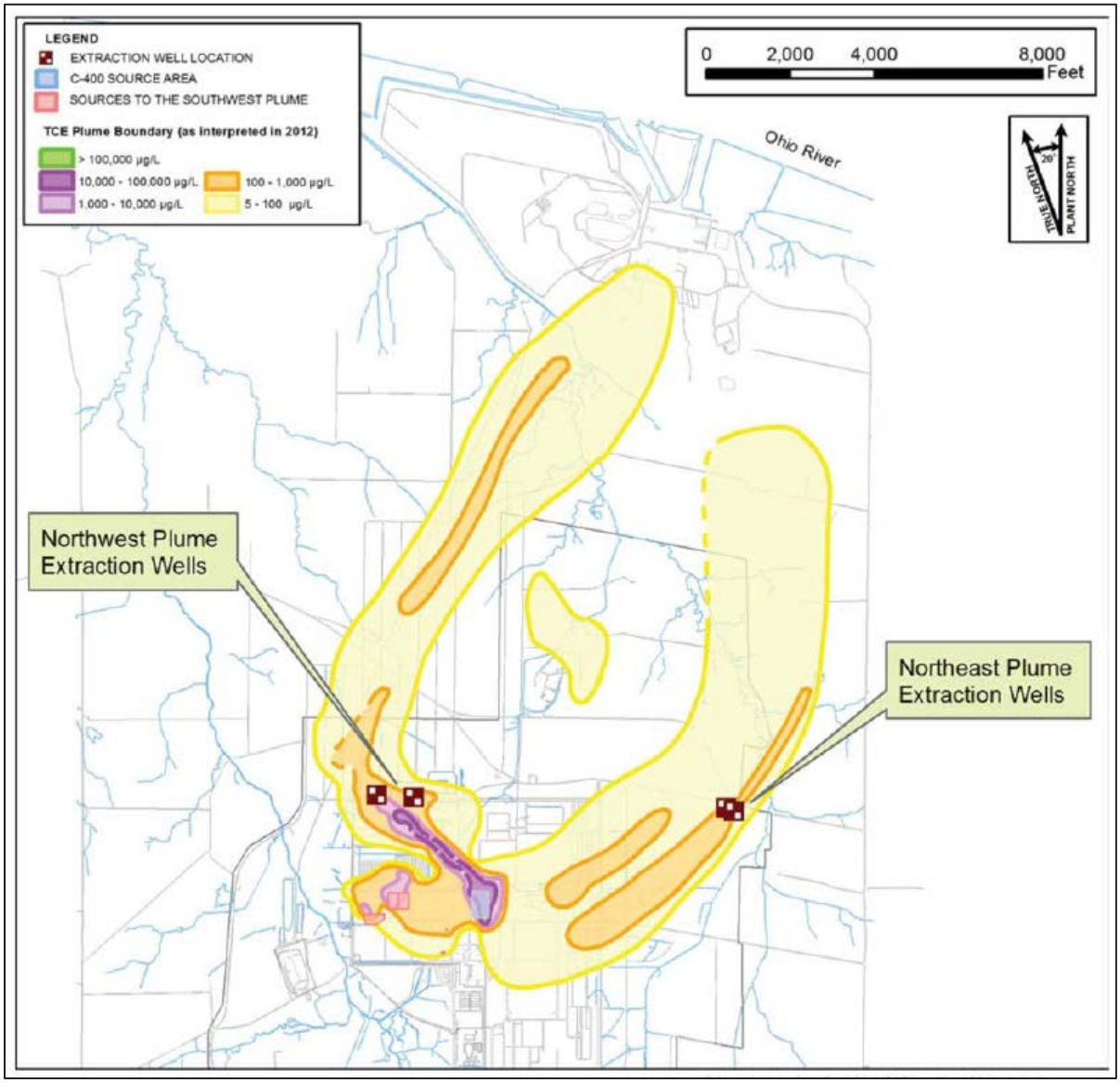

Figure 6.4. Locations of PGDP Groundwater Pump and Treat Extraction Wells

.

