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By Carolee.Thompson at 4:09 pm, May 03, 2023

Department of Energy

Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513
(859) 219-4000

May 3, 2023

Mr. Brian Begley
Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
300 Sower Boulevard, 2nd Floor
Frankfort, Kentucky 40601

PPPO-02-10023859-23C

Mr. Victor Weeks
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Begley and Mr. Weeks:

TRANSMITTAL OF THE 2023 UPDATE OF THE PADUCAH GASEOUS DIFFUSION PLANT PROGRAMMATIC QUALITY ASSURANCE PROJECT PLAN, DOE/LX/07-2490&D1

Reference: Letter from B. Begley to T. Duncan, "Submittal of Comments to the Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan (DOE/LX/07-2479&D1) Paducah Site, Paducah, McCracken County, Kentucky, #KY8-890-008-982," dated May 25, 2022

Please find enclosed the fiscal year (FY) 2023 update of the *Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan,* DOE/LX/07-2490&D1 (P-QAPP).

The P-QAPP has been prepared and updated in accordance with the approach discussed among the members of the P-QAPP Working Group (which includes members from the U.S. Department of Energy, the U.S. Environmental Protection Agency, the Kentucky Department for Environmental Protection [KDEP], and the Kentucky Radiation Health Branch) during a conference call on October 12, 2022, which concerned the FY 2023 P-QAPP update. The P-QAPP was written to address elements of data collection that do not change from project to project and present them in a template to be used to prepare project-specific quality assurance project plans. In addition, this quality assurance project plan addresses comments received from KDEP on May 25, 2022, when it was agreed upon that these comments would be addressed in this update. The worksheets associated with the per- and polyfluoroalkyl substances screening assessment project were intended to be included in this update; however, these worksheets are currently undergoing revision and thus, are not incorporated. These worksheets will be considered for incorporation in the FY 2024 update.

Revisions to the P-QAPP that are in response to project-specific or other issues identified after September 8, 2022, will be completed as part of the FY 2024 update.

If you have any questions or require additional information, please contact Richard Bonczek at (859) 321-7127.

Sincerely,

APRIL LADD Digitally signed by APRIL LADD Date: 2023.05.03 08:43:24 -05'00'

April Ladd
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosure:
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, DOE/LX/07-2490&D1

General Reference Compendium

cc w/enclosure:
abigail.parish@pppo.gov, PPPO
april.ladd@pppo.gov, PPPO
april.webb@ky.gov, KDEP
arcorrespondence@pad.pppo.gov
brian.begley@ky.gov, KDEP
bruce.ford@pad.pppo.gov, FRNP
bwhatton@tva.gov, TVA
dcnorman0@tva.gov, TVA
eric@pgdpcab.org, CAB
fred.dunhour@pppo.gov, PPPO
frnpcorrespondence@pad.pppo.gov
hjlawrence@tva.gov, TVA
jaime.morrow@pad.pppo.gov, FRNP
jennie.freels@pad.pppo.gov, FRNP
joel.bradburne@pppo.gov, PPPO
kentuckyes@fws.gov
kristan.avedikian@TechLawInc.com, EPA
leanne.garner@pad.pppo.gov, FRNP
mac.mcrae@TechLawInc.com, EPA
myrna.redfield@pad.pppo.gov, FRNP
nathan.garner@ky.gov, KYRHB
nrepcdep-dwm-hwb-pgdp@ky.gov
rebecca.goodman@ky.gov, KEEC
reinhard.knerr@pppo.gov, PPPO
richard.bonczek@pppo.gov, PPPO
sebenton@tva.gov, TVA
stefanie.fountain@pad.pppo.gov, FRNP
stephaniec.brock@ky.gov, KYRHB
testher@tva.gov, TVA
thhenry@tva.gov, TVA
timothy.kreher@ky.gov, KDFWS
todd.powers@pad.pppo.gov
weeks.victor@epa.gov, EPA

DOE/LX/07-2490&D1
Secondary Document

Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan

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DOE/LX/07-2490&D1
Secondary Document

Paducah Gaseous Diffusion Plant
Programmatic Quality Assurance Project Plan

Date Issued—April 2023

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Four Rivers Nuclear Partnership, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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CONTENTS

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LIST OF QAPP WORKSHEETS

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ACRONYMS

A	analytical
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHFS	Cabinet for Health and Family Services
COC	contaminant of concern
COPC	chemical (or radionuclide) of potential concern
CPAP	Contractor Performance Assurance Program
CRQL	contract-required quantitation limit
CSM	conceptual site model
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DQI	data quality indicator
DQO	data quality objective
ECD	electron capture detector
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FID	flame ionization detector
FIDLER	field instrument for detection of low energy radiation
FRNP	Four Rivers Nuclear Partnership, LLC
FS	feasibility study
FSP	field sampling plan
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GPS	Global Positioning System
HQ	hazard quotient
HSS&Q	Health, Safety, Support, and Quality
ICP-AES	inductively coupled plasma-atomic emission spectroscopy
ICP-MS	inductively coupled plasma-mass spectrometry
IDQTF	Intergovernmental Data Quality Task Force
KDEP	Kentucky Department for Environmental Protection
MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limit
MPC	measurement performance criteria
MS	matrix spike
MW	monitoring well
N/A	not applicable
NAL	no action level
NVVA	no VISL value available
O	Order
OREIS	Oak Ridge Environmental Information System
ORP	oxidation reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PAL	project action limit
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity

PCB	polychlorinated biphenyl
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PGDP	Paducah Gaseous Diffusion Plant
PPPO	Portsmouth/Paducah Project Office
PM	project manager
P-QAPP	Programmatic Quality Assurance Project Plan
PQL	practical quantitation limit
PQO	project quality objective
PT	proficiency testing
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
qPCR	quantitative polymerase chain reaction
RADCON	radiological control
RfC	inhalation reference concentration
RGA	Regional Gravel Aquifer
RI	remedial investigation
RMD	Risk Methods Document
RPD	relative percent difference
S	sampling
S&A	sampling and analytical
SAP	sampling and analysis plan
SMO	Sample Management Office
SOP	standard operating procedure
SPP	systematic planning process
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TBD	to be determined
TOC	total organic carbon
TPD	training position description
TSA	technical systems audit
UCRS	Upper Continental Recharge System
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
VISL	Vapor Intrusion Screening Level
VOA	volatile organic analyte
VOC	volatile organic compound
XRF	X-ray fluorescence

1. INTRODUCTION

This update to the Programmatic Quality Assurance Project Plan (P-QAPP) has been prepared by Four Rivers Nuclear Partnership, LLC, (FRNP) based on the most recent programmatic Quality Assurance Project Plan (QAPP), *Programmatic Quality Assurance Project Plan* (DOE 2022a), which was developed to align 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.) Because the initial P-QAPP was developed with 37 worksheets and later migrated to the optimized format, additional information from the initial worksheets has been retained such that the updated P-QAPP contains more detail than called for in the Optimized UFP-QAPP 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* (EPA 2012).

The UFP-QAPP is a consensus quality systems document prepared by the Intergovernmental Data Quality Task Force (IDQTF), a working group made up of representatives from the U.S. Environmental Protection Agency (EPA), the U.S. Department of Defense (DoD), and the U.S. Department of Energy (DOE). Originally issued in 2005, the UFP-QAPP was developed to provide procedures and guidance for consistently implementing the national consensus standard: American National Standards Institute/American Society of Quality E-4, *Quality Systems for Environmental Data and Technology Programs*, for the collection and use of environmental data at federal facilities.

DOE quality requirements are defined in DOE Orders and, as a result, DOE (both on a national and site-specific level) does not accept the UFP-QAPP Manual and is not one of its signatories. DOE's Portsmouth/Paducah Project Office (PPPO) has, however, agreed to adopt the UFP-QAPP format (e.g., use of worksheets) and to incorporate, as appropriate, its quality requirements for Paducah projects through a P-QAPP. Additionally, FRNP follows CP2-QA-1000, *Quality Assurance Program Description for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. This document meets the quality assurance (QA) requirements for DOE Order (O) 414.1D, Admin Chg 2, *Quality Assurance*, as the primary QA criteria.

This revised P-QAPP provides a template for development of future project-specific QAPPs. In migrating to the optimized worksheet format, additional information has been added to some of the worksheets to streamline the use of this P-QAPP in the preparation of project-specific QAPPs. As noted in the guidance (IDQTF 2012), this P-QAPP captures some of the elements that would comprise related project-planning documents, such as a sampling and analysis plan (SAP), work plan, and field sampling plan (FSP). The example worksheets provided in the P-QAPP were developed from recent project-specific QAPPs or from the Optimized UFP-QAPP Worksheets guidance (IDQTF 2012). Lessons learned as part of ongoing project work will be incorporated, as appropriate, into project-specific QAPPs and future revisions of this P-QAPP.

The Paducah Gaseous Diffusion Plant (PGDP) employs a range of sampling activities. The goal of this P-QAPP is to streamline the systematic planning process and provide uniformity of data collection and laboratory services by using this P-QAPP as a template in the development of project-specific QAPPs. Data collection activities often are focused on measuring concentrations of a chemical (or radionuclide) of potential concern (COPC). A COPC may be of concern for either potential human health or ecological impacts.

This P-QAPP captures elements of data collection that materially do not change from project to project [e.g., the requirement to use current standard operating procedures (SOPs), target action levels, the analytical methods, the use of data validation]. In addition, it presents examples that allow the P-QAPP to be used as a template to develop a project-specific QAPP to include project-specific information [e.g., data quality objectives (DQOs), schedules, numbers, and types of samples].

To provide uniformity, this P-QAPP does the following:

- Refers to the SOPs already developed for the site;
- Provides routinely available analytical limits, in part, to support an evaluation of the suitability of these limits to meet DQOs as part of the development of the project-specific QAPP;
- Incorporates the *Paducah Gaseous Diffusion Plant Data Management Plan*, DOE/LX/07-2458&D2 (DOE 2021a); and
- Standardizes data validation processes by linking the process to SOPs (see Worksheet #21).

Additional information is provided in the P-QAPP's six appendices.

(1) Appendix A, "Comparison of the Method Detection Limits for Water and Soil to the Project Action Limits Developed Using 2020 Child Resident No Further Action, Background, and Maximum Contaminant Level Concentrations;"

[Note: Child resident no action levels (NALs), background values, and maximum contaminant level concentrations are taken from the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, *Volume* 1. *Human Health*, DOE/LX/07-0107&D2/R12/V1 (DOE 2021b). Maximum contaminant levels (MCLs) apply to water samples only.]

(2) Appendix B, "The Role of Independent Third-Party Data Validation in Meeting Data Quality Objectives at Paducah Gaseous Diffusion Plant;"

(3) Appendix C, "Discussion of the Quality Assurance Criteria To Be Applied to Field Analytical Methods;"

(4) Appendix D, "Conceptual Site Model (from the Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit);"

(5) Appendix E, "Collection of Field Duplicates at the C-404 Hazardous Waste Landfill;" and

(6) Appendix F, "Summary of Survey Activities Associated with Updating the Reference Measuring Point Elevations for the Groundwater Monitoring Well Network at the Paducah Site, Paducah, Kentucky."

This document is not a substitute for the development of project-specific QAPPs, FSPs, the decisions on DQOs, type of analyses, number of samples, type of samples, project schedule, etc., and should not be used to support performance of individual projects. The systematic planning decisions for a given project will be included in the project-specific FSPs and QAPPs.

This P-QAPP focuses on providing worksheets describing fixed-base laboratory methods. However, selected field methods [e.g., X-ray fluorescence (XRF), colorimetric methods for polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbon (PAH) test kits, radionuclide surveys] that may be useful for specific projects are included. Information provided in this P-QAPP shall be reviewed and confirmed as appropriate as part of the development of the project-specific QAPP.

It is emphasized that the final, approved, project-specific QAPP is designed to be a stand-alone document containing the specifications and procedures necessary for project personnel to carry out their assigned responsibilities. For example, the field team should be able to rely on the project-specific QAPP (including the associated FSP and referenced procedures) for sampling instructions, including how to sample, where to sample, how many samples to collect, the types of bottles, preservatives, and related quality control (QC), etc. The approved project-specific QAPP shall list procedures to carry out tasks, including making available SOPs that provide this information. If required elements are contained in other documents, those documents may be referenced; however, the documents must be available to personnel responsible for reviewing and implementing the project-specific QAPP.

2. GUIDE TO PREPARING A PROJECT-SPECIFIC QAPP

This P-QAPP shall be used as a template to prepare a project-specific QAPP. Although used as a template in preparing the project-specific QAPP, the information presented as examples in the P-QAPP shall be reviewed and confirmed during the preparation of the project-specific QAPP. In alignment with the optimized UFP-QAPP worksheet guidance, each worksheet of the P-QAPP includes text (typically presented in green) that provides instruction on how to fill out each worksheet. Typically, the green text will be deleted in the project-specific QAPP. Black text is used for the worksheet template and examples. Because this P-QAPP is to be used as a template, the worksheets generally are presented as they will be filled out for a project-specific QAPP.

This document is presented with current position holders and roles. Some worksheets include names of current position holders. If the person filling a position changes, the approved QAPP need not be updated; rather, the change can be noted as part of routine communication. To the extent the next project-specific QAPP document has names, these will be updated/confirmed at the time of document generation. One alternative for tracking persons working on a project is to collect changes to the approved project-specific QAPP and provide the update in an attachment to the project-specific QAPP, potentially including a crosswalk of position titles to names with dates each person filled the position. The changes applied to a project-specific QAPP will be tracked and may be incorporated into the P-QAPP at its next review if the changes have programmatic implications.

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

(UFP-QAPP Manual Section 2.1)
(EPA 2106-G-05 Section 2.2.1)

This worksheet identifies the principal points of contact for organizations having decision authority in the project and documents their commitment to implement the QAPP. Signatories usually include the lead organization's project manager (PM), QA/QC program manager, and individuals with approval or oversight authority from each regulatory agency. Signatures indicate that officials have reviewed the QAPP and concur with its implementation as written. **If separate concurrence letters are issued (as is typical at PGDP), the original correspondence should be maintained with the final, approved, project-specific QAPP in the project file.** It is the lead organization's responsibility to make sure signatures are in place before work begins.

Site Name/Project Name: Paducah Gaseous Diffusion Plant (PGDP)/*Project Name (to be added)*
Site Location: Paducah, Kentucky
Site Number/Code: KY8890008982
Contractor Name: Four Rivers Nuclear Partnership, LLC (FRNP)
Contractor Number: Contract No. DE-EM0004895
Contract Title: Paducah Gaseous Diffusion Plant Deactivation and Remediation Project
Work Assignment Number: *(to be added)*

Document Title: *Quality Assurance Project Plan for (project name)*

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

Preparer's Name and Organizational Affiliation: *(technical support)*, FRNP

Preparer's Address, Telephone Number, and E-mail Address: 5511 Hobbs Rd, Kevil, KY 42053, (270) 441-XXXX, *first.last*@pad.pppo.gov

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Preparation Date (Month/Year): 4/2023
Document Control Number: DOE/LX/07-2490&D1

FRNP Environmental Services Director	____________________ Signature Bruce Ford	Date:__________
FRNP *(project name)* Project Manager	____________________ Signature *Project Manager*	Date:__________
FRNP Sample Management Office Manager (Acting)	____________________ Signature Jaime Morrow	Date:__________
FRNP Quality Assurance/ Quality Control Program Manager	____________________ Signature Jennie Freels	Date:__________

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

List guidance, plans, and reports from previous investigations relevant to this project.

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.
   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Quality Assurance Project Plans: Part 1 UFP QAPP Manual*, Version 1.0 (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.
   - 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.
   - Intergovernmental Data Quality Task Force, March 2012. The *Uniform Federal Policy for Quality Assurance Project Plans, Optimized UFP QAPP Worksheets*.
   - *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, *Volume* 1. *Human Health*, RMD (EPA 2022b).

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: Initial scoping sessions for programmatic QAPP held December 2010 and January 2011

   Initial scoping sessions for project-specific QAPP held **(add dates here)**

Guidance, plans, and reports from previous investigations relevant to an individual project to be added under the appropriate headers above.

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(s):
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, DOE/LX/07-1269&D2/R1 (DOE 2013)	5/14/2013 5/20/2013
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, Paducah, Kentucky, DOE/LX/07-1269&D2/R2 (P-QAPP) (April 2015)	Not Applicable (N/A)
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, Paducah, Kentucky, DOE/LX/07-2402&D1 (P–QAPP) (March 2016)	N/A
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, Paducah, Kentucky, DOE/LX/07-2409&D1 (P–QAPP) (March 2017)	N/A
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, Paducah, Kentucky, DOE/LX/07-2421&D1 (P–QAPP) (April 2018)	N/A
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, Paducah, Kentucky, DOE/LX/07-2439&D1 (P–QAPP) (April 2019)	N/A
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, DOE/LX/07-2446&D1 (April 2020)	N/A
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, DOE/LX/07-2459&D1 (April 2021)	N/A
Paducah Gaseous Diffusion Plant Data Management Plan, DOE/LX/07-2458&D2 (August 2021) (DOE 2021a)	9/10/2021
Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan, DOE/LX/07-2479&D1 (March 2022) (DOE 2022b)	N/A

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

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

If any of the elements and/or information is not applicable to the project, then indicate the omitted QAPP elements/information on Table 1.

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

This QAPP includes all 28 combined worksheets that are required based on UFP-QAPP guidance, as updated by the optimized worksheet guidance (37 total worksheets). 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		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 & 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 Summary	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 Requirements, Supplies, and Consumables
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

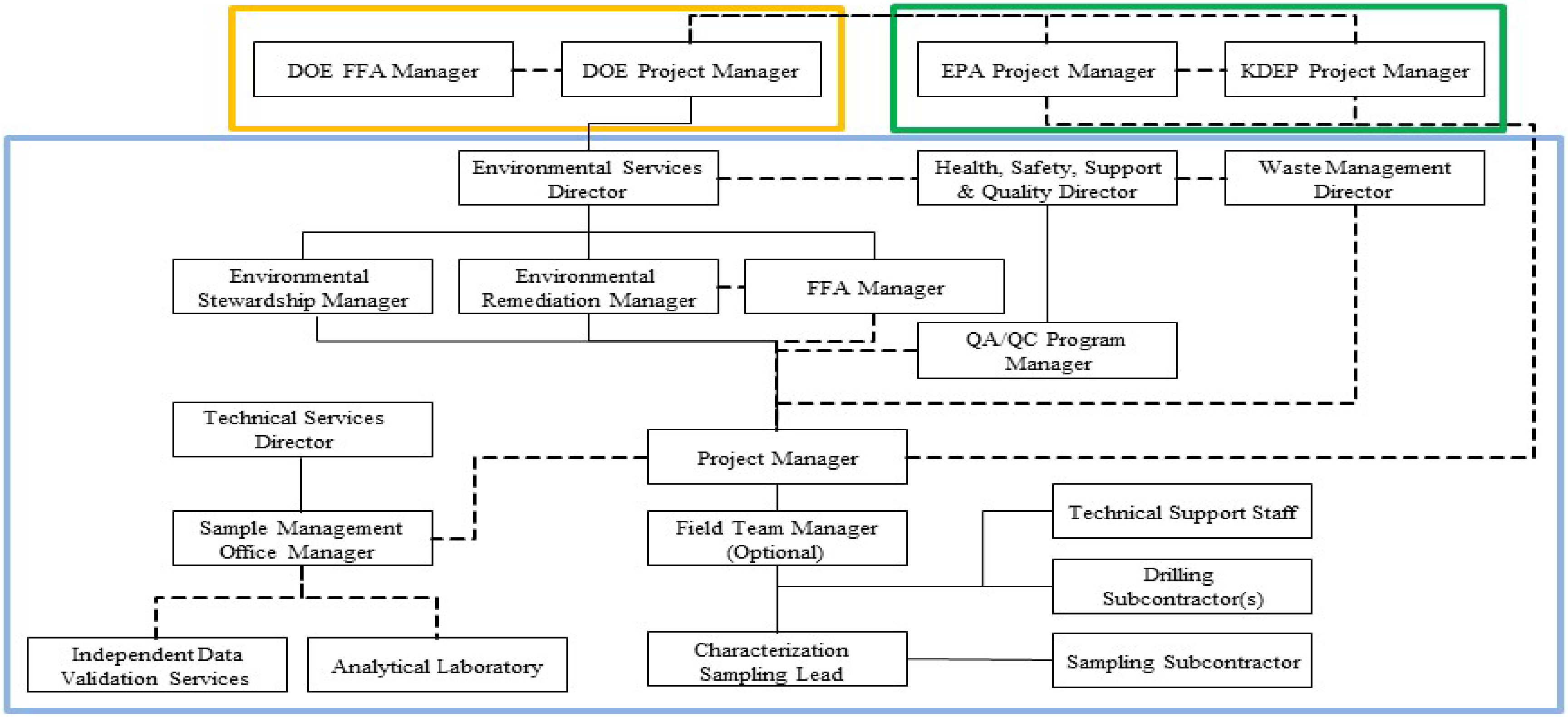
QAPP Worksheets #3 and #5. Project Organization and QAPP Distribution

(UFP-QAPP Manual Section 2.3 and 2.4)
(EPA 2106-G-05 Section 2.2.3 and 2.2.4)

This worksheet identifies key project personnel, as well as lines of authority and lines of communication among the lead agency, prime contractor, subcontractors, and regulatory agencies. An example is provided below. For the purpose of the draft QAPP, it is permissible to show "TBD" (to be determined) in cases where roles have not been assigned; however, key personnel must be identified in the final, approved QAPP.

