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APR 29 2016

Mr. Brian Begley
Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
200 Fair Oaks Lane, 2nd Floor
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PPPO-02-3455524-16B

Ms. Julie Corkran
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Begley and Ms. Corkran:

TRANSMITTAL OF THE C-400 VAPOR INTRUSION STUDY WORK PLAN TO SUPPORT THE ADDITIONAL ACTIONS FOR THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT FIVE-YEAR REVIEW AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY (DOE/LX/07-2403&D1)

Enclosed for your review and approval is the *C-400 Vapor Intrusion Study Work Plan to Support the Additional Actions for the CERCLA Five-Year Review at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2403&D1 (Work Plan). As previously discussed with the Federal Facility Agreement parties, the U.S. Department of Energy (DOE) retained an individual who is one of the authors of the U.S. Environmental Protection Agency's (EPA's) vapor intrusion guidance and an expert on the subject to develop this Work Plan. In order to expedite implementation of the C-400 Vapor Intrusion Study, DOE requests approval/comments on the Work Plan by May 31, 2016.

DOE is available to discuss the Work Plan and looks forward to meeting with EPA and the Kentucky Department for Environmental Protection to finalize the Work Plan and to begin implementation of the C-400 Vapor Intrusion Study.

If you have any questions or require additional information, please contact Cynthia Zvonar at (859) 219-4066.

Sincerely,

Tracey Duncan
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosure:
C-400 Vapor Intrusion Study Work Plan to Support the Additional Actions for the CERCLA Five-Year Review

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DOE/LX/07-2403&D1
Secondary Document

C-400 Vapor Intrusion Study Work Plan to Support the Additional Actions for the CERCLA Five-Year Review at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Secondary Document

C-400 Vapor Intrusion Study Work Plan to Support the Additional Actions for the CERCLA Five-Year Review at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—April 2016

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FLUOR FEDERAL SERVICES, INC.,
Paducah Deactivation Project
managing the
Deactivation Project at the
Paducah Gaseous Diffusion Plant
under Task Order DE-DT0007774

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FIGURES

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	conceptual site model
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERH	electrical resistance heating
FFA	Federal Facility Agreement
FYR	five-year review
IH	industrial hygiene
IRA	interim remedial action
PEM	preemptive mitigation
PGDP	Paducah Gaseous Diffusion Plant
QAPP	quality assurance project plan
RGA	Regional Gravel Aquifer
RI	remedial investigation
SAP	sampling and analysis plan
SWMU	solid waste management unit
UCRS	Upper Continental Recharge System
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound
WAG	waste area grouping
WP	work plan

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1. INTRODUCTION

This Work Plan (WP) has been developed to document a site-specific vapor intrusion (VI) conceptual site model (CSM) for the C-400 Cleaning Building (C-400) at the U.S. Department of Energy (DOE) Paducah Gaseous Diffusion Plant (PGDP) and provide a sampling and analysis plan (SAP) to guide collection of vapor samples within C-400 to evaluate if the VI pathway presents an unacceptable risk to human health under current conditions. This historical data evaluation and additional investigation are being performed in response to a letter from the U.S. Environmental Protection Agency (EPA) dated September 30, 2014, (EPA 2014a) concerning the *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (FYR) (DOE 2014a). In the letter dated September 30, 2014, (EPA 2014a) EPA noted the following project-related uncertainty:

> …Given the magnitude of high concentration volatile organic compounds (VOC) contamination, including TCE DNAPL present in surrounding subsurface soils and below the building, the potential for vapor intrusion is likely. Vapor intrusion into building C-400 is identified as an issue in the FYR with the recommendation that a vapor intrusion analysis be performed as part of any subsequent C-400 action. The vapor intrusion study…should be conducted in the near term to determine whether this potential pathway presents an unacceptable risk to human health such as workers that work in and around the C-400 Cleaning Building. Until a vapor intrusion study is conducted that is consistent with EPA protocol and based on current toxicity values and risk assessment methodology, the protectiveness statement should be "deferred" until the protectiveness of the remedy can be determined.

The C-400 project-related uncertainty is one of three outlined in EPA's letter. The other two uncertainties (VI in the water policy area and demonstration of no groundwater usage over the contaminated plume) have been addressed by DOE and have been documented in an addendum to the 2013 FYR.

Meetings were held to scope VI investigations, both in the water policy area and at C-400, to address the concerns raised by EPA. As a result of a C-400 scoping meeting held September 29, 2015, DOE provided a path forward as summarized in two letters dated December 17, 2015, and January 15, 2016. The path forward includes a compilation and evaluation of the available historical data in the context of a VI CSM for C-400 and a SAP for the additional characterization to be conducted in C-400 to determine the impact of the potential VI pathway on the building's indoor air. This study is being conducted under the provisions of Section XXX, Five-Year Review, of the PGDP Federal Facility Agreement (FFA) (EPA 1998), as documented in the Record of Conversation letter dated August 1, 2014 (DOE 2014).

DOE's compilation of available historical data identified existing information relevant to the assessment of VI at C-400. EPA's 2015 VI Technical Guide, *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air* (EPA 2015), distinguishes "two general levels of VI assessments," which are these: (1) a preliminary analysis that uses available information to develop an initial understanding of the potential for human health risks to be posed by VI; and (2) a detailed investigation, recommended when the preliminary VI analysis indicates that subsurface contamination with vapor-forming chemicals may be present underlying or near buildings. EPA VI guidance states, "the approach for assessing VI will vary from site to site" and the "Technical Guide, therefore, recommends a framework for planning and conducting VI investigations, rather than a prescriptive step-by-step approach to be applied at every site" (EPA 2015).

Consistent with EPA's 2015 VI Guide (EPA 2015), this WP presents background information on C-400 and its investigation history (Section 4); documents that a preliminary assessment of the VI pathway at

C-400 indicates additional evaluation of the VI pathway is warranted (Section 5); and presents a detailed evaluation of the existing site information and data in the context of a site-specific VI CSM (Section 6), including assessment of the completeness of the VI pathway and identification of data gaps. The existing data considered in the preliminary VI assessment and detailed VI pathway evaluation are compared to VI screening levels presented in Section 5. Based on the site-specific VI CSM, Section 7 provides the locations and rationale for the proposed sampling needed to determine the completeness of the VI pathway at C-400. Section 8 documents how the additional samples will be collected and analyzed. Section 9 summarizes how the sampling results will be evaluated. Section 10 provides decision rules for evaluating the newly collected sampling results. The information gathered as a result of this WP and evaluated in the context of the site-specific VI CSM will be used to determine whether measured VOC concentrations in indoor air [primarily trichloroethene (TCE)] present an unacceptable risk to human health due to VI in C-400.

2. PURPOSE

This WP has the following purposes:

1. Provide a compilation and summary of existing information and data relevant to the VI pathway at C-400;

2. Document the preliminary and detailed VI evaluations for C-400;

3. Summarize the site-specific VI-CSM, analyze the completeness of the VI pathway in the context of the VI CSM, and identify data gaps;

4. Present the rationale for additional sampling at C-400;

5. Recommend screening levels based on current toxicity values and risk assessment methodology;

6. Describe the sampling and analysis needed to determine whether VOCs (primarily TCE) concentrations present an unacceptable risk to human health due to VI in C-400; and

7. Provide decision rules for evaluating the data collected as part of this study.

3. INVESTIGATION BOUNDARIES

The vertical investigation boundaries of the VI evaluation and study include a lower boundary of the Upper Continental Recharge System (UCRS) or Regional Gravel Aquifer (RGA) matrix from the first available water below ground surface (bgs) in the C-400 area up through the vadose zone and an upper boundary in C-400. The lateral boundaries include the areas in the immediate vicinity of C-400 defined by 11th Street to the east, Tennessee Avenue to the south, 10th Street to the west, and Virginia Avenue to the north.

4. SITE BACKGROUND

4.1 FACILITY DESCRIPTION

The PGDP (EPA site identification number KY8890008982) is located in McCracken County in western Kentucky, about 3.5 miles south of the Ohio River and approximately 10 miles west of the city of Paducah. Most industrial activities at PGDP were sited in a 750-acre secured area and buffer zone that are restricted from access by the public. This secured area is located on 3,556 acres controlled by the DOE. The C-400 area is located inside the plant secured area, near the center of the industrial section of PGDP.

PGDP is an inactive gaseous diffusion plant that was used to produce enriched uranium beginning in 1952. The facility first was owned and managed by the Atomic Energy Commission and the Energy Research and Development Administration, DOE's predecessors; DOE then managed PGDP until 1993. On July 1, 1993, United States Enrichment Corporation assumed management and operation of the PGDP enrichment facility under a lease agreement with DOE that continued until October 2014 when the facility was returned to DOE. DOE retains ownership of the enrichment complex.

4.2 FACILITY INVESTIGATION HISTORY

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 C-400's basement sump to the storm sewer. The area of contamination became known as the C-400 TCE Leak Site and was given the designation of Solid Waste Management Unit (SWMU) 11. SWMU 11 and the C-400 area have been the subjects of several investigations and remediations since then.

After the discovery of the C-400 TCE Leak Site in June 1986, some of the soils were excavated in an attempt to reduce contamination in the area. Excavation was halted to prevent structural damage to the adjacent infrastructure (a fence, TCE storage tank, and road). Approximately 310 ft^3 of TCE-contaminated soil was removed and drummed for off-site disposal (CH2M HILL 1992). The excavation was backfilled with clean soil and the area was capped with a layer of clay.

The Phase I and Phase II Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Site Investigations (CH2M HILL 1991; CH2M HILL 1992) included installation of soil borings and groundwater wells in the area around C-400. These investigations confirmed that TCE contamination at the southeast corner of C-400 extended from near the surface to the base of the RGA at 92 ft bgs.

The *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995) demonstrated that the area around C-400 was a major source for the Northwest Plume. Also in 1995, a review of C-400 process activities documented in the *C-400 Process and Structure Review*, KY/ERWM-38 (MMES 1995) confirmed that TCE historically was used at the building.

In 1997, the Waste Area Grouping (WAG) 6 remedial investigation (RI) focused on the area around C-400 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 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.

DOE conducted an electrical resistance heating (ERH) treatability study in 2003 (DOE 2004) to assess the constructability and effectiveness of full-scale deployment of ERH to address VOCs in the UCRS and RGA. The ERH treatability study removed approximately 1,900 gal of VOCs from the subsurface in an approximate 43-ft diameter by an approximate 99-ft deep treatment area, extending through the RGA, near the southeast corner of C-400 (DOE 2004). Other treatability studies for the RGA at C-400 have assessed surfactant flushing (laboratory and field tests in 1994, followed by laboratory testing in 1998) and chemical oxidation (laboratory testing in 1998).

DOE completed a record of decision in 2005, *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 2005) to address the Groundwater Operable Unit VOC (primarily TCE) source zones in the UCRS, upper RGA, and lower RGA east, southeast, and southwest of C-400. The interim remedial action (IRA) selected ERH as the primary treatment technology, based on the results of the 2003 ERH treatability study.

The IRA (as discussed further in Section 5) has been executed in two phases, Phase I and Phase II. The east and southwest areas of C-400 were selected for Phase I because they were the smallest of the source areas near the building and had contaminants primarily in the UCRS. Phase I ERH operations were initiated in 2009 and completed in December 2010.

Phase IIa followed Phase I to treat the UCRS and the upper RGA in the southeast area, which contained a larger amount of TCE contamination. Phase IIa ERH operations were completed in fall of 2014. A Phase IIb IRA will address remaining TCE contamination in the lower RGA of the southeast treatment area.

Section 5 describes the TCE contamination remaining that has the potential to serve as sources for the VI pathway and evaluates the likelihood the VI pathway is complete at C-400.

5. PRELIMINARY VI ANALYSIS FOR THE C-400 CLEANING BUILDING

EPA's 2015 VI Guide recommends a preliminary analysis of "available and readily ascertainable information to develop an initial understanding of the potential for human health risk that are or may be posed by VI." This involves (1) assembling, evaluating, and reviewing available information; (2) determining the presence of vapor-forming chemicals under buildings; (3) developing an initial VI CSM; and (4) evaluating preexisting and readily ascertainable sampling data.

EPA's 2015 VI Guide further recommends the preliminary analysis include evaluating the available site data to determine whether subsurface sources that remain have the potential to pose an unacceptable risk to human health due to VI and whether the VI pathway is likely to be "complete." Site-specific information for the C-400 area previously has been provided to EPA via various technical reports and presentations. On the basis of this previously presented information, EPA has determined that there is a potential for VI because of the presence of historically high concentrations of TCE [including TCE dense nonaqueous-phase liquid (DNAPL)] in soil and groundwater under and adjacent to C-400 and because of the presence of workers in the building. Specifically, EPA in 2014 determined that

> …Given the magnitude of high concentration volatile organic compounds (VOC) contamination, including TCE DNAPL present in surrounding subsurface soils and below the building, the potential for vapor intrusion is likely. Vapor intrusion into building C-400 is identified as an issue in the FYR with the recommendation that a vapor intrusion analysis be performed as part of any subsequent C-400 action.

DOE has reviewed and evaluated the available site information and concurs with EPA's determination that VOCs are present in high concentrations in the subsurface groundwater and soils surrounding and below C-400 at levels above the EPA VI Screening Levels (VISLs) (Table 1). The following subsections provide additional detail to support these conclusions: Section 5.1 presents a preliminary evaluation of the remaining subsurface sources with the potential to pose a VI concern and Section 5.2 presents a preliminary evaluation of the likelihood the VI pathway is complete at C-400.

Table 1. VISL for VOCs of Interest at the C-400 Cleaning Building, Commercial

Chemical	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk via Vapor Intrusion from Soil Source?	Is Chemical Sufficiently Volatile and Toxic to Pose inhalation Risk via Vapor Intrusion from Groundwater Sources?	Target Indoor Air Conc. (μg/m^3) @ TCR = 1E-06 or THQ = 1	Toxicity Basis	Target Sub-Slab and Exterior Soil Gas Conc. (μg/m^3) @ TCR = 1E-06 or THQ = 1	Target Groundwater Conc. (μg/L) @ TCR = 1E=06 or THQ = 1
	Cvp > Cia, target?	Chc > Cia, target?	Min (Cia, c; Cia, nc)		Csg	Csg
1,1-Dichloroethene	Yes	Yes	8.8E+02	NC	2.9E+04	8.2E+02
cis-1,2-Dichloroethene	No Inhal. Tox. Info	No Inhal. Tox. Info				
trans-1,2-Dichloroethene	No Inhal. Tox. Info	No Inhal. Tox. Info				
Trichloroethene	Yes	Yes	3.0E+00	C	1.0E+02	7.4E+00
Vinyl Chloride	Yes	Yes	2.8E+00	C	9.3E+01	2.5E+00

C carcinogenic
Cia concentration, indoor air
Chc concentration, groundwater vapor
Csg concentration, sub-slab and exterior soil gas concentration
Cvp concentration, pure phase vapor
NC noncarcinogenic
TCR target risk for carcinogens
THQ target hazard quotient for noncarcinogens

5.1 IDENTIFICATION OF POTENTIAL VI SOURCES

The historical evaluations conducted in and around C-400 have identified several sources that have the potential to yield VOC concentrations above EPA VISL concentrations in indoor air:

- RGA groundwater contaminated with TCE, including TCE in DNAPL form or as residual ganglia, in the vicinity of and underlying C-400;
- UCRS soils with historical DNAPL TCE contamination adjacent to and potentially extending under C-400; and
- UCRS soils with residual TCE contamination in remediated soils adjacent to C-400.

These identified sources have been and are being addressed by the 1986 soil removal, the 1993 closure of the degreasing operations, sump line rerouting, tank and line removal, the 2003 ERH treatability study, and the previous and ongoing IRAs. Nevertheless, subsurface contamination with the potential to pose a VI concern remains and is described in greater detail below.

Figure 1 presents a map of the TCE plume in the RGA at PGDP that demonstrates TCE continues to be present at concentrations indicative of the presence of DNAPL in the RGA in the area of C-400. The RGA Plume moves principally to the northwest (from the southeast) under/adjacent to C-400. This map shows that, as recently as 2014, high levels of TCE (10,000 to 100,000 µg/L) are present in RGA groundwater under the building. These levels exceed EPA's VISL of 7.4 µg/L for groundwater.

Figure 2 presents a contour map of maximum historical TCE concentrations detected in UCRS soil from the WAG 6 RI that shows that the highest TCE concentrations in the UCRS soils were present on the southwest, southeast, and east sides of C-400 and that high levels of TCE—representative of the historical presence of DNAPL—may extend under C-400. Although the exterior-to-C-400 UCRS areas have been remediated, post-remedial residual concentrations in the vicinity of C-400 still are high enough to pose a VI concern; and, based on interpretation of the extent of historical TCE contamination, high levels of TCE may continue to exist under the building.

Figure 3 presents a layout of the C-400 Building with callouts indicating the historical TCE use areas. Although the TCE use units were closed in 1993, there is the potential for the historical TCE use areas to contribute TCE to the indoor air of C-400 through off-gassing of residual TCE potentially absorbed/adsorbed in concrete under or around the former cleaning tanks or TCE remaining in piping or utility bedding areas under C-400.

Tabulation of historical data relevant to these sources and further analysis of data are presented in the site-specific VI CSM (Section 6).

5.2 PRELIMINARY EVALUATION OF THE VI PATHWAY COMPLETENESS

EPA's VI guidance states that a potential VI pathway should be considered complete when the following five key conditions are present:

1. Subsurface sources of vapor-forming chemicals are present;
2. There is a route for the vapors to migrate;
3. The building is susceptible to VI;
4. Vapors are present in the indoor environment; and
5. People are in the indoor environment.

The following discussion presents a preliminary evaluation of the applicability of these conditions at C-400. Additional evaluation of the completeness of the VI pathway is presented in Section 6.

Subsurface sources of vapor-forming chemicals are present. As described above in Section 5.1, there are three primary (and potentially several more) residual sources of VOCs that may cause unacceptable vapor concentrations in the indoor air at C-400.

Routes for vapor migration likely are present. The documented presence of sand in a portion of the UCRS in the vicinity of C-400 and the presence of gravel immediately beneath the building (presented in Section 6) may allow vapor migration through the vadose zone. The large number of utilities present in the vicinity of the building also may serve as preferential pathways for vapor migration into C-400. Thus, it is reasonable to conclude subsurface routes for vapor migration likely are present.

***Building is susceptible to VI*.** A crack has been identified in the building slab and other unidentified VI conduits in the building may exist, which could provide pathways for vapor migration into the building. Thus, it is reasonable to conclude C-400 potentially is susceptible to VI.