Table 6.2 Ranges of Detected Analytes in 2013 Monitoring Well Groundwater Samples

Analyte	Range
Anions	
Chloride (mg/L)	5.1–190*
Fluoride (mg/L)	0.11–0.72
Nitrate as Nitrogen (mg/L)	1–4.5
Sulfate (mg/L)	4.9–1,740
Wet Chemistry Parameters	
Alkalinity (mg/L)	78–382
Chemical Oxygen Demand (mg/L)	26–38
Dissolved Solids (mg/L)	140–618
Iodide (mg/L)	2.6–2.6
Total Organic Carbon (mg/L)	1–12.9
Total Organic Halides (µg/L)	7–290
Radionuclides	
Alpha activity (pCi/L)	3.98–45.2
Beta activity (pCi/L)	4.27–999
Technetium-99 (pCi/L)	16.2–14,900*
Tritium (pCi/L)	572–707
Uranium-234 (pCi/L)	0.301–0.9
Uranium-238 (pCi/L)	0.067–1.01
Volatile Organic Compounds	
1,1-Dichloroethane (µg/L)	1.4–73
1,1-Dichloroethene (µg/L)	1–110
1,2,3-Trichloropropane (µg/L)	16-16
Carbon tetrachloride (µg/L)	28–28
Chloroform (µg/L)	1.2–73
cis-1,2-Dichloroethene (µg/L)	1.1–75,000*
trans-1,2-Dichloroethene (µg/L)	2.2–2.2
Trichloroethene (µg/L)	1–480,000*
Vinyl chloride (µg/L)	5.2–290

*Maximum results are from C-400 MWs.

Analyte	Range
PCBs	
PCB-1242 (µg/L)	0.11–0.31
PCB-1248 (µg/L)	0.57–0.57
PCB-1254 (µg/L)	4.74–5.76
Polychlorinated biphenyl (µg/L)	0.18–5.76
Metals	
Aluminum (mg/L)	0.201–10.9
Arsenic (mg/L)	0.00101–0.0135
Barium (mg/L)	0.0144–0.418
Beryllium (mg/L)	0.00102–0.00102
Boron (mg/L)	0.222–2.02
Cadmium (mg/L)	0.00112–0.00112
Calcium (mg/L)	8.21–512
Chromium (mg/L)	0.0109–2.12
Cobalt (mg/L)	0.00105–0.0404
Iron (mg/L)	0.103–292
Iron (2+) (mg/L)	130–300
Lead (mg/L)	0.00132–0.0142
Magnesium (mg/L)	2.86–120
Manganese (mg/L)	0.00541–23.6
Molybdenum (mg/L)	0.0011–0.00686
Nickel (mg/L)	0.00503–0.406
Potassium (mg/L)	0.233–47.9
Selenium (mg/L)	0.00504–0.0274
Sodium (mg/L)	16.6–154
Uranium (mg/L)	0.00145–0.0135
Zinc (mg/L)	0.0215–0.0215
Arsenic, Dissolved (mg/L)	0.00126–0.0135
Barium, Dissolved (mg/L)	0.0141–0.434
Chromium, Dissolved (mg/L)	0.0107–0.0162
Lead, Dissolved (mg/L)	0.00253–0.00253
Selenium, Dissolved (mg/L)	0.00674–0.00674
Uranium, Dissolved (mg/L)	0.00131–0.0063

Table 6.3 Cumulative TCE Removed from PGDP Groundwater

Source Area	Cumulative TCE Removed (gals)
Northwest Plume Groundwater System	3,250
Northeast Plume Containment System	284
C-400 (including treatability study)	2,545[a]
Southwest Plume[b]	0
Other sources (i.e., SWMU 91, LASAGNAT>)	246

[a] Cumulative through September 30, 2013.
[b] No remedial action implemented to date.

Table 6.4 Summary of MCL Exceedances for C-746-S & -T and C-746-U in 2013

C-746-S and C-746-T Landfills		
UCRS	**Upper RGA**	**Lower RGA**
None	MW372: beta activity, trichloroethene MW384: beta activity MW387: beta activity MW39l: trichloroethene MW394: trichloroethene	MW373: beta activity, trichloroethene MW385: beta activity MW388: beta activity MW392: trichloroethene
C-746-U Landfill		
UCRS	**Upper RGA**	**Lower RGA**
None	MW357: trichloroethene MW372: beta activity, trichloroethene	MW358: trichloroethene MW361: trichloroethene MW373: beta activity, trichloroethene

Shading indicates a background MW.

