DOE/OR/07-2150&D2/R2
Primary Document

Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant Paducah, Kentucky

July 2005

Cleared for Public Release

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not
be considered an eligible contractor for its review.

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Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant Paducah, Kentucky

Date Issued—July 2005

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

Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
Paducah, Kentucky 42001
managed by
Bechtel Jacobs Company LLC
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-ACO5-03OR22980

04-076(E)/072705

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PREFACE

This *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2150&D2/R2, was prepared in accordance with requirements under the Comprehensive Environmental Response, Compensation, and Liability Act, Resource Conservation and Recovery Act, and KRS 224.46-530 for documenting the selection of a preferred remedial action, or corrective measure, for a solid waste management unit. This document was generated as a D1 version under the title *Record of Decision for Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky.* The title was changed to include the Groundwater Operable Unit in response to a comment.

Publication of this document will meet a primary document deliverable for the U.S. Department of Energy, pursuant to the Paducah Gaseous Diffusion Plant's *Federal Facility Agreement*, DOE/OR/07-1707.

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FIGURES

TABLES

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ACRONYMS AND ABBREVIATIONS

ACO	Administrative Order by Consent
ALARA	as low as reasonably achievable
AOC	area of concern
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
BMP	Best Management Practice
CAB	Citizens Advisory Board
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
cis-1,2-DCE	*cis*-1,2-dichloroethene
COC	contaminant of concern
CSM	Conceptual Site Model
CSOU	Comprehensive Site-Wide Operable Unit
CWA	Clean Water Act
DCE	dichloroethene
D&D	Decontamination and Decommissioning
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FFA	*Federal Facility Agreement*
FS	feasibility study
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
IRIS	Integrated Risk Information System
KAR	*Kentucky Administrative Regulations*
KDEP	Kentucky Department for Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
KRS	Kentucky Revised Statutes
LUC	land use control
LUCIP	Land Use Control Implementation Plan
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MEPAS	Multimedia Environmental Pollutant Assessment System (software)
MOU	Memorandum of Understanding
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
NSDD	North-South Diversion Ditch
NWP	Nationwide Permit

O&M	operation and maintenance
OU	operable unit
PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
ppb	parts per billion (by mass)
ppm	parts per million (by mass)
PRAP	proposed remedial action plan
POE	point of exposure
PTSM	principal threat source material
PVC	polyvinyl chloride
RAOs	remedial action objectives
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RDWP	Remedial Design Work Plan
RfD	reference dose
RGA	Regional Gravel Aquifer
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SF	slope factor
SMP	Site Management Plan
SWMU	solid waste management unit
TBC	to be considered
T&E	threatened and endangered
TCA	trichloroethane
TCE	trichloroethene
trans-1,2-DCE	*trans*-1,2-dichloroethene
TSCA	Toxic Substances Control Act
UCRS	Upper Continental Recharge System
VC	vinyl chloride
USC	*United States Code*
VOC	volatile organic compound
WAG	waste area group

PART 1

DECLARATION

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DECLARATION FOR THE RECORD OF DECISION FOR INTERIM REMEDIAL ACTION FOR THE GROUNDWATER OPERABLE UNIT FOR THE VOLATILE ORGANIC COMPOUND CONTAMINATION AT THE C-400 CLEANING BUILDING

SITE NAME AND LOCATION

Volatile Organic Compound Source Zone at C-400
Groundwater Operable Unit
Paducah Gaseous Diffusion Plant
U.S. Department of Energy
Paducah, Kentucky
EPA ID – KY8890008982

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected interim remedial action for the Groundwater Operable Unit (OU) volatile organic compound (VOC) source zone, comprised primarily of trichloroethene (TCE), at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant (PGDP) near Paducah, Kentucky, and includes discussion of the contribution that this interim remedial action will make toward the final decision for the Groundwater OU at the PGDP. This interim remedial action was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and, to the extent practicable, with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record (AR) file for this site.

In addition, this decision document has been prepared in accordance with paragraph II E.2 of the *Secretarial Policy Statement on the National Environmental Policy Act* (NEPA) (DOE 1994), which states, "To facilitate meeting the environmental objectives of CERCLA and to respond to concerns of regulators, consistent with the procedures of most other Federal agencies, the U.S. Department of Energy (DOE) hereafter will rely on the CERCLA process for review of actions to be taken under CERCLA and will address NEPA values and public involvement procedures as provided below … Department of Energy CERCLA documents will incorporate NEPA values, such as analysis of cumulative, off-site, ecological, and socioeconomic impacts, to the extent practicable."

A Feasibility Study (FS) for the Groundwater OU was submitted to the U.S. Environmental Protection Agency (EPA) and Commonwealth of Kentucky on August 27, 2001 (DOE 2001). After approval of the FS by EPA and the Commonwealth of Kentucky, a notice of availability of the FS was published in a regional newspaper, *The Paducah Sun*, November 2, 2001, and a public comment period was held from November 2, 2001, to December 17, 2001. The FS provided an evaluation of alternatives for remediation of various VOC sources, such as those comprised of TCE, to the Groundwater OU and described the strategy for addressing these sources at the PGDP. Subsequently, a Proposed Remedial Action Plan (PRAP) for the VOC contamination at the C-400 Cleaning Building (DOE 2004a) was submitted to the EPA and Commonwealth of Kentucky on April 7, 2004. After approval of the PRAP by EPA and the Commonwealth of Kentucky, a notice of availability of the PRAP was published in *The Paducah Sun* on May 31, 2004, and a public comment period was held from June 2, 2004, to July 16, 2004. The

Commonwealth of Kentucky concurs with the interim remedial action for the contamination comprised of TCE and other VOCs[1] at the C-400 Cleaning Building area selected in this document by the DOE *and EPA* and with the contribution this interim remedial action will make toward the final decision for the Groundwater OU.

ASSESSMENT OF THE SITE

Elevated concentrations of the VOC TCE and its breakdown products in subsurface soils indicate that dense nonaqueous-phase liquid (DNAPL) source areas exist within the Upper Continental Recharge System (UCRS) soils southeast and southwest of the C-400 Cleaning Building. DNAPLs are liquid chemicals that do not readily dissolve in water and are denser than water. Once in the ground, DNAPLs can migrate downward through the subsurface, with a portion being trapped in the soil's pore spaces. The TCE concentrations detected in the Regional Gravel Aquifer (RGA) during the Waste Area Grouping 6 (WAG 6) Remedial Investigation (RI) (DOE 1999a), which included the area around the C-400 Cleaning Building, indicated a maximum of 701,000 parts per billion (ppb) in groundwater (64% of the maximum solubility of TCE in water) southeast of the C-400 Cleaning Building, suggesting that DNAPL has penetrated the RGA and is acting as a secondary source of groundwater contamination. The response action selected in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment from the source zone comprised of TCE and other VOCs at the C-400 Cleaning Building area.

DESCRIPTION OF SELECTED REMEDY

The Groundwater OU is one of five media-specific OUs at PGDP being used to evaluate and implement remedial actions. DOE, EPA, and the Commonwealth of Kentucky have agreed upon five strategic cleanup initiatives as follows (from *Site Management Plan,* DOE 2004b):

- Decontamination and Decommissioning (D&D) OU Strategic Initiative,
- Groundwater OU Strategic Initiative,
- Burial Grounds OU Strategic Initiative,
- Surface Water OU Strategic Initiative, and
- Soils OU Strategic Initiative.

The initiatives' objectives include taking early actions as necessary to prevent and reduce exposure and unacceptable risks. This includes completion of a series of prioritized response actions, ongoing site characterization activities to support future response action decisions, and D&D of the currently operating gaseous diffusion plant once it ceases operation, followed by a comprehensive site-wide evaluation, with implementation of additional and final actions as needed to ensure long-term protectiveness. The intended scope, sequence, and timing of the OU initiatives is documented in the *Site Management Plan* (SMP) (DOE 2004b) and in the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant* (FFA) (EPA 1998).

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[1] Other VOCs present in the source zone at the C-400 Cleaning Building area include *trans*-1,2-dichloroethene; *cis*-1,2-dichloroethene; vinyl chloride; 1,1-dichloroethene; tetrachloroethene; carbon tetrachloride; chloroform; 1,1,1-trichloroethane; 1,1,2-trichloroethane; and toluene.

The primary objectives of these initiatives are to take actions necessary to prevent both on-site and off-site human exposure that presents any unacceptable risk, to ensure safe environmental conditions for industrial workers performing ongoing gaseous diffusion plant operations, and to implement actions that provide the greatest opportunities to achieve significant risk reduction before site closure.

For the Groundwater OU, and consistent with EPA guidance (EPA 1999), a phased approach is used to meet the primary objectives. A phased approach is used because the complex groundwater contamination problems at the site (i.e., complex hydrogeology, multiple sources of contamination, and suspected presence of DNAPL) prevent the PGDP from implementing one comprehensive, cost-effective remedy at this time. Additionally, the phased approach allows the site to use information gained in earlier phases of the cleanup to refine and implement subsequent cleanup objectives and actions.

The phased approach for the Groundwater OU consists of implementing a series of steps that will meet short-term protection goals, intermediate performance goals, and long-term, final cleanup goals. Sequencing the steps in this manner is consistent with EPA's recommendation to use these goals to accomplish the following EPA objectives (EPA 2001; EPA 2004):

- Focus resources at facilities that warrant attention in the near term;
- Control short-term threats;
- Prioritize actions within facilities to address the greatest risks first; and
- Make progress toward the ultimate goal of returning contaminated groundwater to its maximum beneficial use.

As described in the SMP (DOE 2004b), the following steps are used at the PGDP to implement the phased approach for the Groundwater OU:

(1) Prevent human exposure (short-term goal);

(2) Reduce, control, or minimize the major groundwater source areas contributing to off-site contamination (intermediate performance goals); and

(3) Evaluate and select long-term solutions for the off-site dissolved-phase groundwater plumes and remaining groundwater sources (long-term, final cleanup goals).

In implementing this phased approach, the following Groundwater OU actions have been implemented to meet the short-term goal of preventing human exposure to contaminated groundwater:

- Provided an alternative source of drinking water to certain, nearby residences (1989); and
- Extended municipal water lines as a permanent source of drinking water to certain, nearby residences (1995).

The following additional actions have been taken for the Groundwater OU to meet the intermediate performance goal of reducing, controlling, or minimizing major groundwater source areas:

- Constructed and implemented groundwater treatment systems for both the Northwest and Northeast Plumes to reduce contaminant migration (1995 and 1997, respectively);

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

- Removed petroleum-contaminated soil from Solid Waste Management Unit (SWMU) 193 to eliminate a potential source of groundwater contamination (2002); and

- Conducted two key groundwater technology studies, including a successful treatability study to evaluate the effectiveness of the six-phase heating technology for *in situ* treatment of DNAPL at the C-400 Cleaning Building area (DOE 2003), and a partial field demonstration to evaluate the technical constructability of a permeable treatment zone.

Consistent with the results of the Groundwater OU FS and the subsequent successful six-phase heating treatability study, this ROD focuses on reducing the concentration of TCE and other VOCs in the source soils in the UCRS and RGA at the C-400 Cleaning Building area, which has been identified as the major source of groundwater contamination by TCE and other VOCs at the PGDP. This area is located on-site within the plant secured area. This interim remedial action will use treatment to permanently reduce the toxicity, mobility, and volume of any principal threat source material (PTSM) associated with the VOC contamination in the area of the C-400 Cleaning Building.

The primary objectives for the interim remedial action, which meet the intermediate performance goal of reducing, controlling, or minimizing major groundwater source areas and represent a step toward meeting the long-term goal of attaining final cleanup, are as follows:

- Reduce exposure to contaminated groundwater by reducing the source concentrations of TCE and other VOCs in the RGA in the C-400 Cleaning Building area, thereby reducing the migration of these contaminants to off-site points of exposure (POE);

- Prevent exposure to contaminated groundwater by on-site industrial workers through institutional controls (e.g., excavation/penetration permit program); and

- Reduce contamination comprised of TCE and other VOCs found in UCRS soil in the C-400 Cleaning Building area to minimize the migration of these contaminants to RGA groundwater and to off-site POE.

The major components of the selected remedy include the following:

- Reduction of the concentration of TCE and other VOCs in the soils in the C-400 Cleaning Building area through removal and treatment using Electrical Resistance Heating in both the UCRS and RGA[2];

- Collection of post-action sampling results;

- A remedial design investigation to further determine areal and vertical extent of TCE and other VOC contamination in the C-400 Cleaning Building area to determine optimum placement of the remediation system; and

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[2] The forthcoming remedial action design documents will include criteria setting forth the requirements and approach that will apply for determining when operation of the Electrical Resistance Heating System will cease.

- Implementation of Land Use Controls (LUCs) at the C-400 Cleaning Building area (refer to Section 2.12.2 of this ROD for additional details).

The action alternative being presented in this ROD is considered an interim remedial action, in that it would reduce TCE and other VOC contamination in soils and groundwater underlying the C-400 Cleaning Building area, thereby contributing to the final cleanup of the Groundwater OU. After completion of the action described in this interim ROD, the impacts that any other contamination[3] may have on human health and the environment, will be assessed as part of the Groundwater OU and/or Comprehensive Site-Wide OU (CSOU) for the PGDP, as discussed in the SMP (DOE 2004b). Decisions about final remedial action for the Groundwater OU, which will meet the long-term, final cleanup goals for this OU, will be made in the future, after appropriate documentation and public review. The SMP establishes 2010 as the anticipated completion date for the Groundwater OU Strategic Initiatives (DOE 2004b).

Five-year reviews, which will include consideration of the status of the LUCS, will be required for the area because residual contamination will remain in place following performance of the selected interim action.

STATUTORY DETERMINATIONS

This interim remedial action satisfies the mandates of CERCLA §121 and, to the extent practicable, the requirements of the NCP to be protective of human health and the environment. The action will contribute to the final remediation of the Groundwater OU by removing a significant portion of the contaminant mass of TCE and other VOCs at the C-400 Cleaning Building area through treatment. This will reduce the period the TCE concentration in groundwater remains above its Maximum Contaminant Level (MCL) and meets the statutory preference for attaining permanent solutions through treatment. The action will meet federal and state applicable or relevant and appropriate requirements (ARARs) for the scope of this interim action. Although this interim action is not expected to meet the MCL in groundwater for TCE, the action satisfies the requirements set forth in 40 *CFR* 300.430(f)(1)(ii) for interim measures that will become part of the total remedial action that will attain ARARs, including the MCL for TCE, or satisfy the requirements for an ARARs waiver. Based on currently estimated costs, the remedy is cost effective because it represents a reasonable value in remediation effectiveness for the money to be spent. In addition, this interim remedial action is consistent with Resource Conservation and Recovery Act (RCRA) interim corrective action requirements and the Hazardous and Solid Waste Amendments (HSWA) Permit for affected SWMUs.

As noted above, additional assessment of the C-400 Cleaning Building area will be included in the Groundwater OU and/or CSOU. The interim action will permanently remove a significant portion of the TCE and other VOCs in the C-400 Cleaning Building area through treatment, but will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure. The interim action meets CERCLA's preference for remedies that employ treatment as a principal element of the remedy that permanently and significantly reduces toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants.

Because contamination above levels that allow for unrestricted exposure will remain after completion of the action, statutory reviews will be conducted every five years after initiation of the interim remedial action to ensure that the remedy continues to be protective of human health and the environment.

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[3] Other contaminants that have been determined to be contaminants of concern at the PGDP in the Groundwater OU include radionuclides (e.g., ^{99}Tc and uranium isotopes) and metals (e.g., arsenic, chromium, and nickel).

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the AR file for this site.

- Contaminants of concern (COC) and their respective concentrations (Sect. 2.7)
- Baseline risk represented by the COCs (Sect. 2.7)
- Potential remediation criteria for TCE and VOCs, in terms of contaminant recovery in soil vapor, that will determine when operation of the Electrical Resistance Heating array would cease (Sect. 2.12.2)
- How source materials constituting principal threats are addressed (Sect. 2.11)
- Current and reasonably anticipated future land use assumptions (Sect. 2.6)
- Current and potential future beneficial uses of groundwater (Sect. 2.7.1)
- Estimated cost of the interim remedial action (Sect. 2.10.7)
- Key factors that led to selection of the remedy (Sect. 2.12)

ACCEPTANCE OF THE REMEDY

William E. Murphie (signature) Date 8/9/05

William E. Murphie, Manager
Portsmouth/Paducah Project Office
U.S. Department of Energy

(signature) for Date 08/9/05

Winston Smith
Director, Waste Management Division
U.S. Environmental Protection Agency, Region 4

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ERNIE FLETCHER
GOVERNOR

ENVIRONMENTAL AND PUBLIC PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
DIVISION OF WASTE MANAGEMENT
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LAJUANA S. WILCHER
SECRETARY

August 9, 2005

Mr. William E. Murphie, Manager
US Department of Energy
Portsmouth/Paducah Project Office
PO Box 1410
Paducah, KY 42002

Mr. Glenn E. VanSickle
Paducah Manager of Projects
Bechtel Jacobs Company LLC
761 Veterans Avenue
Kevil, KY 42053

RE: *Record of Decision for the Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2150&D2, Revision 2)
McCracken County, Kentucky
KY8-890-008-982

Dear Mr. Murphie and Mr. VanSickle:

The Division of Waste Management (Division) has received the Revision 2 of the D2 C-400 Record of Decision. The Division is in agreement with this proposed action and in accordance with Section XIV. D. of the Federal Facility Agreement hereby adopts the Record of Decision. The Division is encouraged and looks forward to working with the FFA parties as this important project moves toward the field. The Division is similarly encouraged by the many other cleanup projects either currently engaged or planned for the near future at the Paducah Gaseous Diffusion Plant.

Sincerely,

R. Bruce Scott, P.E.
Director

RBS/mg

c: David Williams, USEPA Region 4
DOE Reading File

PART 2

DECISION SUMMARY

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DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The PGDP (site EPA ID KY8890008982) is located in McCracken County in western Kentucky, about 6.5 kilometers (4 miles) south of the Ohio River and approximately 16 kilometers (10 miles) west of the city of Paducah. This ROD addresses source reduction of TCE and other VOCs found at the C-400 Cleaning Building area. The C-400 Cleaning Building area is located inside the plant secured area, near the center of the industrial section of PGDP.

The DOE is the owner and serves as the lead agency for PGDP cleanup activities. Both the EPA and the Kentucky Department for Environmental Protection (KDEP) are oversight agencies for the DOE's environmental restoration of PGDP, in accordance with provisions of the FFA for PGDP, which DOE entered into with the Commonwealth of Kentucky and EPA in 1998. Funding for this cleanup at PGDP is derived from federal appropriations for the DOE.

PGDP is a gaseous diffusion plant that has produced enriched uranium since 1952. Most industrial activities are sited in a 304-hectare (750 acre) security area and buffer zone that are restricted from access by the public. This secured area is located on 1457 hectares (3600 acres) controlled by the DOE.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Historically, some of the primary activities associated with the C-400 Cleaning Building have been cleaning machinery parts, disassembling and testing of cascade components, and laundering plant clothes. The building also has housed various other activities, including recovery of precious metals and treatment of radiological waste streams.

Suspected sources of leaks and spills at the C-400 Cleaning Building include (1) degreaser and cleaning tank pits; (2) drains and sewers; (3) the east side plenum/fan room basement; (4) tanks and sumps outside the building, including underground piping running from tanks; and (5) various first-floor processes. These sources have resulted in the development of a source zone comprised of VOCs (primarily TCE and its breakdown products and 1,1-dichloroethene [DCE]) at the C-400 Cleaning Building area.

After the discovery of off-site groundwater contamination at PGDP, the EPA entered into an Administrative Order by Consent (ACO) with the DOE on November 23, 1988, pursuant to the CERCLA (EPA 1988). The ACO required the DOE to monitor area residential wells, provide an alternate drinking water source to affected residents, identify the nature and extent of contamination, and take action to protect human health and the environment. PGDP was listed on the CERCLA National Priorities List on May 31, 1994.

The DOE has undertaken several actions subsequent to the ACO to protect the neighboring population, to reduce the off-site migration of the portions of the groundwater plumes that contain the highest concentration of contamination and to address on-site sources of TCE and other VOCs. These actions include providing an alternate drinking water source to certain, nearby residences immediately after off-site groundwater contamination was discovered in 1989; extending water lines as a permanent source of drinking water to such residences (*Engineering Evaluation/Cost Analysis for the Water Policy at the Paducah Gaseous Diffusion Plant* [DOE 1993a]); constructing and implementing groundwater treatment systems for both the Northwest and Northeast Plumes to reduce contaminant migration (*Record of*

Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant [DOE 1993b] and *Record of Decision for Interim Remedial Action at the Northeast Plume* [DOE 1995a]); applying *in situ* treatment of TCE-contaminated soil at the cylinder drop test site (SWMU 91) using an innovative technology (i.e., the LASAGNA™ technology) (DOE 1998) to reduce a source of TCE contamination; and removing petroleum-contaminated soil from SWMU 193 to eliminate a potential source of groundwater contamination (DOE 2002).

In June 1986, a routine construction excavation along the 11th Street storm sewer revealed TCE soil contamination. The cause of the contamination was determined to be a leak in a drain line from the C-400 Cleaning Building's basement sump to the storm sewer. The area of contamination became known as the C-400 Trichloroethene Leak Site and was given the designation of SWMU 11. After the initial discovery of contamination, four borings were installed to better define the extent of the soil contamination. SWMU 11 and the C-400 Cleaning Building area have been the subjects of several investigations since then.

The Phase I and Phase II CERCLA Site Investigations (CH2M HILL 1991, 1992) included the area around the C-400 Cleaning Building within their scope, with the installation of soil borings and groundwater wells. These investigations confirmed that TCE contamination at the southeast corner of the C-400 Cleaning Building extended from the surface to the base of the RGA at 92 ft below ground surface (bgs). In 1995, the Phase IV Investigation demonstrated that the area around the C-400 Cleaning Building was a potential major source for the Northwest Plume. Also in 1995, a review of C-400 Cleaning Building process activities was completed and documented in *C-400 Process and Structure Review*, KY/ERWM-38, (MMES 1995).

In 1997, the WAG 6 RI focused on the area around the C-400 Cleaning Building and further delineated contamination at SWMU 11. The RI identified the TCE transfer system at the southeast corner of the building (later named SWMU 533) as a significant source of soil and groundwater contamination. An additional area of soil contamination comprised of TCE and other VOCs and associated with a storm sewer was identified near the southwest corner of the building. The results of the investigation are documented in the *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1727/V1&D2 (DOE 1999a).

Four treatability studies have been conducted to investigate methods for reducing or remediating the contamination comprised of TCE and other VOCs in the area near the C-400 Cleaning Building. The first, using a chemical cosolvent, was conducted in 1994 at the southeast corner of the area near the C-400 Cleaning Building using the existing monitoring wells. The results are reported in *The In-Situ Decontamination of Sand and Gravel Aquifers by Chemically Enhanced Solubilization of Multiple-Component DNAPLs with Surfactant Solutions* (Intera 1995). The next two studies were bench scale studies conducted as part of the WAG 6 RI. One looked at other surfactants and co-solvents, while the other evaluated chemical oxidation. The results of these studies are documented in *Surfactant Enhanced Subsurface Remediation Treatability Study Report for the Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999b) and in *Bench Scale In-Situ Chemical Oxidation Studies of Trichloroethene in Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999c). The fourth treatability study, conducted in 2003, was a pilot field test of Electrical Resistance Heating, specifically the Six-Phase Heating technology, at the southeast corner of the area near the C-400 Cleaning Building. This study is reported in *Six-Phase Heating Treatability Study Final Report at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2003).