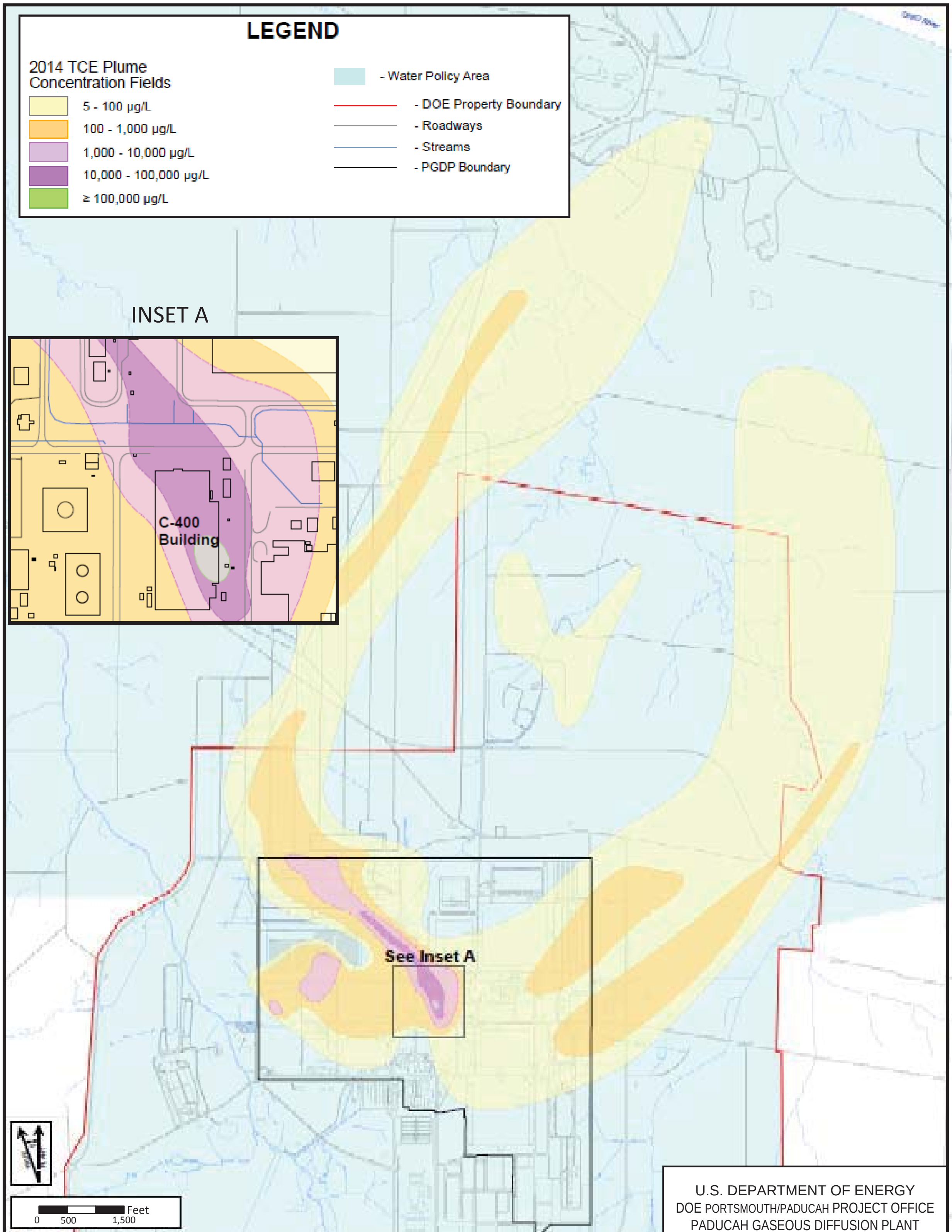

Figure 1. 2014 TCE Plume—Regional Gravel Aquifer

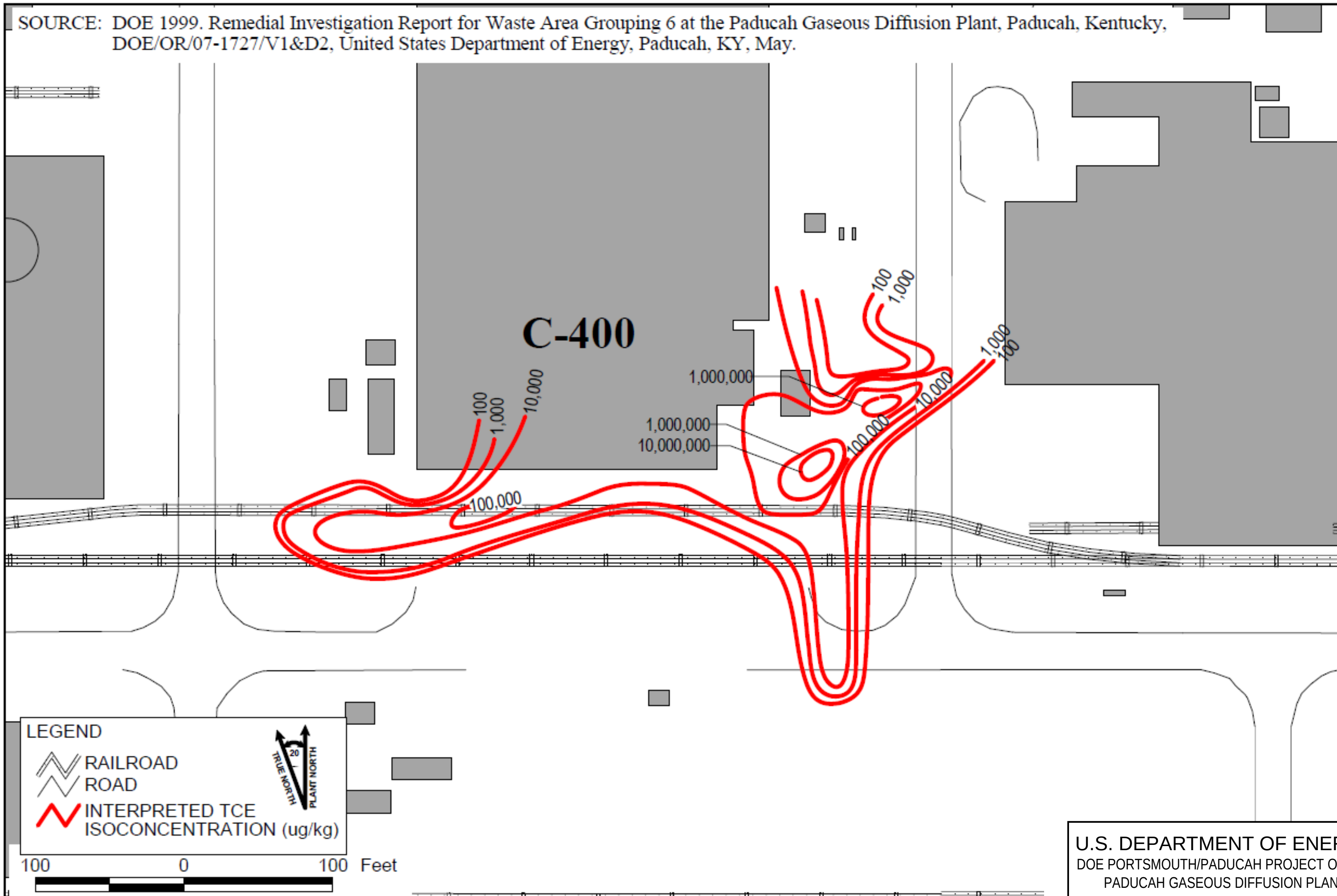

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Figure 2. 1999 Contour Map of Maximum TCE Concentration Detected in UCRS Soil

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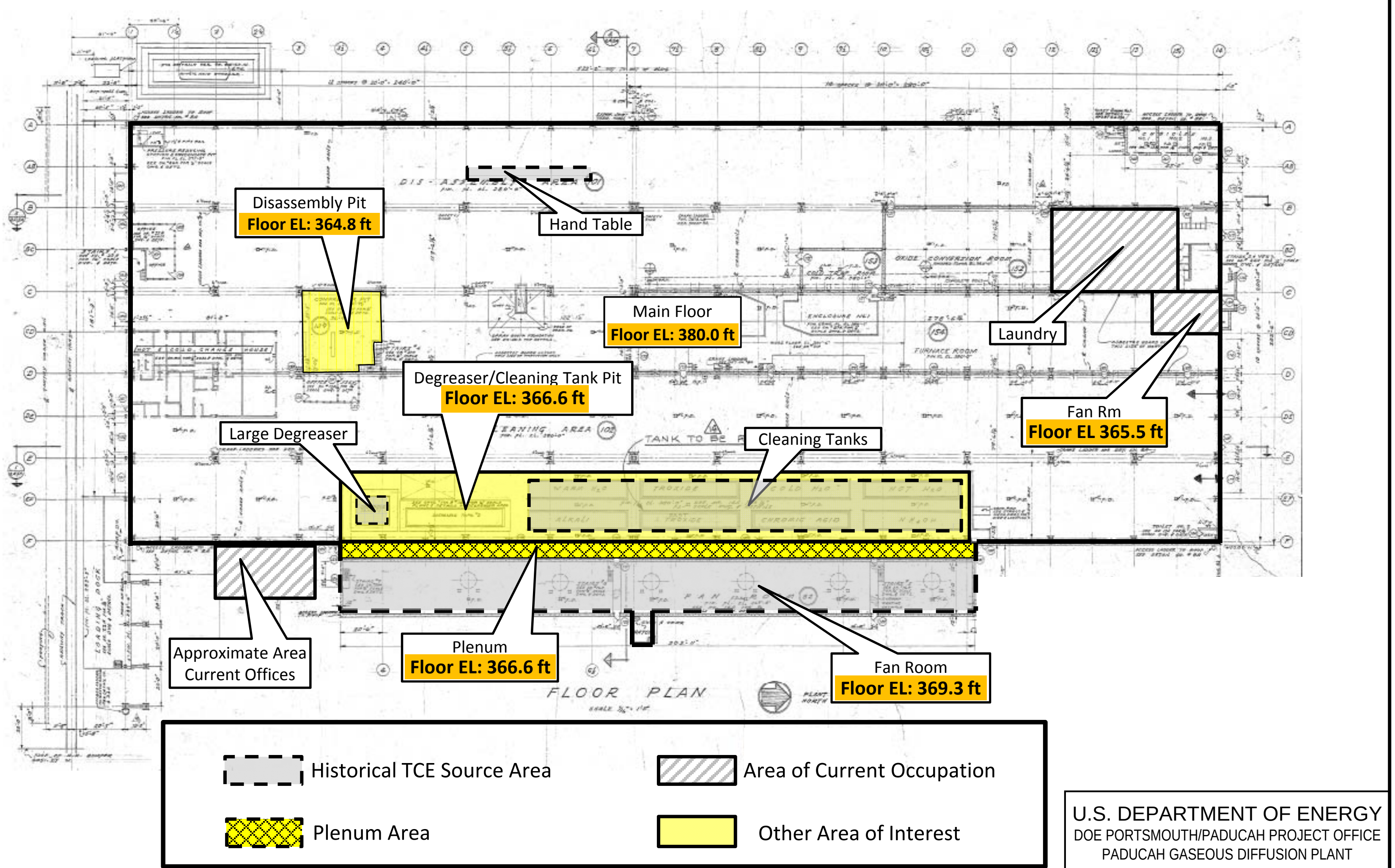

Figure 3. C-400 Layout Showing Historical TCE Source Areas and Areas of Current Occupation

Vapors have been present and may continue to be present in the indoor air environment above VISL values. Previous industrial hygiene (IH) sampling of the indoor air in C-400 identified two indoor air samples collected in 2003 that had measured concentrations of TCE of 2,800 ppbv and 500 ppbv. These results were attributed to seep water in the sump located in the C-400 basement. Other IH sampling results have yielded no detectable VOCs; however, the detection limits were substantially greater than VISL values. Based on this information, it is reasonable to conclude that TCE may be present in the indoor air of C-400 at concentrations above VISL values.

People are in the indoor environment. C-400 is currently occupied by workers, which include: remediation workers, workers associated with the laundry facilities, and office workers in the office area at the southeast end of the building. As a result, these workers have the potential to be exposed to TCE and other VOCs through the VI pathway.

Figure 4 presents a schematic CSM figure based on the conceptual model in the EPA VI Guide (EPA 2015), adapted to the C-400 facility. This figure provides a general illustration of the subsurface sources of contamination with the potential to pose a VI concern in the C-400 area.

EPA's VI Guide notes that, "when these conditions are not well established from existing information…EPA recommends that a detailed VI investigation be scoped and conducted to address these data gaps" (EPA 2015). The corollary is that, when conditions are well established from existing information, additional investigation should focus on the conditions that have not yet been well established.

Alternatively, EPA's VI Guide states that it may be appropriate to implement VI mitigation as an early action, though all pertinent lines of evidence have not been developed completely to characterize the potential VI pathway, when sufficient site-specific data indicate that VI may pose a health concern to building occupants (EPA 2015).

For C-400, four (1, 2, 3, and 5) of the five key conditions regarding completeness of the VI pathway are documented with site-specific data in Section 6. The remaining key condition (4) is considered potentially to exist at C-400, but represents a data gap that needs to be filled (e.g., by collection of indoor air samples) to determine if there are vapors present in the indoor environment at levels that pose an unacceptable risk. Section 6 further evaluates the existing data in the context of a site-specific VI CSM, determines the likelihood the VI pathway is complete, and identifies data gaps that need to be addressed with additional VI investigation.

6. SITE-SPECIFIC VAPOR INTRUSION CONCEPTUAL SITE MODEL

EPA's VI Guide (EPA 2015) recommends using available site data to develop a VI CSM that addresses, at a minimum, the nature, location, spatial extent of the vapor sources in the subsurface as well as location, use, occupancy, and construction of the existing buildings. EPA also recommends the CSM portray the current understanding of the hydrologic and geologic setting and its influence on vapor migration and attenuation in the vadose zone. To address these needs, a VI CSM generally includes descriptions of the following:

- Site operations and activities—the types of site operations and activities that occurred on or near the site that could have released VOCs to the subsurface;

- Chemicals of interest—the types of VOCs that may have been used or disposed at the site;

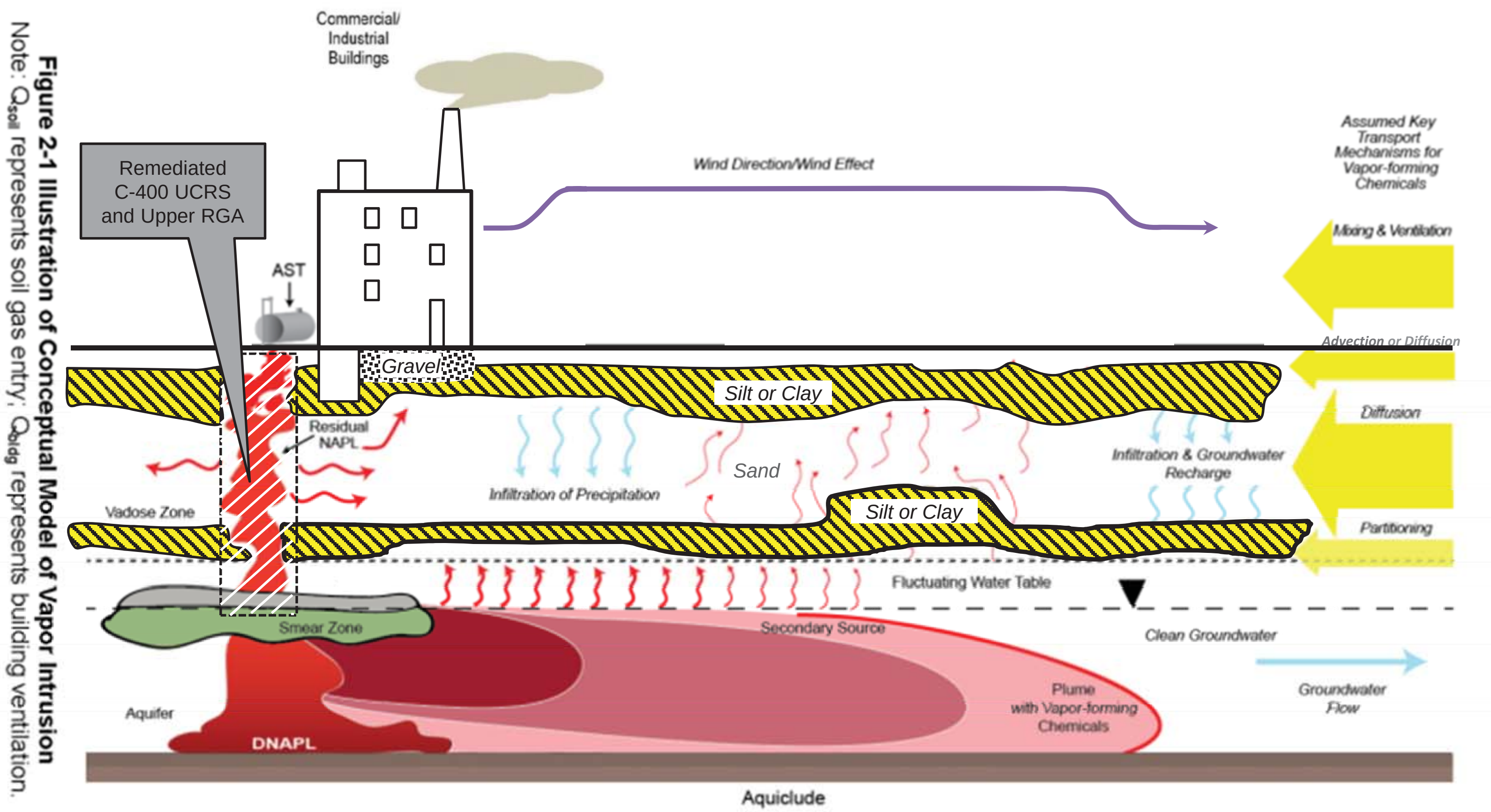

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Figure 4. C-400 Cleaning Building CSM (Approximate Perspective from Northeast Building Corner) Adapted from June 2015 EPA VI Guidance

- Land and facility use—current and reasonably anticipated land and building use and occupancy;
- Building characteristics—such as layout; type and integrity of the building foundation, and heating, ventilating, and air conditioning operations;
- Potential residual subsurface sources—types, locations, and concentrations of vapor-forming sources under or near the building; and
- Potential vapor migration pathways—descriptions of vadose zone features conducive to vapor transport and potential vapor entry points into the building, including potential preferential pathways, such as subsurface utility corridors.

DOE's compilation of available historical data has identified considerable existing information relevant to the assessment of VI at C-400. The following sections present a compilation of the data relevant to the VI pathway and the use of that data to develop a site-specific VI CSM, evaluate the completeness of the VI pathway, and identify data gaps that need to be addressed.

In compiling the existing data, the following rules were used to determine the usability of historical data:

- Historical data that have been qualified as rejected by data validation or by data assessment were not included in the historical data evaluated for use.
- Historical data that contain units inconsistent with the sampled media or with the analysis were not included in the historical data evaluated for use (e.g., a soil sample with analytical units reported in mg/L would not be considered usable).
- Historical data with no reported result and no recorded detection limit were not included in the historical data evaluated for use.
- Data assessment qualifiers previously placed on the data were noted and applied as appropriate.
- A result was considered to be a nondetect if it was qualified by the reporting laboratory with a "U" qualifier or a "<" qualifier.
- A result was considered a nondetect if it has a "U" validation code or a "U" data assessment code.
- Historical data that are no longer representative of the current site conditions being evaluated were excluded (e.g., where site conditions were changed substantially as a result of remedial activities).
- Historical practical quantitation limits were compared to current screening levels to evaluate the usability of the data in the current context and the reliability of conclusions about presence or absence of contaminants.
- Historical analyses derived from an on-site laboratory were not included in historical data evaluated when analyses for duplicate samples were available from a fixed-base laboratory.

6.1 SITE OPERATIONS THAT COULD HAVE RELEASED VOCS

Operations at C-400 began in 1952. Cleaning metal parts and equipment with degreasing solvents (primarily TCE) was one of the principal operations performed in the building and resulted in releases of VOCs inside and outside the building.

6.1.1 TCE Releases Inside C-400

Historically, some of the primary activities associated with C-400 have included cleaning machinery parts. Degreasing solvents were used on metallic items that were contaminated with oil and grease. Due to the efficient cleaning abilities of TCE, it reportedly was used throughout C-400 and at a variety of locations across the plant (MMES 1995). Originally there were three vapor degreasers that used industrial grade TCE as the solvent. After degreasing was complete, the cleaned item was shifted to the side of the degreasing unit and excess solvents were allowed to drain into a collection basin connected to the degreaser. The item then was placed either on the floor next to the degreasers or into one of the cleaning tanks. Items placed on the floor may have been returned directly to service or cleaned in the spray booth (large items) or on the hand tables (small items). Floor drains were located throughout the building to direct spills and overflow into interior and exterior sumps or directly into storm sewer lines.

Each of the degreasers was equipped with a spray hose that could be used to direct a stream of TCE at difficult to clean areas on items within the degreaser or to fill containers (5-gal buckets) used in remote cleaning operations. The TCE tank loading facility was equipped with a hose that also could be used to fill small containers (drums).

Average usages of TCE in C-400 over the decades of plant operation are shown in Table 2.

Table 2. Average Rate of TCE Consumption in the C-400 Cleaning Building by Decade (CH2M HILL 1992)

Decade	TCE Use at the C-400 Cleaning Building
1960s	500 to 2,000 gal/month
1970s	> 15,000 gal/month
1980s	1,000 to 2,000 gal/month
1990s	600 to 700 gal/month

Areas of C-400 where historical TCE leaks and spills are known or suspected (see Figure 3) may include all areas of the building especially (1) degreaser and cleaning tank pits; (2) drains and sewers; (3) the east side 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) at the C-400 area. TCE use was discontinued at C-400 on July 1, 1993, and identified TCE sources within C-400 were addressed. However, historically TCE-contaminated flooring (concrete) may continue to be a source of vapors and TCE releases from leaks in the floor drains and piping may remain under the floor slab where they have the potential to contribute vapors in the interior of the building.

6.1.2 TCE Releases to the Vicinity of C-400

Historical operations released TCE DNAPL to the subsurface, which contaminated UCRS soils and RGA groundwater in the vicinity of C-400, as shown in Figures 1 and 2. To address TCE-contaminated soils located outside C-400, DOE performed a treatability study of ERH near the southeast corner of the building in 2003 to determine its applicability at PGDP as a remedial approach to remove TCE contamination from soil and groundwater. The treatability study results supported development of the record of decision (DOE 2005).

DOE implemented ERH between 2008 and 2010 to address TCE soil contamination east and near the southwest corner of C-400 in Phase I of the IRA and approximately 535 gal of VOCs (primarily TCE) were removed from the subsurface during Phase I. In Phase IIa, ERH was used to address TCE contamination in the UCRS and the upper RGA in the southeast area treatment area, which contained a larger amount of source contamination. Phase IIa operations were completed in fall of 2014 and approximately 1,137 gal of VOCs (primarily TCE) were removed from the subsurface. However, residual TCE remains in soil at concentrations ranging up to ~10,000 μg/kg in the vicinity of C-400 and has the potential to migrate as vapor into the building. The residual soil concentrations are discussed further in Section 6.5.1.2.

6.2 CHEMICALS OF INTEREST

As noted above, large volumes of TCE were used in historical operations at the site, and releases of TCE inside and outside of C-400 have contaminated site media. The VOCs of interest are TCE; its breakdown products (*cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and vinyl chloride); and 1,1-dichloroethene. EPA has not assigned inhalation toxicity values for *cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene; thus, these chemicals do not have VISLs.

6.3 LAND AND FACILITY USE

Current and reasonably foreseeable future land uses at and adjacent to PGDP are industrial for areas located primarily inside the security fence, industrial or recreational for areas located outside the security fence, and residential for areas beyond the DOE property (DOE 2005). 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 used to determine land uses were obtained through a land use survey performed in 1995 and future land use public workshops conducted in 1994 and 1995. Additionally, the subject has been discussed with a number of organizations, including city and county officials and the Citizens Advisory Board.