For the purpose of document control, this worksheet also is used to document recipients of controlled copies of the QAPP (see following Minimum Distribution List). The draft QAPP, final QAPP, and any changes/revisions must be provided to QAPP recipients shown on that chart. Contractors and subcontractors shown on these charts and lists are responsible for document control within their organizations.

QAPP Worksheets #3 and #5. Project Organization and QAPP Distribution (Continued)



Notes:
DOE personnel are in Orange Box, Regulatory personnel are in Green Box, and DOE Prime Contractor personnel are in Blue Box.
Solid lines indicate lines of authority and dashed lines indicate lines of communication.

QAPP Worksheets #3 and #5. Project Organization and QAPP Distribution (Continued)
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 this worksheet and submit page changes to the document holders. This change will not require a review by FFA stakeholders because it is not a substantive change. Alternatively, as with other changes to the approved project-specific QAPP, personnel changes may be tracked and included as an attachment to the QAPP. Managers are responsible for distribution to their staffs.

Controlled copies of the project-specific QAPP derived from this programmatic QAPP will be distributed according to the distribution list below. This list will be updated, as needed, and kept by the FRNP Records Management Department. Each person receiving a controlled copy also will receive updates/revisions. If uncontrolled copies are distributed, it will be the responsibility of the person distributing the uncontrolled copy to provide updates/revisions.

Position Title	Organization	QAPP Recipients	Current Telephone Number	Current E-mail Address
FFA Manager	DOE	April Ladd	(270) 441-6843	april.ladd@pppo.gov
PM	DOE	TBD		
Environmental Services Director	FRNP	Bruce Ford	(270) 441-5357	bruce.ford@pad.pppo.gov
PM	FRNP	TBD		
FFA Manager	KDEP	Brian Begley	(502) 564-6716	brian.begley@ky.gov
PM	KDEP	TBD		
FFA Manager	EPA	Victor Weeks	(404) 562-9189	weeks.victor@epa.gov
PM	EPA	TBD		
FFA Manager	FRNP	LeAnne Garner	(270) 441-5436	leanne.garner@pad.pppo.gov
QA/QC Program Manager	FRNP	Jennie Freels	(270) 441-5407	jennie.freels@pad.pppo.gov
Sample Management Office (SMO) Manager	FRNP	Jaime Morrow (Acting)	(270) 441-5508	jaime.morrow@pad.pppo.gov
Health, Safety, Support, and Quality (HSS&Q) Director	FRNP	Duke Moscon	(270) 441-6538	duke.moscon@pad.pppo.gov
SMO	FRNP	Jaime Morrow	(270) 441-5508	jaime.morrow@pad.pppo.gov

QAPP Worksheets #3 and #5. Project Organization and QAPP Distribution (Continued)
Minimum Distribution List

Position Title	Organization	QAPP Recipients	Current Telephone Number	Current E-mail Address
Data Validator	A2RGC, LLC	TBD	TBD	TBD
Environmental Stewardship Manager	FRNP	Bruce Ford (Acting)	(270) 441-5357	bruce.ford@pad.pppo.gov
Environmental Remediation Manager	FRNP	Todd Powers (Acting)	(270) 441-5791	todd.powers@pad.pppo.gov
Characterization Sampling Lead	FRNP	Chris Skinner	(270) 441-5675	chris.skinner@pad.pppo.gov
Waste Management Director	FRNP	Carrie Maxie	(270) 441-5457	carrie.maxie@pad.pppo.gov
Analytical Laboratory	TBD	TBD	TBD	TBD
Sampling and/or Drilling Subcontractor	TBD	TBD	TBD	TBD

QAPP Worksheets #4, #7, and #8. Personnel Qualifications and Sign-off Sheet

(UFP-QAPP Manual Sections 2.3.2–2.3.4)
(EPA 2106-G-05 Section 2.2.1 and 2.2.7)

This worksheet is used to identify key project personnel for each organization performing tasks defined in this QAPP. In this example, organizations include the prime contractor and laboratory. Add spaces for additional organizations and personnel as needed. This worksheet lists individual's project titles or roles; qualifications; and any specialized/nonroutine training, certifications, or clearances required by the project (e.g., explosives and ordnance disposal technician, professional engineer, certified professional geologist).

ORGANIZATION: Four Rivers Nuclear Partnership, LLC

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date*
Bruce Ford	Environmental Services Director, FRNP	> 4 years relevant work experience	No specialized training or certification. See Training Project Description (TPD).	
TBD	Project Manager, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Jaime Morrow (Acting)	SMO Manager, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Jaime Morrow	SMO, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Chris Skinner	Characterization Sampling Lead	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Duke Moscon	HSS&Q Director, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Bruce Ford (Acting)	Environmental Stewardship Manager, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Todd Powers (Acting)	Environmental Remediation Manager, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
TBD	Data Validator, A2RGC, LLC	Bachelor degree plus relevant experience	No specialized training or certification.	Follows FRNP data validation plans.

QAPP Worksheets #4, #7, and #8. Personnel Qualifications and Sign-off Sheet (Continued)

ORGANIZATION: Laboratory

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date*
Laboratory PM	Analytical Laboratory PM	> 4 years relevant work experience	No specialized training or certification. See TPD.	Follows the laboratory statement of work.

*Signature indicates personnel have read and agree to implement this QAPP as written.

QAPP Worksheet #6. Communication Pathways

(UFP-QAPP Manual Section 2.4.2)
(EPA 2106-G-05 Section 2.2.4)

This worksheet should be used to document specific issues (communication drivers) that will trigger the need to communicate with other project personnel or stakeholders. Its purpose is to ensure that there are procedures in place for providing the appropriate notifications and generating the appropriate documentation when handling important communications, including those involving regulatory interfaces, unexpected events, emergencies, nonconformances, and stop work orders. Examples are provided below; additional drivers may be added as needed.

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway, documentation, etc.)
Regulatory agency interface	DOE, EPA, KDEP	DOE PM: Richard Bonczek; EPA Remedial PM: Victor Weeks; KDEP PM: Brian Begley	rich.bonczek@pppo.gov weeks.victor@epa.gov brian.begley@ky.gov	Formal communication among DOE, EPA, and KDEP.
FFA	DOE, EPA, KDEP	DOE FFA Manager: April Ladd; EPA FFA Manager: Victor Weeks; KDEP FFA Manager: Brian Begley	april.ladd@pppo.gov weeks.victor@epa.gov brian.begley@ky.gov	Formal communication among DOE, EPA, and KDEP.
Field progress reports	FRNP	FRNP Environmental Services Director: Bruce Ford FRNP Project Manager: TBD	bruce.ford@pad.pppo.gov TBD	Formal communication among the project staff, the site lead, and the DOE PM.
Stop work due to safety issues	FRNP	FRNP Environmental Services Director: Bruce Ford; FRNP HSS&Q Director: Duke Moscon	bruce.ford@pad.pppo.gov duke.moscon@pad.pppo.gov	FRNP will communicate work stoppages to DOE PM as required by procedure.
QAPP changes prior to fieldwork	FRNP	FRNP Environmental Services Director: Bruce Ford; FRNP QA/QC Program Manager: Jennie Freels	bruce.ford@pad.pppo.gov jennie.freels@pad.pppo.gov	Obtain approval from DOE PM. Submit QAPP amendments to DOE, KDEP, and EPA.

QAPP Worksheet #6. Communication Pathways (Continued)

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway, documentation, etc.)
QAPP changes during project execution	FRNP	FRNP Environmental Services Director: Bruce Ford; FRNP QA/QC Program Manager: Jennie Freels	bruce.ford@pad.pppo.gov jennie.freels@pad.pppo.gov	Obtain approval from DOE PM. Submit QAPP amendments to DOE, KDEP, and EPA.
Field corrective actions	FRNP	FRNP Environmental Services Director: Bruce Ford	bruce.ford@pad.pppo.gov	Field corrective actions will need to be approved by FRNP Project Director and communicated to the DOE, EPA, and KDEP PMs.
Sample receipt variances	FRNP	FRNP SMO Manager: Jaime Morrow(Acting)	jaime.morrow@pad.pppo.gov	Communication between FRNP and analytical laboratory.
Analytical laboratory interface	FRNP	FRNP SMO Manager: Jaime Morrow (Acting)	jaime.morrow@pad.pppo.gov	Communication between FRNP and analytical laboratory.
Laboratory quality control variances	Contracted Laboratory	Laboratory PM: TBD	TBD	Notify FRNP SMO. SMO will notify FRNP PM to determine corrective actions.
Analytical corrective actions	Contracted Laboratory, FRNP	Laboratory PM: TBD; FRNP SMO Manager: Jaime Morrow (Acting)	TBD jaime.morrow@pad.pppo.gov	Notify FRNP SMO. SMO will notify the project.
Data verification issues (e.g., incomplete records)	A2RGC, LLC	Data Validator: TBD; FRNP SMO Manager: Jaime Morrow (Acting)	TBD jaime.morrow@pad.pppo.gov	Data verification issues will be reported to the FRNP SMO.
Data validation issues (e.g., noncompliance with procedures)	A2RGC, LLC	Data Validator: TBD; FRNP SMO Manager: Jaime Morrow (Acting)	TBD jaime.morrow@pad.pppo.gov	Issues with data quality will be reported to the FRNP SMO.
Data review corrective actions	FRNP	FRNP SMO Manager: Jaime Morrow (Acting)	jaime.morrow@pad.pppo.gov	SMO will notify the project.

NOTE: This QAPP is position-based with names of the current positions presented. In the event the contractor changes and the position titles change, DOE will notify EPA and KDEP of the change.

NOTE: Formal communication across company or regulatory boundaries occurs via letter. Other forms of communication, such as e-mail, telephone calls, meetings, etc., will occur throughout the project. The DOE Project Manager will communicate preliminary analytical results and field updates with the regulatory agencies project managers throughout the project. The project will establish regular conference calls during fieldwork and throughout preparation of the report to discuss analytical data and other project information. Issues identified during fieldwork that require changes to the work plan or deviations will be communicated by the DOE Project Manager to the regulatory agencies project managers using communication tools commensurate with the issue. This type of communication will be as timely as possible.

QAPP Worksheet #9. Project Planning Session Summary

(UFP-QAPP Manual Section 2.5.1 and Figures 9–12)
(EPA 2106-G-05 Section 2.2.5)

A copy of this worksheet should be completed for each project planning session, whether sessions are internal (project teams only) or external (includes regulators and/or stakeholders). It is used to provide a concise record of participants, key decisions or agreements reached, and action items. Depending on the stage of planning, project-planning sessions should involve key technical personnel, as needed. Scoping sessions can be by phone, Web conferencing, and/or face-to-face meeting, depending upon logistical considerations. Previous meeting minutes can be included as attachments, if necessary, and referenced. Users may find it helpful to have copies of worksheets on hand for planning sessions, in whatever state of completion they may be; however, Worksheets #10, #11, #15, and #17 should be prioritized in the early stages of project planning. The following template may be modified to suit both the project and the specific planning session.

Project-specific QAPPs developed in association with FSPs will follow the same systematic planning process. The type and frequency of scoping sessions and the type and number of persons who participate in scoping sessions are related to the size and complexity of the project, technical components of the project, and the number of organizations involved. For example, small projects may use project teams that consist of only two or three people who convene via teleconference. A typical scoping component is a kick-off meeting to establish and define the roles and responsibilities of each team member, set out performance requirements for response times and project execution, and build a project team. QAPP Worksheet #9 will be completed for project-specific QAPPs. Example Worksheet #9 entries are provided below from the C-400 Complex Remedial Investigation/Feasibility Study (RI/FS) sampling.

QAPP Worksheet #9. Project Planning Session Summary (Continued)

Scoping meetings were held concerning the C-400 Complex RI/FS sampling prior to developing the SAP and QAPP. The following tables include details about these meetings. A properly prepared Worksheet #9 should include key decisions or agreements reached and action items. Scoping also may address potential relevant-to-the-project issues (e.g., geology, climate, population distributions, endangered species).

Name of Project: C-400 Complex RI/FS Sampling
Date of Session: March 13–15, 2018
Scoping Session Purpose: DOE and its contractors, EPA and its contractors, and KDEP met to scope the C-400 Complex Operable Unit RI/FS and develop DQOs.

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
Project Manager	DOE	Dollins, David	270-441-6819	dave.dollins@pppo.gov	Project management
Project Manager	FRNP	Powers, Todd	270-441-5791	todd.powers@pad.pppo.gov	Project management
FFA Manager and Project Manager	EPA	Corkran, Julie	404-562-8547	corkran.julie@epa.gov	Project management
FFA Manager	KDEP	Begley, Brian	502-782-6317	brian.begley@ky.gov	Project management
Project Manager	KDEP	Brewer, Gaye	270-898-8468	gaye.brewer@ky.gov	Technical support
Technical Advisor	EPA	Ahsanuzzaman, Noman	404-562-8047	ahsanuzzaman.noman@epa.gov	Technical support
Technical support	FRNP	Baker, Cheryl	270-441-6288	cheryl.baker@pad.pppo.gov	Technical support
Technical support	EPA	Bentkowski, Ben	404-562-8507	bentkowski.ben@epa.gov	Technical support
Technical support	DOE	Bonczek, Richard	859-219-4051	rich.bonczek@pppo.gov	Technical support
Technical support	CHFS	Brock, Stephanie	502-564-8390	stephaniec.brock@ky.gov	Technical support
Technical support	Pro2Serve	Butterworth, George	270-441-6803	george.butterworthiii@pppo.gov	Technical support
Technical support	SMSI	Clauberg, Martin	865-259-7155	martin.clauberg@pppo.gov	Technical support
Technical support	FRNP	Clayton, Bryan	270-441-5412	bryan.clayton@pad.pppo.gov	Technical support
Technical support	EPA	Davis, Eva	580-436-8548	davis.eva@epa.gov	Technical support
Technical support	FRNP	Davis, Ken	270-441-5049	ken.davis@pad.pppo.gov	Technical support
Technical support	TechLaw	Dawson, Jana	703-627-0821	jdawson@techlawinc.com	Technical support
Technical support	FRNP	Flynn, Robert	270-441-5171	robert.flynn@pad.pppo.gov	Technical support
Technical support	FRNP	Ford, Bruce	270-441-5357	bruce.ford@pad.pppo.gov	Technical support
Technical support	FRNP	Fountain, Stefanie	270-441-5722	stefanie.fountain@pad.pppo.gov	Technical support
Technical support	FRNP	Garner, LeAnne	270-441-5436	leanne.garner@pad.pppo.gov	Technical support
Technical support	CHFS	Garner, Nathan	502-564-8390	nathan.garner@ky.gov	Technical support
Technical support	KDEP	Guffey, Mike	502-330-4454	mike.guffey@ky.gov	Technical support
Technical support	KDEP	Higginbotham, Jeri	502-782-6654	jeri.higginbotham@ky.gov	Technical support
Technical support	KDEP	Jung, Christopher	502-782-6391	christopher.jung@ky.gov	Technical support
Technical support	Sapere	Kytola, Kevin	509-524-2343	kkytola@sapereconsulting.com	Technical support

QAPP Worksheet #9. Project Planning Session Summary (Continued)

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
Technical support	DOE	Ladd, April	270-441-6843	april.ladd@pppo.gov	Technical support
Technical support	KDEP	Lainhart, Brian	270-898-8468	brian.lainhart@ky.gov	Technical support
Technical support	FRNP	Layne, Kelly	270-441-5206	kelly.layne@pad.pppo.gov	Technical support
Technical support	TechLaw	McRae, Mac	678-493-1247	mmcrae@techlawinc.com	Technical support
Technical support	FRNP	Morgan, John	270-441-5206	john.morgan@pad.pppo.gov	Technical support
Technical support	KDEP	Newton, Aaron	502-523-8023	aaron.newton@ky.gov	Technical support
Technical support	Sapere	Parsons, Christopher	509-524-2345	cparsons@sapereconsulting.com	Technical support
Technical support	FRNP	Powers, Todd	270-441-5206	todd.powers@pad.pppo.gov	Technical support
Technical support	TechLaw	Rapal, Kristen	312-345-8929	kristen.rapal@techlawinc.com	Technical support
Technical support	Pro2Serve	Taylor, Tracy	270-441-6866	tracy.taylor@pppo.gov	Technical support
Technical support	FRNP	Walker, Curt	270-441-5226	curt.walker@pad.pppo.gov	Technical support
Technical support	FRNP	White, Jana	270-441-5206	jana.white@pad.pppo.gov	Technical support

CHFS = Cabinet for Health and Family Services

Notes/comments:

Consensus decisions made:

- One hundred nine boring locations agreed upon by FFA parties.
- Analytical compounds chosen by the FFA parties.
- During the scoping process, progress was made in defining sample locations, clarifying concepts and identifying data needs, exchanging ideas on investigation methods, and identifying and resolving concerns/issues related to the RI/FS Work Plan development.

Action items:

Action	Responsible Party	Due Date
Action items were identified and resolved during scoping activities by the FFA parties and incorporated into the work plan as appropriate.	FRNP Project Manager	November 19, 2018

QAPP Worksheet #10. Conceptual Site Model

(UFP-QAPP Manual Section 2.5.2)
(EPA 2106-G-05 Section 2.2.5)

This worksheet is used to present the project's conceptual site model (CSM). The CSM is a tool to assist in the development of DQOs. The CSM primarily uses text and/or figures, but also may include tables to convey succinctly what currently is known about the site, and it should be updated as new data are collected. As with the QAPP in general, the level of detail in the CSM should be based on the graded approach. If an investigation includes multiple sites with unique characteristics or problems to be addressed, then a separate CSM should be prepared for each site. The CSM should include the following information.

- Background information (i.e., site history, unless this information is presented in an Executive Summary);
- Sources of known or suspected hazardous waste;
- Known or suspected contaminants or classes of contaminants;
- Primary release mechanism;
- Secondary contaminant migration;
- Fate and transport considerations;
- Potential receptors and exposure pathways;
- Land use considerations;
- Key physical aspects of the site (e.g., site geology, hydrology, topography, climate); and
- Current interpretation of nature and extent of contamination to the extent that it will influence project-specific decision making.

Data gaps and uncertainties associated with the CSM need to be identified clearly.

QAPP Worksheet #10 may be used as an outline for the problem discussion in the QAPP. **The project team developing the project-specific FSP and associated QAPP may choose to include this information in the body of the report rather than populating this worksheet.** An example Worksheet #10 is taken from the RI/FS Work Plan for the C-400 Complex Operable Unit and is found in Appendix D of this document (DOE 2020).

QAPP Worksheet #11. Project/Data Quality Objectives

(UFP-QAPP Manual Section 2.6.1)
(EPA 2106-G-05 Section 2.2.6)

This worksheet is used to develop and document project quality objectives (PQOs) or DQOs using a systematic planning process (SPP). Examples of SPP include (1) the DQO process[1] and (2) the U.S. Army Corps of Engineers' Technical Planning Process.[2] This statement (along with all other statements in this P-QAPP) must be confirmed in the preparation of the project-specific QAPP or modified, as needed. The type of SPP used will vary based on the graded approach. This worksheet mainly is populated as text, although some diagrams that capture decision processes are recommended. Regardless of the SPP applied, the QAPP must document the environmental decisions that need to be made and the level of data quality needed to ensure that those decisions are based on sound scientific data. The following guidelines are based on EPA's seven-step DQO process.

1. State the Problem. The problem statement should be consistent with information contained in the CSM (Worksheet #10).
   - Consider the following drivers:
     - DOE Order (O) 436.1, Departmental Sustainability
     - DOE O 450.1A, Environmental Protection Program
     - DOE O 458.1, Radiation Protection of the Public and the Environment
     - DOE-HDBK-1216-2015, Environmental Radiological Effluent Monitoring and Environmental Surveillance
     - Commonwealth of Kentucky Environmental Permits
     - CERCLA Actions
     - FFA

2. Identify the Goals of the Study. Identify specific study questions and define alternative outcomes. The goals for either decision or estimation problems should explain how the data will be used to answer questions and choose among the stated alternatives. Characterizing the "nature and extent of contamination" is a commonly stated but inappropriate study goal because it is vague and not focused on potential outcomes.