Two actions have remediated some of the soil contamination near the southeast corner of C-400 Cleaning Building. After the discovery of the C-400 Trichloroethene Leak Site in June 1986, some of the soils were excavated in an attempt to reduce the contamination in the area. Excavation was halted to prevent structural damage to the adjacent infrastructure, including a fence, TCE storage tank, and road.

Approximately 310 ft^3 of TCE-contaminated soil was drummed for off-site disposal. The excavation was backfilled with clean soil, and the area was capped with a layer of clay. The 2003 Six-Phase Heating Treatability Study removed over 22,000 pounds of TCE (approximately 1900 gal) from the subsurface in a 43 ft-diameter treatment area in the southeast corner of the area near the C-400 Cleaning Building (DOE 2003). No other remedial actions have been performed in the area near the C-400 Cleaning Building.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The FS for the Groundwater OU at the PGDP in Paducah, Kentucky, was made available to the public on November 2, 2001. Copies of the document can be found in the AR file and the information repository maintained at the Region 4 EPA Docket Room in the Paducah Public Library. The notice of availability of the Groundwater OU FS was published in a regional newspaper, *The Paducah Sun*, on November 2, 2001. A public comment period was held from November 2, 2001, to December 17, 2001.

The PRAP for the VOC contamination at C-400 Cleaning Building area was made available to the public on May 18, 2004. It can be found in the AR file and the information repository maintained at the Region 4 EPA Docket Room in the Paducah Public Library. A notice of availability of the PRAP was published in *The Paducah Sun*, on May 31, 2004. A public comment period was held from June 2, 2004, to July 16, 2004. All written and verbal comments received from the public and other stakeholders are discussed in Section 3.2. Specific groups that received individual copies of the PRAP include the Natural Resource Trustees and the PGDP Citizens Advisory Board (CAB).

2.4 SCOPE AND ROLE OF THE OPERABLE UNIT

At the PGDP, site cleanup includes a series of prioritized response actions through which short-term protection goals, intermediate performance goals, and long-term final cleanup goals will be attained. Within this approach, the short-term protection goals are to control risks to humans and the environment; intermediate-term performance goals are to reduce, control, or minimize contaminants found in source areas; and long-term goals are to evaluate and pursue additional actions determined necessary to achieve the contaminant level reductions to provide long-term protectiveness. To achieve these goals, DOE and the regulatory agencies have agreed to use five media-specific OUs to evaluate and implement response actions. These five OUs, which include response actions in the near- and intermediate-term that will be completed without disrupting ongoing uranium enrichment plant operations, are as follows (DOE 2004b):

- D&D OU,
- Groundwater OU,
- Burial Grounds OU,
- Surface Water OU, and
- Soils OU.

In addition to the response actions, each OU includes site characterization activities to support future response action decisions.

Once the gaseous diffusion plant ceases operation, D&D of the plant will occur. These D&D activities will be followed by the CSOU, which will address any residual contamination not addressed earlier. The timing and sequencing for implementation of activities associated with the OUs and gaseous diffusion plant D&D are based on a combination of factors, including risk, compliance, and technical considerations associated with plant operations as outlined in the FFA. Both the FFA and the SMP document the schedule of actions for the OUs and gaseous diffusion plant D&D.

In accordance with the FFA, all SWMUs and areas of concern (AOCs) requiring investigation and/or potential response actions under the FFA have been assigned to one of the five media-specific OUs listed above. The objective of grouping the sources and areas of contamination into these OUs is to provide a more comprehensive framework to assess site-wide risks, identify and prioritize response actions, and develop integrated cleanup solutions that will reduce any unacceptable risk across the primary exposure pathways through which human health and the environment may be affected. To support implementation of this strategy, the source areas and affected media within each OU have been subjected to a screening process to further segregate the source areas into various categories, including candidate areas designated as a high priority for a response action, areas requiring additional characterization/risk evaluation, and source areas associated with plant operations. Current examples of actions for high-priority areas include the excavation of Sections 1 and 2 of PGDP's North-South Diversion Ditch (NSDD) and scrap metal removal, which were performed as part of the Surface Water OU, and the ongoing implementation of the Water Policy and this source action for TCE and other VOC contamination at the C-400 Cleaning Building area, which are part of the Groundwater OU.

The action at the C-400 Cleaning Building area, which is consistent with the results of the Groundwater OU FS and a successful six-phase heating treatability study, is being undertaken to reduce or minimize a major groundwater source area at the PGDP that contributes to off-site contamination. The activities to be completed at the C-400 Cleaning Building area will contribute to attaining the final goals for remediation of the Groundwater OU. After completion of the interim action described in this ROD, the impacts that any residual contamination by TCE and other VOCs at the C-400 Cleaning Building area may have on human health and the environment will be assessed as part of the Groundwater OU and/or CSOU for the PGDP, as discussed in the SMP (DOE 2004b).

2.5 SUMMARY OF SITE CHARACTERISTICS

2.5.1 Conceptual Site Model

The conceptual site model (CSM) is a three-dimensional "picture" that illustrates contaminant sources, release mechanisms, exposure pathways, migration routes, and potential human and ecological receptors. Figure 1 presents the CSM for the C-400 Cleaning Building area.

For the source zone comprised of TCE and other VOCs at the C-400 Cleaning Building area, there are two primary sources of concern that lead to contaminant migration:

1. Dissolution of DNAPL comprised of TCE in the UCRS into groundwater and downward migration into the RGA, and

2. Dissolution of DNAPL comprised of TCE in the RGA into RGA groundwater.

Dissolved contaminants from these sources entering RGA groundwater subsequently migrate toward the north to areas off DOE-owned property. The much lower hydraulic conductivity of the McNairy Formation, underlying the RGA, limits vertical migration of dissolved contamination below approximately 30.5 m (100 ft).

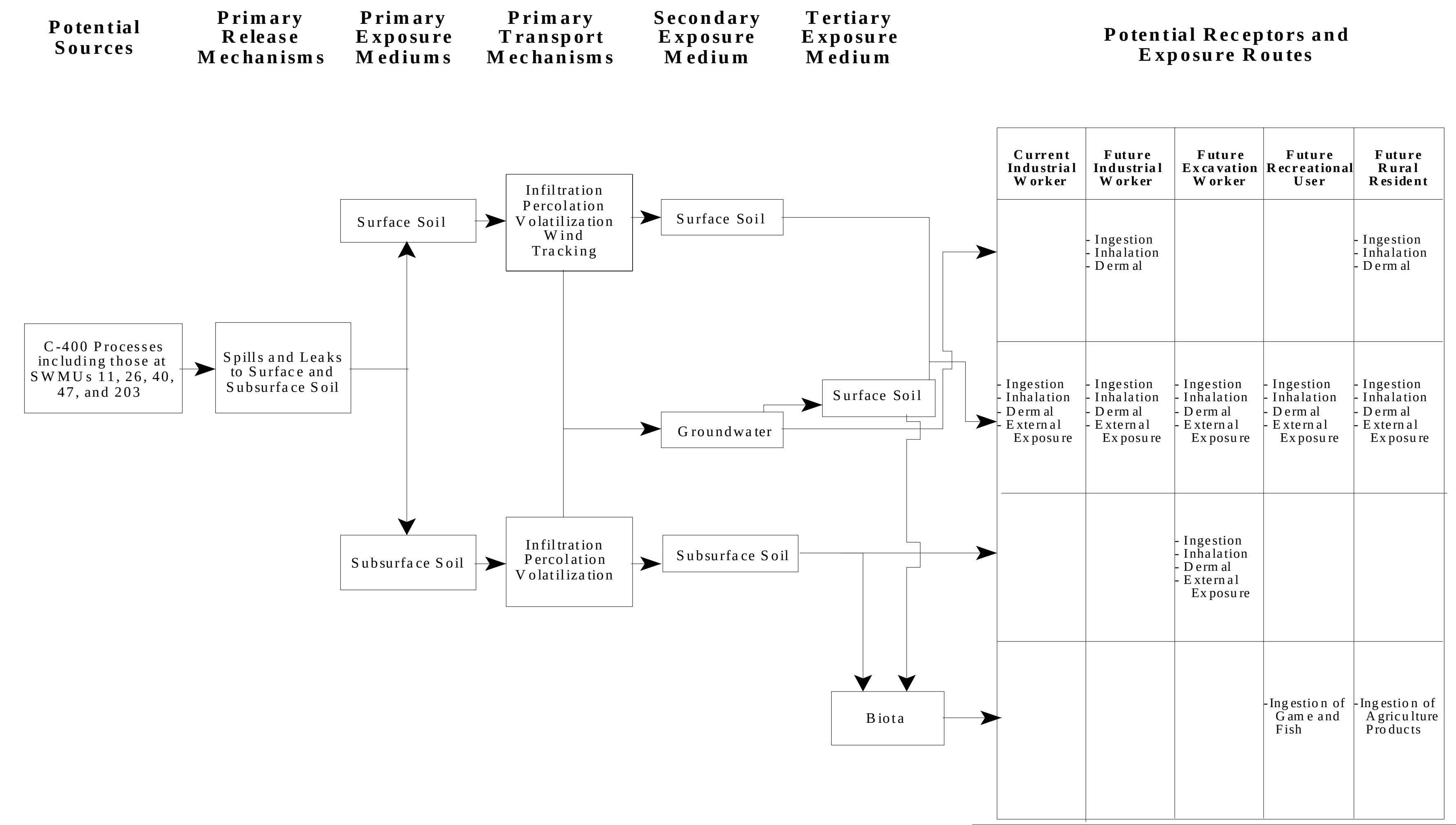

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Fig. 1. Conceptual site model for the C-400 Cleaning Building area.

FIGURE No. DO-188_Fig. 1.r1.ppt
DATE 07-12-05

2.5.2 Overview of the Site/Surface and Subsurface Features

In the area of the C-400 Cleaning Building, the topography is relatively flat, with elevations ranging from approximately 370 to 376 ft above mean sea level. Thick concrete aprons cover the heavy traffic areas immediately north and south of the building, while gravel or asphalt covers the areas on the east and west sides of the building. An active railroad track serves the south side of the building, and an overhead gantry crane and loading dock are present along the south side of the building. Aboveground steam lines run along the west side of the building.

Subsurface features around the building include storm sewers, underground piping running from storage tanks, and a variety of buried utility lines. Most of the storm water from the C-400 Cleaning Building area flows to storm drain inlets around the building and discharges via the storm sewer on the south side of the building to Outfall 008, then to Bayou Creek on the west side of the plant. Runoff from the north side of C-400 Cleaning Building area flows into the NSDD, then is pumped to the C-616 Lagoons and released through Outfall 001 to Bayou Creek.

The southeast and southwest sectors of the C-400 Cleaning Building area, as defined for the WAG 6 RI, encompassed approximately 7.5 acres in the UCRS. Of this area, the RI identified 0.5 acres total in the two sectors that had TCE in-soil concentrations of 10 ppm (parts per million) or greater. These TCE levels approximately delimit the areas of UCRS soils that were directly impacted by TCE spills and that will be addressed by this interim remedial action. Although the location of the VOC contamination in the RGA in the C-400 area is generally defined, the exact locations of the DNAPL contamination remain uncertain.

2.5.3 Sampling strategy

The RI divided the WAG 6 area into nine sectors. Five of the nine sectors contained a SWMU. SWMU 11 was present in the southeast sector; no SWMUs were located in the southwest sector. The RI collected surface soil and UCRS soil and groundwater samples to characterize each of the sectors and each of the SWMUs within the sectors. In addition, the RI included the collection of RGA groundwater samples to characterize the extent of dissolved contamination around C-400 Cleaning Building as a whole. In total, the 1997 RI accumulated 48 surface soil samples, 496 subsurface soil samples (ranging in depth from 1 to 144 ft bgs), and 223 borehole groundwater grab samples. Figure 2[4] shows the areal extent of sampling conducted for the WAG 6 RI and the location of SWMUs and sector boundaries. Figure 3[5] presents a summary of the TCE-in-soil concentrations found in the UCRS soils in the southeast and southwest sectors of the C-400 Cleaning Building.

2.5.4 Known and Suspected Sources of Contamination

The southeast sector contains SWMU 11 and the TCE transfer pumps and piping. The southwest sector contains an area of soil contamination that has not been linked to a particular C-400 Cleaning Building process. Smaller, less significant areas of contamination of soil by TCE and other VOCs were identified on the east and west sides of the C-400 Cleaning Building, as well as near the northwest corner of the building. The elevated concentrations of TCE and its breakdown products in subsurface soils suggest that DNAPL source areas comprised of TCE exist within the UCRS soils of the southeast and southwest sectors of the C-400 Cleaning Building area.

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[4] Reproduction of Figure 3.6 of the WAG 6 RI report.
[5] Reproduction of Figure 4.12 of the WAG 6 RI report.

Document No. DOE/OR/07-2150&D2/R2

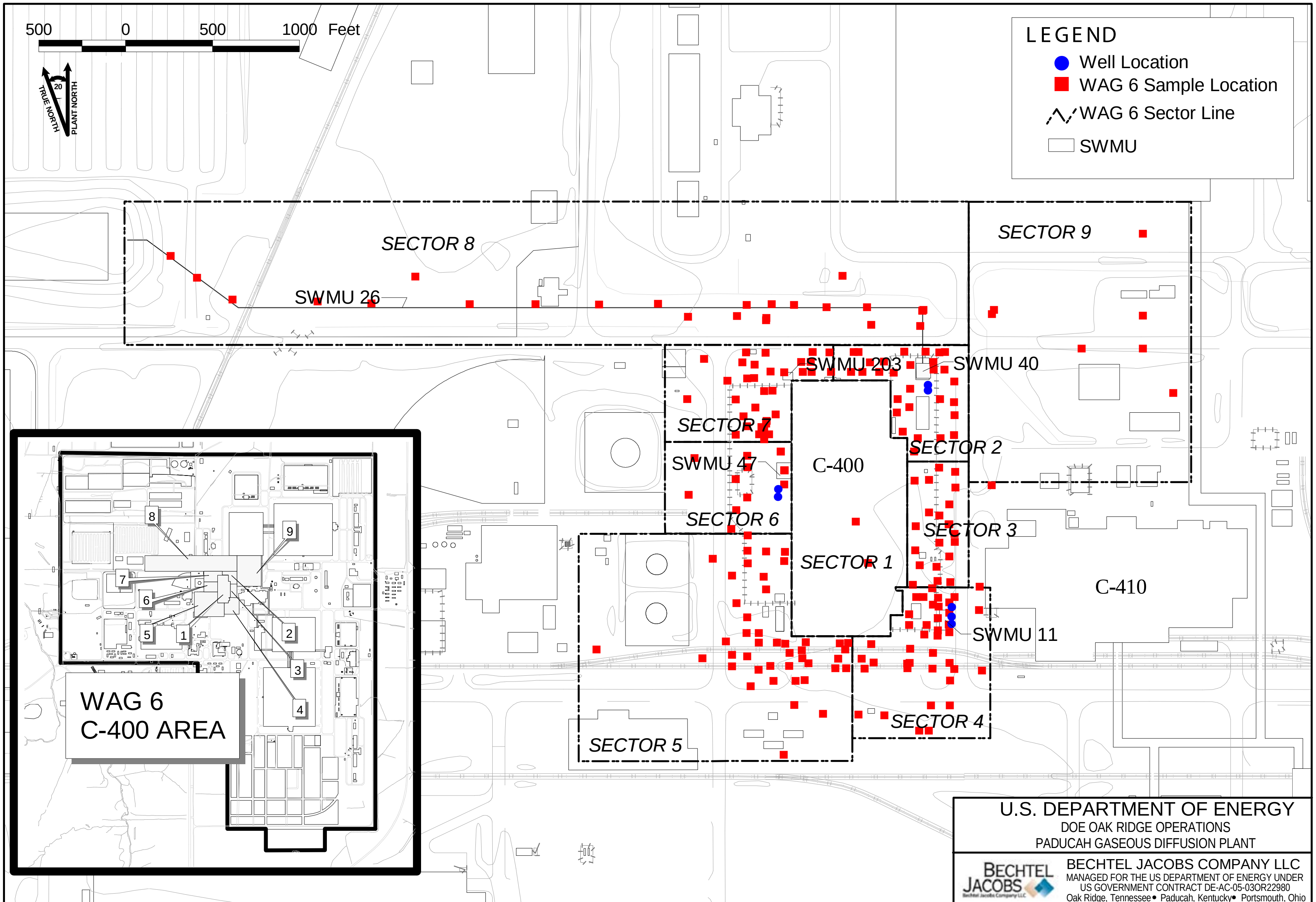


Fig. 2. WAG 6 RI sample locations.

FIGURE No. c5ac90001sk046.apr
DATE 07-22-01

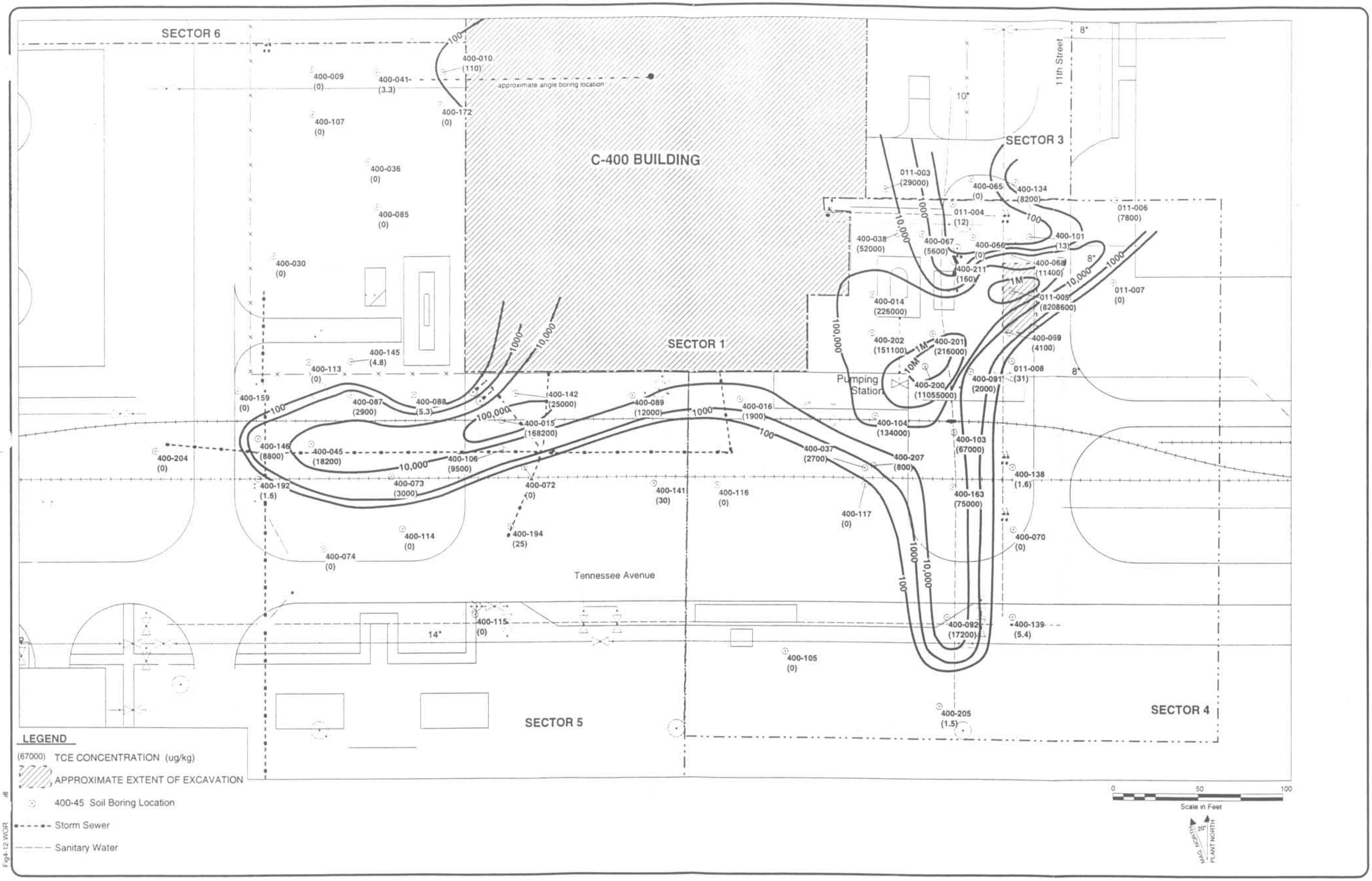


Fig. 3. Contour map of maximum TCE concentration detected in UCRS soil at each sampling location in Sectors 4 and 5.

Types of Contamination and the Affected Media. Sample analyses from the WAG 6 RI indicate that the primary site-related VOCs in subsurface soil and groundwater in the C-400 Cleaning Building area are TCE and its breakdown products (*trans*-1,2- dichloroethene [DCE], *cis*-1,2-dichloroethene [*cis*-1,2-DCE], and vinyl chloride [VC]) and 1,1-DCE. Other VOCs found during the WAG 6 RI include tetrachloroethene, carbon tetrachloride, chloroform, 1,1,1-trichloroethane (TCA), 1,1,2-TCA, and toluene. Both the UCRS and the RGA contain high VOC concentrations. The following summarizes characteristics of the primary VOCs present in soils and groundwater in the C-400 Cleaning Building area.

TCE. TCE was the primary VOC detected in both subsurface soil and groundwater. This contaminant is a halogenated organic compound used by industry in the past for a variety of purposes. It mainly was used as a degreasing agent at the C-400 Cleaning Building. Exposure to this compound has been associated with deleterious health effects in humans, including anemia, skin rashes, liver conditions, and urinary tract disorders. Based on laboratory studies, TCE is considered a probable human carcinogen. Over time, TCE naturally degrades to other organic compounds. TCE currently is not used at PGDP.

1,2-DCE, *cis*- and *trans*-. 1,2-DCE exists in two isomeric forms, *cis*-1,2-DCE and *trans*-1,2-DCE. Although not utilized extensively in industry, 1,2-DCE is used both in the production of other chlorinated solvents and as a solvent. Humans are exposed to 1,2-DCE primarily by inhalation, but exposure also can occur by oral and dermal routes. Information on the toxicity of 1,2-DCE in humans and animals is limited. Studies suggest that the liver is the primary target organ. EPA does not classify 1,2-DCE as a human carcinogen.

VC. VC is a degradation product of TCE. It is also a halogenated organic compound and is used in industry as an intermediary of polyvinyl chloride (PVC) and other chlorinated compounds. VC has not been used in the PGDP manufacturing processes. Exposure to VC has been associated with narcosis and anesthesia (at very high concentrations), liver damage, skin disorders, vascular and blood disorders, and abnormalities in central nervous system and lung function. Liver cancer is the most common type of cancer linked with VC, a known human carcinogen. Other cancers related to exposure include those of the lung, brain, blood, and digestive tract.

1,1-DCE. 1,1-DCE is used primarily in the production of PVC copolymers and as an intermediate for synthesis of organic chemicals. Acute exposure to 1,1-DCE has been associated with central nervous system depression, which may progress to unconsciousness. 1,1-DCE is irritating when applied to the skin, and prolonged contact can cause first-degree burns. Direct contact with the eyes may cause conjunctivitis and transient corneal injury. EPA has classified 1,1-DCE as a possible human carcinogen.

The size and volume of the source zone comprised of TCE and other VOCs at C-400 Cleaning Building area were estimated in the WAG 6 RI report. This information is sufficient to target the UCRS remediation. Additional UCRS and RGA characterization, as part of the remedial design for this interim remedial action, will further delineate the size and volume of the source zone comprised of TCE and other VOCs.