The Kentucky Research Consortium for Energy and Environment worked with federal, commonwealth, and local government representatives and community stakeholders to complete a risk-based end state vision for the site, *The PGDP Future Vision Project*, in 2011 (KRCEE 2011). The process included structured public involvement and technology integration. This end state vision informs DOE of current community preferences for future use of the PGDP site.

TCE and other VOCs in soil and groundwater originate in an area where current and expected future land use is industrial. There are no current exposures to on-site groundwater by nonremediation workers or the general public because of existing on-site restrictions and controls (e.g., the current excavation/penetration permit program). A Land Use Control Implementation Plan (DOE 2008) identifies specific controls and mechanisms to ensure four objectives:

1. Maintain the integrity of any current or future remedial or monitoring system;

2. Prohibit the development and use of the C-400 area for residential housing, elementary and secondary schools, child care facilities, and playgrounds;

3. Prevent exposure of current and future on-site industrial workers to groundwater/soils and prevent use of the groundwater at the C-400 area through institutional controls (e.g., access controls, Excavation/Penetration Permits Program) and through deed restrictions; and

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

There is a potential for TCE vapors from subsurface (and potentially indoor) sources to impact indoor air in C-400; therefore, both the remediation workers currently deactivating the building in anticipation of eventual demolition and non-remediation workers working in the building may come in contact with these vapors.

6.4 C-400 CLEANING BUILDING CHARACTERISTICS

Figure 3 presents the layout of the building with approximate locations of building features. C-400 rests on a 16-inch, on grade concrete slab in most areas, although there are four pits/sumps and an east-side basement area that are up to 15 to 20 ft below grade. Figure 5 shows a typical cross section through C-400. Construction photographs and soil boring logs suggest that the building floor overlies approximately 10 ft of gravel backfill. The east-side basement includes a plenum and fan room system to ventilate the building. Currently, at least one (out of ten) ventilation fans operates continuously to ventilate the building.

Figure 6 shows many buried utilities service C-400, including sanitary water lines, return circulating water lines, storm sewers, sanitary sewers, and electrical lines and ducts. Floor drains found throughout the building have been sealed with epoxy (or equivalently closed) to prevent further releases from the building. These floor drains previously emptied into interior and exterior building sumps or directly into storm sewer lines. Sumps for wastewater treatment and disposal were located northeast (C-403 Neutralization Pit) and northwest (waste discard sump) of C-400. The numerous utilities present under C-400 make collection of sub-slab vapor samples impracticable due to the difficulty in identifying the utility conduit locations.

Historical IH sampling and analysis of indoor air in C-400 (2003) is summarized in Table A.1 of Appendix A. The IH sampling has generally resulted in no detectable TCE or vinyl chloride, although two indoor air samples collected in 2003 in the C-400 basement as part of the ERH Treatability Study (DOE 2004) had TCE concentrations 900 and 5,000 times higher than the commercial TCE VISL screening level of 3 $\mu g/m^3$ (0.56 ppbv) [although the levels were below the American Conference of Governmental Industrial Hygienists (ACGIH) value of 50 ppm]. These samples were considered to have originated from seep water in a sump associated with an abandoned TCE storage tank located in the C-400 basement and not from other indoor sources. This sump remains and has been noted recently to contain water. TCE concentrations in subsequent IH samples, including IH samples collected in 2015, were below detection (at a detection limit of ~500 ppbv). Because the IH detection limits for TCE are greater than EPA's commercial TCE VISL value of 3 $\mu g/m^3$ (0.56 ppbv), it is not known if indoor air concentrations in C-400 currently exceed the TCE VISL value.

Recent walkthroughs of C-400 indicate the integrity of the floor slab appears to be generally good, but did identify a crack in the floor near the center of the building that may extend through the slab and serve as a conduit to subsurface vapors. Due to the size (approximately 144,000 ft^2) and complexity of C-400,

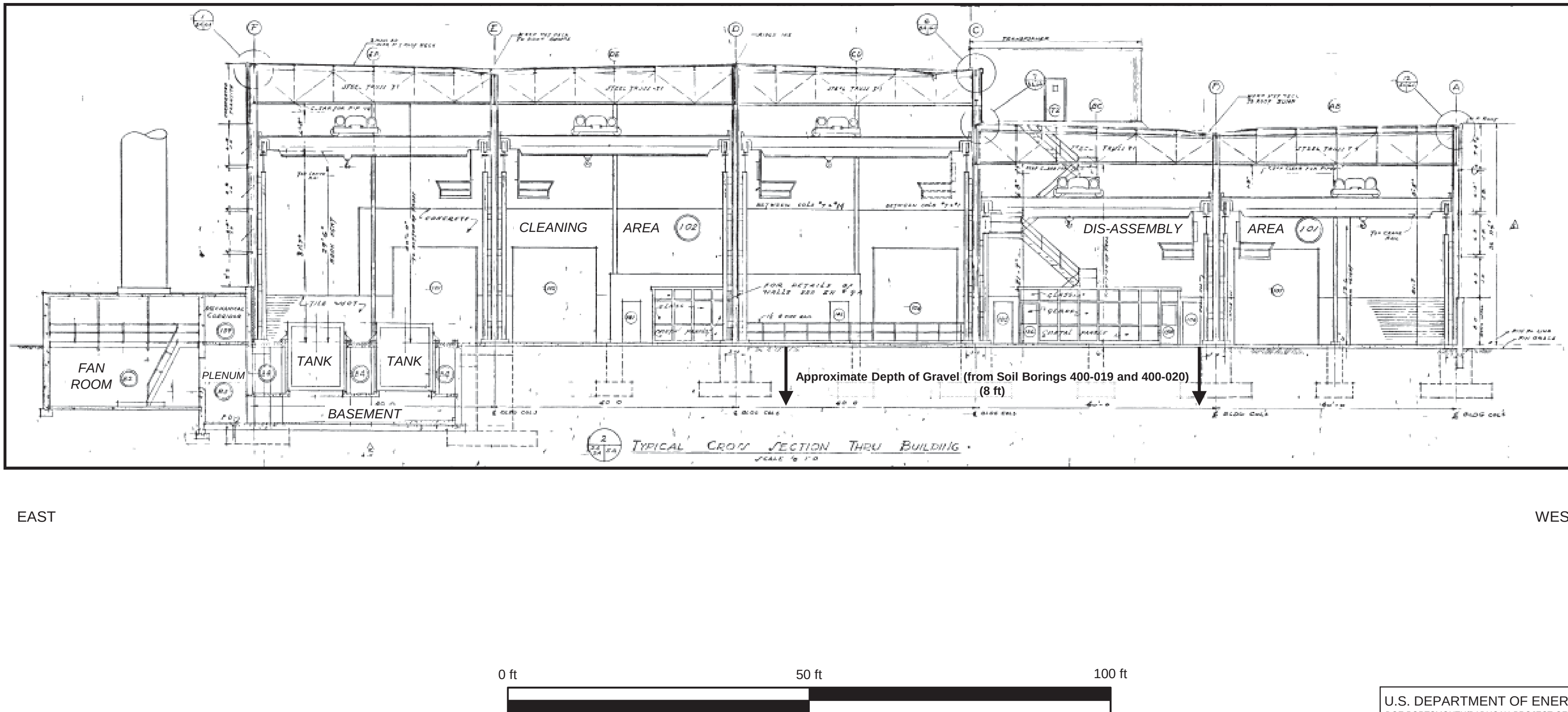

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Figure 5. Cross Section through C-400 Building

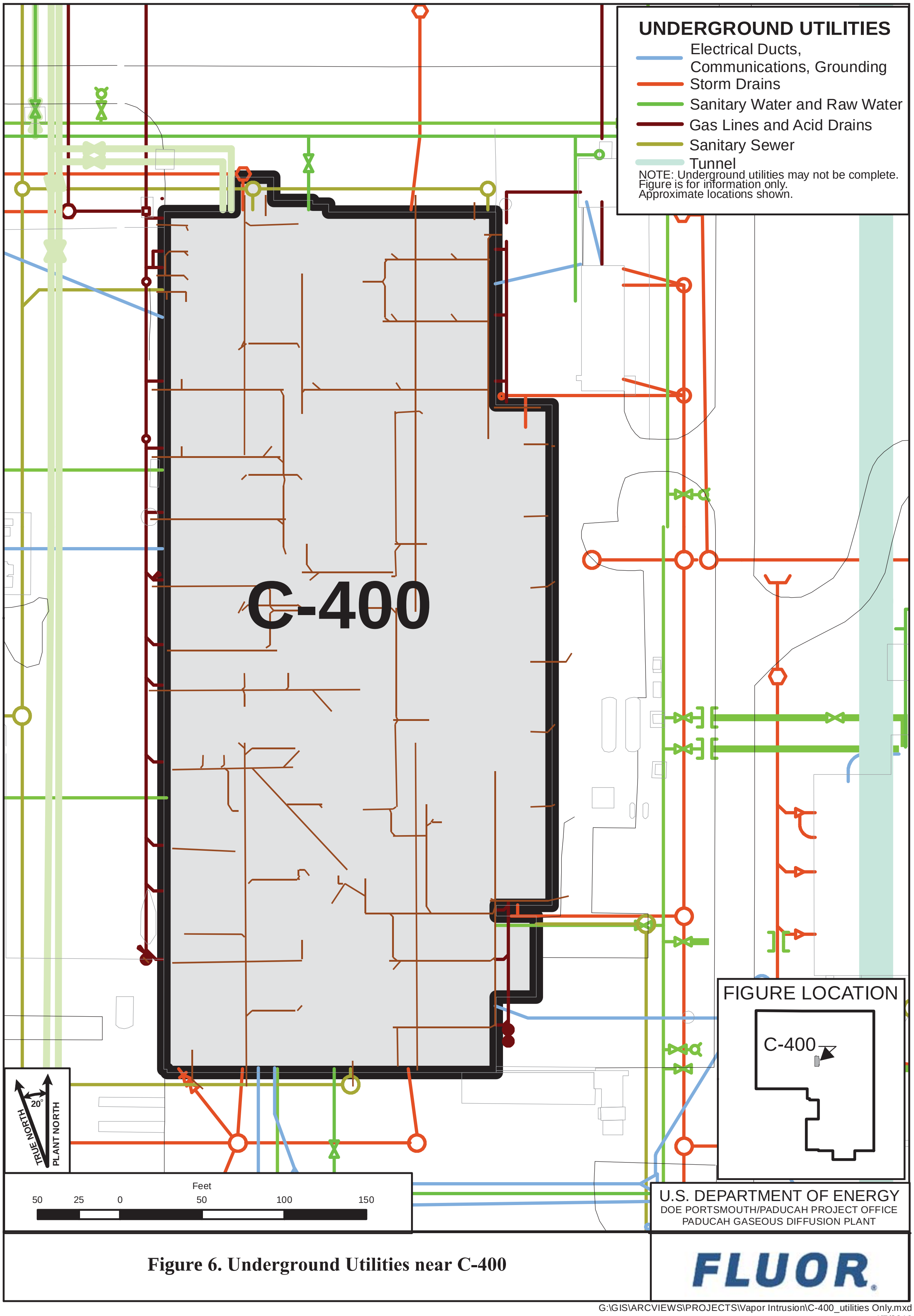

Figure 6. Underground Utilities near C-400

identifying the specific locations of other potential VI conduits is not practicable. Instead, DOE assumes that both a subsurface source of TCE and preferential pathways for VI exist at C-400, and, for risk assessment and risk management purposes, assumes that any measured indoor air exceedances of the TCE VISL value are attributable to VI.

6.5 POTENTIAL SOURCES OF CHEMICALS OF INTEREST

The 1997 WAG 6 RI identified areas of soil and groundwater contaminated with VOCs, primarily TCE, outside of C-400. Similar levels of contamination, as discussed in the previous section, may be present beneath the building. Soil sampling conducted in 1997 at two locations beneath the building, 400-019 and 400-020, documented the presence of TCE in vadose zone soils at concentrations ranging up to 130 µg/kg.

6.5.1 Subsurface Sources

As described in Section 5, leaks and spills from past operations at PGDP have affected soil and groundwater at the site with TCE as both dissolved-phase contamination and DNAPL at locations through the UCRS and down to the base of the RGA. This section presents analytical data documenting the presence of TCE in subsurface media adjacent to and under C-400 with the potential to pose an unacceptable risk to human health via the VI pathway.

6.5.1.1 Groundwater

In the C-400 area, groundwater is encountered at approximately 30 to 35 ft bgs in the UCRS. The sands and gravels of the RGA are encountered at about 50 ft bgs. The sands and gravels of the RGA are highly permeable, and groundwater velocity is thought to be on the order of 0.1 to 0.3 ft per day around C-400. Groundwater flow in the RGA is generally to the north. Figure 7 illustrates the hydrogeology of the C-400 area.

The RGA TCE Plume concentrations are evaluated sitewide every two years and summarized as updates to the site plume maps. Dissolved TCE trends in the vicinity of C-400 continue to indicate the presence of DNAPL in the RGA below the building (i.e., dissolved concentrations in some wells are greater than 1% of TCE's aqueous solubility or approximately 13,000 µg/L.) The most recent plume map [calendar year 2014 (DOE 2015a)] is shown in Figure 8. Appendix A contains a compilation of the groundwater results collected over the past 10 years from wells located in the vicinity of C-400.

Upper and middle RGA wells nearest C-400 include MW156; MW178; and the upper sampled ports of wells MW406, MW407, MW408, MW421, MW422, MW423, MW424, and MW425. TCE concentrations for these wells from the latest round of sampling (2014) are tabulated in Appendix A. TCE Plume concentrations underlying the northwest corner of C-400 currently are higher than concentrations toward the southeast corner, but previously, the reverse was the case. All concentrations are substantially higher than the commercial groundwater TCE VISL of 7.4 µg/L. In the southeast area of C-400 (i.e., the upgradient end), TCE concentrations have been shown to be decreasing. For example, TCE concentrations in MW156 have decreased from previous levels of 56,500 µg/L to 925 µg/L in 2014. Similarly, concentrations in MW408-PRT5 and MW405-PRT5 have decreased from 2012 highs of 1,400,000 µg/L (MW408-PRT5) and 97,000 µg/L (MW405-PRT5) to values of 37.6 and 481 µg/L, respectively, in 2014. Concentrations in monitoring wells near the northwest corner of C-400 (i.e., the downgradient end) still exhibit high levels, generally above 10,000 µg/L. For example, the TCE concentration in MW421-PRT3 was 62,800 µg/L in 2014. These levels are several thousand times higher than the groundwater TCE VISL of 7.4 µg/L.

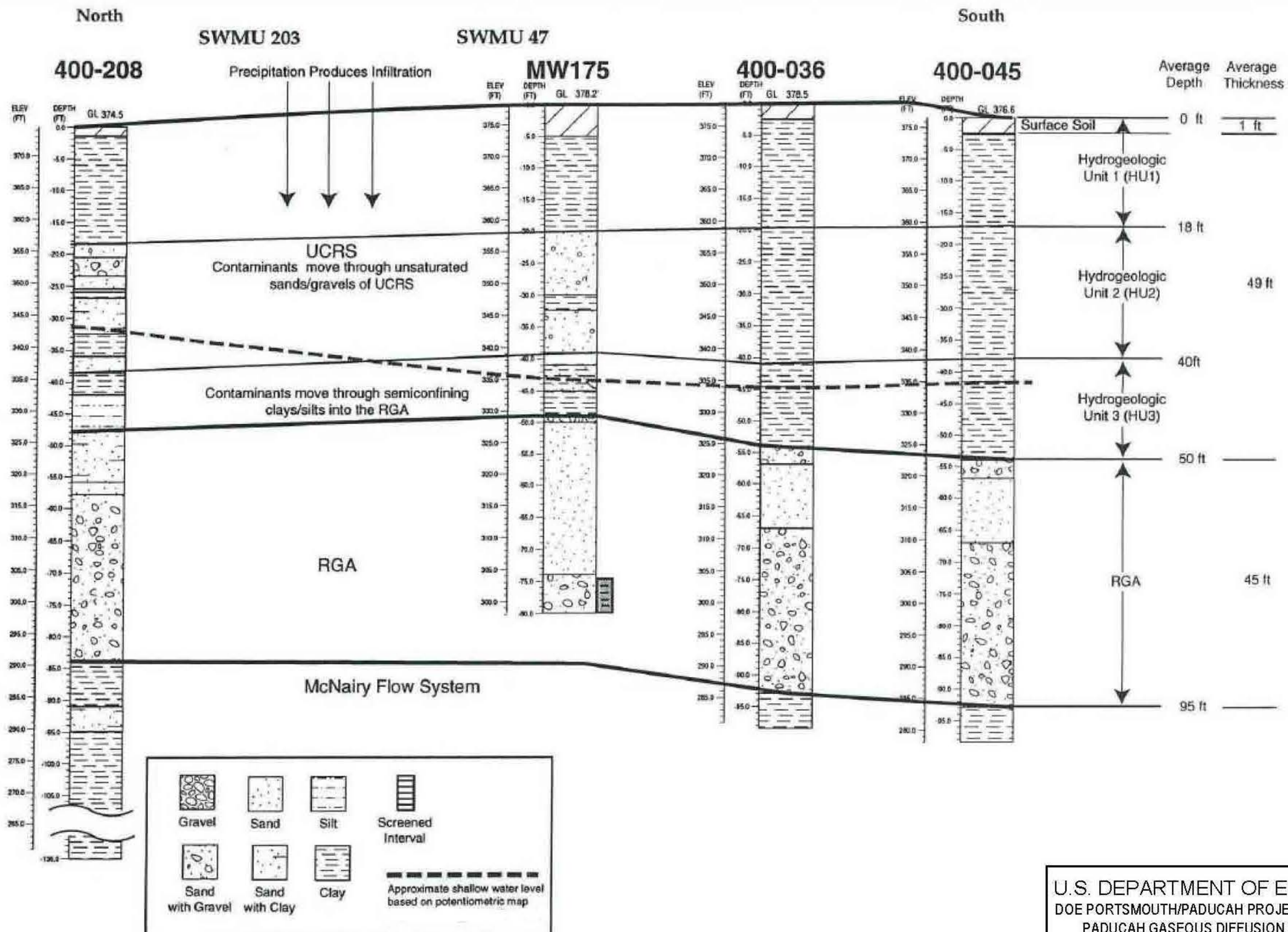

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Figure 7. C-400 Area Hydrogeology (DOE 1999)

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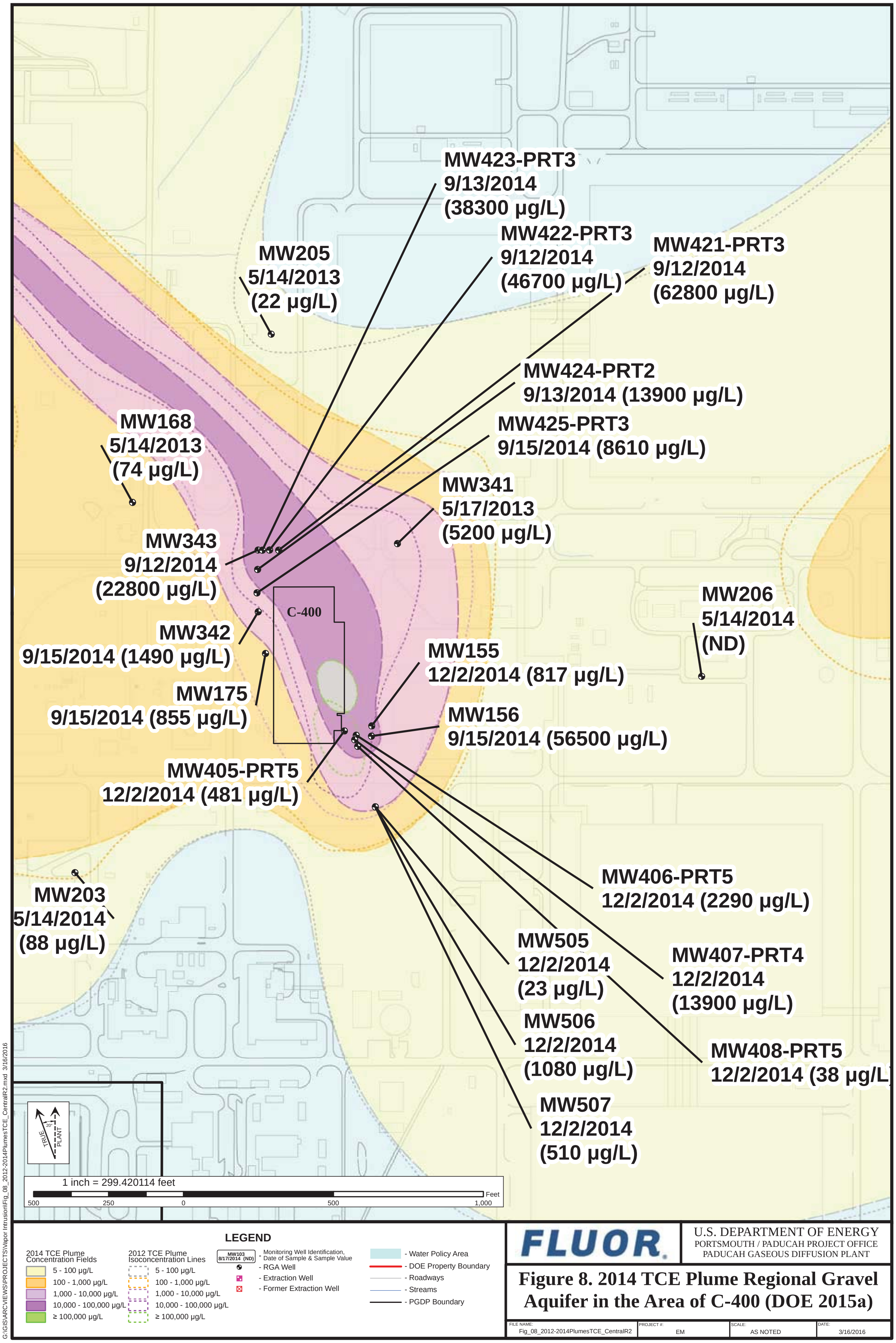

Figure 8. 2014 TCE Plume Regional Gravel Aquifer in the Area of C-400 (DOE 2015a)

These data support the conclusion that TCE is present in groundwater surrounding and potentially below C-400 at aqueous concentrations with the potential to result in TCE soil vapor concentrations under C-400 that are likely to exceed EPA's soil gas TCE VISL of 100 µg/m^3.