3. Identify Information Inputs. Specify the types of data that are required to fill gaps in the CSM. Explain in specific terms how data will be used. In addition to analytical data, this could include published information on geology, climate, population distributions, endangered species, etc. Information inputs should be consistent with decisions made during project scoping, as documented on Worksheet #9.

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[1] *Guidance on Systematic Planning Using the Data Quality Objectives Process*, U.S. EPA, EPA QA/G-4, February 2006.
[2] *Technical Project Planning Process*, U.S. Army Corps of Engineers, EM 200-1-2, August 1998.

QAPP Worksheet #11. Project/Data Quality Objectives (Continued)

4. Define the Boundaries of the Study. Specify the target population and characteristics of interest, define spatial/temporal limits, and the scale of inference (i.e., which populations will be represented by which data). Developing the list of target analytes presents one of the greatest opportunities for streamlining a project, because it can help avoid unnecessary costs associated with sampling, analysis, data review, reporting, and management. Target analytes should be focused on specific constituents reasonably known or suspected to be present. The list of target analytes should be based on data gaps in the CSM. Focusing the list of analytes also provides better opportunities for optimizing method performance to best suit those analytes.

5. Develop the Analytic Approach. Define the parameter(s) of interest; specify the type of inference [e.g., "samples from groundwater monitoring wells (MWs) x, y, and z will represent potable water at the site]; and develop the logic for drawing conclusions from findings (i.e., which sample results will be used to support which decisions.) For decision problems, these are expressed as "if---then" statements, or decision rules, that link potential results with conclusions or future actions. For estimation problems, specify the estimator and the estimation procedure.

6. Specify Performance or Acceptance Criteria. For projects that involve hypothesis testing (e.g., presence or absence of contamination exceeding some threshold value) for decision-making, this will involve specifying probability limits for decision errors. For estimations and other analytic approaches (e.g., estimating the volume of groundwater or soil potentially requiring remediation), this will involve the development of performance criteria (for new data being collected) or acceptance criteria (for existing data being considered for use).

7. Develop the Detailed Plan for Obtaining Data. Worksheet #11 generally will briefly explain the basis for the sampling design and then refer to Worksheet #17, Sample Design and Rationale, for further details. Worksheets #19 and #30, #20, and #24–#28, will specify analysis design requirements.

QAPP Worksheet #11. Project/Data Quality Objectives (Continued)

[Example taken from RI/FS Work Plan for the C-400 Complex Operable Unit (DOE 2020)]

Step 1. State the Problem:

Hazardous substances that historically have been present and/or migrated from the C-400 Complex and its solid waste management units (SWMUs) have been released to surrounding environmental media. These substances, in turn, have infiltrated into groundwater and been transported through subsurface pathways. The nature and extent of contamination have been defined adequately for some SWMUs and areas, and risk assessments have been prepared. For other SWMUs and areas, the nature and extent of contamination have not been defined adequately to assess whether potential contaminants pose unacceptable risks to human health and the environment at the C-400 Complex and at downgradient exposure points. Data gaps must be identified so that a comprehensive RI/FS report can be prepared for the C-400 Complex.

Problem Description: Within the C-400 Complex area, there have been 22 SWMUs identified. Of the SWMUs present, 15 have been identified as requiring no further action. The remaining seven SWMUs requiring action include, SWMUs 11, 40, 47, 98, 203, 480, and 533. In addition numerous potential and known spill areas (stained areas) have been identified requiring further investigation. The COPCs included radionuclides, metals, inorganic compounds, volatile organic compounds, semivolatile compounds, and PCBs. The C-400 Complex area also is the suspected source zone for trichloroethene (TCE) contamination associated with the Northeast and Northwest Groundwater Plumes and likely the source zone for technetium-99 (Tc-99) contamination associated with the Northwest Groundwater Plume.

Problem Approach: The planning team determined that it will be best to divide the C-400 Complex into seven sectors: six of these sectors surround the C-400 Cleaning Building; and the seventh sector is the C-400 Cleaning Building, which is divided further into four subsectors. The sampling strategy for the C-400 Complex will focus on concrete slabs, surface soils, subsurface soils, and groundwater.

Planning Team: FFA parties, FRNP

- Conceptual Model: See Section 4.10 of this work plan.
- Determine Resources:
  - Schedule: See Worksheets #14 and #16
  - Budget: Based upon final scope of work
  - Personnel: FRNP

QAPP Worksheet #11. Project/Data Quality Objectives (Continued)

Step 2. Identify the Goals of the Study:

- Characterize nature of source zone(s).
- Define extent of source and contamination in soil and remaining structures in the operable unit area.
- Evaluate potential for surface and subsurface transport mechanisms and pathways.
- Complete a risk assessment for the C-400 Complex.
- Identify, develop, and evaluate remedial alternatives.

Step 3. Identify Information Inputs:

Concrete, soil, and groundwater sample results for quantitative use in determining contamination contained within the footprint of the C-400 Complex area.

Step 4. Identify the Boundaries of the Study:

Boundary of the study area is defined by the outer edges of the surrounding roadways (Virginia Street to the north, 11th Street to the east, Tennessee Street to the south, and 10th Street to the west) that encompass the C-400 Cleaning Building footprint.

Step 5. Develop the Analytical Approach:

- The samples will undergo chemical analysis at a contract laboratory, consistent with the contract protocols.

Step 6. Specify Performance or Acceptance Criteria:

- Analytical sample results must successfully undergo assessment and validation to be used to support the C-400 Complex RI/FS and to support CERCLA analysis.

Step 7. Develop the Detailed Plan for Obtaining Data:

- The process of obtaining the data has been laid out in the SAP section.

QAPP Worksheet #11. Project/Data Quality Objectives (Continued)

General Notes on Project Quality Objectives/Systematic Planning Process

The following should be considered in the preparation of a project-specific QAPP to ensure that the project quality objectives are met.

- Aluminum analyses in surface soil that will be used for ecological screening also should include pH analysis.
- Metals analyses for surface water to be used for ecological screening should include hardness analysis.
- Lead (Pb) limits are being reevaluated by EPA; future QAPPs may need to update Project Action Limits (PALs) for lead.
- Field methods will not meet the same DQOs as lab data; however, field methods provide additional information at reduced cost.
- Data from grab water samples will not meet the same DQOs as samples from properly installed and developed wells.
- Current SOPs should be provided on electronic storage media along with submitted project-specific QAPP.

QAPP Worksheet #12. Measurement Performance Criteria

(UFP-QAPP Manual Section 2.6.2)
(EPA 2106-G-05 Section 2.2.6)

This worksheet documents the quantitative measurement performance criteria (MPC) in terms of precision, bias, and sensitivity for both field and laboratory measurements and is used to guide the selection of appropriate measurement techniques and analytical methods. MPC are developed to ensure collected data will satisfy the PQOs or DQOs documented on Worksheet #11. Example MPC include relative percent difference (RPD) comparisons and no target compounds greater than practical quantitation limit (PQL) or minimum detectable activity (MDA). A separate worksheet should be completed for each type of field or laboratory measurement. For analytical methods, MPC should be determined for each matrix, analyte, and concentration level. [Qualitative MPC (representativeness and comparability) should be addressed in the sample design, which is documented on Worksheet #17.] If MPC are analyte-specific, include this detail in a separate table or modify this worksheet as necessary. Example QAPP Worksheet #12 information is provided below, representing the currently used analytical methods. The listed methods have been reviewed to ensure that the criteria summarized below are aligned with those presented in the method. In the preparation of the project-specific QAPP, this information shall be confirmed. Changes in the method or laboratory can result in changes to these criteria.

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

QAPP Worksheet #12-A. Measurement Performance Criteria (VOCs, Water)

Matrix	Water
Analytical Group[a]	Volatile Organic Compounds (VOCs)
Concentration Level	Low to High

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8260 and EPA-624.1 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-B. Measurement Performance Criteria (SVOCs, Water)

Matrix	Water
Analytical Group[a]	Semivolatile Organic Compounds (SVOCs)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8270 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-C. Measurement Performance Criteria (Pesticides, Water)

Matrix	Water
Analytical Group[a]	Pesticides (Dieldrin)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8081 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy	RPD—≤ 40%	Dual Column Analysis	A
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-D. Measurement Performance Criteria (Metals, Water)

Matrix	Water
Analytical Group[a]	Metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium (total), chromium (VI), cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc)
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP**[b]	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	EPA-200.8/ SW-846-6010/6020 or EPA-245.2/ SW-846-7470 or SW-846-7196 See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias	RPD—80-120%	Interference Check Sample	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-E. Measurement Performance Criteria (Anions, Water)

Matrix	Water
Analytical Group[a]	Anions (Fluoride)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-9056 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported, divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-F. Measurement Performance Criteria (PCBs, Water)

Matrix	Water
Analytical Group[a]	PCBs
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8082 and EPA-608.3 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy	RPD—≤ 40%	Dual Column Analysis	A
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-G. Measurement Performance Criteria (Radionuclides, Water)

Matrix	Water
Analytical Group[a]	Radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, thorium-230, uranium-234, uranium-235, and uranium-238)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-H. Measurement Performance Criteria (Radionuclides, Water)

Matrix	Water				
Analytical Group[a]	Radionuclides (cesium-137)				
Concentration Level	Low				
Sampling Procedure	**Analytical Method/SOP**[b]	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	Gamma spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-I. Measurement Performance Criteria (Radionuclides, Water)

Matrix	Water
Analytical Group[a]	Radionuclides (technetium-99)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Liquid scintillation See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-J. Measurement Performance Criteria (VOCs, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	VOCs
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8260 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-K. Measurement Performance Criteria (SVOCs, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	SVOCs
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8270 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-L. Measurement Performance Criteria (Pesticides, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete				
Analytical Group[a]	Pesticides (Dieldrin)				
Concentration Level	Low				
Sampling Procedure	**Analytical Method/SOP[b]**	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-8081 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy	RPD—≤ 40%	Dual Column Analysis	A
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-M. Measurement Performance Criteria (Metals, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	Metals [aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium (total), chromium (VI), cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc]
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP**[b]	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-6010/6020 or SW-846-7471 or SW-846-7196 See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias	RPD—80-120%	Interference Check Sample	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-N. Measurement Performance Criteria (Anions, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	Anions (Fluoride)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-9056 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-O. Measurement Performance Criteria (PCBs, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	PCBs
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8082 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy	RPD—≤ 40%	Dual Column Analysis	A
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-P. Measurement Performance Criteria (Radionuclides, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	Radionuclides (uranium-234, uranium-235, and uranium-238)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-Q. Measurement Performance Criteria (Radionuclides, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	Radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, and thorium-230)
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP**[b]	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-R. Measurement Performance Criteria (Radionuclides, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	Radionuclides (actinium-227, cesium-137, cobalt-60, lead-210, and protactinium-231)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Gamma spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-S. Measurement Performance Criteria (Radionuclides, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	Radionuclides (technetium-99)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Liquid scintillation See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-T. Measurement Performance Criteria (Dioxins and Furans, Soil/Sediment or Concrete)

Matrix	Soil/Sediment or Concrete
Analytical Group[a]	Dioxins and Furans
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8290 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-U. Measurement Performance Criteria [Uranium (XRF), Soil/Sediment]

Matrix	Soil/Sediment				
Analytical Group[a]	Metals (uranium)				
Concentration Level	Low				
Sampling Procedure	**Analytical Method/SOP[b]**	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-6200 (XRF) See Worksheet #23	Precision	RPD—≤ 35%	Field Duplicates	S
		Precision—Lab	Duplicate result within 95% confidence interval of original reading	Laboratory Duplicates	A
		Accuracy/Bias Contamination	No target compounds > quantitation limit	Method Blanks/Instrument Blanks	A
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-V. Measurement Performance Criteria (Total PCBs, Soil/Sediment)

Matrix	Soil/Sediment
Analytical Group[a]	Total PCBs (Aroclors 1016, 1232, 1242, 1248, 1254, and 1260)
Concentration Level	Moderate

Sampling Procedure[b]	Analytical Method/SOP[c]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Per manufacturer's instructions	SW-846-4020 (immunoassay test kit) See Worksheet #23	Precision	N/A	Compare results against laboratory values	S
		Accuracy/Bias Contamination	N/A	Compare results against laboratory values	A
		Completeness[d]	N/A	Compare results against laboratory values	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] No procedure specific to method; use manufacturer's instructions.
[c] SW-846 Method; the most current version of the method the laboratory is accredited to perform will be used; No SOP specific to Method; use manufacturer's instructions.
[d] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-W. Measurement Performance Criteria (PAHs, Soil/Sediment)

Matrix	Soil/Sediment
Analytical Group[a]	PAHs (3-, 4-, 5-ring compounds including phenanthrene, anthracene, fluorine, benzo(a)anthracene, chrysene, fluoranthene, and pyrene)
Concentration Level	Moderate

Sampling Procedure[b]	**Analytical Method/SOP**[c]	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
Per manufacturer's instructions	SW-846-4035 (PAH test kit) See Worksheet #23	Precision	N/A	Compare results against laboratory values and/or Field Duplicates	S
		Accuracy/Bias Contamination	N/A	Compare results against laboratory values Method Blanks/Instrument Blanks and/or Field Duplicates	A
		Completeness[d]	N/A	Compare results against laboratory values Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] No procedure specific to method; use manufacturer's instructions.
[c] SW-846 Method; the most current version of the method the laboratory is accredited to perform will be used. No SOP specific to Method; use manufacturer's instructions.
[d] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-X. Measurement Performance Criteria (VOCs, Air)

Matrix	Air
Analytical Group[a]	VOCs including trichloroethene; 1,2-dichloroethene; vinyl chloride; and 1,1-dichloroethene
Concentration Level	Very Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	EPA-TO-15, See Worksheet #23	Precision—Lab	RPD < 25%	Evaluate Lab Data Packages Gas Chromatography/Mass Spectrometry (GC/MS) Results	A
		Precision	RPD ≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[e]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Sensitivity[c]	See Worksheet #15	Samples Reported to PQL	S
		Completeness[d]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Sensitivity as included on this worksheet is defined as the capability of a method or instrument to discriminate between small differences in analyte concentration in combination with the qualitative description of an instrument's or analytical method's detection limit.
[d] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[e] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-Y. Measurement Performance Criteria (Mercury, Air)

Matrix	Air				
Analytical Group[a]	Mercury				
Concentration Level	Low				
Sampling Procedure	**Analytical Method/SOP**	**Data Quality Indicators**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	Field Screening by Mercury Vapor Analyzer (Jerome J505 or equivalent)	Sensitivity[b]	See Worksheet #15	Samples Reported to PQL	S

[a] If information varies within an analytical group, separate by individual analyte.
[b] Sensitivity as included on this worksheet is defined as the capability of a method or instrument to discriminate between small differences in analyte concentration in combination with the qualitative description of an instrument's or analytical method's detection limit.

QAPP Worksheet #12-Z. Measurement Performance Criteria (PCBs, Wipe)

Matrix	Wipe				
Analytical Group[a]	PCBs				
Concentration Level	Low				
Sampling Procedure	**Analytical Method/SOP**[b]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
See Worksheet #21	SW-846-8082 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy	RPD—≤ 40%	Dual Column Analysis	A
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-AA. Measurement Performance Criteria (Radionuclides, Wipe)

Matrix	Wipe
Analytical Group[a]	Radionuclides (uranium-234, uranium-235, and uranium-238)
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP**[b]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-BB. Measurement Performance Criteria (Radionuclides, Wipe)

Matrix	Wipe
Analytical Group[a]	Radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, and thorium-230)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-CC. Measurement Performance Criteria (Radionuclides, Wipe)

Matrix	Wipe
Analytical Group[a]	Radionuclides (cesium-137)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
See Worksheet #21	Gamma spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
- as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
- as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-DD. Measurement Performance Criteria (Radionuclides, Wipe)

Matrix	Wipe
Analytical Group[a]	Radionuclides (technetium-99)
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
See Worksheet #21	Liquid scintillation See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-EE. Measurement Performance Criteria (Dissolved Hydrocarbon Gases, Water)

Matrix	Groundwater
Analytical Group[a]	Dissolved Hydrocarbon Gases (e.g., Methane, Ethane, Ethene)
Concentration Level	Low to Moderate

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
See Worksheet #21	RSKSOP-175 Modified See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-FF. Measurement Performance Criteria (Total Organic Carbon, Water)

Matrix	Groundwater
Analytical Group[a]	Total Organic Carbon
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
See Worksheet #21	SW-846-9060A See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[d]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[d] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-GG. Measurement Performance Criteria (*Dehalococcoides ethenogens* Bacteria, Water)

Matrix	Groundwater				
Analytical Group[a]	*Dehalococcoides ethenogens* (DHC) Bacteria (Quantitative)				
Concentration Level	Low				
Sampling Procedure	**Analytical Method/SOP[b]**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
See Worksheet #21	DHC Bacteria and functional genes by quantitative polymerase chain reaction (qPCR) See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Completeness[c]	90%	Data Completeness Check	S&A

[a] If information varies within an analytical group, separate by individual analyte.
[b] The most current version of the method the laboratory is accredited to perform will be used.
[c] Completeness is calculated by two methods:
— as the number of valid analytical results reported divided by the number of analytical results planned, multiplied by 100 to obtain the percentage.
— as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #13. Secondary Data Uses and Limitations

(UFP-QAPP Manual Section 2.7)
(EPA 2106-G-05 Chapter 3: QAPP Elements for Evaluating Existing Data)

This worksheet should be used to identify sources of secondary data (i.e., data generated for purposes other than this specific project or data pertinent to this project generated under a separate QAPP) and summarize information relevant to their uses for the current project. This worksheet should be supplemented by text describing specifically how secondary data will be used. The project team needs to carefully evaluate the quality of secondary data (in terms of precision, bias, representativeness, comparability, and completeness) to ensure they are of the type and quality necessary to support their intended uses. Secondary data can include the following: sampling and testing data collected during previous investigations, historical data, background information, interviews, modeling data, photographs, aerial photographs, topographic maps, and published literature. When evaluating the reliability of secondary data and determining limitations on their uses, consider the source of the data, the time period during which they were collected, methods by which data were collected, potential sources of uncertainty, the type of supporting documentation available, and the comparability of data collection methods to the currently proposed methods. Examples are provided below.

QAPP Worksheet #13. Secondary Data Uses and Limitations (Continued)

(Example taken from C-400 Complex RI/FS Project)

Secondary Data Type	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/ Collection Dates)	How Data Will Be Used	Factors Affecting Reliability and Limitations on Data Use
OREIS Database	Various	Various	Data will be used to determine whether the concrete slab is a potential secondary source of contamination. The data will be used in conjunction with RI/FS data to be collected at a later date.	Data have been verified, assessed, and validated (if validation is required). Rejected data will not be used.
Historical Documentation	CH2M HILL 1992. *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/Sub/13B-97777C P03/1991/1. DOE 1995. *C-400 Process and Structure Review*, KY/ERWM-38, U.S. Department of Energy, Paducah, KY, May. DOE 1999. *Remedial Investigation Report for Waste Area Grouping 6 (C-400) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1727&D2.	DOE contractors, soil and aqueous, 1992–1999 Various	Information will be used in conjunction with newly collected data to determine chemical or radionuclide of potential concern are present in the concrete slabs. Information will be used as guidance on related project work.	Data have been verified, assessed, and validated (if validation required). Rejected data will not be used. Information from historical documents will be limited to the available documentation as it relates to a specific project. Use of historical data may be limited based on how long ago the data were collected and whether site conditions have changed since data collection.

NOTE: Oak Ridge Environmental Information System (OREIS) is the repository for environmental and waste characterization analytical results. OREIS is a limited access database. Most of the results in OREIS are downloaded to PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS) periodically (usually on a quarterly basis). The general public can access data in PEGASIS.

QAPP Worksheets #14 and #16. Project Tasks & Schedule

(UFP-QAPP Manual Section 2.8.2)
(EPA 2106-G-05 Section 2.2.4)

The QAPP should include a project schedule showing specific tasks, the person or group responsible for their execution, and planned start and end dates. Options for presenting this information include the following template or a Gantt chart that can be attached and referenced. Examples of activities that should be listed include key on-site and off-site activities. Any critical steps and dates should be highlighted.

The table will not need to be included as a worksheet as long as a schedule is included with the site-specific FSP. If the schedule is provided in the FSP, the QAPP should include a statement such as the following: The project-specific FSP includes a project-specific schedule with the minimum information included in Worksheet #16.

Example taken from C-400 Complex RI/FS Project.