Although the WAG 6 RI confirmed the presence of DNAPL in UCRS soil at the south end of the C-400 Cleaning Building, the coarse nature of RGA soils prevented the collection of RGA soil samples that could be used to confirm the presence of DNAPL comprised of TCE in the RGA. However, RGA water samples collected during the RI from the southeast and southwest sectors of the C-400 Cleaning Building area contained TCE concentrations suggestive of the presence of an RGA DNAPL source zone. In addition, a RGA water sample collected during the Six-Phase Heating Treatability Study (DOE 2003) from the suspected source zone contained DNAPL. Figure 4[6] presents the maximum TCE levels observed

[6] From Figure 4.37 of the WAG 6 RI report.

in RGA groundwater in the C-400 Cleaning Building area developed using data collected during the WAG 6 RI. As shown there and in Table 1, high concentrations of TCE and other VOCs in the soil and groundwater are found in the southeast and southwest sectors (Sectors 4 and 5, respectively) of the C-400 Cleaning Building area.

Table 1. Maximum concentrations of TCE and other VOCs in soil and groundwater from the south end of the C-400 Cleaning Building area

	Contaminant Concentrations (ppm) in Soil		Contaminant Concentrations (ppb) in Water	
Contaminant	**Southeast Sector (Sector 4)**	**Southwest Sector (Sector 5)**	**Southeast Sector (Sector 4)**	**Southwest Sector (Sector 5)**
TCE	11,055	168	701,184	24,473
trans-1,2-DCE	102	15	1,200	53
Vinyl chloride	29	<1	133	8
cis-1,2-DCE	2	1	195	ND
1,1-DCE	<1	<1	154	5

ppm = parts per million
ppb = parts per billion
TCE = trichloroethene
DCE = dichloroethene
ND = not detected
VOC = volatile organic compound

Additional information about the source zone at the C-400 Cleaning Building area can be found in the WAG 6 RI report. This document (which is a part of the AR for this response action) can be examined at the DOE Environmental Information Center.

The TCE present in the soil and groundwater addressed by this interim remedial action has originated from activities formerly conducted at PGDP. These activities included use of TCE as a degreaser and as a cleaning solvent. Spills of unused TCE also have been documented. Environmental media and debris contaminated with this spilled TCE may carry hazardous waste codes F001, F002, and U228 under RCRA. These media and debris will be handled appropriately, in accordance with Appendix A, titled "Applicable or Relevant and Appropriate Requirements."

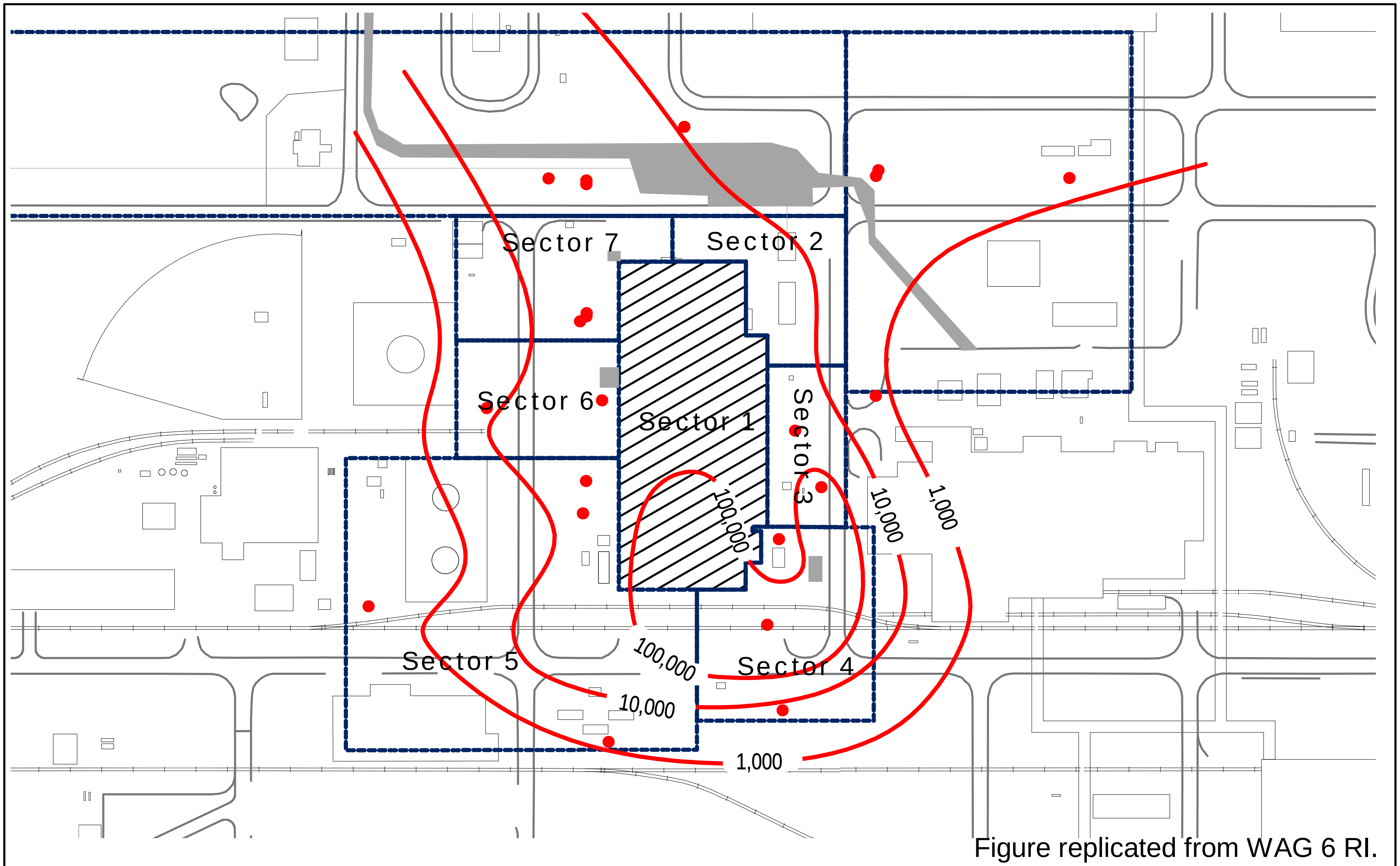
2.5.5 Affected Aquifers and Groundwater Flow Directions

The shallow aquifer underlying PGDP is the RGA. Groundwater flow within the RGA is north-northeast, discharging into the Ohio River and adjacent streams.

Low-conductivity sediments overlie the RGA to a depth of approximately 18 m (60 ft). Groundwater flow in the overlying sediments is principally downward to recharge the RGA. This flow system is termed the UCRS.

2.5.6 Location of Contamination and Routes of Migration

As discussed in the previous section, the WAG 6 RI estimated the extent of the source zone in the C-400 Cleaning Building area comprised of TCE and other VOCs. The remedial design phase of this action includes an investigation to further refine the boundaries of the source zone as part of the interim remedial action. Figure 5 presents the location of the contaminant source zone to be addressed in this ROD, as estimated using information collected during the WAG 6 RI. As shown, contamination by TCE and other VOCs is known to extend through the UCRS soils (with a base at approximately 56 ft bgs) to the base of the RGA (at a depth of approximately 91 ft bgs).



LEGEND
WAG 6 SECTOR BOUNDARY
TCE ISOPLETH (ug/L)
RGA/McNAIRY BORING LOCATION
SWMU BOUNDARY
C-400 BUILDING

250 0 250 Feet

TRUE NORTH 20 PLANT NORTH

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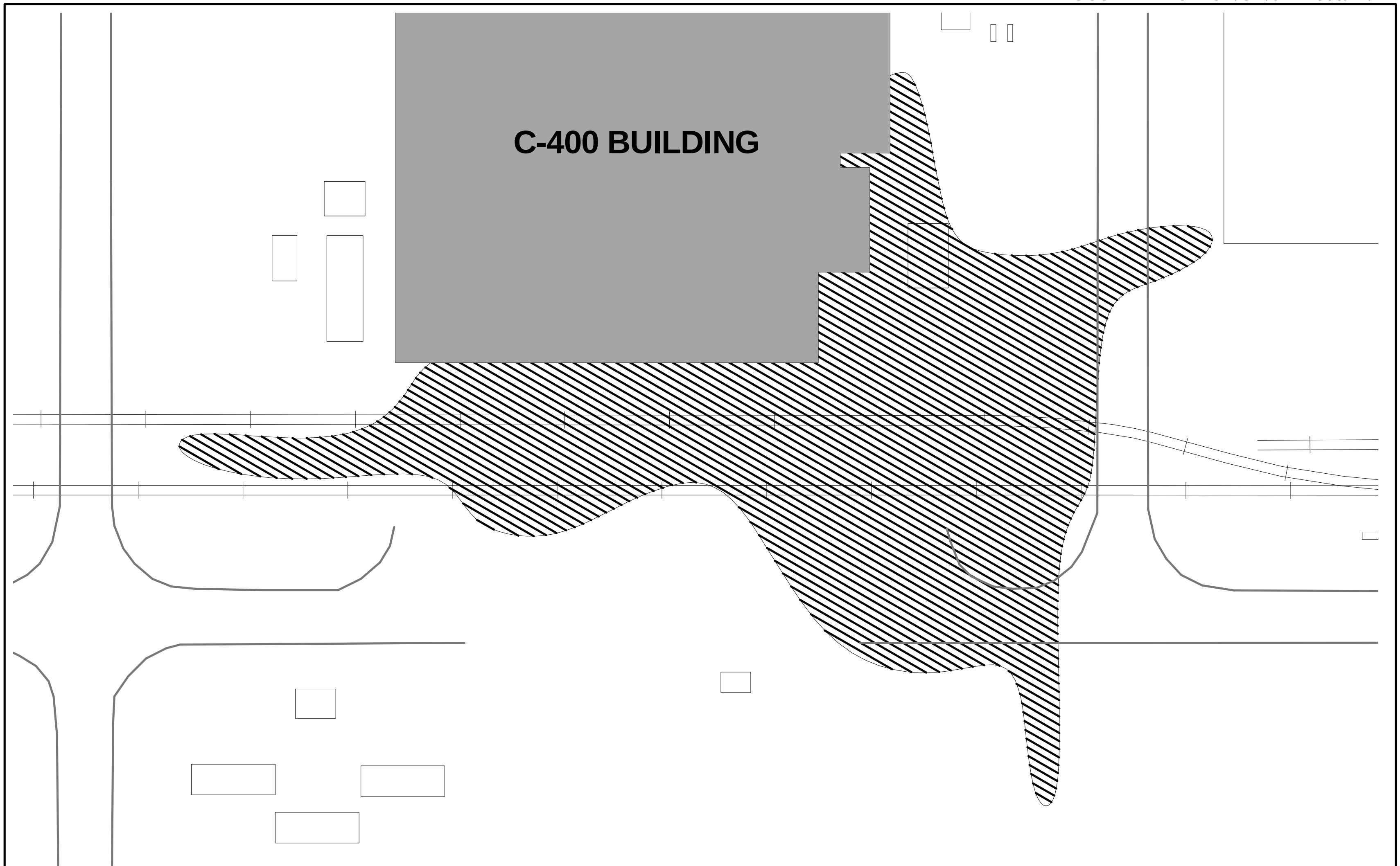
Fig. 4. Maximum concentration of TCE detected in RGA groundwater.

FIGURE No. c5ac90001sk671.apr
DATE 04-22-04



LEGEND

C-400 BUILDING

VOC SOURCE ZONE

250 0 250 Feet

TRUE NORTH 20 PLANT NORTH

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Fig. 5. Location of the VOC source zone to be addressed in this interim remedial action as it currently is known.

FIGURE No. c5ac90001sk671.apr
DATE 04-22-04

Monitored contaminant levels in RGA groundwater associated with the C-400 Cleaning Building area provide empirical evidence of contaminant mobility. Three large plumes of dissolved contaminants have migrated beyond the secured fenced area. Groundwater from the C-400 Cleaning Building area flows primarily with PGDP's Northwest Plume, but also contributes to the Northeast Plume (Fig. 6). The PGDP's Northwest Plume reaches 4.6 km (2.8 miles) beyond the PGDP security-fenced area to Little Bayou Creek in the Ohio River floodplain. Both human receptors and wildlife are exposed to the Northwest Plume contaminants at seeps in and along Little Bayou Creek. The Northeast Plume extends approximately 3.5 km (2.2 miles) from the east side of PGDP northward to Metropolis Lake Road. Contamination within the Northeast Plume does not discharge to the surface. TCE and other VOCs from the C-400 Cleaning Building area also may contribute to the Southwest Plume. The Southwest Plume extends approximately 0.2 km (0.1 miles) west of the PGDP security fence and is completely contained within PGDP property. Potentiometric trends of the RGA indicate that the Southwest Plume likely will travel northward over time and join with PGDP's Northwest Plume.

DOE's provision of municipal water to certain, nearby residents and businesses serves to limit *off-site* human exposure to contaminated groundwater.

2.6 CURRENT AND POTENTIAL FUTURE LAND USE

According to the SMP, current and reasonably foreseeable future land uses at and adjacent to PGDP are for industrial areas located primarily inside the security fence, recreational areas located outside the security fence, and residential areas off DOE property. This land use determination was made after consideration of (1) existing lease agreements, (2) the nature of contamination currently present at the facility, and (3) stakeholder input. Data was gathered for this determination through a land-use survey performed in 1995 and future land-use public workshops performed in 1994 and 1995. Additionally, the subject has been discussed with a number of organizations, including city and county officials and the CAB.

Because the C-400 Cleaning Building area is located inside the PGDP security fence, the area is currently industrial and is expected to remain industrial in the future. There are no current exposures to groundwater on-site because of existing on-site restrictions and controls, (e.g., the current excavation/penetration permit program).

As noted in Section 2.5.6, TCE and other VOCs in soil and groundwater originate in an area where current and expected future land use is industrial and are migrating to areas where current and expected future land use is recreational and residential. However, TCE and VOC concentrations in groundwater discharged to the surface at seeps along Little Bayou Creek currently are at concentrations not expected to impact human health of exposed individuals and not expected to have a deleterious impact upon the environment. Further, by implementing this interim remedial action, the TCE source materials will be reduced in quantity, and this action is expected to lead to reductions in any TCE concentrations in the discharging groundwater. There are no current exposures to groundwater on-site because of existing on-site restrictions and controls, (e.g., the current excavation/penetration permit program).

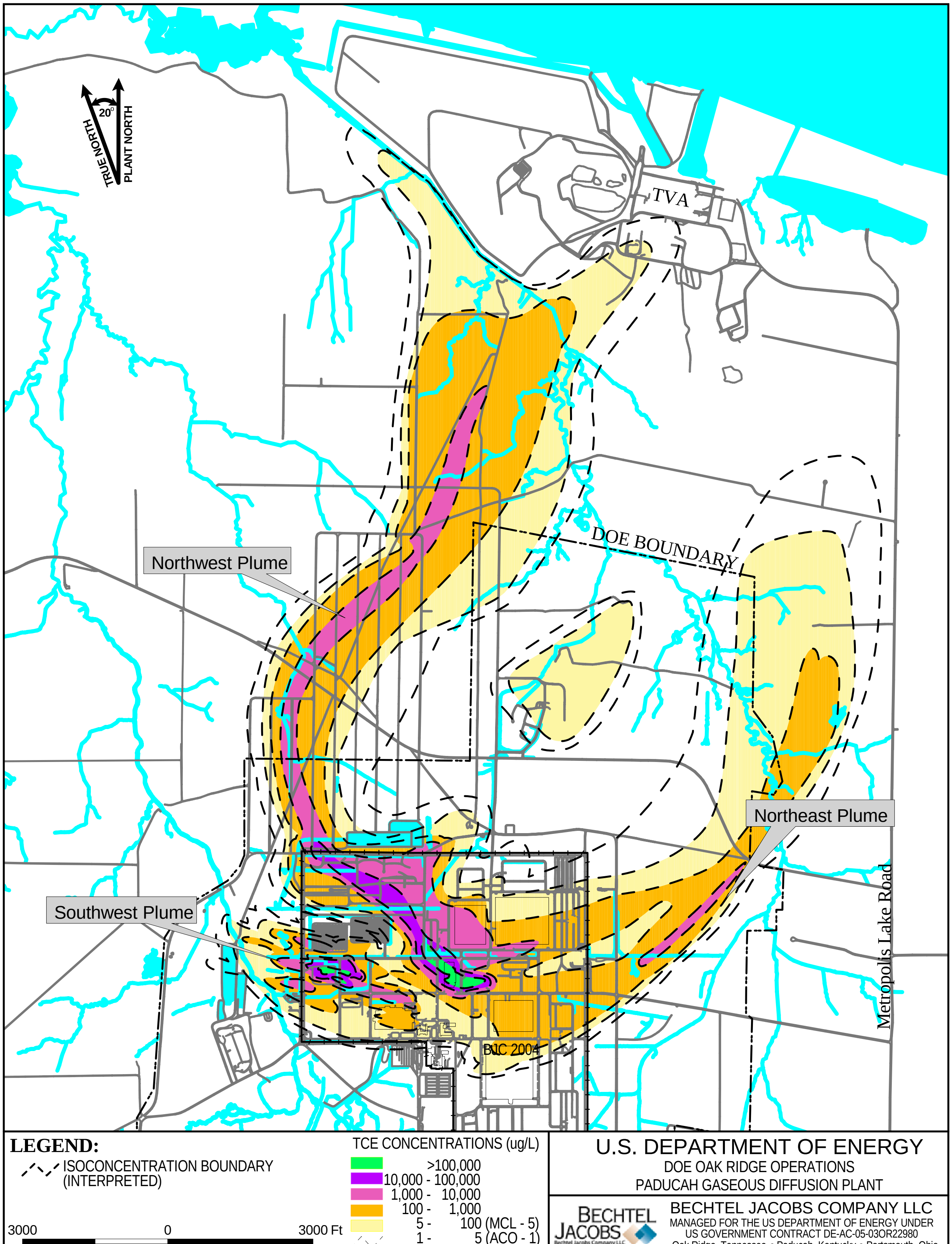

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Fig. 6. Trichloroethene plume locations.

FIGURE No. 2003tce.apr
DATE 03-24-04

2.7 SUMMARY OF SITE RISKS

The baseline risk assessment estimates the risks that a site poses to human and ecological receptors if no action is taken (i.e., if the existing institutional controls limiting groundwater use at and near PGDP through the Water Policy were not in place). It provides the basis for action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the methods used to complete the baseline risk assessments for the source area solvent contamination found to the southwest and southeast of the C-400 Cleaning Building and the pertinent results from these baseline risk assessments. Results presented here were taken from *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1727&D2, and *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1857&D2. (Note that cancer risks and hazard indices reported here were revised from values presented in the RI and FS Reports by using more recent toxicity information presented in DOE 2000a.)

Throughout this discussion, it is important to remember that the only risk assessment results presented are those pertinent to the action being proposed for the VOC sources at the C-400 Cleaning Building area.

2.7.1 Summary of Baseline Human Health Risk Assessment

This section summarizes the steps of the baseline human health risk assessment (BHHRA) and presents significant results used in making the current decisions for source areas at the C-400 Cleaning Building. As noted above, the information presented here is a relevant subset of the information presented in the BHHRAs contained in the aforementioned reports and is not meant to completely describe the baseline risks estimated for all receptors and media assessed.

2.7.1.1 Identification of COCs

This section presents the COCs for the source area contamination found to the southeast and southwest of the C-400 Cleaning Building. The following information is included:

- POE (i.e., the location where the receptor may actually or potentially contact the contaminated media);
- COC (i.e., a chemical that presents a risk level greater than the lower limit of the EPA risk range of 10^{-6} to 10^{-4} and a hazard level greater than 1) (DOE 2000a);
- Minimum and maximum detected concentration;
- Units of measure for the detected concentration;
- Frequency of detection;
- Exposure point concentration (EPC) (i.e., the concentration of the chemical used in deriving the risk estimate at the POE);

- Percent of total risk posed by the individual COC; and
- Statistical measure (i.e., the summary statistic used to represent the COC's average EPC).

The media to be addressed by the current action at the C-400 Cleaning Building area are subsurface soil and groundwater that contain TCE and other VOCs; therefore, only COCs related to these media are summarized here. Table 2, which presents information taken from Table 1.14 and Appendix C of the WAG 6 RI BRA, lists COCs in subsurface soil and groundwater for direct exposure to constituents migrating to groundwater. The POE used in Table 2 is at a point along the PGDP property boundary closest to the sources at the C-400 Cleaning Building area. (See Fig. 7.)

Table 2. Summary of COCs from baseline risk assessment and EPCs for contact with groundwater contaminated by constituents migrating from sources at the C-400 Building area

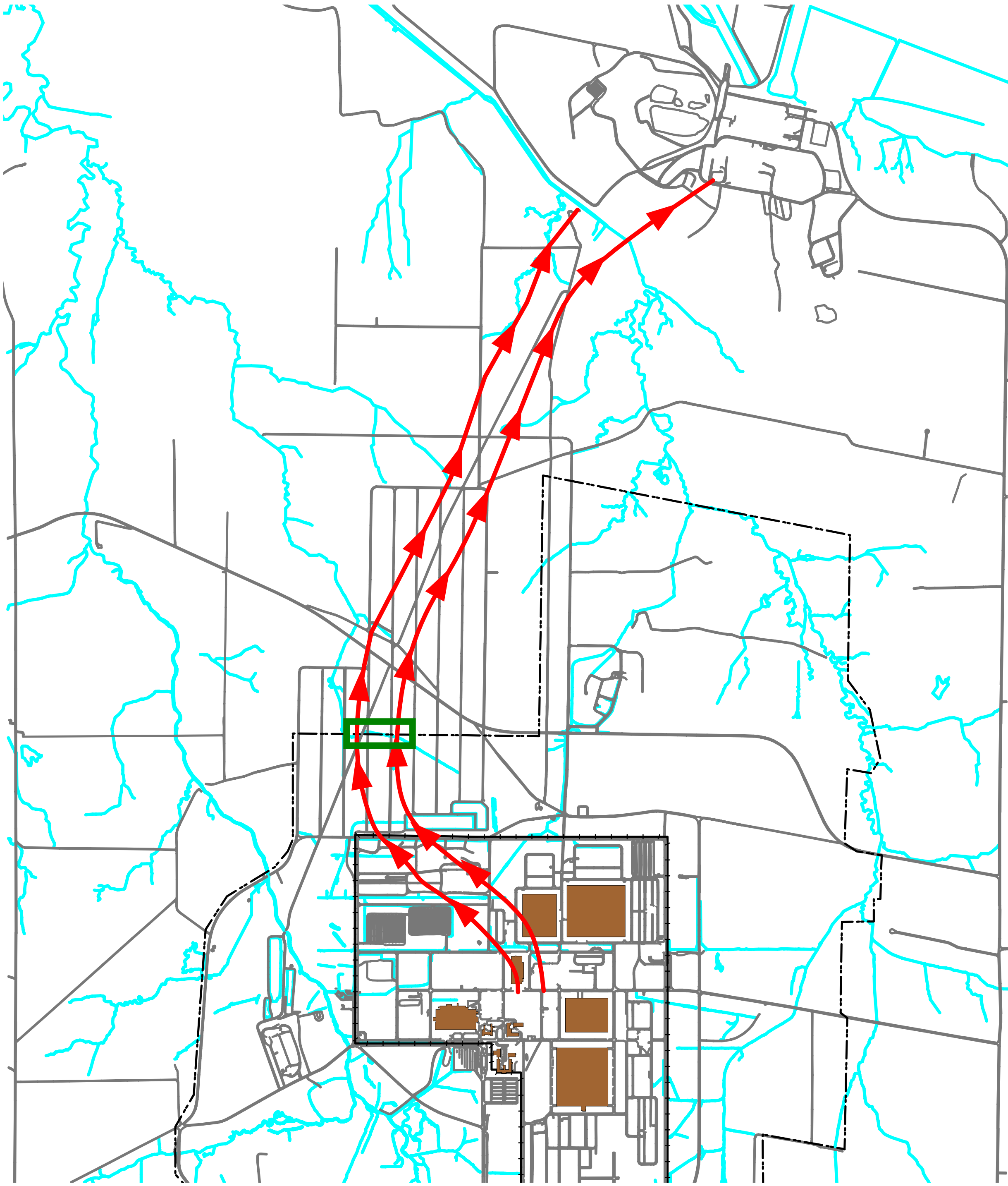
Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Groundwater

POE	COC	Concentration Detected Min	Concentration Detected Max	Units	Frequency of Detection	EPC	Units	% Total Risk	Statistical Measure
At Property Boundary; sources at SE Corner	1,1-Dichloroethene	1.20E-03	9.50E-01	mg/kg	9/61	2.50E-03	mg/L	<1	MAX
	Trichloroethene	1.50E-03	1.10E+04	mg/kg	39/61	3.17E+01	mg/L	99	MAX
	Vinyl chloride	1.90E-03	2.90E+01	mg/kg	13/61	7.27E-04	mg/L	<1	MAX
At Property Boundary; sources at SW Corner	Trichloroethene[a]	1.45E-03	3.50E+01	mg/kg	8/41	1.59E-01	mg/L	76	MAX
	Vinyl chloride	9.40E-03	3.50E-02	mg/kg	3/41	5.09E-04	mg/L	24	MAX
At Property Boundary; sources in the RGA	Trichloroethene	1.50E-03	7.01E+02	mg/kg	146/155	7.12E+00	mg/L	100	MAX

POE = Point of exposure
COC = Contaminant of concern
Min = Minimum detected concentration
Max = Maximum detected concentration
EPC = Exposure point concentration
% Total Risk = Excess lifetime cancer risk (ELCR) due to exposure to the single analyte divided by risk from exposure to all contaminants in soil. Note that the sum of all percentages for an area may not equal 100% due to rounding error.
MAX = The EPC was derived from modeling based upon the maximum detected concentration within the source. The value reported is the peak concentration expected at the POE over the period modeled.