6.5.1.2 Vadose zone

In the C-400 area, the vadose zone generally is comprised of fine-grained sediments (mostly silt and fine sand) of the UCRS, which overlies the RGA (Figure 7). Locally, however, at the south end of C-400, more intervals of sand and gravelly sand are noted. These sandy zones would be more amenable to vapor migration. The UCRS at C-400 is typically unsaturated for approximately the first 35 ft bgs.

Historical TCE contamination in unremediated UCRS soils adjacent to the southern end of C-400 initially exceeded 1,000,000 µg/kg and was interpreted to exceed 100,000 µg/kg under the southeast end of the building (Figure 2). These soil concentrations in the areas surrounding the building have been reduced by 95% to 99% through Phase I (DOE 2011) and Phase IIa of the ERH IRA (DOE 2015b), but residual TCE remains in the soil. Concentrations in the east and southwest remediated areas average 29 µg/kg and 15 µg/kg, respectively, with maximums of 315 µg/kg and 228 µg/kg, respectively. In the southeast remediated area, TCE soil concentrations average 225 µg/kg with a maximum of ~10,100 µg/kg. These levels exceed EPA's VISL of 7.4 µg/L for groundwater. The TCE concentrations remaining in soil after the Phase I and Phase IIa IRAs are summarized in Appendix A.

Historical sampling of sub-slab soil from two borings completed within the. footprint of the building was conducted as part of the WAG 6 RI (DOE 1997). A total of 18 sub-slab soil samples was collected at regular depth intervals of 4 to 8 ft down to 48 ft. Analytical results from these samples are presented in Table 3. Of the 18 samples collected, 16 samples had detectable TCE concentrations, ranging from 1.6 to 130 µg/kg with a median of 22.5 µg/kg. These data are considerably older than the post-remediation data described above, but nevertheless provide insight as to the extent of contamination around and under C-400 (in the vadose zone) because the soils directly under the building have not been subjected to remedial activities.

The EPA VI Guide (EPA 2015) generally recommends against using soil concentrations for VI assessment, because of the likelihood of VOC losses during sampling and analysis, but notes that soil samples are useful for delineating soil source areas with the potential to pose a VI concern. EPA summarizes the challenges in soil sampling and analysis for VI screening of soil and discusses appropriate uses of soil data for VI assessment, which include using soil data to delineate sources (2014b). The report provides bulk soil concentrations corresponding to the target VISL levels for sub-slab soil gas. For TCE, the target soil level for residential settings is 0.02 µg/kg; the equivalent value for commercial settings is approximately 6 times higher or 0.1µg/kg. The measured residual TCE concentrations in the remediated soil adjacent to C-400 (described above) are orders of magnitude higher than the target commercial TCE soil concentration (~0.1 µg/kg) corresponding to the commercial sub-slab VISL of 100 µg/m^3. Therefore, vapor concentrations associated with the residual TCE in the remediated soils as well as the TCE in soils under C-400 are likely to have been (and continue to be) many orders of magnitude higher than the commercial TCE sub-slab VISL of 100 µg/m^3. VOC losses upon soil sampling, the primary concern noted by EPA regarding the use of soil data for VI assessment, would simply mean the soil concentrations and associated soil vapor concentrations were actually higher.

These data support the conclusion that soil vapor concentrations adjacent to and directly under the C-400 floor slab are likely to be higher than the sub-slab TCE VISL value of 100 µg/m^3. The presence of 10 ft of gravel fill under the slab is expected to allow the transport and accumulation of these vapors under the floor slab, under at least a portion of the footprint of the building.

Table 3. Waste Area Grouping 6 Remedial Investigation
Volatile Organic Compound Analyses of Sub-Slab Soil Samples

STATION	Depth (ft)	TCE (μg/kg)	*cis*-1,2-DCE (μg/kg)	*trans*-1,2-DCE (μg/kg)	1,1-DCE (μg/kg)
400-019	0–4	1.6	< 6	< 6	< 6
400-019	8–12	11	< 6	< 6	< 6
400-019	16–20	6.3	< 5	< 5	< 5
400-019	24–28	13	< 6	< 6	< 6
400-019	28–32	< 5	< 5	< 5	< 5
400-019	32–36	7.1	< 6	< 6	< 6
400-019	36–40	< 5	< 5	< 5	< 5
400-019	40–44	< 6	< 6	< 6	< 6
400-020	0–4	< 6	< 6	< 6	< 6
400-020	8–12	17	< 6	< 6	< 6
400-020	16–20	130	< 6	< 6	< 6
400-020	16–20 (duplicate)	75	< 6	< 6	< 6
400-020	20–24	5.6	< 5	< 5	< 5
400-020	28–32	70	< 6	< 6	< 6
400-020	32–36	34	< 6	< 6	< 6
400-020	36–40	28	< 5	< 5	< 5
400-020	40–44	42	< 6	< 6	< 6
400-020	44–48	53	< 6	< 6	< 6

DCE = dichloroethene

The WAG 6 RI also included collection of exterior soil gas samples, but soil air permeabilities were so low that most soil samples reportedly were compromised by ambient air that leaked through joints in the aboveground drill pipe. Under these types of conditions, the primary route of vapor migration is likely to be along preferential conduits, such as utility lines. Of the 145 attempted samples, 10 (9 of which are on the south side of C-400) contained detectable TCE concentrations that were considered to represent some contribution from soil gas. The detected TCE soil gas concentrations from the south side of C-400 ranged from 1.5 to 1,678 μg/L (1,678,000 μg/m^3) with a median of 4.9 μg/L (4,900 μg/m^3). These values support the conclusion derived above, based on soil sampling, that vapor concentrations arising from TCE contamination under and adjacent to C-400 are orders of magnitude greater than the commercial TCE sub-slab VISL of 100 μg/m^3.

There are several lines of evidence that point to the likely continued presence of TCE in the soil under and adjacent to C-400 at levels that exceed VI screening values. Prior to remediation (by the ERH IRA), some of the UCRS soils were interpreted to contain DNAPL, with derived DNAPL saturations up to 4%. Additionally, membrane interface probe logs of historical area soil borings suggested that zones of DNAPL saturation were present. It is possible these zones extended under the building (and outside the remediated areas) as interpreted in Figure 2. The ERH IRA removed approximately 3,500 gal of VOCs from the UCRS and upper RGA soils exterior to the building and reduced soil concentrations, but residual soil concentrations still exceed VISLs at some locations. In addition, ERH was not implemented below the building.

Additionally, leaks from building drains and sewers are known to have contaminated utility trenches and adjacent soils in the vicinity of C-400, as directly evidenced by the SWMU 11 (TCE Leak Site). Other utilities lines and bedding material around the drain pipes leading from the floor drains or other utilities entering or leaving the building have not been investigated because of the presence of building equipment and infrastructure and uncertainties in utility locations (leading to operations and health risks). Given the lines of evidence described above, it is reasonable to conclude that TCE is present under C-400 in the UCRS soil, utility lines (and their bedding materials), and the gravel layer under the C-400 slab at concentrations sufficient to generate soil vapor concentrations higher than the commercial TCE sub-slab VISL of 100 $\mu g/m^3$.

6.5.2 Potential Indoor Sources

As described above, historical operations associated with C-400 resulted in TCE leaks and spills in areas such as the degreaser and cleaning tank pits, drains and sewers, and tanks and sumps outside the building, including underground piping running from tanks. Although the historical operations were terminated and the identified source areas were closed in 1993, potential indoor sources of TCE may remain in the building, such as TCE in concrete that may continue to off-gas. Additionally, there may have been other sources not identified at the time operations ceased. Nevertheless, DOE considers VI from subsurface sources of TCE under and adjacent to the building likely to be the primary source of any TCE detected in indoor air, because the subsurface sources have totaled thousands of gal of TCE and residual TCE contamination has been documented to be present, and the indoor source areas have been closed and have been subject to the ongoing building ventilation since 1993.

6.5.3 Summary of Potential Vapor Sources and Migration Pathways

The VI CSM uses site-specific information collected during characterization studies and IRAs to describe the nature, location, spatial extent of the vapor sources in the subsurface, as well as the uses (including those that could have the potential to serve as indoor vapor sources), occupancy, and construction of C-400. The VI CSM also portrays the hydrologic, hydrogeologic, and geologic setting and its influence on vapor migration and attenuation in the vadose zone.

As described above, TCE contaminated groundwater and soil adjacent to and under C-400 are considered potential sources of vapors that may impact C-400. Subsurface conditions in the C-400 area are considered to allow vapor transport toward the building. Although RGA concentrations in the vicinity of C-400 have decreased, groundwater concentrations still exceed EPA’s groundwater VISLs. Similarly, remedial actions have achieved greater than 95% reduction in soil concentrations, but post remedial residual concentrations still exceed levels considered capable of generating soil gas concentrations above EPA’s soil gas VISLs. Vapor concentrations associated with the remaining TCE contamination in groundwater and soil are expected to be many orders of magnitude higher than the commercial soil gas and sub-slab TCE VISL screening level of 100 $\mu g/m^3$ and, therefore, have the potential to pose an unacceptable health risk to workers in C-400.

Vapor migration from subsurface groundwater and soil sources through the vadose zone is promoted by the presence of sand in the UCRS in the vicinity of C-400, as well as the presence of gravel immediately beneath the building. The large number of utilities present in the vicinity of the building also may serve as preferential pathways for vapor migration. The presence of a crack in the building slab and other potential, but unidentified VI conduits may provide potential pathways for vapor migration into the building.

6.5.4 Evaluation of VI Pathway Completeness

As described earlier in Section 5, EPA’s VI Guide states that a potential VI pathway should be considered complete when the following five key conditions are present:

1. A subsurface source of vapor-forming chemicals exists;
2. There is a route for the vapors to migrate;
3. The building is susceptible to VI;
4. Vapors are present in the indoor environment; and
5. People are in the indoor environment.

The VI CSM documents the presence of sources of TCE immediately under and adjacent to C-400 in the form of dissolved-phase groundwater contamination and residual or adsorbed TCE in soil. Additionally, leaks from building drains and sewers are known to have historically contaminated utility trenches and adjacent soils with TCE DNAPL. TCE concentrations in groundwater underlying C-400 exceed the groundwater screening levels for TCE in EPA’s VISL calculator (EPA 2016). The post-remediation, residual TCE concentrations in soil adjacent to the building and those measured under the building are at levels sufficient to yield soil vapor concentrations exceeding the sub-slab VISLs. Where TCE DNAPL may be present (e.g., in abandoned drain lines and utility bedding material) under C-400 due to past practices, the associated vapor concentrations are expected to be greater (by orders of magnitude) than the sub-slab VISLs.

Known subsurface conditions, including the presence of sandy material in the vadose zone and gravel under the slab, favor vapor migration. There are no impediments (e.g., no laterally continuous clay layers) considered to inhibit vapor transport between the sources and the building sufficient to limit the intrusion to below VISL levels. The presence of a crack in the building slab and potentially unidentified VI conduits in the building may provide pathways for vapor migration into the building. DOE, therefore, considers that vapors may be migrating from the documented source materials under and adjacent to C-400 and through the sand and gravel into the building.

Openings exist in the building’s foundation—openings such as the identified slab crack and potentially other openings such as perimeter cracks, stress relief seams, and perforations for utility conduits and structural supports—that could serve as a pathway for vapor entry into the building. Additionally, DOE has noted cracking in the basement area slabs, though the degree to which vapor migrates through cracks in the 16-inch slab is unknown.

These factors, coupled with the current occupancy of the building, have led DOE to conclude that four of EPA’s (2015) five conditions regarding completeness of the VI pathway are present and documented with site-specific data, which are (1) subsurface sources of vapor are present in soil and groundwater underneath or near C-400; (2) routes exist for vapor transport to the underside of C-400 and vapor sources are immediately adjacent to the building slab; (3) C-400 is susceptible to VI; and (4) the building is occupied.

Indoor air sampling is needed to evaluate the remaining condition regarding completeness of the VI pathway (i.e., one or more of the chemicals in the sub-slab soil gas also are present in the indoor environment and, if present, pose an unacceptable health risk). DOE considers addressing this data gap to be the appropriate next step for a VI investigation. This approach is supported by EPA’s 2015 VI Guide, which states that “if reliable pre-existing sampling data are available and an adequate CSM has been developed (i.e., sufficient subsurface characterization information exists to adequately characterize the locations, forms, and extent of site-specific vapor-forming chemicals and general subsurface conditions (e.g., hydrologic and geologic setting in and around the source(s) and the buildings)), then a risk-based screening may be useful to obtain some preliminary insights about the potential level of exposure and risk posed by vapor intrusion.”

The following sections describe the types of indoor air samples to be collected and their locations and rationale (Section 7); the sampling methodology (Section 8); the approach for evaluating the sampling results (Section 9); and the Investigation Decision Rules (Section 10).

7. SAMPLING LOCATIONS AND RATIONALE

Historical sampling adjacent to and below C-400 indicates VOC contamination (primarily TCE) is present and vapor concentrations under the building likely exceed subsurface screening levels by orders of magnitude. Other chlorinated solvents of interest are 1,1-dichloroethene, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and vinyl chloride. Inspection of C-400 has identified the presence of a crack in the floor as well as minor cracking in basement areas that suggest there is the potential for vapor migration through the floors. Additional soil or soil gas samples collected from below the foundation are not considered a priority because the expectation is that such samples would continue to indicate subsurface contamination is present and that vapor concentrations exceed subsurface screening levels. Indoor air samples, including indoor air samples in basement areas, are considered of high priority and are the focus of the SAP.

The goal of this SAP is to collect samples to determine whether the VI pathway is complete and presents unacceptable risks to humans in C-400. To that end, indoor air samples will be collected in areas believed to be susceptible to VI. The indoor air results will be used to determine if building occupants are exposed to contaminants of interest at levels of concern. Those levels will depend, in part, on the amount of time individuals spend in the building and are exposed to the vapors. Outdoor air and a vapor sample from within the identified large crack (a potential VI conduit) will be collected to assist with interpreting the indoor air results.

This VI investigation will sample 10 locations, for a total of 13 samples (plus 1 duplicate), as shown in Figure 9 and described below. Samples will be collected, as follows, as 8-hour integrated samples during normal work hours to mirror the exposure duration of a typical worker.

- Five locations (five samples) inside C-400 (with building doors maintained closed, as practical), each sampled over an 8-hour day:

  - Southeast office;
  - Laundry work area;
  - Basement furnace room on north end of C-400;
  - Basement area near former degreaser tanks; and
  - Central area main floor.

NOTE: The building doors will be maintained closed as practical, given the potential need for people to enter and leave the building.

- Two locations (total of five samples) from C-400 basement fan room exhaust fan plenum:

  - One location at the air intake of the operating exhaust fan, sampled for eight hours on each of four consecutive days;

  - One location at the air intake with a second operating exhaust fan (that will be turned on after the sampling of the other exhaust fan is completed on the third day) and sampled for eight hours for one day;

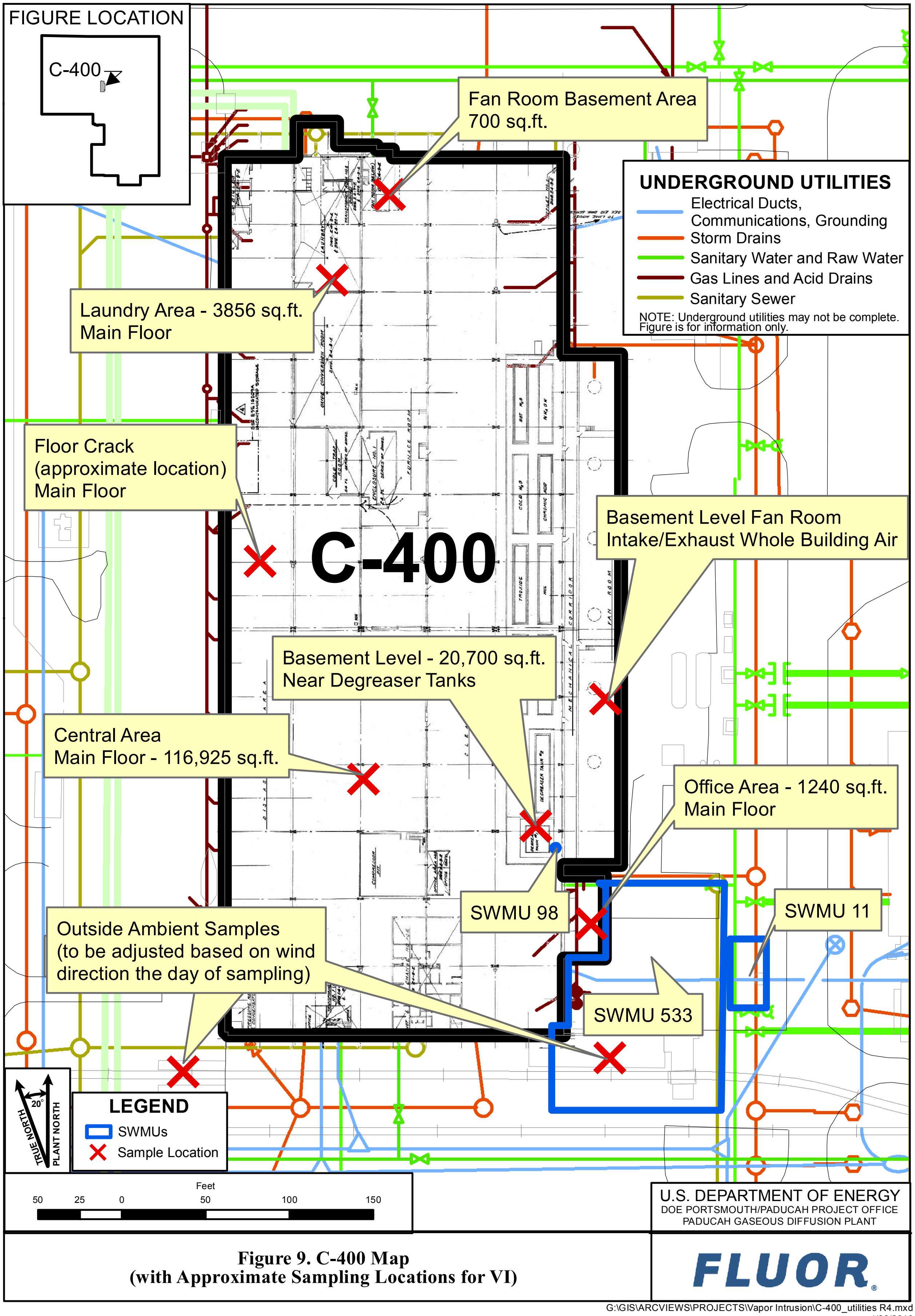

Figure 9. C-400 Map
(with Approximate Sampling Locations for VI)

- Two locations (two samples) outside C-400, one upwind of C-400 and the other outside of the southeast corner of C-400 (plant coordinate system), each sampled for eight hours during the period the indoor air samples are collected; and

- One location (one sample) in the floor crack discovered in the central main floor area, sampled for eight hours. The crack will be covered with polyethylene sheeting to minimize dilution by indoor air.

Table 4 summarizes the rationale for the sampling locations.

The sample locations in the interior of C-400 (Figure 9) include areas currently occupied by building workers (southeast C-400 office and northwest C-400 laundry work area) and locations that are near historical sources (basement area near the former large TCE degreaser/cleaning tanks and central main floor near the hand table) or areas of higher potential for VI (basement/plenum exhaust, basement near the former large TCE degreaser/cleaning tanks, and north basement furnace room).

C-400 currently is ventilated with one of ten available fans (~ 41,000 cfm design) located in a basement room in which proposed indoor air samples are located. The fans draw air through a below grade concrete plenum that is a potential entry point for VI. Comparison of the concentrations obtained from the exhaust fan samples will be compared to the other concentrations to determine if the plenum or other areas serve as points of vapor entry. To assess the benefit of added ventilation, one additional fan (for a total of two fans) will be operated during the fourth day of sampling in the basement fan room. The additional fan is expected to increase the building depressurization (including in the plenum), which will provide a means for assessing changes in the stack effect produced by the building ventilation and operation.