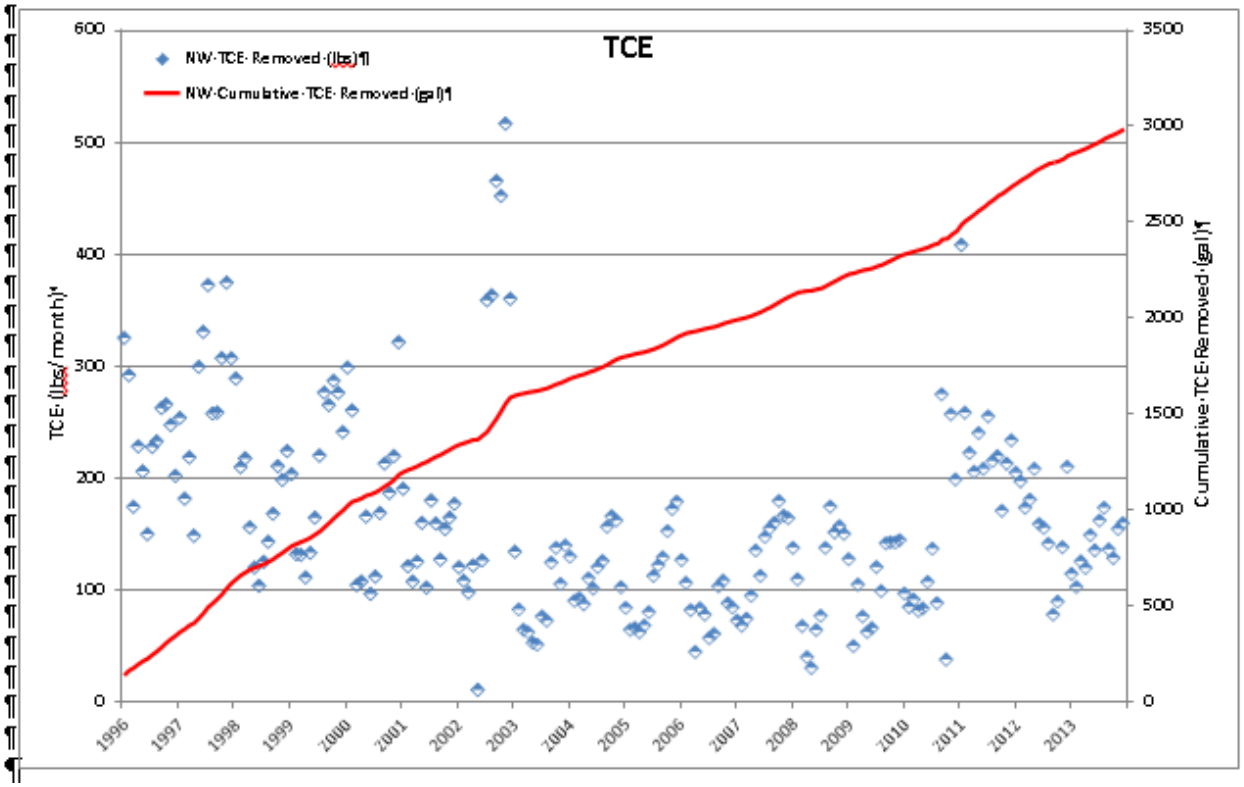

Figure 6.5. Northwest Plume Pump and Treat TCE removal.