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Mobilization/demobilization	FRNP	February 2020	April 2021	Field notes	August 2021
Sample collection	FRNP	February 2020	April 2021	Field notes	August 2021
Analysis	Contract Lab	March 2020	August 2021	Report of analysis	August 2021
Validation	VNSFS	April 2020	August 2021	Validation summary	August 2021
Data report	Project Team	April 2020	October 2021	Data report	October 2021

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

(UFP-QAPP Manual Section 2.6.2.3 and Figure 15)
(EPA 2106-G-05 Section 2.2.6)

This worksheet should be completed for each matrix, analyte, analytical method, and concentration level (if applicable). Its purpose is to ensure the selected analytical laboratory and method can provide accurate data (i.e., quantitative results with known precision and bias) at the PAL. During the systematic planning process, identify target analytes, PALs, and the reference limits (e.g., regulatory limits or risk-based limits) on which action limits are based. (If more than one set of reference limits is applicable, add additional columns.) Target analytes that are critical to project-specific decision-making should be highlighted. Next, determine the matrix-specific quantitation limit goal. The quantitation limit goal should be lower than the PAL by an amount determined by the DQOs/PQOs. This information, along with the MPC documented on Worksheet #12, should be used to select analytical methods and laboratories. Once the methods and laboratories have been selected, the remaining columns should be completed with laboratory-specific information. Project teams need to keep in mind that the laboratory-specific quantitation limit usually is determined in reagent water; therefore, the project quantitation limit goal (matrix-specific quantitation limit) will be higher. Explanations should be provided in cases where the quantitation limit is greater than either the project quantitation limit goal or the PAL. The laboratory must provide documentation that demonstrates precision and bias at the laboratory-specific quantitation limit. The laboratory-specific quantitation limit cannot be lower than the lowest calibration standard for any given method and analyte.

For the initially developed project-specific QAPP, the laboratory-specific columns should be filled out with target values to be used in laboratory solicitation and to support identification of the potential need to seek lower detection limits. The final laboratory-specific values will be populated and the project-specific QAPP updated once the laboratory has been contracted.

As part of the preparation of a project-specific QAPP, the PAL values should be updated with the most recent values or with project-specific values, as appropriate. As these values are updated, the P-QAPP will need to be updated accordingly.

Consideration also should be given to ecological values found in the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 2. Ecological*, DOE/LX/07-0107&D2/R3/V2 (DOE 2019).

QAPP Worksheet #15-A. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Water)

Matrix: Water
Analytical Group: VOCs

Analyte	Chemical Abstracts Service (CAS) Number	Project Action Limit/NAL (µg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/L)	MDL[e] (µg/L)
Acrylonitrile	107-13-1	0.052/0.0523	Tapwater[d]/NAL	Yes	5	1.667
Benzene	71-43-2	5.0/0.455	MCL/NAL	Yes	1	0.333
Bromodichloromethane	75-27-4	80/0.134	MCL[f]/NAL	Yes	1	0.333
Carbon tetrachloride	56-23-5	5.0/0.455	MCL/NAL	Yes	1	0.333
Chloroform	67-66-3	80/0.221	MCL[f]/NAL	Yes	1	0.333
1,2-Dichloroethane	107-06-2	5.0/0.171	MCL/NAL	Yes	1	0.333
1,1-Dichloroethene	75-35-4	7.0/28.5	MCL/NAL	Yes	1	0.333
cis-1,2-Dichloroethene	156-59-2	70/3.47	MCL/NAL	Yes	1	0.333
trans-1,2-Dichloroethene	156-60-5	100/6.78	MCL/NAL	Yes	1	0.333
Ethylbenzene	100-41-4	700/1.50	MCL/NAL	Yes	1	0.333
Tetrachloroethene	127-18-4	5.0/4.06	MCL/NAL	Yes	1	0.333
1,1,1-Trichloroethane	71-55-6	200/801	MCL/NAL	Yes	1	0.333
1,1,2-Trichloroethane	79-00-5	5.0/0.0415	MCL/NAL	Yes	1	0.333
Trichloroethene	79-01-6	5.0/0.283	MCL/NAL	Yes	1	0.333
Vinyl Chloride	75-01-4	2.0/0.0188	MCL/NAL	Yes	1	0.333
Total Xylenes	1330-20-7	10,000/19.3	MCL/NAL	Yes	3	1
o-Xylene	95-47-6	19/19.3	Tapwater/NAL	Yes	1	0.333
m,p-Xylene	179601-23-1	19/19.3[g]	Tapwater/NAL	Yes	2	0.667

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.
[a] This QAPP references the NALs established by the RMD for the child resident scenario and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as contaminants of concern (COCs) in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] Tapwater—Source: EPA regional screening levels, Tapwater Supporting Table (Target Risk = 1E-6, Hazard Quotient = 0.1) May 2021 (EPA 2021a).
[e] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[f] As Total trihalomethanes.
[g] PAL for m-Xylene used.

QAPP Worksheet #15-B. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (SVOCs, Water)

Matrix: Water
Analytical Group: SVOCs

Analyte	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL[c] (µg/L)	MDL[e] (µg/L)
Acenaphthene	83-32-9	53/53.5	Tapwater[d]/NAL	Yes	1	0.3
Acenaphthylene	208-96-8	53.5	NAL	Yes	1	0.3
Anthracene	120-12-7	180/177	Tapwater/NAL	Yes	1	0.3
Benz[a]anthracene	56-55-3	0.03/0.0298	Tapwater/NAL	Yes	1	0.3
Benzo[a]pyrene	50-32-8	0.2/0.0251	MCL/NAL	Yes	1	0.3
Benzo[b]fluoranthene	205-99-2	0.25/0.251	Tapwater/NAL	Yes	1	0.3
Benzo[k]fluoranthene	207-08-9	2.5/2.51	Tapwater/NAL	Yes	1	0.3
Carbazole	86-74-8	2.03	NAL	Yes	1	0.3
Chrysene	218-01-9	25/25.1	Tapwater/NAL	Yes	1	0.3
Dibenz[a,h]anthracene	53-70-3	0.025/0.0251	Tapwater/NAL	Yes	1	0.3
Dieldrin[f]	60-57-1	0.0018/0.00175	Tapwater/NAL	Yes	0.04	0.0125
Fluoranthene	206-44-0	80/80.2	Tapwater/NAL	Yes	1	0.3
Fluorene	86-73-7	29/29.4	Tapwater/NAL	Yes	1	0.3
Hexachlorobenzene	118-74-1	1.0/0.00976	MCL/NAL	Yes	10	3
Indeno[1,2,3-cd]pyrene	193-39-5	0.25/0.251	Tapwater/NAL	Yes	1	0.3
Naphthalene	91-20-3	0.12/0.117	Tapwater/NAL	Yes	1	0.3
2-Nitroaniline	88-74-4	19/18.9	Tapwater/NAL	Yes	10	3
N-nitroso-di-n-propylamine	621-64-7	0.011/0.0108	Tapwater/NAL	Yes	10	3
Pentachlorophenol	87-86-5	1.00/0.0413	MCL/NAL	Yes	10	3
Phenanthrene	85-01-8	53.5	NAL	Yes	1	0.3
Pyrene	129-00-0	12/12.1	Tapwater/NAL	Yes	1	0.3

NOTE: Worksheet #15 will be prepared with preliminary target laboratory-specific PQLs and MDLs to be used to procure the laboratory.
[a] This QAPP references the MCLs (or EPA screening level for tapwater if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD for the child resident scenario and MCLs reproduced in the RMD. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] Tapwater—Source: EPA regional screening levels, Tapwater Supporting Table (Target Risk = 1E-6, Hazard Quotient = 0.1) May 2021 (EPA 2021a).
[e] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[f] SW-846 Method 8081.

QAPP Worksheet #15-C. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Metals, Water)

Matrix: Water
Analytical Group: Metals

Analyte	CAS Number	Project Action Limit/NAL (mg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (mg/L)	MDL[e] (mg/L)
Aluminum	7429-90-5	2.0/2.00	Tapwater[d]/NAL	Yes	0.05	0.0193
Antimony	7440-36-0	0.0060/0.000779	MCL/NAL	Yes	0.003	0.001
Arsenic	7440-38-2	0.010/0.0000517	MCL/NAL	Yes	0.005	0.002
Barium	7440-39-3	2.0/0.377	MCL/NAL	Yes	0.004	0.00067
Beryllium	7440-41-7	0.0040/0.0024	MCL/NAL	Yes	0.0005	0.0002
Boron	7440-42-8	0.40/0.399	Tapwater/NAL	Yes	0.015	0.0052
Cadmium	7440-43-9	0.0050/0.000184	MCL/NAL	Yes	0.001	0.0003
Chromium (total)	7440-47-3	0.10/2.25[f]	MCL/NAL	Yes	0.01	0.003
Chromium (VI)[j]	18540-29-9	0.000035/0.000035	Tapwater/NAL	Yes	0.01	0.0033
Cobalt	7440-48-4	0.0006/0.000601	Tapwater/NAL	Yes	0.002	0.0003
Copper	7440-50-8	1.3/0.0799	MCL/NAL	Yes	0.001	0.0003
Fluoride[k]	16984-48-8	4.0/0.0799	MCL/NAL	Yes	0.1	0.033
Iron	7439-89-6	1.4/1.40	Tapwater/NAL	Yes	0.1	0.033
Lead	7439-92-1	0.015/0.015	MCL[g]/NAL	Yes	0.002	0.0005
Manganese	7439-96-5	0.043/0.0434	Tapwater/NAL	Yes	0.005	0.001
Mercury	7439-97-6	0.0020/0.000566[h]	MCL/NAL	Yes	0.0002	0.000067
Molybdenum	7439-98-7	0.010/0.00998	Tapwater/NAL	Yes	0.001	0.0002
Nickel	7440-02-0	0.039/0.0392[i]	Tapwater/NAL	Yes	0.002	0.0006
Selenium	7782-49-2	0.050/0.00998	MCL/NAL	Yes	0.005	0.002
Silver	7440-22-4	0.0094/0.00941	Tapwater/NAL	Yes	0.001	0.0003
Thallium	7440-28-0	0.0020/0.000020[i]	MCL/NAL	Yes	0.002	0.0006
Uranium	7440-61-1	0.030/0.000399[i]	MCL/NAL	Yes	0.0002	0.000067
Vanadium	7440-62-2	0.0086/0.00864	Tapwater/NAL	Yes	0.02	0.0033
Zinc	7440-66-6	0.60/0.600	Tapwater/NAL	Yes	0.02	0.0033

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

QAPP Worksheet #15-C. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Metals, Water) (Continued)

[a] This QAPP references the MCLs (or EPA screening level for tapwater if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD for the child resident scenario and MCLs reproduced in the RMD for the child resident scenario. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the MDL, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] Tapwater—Source: EPA regional screening levels, Tapwater Supporting Table (Target Risk = 1E-6, Hazard Quotient = 0.1) May 2021 (EPA 2021a).
[e] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[f] An NAL is not available for chromium (total); therefore, the NAL for chromium (III) was used.
[g] The MCL established by the EPA for lead is based on a treatment technique action level of 0.015 mg/L.
[h] The PAL/NAL values were derived for metal salts; the CAS number is presented for the elemental form.
[i] The PAL/NAL values were derived for metal soluble salts.
[j] SW-846 Method 7196.
[k] SW-846 Method 9056.

QAPP Worksheet #15-D. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (PCBs, Water)

Matrix: Water
Analytical Group: PCBs

Analyte	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c] PQL (µg/L)	Laboratory-Specific[c] MDL[d] (µg/L)
Total PCBs	1336-36-3	0.50/0.0436	MCL/NAL	Yes	0.1	0.0333
Aroclor 1016	12674-11-2	0.50[e]/0.140	MCL/NAL	Yes	0.1	0.0333
Aroclor 1221	11104-28-2	0.50[e]/0.00471	MCL/NAL	Yes	0.1	0.0333
Aroclor 1232	11141-16-5	0.50[e]/0.00471	MCL/NAL	Yes	0.1	0.0333
Aroclor 1242	53469-21-9	0.50[e]/0.00785	MCL/NAL	Yes	0.1	0.0333
Aroclor 1248	12672-29-6	0.50[e]/0.00785	MCL/NAL	Yes	0.1	0.0333
Aroclor 1254	11097-69-1	0.50[e]/0.00785	MCL/NAL	Yes	0.1	0.0333
Aroclor 1260	11096-82-5	0.50[e]/0.00785	MCL/NAL	Yes	0.1	0.0333

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

[a] This QAPP references the MCLs (or EPA screening level for tapwater if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD for the child resident scenario and MCLs reproduced in the RMD. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process. This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.

[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.

[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the MDL, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.

[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.

[e] MCL for Total PCBs.

QAPP Worksheet #15-E. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Radionuclides, Water)

Matrix: Water
Analytical Group: Radionuclides

Analyte	CAS Number	Project Action Limit (pCi/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c] MDA[d] (pCi/L)
Americium-241	14596-10-2	6.77E-02	NAL	Yes	1
Cesium-137	10045-97-3	1.71E+00	NAL	Yes	10
Neptunium-237	13994-20-2	7.83E-02	NAL	Yes	1
Plutonium-238	13981-16-3	1.56E-02	NAL	Yes	1
Plutonium-239[e]	15117-48-3	6.03E-02	NAL	Yes	1
Plutonium-240[e]	14119-33-6	3.18E-02	NAL	Yes	1
Technetium-99	14133-76-7	4 mrem/year-dose,[f] 900/1.90E+01	MCL/NAL	Yes	25
Thorium-230	14269-63-7	1.66E-02	NAL	Yes	1
Thorium-232	7440-29-1	3.63E-02	NAL	Yes	1
Uranium-234[g]	13966-29-5	1.24E+02/1.62E-02	MCL[g]/NAL	Yes	1
Uranium-235[g]	15117-96-1	4.66E-01/7.14E-02	MCL[g]/NAL	Yes	1
Uranium-238[g]	7440-61-1	9.99E+00/1.58E-02	MCL[g]/NAL	Yes	1

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

[a] This QAPP references the MCLs (or EPA screening level for tapwater if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD for the resident secular equilibrium scenario and MCLs reproduced in the RMD. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.

[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.

[c] Radiological parameters will be reported per laboratory SOPs and the *Department of Defense Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories*.

[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDAs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.

[e] Reported as Pu-239/240.

[f] The value derived by the EPA from the 4 mrem/year MCL for Tc-99 is 900 pCi/L (see https://www.epa.gov/sites/default/files/2015-06/documents/compliance-radionuclidesindw.pdf). An alternate value derived by the EPA from the 4 mrem/year MCL is 3,790 pCi/L and was proposed in the July 18, 1991, *Federal Register*, http://nepis.epa.gov [document number 570-Z-91-049 (search term: 570Z91049)].
See Table A.9 of the RMD for Tc-99 dose-based groundwater screening levels resulting in a 4 mrem/year dose based upon more recent dosimetry.

[g] Based on RMD.

QAPP Worksheet #15-F. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Soil/Sediment or Concrete)

Matrix: Soil/Sediment or Concrete
Analytical Group: VOCs

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/kg)	MDL[d] (µg/kg)
1,2-Dichloroethane	107-06-2	464	NAL	Yes	1	0.333
1,1-Dichloroethene	75-35-4	22,700	NAL	Yes	1	0.333
cis-1,2-Dichloroethene	156-59-2	6,260	NAL	Yes	1	0.333
trans-1,2-Dichloroethene	156-60-5	6,960	NAL	Yes	1	0.333
Acrylonitrile	107-13-1	255	NAL	Yes	5	1.667
Benzene	71-43-2	1,160	NAL	Yes	1	0.333
Bromodichloromethane	75-27-4	293	NAL	Yes	1	0.333
Carbon Tetrachloride	56-23-5	653	NAL	Yes	1	0.333
Chloroform	67-66-3	316	NAL	Yes	1	0.333
Ethylbenzene	100-41-4	5,780	NAL	Yes	1	0.333
Tetrachloroethene	127-18-4	8,100	NAL	Yes	1	0.333
1,1,1-Trichloroethane	71-55-6	815,000	NAL	Yes	1	0.333
1,1,2-Trichloroethane	79-00-5	150	NAL	Yes	1	0.333
Trichloroethene	79-01-6	412	NAL	Yes	1	0.333
Vinyl Chloride	75-01-4	59.2	NAL	Yes	1	0.333
Total Xylenes	1330-20-7	57,600	NAL	Yes	3	1
m,p-Xylene	179601-23-1	55,100[e]	NAL	Yes	2	0.667
o-Xylene	95-47-6	64,500	NAL	Yes	1	0.333

NOTE: Worksheet #15 will be prepared with preliminary target laboratory-specific PQLs and MDLs to be used to procure the laboratory. Once selected, the PQL/MDL information will be updated.

[a] This QAPP references the NALs established by the RMD for the child resident scenario to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process within the project-specific QAPP.

[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.

[c] The analytical laboratory may not be able to meet the NALs established by the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.

[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.

[e] PAL for m-Xylene used.

QAPP Worksheet #15-G. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (SVOCs, Soil/Sediment or Concrete)

Matrix: Soil/Sediment or Concrete
Analytical Group: SVOCs

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL[d] (µg/kg)	MDL[d] (µg/kg)
Acenaphthene	83-32-9	185,000	NAL	Yes	33.3	10
Acenaphthylene	208-96-8	185,000	NAL	Yes	33.3	10
Anthracene	120-12-7	923,000	NAL	Yes	33.3	10
Benz[a]anthracene	56-55-3	475	NAL	Yes	33.3	10
Benzo[a]pyrene	50-32-8	47.8	NAL	Yes	33.3	10
Benzo[b]fluoranthene	205-99-2	478	NAL	Yes	33.3	10
Benzo[k]fluoranthene	207-08-9	4,780	NAL	Yes	33.3	10
Carbazole	86-74-8	10,400	NAL	Yes	33.3	10
Chrysene	218-01-9	47,800	NAL	Yes	33.3	10
Dibenz[a,h]anthracene	53-70-3	47.8	NAL	Yes	33.3	10
Dieldrin[e]	60-57-1	13.0	NAL	Yes	1.34	0.33
Fluoranthene	206-44-0	123,000	NAL	Yes	33.3	10
Fluorene	86-73-7	123,000	NAL	Yes	33.3	10
Hexachlorobenzene	118-74-1	212	NAL	Yes	333	100
Indeno[1,2,3-cd]pyrene	193-39-5	478	NAL	Yes	33.3	10
Naphthalene	91-20-3	1,040	NAL	Yes	33.3	10
2-Nitroaniline	88-74-4	35,600	NAL	Yes	333	110
N-nitroso-di-n-propylamine	621-64-7	29.7	NAL	Yes	333	100
Pentachlorophenol	87-86-5	254	NAL	Yes	333	100
Phenanthrene	85-01-8	185,000	NAL	Yes	33.3	10
Pyrene	129-00-0	92,300	NAL	Yes	33.3	10

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.
[a] This QAPP references the NALs established by the RMD for the child resident scenario to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[e] SW-846 Method 8081.

QAPP Worksheet #15-H. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Metals, Soil/Sediment or Concrete)

Matrix: Soil/Sediment or Concrete
Analytical Group: Metals

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (mg/kg)	MDL[d] (mg/kg)
Aluminum	7429-90-5	7,740	NAL	Yes	10	4.55
Antimony	7440-36-0	3.13	NAL	Yes	2	0.33
Arsenic	7440-38-2	0.356	NAL	Yes	1	0.338
Barium	7440-39-3	1,530	NAL	Yes	0.8	0.1
Beryllium	7440-41-7	15.6	NAL	Yes	0.1	0.02
Boron	7440-42-8	1,560	NAL	Yes	3	0.8
Cadmium	7440-43-9	0.530	NAL	Yes	0.2	0.02
Chromium (total)	7440-47-3	11,700[e]	NAL	Yes	0.6	0.2
Chromium (VI)[h]	18540-29-9	0.301	NAL	Yes	0.4	0.16
Cobalt	7440-48-4	2.34	NAL	Yes	0.2	0.06
Copper	7440-50-8	313	NAL	Yes	0.4	0.066
Fluoride[i]	16984-48-8	313	NAL	Yes	1	0.34
Iron	7439-89-6	5,480	NAL	Yes	20	6.6
Lead	7439-92-1	400	NAL	Yes	0.4	0.1
Manganese	7439-96-5	183	NAL	Yes	1	0.2
Mercury[f]	7439-97-6	2.35	NAL	Yes	0.024	0.00804
Molybdenum	7439-98-7	39.1	NAL	Yes	0.4	0.08
Nickel[g]	7440-02-0	155	NAL	Yes	0.4	0.1
Selenium	7782-49-2	39.1	NAL	Yes	1	0.36
Silver	7440-22-4	39.1	NAL	Yes	0.5	0.1
Thallium[g]	7440-28-0	0.0782	NAL	Yes	0.4	0.14
Uranium[g]	7440-61-1	1.56	NAL	Yes	0.04	0.0132
Vanadium	7440-62-2	39.3	NAL	Yes	0.4	0.3
Zinc	7440-66-6	2,350	NAL	Yes	4	0.84

NOTE: Worksheet #15 will be prepared with preliminary target laboratory-specific PQLs and MDLs to be used to procure the laboratory.