Table 4. Proposed Locations and Rationale for VI Sampling

SAMPLE LOCATION	RATIONALE
Indoor Air Samples—Areas of Potential Solvent Source	
Basement fan room at the air intake of the operating fan	Fan intake air represents spatially averaged C-400 air. May be biased high by induced VI into the plenum.
Central area main floor	Located near former hand tables. A duplicate sample will be collected here.
Basement level near degreaser tanks	Located in vicinity of former large degreaser, water/solvent separator, cleanout operations, and cleaning tanks; potential indoor air source and/or VI entry point; lower elevations have potential to collect heavier-than-air vapors.
Basement furnace room on north end	Located in a basement area with surface cracks in the concrete and an old sump.
Basement fan room at the air intake of a second fan that will be operated on fourth day of sampling	Located down-stream of concrete corridor serving as building air exhaust plenum; identify impact of enhanced building depressurization.
Indoor Air Samples—Areas of Occupation	
Office area	Occupied office area on main floor.
Laundry area	Occupied laundry area on main floor.
Outdoor Air Sample	
Outside upwind of C-400	Characterize ambient air.
Outside southeast corner (plant coordinate system) of C-400	Characterize ambient at southeast corner (plant coordinate system) of C-400.
Crack Air Sample	
Within floor crack	Potential VI conduit.

Outdoor (ambient) air samples will be collected at two locations (one sample at each location) close to the building nominally upwind (the day for sampling will be chosen based on weather forecast for the week) of the building to differentiate outdoor air contribution to indoor air from subsurface contributions. Based on the wind rose (Figure 10) for Barkley Airport, Paducah, Kentucky, the prevailing winds come from the southwest.

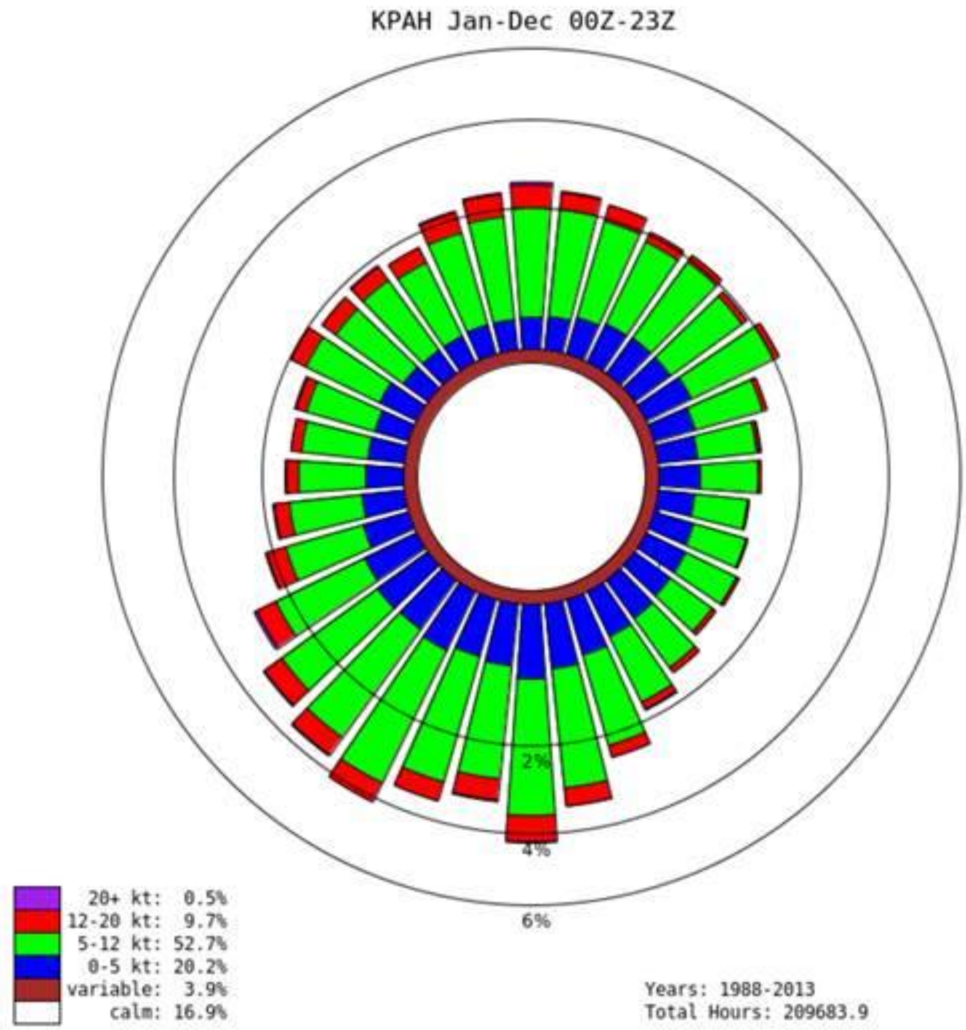

Figure 10. Wind Rose for the Barkley Airport, Paducah, Kentucky

8. SAMPLING AND ANALYSIS METHODS

This sampling was designed to understand the range of indoor air concentrations and potentially any preferential pathways. Sampling will be conducted in accordance with Fluor Federal Services, Inc., Paducah Deactivation Project procedure CP4-ER-1035, *Vapor Sampling*, as described therein.

- Individually certified-clean, evacuated 6 L Summa® canisters (or equivalent), equipped with an individually certified clean orifice that will allow the canister to collect time-integrated samples for 8 hours will be deployed.

- Samplers will be placed at the approximate breathing zone for area type samples. Samplers will be placed to collect intake air of the exhaust fans to collect integrated whole building air samples.

- Intake tubing of the sampler will be inserted into the floor crack to collect a vapor sample presumed to represent subsurface air. A layer of polyethylene sheeting will be placed over the crack to limit potential dilution due to flow of indoor air into the sampling tube.

- The canister valves will be opened and initial sample time noted. The number of ventilation fans running will be documented. The bay doors will be closed and remain closed during the sampling.

- After 8 hours, the valve will be shut, the time and remaining vacuum noted, and the canister packaged for shipping to the laboratory under chain of custody.

- The laboratory will analyze the samples using EPA TO-15 methods with a practical quantitation limit less than the commercial VISL screening levels [see quality assurance project plan (QAPP)].

- The VOCs of concern for this study are TCE and selected other chlorinated solvents (1,1-dichloroethene, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and vinyl chloride).

Prior to sampling, the sample locations will be confirmed; the operation of the fan will be confirmed; and the building ventilation conditions will be confirmed (i.e., windows/doors will be maintained closed, as practical).

9. RESULTS EVALUATION

The VI pathway sampling to be conducted in C-400 (described in Section 7) includes indoor air samples and one sample from within a potential VI entry point in the building (the crack sample). These samples will be analyzed for TCE and other selected chlorinated VOCs. The concentrations of VOCs in the indoor air samples will be compared against EPA's indoor air VISLs for default commercial scenarios (See Table 1). The upwind outdoor air sample results will be used to evaluate potential outdoor air source contributions to indoor air, but the measured concentrations will not be subtracted from the indoor air results. The concentrations of VOCs in the crack sample will be compared to EPA's soil gas/sub-slab VISLs (see Table 1) for default commercial scenarios. EPA maintains a Web-based VISL calculator[2] (EPA 2016), which was last updated in November 2015. The results of these comparisons will be

[2] http://www.epa.gov/oswer/vaporintrusion/documents/VISL-Calculator.xlsm.

evaluated in the context of the site-specific VI-CSM to develop conclusions about VI impacts to C-400 using the decision rules described in Section 10.

The results will also be compared to other benchmarks if the VI pathway is determined to be complete. As described in a recent Strategic Environmental Research and Development Program-Environmental Security Technology Certification Program VI seminar (SERDP-ESTCP 2016), a number of commercial/industrial screening levels are available for TCE (Figure 11), including those intended for industrial hygiene applications such as Occupational Safety and Health Administration permissible exposure limits (PELs) of 537,000 µg/m^3 and the ACGIH threshold limit value of 54,000 µg/m^3. EPA's commercial indoor air VISL of 3.0 µg/m^3 is the same as EPA's commercial regional screening level of 3.0 µg/m^3. Both are based on default commercial worker exposure conditions and correspond to a 1×10^{-6} carcinogenic risk, which is less than the level corresponding to a hazard quotient of 1.0. Under differing site-specific conditions, where workers may be subject to different exposure durations, other target levels may be applicable.

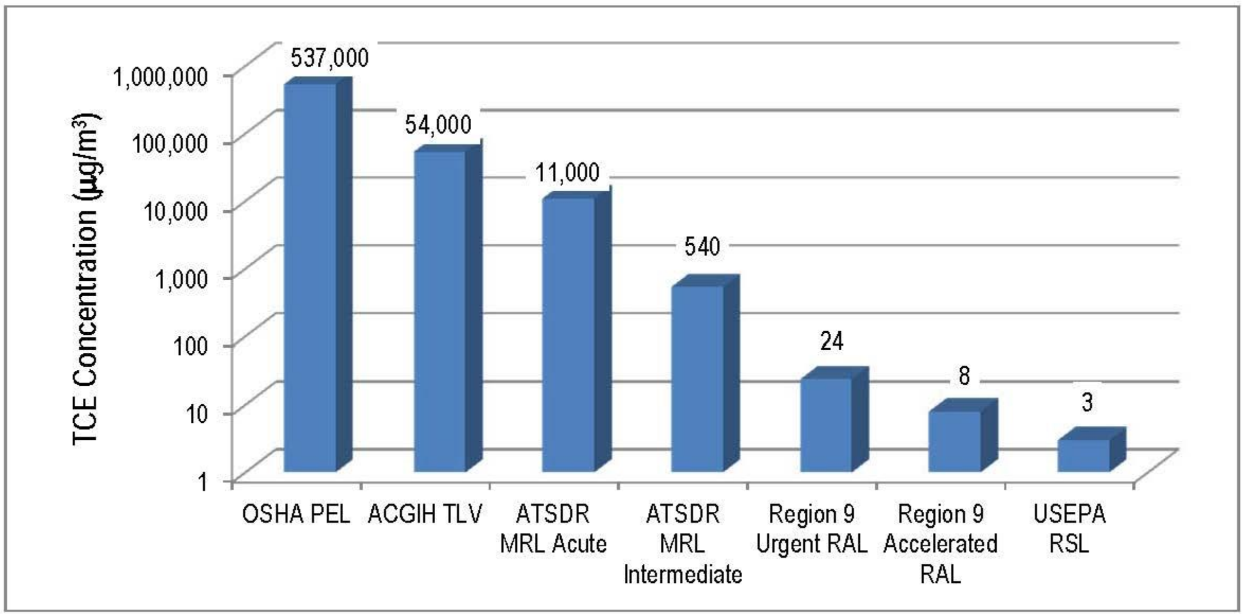

Figure 11. TCE Regulatory Levels for Commercial Industrial Scenarios (SERDP-ESTCP 2016) (Note: EPA RSL = EPA VISL for commercial settings)

10. INVESTIGATION DECISION RULES

The results of the indoor air monitoring will be evaluated to develop conclusions about the impact of VI on the indoor air of C-400. DOE will present the results and evaluations in a report, and subsequent actions will be negotiated among the FFA parties. The evaluation will include comparing results from individual locations against those from other locations, as well as comparing individual locations against the integrated fan exhaust results. The results will be compared to EPA's VISLs for default commercial exposure scenarios and site-specific benchmarks established for the types of workers present for the exposure durations that are representative of the types of workers. This evaluation will seek to understand the range of indoor air concentrations and, to the extent practicable from these data, the general location(s) of VI entry points.

Depending on results of the evaluation, DOE may implement additional actions that could include sampling, personnel monitoring, or other response actions needed to control worker exposure, including additional ventilation, building pressurization, and/or building evacuation. Any actions to address the conclusions of this study will be negotiated among the FFA parties and are not considered part of the FYR action that is the basis for this VI study.

The following are the decision rules that will guide the evaluations and inform the conclusions.

- **IF** indoor air concentrations for selected VOCs in both occupied and non-occupied areas are less than the VISL values or nondetect, **THEN** the pathway is considered to be incomplete and/or to not result in unacceptable concentrations under current conditions. DOE will evaluate the planned uses for the building and may choose to continue to maintain the building in its current occupied condition, which could include continued building ventilation and periodic monitoring.

- **IF** indoor air concentrations for selected VOCs in occupied or nonroutinely occupied indoor areas are greater than the associated VISL values, **THEN** the pathway is considered complete and has the potential to result in unacceptable concentrations. Site-specific exposure scenarios will be evaluated to determine whether the VOC concentrations are protective for the types of workers present in the building as well as how much occupancy can be tolerated by non-remediation workers and/or remediation workers. These results will be used to determine whether response actions are needed to control worker exposure; these response actions could include additional ventilation, personal protective equipment, building pressurization, or building evacuation.

- **IF** indoor air concentrations for selected VOCs in occupied areas are below the associated VISL values, but indoor air concentrations for selected VOCs in nonroutinely occupied areas are greater than the associated VISL values, **THEN** vapor intrusion conduits or indoor sources are considered likely to be present in those areas of the building. These results will be used to determine whether follow-up actions are needed; these could include additional sampling to identify vapor intrusion entry points or preemptive measures such as additional building ventilation, personal protective equipment, or building evacuation.

- **IF** the fan exhaust air concentrations are greater than the other indoor air samples **AND** greater than the VISL values, **THEN** either VI is occurring in the concrete plenum through which building air is drawn prior to exhaust or unsampled indoor locations have VOC concentrations greater than the sampled indoor locations. These results will be used to determine whether follow-up actions are needed; these could include additional sampling to identify vapor intrusion entry points or preemptive measures such as additional building ventilation, personal protective equipment, or building evacuation.

- **IF** the ventilation fan exhaust air concentrations are less than the other indoor air sample concentrations, **THEN** localized VI entry points or indoor sources likely are present in the building, but provide insufficient mass to impact the indoor air of the entire building. These results will be used to determine whether follow-up actions are needed; these could include additional sampling to identify vapor intrusion entry points or preemptive measures such as additional building ventilation, personal protective equipment, or building evacuation.

11. TAKING ACTION WITH LIMITED DATA

Interim Actions. EPA has emphasized the importance of interim actions and site stabilization to control or abate "ongoing risks" to human health and the environment while site characterization is underway or before a final remedy is selected. Interim actions encompass a wide range of institutional and physical corrective action activities and can be implemented at any time during the corrective action process. EPA VI guidance states that interim actions, including preemptive mitigation, be employed as early in the corrective action process as possible, consistent with the human health and environmental protection objectives and priorities for the site (EPA 2015).

<u>Preemptive Mitigation (PEM):</u> The EPA VI guidance (EPA 2015) states that it may be appropriate to implement mitigation of the VI pathway as an early action, even though all pertinent lines of evidence have not been developed completely yet to characterize the VI pathway for the subject building(s), when sufficient site-specific data indicate that VI: (1) is occurring or may occur due to subsurface contamination that is being addressed by federal statutes, regulations, or guidance for environmental protection; and (2) is posing or may pose a health concern to occupants of an existing building(s).

To consider PEM, the EPA VI guidance (EPA 2015) recommends obtaining reliable data supporting a preliminary and risk-based screening. In appropriate circumstances (e.g., where time is of the essence to ensure protection of human health), a formal human health risk assessment need not be conducted and documented before selecting PEM, but a preliminary evaluation of human health risk using individual building data or aggregated community data generally is recommended.

At C-400, there are concentrations of VOCs in media located in the vicinity of the building that are high enough to yield a potential risk. Historical screening has shown sporadic indoor air detections at levels much greater than VISLs. Recent indoor air samples have not had detectable VOCs; however, the detection limits of the method are well above VISL values. Thus, a preliminary evaluation of human health risk using building data indicates the potential for VI sufficient to consider PEM.

If there are insufficient data to perform a preliminary risk analysis, but subsurface vapor sources are known to be present near buildings (see Section 5.3), EPA guidance states that an appropriate VI investigation (see Section 6) be conducted to obtain sufficient data (EPA 2015). The planned investigation is considered an appropriate investigation to fill the data gaps concerning the potential for VI at C-400.

Note that "when these conditions are not well established from existing information…EPA recommends that a detailed VI investigation be scoped and conducted to address these data gaps" (EPA 2015). The corollary is that, when conditions are well established from existing information, additional investigation should focus on the conditions that have not yet been well established.

In summary, PEM, based on limited, but credible, subsurface and building data, can be an appropriate approach to begin to implement response actions quickly and ensure protectiveness of current building occupants. In such circumstances, resources can be used appropriately to focus first on mitigation of buildings and subsurface remediation, rather than site and building characterization efforts, which may be prolonged. Although PEM may be an effective tool to reduce the human exposure and human health risk, building mitigation generally is not intended to address the subsurface vapor source; as such, EPA VI guidance (EPA 2015) states that it typically be used in conjunction with remediation of the subsurface source of vapor-forming chemicals (e.g., source removal or treatment), which has been implemented, and further remediation is planned for the C-400 area.

12. QUALITY ASSURANCE

Appendix B provides the QAPP.

13. PROJECT DOCUMENTATION

The results of this investigation will be documented in an addendum to the *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1289&D2/R1.

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APPENDIX A

COMPILATION OF HISTORICAL DATA COLLECTED FROM VICINITY OF C-400

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A.1. SUMMARY OF HISTORICAL DATA COMPILATION

Historical and recent soil, groundwater, soil gas, and indoor air sample results from within, below, and adjacent to C-400 Building at the Paducah Gaseous Diffusion Plant (PGDP) are compiled in this appendix to support the evaluation of the potential for vapor intrusion (VI) at C-400. As described in Sections 5 and 6 of the Work Plan (WP)/Sampling and Analysis Plan (SAP), review of these data has determined that there continues to be volatile organic compound (VOC) contamination in and around C-400 that exceeds recently-developed, media-specific, VI screening levels by several orders of magnitude. The following are the confirmed subsurface sources relevant to assessment of the VI pathway at the C-400 Cleaning Building:

1. Regional Gravel Aquifer (RGA) groundwater with VOC contamination, including residual trichloroethene (TCE) in dense nonaqueous-phase liquid (DNAPL)/ganglia form;

2. Remediated Upper Continental Recharge System (UCRS) soil adjacent to C-400 with remaining whole soil VOC concentrations sufficiently elevated to result in vapor concentrations above U.S. Environmental Protection Agency's (EPA's) screening levels;

3. UCRS sub-slab soil historically documented to be contaminated with TCE.

In compiling the historical data, the following rules were used to determine the usability of the data:

- Historical data that have been qualified as rejected by data validation or by data assessment were not included in the historical data evaluated for use.

- Historical data that contain units inconsistent with the sampled media or with the analysis were not included in the historical data evaluated for use (e.g., a soil sample with analytical units reported in mg/L would not be considered usable).

- Historical data with no reported result and no recorded detection limit were not included in the historical data evaluated for use.

- Data assessment qualifiers previously placed on the data were noted and applied as appropriate.

- A result was considered to be a nondetect if it was qualified by the reporting laboratory with a "U" qualifier or a "<" qualifier.

- A result was considered a nondetect if it has a "U" validation code or a "U" data assessment code.

- Historical data that no longer are representative of the current site conditions being evaluated were excluded; for example, where site conditions were changed substantially as a result of remedial activities.

- Historical practical quantitation limits were compared to current screening levels to evaluate the usability of the data in the current context and the reliability of conclusions about presence or absence of contaminants.

Because of the transient nature of VOCs, this review focuses on data collected from the vicinity of C-400 within the last 10 years, although older data and its implications are discussed below.

A.2. CONFIRMED SUBSURFACE SOURCES

A.2.1 RGA GROUNDWATER, LAST 10 YEARS

Attachment 1 (electronic) to Appendix B presents a spreadsheet of groundwater results collected within the past 10 years from wells located in the vicinity of C-400. As shown in these data and from a recent map of the TCE plume at PGDP (Figure 8 of this WP/SAP), the RGA groundwater in the vicinity of C-400 continues to be contaminated with TCE at concentrations that indicate the presence of DNAPL, as evidenced by TCE concentrations in the RGA Plume under/adjacent to the C-400 Cleaning Building that range up to 1,400,000 µg/L as recently as 2012.

A.2.2 SOILS, POST-REMEDIATION

Attachment 2 (electronic) to Appendix B, *Technical Performance Evaluation for the C-400 Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-1260&D1, and Attachment 3 (electronic), an e-mail with attachments summarizing Phase IIa interim remedial action (IRA) results, include the whole soil concentrations measured after IRAs were conducted in at the southern end of the C-400 Cleaning Building. Although the remedial actions documented in the attachments have reduced UCRS soil concentrations dramatically in the vicinity of C-400 from their preremediation estimated DNAPL saturation of up to 4%, residual concentrations measured after performance of the C-400 Phase I and Phase IIa IRAs (post-remediation) are elevated sufficiently to result in vapor concentrations above EPA's VI screening levels, thus are high enough to pose a potential VI threat.

A.2.3 SUB-SLAB SAMPLES (1997)

Attachment 4 (electronic) to Appendix B includes the report on sub-slab samples collected as part of the Waste Area Grouping (WAG) 6 Remedial Investigation (RI) (DOE 1997). Eighteen sub-slab soil samples were collected from borings through the slab at depth intervals (4 to 8 ft) down to 48 ft in two locations within the C-400 Cleaning Building. The TCE concentrations in the sub-slab soil samples from these two borings are elevated sufficiently to result in soil vapor concentrations above EPA's VI screening levels, thus are high enough to pose a potential VI threat. These data are considerably older than the post-remediation data described above; nevertheless, they provide insight as to the extent of contamination around and under the C-400 Cleaning Building because the soils directly under the C-400 Cleaning Building have not been subjected to remedial activities.