[a] The maximum detected concentration listed for TCE (35 mg/kg) is from Table 1.14 in the WAG 6 RI BRA. A larger value (168 mg/kg) is listed on page C-57 of Appendix C of the WAG 6 RI BRA. This larger value was used for the transport modeling source term.

This table presents the range of detected concentrations in source zone soil and groundwater taken from Table 1.14 of the WAG 6 RI BRA, and maximum EPCs for COCs in groundwater at the POE taken from Appendix C of the WAG 6 RI BRA. Selection of COCs was based upon EPC in groundwater. The POE used was the PGDP property boundary. In addition to the range of concentrations detected for each COC, the table presents the frequency of detection in the source zone (i.e., the number of times the chemical was detected in samples collected at the C-400 Cleaning Building area), the EPC in groundwater derived using modeling, and the value in source zone used to derive the EPC in groundwater (Statistical Measure).



LEGEND:

PARTICLE TRAVEL PATH

DOE PROPERTY BOUNDARY

POINT OF EXPOSURE

3000 0 3000 Feet

TRUE NORTH 20° PLANT NORTH

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Fig. 7. Point of exposure at the property boundary assumed for the off-site resident.

FIGURE No. 400_part_track.apr
DATE 11-18-04

The COCs presented in Table 2 were selected following guidance presented in Section 5 of the baseline risk assessment contained in the aforementioned report. This guidance is consistent with that in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000a). Using this guidance, COCs are defined as chemicals detected at a site that significantly contribute to a pathway in a use scenario for a receptor that either (a) exceeds a cumulative excess lifetime cancer risk (ELCR) of 1×10^{-6}, or (b) exceeds a cumulative non-carcinogenic hazard index (HI) of 1. Chemicals are considered to be significant contributors to risk if their individual carcinogenic risk contribution is greater than 1×10^{-6} or their non-carcinogenic hazard quotient (HQ) is greater than 0.1.

Table 2 indicates that the COCs found in the sources at the C-400 Cleaning Building area and contributing to groundwater contamination are 1,1-DCE, TCE, and VC.

2.7.1.2 Exposure assessment

This section summarizes the results of the exposure assessment that was performed as part of the BHHRA for the C-400 Cleaning Building area, with specific attention to the exposure routes that were quantitatively evaluated and that are relevant to the selected action. Generally, exposure assessment is a procedure in which pathway analysis is used to identify significant pathways of human exposure, and exposure equations are used to quantify doses to or intakes of receptors. Throughout the exposure assessment, the guiding principal is that, in order to be quantified, the exposure pathway has to be complete either now or in the future. A complete pathway is one that includes a source of contamination and mechanism of release, a method of transport or retention, a POE, and a route of exposure. If any of these parts are absent, then the exposure pathway is deemed incomplete and is not quantified in the risk assessment.

Pathway analysis in the BHHRA identified four human health exposure scenarios to be evaluated for the C-400 Cleaning Building area (see Fig. 1). These were the industrial worker exposure scenario, the excavation worker exposure scenario, the recreational exposure scenario, and the rural residential exposure scenario (on-site and off-site). Of these scenarios, only the off-site rural residential scenario is described in detail because this scenario is most pertinent to the selected remedy. The off-site rural residential scenario in the risk assessment assumed that a homestead would be located along the PGDP property boundary and that water would be withdrawn from the RGA at that location and used in the home. Exposure to water in this location, which is shown in Fig. 7, was assumed to occur over a lifetime.

Contaminant concentrations in groundwater at the POE were estimated from soil concentrations using the Multimedia Environmental Pollutant Assessment System (MEPAS) transport model. This model assumed transport of contaminants from the TCE and VOC source zones found in the southeastern and southwestern portions of the C-400 Cleaning Building area to the POE at the PGDP property boundary. The route assumed to be traveled by TCE and the VOCs followed the paths predicted by the site-wide groundwater flow model developed for the PGDP. This flow path is shown on Fig. 7. Additional information about the MEPAS transport model and the parameters used can be found in Appendix C, "Transport Modeling Results" in Appendix 3b, "Risk Assessment" of *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1727&D2.

Contaminant concentrations in groundwater at the POE from TCE sources in the RGA at the C-400 Cleaning Building area were estimated using information developed using the MODFLOWT transport model. This model assumed transport to the same POE used in the MEPAS model. Additional information about this modeling and the parameters used can be found in Appendices C.1, "Restoration Timeframe Analysis Using Groundwater Modeling Predictive Simulations," and C.5, "Derivation of Trichloroethene and ^{99}Technetium Source Zone Volumes for the WAG 6 Area Paducah Gaseous

Diffusion Plant, Paducah, Kentucky," in Volume 4 of *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1857&D2.

Only direct routes of exposure to contaminated groundwater were considered for the off-site rural residential scenario. The exposure routes assessed included ingestion of groundwater, dermal contact with groundwater during showering, and inhalation of vapors emitted by groundwater during showering and during household use.

Exposure parameters used in all exposure equations were those used to derive chronic dose estimates. (A chronic dose estimate is one derived assuming repeated daily exposure to a contaminated medium over several years.) Therefore, the use of these parameters yielded dose estimates that allowed for the estimation of dose over a lifetime of exposure (i.e., 40 years for the resident) under frequent use (i.e., 350 days/year for the resident.) Also, in keeping with current agreements, doses used to calculate residential risk estimates included exposure durations for both a child (6 years) and an adult (34 years). The values used for all other exposure parameters were taken from those approved by decision makers. Use of these parameters and the EPCs presented in Table 2 yielded reasonable maximum exposure (RME) estimates of dose.

2.7.1.3 Toxicity assessment

This section summarizes the salient points of the toxicity assessment contained in the BHHRA for the C-400 Cleaning Building area. As with the earlier discussion of COCs, most information is contained in the tables presented in this section.

In order to characterize risk from the RME dose estimates calculated during the exposure assessment, toxicity values for cancer effects and noncancer effects (i.e., systemic toxicity or hazard) were gathered from approved sources. Primary among these sources were EPA's Integrated Risk Information System (IRIS), the EPA Superfund Technical Support Center in Cincinnati, and EPA Health Effects Assessment Summary Tables (HEAST). Toxicity values for the COCs taken from these and other sources are in Tables 3 and 4. Table 3 presents toxicity values used to estimate cancer risks, and Table 4 presents toxicity values used to estimate the potential for systemic toxicity.

2.7.1.4 Risk characterization

This section describes how the outputs from the exposure assessment (i.e., RME doses) and toxicity assessment (toxicity values) were combined to characterize the baseline risks. As with the earlier sections, most information is presented in tables. This section concludes with a short discussion of the uncertainties affecting the results presented.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime because of exposure to the carcinogen. ELCR is calculated from the following equation:

$$Risk = CDI \times SF$$

where: risk = a unitless probability (e.g., 2×10^{-5}) of an individual's developing cancer,
CDI = chronic daily intake averaged over 70 years [mg/(kg × day)],
SF = slope factor, expressed as $[mg/(kg \times day)]^{-1}$.

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6} or 1E-6). An ELCR of 1×10^{-6} (1E-06) indicates that an individual experiencing the RME estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing

Table 3. Cancer toxicity data summary for the BHHRA for source areas at the C-400 Cleaning Building area

Route: Ingestion and Dermal Contact

Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Type of Cancers	Source	Date Accessed
1,1-Dichloroethene	6.00E-01	6.00E-01	$[mg/(kg \times day)]^{-1}$	C/kidney, adenocarcinoma	IRIS	2000
Trichloroethene	1.10E-02	7.33E-02	$[mg/(kg \times day)]^{-1}$	C/liver, lung	Superfund	2000
Vinyl chloride	1.40E+00	1.40E+00	$[mg/(kg \times day)]^{-1}$	A/liver, lung, digestive tract, brain	IRIS	2000

Route: Inhalation

Chemical of Concern	Unit Risk	Unit Risk Units	Inhalation Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Type of Cancers	Source	Date Accessed
1,1-Dichloroethene	5.00E-02	$\mu g/m^3$	1.75E-01	$[mg/(kg \times day)]^{-1}$	C/kidney, adenocarcinoma	IRIS	2000
Trichloroethene	1.71E-03	$\mu g/m^3$	6.00E-03	$[mg/(kg \times day)]^{-1}$	C/liver, lung	Superfund	2000
Vinyl chloride	8.80E-03	$\mu g/m^3$	3.08E-02	$[mg/(kg \times day)]^{-1}$	A/liver, lung, digestive tract, brain	IRIS	2000

— = No information available

EPA Weight of Evidence Group:

A = Human carcinogen

C = Possible human carcinogen

Source:

IRIS = Integrated Risk Information System, US EPA

Superfund = Superfund Health Risk Technical Support Center, US EPA

This table provides carcinogenic risk information that is relevant to the COCs in water listed in Table 2. In this table, the slope factors for dermal contact were extrapolated from oral values using adjustment factors based upon the absorption that occurs in the gut.

Table 4. Noncancer toxicity data summary for the BHHRA for source areas at the C-400 Cleaning Building area

Contaminant of Concern	Chronic Oral RfD	Oral RfD Units	Chronic Dermal RfD	Dermal RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Source	Date Accessed
Route: Ingestion, Dermal								
1,1-Dichloroethene	5.00E-02	mg/(mg × day)	5.00E-02	mg/(mg × day)	Liver	1,000	IRIS	2000
Trichloroethene	6.00E-03	mg/(mg × day)	9.00E-04	mg/(mg × day)	Liver	—	Superfund	2000
Vinyl chloride	3.00E-03	mg/(mg × day)	3.00E-03	mg/(mg × day)	Liver	30	IRIS	2000
Route: Inhalation								
Contaminant of Concern	**Chronic Inhalation RfC**	**RfC Units**	**Chronic Inhalation RfD**	**RfD Units**	**Primary Target Organ**	**Combined Uncertainty/ Modifying Factors**	**Source**	**Date Accessed**
1,1-Dichloroethene	2.00E-01	mg/m^3	5.71E-02	mg/(mg × day)	Liver	1,000	IRIS	2000
Trichloroethene	2.10E-02	mg/m^3	6.00E-03	mg/(mg × day)	Liver	—	Superfund	2000
Vinyl chloride	1.00E-01	mg/m^3	2.86E-02	mg/(mg × day)	Liver	30	IRIS	2000

RfD = reference dose
— = No information available

Source:
IRIS = Integrated Risk Information System, US EPA
Superfund = Superfund Health Risk Technical Support Center, US EPA

This table provides noncarcinogenic risk information that is relevant to the COCs in water listed in Table 2. As with carcinogenic data, dermal RfDs were extrapolated from oral RfDs applying an adjustment factor based upon absorption from the gut.

cancer from all other causes has been estimated to be as high as one in three (i.e., approximately 3×10^{-1} or 3E-01). EPA's target risk range for site-related exposures is 10^{-6} to 10^{-4} (or E-06 to E-04).[7]

The potential for noncarcinogenic effects (i.e., systemic toxicity or hazard) is evaluated by comparing an exposure level over a specific time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious health effects. The ratio of the dose estimate to the RfD is called an HQ. An HQ < 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from the chemical are unlikely. The HI is generated by adding the HQs for all chemicals of concern that effect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may be reasonably exposed. An HI < 1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI greater than 1 does not mean that a toxic effect is certain in the exposed individual. An HI > 1 indicates that site-related exposures *may* result in a deleterious health effect.

The HQ is calculated as follows:

$$\textit{Non-cancer HQ} = CDI \div RfD$$

where: CDI = chronic daily intake or dose,
RfD = reference dose.

The CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term). EPA does not have a target range for hazard; however, cumulative values less than 1 are deemed to be unimportant.

Tables 5 and 6 present the results of risk characterization for the source areas at the C-400 Cleaning Building area used in developing the current action. Other results are in the RI and FS Reports mentioned earlier. Table 5 presents the cancer risk results, and Table 6 presents the systemic toxicity results.

For the source areas at the C-400 Cleaning Building area, both the ELCR and hazard posed to the receptor under the scenario used to determine if action is needed in the C-400 Cleaning Building area have been deemed unacceptable because the cancer risk exceeds the upper limit of the EPA target risk range (10^{-4}), and hazard exceeds 1. The primary contaminant driving cancer risk and hazard is TCE.

Although the BHHRA was completed using the best information available and following approved methods, several uncertainties should be considered when using the risk assessment results in decision making. These uncertainties and their effects upon the risk and hazard estimates are discussed in detail in the WAG 6 RI and FS reports. As discussed there, the following are the most important uncertainties affecting the estimates presented in this ROD.

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[7] The NCP requires that 1×10^{-6} risk level (40 *CFR* 300.430 (e)(2)(i)(A)(2)) shall be "used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of multiple contaminants at a site or multiple pathways of exposure."

Table 5. Cancer risk characterization summary for chemicals of concern for sources at the C-400 Cleaning Building area

Scenario Timeframe: Future
Receptor Population: Off-Site Rural Resident
Receptor Age: Child and Adult (Lifetime)

Medium	Exposure Medium	POE	Chemical of Concern	Excess Lifetime Cancer Risk: Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
				Southeast Corner				
Soil	Groundwater	Property Boundary	1,1-Dichloroethene	NV	NV	NV	NA	5.32E-05
			Trichloroethene	NV	NV	NV	NA	1.83E-02
			Vinyl chloride	NV	NV	NV	NA	2.08E-05
Total								**1.84E-02**
				Southwest Corner				
Soil	Groundwater	Property Boundary	Trichloroethene	NV	NV	NV	NA	9.19E-05
			Vinyl chloride	NV	NV	NV	NA	1.45E-05
Total								**1.06E-04**
				RGA				
Soil	Groundwater	Property Boundary	Trichloroethene	NV	NV	NV	NA	4.12E-03
Total								**4.12E-03**

NA = Route of exposure is not relevant for the COC.
NV = No value available. Values for individual exposure routes were not available in the BHHRA.

This table provides cancer risk estimates for the scenarios utilized to determine whether action is needed at sources at the C-400 Cleaning Building area. Cancer risk estimates for other scenarios and media are available in the RI and FS Report, but these estimates are not presented here because they are not relevant to the current action.

The risk estimates presented here were based upon a reasonable maximum exposure and were developed by taking into account various assumptions about frequency and duration of exposure to groundwater, as well as the toxicity of the COCs listed. Generally, exposure parameters used in the derivation of the risk estimates were chosen to ensure that risk was not underestimated (i.e., conservative assumptions, such as assuming a single individual would be exposed over a 40 year period and that this individual would drink 2 liters of water per day, were used when choosing the exposure parameters).

The total cancer risk levels presented above indicate that if no clean-up action is taken, then an off-site rural resident could have increased probability greater than 1 in 100 of developing cancer from exposure to groundwater contaminated by constituents migrating from source areas. Note, as discussed in Section 2.2, there are current mechanisms in place that prevent exposure by off-site rural residents to contaminated groundwater.

As discussed in the RI and FS reports, the summation of risks across chemicals potentially migrating from the source at the C-400 Cleaning Building area is a very conservative assumption because transit times for contaminants may vary. In addition, the risk estimates shown here are conservative because they are based upon the maximum concentration of each COC expected in groundwater at the selected POE rather than the average concentration expected during the period of exposure. This is a conservative assumption because contaminant concentrations would fall over time as the COC mass in the source zone is depleted.

Table 6. Hazard characterization summary for chemicals of concern for sources at the C-400 Cleaning Building area

Scenario Timeframe: Future
Receptor Population: Off-site Rural Resident
Receptor Age: Child

Medium	Exposure Medium	POE	Chemical of Concern	Primary Target Organ	Excess Lifetime Cancer Risk			Exposure Routes Total
					Ingestion	Inhalation	Dermal	
				Southeast Corner				
Soil	Groundwater	Property Boundary	1,1-Dichloroethene	Liver	NV	NV	NV	0.1
			Trichloroethene	Liver	NV	NV	NV	1,900
			Vinyl chloride	Liver	NV	NV	NV	<0.1
Scenario Total								**1,900**
Liver Total								**1,900**
				Southwest Corner				
Soil	Groundwater	Property Boundary	Trichloroethene	Liver	NV	NV	NV	10
			Vinyl chloride	Liver	NV	NV	NV	<0.1
Scenario Total								**10**
Liver Total								**10**
				RGA				
Soil	Groundwater	Property Boundary	Trichloroethene	Liver	NV	NV	NV	450
Scenario Total								**450**
Liver Total								**450**

NV = No value available. Values for individual exposure routes were not available in the BHHRA.

This table provides hazard quotients for the scenarios utilized to determine whether action is needed for source areas at the C-400 Cleaning Building. Hazard estimates for other scenarios and media are available in the RI and FS Reports, but these estimates are not presented here because they are not relevant to the current action.

The hazard estimates presented here were based upon a reasonable maximum exposure and were developed by taking into account various assumptions about frequency and duration of exposure to groundwater, as well as the toxicity of the COCs listed. Generally, exposure parameters used in the derivation of the hazard estimates were chosen to ensure that hazard was not underestimated (i.e., conservative assumptions, such as assuming a single individual would be exposed over a 40 year period and that this individual would drink 2 liters of water per day, were used when choosing the exposure parameters).

The total hazard levels presented above indicate that if no clean-up action is taken, then an off-site rural resident may experience adverse effects from exposure to groundwater contaminated by COCs migrating from source areas at the C-400 Cleaning Building. The information also indicates that the liver is the most likely target organ to be affected. Note, as discussed in Section 2.2, there are current mechanisms in place that prevent exposure by off-site rural residents to contaminated groundwater.

As discussed in the RI and FS reports, the summation of hazards across chemicals potentially migrating from the source at the C-400 Cleaning Building area is a very conservative assumption because transit times for contaminants may vary. In addition, the hazard estimates shown here are conservative because they are based upon the maximum concentration of each COC expected in groundwater at the selected POE rather than the average concentration expected during the period of exposure. This is a conservative assumption because contaminant concentrations would fall over time as the COC mass in the source zone is depleted.

- Setting the POE at the location along the property boundary where the highest contaminant concentrations are expected – This is a conservative assumption because it assumes that the worst possible location would be selected by the hypothetical off-site rural resident for the water supply well.

- Using the highest modeled COC concentrations over time as the exposure concentrations rather than the average COC concentrations predicted over the period of exposure – This is a conservative assumption because it does not consider that COC concentrations would fall over time as the source zone is depleted.

- Assuming that all COCs will attain their maximum concentrations at the POE at the same time – This is a conservative assumption because the modeling predicts that the COCs will attain their maximum concentrations at different times.

The overall effect of these and other uncertainties discussed in the WAG 6 RI and FS reports are the derivation of risk and hazard estimates that are unlikely to be exceeded due to real-life exposures (i.e., the estimates are conservative).

2.7.2 Summary of Ecological Risk Assessment

This section summarizes the baseline ecological risk assessment (BERA) and presents significant results used in making the current decisions for source areas at the C-400 Cleaning Building area. As noted above, the information presented here is a relevant subset of the information presented in the BERA contained in the aforementioned reports for WAG 6 and is not meant to completely describe the baseline risks estimated for all receptors and SWMUs assessed.

The BERA for the C-400 Cleaning Building area, which appears in the RI Report, concluded that a quantitative assessment of current risk to ecological receptors was not required for the area because the C-400 Cleaning Building area is located in the industrialized portion of PGDP. Groundwater potentially impacted by releases from sources at the C-400 Cleaning Building area was not evaluated in the BERA.

Groundwater impacted by releases from the C-400 Cleaning Building area was evaluated in the BERA for the Northwest Dissolved Phase Plume (DOE 1994). The Northwest Plume BERA evaluated three exposure pathways in the floodplain between PGDP and the Ohio River: 1) groundwater discharge into the Ohio River, 2) pumped groundwater for use in aquaculture and irrigation, and 3) groundwater contribution to surface water resources such as seeps and springs in the vicinity of the Ohio River. The BERA for the Northwest Dissolved Phase Plume (1994) concluded that, if groundwater discharges to the surface naturally or as a result of pumping for irrigation, then chemical contamination could pose a potential hazard to ecological receptors; however, the magnitude of this hazard was judged to be minimal for the exposure scenarios evaluated.

The major uncertainty associated with the BERA for the Northwest Dissolved Phase Plume is whether the risk characterization results are representative of current and future risk to aquatic and terrestrial biota exposed to groundwater discharging to the surface at seeps along Little Bayou Creek. These risks were assessed in draft screening ecological risk assessments. These assessments, which utilized simple comparisons between measured and predicted concentrations of contaminants potentially discharged to the surface at seeps along the creek and no action ecological risk-based screening values, indicate that no adverse impacts are likely on ecological receptors from exposure to TCE in groundwater discharged at the seeps.

2.7.3 Conclusions from Risk Assessment

This section presents the overall conclusions reached in the baseline risk assessment for the source areas at the C-400 Cleaning Building area that drive the need for action. These conclusions are used to develop the basis for the action statement that appears at the end of this section.

2.7.3.1 Risks to human health

The basis for risk to human health considered in this decision was the potential for contaminants in the source area to migrate to groundwater, for this contaminated groundwater to migrate to a point along the PGDP property boundary, and for an off-site rural resident to use the contaminated groundwater in the home. (Note that the current Water Policy prevents the use of groundwater by certain, nearby residences; therefore, the exposure pathway leading to the risks reported here currently is incomplete, and risks are mitigated.) The maximum risks over all sources at the C-400 Cleaning Building area for this scenario following the methods discussed above, which included several conservative assumptions (see Sect. 2.7.1.4), were greater than 1×10^{-2} and 1,000 for ELCR and systemic toxicity, respectively. These conservative estimates of risk and hazard, which are unlikely to be exceeded due to real-life exposures currently or in the future, indicate that the total ELCR to a hypothetical off-site rural resident using groundwater at a POE along the PGDP property boundary could be as great as 2 in 100 and that a systemic toxic effect is possible. Both the cancer risk and hazard values under these conservative assumptions exceed their EPA limits. The COCs in the soil source area are TCE, VC, and 1,1-DCE. Of these, the contaminant posing the greatest ELCR and hazard is TCE.