QAPP Worksheet #15-H. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Metals, Soil/Sediment or Concrete) (Continued)

[a] This QAPP references the NALs established by the RMD for the child resident scenario to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[e] An NAL is not available for chromium (total); therefore, the NAL for chromium (III) was used.
[f] The PAL/NAL values (for metals identified as salts) were derived for metal salts; the CAS number is presented for the elemental form.
[g] The PAL/NAL values were derived for metal soluble salts.
[h] SW-846 Method 7196.
[i] SW-846 Method 9056.

QAPP Worksheet #15-I. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (PCBs, Soil/Sediment or Concrete)

Matrix: Soil/Sediment or Concrete
Analytical Group: PCBs

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (mg/kg)	MDL[d] (mg/kg)
Total PCBs	1336-36-3	0.0788	NAL	Yes	0.0033	0.001099
Aroclor 1016	12674-11-2	0.206	NAL	Yes	0.0033	0.001099
Aroclor 1221	11104-28-2	0.0752	NAL	Yes	0.0033	0.001099
Aroclor 1232	11141-16-5	0.0708	NAL	Yes	0.0033	0.001099
Aroclor 1242	53469-21-9	0.0791	NAL	Yes	0.0033	0.001099
Aroclor 1248	12672-29-6	0.0788	NAL	Yes	0.0033	0.001099
Aroclor 1254	11097-69-1	0.0588	NAL	Yes	0.0033	0.001099
Aroclor 1260	11096-82-5	0.0803	NAL	Yes	0.0033	0.001099

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

[a] This QAPP references the NALs established by the RMD for the child resident scenario to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.

[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.

[c] The analytical laboratory may not be able to meet the NALs established by the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.

[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.

QAPP Worksheet #15-J. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Radionuclides, Soil/Sediment or Concrete)

Matrix: Soil/Sediment or Concrete
Analytical Group: Radionuclides

Analyte	CAS Number	Project Action Limit (pCi/g)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]
					MDA[d] (pCi/g)
Americium-241	14596-10-2	4.55E-02	NAL	Yes	1
Cesium-137[e]	10045-97-3	3.95E-02	NAL	Yes	0.1
Neptunium-237[e]	13994-20-2	4.66E-02	NAL	Yes	1
Plutonium-238	13981-16-3	1.10E-02	NAL	Yes	1
Plutonium-239[f]	15117-48-3	3.97E-02	NAL	Yes	1
Plutonium-240[f]	14119-33-6	8.54E-03	NAL	Yes	1
Technetium-99	14133-76-7	1.12E+02	NAL	Yes	5
Thorium-230	14269-63-7	1.11E-02	NAL	Yes	1
Thorium-232	14269-63-7	8.57E-03	NAL	Yes	1
Uranium-234	13966-29-5	1.11E-02	NAL	Yes	1
Uranium-235[e]	15117-96-1	4.01E-02	NAL	Yes	1
Uranium-238[e]	7440-61-1	1.09E-02	NAL	Yes	1

NOTE: For consistency at a programmatic level, these worksheets will be reviewed and updated for project-specific QAPPs. Worksheet #15 of each project-specific QAPP will have a Project QL column that will be related to action levels deemed appropriate for the specific analytes as a result of three-party project scoping.
[a] This programmatic QAPP references the NALs established by the RMD for the resident secular equilibrium scenario to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process within the project-specific QAPP.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COC in risk assessments previously performed at PGDP.
[c] Radiological parameters will be reported per laboratory SOPs and the *Department of Defense Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories*.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[e] PAL/NAL was derived considering the contribution from short-lived decay products.
[f] Reported as Pu-239/240.

QAPP Worksheet #15-K. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Dioxins and Furans, Soil/Sediment or Concrete)

Matrix: Soil/Sediment or Concrete
Analytical Group: Dioxins and Furans

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (mg/kg)	MDL[d] (mg/kg)
2,3,7,8-TCDD	1746-01-6	3.08E-06	NAL	Yes	1.00E-06	3.33E-07
1,2,3,7,8-PeCDD	40321-76-4	3.14E-06[e]	NAL	Yes	5.00E-06	1.92E-06
1,2,3,4,7,8-HxCDD	39227-28-6	3.14E-05[f]	NAL	Yes	5.00E-06	1.67E-06
1,2,3,6,7,8-HxCDD	57653-85-7	3.14E-05[f]	NAL	Yes	5.00E-06	1.67E-06
1,2,3,7,8,9-HxCDD	19408-74-3	3.14E-05[f]	NAL	Yes	5.00E-06	2.42E-06
1,2,3,4,6,7,8-HpCDD	35822-39-4	3.09E-04[g]	NAL	Yes	5.00E-06	1.67E-06
OCDD	3268-87-9	1.05E-02	NAL	Yes	1.00E-05	3.33E-06
Total TCDD	41903-57-5	3.08E-06[h]	NAL	Yes	1.00E-06	3.33E-07
2,3,7,8-TCDF	51207-31-9	3.09E-05	NAL	Yes	1.00E-06	3.33E-07
1,2,3,7,8-PeCDF	57117-41-6	1.05E-04	NAL	Yes	5.00E-06	1.70E-06
2,3,4,7,8-PeCDF	57117-31-4	1.05E-05	NAL	Yes	5.00E-06	1.67E-06
1,2,3,4,7,8-HxCDF	70648-26-9	N/A	NAL	No	5.00E-06	1.67E-06
1,2,3,6.7,8-HxCDF	57117-44-9	N/A	NAL	No	5.00E-06	1.92E-06
1,2,3,7,8,9-HxCDF	72918-21-9	N/A	NAL	No	5.00E-06	1.67E-06
2,3,4,6,7,8-HxCDF	60851-34-5	N/A	NAL	No	5.00E-06	1.67E-06
1,2,3,4,6,7,8-HpCDF	67562-39-4	N/A	NAL	No	5.00E-06	2.28E-06
1,2,3,4,7,8,9-HpCDF	55673-89-7	N/A	NAL	No	5.00E-06	2.26E-06
OCDF	39001-02-0	1.05E-02	NAL	Yes	1.00E-05	3.33E-06
Total PeCDD	36088-22-9	3.14E-06[e]	NAL	Yes	5.00E-06	1.92E-06
Total HxCDD	34465-46-8	3.14E-05[f]	NAL	Yes	5.00E-06	2.42E-06
Total HpCDD	37871-00-4	3.09E-04[g]	NAL	Yes	5.00E-06	1.67E-06
Total TCDF	30402-14-3	3.09E-05[i]	NAL	No	1.00E-06	3.33E-07
Total PeCDF	30402-15-4	N/A	-	No	5.00E-06	1.70E-06
Total HxCDF	55684-94-1	3.14E-05[j]	NAL	No	5.00E-06	1.92E-06
Total HpCDF	38998-75-3	3.12E-04	NAL	Yes	5.00E-06	2.28E-06

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

QAPP Worksheet #15-K. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Dioxins and Furans, Soil/Sediment or Concrete) (Continued)

[a] This QAPP references the NALs established by the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.
[e] Child resident NAL for PeCDD, 2,3,7,8-used for PAL.
[f] Child resident NAL for HxCDD used for PAL.
[g] Child resident NAL for HpCDD, 2,3,7,8-used for PAL.
[h] Child resident NAL for TCDD, 2,3,7,8-used for PAL.
[i] Child resident NAL for TCDF, 2,3,7,8-used for PAL.
[j] Child resident NAL for HxCDF, 2,3,7,8-used for PAL.

QAPP Worksheet #15-L. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [Uranium (XRF), Soil/Sediment]

Matrix: Soil/Sediment
Analytical Group: Metals (uranium by XRF)

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference	Site COPC?[a]	Laboratory-Specific	
					PQL (mg/kg)	MDL (mg/kg)
Uranium	7440-61-1	10[b]	Project scoping	Yes	N/A	10

[a] Analytes marked with COPC are from Table 2.1 of the RMD.
[b] The PAL for uranium was set to ensure the DQOs agreed to by the FFA parties were met using the XRF analytical method. The PAL approaches the PGDP surface soil background concentration of 4.9 mg/kg for uranium, and is below the risk-based NAL of 23.4 mg/kg established by the RMD for the child resident for uranium (insoluble compounds). Finally, an acknowledged XRF subject matter expert confirmed detection at the PAL could be achieved reliably with an XRF calibrated to detect uranium.

QAPP Worksheet #15-M. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Total PCBs, Soil/Sediment)

Matrix: Soil/Sediment
Analytical Group: Total PCBs (by immunoassay test kit)

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference	Site COPC?[a]	Laboratory-Specific	
					PQL (mg/kg)	MDL (mg/kg)
Total PCBs	1336-36-3	1[b]	Project scoping	Yes	N/A	1

[a] Analytes marked with COPC are from Table 2.1 of the RMD.
[b] The PAL for Total PCBs was set to ensure the DQOs agreed to by the FFA parties were met using the immunoassay test kit.

QAPP Worksheet #15-N. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (PAHs, Soil/Sediment)

Matrix: Soil/Sediment
Analytical Group: PAHs (by test kit)

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference	Site COPC?[a]	Laboratory-Specific	
					PQL (mg/kg)	MDL (mg/kg)
PAHs	N/A	1[b]	Project scoping	Yes	N/A	1

[a] Analytes marked with COPC are from Table 2.1 of the RMD.
[b] The PAL for PAHs was set to ensure the DQOs agreed to by the FFA parties were met using the immunoassay test kit.

QAPP Worksheet #15-O. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Air)

Matrix: Air
Analytical Group: VOCs

Analyte	CAS Number	Project Action Limit (µg/m³)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/m³)	MDL[e, g] (µg/m³)
1,1-Dichloroethane	75-34-3	7.67E+00	VISL, Commercial[d]	No	2.0	0.61
1,1-Dichloroethene	75-35-4	8.76E+02	VISL, Commercial[d]	Yes	2.0	0.59
1,1,1-Trichloroethane	71-55-6	2.19E+04	VISL, Commercial[d]	Yes	4.37	0.164
cis-1,2-Dichloroethene	156-59-2	NVVA[e], 3.50E+03[f]	No VISL[e], Provisional Value[f]	Yes	3.17	0.238
trans-1,2-Dichloroethene	156-60-5	NVVA[e], 3.50E+03	No VISL, Reference Concentration	Yes	3.17	0.198
Chloroform	67-66-3	5.33E-01	VISL, Commercial[d]	Yes	3.91	0.186
Trichloroethene	79-01-6	2.99E+00	VISL, Commercial[d]	Yes	2.15	0.193
Vinyl Chloride	75-01-4	2.79E+00	VISL, Commercial[d]	Yes	1.02	0.181

[a] VISL = Vapor Intrusion Screening Level (EPA 2021b) (Commercial, Carcinogen Target Risk = 1.0E-6, Target Hazard Quotient = 1.0). The agreed upon VISLs in the *Paducah Gaseous Diffusion Plant Industrial Area Vapor Intrusion Preliminary Risk Assessment Report* (DOE/LX/07-2471&D2) were calculated at a hazard quotient of 1 because this was a preliminary assessment and was not intended to be used for human health risk assessment. Projects should consider using reporting limits targeted to meet the hazard quotient of 0.1 to ensure usability for future risk assessment.

[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.

[c] Laboratory has a PQL of 0.5 parts per billion (in air) by volume (ppbv) and MDL of 0.15 ppbv. These values were converted to µg/m³ at 25°C.

[d] The VISL values are taken from the VISL calculator (results generated April 5, 2022, https://epa-visl.ornl.gov/cgi-bin/visl_search) derived for a commercial exposure scenario at a target excess cancer risk of 1.0E-06 and a target hazard quotient of 1.0. Per the VISL calculator, the commercial exposure scenario has a 70-year averaging time for carcinogens, a 25-year averaging time for noncarcinogens, an exposure duration of 25 years, an exposure frequency of 250 days/year, and an exposure time of 8 hours/day.

[e] Provisional value provided by EPA, as documented in Section E.9 of the RMD, because VISL value is not available.

[f] The reference concentration for *trans*-1,2-DCE was used as a surrogate to calculate the screening levels for *cis*-1,2-DCE.

[g] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.

QAPP Worksheet #15-O. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Air) (Continued)

Supplemental Information on Air Sampling, including Benchmarks for Exposure of Pregnant Women to TCE

"TRICHLOROETHYLENE: ASSESSING & MANAGING VAPOR INTRUSION RISKS," slides prepared by Kelly Schumacher, EPA Region 7, presented at the Missouri Waste Control Coalition Vapor Intrusion Seminar, January 14, 2016 (https://missouriwastecontrolcoalition.wildapricot.org/Vapor-Intrusion-Seminar).

Region 7: Two co-critical endpoints [each can support inhalation reference concentration (RfC) independently]:\

- Autoimmune disease following chronic exposure in adults (1.8 µg/m^3)
- Heart defects following exposure during early pregnancy (2.0 µg/m^3)

Region 7: One supporting endpoint (less confidence than critical endpoints):

- Nephrotoxicity (kidney effects) following chronic exposure in adults (3.0 µg/m^3)

Add information on air sampling, including benchmarks for exposure of pregnant women to TCE.
EPA's Developmental Toxicity Risk Assessment Guidelines states that "a single exposure at a critical time in development may produce an adverse developmental effect." A single exposure to ***some*** level of TCE at any time during the three-week critical window of valvuloseptal morphogenesis could result in one or more types of heart defects. The Integrated Risk Information System combined the incidence of all the types of heart defects observed in the critical study to calculate the benchmark dose level (lower, 95% confidence) associated with a 1% excess risk of an "abnormal heart." Since the heart defects occurred throughout valvuloseptal morphogenesis, **the critical exposure period used to derive the RfC = 3 weeks.**

Schumacher cited: June 30, 2014, EPA Region 9 Interim Action Levels and Response Recommendations to Address Potential Developmental Hazards Arising from Inhalation Exposures to TCE in Indoor Air from Subsurface Vapor Intrusion.

QAPP Worksheet #15-O. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Air) (Continued)

Supplemental Information on Air Sampling, Including Benchmarks for Exposure of Pregnant Women to TCE (Continued)

EPA Region 9 Interim TCE Indoor Air Response Action Levels—Residential and Commercial TCE Inhalation Exposure from Vapor Intrusion		
Exposure Scenario	**Accelerated Response Action Level (HQ=1)**	**Urgent Response Action Level (HQ=3)**
Residential[a]	2 µg/m^3	6 µg/m^3
Commercial/Industrial[b] (8-hour workday)	8 µg/m^3	24 µg/m^3
Commercial/Industrial[b] (10-hour workday)	7 µg/m^3	21 µg/m^3

[a] The residential HQ=1 accelerated response action level is equivalent to the RfC since exposure is assumed to occur continuously.
[b] Commercial/Industrial accelerated response action levels are calculated as a time-weighted average from RfC, based on the length of a workday and rounding to one significant digit (e.g., for an 8-hour workday:
Accelerated Response Action Level = (168 hours per week/40 hours per week) × 2 µg/m^3 = 8 µg/m^3). Time-weighted adjustments can be made as needed for workplaces with longer work schedules.
NOTE: Indoor air TCE exposures corresponding to these accelerated response action levels would pose cancer risks near the lower end of the Superfund target cancer risk range, considering the IRIS toxicity assessment; thus, the health protective risk range for both accelerated response actions and long-term exposures becomes truncated to: 0.5–2 µg/m^3 for residential exposures and 3–8 µg/m^3 for 8-hour/day commercial/industrial exposures.

Schumacher also cited EPA REGION 10: "…to protect against potential noncancer fetal malformation outcomes, it is appropriate to recommend that average exposures over any 21-day period of time not exceed the concentrations in air or other media that are calculated to be protective…." Not to be exceeded, average 21-day exposure to women of reproductive age to prevent fetal cardiac malformations, HQ = 1.0:

- Residential settings = 2.0 µg/m^3
- Industrial/commercial settings = 8.4 µg/m^3
- Based on 260 days/year (i.e., 5 days/week for 52 weeks/year)

QAPP Worksheet #15-O. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Air) (Continued)

Supplemental Information on Air Sampling, Including Benchmarks for Exposure of Pregnant Women to TCE (Continued)

Schumacher also cited: Massachusetts Department of Environmental Protection

Imminent Hazard Values for Pregnant Women and Those Who May Become Pregnant

Residential Exposure Scenario	Indoor Air Concentration	Concern Level	Actions
Fetal developmental effects (Subchronic Exposure Noncancer Risk, HQ = 1)	> 6 µg/m³	Imminent Hazard 2-hour Notification	Immediate Response Action Goal to reduce levels to *at least* less than 6 µg/m³ ASAP (within several days if possible)
Typical Workplace Exposure Scenario	**Indoor Air Concentration**	**Concern Level**	**Actions**
Fetal developmental effects (Subchronic Exposure Noncancer Risk, HQ = 1)	> 24 µg/m³	Imminent Hazard 2-hour Notification	Immediate Response Action Goal to reduce levels to *at least* less than 24 µg/m³ ASAP (within several days if possible)

QAPP Worksheet #15-P. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Mercury, Air)

Matrix: Air
Analytical Group: Mercury

Analyte	CAS Number	Project Action Limit (µg/m³)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific	
					PQL (µg/m³)	MDL[c] (µg/m³)
Mercury	7439-97-6	1.31	VISL, Commercial	Yes	N/A	0.05

[a] VISL = Vapor Intrusion Screening Level (EPA 2021b) (Commercial, Carcinogen Target Risk = 1.0E-6, Target Hazard Quotient = 1.0).
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The VISL values are taken from the VISL calculator (results generated August 4, 2020, https://epa-visl.ornl.gov/cgi-bin/visl_search) derived for a commercial exposure scenario at a target excess cancer risk of 1.0E-06 and a target hazard quotient of 1.0. Per the VISL calculator, the commercial exposure scenario has a 70-year averaging time for carcinogens, a 25-year averaging time for noncarcinogens, an exposure duration of 25 years, an exposure frequency of 250 days/year, and an exposure time of 8 hours/day.

QAPP Worksheet #15-Q. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (PCBs, Wipe)

Matrix: Wipe
Analytical Group: PCBs

PCB	CAS Number	Project Action Limit	Project Action Limit Reference	Site COPC?[a]	Laboratory-Specific[b]	
					PQL (µg/sample)	MDL[c] (µg/sample)
Aroclor 1016	12674-11-2	N/A	N/A	Yes	0.1	0.0333
Aroclor 1221	11104-28-2	N/A	N/A	Yes	0.1	0.0333
Aroclor 1232	11141-16-5	N/A	N/A	Yes	0.1	0.0333
Aroclor 1242	53469-21-9	N/A	N/A	Yes	0.1	0.0333
Aroclor 1248	12672-29-6	N/A	N/A	Yes	0.1	0.0333
Aroclor 1254	11097-69-1	N/A	N/A	Yes	0.1	0.0333
Aroclor 1260	11096-82-5	N/A	N/A	Yes	0.1	0.0333
Aroclor Total	1336-36-3	N/A	N/A	Yes	0.1	0.0333

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

[a] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.

[b] Standard practices for qualifying data will apply for any result reported below the laboratory PQL.

[c] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.

QAPP Worksheet #15-R. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Radionuclides, Wipe)

Matrix: Wipe
Analytical Group: Radionuclides

Radionuclide	CAS Number	Project Action Limit	Project Action Limit Reference	Site COPC?[a]	Laboratory-Specific[b]
					MDA[c] (pCi/sample)
Americium-241	14596-10-2	N/A	N/A	Yes	1
Cesium-137	10045-97-3	N/A	N/A	Yes	25
Neptunium-237	13994-20-2	N/A	N/A	Yes	1
Plutonium-238	13981-16-3	N/A	N/A	Yes	1
Plutonium-239/240	15117-48-3/ 14119-33-6	N/A	N/A	Yes	1
Technetium-99	14133-76-7	N/A	N/A	Yes	10
Thorium-230	14269-63-7	N/A	N/A	Yes	1
Thorium-232	7440-29-1	N/A	N/A	Yes	1
Uranium-234	13966-29-5	N/A	N/A	Yes	1
Uranium-235	15117-96-1	N/A	N/A	Yes	1
Uranium-238	7440-61-1	N/A	N/A	Yes	1

[a] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[b] Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[c] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDAs identified in the worksheets, the laboratory will submit documentation of its actual MDAs and this information will be appended to the QAPP.