A.2.4 SOIL GAS SAMPLES

Soil gas samples were collected in the vicinity of C-400 in 1986 and 1990. Because these results are more than 10 years old, they are presented below to support the overall understanding of vapor transport in the vicinity of the C-400 Building, but with the recognition that the levels measured at the time of the studies are unlikely to be representative of current conditions.

A.2.4.1 1986 Tracer Soil Gas Survey

Attachment 5 (electronic) to Appendix B provides the report summarizing a 1986 soil gas survey. This survey was conducted at a time when the C-400 degreaser operations still were in use and before the

C-400 tank and line remediation were conducted. A total of 28 soil gas samples was collected. Soil gas concentrations ranged from < 0.001 µg/L to 370 µg/L, with the highest concentrations found in the area along the C-400 sewer line between the C-400 Building and the TCE tank. This area has been remediated; thus, these measured soil gas concentrations are not considered representative of current conditions.

A.2.4.2 1990 Soil Excavation

Attachment 6 (electronic) provides an excerpt from the report summarizing the 1990 soil gas study. Soil gas samples were collected at 250-ft intervals around C-400. Forty-one samples were collected from 43 planned locations. “Sample collection at all locations was more difficult than expected due to the tightness of the soil formation being sampled.” Only 2 samples had detectable TCE:

- 2.0 ppmv TCE at the southeast corner, near the former tank location, and
- 0.28 ppmv at the northwest corner (near the Northwest Plume centerline).

These results are consistent with the Tracer Study (i.e, shallow soils in the vicinity of C-400 are tight and generally not amenable to soil gas migration). There was, however, detectable TCE in soil gas directly adjacent to/above high soil/groundwater concentrations, which suggests that preferential pathways through openings in the soil may facilitate vapor transport.

A.2.4.3 2005 EPA Soil Gas Study

EPA attempted to collect soil gas samples from three locations in the water policy area. One sample was successfully collected. That sample had no TCE. Electronic Attachment 7 provides the letter report.

A.2.4.4 2013 SWMU 4 Passive Soil Gas Study

As part of Phase 1 of the Solid Waste Management Unit (SWMU) 4 investigation, at the recommendation of EPA, passive samplers were deployed in a grid pattern above the Southwest Plume at SWMU 4. Electronic Attachment 8 provides the report on the study. Two (of 69 passive samples) had TCE detected near the detection limits. One result was 29 ng and the other was 54 ng (25 ng TCE detection limit). This evaluation again demonstrated that soil gas does not migrate easily through the shallow soil of UCRS at PGDP. This information is provided to support the understanding of how soil vapors may move through the UCRS in the vicinity of PGDP. It is recognized that conditions at SWMU 4 are quite different from those in the vicinity of C-400.

A.3. INDOOR AIR SAMPLING

Table A.1 summarizes the indoor air samples collected over time at the C-400 Cleaning Building.

A.3.1 2000 INDUSTRIAL HYGIENE SUMMA® MONITORING

Samples were collected from C-400, C-300, C-333, C-337, and the vault at extraction well, EW230. No TCE (detection limit ~ 1.4 ppbv) or vinyl chloride (VC) was detected in any of the buildings. Electronic Attachment 9 provides a spreadsheet of the results.

A.3.2 2003 INDOOR AIR STUDY DURING SIX-PHASE TREATABILITY STUDY

An indoor air study was conducted during heating of the ground adjacent to C-400 during the Six-Phase Treatability Study. Electronic Attachment 10 summarizes the results. During the first 30 days, detector tube air samples were collected from the basement of C-400 and three locations in a tunnel located east of the Six-Phase site (i.e., not associated with the C-400 Building). None of these samples had detectable TCE (at 2 ppmv) or VC. (at 0.5 ppmv). Thus, the frequency was reduced to weekly. None of the sample tubes collected during the Six-Phase study had detectable TCE or VC.

In addition, SUMMA® canister samples were collected at the same locations for 10 weeks (although one of the tunnel locations was moved to the C-400 office area. Two of these samples from the C-400 basement had detectable TCE at 2.8 ppmv and 0.5 ppmv. These detections were attributed to seep water in a sump located in the vicinity of an abandoned TCE tank in the C-400 building.

A.3.3 2015 INDUSTRIAL HYGIENE CHARCOAL TUBE MONITORING

Fluor Federal Services, Inc., Paducah Deactivation Project conducted an indoor air study during 2015 (electronic Attachment 11) that included the collection of 5-hour charcoal tube samples at four locations in C-400. All four samples had no detectable TCE with detection limits of ~ 0.6 mg/m^3.

Table A.1. Summary VOC Analyses of Inside C-400 Air Samples

Sample Event and Method	Sample Method and Location	Number of Samples and Analytes	Results NOTE: Commercial VISLs (at 25°C) TCE = 3.0 μg/m^3 = 0.56 ppbv Vinyl Chloride = 2.8 μg/m^3= 1.1 ppbv	Date of Sample(s)
Industrial Hygiene Sampling Summa® Canister	Indoor C-400	1 Sample • VOC suite	Nondetect: • 1.3 ppbv **TCE** • 1.3 ppbv **Vinyl chloride**	7/25/2000
Six-Phase Heating Treatability Study Draeger Tube	C-400 Basement	42 Samples • TCE • VC	Nondetect: • 2 ppm **TCE** • 0.5 ppm **Vinyl Chloride**	Daily: 2/19/03–3/26/03 Weekly: 4/2/03–8/26/03
Six-Phase Heating Treatability Study Summa® Canister (24-hr integrated sample)	C-400 Basement	18 Samples • TCE • VC	**<u>TCE</u>** 16 Nondetect: 500–1,000 ppbv • Detect: 2,800 ppbv on 3/19/03 • Estimated: 500 ppbv on 5/13/03 **<u>Vinyl Chloride</u>** 18 Nondetect: 500 - 1,000 ppbv	Weekly: 2/20/03–4/22/03 5/13/2003 Biweekly: 6/3/03–8/26/03
	C-400 Administrative Office	12 Samples • TCE • VC	Nondetect: • 500–540 ppbv **TCE** • 500–540 ppbv **Vinyl Chloride**	Weekly: 4/2/03–4/22/03 5/13/03 Biweekly: 6/3/03–8/26/03
Industrial Hygiene Sampling Charcoal Tube (5-hr integrated sample)	Laundry Break Area	1 Sample • TCE	Nondetect: 539 μg/m^3 **TCE**	4/22/15
	Southeast Corner of Office	1 Sample • TCE	Nondetect: 546 μg/m^3 **TCE**	4/22/15
	Boundary Control Station Near Cylinder Wash	1 Sample • TCE	Nondetect: 562 μg/m^3 **TCE**	4/22/15
	Basement Fan Room Catwalk	1 Sample • TCE	Nondetect: 608 μg/m^3 **TCE**	4/22/15

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ELECTRONIC ATTACHMENTS

A1. Excel File of Past 10 Years of Groundwater Data from RGA Wells in Vicinity of C-400
A2. *Technical Performance Evaluation for the C-400 Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-1260&D1
A3. Response to EPA for C-400 Well Abandonment, with Attachments, April 17, 2015
A4. C-400 Sub-Slab Sample Results Summary Excerpt from WAG 6, 1997
A5. 1986 Tracer Soil Gas Report
A6. 1990 Soil Gas Study Report Excerpt from Phase I & Phase II Report
A7. 2005 EPA Soil Gas Study Results Summary
A8. 2013 SWMU 4 Passive Soil Gas Study Report
A9. 2000 IH SUMMA® Monitoring Study Results Summary
A10. Excerpt from the Feasibility Study for the Groundwater Operable Unit
A11. Excerpt from the Final Report Six-Phase Treatability Study Report

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APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) has been updated from the QAPP provided for the Sampling and Analysis Plan used for the Vapor Intrusion Study for the Water Policy Area. This project-specific QAPP incorporates updated information included in the final 2016 Programmatic QAPP (P-QAPP).

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CONTENTS

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LIST OF QAPP WORKSHEETS

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ACRONYMS

CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	chemical (or radionuclide) of potential concern
DOE	U.S. Department of Energy
DOECAP	U.S. Department of Energy Consolidated Audit Program
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FPDP	Fluor Federal Services, Inc., Paducah Deactivation Project
FFA	Federal Facility Agreement
FSP	field sampling plan
GC/MS	gas chromatograph/mass spectrometer
ID	identification
IDQTF	Intergovernmental Data Quality Task Force
KDEP	Kentucky Department for Environmental Protection
KY	Commonwealth of Kentucky
LATA Kentucky	LATA Environmental Services of Kentucky, LLC
LSRS	LATA-Sharp Remediation Services, LLC
MDL	method detection limit
MS	mass spectroscopy
N/A	not applicable
OREIS	Oak Ridge Environmental Information System
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PEGASIS	Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System
PGDP	Paducah Gaseous Diffusion Plant
P-QAPP	programmatic quality assurance project plan
PQL	practical quantitation limit
QA	quality assurance
QC	quality control
QAPP	quality assurance project plan
SAP	sampling and analysis plan
SOP	standard operating procedure
TBD	to be determined
TPD	training position description
UCRS	Upper Continental Recharge System
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
VOC	volatile organic compound

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1. INTRODUCTION

This project-specific Quality Assurance Project Plan (QAPP) has been prepared to support the vapor intrusion investigation at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant (PGDP) by Fluor Federal Services, Inc., Paducah Deactivation Project (FPDP) based on the final 2016 Programmatic QAPP (P-QAPP) updates to the *Programmatic Quality Assurance Project Plan* (DOE 2015), which was developed in alignment with the *Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP Manual) guidelines for QAPPs (IDQTF 2005), as updated by the *Optimized UFP-QAPP Worksheets* guidance (IDQTF 2012). (NOTE: As in the optimized guidance, the original worksheet numbers are retained, but combined per the guidance.) Table 1 in Worksheet #1 provides a crosswalk between the UFP-QAPP and the *U.S. Environmental Protection Agency Guidance on Quality Assurance Project Plans*, CIO 2106-G-05-QAPP (EPA 2012).

QAPP Worksheets #1 and #2. Title and Approval Page

Site Name/Project Name: PGDP/C-400 Vapor Intrusion Study
Site Location: Paducah, Kentucky
Site Number/Code: KY8890008982
Contractor Name: FPDP
Contractor Number: Task Order DE-DT0007774
Contract Title: Paducah Gaseous Diffusion Plant Deactivation Project

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Document Title: *C-400 Vapor Intrusion Study Work Plan to Support the Additional Actions for the CERCLA Five-Year Review at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky; Appendix A, Quality Assurance Project Plan for C-400 Vapor Intrusion Study to Support the Five-Year Review*

Lead Organization: U.S. Department of Energy (DOE)

Preparer's Name and Organizational Affiliation: Joseph Towarnicky, Ph.D., FPDP

Preparer's Address, Telephone Number, and E-mail Address: 5511 Hobbs Road, Kevil, KY, 42053, Phone (270) 441-5134, joseph.towarnicky@ffspaducah.com

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Preparation Date (Month/Year): 4/2016

Document Control Number: Appendix B to the Work Plan, DOE/LX/07-2403&D1

FPDP Signature: [signature] Date: 4-28-16
Mark J. Duff
Environmental Management, Director

FPDP Signature: [signature] Date: 4/28/16
Myrna Espinosa Redfield
Regulatory Affairs Manager

FPDP Signature: [signature] Date: 4/28/16
Lisa Crabtree
Environmental Monitoring Project Manager

FPDP Signature: [signature] Date: 4/28/16
Jim Quinnette
QA Manager

QAPP Worksheets #1 and #2. Title and Approval Page (Continued)

1. Identify guidance used to prepare QAPP:

   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Implementing Environmental Quality Systems*, Version 2.0, 126 pages.
   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Quality Assurance Project Plans: Part 1 UFP QAPP Manual*, Version 1.0, 177 pages (DTIC ADA 427785 or EPA-505-B-04-900A).
   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Quality Assurance Project Plans: Part 2A UFP QAPP Worksheets*, Version 1.0, 44 pages.
   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Quality Assurance Project Plans: Part 2B Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities*, Version 1.0, 76 pages.
   - Intergovernmental Data Quality Task Force, March 2012. Uniform Federal Policy for Quality Assurance Project Plans, Optimized UFP QAPP Worksheets, 42 pages.
   - *Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan*, DOE/LX/07-1269&D2/R2, March 2015, 352 pages.
   - EPA 2016. OSWER Vapor Intrusion Screening Level (VISL) Calculator, Version 3.4, November 2015. http://www.epa.gov/oswer/vaporintrusion/documents/VISL-Calculator.xlsm.

2. Identify regulatory program: Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1707 (FFA)

3. Identify approval entities: DOE, U.S. Environmental Protection Agency (EPA) Region 4, and Kentucky Department for Environmental Protection (KDEP)

4. Indicate whether the QAPP is a generic or a project-specific QAPP (circle one).

5. List dates of scoping sessions that were held: Vapor Intrusion Scoping Sessions

August 2014 Conference Call:	Vapor Intrusion for the Water Policy Area
February 2015 DQO Scoping:	Vapor Intrusion for the Water Policy Area
April 2015 DQO Scoping:	Vapor Intrusion for the Water Policy Area
September 2015 DQO Scoping:	Vapor Intrusion for the C-400 Cleaning Building

QAPP Worksheets #1 and #2. Title and Approval Page (Continued)

6. List dates and titles of QAPP documents written for previous site work, if applicable:

Title:	**Approval Date:**
Sampling and Analysis Plan to Support the Additional Action for the CERCLA Five-Year Review at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Appendix A, DOE/LX/07-2200&D2	5/2015

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7. List organizational partners (stakeholders) and connection with lead organization:
   EPA Region 4, KDEP

8. List data users: DOE, FPDP, subcontractors, EPA Region 4, KDEP

9. Table 1 provides a crosswalk of required QAPP elements. No elements are omitted intentionally from this QAPP.

   This QAPP includes all 28 worksheets that are required based on UFP-QAPP guidance, as updated with the optimized worksheet guidance. Each of these worksheets has been reviewed to ensure the accuracy of the information presented in this QAPP.

Table 1. Crosswalk: UFP-QAPP Workbook to 2106-G-05-QAPP

Optimized UFP-QAPP Worksheets		**CIO 2106-G-05 QAPP Guidance Section**	
1 & 2	Title and Approval Page	2.2.1	Title, Version, and Approval/Sign-Off
3 & 5	Project Organization and QAPP Distribution	2.2.3	Distribution List
		2.2.4	Project Organization and Schedule
4, 7, & 8	Personnel Qualifications and Sign-off Sheet	2.2.1	Title, Version, and Approval/Sign-Off
		2.2.7	Special Training Requirements and Certification
6	Communication Pathways	2.2.4	Project Organization and Schedule
9	Project Planning Session Summary	2.2.5	Project Background, Overview, and Intended Use of Data
10	Conceptual Site Model	2.2.5	Project Background, Overview, and Intended Use of Data
11	Project/Data Quality Objectives	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
12	Measurement Performance Criteria	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
13	Secondary Data Uses and Limitations	Chapter 3	QAPP ELEMENTS FOR EVALUATING EXISTING DATA
14 & 16	Project Tasks and Schedule	2.2.4	Project Organization and Schedule
15	Project Action Limits and Laboratory-Specific Detection/Quantitation Limits	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
17	Sampling Design and Rationale	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
18	Sampling Locations and Methods	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
		2.3.2	Sampling Procedures and Requirements
19 & 30	Sample Containers, Preservation, and Hold Times	2.3.2	Sampling Procedures and Requirements
20	Field QC	2.3.5	Quality Control Requirements
21	Field SOPs	2.3.2	Sampling Procedures and Requirements
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Requirements, Supplies and Consumables
23	Analytical SOPs	2.3.4	Analytical Methods Requirements and Task Description
24	Analytical Instrument Calibration	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Require
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Requirements, Supplies and Consumables
26 & 27	Sample Handling, Custody, and Disposal	2.3.3	Sample Handling, Custody Procedures, and Documentation
28	Analytical Quality Control and Corrective Action	2.3.5	Quality Control Requirements
29	Project Documents and Records	2.2.8	Documentation and Records Requirements
31, 32, & 33	Assessments and Corrective Action	2.4	ASSESSMENTS AND DATA REVIEW (CHECK)
		2.5.5	Reports to Management
34	Data Verification and Validation Inputs	2.5.1	Data Verification and Validation Targets and Methods
35	Data Verification Procedures	2.5.1	Data Verification and Validation Targets and Methods
36	Data Validation Procedures	2.5.1	Data Verification and Validation Targets and Methods
37	Data Usability Assessment	2.5.2	Quantitative and Qualitative Evaluations of Usability
		2.5.3	Potential Limitations on Data Interpretation
		2.5.4	Reconciliation with Project Requirements

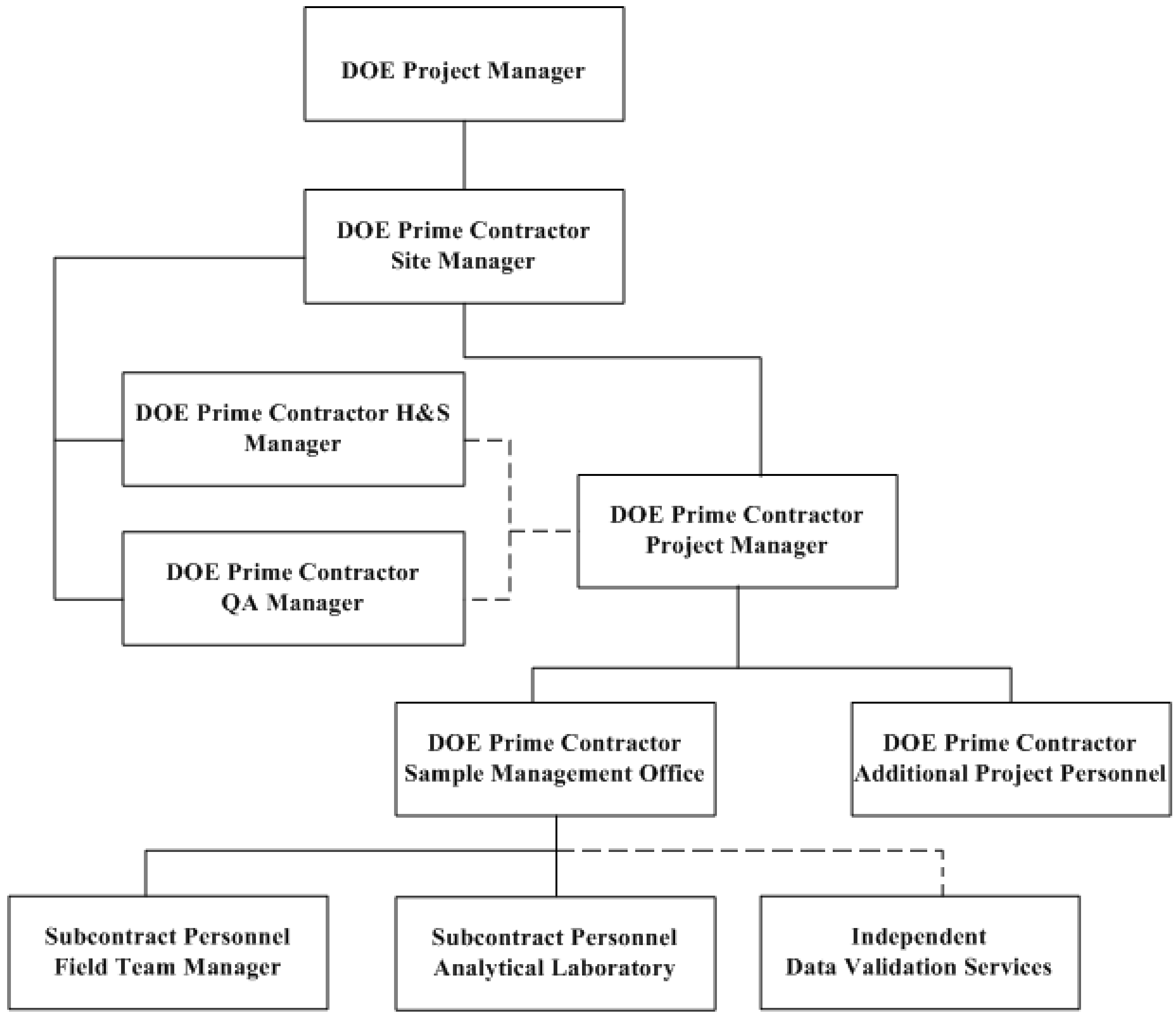
QAPP Worksheet #3. Minimum Distribution List

Distribution is based on the position title. A change in the individual within an organization will not trigger a resubmittal of the QAPP. DOE may choose to update the sheet and submit changes to the document holders. This change will not require a review by FFA stakeholders because it is not a substantive change. Managers are responsible for distribution to their staff.

Controlled copies of this QAPP will not be generated nor submitted. Uncontrolled copies of the QAPP will be distributed with the SAP according to the distribution list below.