2.7.3.2 Risks to ecological receptors

The basis for risk to ecological receptors considered in making the current decision was the potential for TCE and other VOCs in the source area at the C-400 Cleaning Building to migrate to groundwater and for this contaminated groundwater to migrate to points where exposure at the surface was possible. Of the risks presented, only those resulting from discharge of TCE in groundwater to surface water at seeps along Little Bayou Creek were determined potentially to pose risks. However, the analysis determined that no adverse impacts are likely on ecological receptors from exposure to TCE in groundwater discharged at the seeps.

2.7.4 Summary of Radiation Dose Assessment

Neither the RI nor the FS Report contains a radiation dose assessment; therefore, a screening-level assessment was prepared for this document. In this dose assessment, the radiation doses that could be expected by an off-site rural resident using groundwater contaminated by constituents migrating from sources at the C-400 Cleaning Building area were determined using the MEPAS model presented in the WAG 6 RI report. Because the WAG 6 RI report modeling indicated that no radionuclides were migrating from source areas at the C-400 Cleaning Building area to be addressed by the interim action, the dose assessment concluded that the dose estimate for exposure to groundwater by the off-site rural resident is below 1 mrem/yr. This value is below the EPA and Nuclear Regulatory Commission (NRC) limits (15 and 25 mrem/yr, respectively).

2.7.5 Basis for Action Statement

A response action generally is warranted if one or more of the following conditions exist at a site: (1) the cumulative ELCR to an individual exceeds 1×10^{-4} (using RME assumptions for either the current or reasonably anticipated future land use or current or potential beneficial use of groundwater and/or surface water); (2) the systemic toxicity HI is greater than one (using RME assumptions for either the current or reasonably anticipated future land use or current or potential beneficial use of groundwater and/or surface water); (3) site contaminants cause adverse environmental impacts; or (4) chemical-specific standards or other measures that define acceptable risk levels are exceeded, and exposure to contaminants above these levels is predicted under current or reasonably anticipated future land use. Because, under the assumptions discussed in Section 2.7.3.1, one or more of these conditions exists for sources of contamination consisting of TCE and other VOCs at the C-400 Cleaning Building area, a response action for these sources is appropriate.

The response action selected in this ROD for the source area comprised of TCE and other VOCs found at the C-400 Cleaning Building area is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants from these areas that may present an imminent and substantial endangerment to public health and welfare.

2.8 INTERIM REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are medium-specific or OU-specific goals for protecting human health and the environment (EPA 1988). The RAOs are developed by taking into account the results of the risk assessment and ARARs.

The RAOs for the C-400 Cleaning Building source area are as follows:

- Prevent exposure to contaminated groundwater by on-site industrial workers through institutional controls (e.g., excavation/penetration permit program);
- Reduce VOC contamination (primarily TCE and its breakdown products) in UCRS soil at the C-400 Cleaning Building area to minimize the migration of these contaminants to RGA groundwater and to off-site POEs; and
- Reduce the extent and mass of the VOC source (primarily TCE and its breakdown products) in the RGA in the C-400 Cleaning Building area to reduce the migration of the VOC contaminants to off-site POEs.

The contamination by TCE in the C-400 source zone is present as dissolved TCE in groundwater and as DNAPL. EPA recognizes that DNAPL is a significant technical challenge for both characterization and remediation. DOE anticipates that the interim remedial action may not reduce soil contamination to levels that meet ARARs for groundwater by the time treatment is terminated.

This interim remedial action would achieve the RAOs by removing significant amounts of TCE and other VOCs from the source zone (thereby decreasing the amount of mass available for off-site migration and the timeframe that off-site contamination will remain above health-based levels), continuing select institutional controls (e.g., the current excavation/penetration permit program), and employing LUCs. The following LUC objectives are necessary to ensure the protectiveness of the selected remedy:

- Maintain the integrity of any current or future remedial or monitoring system;
- Prohibit the development and use of the C-400 Cleaning Building for residential housing, elementary and secondary schools, child care facilities, and playgrounds;
- Prevent exposure of current and future on-site industrial workers to groundwater and prevent use of the groundwater at the C-400 Cleaning Building area through institutional controls (e.g., the current excavation/penetration permit program) and through deed restrictions;

- Provide notice in property records regarding contamination and response actions at the C-400 Cleaning Building area.

2.9 DESCRIPTION OF ALTERNATIVES

The following four remedial alternatives were assessed for application in the source zone comprised of TCE and other VOCs in the UCRS and the RGA at the C-400 Cleaning Building area:

- Alternative 1: No Action.

- Alternative 2: Limited Action consists of on-site and off-site LUCs, including institutional controls, to prevent human exposure to the contaminants, groundwater monitoring, and no additional contaminant removal or treatment. Additional institutional controls would restrict use of and access to the groundwater.

- Alternative 3: Electrical Resistance Heating in both the UCRS and the RGA to remove contaminants, groundwater monitoring, and LUCs, including institutional controls.

- Alternative 4: Vapor extraction in the UCRS and steam extraction in the RGA to remove contaminants, groundwater monitoring, and LUCs, including institutional controls.

The LUCs required for Alternatives 2, 3, and 4 will be implemented and maintained to achieve protection of human health and the environment. The selected alternative is Electrical Resistance Heating in both the UCRS and the RGA, LUCs, and groundwater monitoring. A description of each alternative evaluated for the C-400 Cleaning Building area is included below.

2.9.1 Alternative 1: No Action

Under the No Action Alternative, active mass removal, treatment, or containment would not be performed. This remedial alternative provides a basis for assessing the effects of taking no action at the C-400 Cleaning Building area and provides a baseline against which the other alternatives are compared. For evaluation purposes only, the scope of this alternative does not include continuation of any existing interim remedial actions or existing institutional controls. (Note that existing interim remedial actions [such as the Northwest and Northeast Plume pump-and-treat actions], the existing institutional controls [e.g., the Water Policy removal action and plant security measures], and the groundwater monitoring activities could continue, but they were not considered to be components within the scope of this remedial alternative.) Natural attenuation processes eventually would remove the contamination; however, the remediation period could be very long (thousands of years). The No Action Alternative has no capital cost and no operation and maintenance (O&M) costs.

2.9.2 Alternative 2: Limited Action

Under the Limited Action Alternative, active mass removal, treatment, or containment would not be performed. However, other protective measures would be continued and enhanced to prevent on- and off-site human exposure to the contaminants in the UCRS and RGA. Existing institutional controls, such as the Water Policy and control of the C-400 Cleaning Building area, would be maintained and augmented by additional actions to restrict use of and access to the groundwater. Natural attenuation processes eventually would remove the contamination; however, the remediation period could be as long as thousands of years. The long-term reliability of this remedy hinges on DOE's ability to maintain control of groundwater use in the affected area for thousands of years until groundwater quality is restored.

Capital and O&M costs for this alternative are dependent upon the additional institutional controls that would be implemented. These institutional controls remain undefined. Alternative 2 is not expected to have any long-term impact on land use in the C-400 source zone area. On- and off-site groundwater use could remain restricted for thousands of years.

2.9.3 Alternative 3: Electrical Resistance Heating in both the UCRS and RGA

Alternative 3 consists of volatilization and removal of contaminated groundwater and TCE and other VOCs by application of Electrical Resistance Heating. The Groundwater OU FS evaluated Electrical Resistance Heating for application in the UCRS. A contemporaneous innovative technology review identified Electrical Resistance Heating as a promising remedial measure to be tested in the RGA. The Six-Phase Heating Treatability Study (DOE 2003) demonstrated that Electrical Resistance Heating could be effective in the RGA.

Two common applications of Electrical Resistance Heating are Three-Phase Heating and Six-Phase Heating. In both applications, this technology uses *in situ* (in place) heating to raise the temperature of the soil to a level where the target contaminant(s) is/are turned into gas (i.e., volatilized). Common power sources (60 hertz) may be used to heat the ground (typical subsurface applied voltages range from 150–600 volts), producing *in situ* steam to liberate the contaminants, which are removed by way of a vapor recovery system. The technology can be deployed in the vadose (above the water table) and saturated (below the water table) zones and may be used in moist soils with either low- or high-permeability.

The Three-Phase Heating system consists primarily of a network of in-ground electrodes and co-located vapor extraction wells distributed throughout the zone of contamination. Three-Phase Heating is the preferred electrical phasing method for large and noncircular remediation areas. Six-Phase Heating employs six electrodes located in a hexagonal shape with a neutral electrode located in the center of the hexagon serving as a vapor extraction well. It is the preferred electrical phasing method for smaller, discrete areas.

Three-Phase versus Six-Phase Heating

Both "Three-Phase Heating" and "Six-Phase Heating" are varieties of Electrical Resistance Heating. Three-Phase Heating was invented as an oilfield enhancement technique and is a technology available in the public domain. Six-Phase Heating was developed and patented by DOE and Batelle. This patent has not expired.

The primary difference between Three- and Six-Phase Heating is in the arrangement of the electrodes used to heat the ground. Generally, the electrode array used for Three-Phase Heating allows for its application in large, irregularly shaped areas, and the electrode array used for Six-Phase Heating is optimal for single, circular areas less than about 65-ft (20-m) in diameter. Six-Phase Heating is less desirable in larger, irregularly shaped areas because when two or more Six-Phase Heating electrode arrays abut, areas with no current flow (creating a "cold spot") and with current flow higher than optimum (creating a "hot spot") are developed, resulting in inefficient energy usage and uneven heating.

To date, all successful full-scale Electrical Resistance Heating implementations have utilized either Three-Phase Heating or a combination of Six- and Three-Phase Heating.

Information taken from *Three-Phase Heating? Six-Phase Heating? Which is Better?* (TRH 2004).

Alternative 3 includes the following components: (1) installation of the Electrical Resistance Heating array; (2) withdrawal of TCE and other VOCs and steam by high vacuum (approximately 20 to 25 inches of mercury) extraction; (3) treatment of soil vapor by an appropriate, applicable technology (e.g., catalytic oxidation, thermal oxidation, and/or activated carbon) and treatment of steam condensate and water by an appropriate, applicable technology (e.g., ion exchange, air stripping, and/or activated carbon); (4) discharge of treated groundwater through a permitted Kentucky Pollutant Discharge Elimination System (KPDES) outfall; (5) removal and disposition, as appropriate, of interfering, nonessential, miscellaneous infrastructure(s) in the area to be treated; and (6) LUCs.

The remediation goal for this interim action is to operate the Electrical Resistance Heating system until monitoring indicates that heating has stabilized in the subsurface and that recovery of TCE, as measured in the recovered vapor, diminishes to a point at which further recovery is at a constant rate (i.e., recovery is asymptotic). At asymptosis, continued heating would not be expected to result in any further significant reduction of toxicity, mobility, or volume of the zone of contamination. The forthcoming remedial action design documents will include criteria setting forth the requirements and approach that will apply for determining when asymptosis is achieved and heating stabilization has occurred, signaling when operation of the Electrical Resistance Heating System will cease.

Approximately 4 years (total) would be required for design (approximately 1 year), construction and operation (approximately 3 years), with an estimated capital cost of $32,054,750 and estimated O&M costs of $7,897,350[8]. Although this alternative is not expected to attain the MCL in groundwater for TCE at the conclusion of heating, natural attenuation processes would achieve the MCL for TCE over a few hundred years.[9] Although this technology is not expected to remove 100% of the mass of the TCE and VOC contaminants in the source area treated, it is considered reliable because the extracted contaminant mass will be permanently removed from the subsurface. Alternative 3 would not be expected to have any long-term impact on land use in the C-400 source zone area, and this would be reinforced by on-site LUCs that restrict use of the area by a future property owner.

2.9.4 Alternative 4: Vapor Extraction in the UCRS and Steam Extraction in the RGA

Alternative 4 consists of the removal and treatment of contaminated groundwater and TCE and other VOCs by application of a Dual-Phase Extraction System in the UCRS and a Steam Extraction System in the RGA. Dual-Phase Extraction, also known as multi-phase extraction or vacuum-enhanced extraction, uses a high vacuum system to remove various combinations of contaminated groundwater, separate-phase VOC product, and soil vapor from low-permeability and heterogeneous formations. The vacuum extraction well is constructed with a screened section in the zone of contaminated soils and groundwater. In operation, the system lowers the water table around the well, dewatering the formation. Contaminants in the vadose zone then are accessible to vapor extraction. Once above the ground, the system separates and treats the extracted vapors, liquid-phase organics, and groundwater.

Steam Extraction requires a series of injection and extraction wells in the treatment area to inject and recover steam in the subsurface. The injected steam volatilizes the TCE and other VOC contaminants (converts the contaminants from a liquid state to a vapor state by the application of heat). VOC-contaminated steam and water are collected in the extraction wells. An aboveground treatment system separates contaminants from the wastewater and gas before release.

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[8] Timeframes and costs set forth herein are for estimation purposes only. Enforceable schedules are set forth in the FFA.

[9] The determination that natural attenuation would return the TCE concentrations in groundwater to the MCL in a few hundred years was based on an evaluation set forth in the Groundwater OU FS. This evaluation determined that the reduction of TCE in the source area would lead to less contaminant mass to be transported and, therefore, lower contaminant concentrations in the same volume of water migrating from the site.

Alternative 4 includes the following components:

1. Dual-Phase Extraction: (1) installation of recovery wells, (2) withdrawal of UCRS groundwater by pumping, (3) withdrawal of TCE and other VOCs from the vadose zone by high vacuum (approximately 20–25 inches of mercury) extraction, (4) treatment of groundwater and soil vapor, (5) discharge of treated groundwater through a KPDES-permitted outfall, and (6) removal and disposition, as appropriate, of interfering, nonessential, miscellaneous infrastructure(s) in the area to be treated. The operation of the Dual-Phase Extraction array would continue at least as long as operation of the Steam Extraction system continues; and otherwise would cease when the monitoring system indicates that the induced soil gas vacuum has stabilized in the subsurface and when contaminant recovery, as measured by volume in the recovered vapor, has diminished to an asymptotic rate.

2. Steam Extraction: (1) installation of injection and recovery wells, (2) injection of steam, (3) withdrawal of TCE and other VOCs from the RGA in recovered steam and effluent water, (4) treatment of groundwater and steam, and (5) discharge of treated water through a KPDES-permitted outfall. Operation of the Steam Extraction system would cease when the monitoring system indicates that heating has stabilized in the subsurface and when contaminant recovery, as measured in the recovered vapor, has diminished to an asymptotic rate.

LUCs also are required for Alternative 4.

Design (including a design characterization study [Membrane Interface Probe study] to support finalization of the detailed design), construction, and operation of the interim remedy would be completed within 5 years (more operational time is required for this alternative than for Alternative 3, because less heat is applied at a slower rate) with an estimated capital cost of $65,040,050 and an estimated total O&M cost of $10,213,975[10]. Although the interim remedial action is not expected to reduce contamination by TCE in soil in the source zone to levels that meet MCLs/ARARs at the conclusion of active treatment, natural attenuation processes are expected to achieve MCLs in groundwater over a few hundred years. Like Alternative 3, although this technology is not expected to remove 100% of the mass of the TCE and VOC contaminants in the source area treated, it is considered reliable because the extracted contaminant mass will be permanently removed from the subsurface. The immediate area surrounding the C-400 source zone currently is governed by institutional controls that restrict access. These controls will remain in place under Alternative 4 as LUCs to ensure that the surfaces above the source zones remain limited to industrial uses.

2.9.5 Interim remedial action location

Alternatives 3 and 4 include a subsurface investigation as part of the remedial design process to determine the areal and vertical extent of the contamination associated with the source zones defined by TCE and other VOCs to the southeast and southwest of the C-400 Cleaning Building. This subsurface investigation will direct the optimum placement of the remediation systems.

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[10] Timeframes and costs set forth herein are for estimation purposes only. Enforceable schedules are set forth in the FFA.

2.9.6 Land use controls

LUCs are an integral part of Alternatives 2, 3, and 4. These include property record notices and administrative and access controls to DOE property. Property record notices would alert anyone performing a search of property records to important information about contamination and response actions on the property. The language comprising the property record notice will be filed at the McCracken County Clerk's Office, in accordance with state law, within 120 days of regulatory approval of the Land Use Control Implementation Plan (LUCIP). Administrative controls would include measures such as the current "excavation/penetration permit program," which requires workers to obtain formal authorization (i.e., internal permits/ approvals) before beginning any intrusive activities. Access controls could include measures, as necessary, to ensure protectiveness after performance of response actions. The LUCs will also include Deed Restrictions to be recorded prior to any other interest(s) being created in the DOE property that is the subject of this interim action, including but not limited to, liens, mortgages, leases, easements, licenses, profits, servitudes, covenants, or life estates; or before any actual transfer of such property. The Deed Restrictions are to be recorded at the McCracken County Clerk's office in accordance with applicable state and federal law.

2.9.7 Continued groundwater monitoring

Alternatives 2, 3, and 4 include continued monitoring of the source area and dissolved-phase plumes until groundwater concentrations of TCE and other VOCs are reduced to concentrations acceptable for beneficial use (e.g., use in the off-site residences for drinking, showering, washing, etc.; use in livestock raising; use in garden and crop irrigation; and use as a drinking water source for game animals). Alternative 1, as the "No Action Alternative," does not include groundwater monitoring or the provision of public water to impacted residences.

2.9.8 Five-year reviews

Because contamination above levels that would prevent unrestricted use would remain on-site during and after implementation of each of the alternatives, CERCLA mandates continuing five-year reviews.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The NCP requires that the CERCLA remedy selection be based on evaluation of nine selection criteria.

1. **Overall protection of human health and the environment.** This threshold criterion requires that the remedial alternative selected adequately protect human health and the environment, in both the short and long term. Protection must be demonstrated by the elimination, reduction, or control of unacceptable risks.

2. **Compliance with ARARs.** This threshold criterion requires that the alternatives be assessed to determine if they attain compliance with ARARs or satisfy the requirements for waiver of ARARs.

3. **Long-term effectiveness and permanence.** This primary balancing criterion focuses on the magnitude and nature of the risks associated with untreated waste and/or treatment residuals remaining at the conclusion of remedial activities. This criterion includes consideration of the adequacy and reliability of any associated containment systems and institutional controls, such as monitoring and maintenance requirements**,** necessary to manage treatment residuals and untreated waste.

4. **Reduction of contaminant toxicity, mobility, or volume through treatment.** This primary balancing criterion is used to evaluate the degree to which the alternative employs recycling or treatment to reduce the toxicity, mobility, or volume of the contamination.

5. **Short-term effectiveness.** This primary balancing criterion is used to evaluate the effect of implementing the alternative relative to the potential risks to the general public, potential threat to workers, potential environmental impacts, and the time required until protection is achieved.

6. **Implementability.** This primary balancing criterion is used to evaluate potential difficulties associated with implementing the alternative. This may include technical feasibility, administrative feasibility, and the availability of services and materials.

7. **Cost.** This primary balancing criterion is used to evaluate the estimated costs of the alternatives. Expenditures include the capital cost and O&M.

8. **State acceptance.** This modifying criterion provides for consideration of any formal comments from the state on the PRAP.

9. **Community Acceptance.** This modifying criterion provides for consideration of any formal comments from the community on the PRAP.

2.10.1 Overall Protection of Human Health and the Environment

Because Alternative 1 would not prevent exposure to the contaminants, it alone does not meet the threshold criterion of providing overall protection of human health and the environment. Based on the result of the detailed analysis, Alternatives 2, 3, and 4 meet the threshold criterion of overall protection of human health and the environment when combined with restrictions on groundwater use. The goal of Alternative 2 is to prevent exposure to human receptors (for thousands of years until natural attenuation reduces concentrations of TCE and other VOCs to acceptable levels). The goal of both Alternatives 3 and 4 is (1) to remove a significant amount of TCE and other VOCs from a major source area, thereby reducing the period that concentrations of TCE in groundwater remain above health-based levels, and (2) to employ on-site LUCs to achieve the LUC objectives for this action listed in Section 2.8 above. Alternatives 3 and 4 will leave residual amounts of TCE and other VOCs in the treated source zone that, if left alone, could continue to result in concentrations in groundwater greater than the MCL for TCE for a few hundred years. Any residual TCE and other VOCs remaining at the completion of Alternatives 3 or 4 would be addressed during other evaluations of the Groundwater OU and/or the CSOU.

2.10.2 Compliance with ARARs

Alternative 1 would not be compliant with ARARs. Alternatives 2, 3, and 4 will meet location-specific ARARs (addressing wetlands and endangered and protected species) and the identified action-specific ARARs (involving construction, collection, and treatment of TCE and other VOCs in soil vapor and steam condensate, water treatment, waste management, and transportation). While Alternatives 2, 3, and 4 will meet chemical-specific ARARs for surface water (related to the quality of groundwater recharge to Little Bayou Creek), and radiation protection requirements, the alternatives are not expected to meet the groundwater MCL for TCE. Although Alternatives 2, 3, and 4 are not expected meet the groundwater MCL for TCE, the alternatives satisfy the requirement set forth in 40 *CFR* 300.430(f)(1)(ii) for interim measures that will become part of the total remedial action that will attain ARARs for groundwater, including the MCL for TCE, or satisfy the requirements of an ARAR waiver. Alternatives 3 and 4 would permanently remove a significant amount of TCE and other VOCs from the C-400 source zone. The selected interim remedial action will address only TCE and other VOCs in the treatment area.

The interim action will be implemented in a manner that is protective of human health and the environment (i.e., chemical-specific ARARs for surface water and radiation protection will be achieved during the implementation of this interim action).

2.10.3 Long-Term Effectiveness and Permanence

Alternatives 1 and 2 have less long-term effectiveness and permanence than Alternatives 3 and 4. Under Alternatives 1 and 2, TCE and other VOCs that might migrate into the environment are not removed from the source zone. Alternatives 3 and 4 achieve greater long-term effectiveness and permanence because both alternatives result in significant removal of TCE and other VOCs from the C-400 source zone area. Alternatives 2, 3, and 4 will include continued groundwater monitoring.

Potential long-term impacts to resources and mitigative measures to offset any potential impacts are described in the text below. Resources that may be impacted to the greatest extent receive the more detailed analysis.

Land use. Alternative 1 (No Action) places no restrictions on land use. Alternatives 2, 3, and 4 are not expected to have any long-term impact on land use in the C-400 source zone area. The immediate area surrounding the source zone currently is governed by institutional controls that restrict access. Controls would remain in place under Alternatives 2, 3, and 4 as LUCs to ensure that the surfaces above the source zone remain limited to industrial uses that are integral to each of these alternatives; thus, land use would be unchanged.

Because Alternative 2 does not include treatment to reduce the amount of TCE and other VOCs in the C-400 source zone, LUCs could be needed for a much longer period under Alternative 2 than under Alternatives 3 and 4.

Air quality and noise. No long-term impacts to air quality or noise would result from any of the alternatives. After completion of the interim remedial action of Alternative 3 or 4, air pollutant and noise levels would be similar to current background levels.

Geology and soils. Under Alternatives 1, 2, and 4, no long-term adverse impacts to on-site geology and soils would occur; however, under Alternative 3, heating could result in slight, but irreversible, increases in soil permeability. The permeability increase is expected to be minimal. Both Alternatives 3 and 4 would have a positive long-term impact on soils because the significant source comprised of TCE and other VOCs at the C-400 Cleaning Building area would be eliminated or reduced.

Water resources. Alternatives 3 and 4 should have an overall, positive, long-term impact on surface and groundwater resources since a significant source zone comprised of TCE and other VOCs would be removed from PGDP soils and aquifer.