QAPP Worksheet #15-S. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Dissolved Hydrocarbon Gases, Water)

Matrix: Groundwater
Analytical Group: Dissolved Hydrocarbon Gases

Parameter	CAS Number	Project Action Limit	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/L)	MDL[d] (µg/L)
Methane	74-82-8	N/A	N/A	No	25	10
Ethene	74-85-1	N/A	N/A	No	25	10
Ethane	74-84-0	N/A	N/A	No	25	10

[a] This project does not have applicable groundwater cleanup levels. These analytes are used to evaluate the presence of biological reactions occurring in the subsurface.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and this information will be appended to the QAPP.

QAPP Worksheet #15-T. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Total Organic Carbon, Water)

Matrix: Groundwater
Analytical Group: Total Organic Carbon

Parameter	CAS Number	Project Action Limit	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (μg/L)	MDL[d] (μg/L)
Total Organic Carbon	N/A	N/A	N/A	No	1	0.33

[a] This project does not have applicable groundwater cleanup levels. These analytes are used to evaluate the presence of biological reactions occurring in the subsurface.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and this information will be appended to the QAPP.

QAPP Worksheet #15-U. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (DHC Bacteria, Water)

Matrix: Groundwater
Analytical Group: DHC Bacteria

Parameter	CAS Number	Project Action Limit	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/L)	MDL[d] (µg/L)
DHC Bacteria	N/A	N/A	N/A	No	N/A	N/A

[a] This project does not have applicable groundwater cleanup levels. These analytes are used to evaluate the presence of biological reactions occurring in the subsurface.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and this information will be appended to the QAPP.

QAPP Worksheet #17. Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)
(EPA 2106-G-05 Section 2.3.1)

This worksheet should be used to describe the sampling design and the basis for its selection. This worksheet mainly will consist of text. It documents the last step of the systematic planning process. If a site consists of multiple areas to be sampled, a separate worksheet should be used for each.

There are two general types of sampling designs: (1) probability-based designs, which should be used when statistical conclusions are required; and (2) judgmental designs, which are more applicable to help refine CSMs when further study is planned or to confirm previous findings, but that usually do not provide sufficient basis on their own to support statistical conclusions. Advice on selecting appropriate sample designs may be found in Chapter 2 of *Guidance for Choosing a Sampling Design for Environmental Data Collection*, EPA QA/G-5s (EPA 2002). *Regardless of the type of design selected, this worksheet should explain the basis for its selection*. It also should describe the following:

1. The physical boundaries for the area under study (include maps or diagrams);
2. The time period being represented by the collected data;
3. The descriptions and basis for dividing the site into sampling areas (e.g., decision units, exposure units) that support the decision statements documented on Worksheet #11;
4. The basis for the number and placement of samples within sampling areas;
5. If sample locations are specified in the QAPP, descriptions of how actual sample positions will be located once in the field (include maps or diagrams);
6. If a sample cannot be collected where planned, the decision process for changing the location;
7. If sample locations will be determined in the field, the decision process for doing so; and
8. Contingencies in the event field conditions are different than expected and could have an effect on the sample design.

Site-specific sampling process design and rationale may be outlined in a companion FSP developed for projects. Either the FSP or Worksheet #17 will provide the sampling and analysis requirements for each project, sampling locations, frequencies, rationale for selection, and analytical parameters for each location.

QAPP Worksheet #17-A. Sampling Design and Rationale

Worksheet #17 provides the sampling and analysis requirements for the project, including sampling locations, frequencies, rationale for selection, and analytical parameters for each location. The exact sample locations and the total number of samples might change from those described, depending on field conditions encountered. The purpose of the sampling process design is to describe relevant components of the investigation design; define the key parameters to be investigated; indicate the number and type of samples to be collected; and describe where, when, and how the samples are to be collected. The example information provided below is for a SWMU 4 investigation project.

This sheet is a summary of the project and will be described in the project-specific FSP sampling design and rationale information. The project manager will ensure these components are part of the FSP. Completion of a separate Worksheet #17 to identify where these components are located in the FSP is at the discretion of the project manager.

Example taken primarily from SWMU 4.

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach): Describe in the project-specific FSP or describe in this worksheet for simple projects.

Describe the sampling design and rationale in terms of which matrices will be sampled: A description of the analyses, methods, and the method detection limits should be provided. The choice of methods and method detection limits should be justified, especially regarding screening levels that will not be attained.

- **What analyses will be performed and at what analytical limits?** See Worksheets #12 and #15.
- **Where are the sampling locations (including QC, critical, and background samples)?** See FSP.
- **How many samples to be taken?** See FSP.

What is the sampling frequency (including seasonal considerations)? (May refer to map or Worksheet #18 for details.)

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, judgmental statistical approach): The investigation will be implemented in five phases. A general description of the planned work for each phase is described below. Contingencies and decision rules for the planned work are found in Section 5 of the SAP/work plan. The FFA parties have agreed that the additional investigative sampling at SWMU 4 as contained within the Field Sampling Plan will conclude sampling for the SWMU 4 project such that EPA and/or KDEP will not request or require any additional sampling other than confirmatory sampling for the remainder of the SWMU 4 project.

Phase I will utilize passive soil gas technology to identify areas within the SWMU that feature elevated VOC soil vapor readings. The rationale for this phase is to provide screening level data to determine the best location of subsequent data collection efforts. These are employed because they are fast, easy, inexpensive, and provide data adequate for this screening-level phase of the project. Though the sphere, or radius, of effectiveness is influenced by many factors (e.g., depth and concentration of the source, soil porosity) and is difficult to determine, the method will detect VOCs over a larger area than a conventional soil sample. The first phase also will consist of collecting surface soil samples to determine contaminant distribution and concentration in surface soils. This will be accomplished using five-point composite sampling that will be analyzed using field techniques (i.e., PCB test kits and metals analysis by XRF) and sending 10% of the total to a fixed-base laboratory. The rationale for this is to get the maximum coverage of the area while minimizing analytical costs.

QAPP Worksheet #17-A. Sampling Design and Rationale (Continued)

Phase II will collect shallow (< 20 ft bgs) samples. These samples will be used to identify VOC concentrations, along with other COCs, in the disposal cells and adjacent shallow soils. The results from the passive soil gas sampling and historical soil and water sample results will be used to select locations that are the most likely to contain elevated COCs. Test pits also will be excavated to gather subsurface information between 0 and 20 ft bgs. (Note: Though test pits are considered part of Phase II, for logistical reasons, they will be excavated after Phase V.) Additionally, Phase II will include installation of seven shallow (20 ft bgs) Upper Continental Recharge System (UCRS) MWs; water elevations and samples will be collected from these wells. Phase III will include a maximum of 27 Direct Push Technology borings to 60 ft bgs at the locations agreed to by the FFA parties. The rationale for this phase is to determine the depth and the lateral extent of contamination.

Phase IV will install 10 borings to the top of the McNairy Formation, approximately 105 ft. The rationale for these borings is to determine the extent and mass of TCE source term with sufficient accuracy to effectively and efficiently complete a remedial design for source term in the Regional Gravel Aquifer (RGA).

Phase V will include installation of five additional RGA MWs. The rationale for this sampling is to define the nature and extent of VOC source term so that a remedial design for VOCs can be completed. Samples will be collected from soil and water (where encountered) at UCRS (Hydrogeologic Unit 4)/RGA interface to identify where VOC source term may have penetrated to the RGA. Additional samples will be collected from soil at the RGA interface with the McNairy to complete a remedial design for a VOC remedy in the RGA, if a free-phase TCE source is found at the base of the RGA. A second objective of Phase V is to collect sufficient quality and quantity of data to determine the RGA groundwater velocity and flow direction.

Describe the sampling design and rationale in terms of which matrices will be sampled: Passive soil gas sampling will be used to determine the locations of soil boring based on the highest VOC concentrations. Soil and water samples will be collected from the borings to a depth of 105 ft. Samples will be analyzed for VOCs, SVOCs, PCBs, metals, and radionuclides (refer to QAPP Worksheet #18 for the number samples and analytical methods by depth). Twenty-two soil borings will be sampled down to 20 ft bgs. Data from the 20 ft borings will be used in part to select locations for 27 borings that will be extended to 60 ft bgs. Ten additional borings will be advanced 105 ft (approximate bottom of the RGA/top of the McNairy Formation). Contingency sampling, as described in Section 5 of the SAP/Work Plan, may occur.

What analyses will be performed and at what analytical limits? See Worksheets #12 and #15.
Standard Environmental Sampling: Total VOC analysis by SW-846, 8260; PCB extraction by SW-846-3150C for water, PCB extraction for soil by SW-846-3540C or SW-846-3546, analysis by 8082, metal analysis by SW-846, 200.8/6010B/6020; radiological analysis by alpha spec, gamma spec, and liquid scintillation; SVOC analysis by SW-846, 8270. See Worksheet #15 for method detection limit.
Engineering and Design Sampling: Chemical oxygen demand by EPA 410.4; total and dissolved organic carbon by SW-846-9060 EPA 415.1, slug test by ASTM D7242-06. See Worksheet #17-B for complete list and additional details.

Where are the sampling locations (including QC, critical, and background samples)? See Worksheet #18.
How many samples to be taken? 161 soil samples, up to 132 water samples (dependent on water yield). See Worksheet #18.
What is the sampling frequency (including seasonal considerations)? This is a one-time sampling event except for the 20 ft wells installed under the scope of Phase II, which will be measured monthly for 12 months in order to determine the effects of various seasonal conditions on groundwater level. Installed wells will be sampled once upon completion; subsequent sampling will be based on the Environmental Monitoring Plan for the PGDP, which is updated annually. Thus seasonal conditions at the time of sampling are unknown. Passive soil gas sampling is the only other sampling that may be affected by seasonal conditions; it is assumed that unsaturated soil conditions are optimal for this data gathering; the manufacturer will be consulted and the deployment schedule may be altered to avoid seasonal saturation.

QAPP Worksheet #17-B. Sampling Design and Rationale (Engineering and Design Sampling)

Analysis	Media Type	# of Samples	Test/Analytical Method	Project Reference Value	PQL
Standard Penetration Test	Soil	4 UCRS, 3 RGA	ASTM D1586-11	N/A	N/A
Grain Size Data	Soil	4 UCRS, 3 RGA	ASTM D422-63(2007)	N/A	N/A
Air Permeability	Soil	1	ASTM D6539-13	N/A	N/A
Percolation Test	Soil	4 UCRS	ASTM D338509	N/A	N/A
Fraction Organic Carbon	Soil	1	SW-846-9060 as modified for soil samples	N/A	N/A
Electron Donor Parameters					
Chemical Oxygen Demand	Water	2	EPA 410.4	N/A	27 mg/L
Total Organic Carbon	Water	2	EPA 415.1/ SW-846-9060	20 mg/L	1 mg/L
Dissolved Organic Carbon	Water	2	EPA 415.1/ SW-846-9060	20 mg/L	1 mg/L
Field Parameters					
DO	Water	All Water	YSI ProDSS Water Quality Meter	0.5 mg/L	0.1 mg/L
pH	Water	All Water	YSI ProDSS Water Quality Meter	5 to 9 Std Units	0.2 Std Units
Oxidation Reduction Potential (ORP)	Water	All Water	YSI ProDSS Water Quality Meter	Per Procedure CP4-ES-0109	20 mV
Eh (Approximate)	Water	All Water	YSI ProDSS Water Quality Meter	Per Procedure CP4-ES-0109	20 mV
Temperature	Water	All Water	YSI ProDSS Water Quality Meter	20°C	+/- 0.2°C
Specific Conductance		All Water	YSI ProDSS Water Quality Meter	N/A	0.001 mS/cm
Alkalinity	Water	4 UCRS, 3 RGA	Hach® Alkalinity Test Kit, Model AL-DT	N/A	0.1–10 mg/L
Slug Test	Water	5	ASTM D7242-06	N/A	N/A
Microbial Parameters					
Microbial Community	Water	2	Laboratory SOP	N/A	N/A
Water Quality Parameters					
Sulfate	Water	1	EPA 300.0/SW-846-9056	N/A	2 mg/L
Chloride	Water	1	EPA 300.0/SW-846-9056	N/A	2 mg/L
Calcium	Water	1	SW-846-6010B	N/A	1 mg/L
Nitrate	Water	1	EPA 300.0/SW-846-9056	N/A	4 mg/L
Ferrous Iron	Water	1	SM 3500-Fe B	N/A	0.2 mg/L

QAPP Worksheet #18. Sampling Locations and Methods

(UFP-QAPP Manual Section 3.1.1 and 3.1.2)
(EPA 2106-G-05 Section 2.3.1 and 2.3.2)

The primary value of this worksheet is as a completeness check for field personnel and auditors/assessors. As with Worksheet #17 above, this sheet is a summary of the project and will be described in the project-specific FSP sampling design and rationale information. The project manager will ensure these components are part of the FSP. Completion of a separate Worksheet #18 to identify where these components are located in the FSP is at the discretion of the project manager.

Worksheet #18 facilitates checks to make sure all planned samples have been collected and appropriate methods have been used. Ideally, this worksheet should list each individual sample that is planned to be collected, including field QC samples. Samples with common entries may be grouped, but field QC samples and samples that are unique must be listed separately. If a sample is being collected in increments, use only one line to identify the sample as it will be analyzed; there is no need to list the increments separately. (If the increments are placed in separate containers to be combined in the laboratory, then each container must be labeled.) If a project involves the collection of a large number of samples, however, it may be acceptable to list groups of similar samples on a single row. Detailed sampling SOPs must be available to field personnel and should be included as an appendix to the QAPP and referenced in this worksheet. The comments field can be used as a reminder to note any special sample handling required in the field and/or Global Positioning System (GPS) coordinates. A map with locations marked should be included. Use additional worksheets as necessary.

Worksheet #18 provides information pertaining to sampling planned for this project. Example taken from SWMU 4 Project.

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Number of Samples (Identify Field Duplicate %)[b]	Sampling SOP Reference[c]	Rationale for Sampling Location
TBD	Soil	Surface/ subsurface	Metals 6200 by XRF	TBD (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Soil	Surface/ subsurface	PCB by Hach® Pocket Colorimeter™ II Test Kit (or equivalent)	TBD (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Soil	Surface/ subsurface	Gamma radiation by sodium iodide detector (or equivalent)	N/A	N/A	See Worksheet #17
TBD	Soil	Surface/ subsurface	Metals	TBD (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Soil	Surface/ subsurface	PCBs	TBD (minimum of 5%)	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods (Continued)

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Number of Samples (Identify Field Duplicate %)[b]	Sampling SOP Reference[c]	Rationale for Sampling Location
TBD	Soil	0–20 ft (5 ft intervals)	VOC, SVOCs, PCBs, Radiological, Metals	94 (4 samples from each of 22, 20 ft-borings, and 1 sample from each of 6 test pits) (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Soil	20–60 ft (10 ft intervals)	VOCs (all intervals); Metals, Radiological, and PCBs in the Top and Bottom Intervals	108 (4 samples from each of 27, 60-ft borings) (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Water	0–20 ft	VOC, SVOCs, PCBs, Radiological, Metals	35 (1 sample from each of 22, 20-ft borings, 1 from each of 7 newly installed UCRS MWs, and 1 from each of 6 test pits) (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Water	20–60 ft	VOCs	27 (1 sample from each of 27, 60-ft borings) (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Soil	0–1 ft	PCBs test kits, XRF Metals analysis (performed in field lab); PCBs, Metals SVOCs, radiological (performed in fixed-base lab)	154 (1 sample from each of 154 five-point composite grids) will be sent to a field lab, of these 16 will be sent to a fixed-base lab for verification (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Soil	60–105 ft	VOCs, Tc-99	20 (2 intervals from each of 10 105 ft borings) (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Water	60–105 ft	VOCs, Tc-99	95 (9 intervals from each of 10 105-ft borings and 1 from each of 5 newly installed RGA MWs) (minimum of 5%)	See Worksheet #21	See Worksheet #17
TBD	Soil	0–105 ft	Geotechnical	8 samples taken for grain size and air permeability (no duplicates)	See Worksheet #21	See Worksheet #17
TBD	Soil gas	0–1 ft	VOCs	48	See Worksheet #21	See Worksheet #17

[a] See Analytical SOP References Table (Worksheet #23).
[b] Contingency locations not included.
[c] See Field SOP References Table (Worksheet #21).

QAPP Worksheets #19 and #30. Sample Containers, Preservation, and Hold Times

(UFP-QAPP Manual Section 3.1.2.2)
(EPA 2106-G-05 Section 2.3.2)

The purpose of this worksheet is to serve as a reference guide for field personnel. It is also an aid to completing the chain-of-custody form and shipping documents. Complete this table for each laboratory used. If laboratory accreditation/certification is required for this project, the project team must verify that the laboratory maintains current accreditation/certification status for each analyte/matrix/method combination, as applicable, throughout its involvement with the project. If the accreditation expiration dates are the same for all entries then a global expiration date can be added at the top of the table, as appropriate. Examples are taken primarily from the C-400 Complex RI/FS Project and Environmental Monitoring Plan; examples from other projects have been included as appropriate.

Laboratory: TBD
List any required accreditations/certifications: DOE Consolidated Audit Program (DOECAP), if applicable
Back-up Laboratory: N/A
Sample Delivery Method: Overnight delivery

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size, & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround Time
VOCs	Water	EPA Methods SW-846-8260 or EPA-624.1	TBD	3 × 40 ml Glass VOA vials	Hydrochloric acid (HCl) to pH < 2; 0–6°C	N/A	14 days	28 days
SVOCs	Water	EPA Method SW-846-8270	TBD	2 × 1,000 ml amber glass	0–6°C	7 days	40 days	28 days
Dieldrin	Water	EPA Method SW-846-8081	TBD	2 × 1,000 ml amber glass	0–6°C	7 days	40 days	28 days
Metals	Water	EPA Methods SW-846-6010/6020 and EPA-200.8	TBD	1 × 500 ml glass	Nitric acid (HNO_3) to pH < 2	N/A	180 days	28 days
Mercury	Water	EPA Methods SW-846-7470 and EPA-245.2	TBD	1 × 250 ml amber glass	HNO_3 to pH < 2	N/A	28 days	28 days
PCBs	Water	EPA Method SW-846-8082	TBD	2 × 1,000 ml amber glass	0–6°C	N/A	N/A*	28 days

QAPP Worksheets #19 and #30. Sample Containers, Preservation, and Hold Times (Continued)

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size, & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround Time
PCBs	Water	EPA-608.3	TBD	1 × 250 ml glass	Sulfuric acid (H_2SO_4) or sodium hydroxide (NaOH) to pH 5-9; 4°C	7 days	40 days	28 days
Radionuclides	Water	Alpha Spec, Gamma Spec, Liquid Scintillation	TBD	3 × 1L plastic	HNO_3 to pH < 2	N/A	180 days	28 days
Chromium (VI)	Soil/Sediment or Concrete	EPA Method SW-846-7196	TBD	1 × 4 oz polypropylene or glass jar	0–6°C	30 days to digestion	7 days from digestion to analysis	28 days
Fluoride	Soil/Sediment or Concrete	EPA Method SW-846-9056	TBD	1 × 4 oz wide mouth glass	N/A	N/A	28 days	28 days
PCBs	Soil/Sediment or Concrete	EPA Method SW-846-8082	TBD	1 × 250 ml wide mouth amber glass	0–6°C	N/A	N/A*	28 days
Radionuclides	Soil/Sediment or Concrete	Alpha Spec, Gamma Spec, Liquid Scintillation	TBD	1 × 16 oz wide mouth poly/plastic jar	N/A	N/A	180 days	28 days
Dioxins and Furans	Soil/Sediment or Concrete	EPA Method SW-846-8290	TBD	125 ml wide mouth amber glass	0–6°C	30 days	45 days	28 days
Metals	Soil/Sediment or Concrete	EPA Method SW-846-6020	TBD	1 × 4 oz wide mouth glass	N/A	N/A	180 days	28 days
Mercury	Soil/Sediment or Concrete	EPA Method SW-846-7471	TBD	1 × 4 oz wide mouth glass	0–6°C	N/A	28 days	28 days
Metals (uranium)	Soil/Sediment	EPA Method SW-846-6200	N/A	Sealable plastic bag	N/A	N/A	180 days	28 days
Total PCBs	Soil/Sediment	EPA Method SW-846-4020	N/A	Sealable plastic bag	N/A	N/A	N/A	28 days
PAHs	Soil/Sediment	EPA Method SW-846-4035	N/A	Sealable plastic bag	N/A	N/A	N/A	28 days

QAPP Worksheets #19 and #30. Sample Containers, Preservation, and Hold Times (Continued)

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size, & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround Time
VOCs	Air	EPA-TO-15	TBD	SUMMA® canister with 10-hour sample duration	N/A	N/A	30 days	28 days
PCBs	Wipe	EPA Method SW-846-8082	TBD	1 × 8 oz amber glass jar	Hexane	N/A	N/A*	28 days
Radionuclides	Wipe	Alpha Spec, Gamma Spec, Liquid Scintillation	TBD	Sealable plastic bag or vial	N/A	N/A	180 days	28 days
Dissolved Hydrocarbon Gases	Water	RSKSOP-175 Modified	TBD	3 × 40 ml glass VOA vial	0-6°C, HCl to pH < 2	N/A	14 days	28
Total Organic Carbon	Water	EPA Method SW-846-9060A	TBD	250 ml amber glass	0-6°C, H2SO4 to pH < 2, zero headspace	N/A	28 days	28
DHC Bacteria	Water	qPCR for DHC Bacteria and key functional genes	TBD	1L poly bottle with screw cap	Cool < 4°C	N/A	48 hours	28

NOTE: Sample volume and container requirements will be specified by the laboratory.
*There is no analytical holding time listed for PCB analysis by EPA Method 8082A.