Position Title	Organization	QAPP Recipients	Current Telephone Number	Current E-mail Address	Document Control Number
Paducah Site Lead	DOE	Jennifer Woodard	(270) 441-6820	jennifer.woodard@lex.doe.gov	1
FFA Manager	DOE	Tracey Duncan	(270) 441-6862	tracey.duncan@lex.doe.gov	2
Project Manager	DOE	Cynthia Zvonar	(859) 219-4066	cynthia.zvonar@lex.doe.gov	3
Director of Environmental Management	FPDP	Mark Duff	(270) 441-5030	mark.duff@ffspaducah.com	4
Regulatory Affairs Manager	FPDP	Myrna Redfield	(270) 441-5113	myrna.redfield@ffspaducah.com	5
Project Manager	FPDP	Craig Jones	(270) 441-5114	craig.jones@ffspaducah.com	6
Division of Waste Management, Hazardous Waste Branch, PGDP Section Supervisor and FFA Manager	KDEP	Brian Begley	(502) 564-6716	brian.begley@ky.gov	7
Kentucky Division of Waste Management	KDEP	Gaye Brewer	(270) 898-8468	gaye.brewer@ky.gov	8
FFA Manager	EPA	Julie Corkran	(404) 562-8547	corkran.julie@epa.gov	9
Remedial Project Manager	EPA	Jon Richards	(404) 562-8648	richards.jon@epa.gov	10
Environmental Radiation Protection and Risk Assessment Manager	FPDP	LeAnne Garner	(270) 441-5136	leanne.garner@ffspaducah.com	11
Senior Remedial Project Manager and FFA Manager	FPDP	Jana White	(270) 441-5185	jana.white@ffspaducah.com	12
Quality Assurance Manager	FPDP	Jim Quinnette	(270) 441-5226	jim.quinnette@ffspaducah.com	13
Environmental Monitoring and Reporting Project Manager	FPDP	Lisa Crabtree	(270) 441-5135	lisa.crabtree@ffspaducah.com	14
Health and Safety Manager	FPDP	Steve Wentzel	(270) 441-6239	steve.wentzel@ffspaducah.com	15
Regulatory Compliance Manager	FPDP	Michael Gerle	(270) 441-6680	michael.gerle@ffspaducah.com	16
Sample Management Office	FPDP	Jaime Morrow	(270) 441-5508	jaime.morrow@ffspaducah.com	17

QAPP Worksheet #5-A. Project Level Organizational Chart



QAPP Worksheet #4. Project Personnel Sign-Off Sheet: Sample Collection, Data Analysis, Data Validation

Personnel actively engaged in sample collection, data analysis, and data validation for this project are required to read applicable sections of this QAPP and sign a Personnel Sign-off Sheet. The master list of signatures will be kept with the project work control documentation.

Project Position Title	Organization	Specialized Training/ Certification, if any	Signature*	Date
Sampler	FPDP	Per Training Position Description (TPD)		
Sample Management Office	FPDP	Per TPD		
Independent Third-Party Data Validator	Los Alamos Technical Associates (LATA), Ohio	Bachelor degree plus relevant experience		
Environmental Radiation Protection and Risk Assessment Manager	FPDP	Per TPD		
Environmental Monitoring Project Manager	FPDP	Per TPD		

*Signatures indicate personnel have read and agree to implement this project-specific QAPP as written.

QAPP Worksheet #7. Personnel Responsibility and Qualifications Table

ORGANIZATION: FPDP

Name	Position Title Responsible	Organization Affiliation	Responsibilities	Education and Experience Qualifications[1]
Craig Jones	Program Manager	FPDP	Overall project responsibility	> 4 years relevant work experience
Teresa Overby	Project Manager	FPDP	Project SAP	Bachelor degree plus > 1 year relevant work experience
Myrna Redfield	Regulatory Affairs Manager	FPDP	Project environmental compliance responsibility	Bachelor degree plus > 4 years work experience
Jana White	FFA Manager	FPDP	Project compliance with the FFA	> 4 years work relevant experience
Lisa Crabtree	Environmental Monitoring Project Manager	FPDP	Support project on sampling and reporting activities	> 4 years relevant work experience
Jaime Morrow	Sample Management Office	FPDP	Project sample and data management	> 2 years relevant work experience
Steve Wentzel	Health and Safety Manager	FPDP	Project health and safety responsibility	Bachelor degree plus > 1 year relevant experience
Bill Chase	Waste Coordinator	FPDP	Overall project waste management responsibility	> 4 years relevant experience
James Moore	Data Validator	Los Alamos Technical Associates, Inc.	Performing data validation according to specified procedures	Bachelor degree plus relevant experience
Laboratory Project Manager	Analytical Laboratory Project Manager	Laboratory	Sample analysis and data reporting	Bachelor degree plus relevant experience

[1] Candidates who do not have a certificate or required degree but demonstrate additional "equivalent relevant work experience" can be considered when evaluating qualifications. This assessment will be conducted by the project manager as he/she assembles the appropriate team for the project.

QAPP Worksheet #8. Special Personnel Training Requirements Table

Personnel are trained in the safe and appropriate performance of their assigned duties in accordance with requirements of work to be performed. For this project, there are no special training requirements other than what normally is required for work at the PGDP site.

QAPP development uses a graded approach. A work control package will be generated prior to implementation of the project; the package will list any specific project-level training requirements.

Project Function	Specialized Training—Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates
Project Tasks	There has been no specialized training required for this program other than what normally is required for site work at PGDP. The contractor will evaluate specific tasks and personnel will be assigned training as necessary to perform those tasks. Training may address health and safety aspects of specific tasks as well as contractor-specific, site-specific, and task-specific requirements. .	FPDP	Prior to fieldwork	Based upon required duties	FPDP staff, subcontractors	Training files are maintained by the FPDP training organization. A training database is used to manage and track training.

QAPP Worksheet #6. Communication Pathways

NOTE: Formal communication across company or regulatory boundaries occurs via letter. Other forms of communication, such as e-mail, meetings, etc., will occur throughout the project.

Communication Drivers	Organizational Affiliation	Position Title Responsible	Procedure
Federal Facility Agreement, DOE/OR/07-1707	DOE Paducah Site Lead	Paducah Site Lead	Formal communication among DOE, EPA, and KDEP.
Federal Facility Agreement, DOE/OR/07-1707	DOE Paducah	DOE Project Manager	Formal communication between DOE and contractor for Environmental Remediation Projects.
Project requirements	FPDP	Director of Environmental Management	Formal communication among the project, the Site Lead, and the DOE Project Manager.
Project requirements	FPDP	Project Manager	Communication between the project and the FPDP Environmental Remediation Project Manager.
Project quality assurance (QA) requirements	FPDP	Quality Manager	Project quality-related communication between the QA department and FPDP project personnel.
FFA Compliance	FPDP	Regulatory Affairs Manager	Internal communication regarding FFA compliance with the FPDP Project Manager.

QAPP Worksheet #6. Communication Pathways (Continued)

Communication Drivers	Organizational Affiliation	Position Title Responsible	Organizational Department Manager	Procedure
Sampling Requirements	FPDP	Sample Team Lead	Environmental Monitoring	Internal communication regarding field sampling with the FPDP Project Manager.
Analytical Laboratory Interface	FPDP	Scientist	Sample Management Office	Communication between FPDP and analytical laboratory.
Waste Management Requirements	FPDP	Waste Coordinator	Project Integration and Operations Manager	Internal communication regarding project waste management with FPDP Project Manager.
Environmental Compliance Requirements	FPDP	Regulatory Compliance Manager	Regulatory Affairs Manager	Internal correspondence regarding environmental requirements and compliance with the FPDP Project Manager.
Subcontractor Requirements (if applicable)	FPDP	Subcontract Administrator	Business Manager	Correspondence among the project and subcontractors, if applicable.
Health and Safety Requirements	FPDP	Health and Safety Manager	Health and Safety Manager	Internal communication regarding safety and health requirements with the FPDP Project Manager.

QAPP Worksheet #9. Project Scoping Session Participant Sheet

Project scoping is the key to the success of any project and is part of the systematic planning process. The preparation of this QAPP included review of past documents produced and planning meetings to establish the objectives of the project. This QAPP has been prepared to be consistent with the Data Management Plan (DOE 1998) developed for the FFA. The summary of the results of the project scoping is presented in the SAP. Participant Scoping Sheets follow.

Name of Project: Addendum for the Five-Year Review, SAP
Date of Session: August 21, 2014
Scoping Session Purpose: Develop data quality objectives (DQOs)

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
LATA Kentucky Project Manager	LATA Kentucky	Teresa Overby	270-441-5188	teresa.overby@lataky.com	Project management
DOE Project Manager	DOE	Cynthia Zvonar	859-219-4066	cynthia.zvonar@lex.doe.gov	Program management
Risk Manager	DOE	Rich Bonczek	859-219-4051	rich.bonczek@lex.doe.gov	Technical support
FFA Manager	KDEP	Todd Mullins	502-564-6716	todd.mullins@ky.gov	Project management
Geologist	LATA Kentucky	Ken Davis	270-441-5049	ken.davis@lataky.com	Technical support
FFA Manager	EPA	Jennifer Tufts	404-562-8513	tufts.jennifer@epa.gov	Project management
Technical Advisor	KDEP	Mike Guffey	502-564-1299	mike.guffey@ky.gov	Technical support
Technical support	DOE PPPO Contractor, Pro2Serve	Tracey Duncan	270-441-5060	tracey.duncan@lataky.com	Technical support
Technical support	DOE PPPO Contractor, Strategic Management Solutions, LLC (SMSI)	Bobette Nourse	865-712-2669	bobette.nourse@lex.doe.gov	Technical support
LATA Kentucky Risk Manager	LATA Kentucky	Joe Towarnicky	270-441-5134	joseph.towarnicky@lataky.com	Technical support

QAPP Worksheet #9 (Continued)
Project Scoping Session Participants Sheet

Project scoping is the key to the success of any project and is part of the systematic planning process. A scoping meeting was held to develop the DQOs of the project.

Name of Project: Addendum for the Five-Year Review, SAP
Date of Session: February 24, 2015
Scoping Session Purpose: Develop DQOs

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
LATA Kentucky Project Manager	LATA Kentucky	Teresa Overby	270-441-5188	teresa.overby@lataky.com	Project management
DOE Project Manager	DOE	Cynthia Zvonar	859-219-4066	cynthia.zvonar@lex.doe.gov	Program management
Risk Manager	DOE	Rich Bonczek	859-219-4051	rich.bonczek@lex.doe.gov	Technical support
FFA Manager	KDEP	Todd Mullins	502-564-6716	todd.mullins@ky.gov	Project management
Geologist	LATA Kentucky	Ken Davis	270-441-5049	ken.davis@lataky.com	Technical support
FFA Manager	EPA	Jennifer Tufts	404-562-8513	tufts.jennifer@epa.gov	Project management
Technical Advisor	KDEP	Mike Guffey	502-564-1299	mike.guffey@ky.gov	Technical support
Facilitator	LATA Kentucky	Tracey Duncan	270-441-5060	tracey.duncan@lataky.com	Facilitator
Technical support	DOE PPPO Contractor, SMSI	Bobette Nourse	865-712-2669	bobette.nourse@lex.doe.gov	Technical support
LATA Kentucky Risk Manager	LATA Kentucky	Joe Towarnicky	270-441-5134	joseph.towarnicky@lataky.com	Technical support
Groundwater Project Manager	DOE	David Dollins	270-441-6819	dave.dollins@lex.doe.gov	Technical support
Technical Advisor	EPA	Ben Bentkowski	404- 562-8507	bnentkowski.ben@epa.gov	Technical support
Technical Advisor	KDEP	Brian Begley	502- 564-6716	brian.begley@ky.gov	Technical support
Technical Advisor	EPA	Jon Richards	404-562-8648	richards.jon@epa.gov	Technical support

QAPP Worksheet #9 (Continued)
Project Scoping Session Participants Sheet

Project scoping is the key to the success of any project and is part of the systematic planning process. A scoping meeting was held to develop the DQOs of the project.

Name of Project: Addendum for the Five-Year Review, SAP
Date of Session: April 22, 2015
Scoping Session Purpose: Develop DQOs

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
LATA Kentucky Project Manager	LATA Kentucky	Teresa Overby	270-441-5188	teresa.overby@lataky.com	Project management
DOE Project Manager	DOE	Cynthia Zvonar	859-219-4066	cynthia.zvonar@lex.doe.gov	Program management
Risk Manager	DOE	Rich Bonczek	859-219-4051	rich.bonczek@lex.doe.gov	Technical support
FFA Manager	KDEP	Todd Mullins	502-564-6716	todd.mullins@ky.gov	Program management
Geologist	LATA Kentucky	Ken Davis	270-441-5049	ken.davis@lataky.com	Technical support
FFA Manager	EPA	Julie Corkran	404-562-8547	corkran.julie@epa.gov	Program management
Technical Advisor	KDEP	Mike Guffey	502-564-1299	mike.guffey@ky.gov	Technical support
Project Support	LATA Kentucky	Tracey Duncan	270-441-5060	tracey.duncan@lataky.com	Facilitator
Technical Advisor	DOE PPPO Contractor, SMSI	Bobette Nourse	865-712-2669	bobette.nourse@lex.doe.gov	Technical support
LATA Kentucky Risk Manager	LATA Kentucky	Joe Towarnicky	270-441-5134	joseph.towarnicky@lataky.com	Technical support
Groundwater Project Manager	DOE	David Dollins	270-441-6819	dave.dollins@lex.doe.gov	Technical support
Technical Advisor	EPA	Ben Bentkowski	404- 562-8507	bentkowski.ben@epa.gov	Technical support
Technical Advisor	KDEP	Brian Begley	502- 564-6716	brian.begley@ky.gov	Technical support
Technical Advisor	EPA	Jon Richards	404-562-8648	richards.jon@epa.gov	Technical support

QAPP Worksheet #9 (Continued)
Project Scoping Session Participants Sheet

Name of Project: Addendum for the Five-Year Review, SAP
Date of Session: April 22, 2015
Scoping Session Purpose: Develop DQOs

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
Technical Advisor	KDWM	Jeri Higgenbotham	502-564-6716, ext. 4726	jeri.higginbotham@ky.gov	Technical support
Technical Advisor	Geosyntec	Helen Dawson	703-533-3148	hdawson@geosyntec.com	Technical support
Technical Advisor	EPA	Noman Ahsanuzzamen	404-562-8047	ahsanuzzaman.noman@epa.gov	Technical support
Technical Advisor	EPA	Glenn Adams	404-562-8771	adams.glenn@epa.gov	Technical support
Technical Advisor	KDWM	Gaye Brewer	270-898-8468	gaye.brewer@ky.gov	Technical support
Technical Advisor	DOE PPPO Contractor, Pro2Serve	Allison Keefer	270-441-6809	allison.keefer@lex.doe.gov	Technical support
Technical Advisor	DOE PPPO Contractor, Pro2Serve	Tracy Taylor	270-441-6866	tracy.taylor@lex.doe.gov	Technical support

QAPP Worksheet #9 (Continued)
Project Scoping Session Participants Sheet

Name of Project: Addendum for the Five-Year Review, C-400 VI Scoping
Date of Session: September 29, 2015
Scoping Session Purpose: Develop DQOs

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
Fluor Project Manager	FFS	Teresa Overby	270-441-5188	teresa.overby@ffspaducah.com	Project management
DOE Project Manager	DOE	Cynthia Zvonar	859-219-4066	cynthia.zvonar@lex.doe.gov	Program management
Risk Manager	DOE	Rich Bonczek	859-219-4051	rich.bonczek@lex.doe.gov	Technical support
FFA Manager	KDEP	Brian Begley	502- 564-6716	brian.begley@ky.gov	Program management
Geologist	FFS	Ken Davis	270-441-5049	ken.davis@ffspaducah.com	Technical support
FFA Manager	EPA	Julie Corkran	404-562-8547	corkran.julie@epa.gov	Program management
FFA Manager	DOE	Tracey Duncan	270-441-5060	tracey.duncan@lex.doe.gov	Facilitator
Technical Advisor	DOE PPPO Contractor, SMSI	Bobette Nourse	865-712-2669	bobette.nourse@lex.doe.gov	Technical support
Project Scientist	FFS	Joe Towarnicky	270-441-5134	joseph.towarnicky@ffspaducah.com	Technical support
Groundwater Project Manager	DOE	David Dollins	270-441-6819	dave.dollins@lex.doe.gov	Technical support
Technical Advisor	EPA	Ben Bentkowski	404- 562-8507	bentkowski.ben@epa.gov	Technical support
Technical Advisor	EPA	Jon Richards	404-562-8648	richards.jon@epa.gov	Technical support

QAPP Worksheet #9 (Continued)
Project Scoping Session Participants Sheet

Name of Project: Addendum for the Five-Year Review, C-400 VI scoping
Date of Session: September 29, 2015
Scoping Session Purpose: Develop DQOs

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
Technical Advisor	KDWM	Jeri Higgenbotham	502-564-6716, ext 4726	jeri.higginbotham@ky.gov	Technical support
Technical Advisor	KDWM	Gaye Brewer	270-898-8468	gaye.brewer@ky.gov	Technical support
Technical Advisor	DOE PPPO Contractor, Pro2Serve	Tracy Taylor	270-441-6866	tracy.taylor@lex.doe.gov	Technical support
Technical Advisor	DOE PPPO Contractor, Pro2Serve	Jennifer Johnson	270-441-6846	jennifer.johnson@lex.doe.gov	Technical support

QAPP Worksheet #10.
Problem Definition

The problem to be addressed by the project: The problem being addressed is a concern that volatile organic compounds (VOCs) vapors including 1,1-dichloroethene (1,1-DCE); *cis*-1,2-DCE; *trans*-1,2-DCE; trichloroethene; and vinyl chloride may be migrating from the PGDP Regional Gravel Aquifer plume and from contaminated soils of the Upper Continental Recharge System (UCRS) and into the C-400 Cleaning Building at unacceptable levels.

The environmental questions being asked: Are vapors migrating from VOCs in the groundwater into the air of C-400 Cleaning Building?

Observations from any site reconnaissance reports: See Section 6 of the Work Plan.

A synopsis of secondary data or information from site reports: See Section 6 of the Work Plan.

The possible classes of contaminants and the affected matrices: The primary contaminant of concern is TCE.

The rationale for inclusion of chemical and nonchemical analyses: See Worksheets #11 and #17.

Information concerning various environmental indicators: Based on KDEP Environmental Indicator determination, contaminated groundwater migration currently is not considered to be under control at PGDP, under the Government Performance and Results Act.

Project decision conditions ("If..., then..." statements): See Section 10 of the Work Plan.

QAPP Worksheet #11. Project Quality Objectives/Systematic Planning Process Statements

This worksheet details the standards for field and analytical data quality. Analytical data will be generated by DOE Consolidated Audit Program (DOECAP) laboratories utilizing approved laboratory test methods. The overall project quality objectives are to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will meet the DQOs of this project.

Who will use the data? DOE, FPDP, KDEP, and EPA.

What will the data be used for? To eliminate the data gaps identified in Worksheet #10.

What type of data is needed? (target analytes, analytical groups, field screening, on-site analytical or off-site laboratory techniques, sampling techniques): Indoor air data, ambient (upwind) air data, air from floor crack.

How "good" do the data need to be in order to support the environmental decision? Data need to have practical quantitation limits below the respective VISL. Data will meet the measurement quality objective and data quality indicators established by the systematic planning process consistent with procedure CP3-ES-5003, *Quality Assured Data*. Results will undergo 100% data validation.

Where, when, and how should the data be collected/generated? See Section 9, "Sampling Method."

Who will collect and generate the data? FPDP. Additionally, meteorological data may be acquired from other sources, as needed.

How will the data be reported? Field data will be recorded on chain-of-custody forms, in field logbooks, and field data sheets. The fixed-base laboratory will provide data in an Electronic Data Deliverable. Project data following verification assessment and validation will be placed into and reported from the Paducah Oak Ridge Environmental Information System (OREIS). Data loaded into Paducah OREIS will be made available to the public stakeholders via the Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System (PEGASIS).

How will the data be archived? Electronic data will be archived in OREIS in accordance with Section 8.5 (Data and Records Archival) of the *Data and Documents Management and Quality Assurance Plan* (DOE 1998).

NOTE: The worksheet is completed partially with items that will be consistent across project-specific field sampling plans (FSPs). The project-specific FSPs will need to populate the balance of this worksheet.

Sampling will follow the referenced standard operating procedures. The following tables provide the measurement performance criteria.

QAPP Worksheet #12. Measurement Performance Criteria

Matrix	Air
Analytical Group[a]	C-400 VOCs, including trichloroethene, 1,2-DCE, vinyl chloride, 1,1-DCE
Concentration Level	Very Low

Sampling Procedure[b]	**Analytical Method/SOP**	**Data Quality Indicators**	**Measurement Performance Criteria**	**Quality Control (QC) Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
CP4-ER-1035, Vapor Sampling	EPA-TO-15. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)	Precision-Lab	N/A	Evaluate lab data packages	A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method will be used.

QAPP Worksheet #13. Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/Collection Dates)	How Data Will Be Used	Limitations on Data Use
OREIS Database	Various	Various	Data for soil and groundwater contamination will be used to approximate expected sub-slab VOC concentrations.	Data have been verified, assessed, and validated (if validation is required). Rejected data will not be used.

QAPP Worksheet #14. Summary of Project Tasks*

Sampling Tasks: Collect samples, document field notes, complete chain-of-custody, label samples, package/ship samples per standard operating procedures Worksheet #21.

Analysis Tasks: Receive samples, complete chain-of-custody, extract samples, analyze extract, review data, report data per standard methods in Worksheet #21.