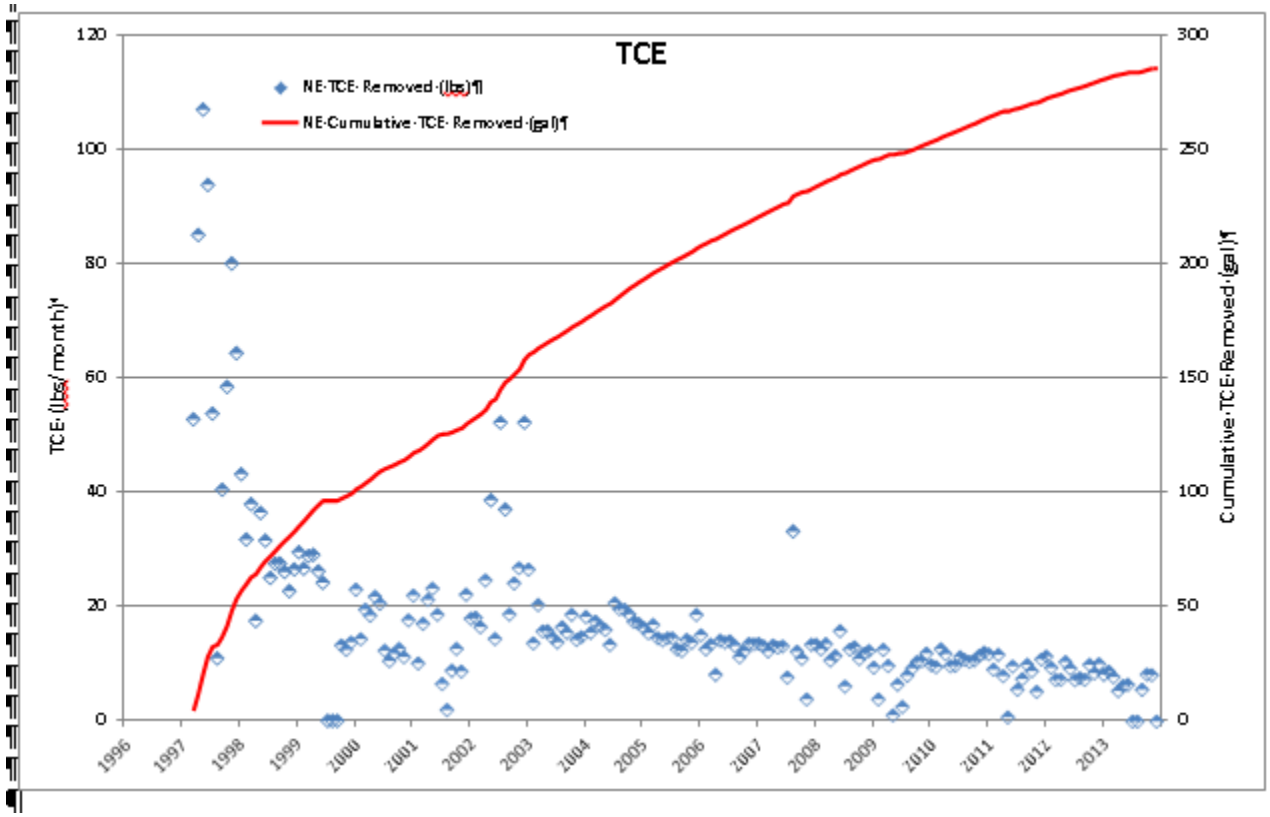

Figure 6.6. Northeast Plume Pump and Treat TCE removal.

7. QUALITY ASSURANCE

To ensure that data being released to government agencies and the public accurately reflects the conditions around the PGDP, a Quality Assurance and Quality Control (QA/QC) Program is in place. The QA/QC Program addresses activities for environmental monitoring as well as health and safety and covers sample collection, sample analyses, data recording, data management and data assessment. The PGDP QA/QC Program is required to meet guidelines established by DOE, the PGDP site, and organizations responsible for setting industry standards including the following:

- DOE Order 414.1D, *Quality Assurance*;
- *Quality Assurance Program and Implementation Plan*, PAD-PLA-QM-001 (LATA Kentucky 2013f);
- Commonwealth of Kentucky and federal regulations and guidance from EPA;
- American National Standards Institute;
- American Society of Mechanical Engineers;
- American Society for Testing and Materials; and
- American Society for Quality Control.

The QA/QC Program requires that projects conducted at the PGDP include Quality Assurance (QA) plans. PGDP uses DOE's Consolidated Audit Program to audit laboratories responsible for analyses of PGDP samples. The laboratories undergo annual performance audits to ensure that data being generated is accurate.

The PGDP Environmental Monitoring Plan (EMP) defines the elements of project QA Plans for meeting key quality and data management requirements. The QA Plan implemented in 2013 is an appendix to the PGDP EMP (LATA Kentucky 2012/2013) and applies to individual projects. Additional procedures that ensure quality in all projects include; use of standard forms; documentation of communication between field sampling and data management organization; standard labeling of samples, chain of custody forms; and standard preparation of logbooks.

These procedures described above and the EMP QA Plan were effective and covered data and project activities from January-December of 2013.

7.1 FIELD SAMPLING QUALITY CONTROL

7.1.1 Data Quality Objectives and Sample Planning

Data Quality Objectives (DQOs) play an important role in any sampling program. This includes determining the number of samples, sampling methods, and sampling schedules.

Each sample and sampling location has its own identification number. A statement of work (SOW) is generated for each project to track the project's progress from planning to implementing DQO's.

7.1.2 Field Measurements

Many measurements for the groundwater and surface water monitoring program are collected in the field. They include water level, pH, temperature, dissolved oxygen, etc. Environmental conditions, such as ambient temperature, are recorded. Measurements are collected manually, downloaded from instruments, recorded, and then entered into PEMS (Project Environmental

Measurements System) database.

7.1.3 Sampling Procedures

Samples are collected according to EPA approved sampling methods using media-specific procedures. Sample media consist of surface water, groundwater, and sediment. Sample information consists of the sample ID number, station (location), date, time, and the person who performed sampling. This information is put into PEMS.