QAPP Worksheet #20. Field QC Summary

(UFP-QAPP Section 3.1.1 and 3.1.2)
(EPA 2106-G-05 Section 2.3.5)

This worksheet provides a summary of the types of samples to be collected and analyzed for the project. Its purpose is to show the relationship between the number of field samples and associated QC samples for each combination of analyte/analytical group and matrix. This worksheet also is useful for informing the laboratory of the number of samples to expect and for preparing analytical cost estimates. The number and types of QC samples should be based on project-specific DQOs, and this worksheet should be adapted as necessary to accommodate project-specific requirements. Not all types of QC samples shown in the example below will be necessary for all projects. However, some projects may require additional QC samples [e.g., proficiency testing (PT) samples], which can be listed in the “other” column.

Samples that are collected at different depths at the same location, and analyzed separately, should be counted as separate field samples. Even if they are taken from the same container as the parent field sample, matrix spikes (MSs) and MS duplicates are counted separately, because they are analyzed separately. If composite samples or incremental samples are being collected, include only the sample that will be analyzed, subsamples and increments should not be listed separately; however, containers making up the sample (as received by the laboratory) must be labeled.

Example taken from C-400 Complex RI/FS Project.

Matrix	Analyte/ Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Equipment Blanks	Trip Blanks	Other	Total # of Analyses
Solid (Concrete)/Soil	VOCs	857	43	43	43	43	43	1 per day or 1 per cooler	N/A	1,072
Solid (Concrete)/Soil	Metals	857	43	43	43	43	43	N/A	N/A	1,072
Solid (Concrete)/Soil	SVOCs	857	43	43	43	43	43	N/A	N/A	1,072
Solid (Concrete)/Soil	PCBs	857	43	43	43	43	43	N/A	N/A	1,072
Solid (Concrete)/Soil	Radionuclides	857	43	43	43	43	43	N/A	N/A	1,072
Solid (Concrete)/Soil	Dioxins	63	4	4	4	4	4	N/A	N/A	83

QAPP Worksheet #20. Field QC Summary (Continued)

Matrix	Analyte/ Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Equipment Blanks	Trip Blanks	Other	Total # of Analyses
Solid (Concrete)/Soil	Additional Radionuclides (thorium-228, thorium-232, actinium-227, cobalt-60, lead-210, protactinium-231, radium-226, strontium-90)	8	1	1	1	1	1	N/A	N/A	13
Groundwater (MWs)	VOCs	184	10	10	10	10	10	1 per day or 1 per cooler	N/A	234 (plus Trip Blanks)
Groundwater (MWs)	Metals	184	10	10	10	10	10	N/A	N/A	234
Groundwater (MWs)	SVOCs	184	10	10	10	10	10	N/A	N/A	234
Groundwater (MWs)	PCBs	184	10	10	10	10	10	N/A	N/A	234
Groundwater (MWs)	Radionuclides	184	10	10	10	10	10	N/A	N/A	234
Groundwater (Grab, Unfiltered)	VOCs	129	7	7	7	7	7	1 per day or 1 per cooler	N/A	164
Groundwater (Grab, Unfiltered)	SVOCs (PAHs)	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, Unfiltered)	PCBs	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, Unfiltered)	Radionuclides (Tc-99)	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, filtered)	SVOCs (PAHs)	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, filtered)	PCBs	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, filtered)	Radionuclides (Tc-99)	129	7	7	7	7	7	N/A	N/A	164

QAPP Worksheet #21. Field SOPs

(UFP-QAPP Manual Section 3.1.2)
(EPA 2106-G-05 Section 2.3.2)

This worksheet is intended for use to document the specific field procedures being implemented, which is important for measurement traceability. The QAPP must contain detailed descriptions of procedures for field activities, including sample collection; sample preservation; equipment cleaning and decontamination; equipment testing, maintenance, and inspection; and sample handling and custody. If these procedures are included in existing SOPs, then the SOPs should be reviewed to make sure they either are (1) sufficiently prescriptive to be implemented as written or (2) modified as necessary for this project. If an SOP provides more than one procedure or option (for example, one SOP covers the use of several different types of field equipment for the same procedure) this worksheet must note the specific option or equipment being used. Basic information about the SOPs should be provided in this table, and the SOPs themselves should be included in an appendix to the QAPP. Field SOPs must be readily available to field personnel responsible for their implementation. The QAPP must explain any planned modifications to field SOPs. Modifications should be noted clearly on the SOPs. The specific type(s) of SOP modifications/deviations must be summarized in the comments column or a reference provided.

Reference Number	Title and Number Revision Date[a]	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
1	CP2-ES-0026, *Wet Chemistry and Miscellaneous Analyses Data Verification and Validation* (12/2017)	Contractor	N/A	N	N/A
2	CP2-ES-0063, *Environmental Monitoring Data Management Implementation Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (7/2019)	Contractor	N/A	N	N/A
3	CP2-ES-0811, *Pesticide and PCB Analyses Data Verification and Validation, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/2017)	Contractor	N/A	N	N/A
4	CP2-ES-5102, *Radiochemical Analysis Data Verification and Validation, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/2017)	Contractor	N/A	N	N/A
5	CP2-ES-5103, *Polychlorinated Dibenzodioxins/Polychlorinated Dibenzofurans Analyses Data Verification and Validation, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/2017)	Contractor	N/A	N	N/A
6	CP2-ES-5105, *Volatile and Semivolatile Analyses Data Verification and Validation, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (9/2018)	Contractor	N/A	N	N/A

QAPP Worksheet #21. Field SOPs (Continued)

Reference Number	Title and Number Revision Date[a]	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
7	CP2-ES-5107, *Inorganic Analyses Data Verification and Validation, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/2017)	Contractor	N/A	N	N/A
8	CP3-ES-1003, *Developing, Implementing, and Maintaining Data Management Plans* (10/31/2022)	Contractor	N/A	N	N/A
9	CP3-ES-5003, *Quality Assured Data* (11/1/2022)	Contractor	N/A	N	N/A
10	CP4-ES-0036, *Asbestos Inspections, Bulk Material and Waste Sampling* (11/1/2022)	Contractor	N/A	N	N/A
11	CP3-ES-0043, *Temperature Control for Sample Storage* (10/31/2022)	Contractor	Sampling	N	N/A
12	CP4-ES-0074, *Monitoring Well Inspection and Maintenance* (9/8/2021)	Contractor	Sampling	N	N/A
13	CP4-ND-0479, *Visual Inspection* (10/17/2022)	Contractor	N/A	N	N/A
14	CP4-ES-1001, *Transmitting Data to the Paducah Oak Ridge Environmental Information System* (11/1/2022)	Contractor	N/A	N	N/A
15	CP4-ES-1002, *Submitting, Reviewing, and Dispositioning Changes to the Environmental Databases* (11/3/2022)	Contractor	N/A	N	N/A
16	CP4-ES-2002, *Sampling of Structural Elements and Miscellaneous Surfaces* (11/3/2022)	Contractor	N/A	N	N/A
17	CP4-ES-2100, *Groundwater Level Measurement* (11/3/2022)	Contractor	Sampling	N	N/A
18	CP4-ES-2101, *Groundwater Sampling* (3/16/2023)	Contractor	Sampling	N	N/A
19	CP3-ES-2203, *Surface Water Sampling* (3/16/2023)	Contractor	Sampling	N	N/A
20	CP4-ES-2300, *Collection of Soil Samples* (11/3/2022)	Contractor	N/A	N	N/A
21	CP4-ES-2302, *Collection of Sediment Samples Associated with Surface Water* (11/3/2022)	Contractor	Sampling	N	N/A
22	CP4-ES-2303, *Borehole Logging* (11/30/2017)	Contractor	N/A	N	N/A
23	CP4-ES-2700, *Logbooks and Data Forms* (11/3/2022)	Contractor	N/A	N	N/A
24	CP4-ES-2702, *Decontamination of Sampling Equipment and Devices* (11/3/2022)	Contractor	Sampling	N	N/A
25	CP4-ES-2704, *Trip, Equipment, and Field Blank Preparation* (1/11/2023)[c]	Contractor	N/A	N	N/A
26	CP3-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals* (10/31/2022)	Contractor	N/A	N	N/A

QAPP Worksheet #21. Field SOPs (Continued)

Reference Number	Title and Number Revision Date[a]	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
27	CP3-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling* (11/28/2022)	Contractor	N/A	N	N/A
28	CP4-ES-5007, *Data Management Coordination* (11/3/2022)	Contractor	N/A	N	N/A
29	*Standard Operating Procedure for Sampling Porous Surfaces for Polychlorinated Biphenyls (PCBs)* (EPA 2011) (5/2011)	EPA	N/A	N	N/A
30	CP4-ER-1020, *Collection of Soil Samples with Direct Push Technology Sampling* (8/31/2021)	Contractor	N/A	N	N/A
31	CP4-ER-1035, *Vapor Sampling* (1/19/2023)	Contractor	N/A	N	N/A
32	CP2-HS-2040, *Asbestos Controls Program at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (1/2023)	Contractor	N/A	N	N/A
33	CP3-OP-0500, *Performance/Process Observation and Tour Process* (5/23/2022)	Contractor	N/A	N	N/A
34	CP3-QA-1003, *Management and Self-Assessment* (7/21/2021)	Contractor	N/A	N	N/A
35	CP3-RD-0010, *Records Management Process* (6/30/2022)	Contractor	N/A	N	N/A
36	CP5-RP-2016, *Radiological Protection Contamination Control and Monitoring Technical Basis Document* (4/2022)	Contractor	N/A	N	N/A
37	CP5-RP-2022, *Radiological Protection Instrumentation Operation Technical Basis Document* (1/2023)	Contractor	N/A	N	N/A
38	CP3-RP-1109, *Radioactive Contamination Control and Monitoring* (9/26/2022)	Contractor	N/A	N	N/A
39	CP4-RP-1110, *Radiation Surveys* (1/30/2023)	Contractor	N/A	N	N/A
40	CP4-RP-1309, *Setup for Operability Tests of Portable Field Instruments* (2/7/2022)	Contractor	N/A	N	N/A
41	CP4-RP-1336, *Radiological Instrumentation Field Operability Tests* (2/7/2022)	Contractor	N/A	N	N/A
42	CP2-WM-0001, *Four Rivers Nuclear Partnership, LLC, Paducah Deactivation and Remediation Project Waste Management Plan* (1/2021)	Contractor	N/A	N	N/A
43	CP5-SD-1013, *Work Controls and Methods for Demolition Completed Under DOE Authority* (7/1/2021)	Contractor	N/A	N	N/A

[a] SOPs are posted to the FRNP intranet website. External FFA parties can access this site using remote access with privileges upon approval. It is understood that SOPs are contractor specific. The project reports will specify any deviation between the procedures presented in this worksheet, those at the FRNP intranet website, and those actually used during the project.
[b] The work will be conducted by FRNP staff or a subcontractor. In either case, SOPs listed will be followed.

QAPP Worksheet #21. Field SOPs (Continued)

[c] The Hazardous Waste Management Facility Permit defines a duplicate as being collected from a single sample collection container or sample mixing container. This SOP defines a duplicate as being collected using the same procedural requirements as the original sample. Duplicates collected from MWs at the C-404 Landfill under the permit will be collected as prescribed in the permit and as prescribed in this SOP. Additional information can be found in Appendix E.

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

(UFP-QAPP Manual Section 3.1.2.4)
(EPA 2106-G-05 Section 2.3.6)

This worksheet should document procedures for calibrating, maintaining, testing, and/or inspecting field equipment (e.g., tools, pumps, gauges, magnetometers, pH meters, water-level measurement devices). If these activities are documented in an SOP or manufacturer's instructions, and the relevant SOP or instruction is attached, then the frequency, acceptance criteria, and corrective action columns may be left blank. Note that the information summarized in this worksheet should be recorded in the field notes/logs.

Field Equipment*	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
MiniRAE Photoionization Detector Toxic Gas Monitor with 10.5 eV Lamp or Similar Meter	Calibrate at the beginning of the day; check at the end of the day	As needed in the field; semiannually by the supplier	Measure known concentration of isobutylene 100 ppm (calibration gas)	Upon receipt, successful operation	Calibrate a.m., check p.m.	± 10% of the calibrated value	Manually zero meter or service as necessary and recalibrate	Field Team Leader	Manufacturer's specifications
Water Quality Meter	Calibrate at the beginning of the day	Performed annually and as needed	Measure solutions with known values (National Institute for Standards and Technology traceable buffers and conductivity calibration solutions)	Upon receipt, successful operation	Daily before each use	pH: ± 0.1 s.u. Specific Conductivity: ± 3% ORP: ± 10 mV DO: ± 0.3 mg/L Temp.: ± 0.3ºC	Recalibrate or service as necessary	Field Team Leader	Manufacturer's specifications

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection (Continued)

Field Equipment*	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Turbidity Meter (Nephthelometer)	Calibrate daily before each use	As needed	Measure solutions with known turbidity standards	Upon receipt, successful operation	Daily before each use	N/A (instrument zeroed)	Manually zero meter or service as necessary and recalibrate	Field Team Leader	Manufacturer's specifications
Ferrous Iron Colorimeter	Accuracy check at the beginning of each day	Return to instrument rental for replacement	Measure with standard solution	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Return to rental company for replacement	Field Team Leader	Manufacturer's specifications
PCB Colorimeter	Accuracy check at the beginning of each day	As needed	Measure with standards	Upon receipt, successful operation	Check daily before each use	Within range of manufacturer's standard	Service by manufacturer	Field Team Leader	Manufacturer's specifications
Titrator (for total residual chlorine)	Calibrate to manufacturer's solution weekly	As needed	Measure with standard solution	Upon receipt, successful operation	Weekly	With range of manufacturer's standard	Service by manufacturer	Field Team Leader	Manufacturer's specifications
Global Flow Meter	Calibrate when replace battery	As needed	Spin prop to verify instrument reading	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Service by manufacturer	Field Team Leader	Manufacturer's specifications
Electron Water Level Meter	N/A	None	Check daily before each use	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Return to rental company for replacement	Field Team Leader	Manufacturer's specifications
Pressure Transducer (Data Logger typically used for water level measurement in MWs)	Return to manufacturer annually for calibration	Return to manufacturer for maintenance, as needed	Compare water level reading against reading from electron water level meter	Upon receipt, successful operation	Before each use, as needed	Per manufacturer's specifications	Return to manufacturer for repair or replacement	Field Team Leader	CP4-ES-2100, *Groundwater Level Measurement*/ Manufacturer's specifications
Hach® Flow Meter	Calibrate to readings on flume	Quarterly or as needed	Measure against flume	Upon receipt, successful operation	Weekly as needed	Pass/Fail	Service by manufacturer	Field Team Leader	Manufacturer's specifications

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection (Continued)

Field Equipment*	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Alpha Scintillator	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Remove from service and replace or recalibrate prior to reuse	RADCON Supervisor	Manufacturer's specifications
Geiger Mueller	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Remove from service and replace or recalibrate prior to reuse	RADCON Supervisor	Manufacturer's specifications
Gamma Scintillator or FIDLER	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Remove from service and replace or recalibrate prior to reuse	RADCON Supervisor	Manufacturer's specifications
Field Equipment GPS	Daily check of known point beginning and end of each field day	Per manufacturers specifications	Measure known control points and compare values	Upon receipt, successful operation	Beginning and end of each field day	Pass/Fail	Service by manufacturer	Field Team Leader	Manufacturer's specifications
GPS Gamma Ray Survey Instrumentation	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Annually or as needed	Pass/Fail	Remove from service and replace or recalibrate prior to reuse	RADCON Supervisor	Manufacturer's specifications
Colloidal Borescope	Check of magnetic north before each use and return to manufacturer as needed	Clean as needed	Ensure aligned with magnetic north	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Service by manufacturer or replace	Field Team Leader	Manufacturer's specifications
Magnetic Hand-held compass	N/A	None	None	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Service by manufacturer or replace	Field Team Leader	Manufacturer's specifications

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection (Continued)

Field Equipment*	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Differential Pressure/Flow Gauge and Recorder (The Energy Conservatory DG-700 or equivalent)	As specified by manufacturer	Replace batteries as needed	Per instrument specifications	N/A	Check if operating properly daily	Pass/Fail	Return to manufacturer or rental vendor, if necessary	Sample Team Leader	Manufacturer's user manual
Landfill Gas Meter (GEM 5000 or equivalent)	Calibrate at the beginning of the day; check at the end of the day	As needed in the field; semiannually by the supplier	Measure known concentrations of CH_4, CO_2, and O_2 gases (calibration gases)	Upon receipt, successful operation	Calibrate a.m., check p.m.	± 10% of the calibrated value	Service as necessary and recalibrate	Sample Team Leader	Manufacturer's specifications
Mercury Vapor Analyzer (Jerome J505 or equivalent)	As specified by manufacturer	Change fuse as needed in the field; regular maintenance by the supplier	Measure known concentrations of mercury vapor (calibration test kit)	Upon receipt, successful operation	Check a.m. and p.m.	± 10% of the known value	Service as necessary	Sample Team Leader	Manufacturer's specifications
MIP Transfer Line and Detectors	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Service by manufacturer	Field Team Leader	Manufacturer's specifications
MIP Soil Conductivity Tip	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Service by manufacturer	Field Team Leader	Manufacturer's specifications
DyeLIF	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Service by manufacturer	DyeLIF Operator	Manufacturer's specifications

*Additional equipment may be needed; additional equipment will follow manufacturer's specifications for calibration, maintenance, inspection, and testing. Calibration data will be documented in logbooks consistent with CP4-ES-2700, *Logbooks and Data Forms*.
FIDLER = field instrument for detection of low energy radiation
RADCON = radiation control

QAPP Worksheet #23. Analytical SOPs

(UFP-QAPP Manual Section 3.2.1)
(EPA 2106-G-05 Section 2.3.4)

This worksheet documents information about the specific sample preparation and analytical procedures to be used, which is important for measurement traceability. Screening data are used for interim investigations and/or will not be used for final risk assessment or site assessment decisions unless they have been confirmed with definitive procedures. SOPs for sample preparation and analytical procedures must be current and referenced whether these activities are performed in the field or in an off-site laboratory. If this information is not known at the time the QAPP is being prepared (i.e., laboratory selection has not occurred), it is acceptable to enter “TBD” for the required information. This worksheet must be completed, however, before the QAPP is approved. If required by the project, copies of the SOPs should be included as a hard copy or electronic appendix. The project team should review SOPs to make sure they are either (1) sufficiently prescriptive to be implemented as written or (2) modified, as necessary, for this project. If an SOP provides more than one procedure or option [e.g., extraction procedures for analytes of different concentration levels (SW5035), sulfur cleanup options (SW3660), or derivatization techniques (SW8151)], the specific option being implemented must be noted. This worksheet must summarize planned modifications to existing SOPs, and modifications should be noted clearly on the copies of the SOPs themselves. Personnel responsible for implementing sample preparation and analytical SOPs must have access to the specific SOPs they are using.