Wetlands and floodplains. No wetlands or floodplains are located within the C-400 Cleaning Building area that would be remediated under Alternatives 3 or 4; measures would be employed to minimize long-term impacts from the discharge of treated water.

No long-term negative impacts to the area along Little Bayou Creek in the area of the seeps are expected under any of the alternatives.

Ecological resources. Alternatives 3 and 4 should have an overall positive long-term impact on ecological resources, including any potential threatened and endangered (T&E) species in the vicinity of the C-400 Cleaning Building area because TCE and other VOC contaminants would be removed from area soils and the contaminated groundwater would be treated. In addition, removal of the TCE and other VOCs from the source zone and treatment of groundwater would help reduce the concentration of TCE and other VOCs in groundwater discharged at seeps along Little Bayou Creek. This would eliminate a potential source of contamination that could affect aquatic and terrestrial resources within and adjacent to Little Bayou Creek.

Cultural resources. No long-term impacts to cultural resources are anticipated from any of the alternatives. It is very unlikely that any intact archaeological resources still are present because the C-400 Cleaning Building area is an industrialized portion of PGDP and has been previously disturbed from construction and maintenance activities. In addition, no PGDP historical resources would be impacted.

Socioeconomics. No long-term socioeconomic impacts, including any environmental justice issues, would result from implementation of Alternative 2, 3, or 4. Construction contractors would perform the construction and operation of facilities for the alternatives. The permanent jobs that could develop as a result of this interim action are small in relation to the size of the population of the surrounding area. The implementation of these alternatives would not result in a substantial decrease or increase in the personnel at PGDP. However, the continued presence of contaminants in the groundwater after the implementation of Alternatives 2, 3, and 4 would limit groundwater use and could limit economic development opportunities related to beneficial use of groundwater.

Transportation. No long-term direct or indirect transportation impacts are anticipated for any of the alternatives. Shipment of waste off-site would not result in a noticeable increase in traffic.

Cumulative impacts. Cumulative impacts are those that may result from the incremental impacts of an action considered additive with the impacts of other past, present, and reasonably foreseeable future actions. No notable cumulative impacts resulting from Alternatives 2, 3, or 4 have been identified except for the positive long-term impacts that would result from the removal and treatment of contamination under Alternatives 3 and 4.

2.10.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. Alternatives 1 and 2 do not fulfill any of the criteria that are assessed under reduction of toxicity, mobility, or volume through treatment.

Both Alternative 3 (Electrical Resistance Heating in both the UCRS and RGA) and Alternative 4 (Vapor Extraction in the UCRS and Steam Extraction in the RGA) include treatment of TCE and other VOCs in an aboveground treatment unit satisfying the CERCLA preference for remedies that employ treatment. Electrical Resistance Heating is expected to be significantly more effective than Vapor Extraction for the reduction of volume of TCE and other VOCs in the UCRS. However, unlike Vapor Extraction, Electrical Resistance Heating causes irreversible changes in the soil. The addition of heat through Electrical Resistance Heating would dehydrate the soils and result in a permanent increase in soil permeability. The permeability increase is expected to be minimal and in most instances would be beneficial to the implementation of future technologies.

In the RGA, Electrical Resistance Heating and Steam Extraction rely on similar physical processes to volatilize the TCE and other VOCs and are expected to have comparable results in the source zone. Design constraints require that the location of the RGA source zone be better defined for the application of Electrical Resistance Heating.

2.10.5 Short-Term Effectiveness

Alternative 1, the No Action Alternative, includes no actions that would effectively reduce risk from use of contaminated groundwater in the short-term; however, because no actions are implemented in this alternative, no short-term effects would be realized from its selection.

Under Alternative 2, the Limited Action Alternative, protective measures would be continued and enhanced to prevent on-site and off-site human exposure to the groundwater contaminated by TCE and other VOCs found in both the UCRS and the RGA. Existing institutional controls would be maintained and augmented by additional actions to restrict use of and access to the groundwater. These existing institutional controls include protection of the public by continuation of the Water Policy and protection of workers through programmatic risk management controls that require signed authorizations prior to any on-site excavations that may contact TCE and other VOCs in the source zone at the C-400 Cleaning Building. For both the No Action and Limited Action Alternatives, there would be no short-term impacts anticipated to air quality and noise, geology and soils, water resources, wetlands and floodplains, ecological resources, cultural resources, socioeconomics, or transportation.

The potential for adverse impacts to the surrounding community during the implementation of Alternatives 3 and 4 is minimal. Although both alternatives might result in atmospheric emissions and water releases, each alternative would use engineering controls to treat the vapors and water before releasing them. Both alternatives would be performed inside the PGDP secured area, which would minimize the danger to the community from the construction and operation of the alternatives. Additionally, environmental monitoring would be performed during construction and operation to ensure no contaminants are inadvertently released from the target locations.

Both Alternatives 3 and 4 have the potential for worker exposure to contaminated soil and groundwater and to volatile emissions from these contaminated media during construction, operation, and sampling during the interim remedial action. Likewise, Alternatives 3 and 4 would potentially subject workers to soils and groundwater at elevated temperatures due to the subsurface heating once the interim remedial action was activated. Additionally, Alternative 3, Electrical Resistance Heating, would provide the potential for workers to be exposed to electrical currents. However, worker exposure is unlikely due to PGDP programmatic risk management controls that include the use of appropriate personal protection equipment, operating procedures, and engineering controls.

Land use. None of the alternatives is expected to have short-term effects on land use because land use would remain restricted under each of the alternatives. However, source reduction under Alternatives 3 and 4 would result in significant removals of TCE and other VOCs from the C-400 source zone area, allowing for consideration of more and additional land use options sooner.

Air quality and noise. Impacts to air quality under Alternatives 3 and 4 would include emissions from vehicle and equipment exhaust and fugitive dust from vehicle traffic and disturbance of soils. Preparation and construction activities would be short-term, sporadic, and localized (except for emissions from vehicles of construction workers and transport of construction materials and equipment). Fugitive dust from earthwork activities would be noticeable on-site in the immediate vicinity. Dispersion would decrease concentrations of pollutants in the ambient air as distance from the construction site increased. The use of control measures (e.g., covers and water or chemical dust suppressants) would minimize fugitive dust emissions. No exceedances of primary or secondary National Ambient Air Quality Standards are expected.

Increased noise levels from the transport and use of construction equipment in the immediate vicinity of the interim remedial action also would be short-term, sporadic, and localized. Noise levels are already slightly elevated in the vicinity of the C-400 Cleaning Building area because it is located within the industrialized portion of PGDP. No sensitive noise receptors (e.g., residences) are located near the C-400 Cleaning Building area; thus, no noise impacts would occur.

Geology and soils. Under Alternatives 1, 2, and 4, no short-term adverse impacts to on-site geology would occur; however, under Alternative 3, heating could result in a slight, but irreversible, increase in soil permeability. The permeability increase is expected to be minimal and would enhance the removal of TCE and other VOCs from the C-400 source zone soils. Soil erosion impacts during the interim remedial actions would be mitigated by control measures (e.g., covers, silt fences, and straw bales). Soils at the C-400 Cleaning Building area have been previously disturbed because of PGDP construction and maintenance activities. No impacts to prime farmland soils would occur.

Water resources. Under Alternatives 3 and 4, potential short-term adverse impacts to surface waters could result from soil erosion, runoff, and increased sedimentation during the interim remedial actions and from an accident involving the release of fuel or other hazardous materials. Soil erosion impacts would be mitigated through the use of appropriate control measures (e.g., covers, silt fences, straw bales), and the potential for an accident and subsequent spill would be mitigated through the adherence to proper safety procedures and spill prevention plans. In the event of a spill from an accident, spill response measures (e.g., booms, berms, sorbents, neutralizers, secondary containment, and mechanical removal equipment) would minimize potential adverse impacts to the receiving surface waters.

Wetlands and floodplains. No wetlands or floodplains are located within the area of the C-400 Cleaning Building that would be remediated under Alternative 3 or 4; thus no short-term impacts would occur.

Ecological resources. Due to the industrialized and previously disturbed nature of the area near the C-400 Cleaning Building, only limited ecological resources are present and short-term impacts to ecological resources under Alternative 3 or 4 would be expected to be negligible. No T&E species are known to exist within the vicinity of the C-400 Cleaning Building area that would be impacted during the interim remedial actions.

Cultural resources. No short-term impacts to cultural resources would be anticipated from either Alternative 3 or 4. It is very unlikely that any intact archaeological resources still are present in the C-400 Cleaning Building area because this area has been previously disturbed during construction and maintenance activities. No PGDP historical resources would be impacted.

Socioeconomics. Alternative 3 or 4 would not have any direct or indirect short-term adverse impacts on local socioeconomic resources such as population, employment, housing, schools, public services, and local government expenditures (i.e., utilities, hospitals, and police and fire protection). The workforce that would be required for interim remedial actions would be small and likely would be drawn from the local labor market, resulting in no new influx of workers to the area.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations," requires agencies to identify and address disproportionately high and adverse human health or environmental effects their activities may have on minority and low-income populations. No census tracts near the Paducah site include a higher proportion of minorities than the national average. Some nearby tracts meet the definition of low-income populations, including two tracts in the north-northeast direction of the prevailing wind; however, the distance of these tracts from the C-400 Cleaning Building area makes it unlikely that there would be disproportionate high and adverse environmental justice impacts to any low-income populations found in those areas.

Transportation. Only minor short-term transportation impacts would result from Alternative 3 or 4. During the interim remedial actions there would be a slight increase in the volume of truck traffic in the immediate vicinity, but the affected roads are capable of handling the additional traffic. Also, an increased potential for accidents would be expected with any equipment transportation and off-site transport of waste commensurate with the volume of waste being transported.

Cumulative impacts. No notable short-term cumulative impacts resulting from Alternatives 3 and 4 have been identified.

2.10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities also are considered. Each of the four alternatives is technically and administratively feasible; however, because there are fewer vendors offering Electrical Resistance Heating than the combined Vapor Extraction and Steam Extraction, the availability of services and materials is more limiting for Alternative 3 than for Alternative 4.

2.10.7 Cost

Under this balancing criterion, the cost of each alternative is evaluated. The estimates are intended to aid in making project evaluations and comparisons between alternatives. Consistent with EPA guidance (EPA 1988), the estimates have an expected accuracy of -30% to +50% for the scope of action described for each alternative. Table 7 presents the initial cost estimates that were developed for each alternative.

Table 7. Cost comparison of remedial alternatives

Present Worth Cost ($K)	Alternative 1: No Action	Alternative 2: Limited Action	Alternative 3: Electrical Resistance Heating and LUC	Alternative 4: Vapor Extraction, Steam Extraction, and LUC
Estimated Capital Cost:	$0	Amount necessary to implement additional institutional controls	$32,054,750	$65,040,050
Estimated Total O&M[1]:	$0	$4,861,000 to an amount necessary to implement additional institutional controls	$7,897,350	$10,213,975

[1]O&M costs include sampling after treatment is complete and D&D.
O&M = Operation and Maintenance LUC = Land Use Control

Elements of the costs include project management, design, supplies and equipment, construction, construction support, operation, waste characterization, and waste shipping and disposal. The costs do not include an allowance for contingency actions, which would involve implementing one or more alternative technologies. Because Alternative 1 is a No Action Alternative, no costs are associated with its implementation. Alternative 2 capital and O&M costs equal the amount necessary to implement additional institutional controls. Between Alternatives 3 and 4, Alternative 3 has lower capital and O&M costs.

2.10.8 State Acceptance

The FS, PRAP, and draft ROD were issued for review and comment to both the KDEP and EPA. The KDEP and EPA concur with the need for an interim remedial action for the source zone comprised of TCE and other VOCs in the UCRS and RGA at the C-400 Cleaning Building area. These agencies also concur with the selection of Alternative 3 and agree that the selection of Alternative 3 is consistent with the requirements of the Commonwealth of Kentucky's Hazardous Waste Permit.

2.10.9 Community Acceptance

No groups or organizations opposed an interim remedial action for the source zone comprised of TCE and other VOCs in the UCRS and RGA at the C-400 Cleaning Building area. Community response to the alternatives is presented in the responsiveness summary, which addresses comments received during the public comment period that ran from June 2 to July 16, 2004. A public meeting was not requested during the public comment period; therefore no public meeting was held.

2.11 PRINCIPAL THREAT SOURCE MATERIAL

Per EPA guidance (EPA 1991), PTSM is a term used for waste or other material (e.g., DNAPL) that is an obvious threat to human health and the environment, due either to the nature and concentration of contamination or to a large mass of leachable material in the ground. At PGDP, expedited remediation decisions can be made at locations that contain PTSM. Because DNAPL is present, the TCE in the source zone in the UCRS and the RGA at the C-400 Cleaning Building area can be considered PTSM.

The alternatives chosen for the source zone comprised of TCE and other VOCs in the UCRS and the RGA at the C-400 Cleaning Building area address this PTSM in the following ways.

- Alternative 1: No Action – This alternative is included, in part, as a baseline against which other alternatives can be compared. It does not address the PTSM present at the C-400 Cleaning Building area.

- Alternative 2: Limited Action – This alternative does not include active mass removal, treatment, or containment; therefore, it does not actively reduce the PTSM present at the C-400 Cleaning Building area.

- Alternative 3, Electrical Resistance Heating in both the UCRS and RGA – This alternative would remove a significant amount of TCE DNAPL from UCRS and RGA soils and groundwater in the source zone at the C-400 Cleaning Building area; therefore, this alternative would actively reduce the PTSM. The volatile contamination in the off-gas would be treated with an appropriate, applicable technology (such as catalytic oxidation, thermal oxidation, and/or absorbed onto activated carbon) and treated off-site.

- Alternative 4: Vapor Extraction in the UCRS and Steam Extraction in the RGA – This alternative would remove a significant amount of TCE DNAPL from UCRS and RGA soils and groundwater in the source zone at the C-400 Cleaning Building area; therefore, this alternative would actively reduce the PTSM. The volatile contamination in the off-gas would be treated with either an appropriate, applicable technology (such as catalytic oxidation, thermal oxidation, and/or absorbed onto activated carbon) and treated off-site.

2.12 SELECTED REMEDY

Based upon the evaluation of the alternatives with regard to the nine criteria, the selected remedy is Alternative 3, Electrical Resistance Heating in both the UCRS and RGA.

2.12.1 Summary of Rationale for the Selected Remedy

The following rationale supports the selection of Alternative 3:

- The UCRS soils of the source zone comprised of TCE and other VOCs are fine grained and are not well suited for the use of air alone as a carrier for contaminant removal, as required for Vapor Extraction. Potential exists that contaminants would be left in place in areas through which the carrier air would not migrate. The addition of heat from Electrical Resistance Heating would increase the air permeability of the soils (the soils would desiccate and crack) and also increase the volatility of the TCE and other VOCs. Increased air permeability and contaminant volatility would benefit contaminant extraction.

- Electrical Resistance Heating would heat by conduction those areas not swept by air. The addition of the heat would result in the volatilization and expansion/movement of the TCE and other VOCs. This volatilization would result in the recovery of additional contaminant volumes that otherwise would not be recovered.

- The Alternative 3 interim remedial action cost is approximately $33.0 million dollars less than that of Alternative 4. Estimated capital costs for Alternative 3 (*in situ* generation of heat) are significantly less than those of Alternative 4 (aboveground generation of steam and injection).

The preferred alternative is Direct Heating, as Electrical Resistance Heating, based on its demonstrated ability to remove TCE from soil and groundwater in UCRS and the RGA source areas. The Groundwater OU FS estimated that Direct Heating, as applied in Alternative 3, could be effective at removing up to 95% of the TCE DNAPL in the UCRS. The Six-Phase Heating Treatability Study (DOE 2003) achieved average reductions of DNAPL and dissolved TCE concentrations in the UCRS of 98 and 99%, respectively. The DNAPL removal efficiencies of Direct Heating in the RGA, in Alternative 3, and Steam Extraction, in Alternative 4, are expected to be comparable.

Based on the information currently available, DOE believes that Alternative 3 meets the threshold criteria and provides the best balance of tradeoffs among the alternatives with respect to the balancing and modifying criteria for remedy selection. This preferred alternative is expected to (1) be protective of human health and the environment; (2) meet federal and state ARARs for the scope of this interim action; (3) be cost-effective; (4) utilize permanent solutions and alternative treatment technologies to the maximum extent practicable; and (5) satisfy CERCLA's preference for treatment as a principal element of the remedy. The implementation of Alternative 3 is integral to attaining the long-term goal at the PGDP of meeting the MCL in groundwater for TCE because it permanently removes a significant portion of the TCE contamination found in the source zone at the C-400 Cleaning Building area.

2.12.2 Description of the Selected Remedy

Alternative 3 is the selected remedy. It will consist of the following primary elements:

- A remedial design investigation to further determine areal and vertical extent of the contamination in the C-400 Cleaning Building area to determine optimum placement of the remediation system.

- Removal and treatment of TCE and other VOCs from the contaminant source zone in the UCRS and RGA at the C-400 Cleaning Building area using Electrical Resistance Heating. The operation of Electrical Resistance Heating would cease when monitoring indicates that heating has stabilized in the subsurface and when recovery diminishes to a point at which the rate of removal of TCE, as measured in the recovered vapor, becomes asymptotic. The forthcoming remedial action design documents will include criteria setting forth the requirements and approach that will apply for determining when asymptosis is achieved and heating stabilization has occurred, signaling when operation of the Electrical Resistance Heating System will cease.

- Implementation, maintenance, and reporting of LUCs on the C-400 Cleaning Building area.

- Continuation of groundwater monitoring of the source and dissolved-phase plumes, since contamination would remain in place following the interim remedial actions.

Alternative 3 consists of volatilization and removal of contaminated groundwater and TCE and other VOCs by application of Electrical Resistance Heating. Two common applications of Electrical Resistance Heating are Three-Phase Heating and Six-Phase Heating.[11] In both applications, this technology uses *in situ* (in place) heating to raise the temperature of the soil to a level where the target contaminant(s) (i.e., TCE and other VOCs for this action) is/are volatilized. Common power sources (60 hertz) may be used to heat the ground (typical subsurface applied voltages range from 150–600 volts), producing *in situ* steam to liberate the contaminants, which are removed by way of a vapor recovery system. The technology can be deployed in the vadose (above the water table) and saturated (below the water table) zones and may be used in moist soils with either low or high permeability.

The Three-Phase Heating system consists primarily of a network of in-ground electrodes and co-located vapor extraction wells distributed throughout the zone of contamination. Three-Phase Heating is the preferred electrical phasing method for large and noncircular remediation areas. Three-Phase Heating typically utilizes arrays of three electrodes located in a triangular pattern, which is a geometric portion of the Six-Phase Hexagon. The typical Three-Phase Array will cover approximately one-sixth of the area of the applicable Six-Phase Array and will heat an area that is approximately 40% larger than the array (i.e., approximate volume of 775 yd^3, assuming a 100 ft depth).

Six-Phase Heating typically utilizes arrays of six electrodes located in a hexagonal shape with a neutral electrode located in the center of the hexagon serving as a vapor extraction well. A typical array diameter is 25–35 ft, with the heated zone being approximately 40% larger than the array diameter (i.e., approximate volume of 4650 yd^3, assuming 100 ft depth). It is the preferred electrical phasing method for smaller, discrete areas.

Electrical Resistance Heating includes the following components:

- Installation of electrodes and vapor extraction wells in the source zone comprised of TCE and other VOCs at the C-400 Cleaning Building area. The estimated volume of soil to be treated at the source zone locations assuming a 100 ft treatment depth is approximately 80,000 yd^3;

- Heating of subsurface soil, contaminants, and groundwater via application of electrical current to the UCRS and RGA soils;

- Withdrawal of volatilized TCE and other VOCs from the vadose zone by high vacuum (approximately 20–25 inches of mercury) extraction;

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[11] Because either Three-Phase Heating or Six-Phase Heating or some combination of both may be used to treat the source zone at the C-400 Cleaning Building area, both technologies are discussed here and are described in Section 2.9.3. The optimum mix of the two technologies employed at the C-400 Cleaning Building area will be determined when the treatment system is designed.

- Treatment of contaminated soil vapor through the use of an aboveground treatment system;
- Monitoring of contaminants in groundwater and air;
- Discharge of treated groundwater through a KPDES permitted outfall;
- Waste classification for on- or off-site disposal; and
- Discharge of treated vapors to the atmosphere.

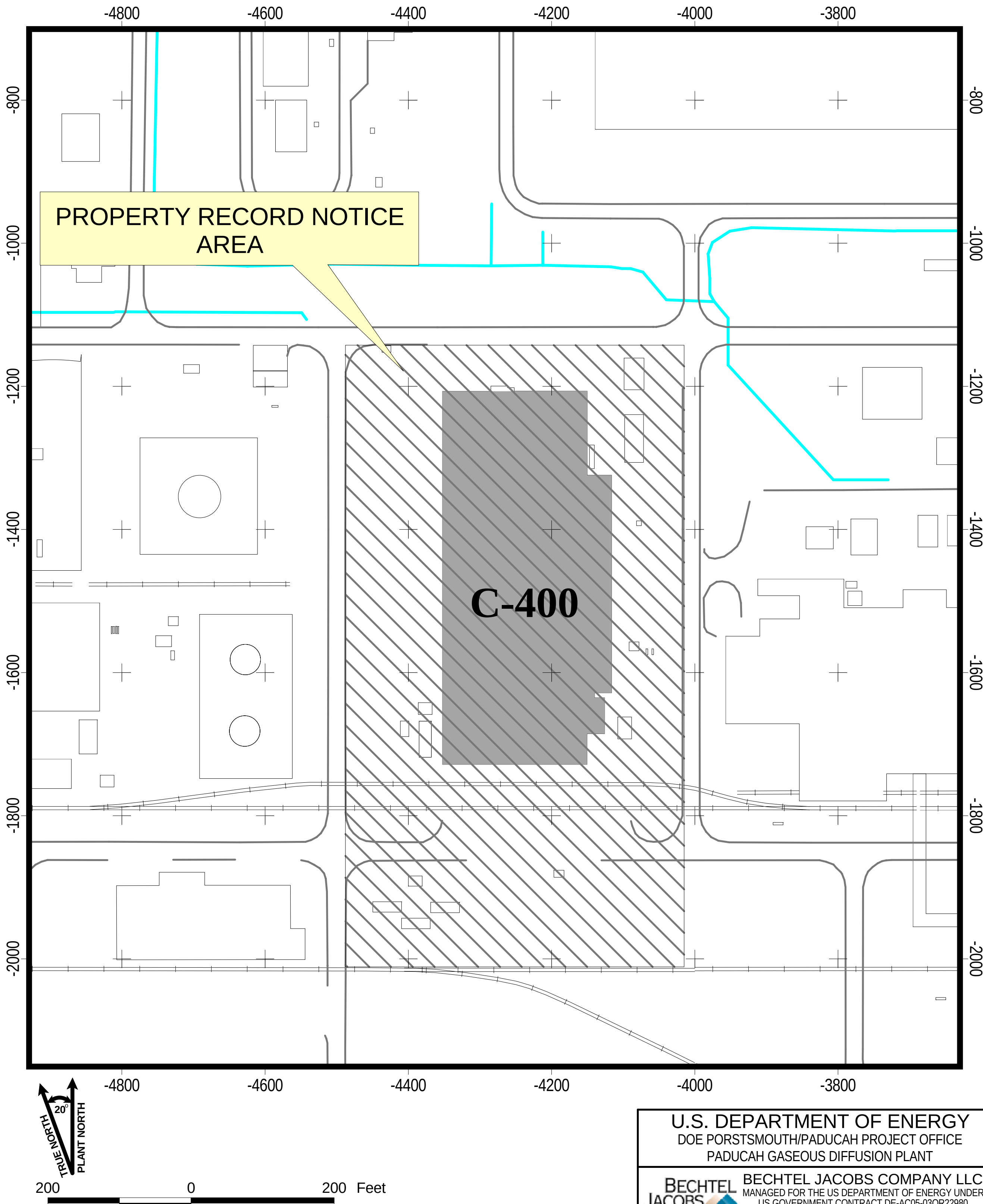
The off-gas volatile concentrations are used as a measure to determine when sufficient heat has been applied to the subsurface such that additional heating would not be productive or cost effective. Operation of the Electrical Resistance Heating array would cease when the monitoring system indicates that heating has stabilized in the subsurface and the contaminant recovery diminishes to a point where significant additional decreases in this rate of recovery are not anticipated (i.e., the rate of removal of TCE and other VOCs becomes asymptotic). Treatment time is estimated to be from 6 months to one year[12]. A significant extension of treatment time may require reconsideration of the cost-effectiveness of the selected remedy.