Quality Control Tasks: QC will be per QAPP worksheets as follows:

- QC samples—Worksheets #20 and #28
- Equipment calibration—Worksheets #22 and #24
- Data review/validation—Worksheets #34, #35, #36, and #37

Secondary Data: See Section 9, "Sampling Method."

Data Management Tasks: Data management will be per procedure CP4-ES-5007, *Data Management Coordination*; CP3-ES-1003, *Developing, Implementing, and Maintaining Data Management Implementation Plan;* and CP2-ES-0063, *Environmental Monitoring Data Management Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*.

Documentation and Records: Documentation and records will be per procedure CP3-RD-0010, *Records Management Process.*

Assessment/Audit Tasks: Assessments and audits will be per procedure CP3-QA-1003, *Management and Self Assessments.*

Data Review Tasks: Data review tasks will be per procedure CP3-ES-5003, *Quality Assured Data;* and CP2-ES-0063, *Environmental Monitoring Data Management Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*.

*It is understood that SOPs are DOE Prime Contractor specific.

QAPP Worksheet #16. Project Schedule/Timeline Table

The schedule for this project has not been developed yet.

QAPP Worksheet #15. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits

Matrix: Air
Analytical Group: VOCs

VOCs	CAS Number	Project Action Limit (μg/m^3)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					Practical Quantitation Limits (PQLs) (μg/m^3)	Method Detection Limits (MDLs) (μg/m^3)
1,1-Dichloroethene	75-35-4	880	VISL, Commercial[d]	Yes	2.0	0.59
cis-1,2-Dichloroethene	156-59-2	N/A	No VISL[d]	Yes	2.0	0.59
trans-1,2-Dichloroethene	156-60-5	N/A	No VISL[d]	Yes	2.0	0.59
Trichloroethene	79-01-6	3.0	VISL, Commercial[d]	Yes	2.7	0.81
Vinyl Chloride	75-01-4	2.8	VISL, Commercial[d]	Yes	1.28	0.38

[a] VISL = Vapor Intrusion Screening Level (Commercial, Carcinogen Target Risk = 1.0E-6, Target Hazard Quotient = 1.0).
[b] Analytes marked with chemical of potential concern (COPC) are from Table 2.1 of the Paducah Risk Methods Document (DOE 2015).
[c] Laboratory has PQL of 0.5 ppbv and MDL of 0.15 ppbv. Values were converted to μg/m^3 at 25°C.
[d] VISL Calculator Version 3.4, November 2015 Regional Screening Levels.

QAPP Worksheet #17. Sampling Design and Rationale

See Section 9, "Sampling Method."

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure Requirements Table

See Section 9, "Sampling Method."

QAPP Worksheet #19. Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference[a]	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Air	VOCs	Very Low	See Worksheet #12	SUMMA canister with 8-hour orifice.			

[a] See Analytical SOP References table (Worksheet #23).

QAPP Worksheet #30. Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Locations/ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/ Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)[a]
Air	VOCs	Low	See Section 9, "Sampling Method"	See Worksheet #23	7-day	ALS Global 960 West LeVoy Drive Salt Lake City, UT 84123 PM: Kevin Griffiths (801) 266-7700	TBD

[a] Laboratory contracting will be subsequent to the approval of the SAP to Support Additional Action for the CERCLA Five-Year Review.

QAPP Worksheet #20. Field Quality Control Sample Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference	No. of Sampling Locations	No. of Field Duplicate Pairs	Inorganic No. of MS	No. of Field Blanks	No. of Equip. Blanks	No. of Proficiency Testing (PT) Samples[a]	Total No. of Samples to Lab[b]
Air	VOCs	Low	See Worksheet #12	10 (See SAP p. 21)	0	NA	0	0	N/A	13 (See SAP p.21)

[a] PT sample will be collected only when required by a specific project.
[b] All analyses will be performed by a fixed-base laboratory.

QAPP Worksheet #21. Project Sampling SOP References Table

SOPs to be used on this project are summarized below.

Reference Number	Title and Number[a]	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
1	CP4-ES-0043, *Temperature Control for Sample Storage*	Contractor	Sampling	N	N/A
2	CP2-ES-0025, *Paducah Environmental Monitoring Waste Management Plan*	Contractor	N/A	N	N/A
3	CP4-ES-1001, *Transmitting Data to the Paducah Oak Ridge Environmental Information System (OREIS)*	Contractor	N/A	N	N/A
4	CP4-ES-2700, *Logbooks and Data Forms*	Contractor	N/A	N	N/A
5	CP4-ES-2702, *Decontamination of Sampling Equipment and Devices*	Contractor	Sampling	N	N/A
6	CP4-ES-2704, *Trip, Equipment, and Field Blank Preparation*	Contractor	N/A	N	N/A
7	CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*	Contractor	N/A	N	N/A

QAPP Worksheet #21. Project Sampling SOP References Table (Continued)

Reference Number	Title and Number[a]	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
8	CP3-ES-5003, *Quality Assured Data*	Contractor	N/A	N	N/A
9	CP3-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling Guidance*	Contractor	N/A	N	N/A
10	CP4-ES-5007, *Data Management Coordination*	Contractor	N/A	N	N/A
11	CP2-ES-5105, *Volatile and Semivolatile Data Verification and Validation*	Contractor	N/A	N	N/A
12	CP4-ES-1002, *Submitting, Reviewing, and Dispositioning Changes to the Environmental Databases OREIS and PEMS*	Contractor	N/A	N	N/A
13	CP4-ER-1035, *Vapor Sampling*	Contractor	N/A	N	N/A

[a] SOPs are posted to the FPDP intranet Web site. External FFA parties can access this site using remote access with privileges upon approval. It is understood that SOPs are contractor specific.
[b] The work will be conducted by FPDP staff or a subcontractor. In either case, SOPs listed will be followed.

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection Table

None.

QAPP Worksheet #23. Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?(Y/N)
TO-15	Determination of VOCs In Air Collected In Specially-Prepared Canisters and Analyzed by GC/MS	Definitive	VOCs	GC/MS	ALS Global	No

QAPP Worksheet #24. Analytical Instrument Calibration

Laboratory equipment and instruments used for quantitative measurements are calibrated in accordance with the laboratory's formal calibration program as summarized in the SOPs. Whenever possible, the laboratory uses recognized procedures for calibration such as those published by EPA or American Society for Testing and Materials. If established procedures are not available, the laboratory develops a calibration procedure based on the type of equipment, stability, characteristics of the equipment, required accuracy, and the effect of operation error on the quantities measured. Whenever possible, physical reference standards associated with periodic calibrations such as weights or certified thermometers with known relationships to nationally recognized standards are used. Where national reference standards are not available, the basis for the reference standard is documented. Equipment or instruments that fail calibration or become inoperable during use are tagged to indicate they are out of calibration. Such instruments or equipment are repaired and successfully recalibrated prior to reuse. High resolution mass spectrometer instruments undergo extensive tuning and calibration and are checked prior to running each sample set. The calibrations and ongoing instrument performance parameters are recorded and reported as part of the analytical data package.

QAPP Worksheet #25. Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference*
GC/MS	Replace/clean ion source; clean injector, replace injector liner, replace/clip capillary column, flush/replace tubing on purge and trap; replace trap	QC standards	Ion source, injector liner, column, column flow, purge lines, purge flow, trap	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Section Manager	See Worksheet #23

*The laboratory is responsible for instrument and equipment maintenance, testing, and inspection information per their QA Plan. This information is audited annually by DOECAP. Laboratory(s) contracted will be DOECAP audited. Field survey/sampling instrumentation will be maintained, tested, and inspected according to manufacturer's instructions.

QAPP Worksheet #26. Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT	
Sample Collection (Personnel/Organization):	Sampling Teams/DOE Prime Contractor and Subcontractors
Sample Packaging (Personnel/Organization):	Sampling Teams/DOE Prime Contractor and Subcontractors
Coordination of Shipment (Personnel/Organization):	Lab Coordinator/DOE Prime Contractor
Type of Shipment/Carrier:	Direct Delivery or Overnight/Federal Express in accordance with the on-site transportation plan or U. S. Department of Transportation requirements
SAMPLE RECEIPT AND ANALYSIS	
Sample Receipt (Personnel/Organization):	Sample Management/Contracted Laboratory
Sample Custody and Storage (Personnel/Organization):	Sample Management/Contracted Laboratory
Sample Preparation (Personnel/Organization):	Analysts/Contracted Laboratory
Sample Determinative Analysis (Personnel/Organization):	Analysts/Contracted Laboratory
SAMPLE ARCHIVING	
Field Sample Storage (No. of days from sample collection):	The field laboratory is required to analyze samples within 48 hours of collection and those samples are archived until results are screened (same day as analysis). The fixed-base laboratory will archive samples for 4 months or less depending on project-specific requirements.
Sample Extract/Digestate Storage (No. of days from extraction/digestion):	120 Days
Biological Sample Storage (No. of days from sample collection):	Not applicable.
SAMPLE DISPOSAL	
Personnel/Organization:	Waste Disposition/Sample Management Office/DOE Prime Contractor and Subcontractors
Number of Days from Analysis	6 months

QAPP Worksheet #27. Sample Custody Requirements*

Chain-of-custody procedures are comprised of maintaining sample custody and documentation of samples for evidence. To document chain-of-custody, an accurate record of samples must be maintained in order to trace the possession of each sample from the time of collection to its introduction to the laboratory.

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):

Field sample custody requirements will be per DOE Prime Contractor procedures, CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*; and CP3-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling Guidance.*

Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal):

Are per the DOECAP-audited laboratory's standard procedures. When the samples are delivered to the laboratory, signatures of the laboratory personnel receiving them and the courier personnel relinquishing them will be completed in the appropriate spaces on the chain-of-custody record, unless the courier is a commercial carrier. This will complete the sample transfer. It will be every laboratory's responsibility to maintain internal logbooks and records that provide custody throughout sample preparation and analysis process.

Sample Identification Procedures:

Sample identification requirements will be specified in work package documents.

Chain-of-custody Procedures:

Chain-of-custody requirements will be per DOE Prime Contractor procedures, CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*; and CP3-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling Guidance.*

*It is understood that SOPs are DOE Prime Contractor specific.

QAPP Worksheet #28-A. QC Samples Table

Matrix: Air

Analytical Group/Concentration Level: VOCs/Low

Sampling SOP: See Worksheet #21

Analytical Method/SOP Reference: TO-15

Sampler's Name/Field Sampling Organization: FPDP

Analytical Organization: GEL

No. of Sample Locations: 10 Locations for a total of 13 + 1 duplicate = 14 samples

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field duplicate	1	As with other samples	Data reviewer will place qualifiers on samples affected	Project	Homogeneity/ Precision	RPD $\leq$ 50%
Routine Laboratory	Per laboratory SOP	Per laboratory SOP	Per laboratory SOP	Per laboratory SOP	Per laboratory SOP	Per laboratory SOP

QAPP Worksheet #29. Project Documents and Records Table

All project data and information must be documented in a format that is usable by project personnel. The QAPP describes how project data and information shall be documented, tracked, and managed from generation in the field to final use and storage in a manner that ensures data integrity, defensibility, and retrieval.

Sample Collection Documents and Records	On-site Analysis Documents and Records	Off-site Analysis Documents and Records	Data Assessment Documents and Records*	Other
Data logbooks and associated completed sampling forms; sample chains-of-custody	Laboratory data packages, OREIS database, and associated data packages	OREIS database and associated data packages	CP3-ES-5003, Att. G, Data Assessment Review Checklist and Comment Form	CP3-OP-0009-F01, Observation Checklist Form

*It is understood that SOPs are DOE Prime Contractor specific.

QAPP Worksheet #31. Planned Project Assessments Table

FPDP will ensure that protocol outlined in the QAPP is implemented adequately. Assessment activities help to ensure that the resultant data quality is adequate for its intended use and that appropriate responses are in place to address nonconformances and deviations from the QAPP. Below is a list of assessments project teams may use.

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (Title and Organizational Affiliation)
Independent Assessment/ Surveillance	A	Internal	QA Manager or designee	QA Specialists	Project Manager	Project Manager	QA Manager
Laboratory Audit	Annual	External	DOECAP	Laboratory Assessor	Laboratory	Laboratory	DOECAP
Management Assessments	Annual	Internal	Project Manager or designee	Project Manager or Designee	Project Manager	Project Manager	QA Manager
Performance Observation	B	Internal	Project Manager or designee	Project Manager	Project Manager	Project Manager	Project Manager
Performance Observation Follow-up surveillances	Quarterly	Internal	Project Manager or designee	Project Manager or designee	Project Manager	Project Manager	Project Manager

A = Assessment frequency determined by QA Manager and conducted per CP3-QA-1003, *Management and Self Assessments*.
B = Assessment frequency determined by project manager.
*Reference: CP3-OP-0009, *Performance Observations Desk Instructions*.

QAPP Worksheet #32. Assessment Findings and Corrective Action Responses

Provisions shall be taken in the field and laboratory to ensure that any problems that may develop shall be dealt with as quickly as possible to ensure the continuity of the project/sampling events. Field modifications to procedures in the QAPP must be approved by the FFA parties before the modifications are implemented and then documented. The process controlling procedure modification is CP3-OP-0002, *Development, Approval, and Change Control for FPDP Performance Documents*. Field modifications are documented through the work control process per CP3-SM-1003. Corrective action in the field may be necessary when the sampling design is changed. For example, a change in the field may include increasing the number or type of samples or analyses, changing sampling locations, and/or modifying sampling protocol. When this occurs, the project team shall identify any suspected technical or QA deficiencies and note them in the field logbook. Listed in Worksheet #32 is how project teams will address assessment findings.

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)**	Time frame of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Time Frame for Response
Management, Independent, and Surveillances	Form CP3-QA-1003-F02, Management/Self-Assessment Report; Form CP3-QA-1003-F03, Management/Self-Assessment Checklist; and Form CP3-QA-3001-F02, Issue Identification Form	Project management, issue owner, contractor	Upon issuance of Forms CP3-QA-1003-F02, Management/ Self-Assessment Report, and CP3-QA-1003-F03, Management/Self-Assessment Checklist, form CP3-QA-3001-F02, Issue Identification Form, will be completed and attached to the assessment report.	CP3-QA-3001, Issue Identification Form, documents the issue response and/or corrective actions.	Action owner as designated by issue owner, contractor	Fifteen days for initial issue response, corrective action schedule determined by issue owner, per CP3-QA-3001*

*It is understood that SOPs are DOE Prime Contractor specific.
**General project communications and those related to corrective actions are summarized on Worksheets #6, #31, and #33.

QAPP Worksheet #33. QA Management Reports Table

Reports to management include project status reports, field and/or laboratory audits, and data quality assessments. These reports will be directed to the QA Manager and Project Manager who have ultimate responsibility for assuring that any corrective action response is completed, verified, and documented.

Type of Report*	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Field Change Requests	As needed	Ongoing	Field staff	QAPP recipients
QAPP Addenda	As needed	Not Applicable	Project Manager	QAPP recipients
Field Audit Report	TBD as determined by QA Manager	30 days after completion of audit	QA Manager	FPDP Project Manager QA Manager
Corrective Action Plan	As needed	Within 3 weeks of request	Project Manager	QA Manager

TBD = to be determined
*Worksheet #31 and #32 summarize the nature and frequency of other QA assessments.

QAPP Worksheet #34. Verification (Step I) Process Table

This section of the QAPP provides a description of the QA activities that will occur after the data collection phase of the project is completed. Implementation of this section will determine whether the data conforms to the specified criteria satisfying the project objectives.

Verification Input	Description*	Internal/ External	Responsible for Verification (Name, Organization)
Field Logbooks	Field logbooks are verified per DOE Prime Contractor (FPDP) procedure CP4-ES-2700, *Logbooks and Data Forms*, and CP3-ES-5003, *Quality Assured Data*.	Internal	Project Management or designee, Contractor
Chains-of-custody	Chains-of-custody are controlled by DOE Prime Contractor procedure CP3-ES-5004, *Sample Tracking, Lab Coordination and Sample Handling Guidance*; and CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals.* Chains-of-custody will be included in data assessment packages for review as part of data verification and data assessment.	Internal	Sample Management Office Personnel and Project Management, Contractor
Field and Laboratory Data	Field and analytical data are verified and assessed per DOE Prime Contractor procedure CP3-ES-5003, *Quality Assured Data*. Data assessment packages will be created per this procedure. The data assessment packages will include field and analytical data, chains-of-custody, data verification and assessment queries, and other project-specific information needed for personnel to review the package adequately. Data assessment packages will be reviewed to document any issues pertaining to the data and to indicate if data met the DQOs of the project.	Internal	Sample Management Office Personnel and Project Management, Contractor
Sampling Procedures	Evaluate whether sampling procedures were followed with respect to equipment and proper sampling support using audit and sampling reports, field change requests and field logbooks.	Internal	Sample Management Office Personnel, Project Management, and QA Personnel,** Contractor
Laboratory Data	Laboratory data will be verified by the laboratory performing the analysis for completeness and technical accuracy prior to submittal to FPDP. Subsequently, FPDP will evaluate the data packages for completeness and compliance.	External/ Internal	Laboratory Manager, FPDP Sample Management Office Personnel
Electronic Data Deliverables	Determine whether required fields and format were provided.	Internal	Sample Management Office Personnel
QAPP	Planning documents will be available to reviewers to allow reconciliation with planned activities and objectives.	Internal	All data users

*It is understood that SOPs are DOE Prime Contractor specific.
**QA specialist performs general QA review.

QAPP Worksheet #35. Assessment, Verification, and Validation (Steps IIa and IIb) Process Table

Step IIa/IIb	Validation Input	Description[a]	Responsible for Validation (Name, Organization)
IIa	Data Deliverables, Analytes, and Holding Times	The documentation from the contractual screening will be included in the data assessment packages, per DOE Prime Contractor procedure CP3-ES-5003, *Quality Assured Data*.	Sample Management Office Personnel, Contractor
IIa	Chain-of-Custody, Sample Handling, Sampling Methods and Procedures, and Field Transcription	These items will be validated during the data assessment process as required by DOE Prime Contractor procedure CP3-ES-5003, *Quality Assured Data*, and CP3-ES-1003, *Developing, Implementing, and Maintaining Data Management Implementation Plans.* The documentation of this validation will be included in the data assessment packages.	Sample Management Office Personnel, Contractor
IIa	Analytical Methods and Procedures, Laboratory Data Qualifiers, and Standards	These items will be reviewed during the data validation process as required by DOE Prime Contractor data validation procedures. Data validation will be performed in parallel with data assessment. The data validation report and data validation qualifiers will be considered when the data assessment process is being finalized.	Data Validation Subcontractor, and Sample Management Office Personnel, Project, Contractor
IIa	Audits	The audit reports and accreditation and certification records for the laboratory supporting the projects will be considered in the bidding process.	QA Personnel
IIb	Deviations and qualifiers from Step IIa	Any deviations and qualifiers resulting from Step IIa process will be documented in the data assessment packages.	Sample Management Office Personnel, Project, and QA Personnel, Contractor
IIb	Sampling Plan, Sampling Procedures, Co-located Field Duplicates, PQLs, Confirmatory Analyses, Performance Criteria	These items will be evaluated as part of the data verification and data assessment process per DOE Prime Contractor procedure CP3-ES-5003, *Quality Assured Data*. These items will be considered when evaluating whether the project met their DQOs.	Sample Management Office Personnel, Project, and QA Personnel, Contractor

[a] It is understood that SOPs are DOE Prime Contractor specific.

QAPP Worksheet #36. Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator (title and organizational affiliation)
Step IIa/IIb	Air	VOCs	Very Low	National Functional Guidelines; Worksheets #12, #15, and #28	Data Validator[a]

[a] Validation is to be conducted by a qualified individual, independent of sampling, laboratory, project management, or other decision making personnel for the task. This could be an outside party or someone within FPDP who is not involved in the project.

QAPP Worksheet #37. Usability Assessment[1, 2]

FPDP shall determine the adequacy of data based on the results of validation and verification. The usability step involves assessing whether the process execution and resulting data meet project quality objectives documented in the QAPP.

Summarize the usability assessment process and procedures, including interim steps and any statistics, equations, and computer algorithms that will be used: Field and analytical data are verified and assessed per procedure CP3-ES-5003, *Quality Assured Data*. Data assessment packages will be created per this procedure. Data assessment packages will include field and analytical data, chains-of-custody, data verification and assessment queries, and other project-specific information needed for personnel to review the package adequately. Data assessment packages will be reviewed to document any issues pertaining to the data and to indicate if DQOs of the project were met. For data selected for validation, the following procedures are used: CP2-ES-5105 and CP2-ES-5107.

Describe the evaluative procedures used to assess overall measurement error associated with the project: PARCCS parameters (precision, accuracy, representativeness, comparability, completeness, and sensitivity) will be evaluated per procedure, CP3-ES-5003, *Quality Assured Data*. This information will be included in the data assessment packages for review by project personnel. Data assessment also will include documentation of QC exceedances, trends, and/or bias in the data set. Data assessment will document any statistics used.

Identify the personnel responsible for performing the usability assessment: Project personnel, as verified by QA personnel.

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies: Data assessment packages will be created, which will include data assessment comments/questions and laboratory comments. Data verification and assessment queries indicating any historical outliers and background exceedances also will be included in the data assessment packages.

[1] It is understood that SOPs are DOE Prime Contractor specific.
[2] Additional usability assessment information can be referenced on Worksheets #11, #13, #14, and #16.

2. REFERENCES

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