7.1.4 Field Quality Control Samples

The QC Program specifies a minimum target rate of 5%, or 1 per 20 for field QC samples. Table 7.1 shows the types of field QC samples collected and analyzed. Analytical results are evaluated to determine if the sampling event biased he sample results.

Table 7.1 Field and Laboratory Quality Control Samples

Field QC Samples	Laboratory QC Samples
Field blanks[a]	Laboratory duplicates
Field duplicates	Reagent blanks
Trip blanks[a]	Matrix spikes[b]
Equipment rinseates[c]	Matrix spike duplicates
	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 overall method effectiveness during the analysis process, as well as possible sample/matrix interferences.
[c] Rinseates = Samples of deionized water that have been used to rinse the sampling equipment. It is collected after completion of decontamination and prior to sampling. It is used to assess adequate decontamination of sampling equipment.

7.2 ANALYTICAL LABORATORY QUALITY CONTROL

7.2.1 Analytical Procedures

When available and appropriate for environmental media samples, EPA SW-46 methods are used for analyses. When SW-46 methods are not available, other methods are used, such as American Society for Testing and Materials. Using guidance from EPA laboratories document the steps in the analytical and data reporting process.

7.2.2 Independent Quality Control

The Paducah Site is required by DOE and EPA to participate in independent QC Programs. Results exceeding acceptable limits are investigated and documented according to formal procedures. The degree of participation is voluntary.

These programs are conducted by EPA, DOE, and commercial laboratories.

The EPA and KDOW require a laboratory QA study. Each laboratory demonstrating KPDES (Kentucky Pollutant Discharge Elimination System) permit compliance is required to participate. Final reports were “acceptable” for the Discharge Monitoring Report QA Study Number 33. Results were provided to KDOW and EPA.

7.2.3 Laboratory Audits/Sample and Data Management Organization

Laboratory audits are performed annually by DOE Consolidated Audit Program to make sure labs are meeting regulations, methods, and procedures and that laboratories are included on the audited listing.

7.3 DATA MANAGEMENT

7.3.1 Project Environmental Measurement System

Data generated from sampling events are stored in PEMS (a system for tracking and managing data.) The system is used to manage/import/input data identified in the data review process. It is then transferred to the Paducah OREIS (Oak Ridge Environmental Information System) database.

7.3.2 Paducah OREIS

OREIS is the database used to consolidate data generated by the EMP. Data consolidation includes the activities necessary to prepare evaluated data. The data manager notifies the project team of available data. OREIS data is distributed to external agencies.

7.3.3 PEGASIS

The Paducah Environmental Geographic and Spatial Information System (PEGASIS) allows access to environmental sampling data and site-specific geographic information system features through the Internet. PEGASIS includes maps, GIS data, analytical sample results, restoration reports, etc. Environmental data is loaded to PEGASIS on a monthly basis.

7.3.4 Electronic Data Deliverables

An electronic data deliverable is requested for all samples analyzed by each laboratory conducting work at the PGDP. Results and fields provided are checked and discrepancies are corrected. Ten percent of the data is checked randomly to ensure data meets quality assurance and quality control standards.

7.3.5 Data Packages

A "forms only" Level III data package is requested when a data validation is to be performed. All data packages are tracked, reviewed, and maintained in a secure environment. The information tracked includes sample delivery group number, date received, receipt of EDD, and comments. All data packages are forwarded to the Document Management Center for permanent storage.

7.3.6 Laboratory Contractual Screening

This is the process of evaluating a set of data against the requirements specified in the SOW for a project to ensure all requested information is received. The contractual screening includes he chain-of-custody form, analytical information requested, analysis method used, data units, sample holding times, and sample reporting limits achieved. Laboratory contractual screening is conducted electronically.

Data verification is the process performed by a qualified individual. Data validation evaluates laboratory adherence to analytical method requirements. Data from sampling events are validated at a frequency of 5% of total data packages. Each of the selected packages is validated 100%.

Data assessment is the process for ensuring that the type, quality, and quantity of data are appropriate based on the DQOs for a project. DQOs allow for determination that a decision based on the data can be made with the specified and desired level of confidence. The data assessment is conducted by trained personnel and other project team members. Assessment qualifiers are stored in the PEMS and transferred to Paducah OREIS. Data is made available (released) upon completion of the data assessment. Rejected data identified in the data validation process is noted in OREIS.

APPENDIX 1: MCHS PGDP SITE ACTIVITIES

APPENDIX 2: MCHS WKWMA FIELD ACTIVITIES