LUCs will be included in Alternative 3 and will consist of the following activities in order to meet the objectives listed in Sect. 2.8:

- Placement of Property Record Notices to alert anyone searching property records to the information about contamination and this interim response action for the area outlined on Fig. 8. The language comprising the Property Record Notice will be filed at the McCracken County Clerk's Office, in accordance with state law, within 120 days of regulatory approval of the LUCIP.
- Deed Restrictions to limit use of the property to industrial activities, to prevent exposure of the groundwater to industrial workers, and to restrict drinking or other interest(s) being created in the DOE property that is the subject of this interim action, including but not limited to, liens, mortgages, leases, easements, licenses, profits, servitudes, covenants or life estates; or before any actual transfer of such property. Deed restrictions are to be recorded at the McCracken County Clerk's office in accordance with applicable state and federal law.
- Administrative Controls in the form of an "excavation/penetration permit program" that would require a worker to obtain formal authorization prior to excavating or performing other intrusive activities in the C-400 Cleaning Building area.
- Access controls, as necessary to ensure protectiveness following the remedial action.

These LUCs, further explained in Table 8, will be implemented, reported on, monitored, maintained, and enforced by DOE as described above and in accordance with the LUCIP approved for these LUCs. The LUCIP for the LUCs selected as part of this action will be submitted concurrently with (and have the same review periods and procedures as) the Remedial Design Work Plan (RDWP) for review and approval by EPA and KDEP. Upon final approval, the LUCIP will be appended to the Land Use Control Assurance Plan and the RDWP. The LUCIP will establish the implementation, reporting, and maintenance requirements enforceable under CERCLA and the FFA, including enforceable requirements

[12] Timeframes set forth herein are for estimation purposes only. Enforceable schedules are set forth in the FFA.



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

BECHTEL JACOBS COMPANY LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER
US GOVERNMENT CONTRACT DE-AC05-03OR22980
Oak Ridge, Tennessee • Paducah, Kentucky • Portsmouth, Ohio

Science Applications
International Corporation
P.O. Box 2502
Oak Ridge, Tennessee 37831

Fig. 8. Property record notice area.

FIGURE No. c5ac90001sk671r6-PRN.apr
DATE 02-17-05

Table 8. Summary of LUCs for the area of VOC contamination at C-400 at PGDP

Type of Control	Purposes of Control	Duration[e]	Implementation	Affected areas
Property Record Actions Notices[a]	Provide notice, to anyone searching records, about the existence and location of contaminated areas, land use assumptions, and the Deed Restrictions to be recorded prior to any other interest(s) being created in the DOE property that is the subject of this interim action or before any actual transfers of such property.	Land Use Controls will be maintained until the concentration of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and exposure. The LUC will remain in place until Kentucky/EPA approve DOE's request to modify/delete LUC.	Notice recorded by DOE in accordance with state law at the McCracken County Clerk's Office: 1) within 120 days of regulatory approval of the LUCIP.	• C-400 area (Located within the PGDP security fence.)
Deed Restrictions[b]	Limit use of the property to industrial activities, prevent industrial worker exposure to groundwater contamination, and restrict use of the groundwater.	Land Use Controls will be maintained until the concentration of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and exposure. The LUC will remain in place until Kentucky/EPA approve DOE's request to modify/delete LUC.	DOE will draft the Deed Restrictions in accordance with applicable federal and state laws and propose it to Kentucky/EPA as an attachment to the LUCIP. DOE is to record the restrictive covenant prior to any other interest(s) being created in the DOE property that is the subject of this interim action, including, but not limited to, liens, mortgages, leases, easements, licenses, profits, servitudes, covenants, or life estates, or before any actual transfer of such property. Deed restrictions are to be recorded at the McCracken County Clerk's Office in accordance with the applicable state and federal law.	• C-400 area (Located within the PGDP security fence.)
Excavation/Penetration Permits Program[c]	Require review and approval of any proposed intrusive activities to protect workers and remedy; process may prohibit or limit intrusive activities.	Land Use Controls will be maintained until the concentration of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and exposure. The LUC will remain in place until Kentucky/EPA approve DOE's request to modify/delete LUC.	• Implemented by DOE and its contractors. • Provide permits program with contamination information as soon as practicable after signing the ROD, and update information regularly while remediation proceeds. • Initiated by permit request.	• C-400 area (Located within the PGDP security fence.)

Table 8. Summary of LUCs for the area of VOC contamination at C-400 at PGDP (continued)

Type of Control	Purposes of Control	Duration[e]	Implementation	Affected areas
Access Controls[d] (e.g., signage, fences, gates, security measures, etc.)	Restrict access to workers and prevent public/uncontrolled access.	Land Use Controls will be maintained until the concentration of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and exposure. The LUC will remain in place until Kentucky/EPA approve DOE's request to modify/delete LUC.	• Controls evaluated and selected upon completion of remedial action. • Controls maintained by DOE.	• C-400 area (Located within the PGDP security fence.)

[a] Property Record Notices – Refers to any nonenforceable, purely informational document recorded along with the original property acquisition records of DOE and its predecessor agencies that alerts anyone searching property records to important information about contamination/waste on the property.
[b] Deed Restrictions– Refers to conditions and/or covenants that restrict or prohibit certain uses of real property and to limitations on its use necessitated by residual contamination in accordance with federal and state law.
[c] Excavation/Penetration Permit Program – Refers to the internal DOE/DOE contractor administrative program(s) that require the permit requestor to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.
[d] Access Controls – Physical barriers or restrictions to entry.

for regular periodic monitoring of each LUC after its implementation. The PGDP Land Use Control Assurance Plan (DOE 2000b) establishes procedures designed to ensure that each selected LUC will be implemented and properly maintained for as long as the LUC is needed to protect public health and the environment.

Through the implementation of the selected remedy, each of the RAOs for this interim action presented in Section 2.8 will be addressed. The RAO to prevent exposure to contaminated groundwater by on-site industrial workers will be met by the administrative and access controls (i.e., LUCs) discussed above. The RAO to reduce VOC contamination (primarily TCE and its breakdown products) in UCRS soil at the C-400 Cleaning Building area to minimize migration of these contaminants to RGA groundwater and to off-site POEs will be met by removing a significant mass of TCE and other VOCs from the source zone. The RAO to reduce the extent and mass of the VOC source (primarily TCE and its breakdown products) in the RGA at the C-400 Cleaning Building area to reduce the migration of the VOC contamination to off-site POEs will be met by removing a significant mass of TCE and other VOCs from the source zone.

Preparation of the remedial designs necessary to implement Alternative 3 will follow the completion and signing of this ROD. Consistent with the FFA, Section XIV, (D), DOE will develop a draft RDWP for submission 30 days after ROD signature. Additionally, the RDWP will contain a schedule for the submission of the Remedial Design Report and the Operations Plan. As noted earlier, the Remedial Design Report will include criteria setting forth the requirements and approach that will apply for determining when operation of the Electrical Resistance Heating System will cease. The Operations Plan will include a compliance plan that incorporates a discussion of substantive requirements that the action will meet and the administrative requirements that are exempted for the action due to its CERCLA status.

2.12.3 Summary of the Estimated Remedy Cost

Table 9 presents a cost estimate summary of Alternative 3. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30 percent of the actual project cost. The information in this cost estimate summary table is based on the best available information regarding the

Table 9. Cost estimate summary for the selected remedy*

Description	Quantity[a]	Unit	Unit Cost	Cost	Overhead	Contingency[b]	Totals
Design Characterization[c]	1	Event	$1,110,000	$1,110,000	$188,431	$111,380	$1,409,811
Capital Costs							
Design[d]	50	Acre ft	$18,899	$944,943	$160,412	$94,818	$1,200,172
Construction[e,g]	50	Acre ft	$441,127	$22,056,361	$3,744,244	$2,213,188	$28,013,792
Reporting	1	Event	$46,096	$46,096	$7,825	$4,625	$58,547
Operations & Maintenance[f,g]	50	Acre ft	$157,947	$7,897,350	$1,340,638	$792,439	$10,030,427
Total Costs				$32,054,750	$5,441,550	$3,216,450	$40,712,750

[a] Total area to be remediated underlies 0.5 acres to a depth of 100 ft.
[b] These costs are estimated to be incurred if an area larger that expected needs to be addressed by the selected alternative. This cost is based on an additional area of similar size as the base treatment area (50 acre ft).
[c] Design Characterization Costs are estimated to be incurred during Fiscal Years 2005 and 2006.
[d] Design Capital Costs are estimated to be incurred during Fiscal Years 2005 and 2006.
[e] Construction Capital Costs are estimated to be incurred during Fiscal Years 2006, 2007, and 2008.
[f] O & M Costs are estimated to be incurred during Fiscal Years 2008, 2009 and 2010.
[g] Construction and O & M will be phased to efficiently support the remediation.
* NOTE: Timeframes and costs set forth, herein, are for estimation purposes only. Enforceable schedules are set forth in FFA.

anticipated implementation costs of the remedial alternative, including a contingency for treating an area larger than expected with the selected alternative. Changes in the cost elements in Table 8 are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative (i.e., in the Remedial Action Work Plan), which will include the development of a more detailed project cost estimate breakdown. Significant cost increases may require re-evaluation of the cost-effectiveness of the selected remedy. If, after this ROD is signed, DOE anticipates that, for any reason, the cost of the selected remedy will exceed by a significant amount the cost estimate in the ROD, that increase will be documented, with appropriate public notice, in accordance with Section 300.435(c)(2) of the NCP.

2.12.4 Expected Outcomes of the Selected Remedy

Alternative 3 will treat the source zone comprised of TCE and other VOCs at the C-400 Cleaning Building area. The levels of TCE contamination in this area indicate that TCE exists as DNAPL in the UCRS and RGA. Some residual contamination will remain after implementation of this interim remedial action due to limitations of the available remediation technologies. The DNAPL zone will be subject to continued groundwater monitoring and long-term land-use restrictions to prevent exposure under current, and potential future, land-use activities.

This source reduction action is an interim remedial action. Reducing levels in soil of TCE and other VOCs at the C-400 Cleaning Building area will decrease the time that the dissolved concentration of TCE and other VOCs in groundwater of the off-site plumes due to this source remains above health-based levels.

The C-400 Six-Phase Treatability Study (DOE 2003) achieved a TCE removal efficiency of 98% in UCRS soils in the Treatability Study test cell. It is likely that Electrical Resistance Heating, when applied over the larger area of the C-400 source zone, will not reduce concentrations of TCE to its MCL; however, permanent removal of a significant portion of the TCE at the C-400 Cleaning Building area source zone will shorten the time required to attain the MCL.

2.13 STATUTORY DETERMINATIONS

Under CERCLA §121 and the NCP, DOE as the lead agency must select remedies that are protective of human health and the environment, comply with ARARs, are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

2.13.1 Overall Protection of Human Health and the Environment

The selected remedy, Alternative 3, is protective of human health and the environment in the C-400 Cleaning Building area through the treatment of contaminated soil by Electrical Resistance Heating and the institution of LUCs. Electrical Resistance Heating will permanently remove a significant portion of the TCE and other VOCs at the C-400 Cleaning Building area source zone reducing the period that concentrations of these contaminants in the off-site plumes remain above health-based levels and thereby lessening potential human health and ecological risks estimated using conservative assumptions. (Please see Sect. 2.7.1.4 for a description of conservative assumptions.) Additionally, the institution of LUCs will prevent human exposure to the residual contamination and treatment residuals remaining in the subsurface soils at the C-400 Cleaning Building area. (A separate, on-going CERCLA response action, [the Water Policy], limits human exposure to the off-site plumes.) The immediate area surrounding the source zone comprised of TCE and other VOCs at the C-400 Cleaning Building area currently is governed by institutional controls that restrict access. These controls that will remain in place under Alternative 3 include, as a component, LUCs to ensure that the surfaces above the source zone remain limited to industrial uses.

The potential cancer risk associated with exposure via direct exposure to contaminated groundwater at a POE at the property boundary is over 1×10^{-2} (one in one hundred). Through removal of a significant portion of the TCE and other VOCs at the C-400 Cleaning Building area, this interim remedial action would shorten the time necessary to reduce cancer risks. There are no short-term threats associated with the Selected Remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from Alternative 3.

2.13.2 Compliance with ARARs

Alternative 3 complies with ARARs for the scope of this interim action. While this interim action is not expected to attain the MCL for TCE in the RGA at the time treatment is complete, the alternative satisfies the requirement in 40 *CFR* 300.430(f)(1)(ii) for interim actions to meet ARARs. Under the NCP at 40 *CFR* 300.340(f)(1)(ii)(C)(1), an alternative that does not meet an ARAR may be selected when the alternative is an interim measure and the ARAR will be attained or waived as part of a total remedial action. On completion of the source reduction at the C-400 Cleaning Building area, continued decreases in the concentration of TCE and other VOCs in the RGA are expected. Because the complex groundwater contamination problems at the PGDP (i.e., complex hydrogeology and suspected presence of DNAPL) prevent the PGDP from implementing one comprehensive, cost-effective remedy for the Groundwater OU, multiple actions are planned to provide overall remediation of the groundwater. Alternative 3 is one of the interim remedial actions to be taken to contribute to the overall remediation of the Groundwater OU. The ARARs are presented below and in more detail in Tables A.1, A.2, and A.3.

Chemical, location, and action-specific ARARs include the following:

- National Primary Drinking Water Standards MCLs (40 *CFR* Part 141), which specify acceptable concentrations in groundwater that serves as a potential drinking water aquifer.

- Kentucky Surface Water Standards (401 *KAR* 5:031 and 5:026)

- Decommissioning Standards at Nuclear Facilities (10 *CFR* 20, Subpart E)

- Protection of Wetlands (10 *CFR* Section 1022, Executive Order 11990, 40 *CFR* 230.10, 33 *CFR* 330.5)

- Endangered Species Act (16 *USC* 1531 *et seq.* Section 7(a)(2))

- Migratory Bird Treaty Act (16 *USC* 703-711, Executive Order 13186)

- Fugitive Dust Emissions (401 *KAR* 63:010)

- Toxic Emissions (401 *KAR* 63:022)

- Monitoring Well Installation (401 *KAR* 6:310)

- Discharge of Storm water and Treated Groundwater (40 *CFR* 122, 401 *KAR* 5:055)

- Hazardous Waste Management (40 *CFR* 260 through 264 and 268, 401 *KAR* 31 through 34, 36 and 37)

- Polychlorinated Biphenyl (PCB) Waste Management (40 *CFR* 761)
- Compliance with Flood Plains/Wetlands Environmental Review Requirements (10 *CFR* 1022)
- Environmental Radiation Protection Standards for Nuclear Power Operations (40 *CFR* 190, Subpart B)
- National Emission Standards for Hazardous Air Pollutants – (NESHAP) (401 *KAR* 57:002)

DOE's review of remediation criteria identified the following as to be considered (TBC) for this interim remedial action.

- Radiation Exposure of the General Public at DOE Facilities (DOE Order 5400.5)

The Groundwater OU FS estimated that Direct Heating, as will be applied in the selected alternative would be capable of removing up to 95% of the VOC DNAPL, while Alternative 4 would have recovery efficiency of 90%. The 2003 Six-Phase Heating Treatability Study demonstrated that electrical resistance heating can achieve an average DNAPL reduction of 98%, which further supports the selection of Alternative 3.

2.13.3 Cost Effectiveness

Based on the current assumptions and cost estimates, Alternative 3 is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." [NCP §300.430(f)(1)(ii)(D)]. This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant to the extent practicable). Overall effectiveness was evaluated by assessing the five balancing criteria. Based upon this evaluation, the relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its currently estimated costs; hence, this alternative represents a reasonable value for the money to be spent.

The estimated total cost of Alternative 3 is $40,712,750. DOE believes that Alternative 3 will provide a significantly faster reduction of concentrations of TCE and other VOCs in soil and groundwater in the source zone than Alternative 4 and at significantly lower cost.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. Alternative 3 represents the best balance of trade-offs among alternatives with respect to pertinent criteria, given the limited scope of the action. This interim remedial action supports the CERCLA preference for treatment by removal of contaminant mass.

Alternative 3 treats the source materials comprised of TCE DNAPL that constitute a principal threat at the C-400 Cleaning Building area, achieving significant reductions in the concentrations of TCE in the C-400 source zone and satisfying the criterion for long-term effectiveness to the extent possible. Alternative 3 does not present short-term risks different from the other treatment alternatives. There are no special implementability issues that set Alternative 3 apart from any of the other alternatives evaluated.

2.13.5 Preference for Treatment as a Principal Element

By treating the soils and groundwater contaminated with TCE and other VOCs with Electrical Resistance Heating, Alternative 3 addresses contamination at the C-400 Cleaning Building area using treatment technologies. By utilizing treatment as a significant portion of the remedy, the CERCLA preference for remedies that employ treatment as a principal element is satisfied.

2.14 FIVE-YEAR REVIEW

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of the interim remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

2.15 DOCUMENTATION OF SIGNIFICANT CHANGES

The *Proposed Remedial Action Plan for the Volatile Organic Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2114&D2, was made available for a 45-day public review and comment period June 2, 2004, through July 16, 2004. The PRAP identified Alternative 3, Electrical Resistance Heating and LUCs, as the preferred alternative. After review and consideration of the comments received during that period, it has been determined that no significant changes to the preferred alternative are necessary or appropriate.

PART 3

RESPONSIVENESS SUMMARY

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RESPONSIVENESS SUMMARY

3.1 RESPONSIVENESS SUMMARY INTRODUCTION

The responsiveness summary has been prepared to meet the requirements of Sections 113(k)(2)(b)(iv) and 117 (b) of CERCLA, as amended by SARA, which requires the DOE as "lead agency" to respond "… to each of the significant comments, criticisms, and new data submitted in written or oral presentations" on the PRAP.

The DOE has gathered information on the types and extent of contamination found, evaluated remedial measures, and has recommended an interim remedial action for the source zone comprised of TCE and other VOCs in the UCRS and the RGA soils at the C-400 Cleaning Building area. As part of the remedial action process, a notice of availability regarding the PRAP was published in *The Paducah Sun*, a major regional newspaper of general circulation. The *Proposed Remedial Action Plan for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-2114&D2, was released to the general public May 31, 2004. This document was made available to the public at the Environmental Information Center, 115 Memorial Drive, Barkley Centre, Paducah, KY 42001, and at the Paducah Public Library. Specific groups that received individual copies of the PRAP included the Natural Resource Trustees and the PGDP CAB.

A 45-day public comment period began June 2, 2004, and continued through July 16, 2004. The PRAP also contained information that provided the opportunity for a public meeting to be held, if requested. Because no request was made, a public meeting was not held.

Public participation in the CERCLA process is required by SARA. Comments received from the public are considered in the selection of the interim remedial action and are documented in a responsiveness summary. The responsiveness summary serves two purposes: (1) to provide the DOE with information about the community preferences and concerns regarding the remedial alternatives, and (2) to show members of the community how their comments were incorporated into the decision-making process.

3.2 COMMUNITY PREFERENCES/INTEGRATION OF COMMENTS

One written public comment was received concerning the *Proposed Remedial Action Plan for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. No request for a public meeting was received; therefore a public meeting was not held. No oral comments were received that altered the selection of Alternative 3 as the preferred alternative.

The written public comment was provided by the PGDP CAB. This comment supported the application of direct heating technology at the C-400 Cleaning Building area and went on to request that the treatment equipment be left in place for an extended period while groundwater monitoring of the C-400 area continues. The basis for this request was the conjecture that "rebounding" in TCE concentrations in the C-400 source zone after treatment was possible and that the technology could be reapplied if "rebounding" did occur.

DOE believes that the permanent removal of TCE and other VOCs from the UCRS portion of the source zone makes it unlikely that concentrations of these contaminants will "rebound" in the UCRS portion of the C-400 source zone following treatment. However, since it is possible that dissolved concentrations of TCE and other VOCs could "rebound" in the RGA portion of the source zone, the remedial design will evaluate whether remediation equipment should be left in place following the treatment period.

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APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, requires, in part, that remedial actions for cleanup of hazardous substances comply with promulgated requirements and/or standards under federal or more stringent state environmental laws and regulations where the requirements are applicable or relevant and appropriate (ARAR). These requirements are identified as those being specific to the hazardous substances or particular circumstances at a site and must be complied with, or be waived, as part of a total remedial action, under the CERCLA decision-making process (40 *CFR* 300.430(f)(1)(ii)(B)). ARARs include only federal and state environmental or facility siting laws/regulations and do not include occupational safety or worker radiation protection requirements. Per 40 *CFR* 300.405(g)(3), non-promulgated advisories, criteria, or guidance, known as to be considered (TBC), may be considered in determining remedies. Because this remedial action will be conducted on-site, it is exempted from procedural requirements to obtain federal, state, and local permits, consistent with Section XXI of the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant (FFA)* and Section 121(e)(1) of CERCLA. Tables A.1, A.2, and A.3, list the chemical-specific, location-specific, and action-specific ARARs/TBCs for the interim remedial actions in the selected remedy. A brief summary of the interim remedial actions and associated ARARs/TBCs follows.

CHEMICAL-SPECIFIC ARARS/TBC

These requirements provide health or risk-based concentration limits or values in environmental media for hazardous substances, pollutants, or contaminants. The specific requirements associated with Alternative 3 are presented in Table A.1 and are discussed further below.

Groundwater. Alternative 3 will result in reduction of TCE and other VOC contaminants reaching groundwater through source reduction. The National Primary Drinking Water Standards include maximum contaminant levels (MCLs) for several of the contaminants found within groundwater at the PGDP and are considered relevant and appropriate requirements for potable groundwater. While Alternative 3 is not expected to result in attainment of the MCL for TCE at the time treatment ceases, it satisfies the requirements in 40 *CFR* 300.430(f)(1)(ii) for interim actions to meet ARARs. Under the NCP at 40 *CFR* 300.340(f)(1)(ii)(C)(1), an alternative that does not meet an ARAR may be selected when the alternative is an interim measure and the ARAR will be attained or waived as part of a total remedial action. On completion of the source reduction, a continued decrease in concentrations of TCE and other VOCs is expected. Since the Groundwater OU contamination is extensive, multiple actions are planned to provide overall remediation of the groundwater. Alternative 3 is one of the interim remedial actions to be taken to provide overall remediation of groundwater and its sources of contamination.

Surface Water. Kentucky Surface Water Standards are included as ARARs for this interim remedial action because contaminated groundwater discharges to surface water bodies. Source reduction of the TCE and other VOCs to reduce overall groundwater contamination will be part of an overall approach to ensure that Kentucky Standards are met. Surface water contamination at PGDP not related to discharge of contaminated groundwater is to be addressed in a separate decision document (i.e., ROD); however, that decision will be supported by this interim remedial action. Therefore, this action supports the general remedial objectives anticipated for the Surface Water OU. The Surface Water OU decision documents will address surface water contamination and evaluate the need for further reduction of contributions made from groundwater, as necessary.

LOCATION-SPECIFIC ARARS/TBC

Location-specific requirements establish restrictions on activities conducted within protected or environmentally sensitive areas. In addition, these requirements establish restrictions on permissible concentrations of hazardous substances within these areas. Table A.2 lists the federal and state location-specific ARARs for protection of sensitive resources.

Aquatic Resources (including wetlands). Installation of treatment systems may impact nondelineated wetlands during the construction phase of remedy implementation. As required at 10 *CFR* 1022, 40 *CFR* 230.10, and 33 *CFR* 330.5, all activities will be designed to avoid or minimize impacts to wetlands identified within the area of deployment of the remedy. The use of Best Management Practices (BMPs) and proper siting of equipment and construction areas will be considered and conducted, as necessary, to comply with these requirements.

Endangered/Protected Species. Installation activities must not impact or jeopardize the existence of a listed species or result in the destruction or impact to critical habitat. These requirements are specified at 16 USC 1531 Section 7(a)(2). Possible existence of endangered species or species habitat must be considered within the area of deployment of the remedy. This ARAR shall be achieved by avoiding such areas. In addition, the requirements of the Migratory Bird Treaty Act requires similar measures be taken with regard to protected migratory species. As with endangered species, these requirements shall be complied with through assessment of the area of deployment to ensure no adverse impact occurs.

ACTION-SPECIFIC ARARS/TBCS

Action-specific ARARs include operation, performance, and design requirements or limitations based on waste types, media, and remedial activities. Component actions include groundwater extraction, treatment and monitoring, institutional controls, waste management, and transportation. ARARs/TBCs for each component action are listed in Table A.3.

General Construction Activities. Requirements for the control of fugitive dust and storm water runoff potentially provide ARARs for all construction and site preparation activities. Reasonable precautions must be taken, including the use of BMPs for erosion control to prevent runoff and application of water on exposed soil/debris surfaces to prevent particulate matter from becoming airborne. In addition, diffuse or fugitive emissions of radionuclides to the ambient air from remediation activities, which are only one of potentially many sources of radionuclide emissions at a DOE facility, must comply with the Clean Air Act of 1970 requirements in 40 *CFR* 61.92, as amended. Chemical-specific ARARs for these actions include radiation protection requirements for the public and control of potential fugitive emissions of TCE and other VOCs, as applicable.

Collection/Treatment of Volatile Organic Constituents. Alternative 3 involves *in situ* heating of soils by use of an Electrical Resistance Heating process. This will result in the collection and recovery of contaminants from the aquifer and vadose zone. Prior to emission of collection vapor/gases, contaminants must be removed to comply with 401 *KAR* 63:020. An off-gas treatment system shall be employed to ensure contaminant emissions do not exceed allowable levels. This system may include such equipment as condensers and/or filters to accomplish the required contaminant removal.

Water Treatment. Contaminated water, including decontamination fluid, collected storm water, groundwater, and condensate from the off-gas treatment system, shall be treated before discharge. Where these waters meet the acceptance criteria for on-site treatment facilities at PGDP, treatment is expected to occur on-site with discharge through permitted KPDES outfalls. Where these waters do not meet on-site appropriate off-site wastewater treatment facility for treatment and subsequent discharge. Shipment to any off-site facility shall be conducted in accordance with the applicable requirements of 40 *CFR* 300.440 *et seq.* (CERCLA Off-site Rule).

Waste Management. All primary wastes (i.e., groundwater and contaminated soils) and secondary wastes (i.e., contaminated personal protective equipment, treatment residuals, and decontamination wastewaters) generated during remedial activities will be appropriately characterized as RCRA wastes (solid or hazardous), PCB waste, radioactive waste(s), and/or mixed waste(s), as appropriate, and, respectively, be managed in accordance with appropriate RCRA, Toxic Substances Control Act (TSCA), or DOE Order/Manual requirements. Wastes managed on-site must comply with the substantive requirements of the aforementioned ARARs. When wastes are transferred off-site, waste management must be conducted in compliance with all applicable laws and regulations. Shipment of CERCLA wastes to any off-site facility shall be conducted in accordance with the approval requirements of 40 *CFR* 300.440 *et seq.* (CERCLA Off-site Rule). The Cabinet has agreed to consult with the DOE and the State where the off-site facility is located to reach agreement on the appropriate health-based standard for making contained-in-determinations for wastes that are to be shipped to such a facility.

Health-based standards of 39.2 ppm TCE and 2080 ppm 1,1,1-TCA in solids[13] will be used as the criteria for making contained-in determinations for environmental media and debris designated for disposal at the C-746-U Landfill. Solid wastes disposed of at landfills other than C-746-U will be subject to a contained-in determination that will be approved by the State of Kentucky and the state in which the receiving landfill is located. The Cabinet has agreed to consult with the DOE and the State where the off-site facility is located to reach agreement on the appropriate health-based standard for making contained-in-determinations for wastes that are to be shipped to such a facility. Groundwater and any related aqueous liquids generated from well sampling, well development, and well purging shall not be considered a hazardous waste at the point of generation, if the TCE concentrations are below 1 ppm and the 1,1,1-TCA concentrations are below 25 ppm, provided that the subject aqueous liquids will be further treated in an on-site wastewater treatment unit and discharged through a PGDP KPDES-permitted outfall as required by 401 KAR 31:010, Section 3(1)(b) 4.a or b. Other aqueous-based environmental media contaminated with TCE or 1,1,1-TCA that do not qualify for the exemption under 401 KAR 31:010, Section 3(1)(b) 4.a or b will use a health-based concentration of 0.081 ppm as the criterion for making contained-in determinations for media destined for on-site treatment and discharge through a KPDES-permitted outfall. DOE will submit a Sampling and Analysis Plan (SAP) defining the sampling and characterization approach that will be used as the basis to compare contamination levels in the environmental media and debris to the health-based levels and the appropriate landfill waste acceptance criteria. DOE will submit the SAP as part of the Waste Management Plan, which, in turn, is a part of the Remedial Action Work Plan (RAWP). The SAP will be subject to regulator review and approval under the procedures outlined in the FFA for review and approval of the RAWP. The results of the SAP then will be compared against the contained-in, health-based levels listed above, and a contained-in determination will be made. Land Disposal Restrictions apply to media and debris that no longer contain or are no longer contaminated with RCRA regulated waste.

Transportation. Any remediation wastes transferred off-site or transported in commerce along public rights-of-way must meet all applicable requirements found in the federal and Commonwealth of Kentucky transportation laws and regulations. These transportation requirements include provisions for proper packaging, labeling, marking, manifesting, record keeping, licensing, and placarding that must be fully complied with for shipment. Before shipment of CERCLA wastes to any off-site facility, DOE must ensure the acceptance of the receiving site under the CERCLA Off-site Rule (40 *CFR* 300.440 *et seq.*).

[13] Contained-In, health-based levels were derived as part of a separate task. Related information can be found in the Administrative Record.

Radiation Protection. Nuclear Regulatory Commission (NRC) radiation protection requirements include a residual activity at nuclear facilities for unrestricted release of 25 mrem/year as specified at 10 *CFR* 20 Subpart E. The relevant and appropriate requirements found at 40 *CFR* 190, Subpart B, require that exposure to the public not exceed an annual dose equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as a result of exposure to planned discharges of radioactive materials (radon and its daughters excepted). These requirements are equivalent to the exposure criteria under the NRC standards. The dose limit addresses exposure to radiation from all sources and activities at a facility. In addition, DOE is required to utilize procedures to maintain dose As Low as Reasonably Achievable (ALARA) and must not allow an effective dose of >100 mrem/year to the general public from all exposure pathways under DOE Order 5400.5 (TBC). The actual dose that the public might receive from an individual activity such as this interim remedial action is expected to be a very small fraction of the 100-mrem/year dose limit.

EPA regulations also include limitations on the radiological dose allowed to members of the public in the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations in 40 *CFR* 61 (and 401 *KAR* 57:002 which incorporates the federal regulations by reference). 40 *CFR* 61.92 establishes a limit of 10 mrem/year to the most exposed member of the public from radionuclide emissions to the atmosphere.

Table A.1. Summary of chemical-specific ARARs for primary source area – electrical resistance heating

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
National Primary Drinking Water Standards	40 *CFR* 141	Provides chemical-specific numeric standards for toxic pollutants expressed as MCLs and MCLGs.	The substantive requirements are relevant and appropriate due to the nature of the contaminants found within the groundwater. The substantive requirements will be met to the extent practicable for an interim action.
Kentucky Surface Water Standards including • Warm Water Aquatic Habitat Criteria • Kentucky Domestic Water Supply • Kentucky General Standards • Kentucky Outstanding State Resource Waters	401 *KAR* 5:031 and 5:026	Provides chemical-specific numeric standards for pollutants in domestic water supplies. Provides chemical-specific numeric standards for pollutants discharged or found in surface waters.	The substantive standards are ARAR to the segment of the Ohio River (domestic water supply) into which the Little Bayou Creek discharges. The substantive requirements found in these standards are ARAR due to the discharges at seeps in to Little Bayou Creek (outside of the current KPDES outfalls), which subsequently discharges to the Ohio River. Note: CWA Water Quality Criteria are not ARAR because Kentucky has promulgated state standards determined to be appropriate for Kentucky waters.
Radiation Exposure of the General Public at DOE Facilities	DOE Order 5400.5	Specifies that the public must not receive an effective dose equivalent of >100 mrem/year from all exposure pathways. In addition, all releases of radioactive materials resulting in doses to the public must meet the ALARA criteria.	The substantive requirement is TBC information.
Decommissioning Standards at Nuclear Facilities	10 *CFR* 20, Subpart E	Specifies a residual activity at nuclear facilities for unrestricted release of 25 mrem/year.	The substantive standards are considered to be relevant and appropriate because radionuclides are found in groundwater in the C-400 Cleaning Building area.

ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
CWA = Clean Water Act
DOE = U.S. Department of Energy
KAR = Kentucky Administrative Regulation
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
TBC = to be considered

Table A.2. Summary of location-specific ARARs for primary source area – electrical resistance heating

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Protection of Wetlands	10 *CFR* Section 1022 Executive Order 11990 40 *CFR* 230.10 33 *CFR* 330.5	Activities must avoid or minimize impacts to wetlands to preserve and enhance their natural and beneficial value. If wetland resources are not avoided, measures must be taken to address ecologically sensitive areas and mitigate adverse effects. Such measures may include, minimum grading requirements, runoff controls, design and construction considerations. Allows minor discharges of dredge and fill material or other minor activities for which there is no practicable alternative, provided that the substantive requirements of the Nationwide Permit (NWP) system are met.	The substantive requirements of the regulations are ARAR due to the presence of wetlands but will be met through avoidance of wetlands during construction and implementation of alternatives. Discharges of dredge and fill material will not be necessary in this interim action.
Endangered Species Act	16 U.S.C. 1531 et seq. Section 7(a)(2)	Actions that jeopardize the existence of listed species or result in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken.	The substantive requirements are ARAR because habitat for T&E species is present near the PGDP outside the industrialized area. They will be met through avoidance of critical habitat because the construction of this interim action is within the industrial section of the plant.
Migratory Bird Treaty Act	16 U.S.C. 703-711 Executive Order 13186	Federal Agencies are encouraged (until requirements are established under a formal MOU) to do the following: • avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions; • restore and enhance the habitats of migratory birds, as practicable; • prevent or abate the pollution or detrimental alteration of the environment for the benefit of migratory birds, as practicable; • ensure that environmental analysis of federal actions required by the NEPA or other established environmental review processes evaluate the effects of actions and agency plans on migratory birds, with emphasis on species of concern; and • identify where unintentional uptake likely will result from agency actions and develop standards and/or practices to minimize such unintentional take.	The substantive requirements are ARAR because migratory birds frequent the PGDP. They will be met by avoiding habitat and controlling contaminated media. Due to the highly industrialized nature of the C-400 Cleaning Building area the substantive requirements are to be considered since migratory bird habitat located in the interim action area is unlikely.

ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
MOU = Memorandum of Understanding
NEPA = National Environmental Policy Act
NWP = Nationwide Permit
T&E = threatened and endangered species

Table A.3. Summary of action-specific ARARs for primary source area – electrical resistance heating

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Fugitive Dust Emissions during site preparation and construction activities.	401 *KAR* 63:010	Precautions must be taken to prevent particulate matter from becoming airborne. Such precautions must be incorporated into the planning and design of activities and include actions such as • wetting or adding chemicals to control dust from construction activities; • using materials such as asphalt or concrete (or other suitable chemicals/fixing agents) on roads or material stockpiles to prevent fugitive emissions; and • using covers on trucks when transporting materials to and from the construction site(s). This requirement specifies that for on-site construction activities, no visible emissions may occur at the PGDP fence line.	The substantive requirements are applicable and will be met through the use of appropriate dust control practices identified during the alternative design phase.
Toxic Emissions	401 *KAR* 63:020, 401 *KAR* 57:002, and 401 *KAR* 63:002	These regulations require that a determination of toxic emissions be made in order to assess the applicability of required controls. Calculations of the significant emission levels are compared to the allowable emission limits specified in Appendix A of 401 *KAR* 63:020. If emission levels are exceeded, the best available control technologies must be incorporated into equipment/process design. 401 KAR 57:002 would apply in the event that a PTE of over 1% mrems/yr were to occur.	The substantive requirements of these regulations are considered to be applicable. Consistent with CERCLA Section 121(e)(1), no Title V Air Permit will be required for the production of toxic emissions. If design calculations demonstrate that emission levels will be exceeded, the best available control technology will be incorporated into the design of the treatment equipment.
Monitoring Well Installation	401 *KAR* 6:310	Monitoring wells (including extraction wells) must be constructed in a manner to maintain existing protection against the introduction of pollutants into aquifers and to prevent the entry of pollutants through the borehole. In addition, abandoned wells must be plugged and abandoned in accordance with the requirements specified.	The substantive requirements are considered to be ARAR. Compliance with well design and protection standards shall be achieved using approved well design and materials of construction. While in service, wells shall be secured as required. Abandoned wells shall be plugged and abandoned as required.

Table A.3. Summary of action-specific ARARs for primary source area – electrical resistance heating (continued)

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Discharge of Stormwater and Treated Groundwater	40 *CFR* 122 401 *KAR* 5:055 401 *KAR* 5:031 and 5:026	Stormwater discharges from construction activities on-site are subject to the substantive requirements of the KPDES permit. This requires that BMPs to control storm water runoff and sedimentation be employed. Discharge of treated groundwater will be conducted in compliance with the substantive requirements of the KPDES program and the CWA. Provides chemical-specific numeric standards for pollutants discharged or found in surface waters. Provides chemical-specific numeric standards for pollutants in domestic water supplies.	The substantive requirements are considered applicable for all on-site construction or treatment activities where a discharge of storm water or treated groundwater occurs. Compliance with these ARARs shall be achieved by application of required controls during the design phase of the alternative. Consistent with CERCLA Section 121(e)(1), no KPDES permit will be required for on-site discharges of stormwater, decontamination water, and treated groundwater. The applicable and substantive requirements will be met through the use of on-site treatment systems, which may include the Northwest Plume treatment system.
Hazardous Waste Management	40 *CFR* 260 through 264 and 268 401 *KAR* 31 through 34, 36 and 37	All wastes or environmental media and debris containing wastes must be characterized to determine whether the waste also is a hazardous waste in accordance with 40 *CFR* 262.11 and 401 *KAR* 32:010. If it is determined that a waste is a hazardous waste or that environmental media and/or debris contain a hazardous waste subject to the RCRA regulation, the substantive requirements of 40 *CFR* 262 through 268 are applicable.	The substantive requirements are ARAR and will be complied with through characterization of wastes and environmental media and debris generated as a result of implementation of the alternative. Waste management will be predicated upon the characterization and will comply with all substantive requirements associated with hazardous waste management, if identified as such. Consistent with CERCLA Section 121(e)(1), no RCRA permits (e.g. treatment permits) will be required for this action. Health-based standards of 39.2 ppm TCE and 2080 ppm 1,1,1-TCA in solids[14] will be used as the criteria for making contained-in determinations for environmental media and debris designated for disposal at the C-746-U Landfill. Solid wastes disposed of at landfills other than C-746-U will be subject to a contained-in determination that will be approved by the State of Kentucky and the state in which the receiving landfill is located. The Cabinet has agreed to consult with the DOE and the State where the off-site facility is located to reach agreement on the appropriate health-based standard for making contained-in-determinations for wastes that are to be shipped to such a facility. Groundwater and any related aqueous liquids generated from well sampling, well development, and well purging shall not be considered a hazardous waste at the point of generation, if the TCE concentrations are below

[14] Contained-In, health-based levels were derived as part of a separate task. Related information can be found in the Administrative Record.

Table A.3. Summary of action-specific ARARs for primary source area – electrical resistance heating (continued)

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
			1 ppm and the 1,1,1-TCA concentrations are below 25 ppm, provided that the subject aqueous liquids will be further treated in an on-site wastewater treatment unit and discharged through a PGDP KPDES-permitted outfall as required by 401 KAR 31:010, Section 3(1)(b) 4.a or b. Other aqueous-based environmental media contaminated with TCE or 1,1,1-TCA that do not qualify for the exemption under 401 KAR 31:010, Section 3(1)(b) 4.a or b will use a health-based concentration of 0.081 ppm as the criterion for making contained-in determinations. DOE will submit a Sampling and Analysis Plan (SAP) defining the sampling and characterization approach that will be used as the basis to compare contamination levels in the environmental media and debris to the health-based levels and the appropriate landfill waste acceptance criteria. DOE will submit the SAP as part of the Waste Management Plan, which, in turn, is a part of the RAWP. The SAP will be subject to regulator review and approval under the procedures outlined in the FFA for review and approval of the RAWP. The results of the SAP then will be compared against the contained-in, health-based levels listed above, and a contained-in determination will be made. Land Disposal Restrictions apply to media and debris that no longer contain or are no longer contaminated with RCRA regulated waste.
PCB Waste Management	40 *CFR* 761	TSCA requirements for the management of PCB wastes or items containing >50 ppm PCBs or from a source of 50 ppm or greater. Requirements include the following: • management of waste and material; • characterization of PCB-containing materials; • labeling and storage for disposal; • manifest completion for shipment off-site; • decontamination of affected equipment or items; and • disposal of PCB wastes. These requirements will be complied with in the event that PCBs are found at concentrations requiring compliance with this part.	The substantive requirements are ARAR if PCBs are found or result from items or equipment regulated under 40 *CFR* 761. Activities necessary to comply with these ARARs shall be incorporated into the planning phase of the alternative implementation.

Table A.3. Summary of action-specific ARARs for primary source area – electrical resistance heating (continued)

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
National Emission Standards for Hazardous Air Pollutants	401 *KAR* 57:002	The radiological dose to the most exposed member of the public resulting from radionuclide emissions to the atmosphere must not exceed 10 mrem/year.	The substantive requirements shall be complied with through calculation of emission levels for hazardous air pollutants during design and operation of the remedial action and application of the best available control technology. Consistent with CERCLA Section 121(e)(1), no Title V Air Permit will be required for the production of hazardous air pollutants.
Environmental Radiation Protection Standards for Nuclear Power Operations	40 *CFR* 190, Subpart B	Requires that the annual dose equivalent to the public not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and radiation from these operations.	The substantive standards are considered ARAR and are equivalent to the NRC standards.

ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
BMP = best management practice
CFR = *Code of Federal Regulations*
CWA = Clean Water Act
PTE = Potential To Emit
KAR = Kentucky Administrative Regulation
KPDES = Kentucky Pollutant Discharge Elimination System
PCB = polychlorinated biphenyl
DOE = Department of Energy
SAP = Sampling and Analysis Plan
PGDP = Paducah Gaseous Diffusion Plant
RCRA = Resource Conservation and Recovery Act
TSCA = Toxic Substances Control Act
NRC = Nuclear Regulatory Commission
RAWP = Remedial Action Work Plan

APPENDIX B

TABULAR SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

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Table B.1. Tabular summary of comparative analysis of alternatives

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Limited Action [a]	Alternative 3: Direct Heating in the UCRS and RGA and LUCs	Alternative 4: Vapor Extraction in the UCRS and Steam Extraction in the RGA and LUCs
Overall Protection of Human Health and the Environment	Not protective.	Protective via continued or augmented institutional controls and LUCs. Existing TCE and other VOCs would remain in the UCRS and RGA for over 100 years.	Protective with LUCs for the C-400 area, based on limited scope of this remedial action. TCE and other VOCs removed from both the UCRS and RGA.	Protective with LUCs for the C-400 area, based on limited scope of this remedial action. TCE and other VOCs removed from both the UCRS and RGA.
Compliance with ARARs	Would not comply with ARARs. Chemical-specific ARARs waivers will be required.	Although the Alternative does not meet the groundwater MCLs for TCE in the short-term, the Alternative satisfies the requirement set forth in 40 *CFR* 300.430(f) (1)(ii) for interim remedial actions to meet ARARs. This Alternative does not violate any other chemical specific, location specific, action specific, or general environmental ARARs.	Although the Alternative is not expected to meet the groundwater MCL for TCE at the time treatment is expected to cease, the Alternative satisfies the requirement set forth in 40 *CFR* 300.430(f)(1)(ii) for interim remedial actions to meet ARARs. This Alternative does not violate any other chemical specific, location specific, action specific, or general environmental ARARs and it would significantly reduce the mass of TCE and other VOCs.	Although the Alternative is not expected to meet the groundwater MCL for TCE at the time treatment is expected to cease, the Alternative satisfies the requirement set forth in 40 *CFR* 300.430(f)(1)(ii) for interim remedial actions to meet ARARs. This Alternative does not violate any other chemical specific, location specific, action specific, or general environmental ARARs, and it would significantly reduce the mass of TCE and other VOCs.
Long-Term Effectiveness and Permanence	Not effective for at least 100 years. Five-year reviews required	Not effective for at least 100 years. Five-year reviews required.	Effective in removing a large mass of TCE and other VOCs. May not meet MCL for TCE in less than 100 years.	Effective in removing a large mass of TCE and other VOCs. May not meet MCL for TCE in less than 100 years.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	Reduced mass of TCE and other VOCs through Electrical Resistance Heating Extraction and treatment in the RGA and UCRS.	Reduced mass of TCE and other VOCs through Dual-Phase Extraction in the UCRS and Steam Extraction in the RGA and treatment.
Short-Term Effectiveness	Ineffective.	Effective and would not pose any additional risks during implementation.	Steam, electrical, drilling, and construction hazards to workers may be present during the design investigation and implementation of the action. Would not pose any additional risks to the public during implementation.	Steam, drilling, and construction hazards to workers may be present during the design investigation and implementation of the action. Would not pose any additional risks to the public during implementation.
Implementability	Easily implemented.	Feasible to implement.	Feasible to implement, but vendors are limited. Assumes on-site and off-site disposal facilities are available.	Feasible to implement. Assumes on-site and off-site disposal facilities are available.
Cost (estimated)	Capital Cost: $0 Total O&M: $0	Capital Cost: amount necessary to implement additional institutional controls[a] Total O&M: $4,861,000 to an amount necessary to implement additional institutional controls	Capital Cost: $32,054,750 Total O&M: [b] $ 7,897,350	Capital Cost: $65,040,050 Total O&M: [b] $10,213,975

[a]Alternative 2 includes a range of institutional controls. Cost for institutional controls are not included here because no specific institutional controls have been identified.
[b]O&M costs for Alternatives 3 and 4 include sampling of the source area after treatment is complete.

ARAR = applicable or relevant and appropriate requirement
CRS = Upper Continental Recharge System
LUCs = Land Use Controls
O&M = operation and maintenance
RGA = Regional Gravel Aquifer
TCE = trichloroethene
VOCs = volatile organic compounds

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