Reference Number[a]	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group/ Matrix	Instrument	Organization Performing Analysis	Modified for Project Work?(Y/N)
8260	Volatile Organic Compounds by GC/MS	Definitive	VOCs/Soil/Sediment or Concrete and Water	GC/MS	TBD	No
624.1	Purgeables by GC/MS	Definitive	Water	GC/MS	TBD	No
8270	Semivolatile Organic Compounds by GC/MS	Definitive	SVOCs/Soil/Sediment or Concrete and Water	GC/MS	TBD	No
8081	Organochlorine Pesticides by Gas Chromatography (GC)	Definitive	Pesticides (Dieldrin)/ Soil/Sediment or Concrete and Water	GC	TBD	No
200.8	Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma – Mass Spectrometry (ICP-MS)	Definitive	Metals/Water	ICP-MS	TBD	No
6010	Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	Definitive	Metals/Soil/Sediment or Concrete and Water	ICP	TBD	No
6020	Inductively Coupled Plasma-Mass Spectrometry	Definitive	Metals/Soil/Sediment or Concrete and Water	ICP-MS	TBD	No

QAPP Worksheet #23. Analytical SOPs (Continued)

Reference Number[a]	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group/Matrix	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
7470/ 7471/ 245.2	Mercury in Liquid Waste (Manual Cold-Vapor Technique) Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique) Mercury (Automated Cold Vapor Technique)	Definitive	Metals (Mercury)/ Soil/Sediment or Concrete and Water	Atomic Absorption	TBD	No
9056	Determination of Inorganic Anions by Ion Chromatography	Definitive	Anions (Fluoride)/ Soil/Sediment or Concrete and Water	Ion Chromatograph	TBD	No
7196	Chromium, Hexavalent (Colorimetric)	Definitive	Metals [Chromium (VI)]/ Soil/Sediment or Concrete and Water	Spectrophoto-meter or Filter Photometer	TBD	No
8082	PCBs by GC	Definitive	PCBs/Soil/Sediment or Concrete and Water	GC	TBD	No
608.3	Organochlorine Pesticides and PCBs by GC/Halogen-Specific Detector (HSD)	Definitive	Water	GC/HSD	TBD	No
8290	Dioxins and Furans by High Resolution Gas Chromatography (HRGC) and High Resolution Mass Spectrometry (HRMS)	Definitive	Dioxins/Soil/Sediment or Concrete	HRGC/HRMS	TBD	No
6200	Field Portable X-ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment	Screening	Metals (Uranium)/ Soil/Sediment	Field Portable XRF	FRNP	No
4035	Soil Screening for Polynuclear Aromatic Hydrocarbons by Immunoassay	Screening	PAHs/ Soil/Sediment	Field Test Kit	FRNP	No
4020	Screening for Polychlorinated Biphenyls by Immunoassay	Screening	PCBs/ Soil/Sediment	Field Test Kit	FRNP	No
9060A	Nonhalogenated Organics by GC	Definitive	Water	Carbonaceous Analyzer	TBD	No
TO-15	Determination of VOCs in Air Collected in Specially-Prepared Canisters and Analyzed by GC/MS	Definitive	VOCs/ Air	GC/MS	TBD	No

QAPP Worksheet #23. Analytical SOPs (Continued)

Reference Number[a]	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group/Matrix	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
Gas Flow Proportional[b]	Gas Flow Proportional	Definitive	Rads/Soil and Water	Gas Flow Proportional Counter	TBD	No
Alpha Spec[b]	Alpha Spectrometry	Definitive	Rads/Soil and Water	Alpha Spectrometry	TBD	No
Gamma Spec[b]	Gamma Spectrometry	Definitive	Rads/Soil and Water	Gamma Spectrometry	TBD	No
Liquid Scintillation[b]	Tc-99 by Liquid Scintillation	Definitive	Rads/Soil and Water	Liquid Scintillation	TBD	No
RSKSOP-175 Modified	Dissolved Gases by GC	Definitive	Water	GC	TBD	No
qPCR for DHC Bacteria and key functional genes—TBD	DHC Bacteria	Screening	Water	TBD	TBD	No

[a] Information will be based on laboratory used. Analysis will be by the most recent revision.
[b] Analytical methods for radiochemistry parameters are laboratory specific.

QAPP Worksheet #24. Analytical Instrument Calibration

(UFP-QAPP Manual Section 3.2.2)
(EPA 2106-G-05 Section 2.3.6)

This worksheet should be completed for analytical instruments, whether used in the field or the laboratory. As appropriate to the instrument, calibration procedures should include tuning, initial calibration, calibration blank, initial calibration verification (second source), continuing calibration verification, linear dynamic range (ICP and ICP/MS only), and verification of detection and quantification limits (however defined.) See also Worksheet #15. If information for a specific procedure is provided in an SOP, and the SOP is attached, then this worksheet can reference the SOP and identify the responsible person.

Laboratories used by the DOE Prime Contractor are participants in DOECAP. In the fall of 2017, DOECAP began implementing accreditation of environmental laboratories through third-party organizations. If not in DOECAP, laboratories are audited by contractors for compliance with DOECAP program requirements. As such, laboratory equipment and instruments used for quantitative measurements are calibrated in accordance with the laboratory's formal calibration program as summarized in the SOPs. The laboratory is responsible for maintaining instrument calibration information per its QA Plan, including control charts established for instrumentation.

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 prior to running each sample set. The calibrations and ongoing instrument performance parameters are recorded and reported as part of the analytical data package.

Instrument*	Calibration Procedure	Calibration Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference

*The laboratory is responsible for maintaining instrument calibration information per their QA Plan, including control charts established for instrumentation. This information is audited. Additional certifications may be needed based on project-specific requirements (e.g., National Environmental Laboratory Accreditation Program, KDEP Drinking Water Laboratory Program). Field survey/sampling instrumentation will be calibrated according to manufacturer's instructions.

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

(UFP-QAPP Manual Section 3.2.3)
(EPA 2106-G-05 Section 2.3.6)

The project team should determine whether it is necessary to complete fields in this table. For example, if the selected laboratory is operating under a quality system that conforms to ISO 17025:2005, then the activities documented in this table will be documented in the laboratory's quality manual (however named). In this case, it may be acceptable simply to reference the quality manual (including revision number and date.) If the project has specific requirements that are different from those contained in the laboratory's quality manual, this table should be completed for those items.

Laboratories used by the DOE Prime Contractor are participants in DOECAP. In the fall of 2017, DOECAP began implementing accreditation of environmental laboratories through third-party organizations. If not in DOECAP, laboratories are audited by contractors for compliance with DOECAP program requirements. As such, laboratory equipment and instruments used for quantitative measurements are calibrated in accordance with the laboratory's formal calibration program as summarized in the SOPs. The laboratory is responsible for maintaining instrument calibration information per its QA Plan, including control charts established for instrumentation. If the project has specific requirements that are different from those contained in the laboratory's quality manual, this table should be completed for those items.

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference*
All	Per laboratory quality manual	QC standards	Per laboratory quality manual	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Section Manager	See Worksheet #23

QAPP Worksheet #25. Analytical Instrument and Equipment Maintenance, Testing, and Inspection (Continued)

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
GC	Electron capture detector (ECD)/flame ionization detector (FID) maintenance; replace/clip capillary column	QC standards	ECD, FID, injector, injector liner, column, column flow	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Section Manager	See Worksheet #23
ICP-AES	Clean plasma torch; clean filters; clean spray and nebulizer chambers; replace pump tubing	Metals	Torch, filters, nebulizer chamber, pump, pump tubing	As needed	Initial and/or continuing calibration criteria must be met	Repeat maintenance activity or remove from service	Laboratory Area Supervisor	See Worksheet #23
ICP-MS	Clean plasma torch; clean filters; clean spray and nebulizer chambers; replace pump tubing	Metals	Torch, filters, nebulizer chamber, pump, pump tubing	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Area Supervisor	See Worksheet #23
pH Meter	Clean probe	QC standards	Probe	As needed	The value for each of the certified buffer solutions must be within ± 0.05 pH units of the expected value	Repeat maintenance activity or remove from service	Laboratory Manager	See Worksheet #23

QAPP Worksheet #25. Analytical Instrument and Equipment Maintenance, Testing, and Inspection (Continued)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference*
Spectro-photometer	Flush/replace tubing	QC standards	Tubing	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Manager	See Worksheet #23
Cold Vapor Atomic Absorption	Replace tubing, check instrument lines and connections, check windows in cell, ensure lamp operational	Metals	Instrument lines and connections, windows and lamp	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Area Supervisor	See Worksheet #23

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

QAPP Worksheets #26 and #27. Sample Handling, Custody, and Disposal

(UFP-QAPP Manual Section 3.3)
(EPA 2106-G-05 Section 2.3.3)

This worksheet is used to document responsibilities for maintaining custody of samples from sample collection through disposal. Examples of forms, sample labels, and chain-of-custody documentation should be included as an attachment to the QAPP. The information in this worksheet table can be referenced to the appropriate SOPs if they are attached to the QAPP.

Example adapted from C-400 Complex RI/FS Project.

Sampling Organization: TBD
Laboratory: TBD
Method of sample delivery (shipper/carrier): Overnight
Number of day from reporting until sample disposal: Six months (182 days)

Activity	Organization and title or position of person responsible for the activity	SOP reference
Sample labeling	Sampling Teams/DOE Prime Contractor and Subcontractors	CP3-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*
Chain of custody form completion	Sampling Teams/DOE Prime Contractor and Subcontractors	CP3-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*
Packaging	Sampling Teams/DOE Prime Contractor and Subcontractors	CP3-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*
Shipping coordination	SMO/DOE Prime Contractor	CP3-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*
Sample receipt, inspection, and log-in	Sample Management/Contracted Laboratory	TBD
Sample custody and storage	Sample Management/Contracted Laboratory	TBD
Sample disposal	Sample Management/Contracted Laboratory	TBD

QAPP Worksheet #28. Analytical Quality Control and Corrective Action

(UFP-QAPP Manual Section 3.4 and Tables 4, 5, and 6)
(EPA 2106-G-05 Section 2.3.5)

The purpose of this worksheet is to ensure that the selected analytical methods are capable of meeting project-specific MPC, which are based on PQOs/DQOs. Complete a separate worksheet for each sampling technique, analytical method/SOP, matrix, and analytical group. If method/SOP QC acceptance criteria do not meet the project-specific MPC, the data obtained may be unusable for making reliable project decisions. In this case, the project team should consider selecting an alternate method or modifying the method. The list of QC samples in this example is incomplete. See Section 2.2 of Part 2B of the UFP-QAPP QA/QC Compendium, the QA Matrix in Section 3.4, and Tables 4, 5, and 6 for further information and guidance on QC samples.

QAPP Worksheet #28-A. Analytical Quality Control and Corrective Action (Aqueous)

Matrix: Aqueous Samples
Analytical Group/Concentration Level: VOCs, Metals, Anions, PCBs, Rads, SVOCs (including pesticides)
Sampling SOP: See Worksheet #21
Analytical Method/SOP Reference: 8260/624.1, 200.8/6010/6020/7196/7470/245.2, 9056, 8082/608.3, Alpha Spec, Gamma Spec, Liquid Scint, 8270, and 8081
Sampler's Name/Field Sampling Organization: FRNP
Analytical Organization: TBD
No. of Sample Locations: TBD

QC Sample	Frequency/Number[a]	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Field blank	Minimum 5%	≤ CRQL[b]	Verify results; reanalyze	Laboratory should alert project	Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Trip blank	1 per cooler containing VOC samples	≤ CRQL[b]	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Equipment blank	Minimum 5%	≤ CRQL[b]	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Spiked field samples (matrix spike and/or matrix spike duplicate)	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy/Precision	See procedure CP3-ES-5003, *Quality Assured Data*
Laboratory spiked blanks (laboratory control sample)	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Contamination—Accuracy/Bias	See procedure CP3-ES-5003, *Quality Assured Data*

Worksheet #28-A. Analytical Quality Control and Corrective Action (Aqueous) (Continued)

QC Sample	Frequency/Number[a]	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5105, -5107	Check calculations and instrument; reanalyze affected samples	Laboratory should alert project	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Surrogate Standards	All samples, blanks and QA samples	See data validation plans CP2-ES-0811, -5105	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Internal standards	All samples and standards	See data validation plans CP2-ES-5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Field duplicate	Minimum 5%	See data validation plans CP2-ES-0026, -0811, -5102, -5105, -5107	Data reviewer will place qualifiers on samples affected	Project	Homogeneity/ Precision	Specific RPD defined for each group in Worksheet #12
Laboratory duplicate	Per laboratory procedure	See data validation plans CP2-ES-0026, -0811, -5102, -5105, -5107	Verify results re-prepare and reanalyze	Laboratory analyst	Precision	See procedure CP3-ES-5003, *Quality Assured Data*
Tracers/Carriers	Each sample tested by a radiochemical separations method	See data validation plan CP2-ES-5102	Check calculations and instrument; reanalyze affected samples	Laboratory analyst	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*

[a] The number of QC samples is listed on Worksheet #20.
[b] Unless dictated by project-specific parameters, ≤ contract-required quantitation limit (CRQL).

QAPP Worksheet #28-B. Analytical Quality Control and Corrective Action (Soil/Sediment)

Matrix: Soil/Sediment
Analytical Group/Concentration Level: VOCs, Metals, PCBs, Radionuclides, SVOCs (including pesticides)
Sampling SOP: See Worksheet #21
Analytical Method/SOP Reference: 8260, 6010/6020/7471/7196/9056, 8082, Alpha Spec, Gamma Spec, Liquid Scint, 8270, and 8081
Sampler's Name/Field Sampling Organization: FRNP
Analytical Organization: TBD
No. of Sample Locations: TBD

QC Sample	Frequency/Number[a]	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Field blank	Minimum 5%	≤ CRQL[b]	Verify results; reanalyze	Laboratory should alert project	Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Trip blank	1 per cooler containing VOC samples	≤ CRQL[b]	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Equipment blank	Minimum 5%	≤ CRQL[b]	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Spiked field samples (matrix spike and/or matrix spike duplicate)	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy/Precision	See procedure CP3-ES-5003, *Quality Assured Data*
Laboratory spiked blanks (laboratory control sample)	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Contamination—Accuracy/Bias	See procedure CP3-ES-5003, *Quality Assured Data*

QAPP Worksheet #28-B. Analytical Quality Control and Corrective Action (Soil/Sediment) (Continued)

QC Sample	Frequency/Number[a]	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, 5102, -5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples	Laboratory should alert project	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Surrogate Standards	All sample blanks and QA samples	See data validation plans CP2-ES-0811, -5105	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Internal standards	All sample blanks and QA samples	See data validation plans CP2-ES-5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Field duplicate	Minimum 5%	See data validation plans CP2-ES-0026, -0811, -5102, -5103, -5105, -5107	Data reviewer will place qualifiers on samples affected	Project	Homogeneity/ Precision	Specific RPD defined for each group in Worksheet #12
Laboratory duplicate	Per laboratory procedure	See data validation plans CP2-ES-0026, -0811, 5102, -5103, -5105, -5107	Verify results re-prepare and reanalyze	Laboratory analyst	Precision	See procedure CP3-ES-5003, *Quality Assured Data*
Tracers/Carriers	Each sample tested by a radiochemical separations method	See data validation plan CP2-ES-5102	Check calculations and instrument; reanalyze affected samples	Laboratory analyst	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*

[a] The number of QC samples is listed on Worksheet #20.
[b] Unless dictated by project-specific parameters, ≤ CRQL.

QAPP Worksheet #28-C. Analytical Quality Control and Corrective Action (Air)

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: FRNP
Analytical Organization: TBD
No. of Sample Locations: TBD

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Field duplicate	Minimum 5%	As with other samples	Data reviewer will place qualifiers on samples affected	Project	Homogeneity/ Precision	RPD ≤ 50%
Routine Laboratory	Per lab SOP	Per lab SOP	Per lab SOP	Per lab SOP	Per lab SOP	Per lab SOP

QAPP Worksheet #29. Project Documents and Records

(UFP-QAPP Manual Section 3.5.1)
(EPA 2106-G-05 Section 2.2.8)

This worksheet should be used to record information for documents and records that will be generated for the project. It describes how information will be collected, verified, and stored. Its purpose is to support data completeness, data integrity, and ease of retrieval.

Example taken from C-400 Complex RI/FS Project.

Sample Collection and Field Records			
Record	**Generation**	**Verification**	**Storage location/archival**
Field logbook or sample data forms	Field Team	Field Team Leader	Project File
Chain-of-Custody Forms	Field Team	Field Team Leader	Project File
Air Bills	Contract Laboratory	Contract Laboratory	Project File
Equipment Calibration Forms	Field Team	Field Team Leader	Project File
Deviations	Project Manager	Project Director	Project File
Corrective Action Reports	Project Manager	Project Director	Project File
Correspondence	Project Manager	Project Director	Project File

Project Assessments			
Record	**Generation**	**Verification**	**Storage location/archival**
Data verification checklists	SMO/Data Validator	SMO	Project File
Data validation report	Data Validator	SMO	Project File
Data usability assessment report	Data Validator	SMO	Project File

Laboratory Records			
Record	**Generation**	**Verification**	**Storage location/archival**
Level IV Laboratory Reports	Laboratory Staff	Laboratory Project Manager	Project File
Electronic Data Deliverables (EDDs)	Laboratory Staff	Laboratory Project Manager	Project File

QAPP Worksheets #31, #32, and #33. Assessments and Corrective Action

(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)
(EPA 2106-G-05 Section 2.4 and 2.5.5)

This worksheet is used to document responsibilities for conducting project assessments, responding to assessment findings and implementing corrective action. Appropriately scheduled assessments (e.g., field sampling technical systems audits at the beginning of sampling) allow management to implement corrective action in a timely manner, thereby correcting nonconformances and minimizing their impact on DQOs/PQOs. Assessment checklists should be included in the QAPP or referenced.

Assessments:

Assessment Type	Responsible Party & Organization	Number/Frequency	Estimated Date	Assessment Deliverable	Deliverable Due Date
Field Sampling technical systems audit (TSA)	Field Team Leader/ FRNP	One each on first day of soil and groundwater sampling episodes	[fill in planned dates]	As described in CP3-QA-1003, *Management and Self-Assessment*	As described in CP3-QA-1003, *Management and Self-Assessment*
On-site analytical TSA	Field Team Leader/ FRNP	Prior to start of on-site analytical work and every 2 weeks thereafter	[fill in planned dates]	As described in CP3-QA-1003, *Management and Self-Assessment*	As described in CP3-QA-1003, *Management and Self-Assessment*
Off-site Laboratory Technical Systems Audit	Laboratory Manager/Technical Director	Annually	Annually/Ongoing	Internal Audit Repot	Per Individual Laboratory QA Manual
Management Assessment	Project Director/ FRNP	Interim management review following site mobilization; final management review upon completion of fieldwork	[fill in planned dates]	As described in CP3-QA-1003, *Management and Self-Assessment*	As described in CP3-QA-1003, *Management and Self-Assessment*
Independent Assessment	Contractor Performance Assurance Program (CPAP) Manager	As needed	[fill in planned dates]	As described in CP3-QA-1004, *Independent Assessment Program*	As described in CP3-QA-1004, *Independent Assessment Program*

QAPP Worksheets #31, #32, and #33. Assessments and Corrective Action (Continued)

Assessment Response and Corrective Action:

Assessment Type	Responsibility for Responding to Assessment Findings	Assessment Response Documentation	Time Frame for Response	Responsibility for Implementing Corrective Action	Responsible for Monitoring Corrective Action implementation
Field Sampling TSA	Field Team Leader/FRNP	Field Sampling Corrective Action Response (following CP3-QA-3001, *Issues Management*)	24 hours from receipt of memorandum	Field Team Leader/FRNP	CPAP Manager/FRNP
On-site analytical TSA	Field Team Leader/ FRNP	On-site Analytical Corrective Action Response (following CP3-QA-3001, *Issues Management*)	48 hours from receipt of memorandum and before further analyses can be conducted.	Field Team Leader/ FRNP	CPAP Manager/FRNP
Off-site Laboratory Technical Systems Audit	Laboratory Manager/Technical Director	Internal Audit Report Deficiency Memorandum	7 days following receipt of PT deficiency report and before analysis field samples	Laboratory Technical Director	QA/QC Program Manager/FRNP
Management Assessment	Project Director/ FRNP	Management Response	As described in CP3-QA-1003, *Management and Self-Assessment*	As assigned in Management Response	CPAP Manager/FRNP
Independent Assessment	Director/Manager of the Assessed Organization	As required by CP3-QA-1004, *Independent Assessment Program*	As required by CP3-QA-1004, *Independent Assessment Program*	Field Team Leader/ FRNP	CPAP Manager/FRNP

QAPP Worksheet #34. Data Verification and Validation Inputs

(UFP-QAPP Manual Section 5.2.1 and Table 9)
(EPA 2106-G-05 Section 2.5.1)

This worksheet is used to list the inputs that will be used during data verification and validation. Inputs include planning documents, field records, and laboratory records. Data verification is a check that specified activities involved in collecting and analyzing samples have been completed and documented and that the necessary records (objective evidence) are available to proceed to data validation. Data validation is the evaluation of conformance to stated requirements, including those in the contract, methods, SOPs, and the QAPP. Examples of records subject to verification and validation are listed below. The actual inputs required should be based on the graded approach, as defined during project planning.

The Optimized UFP QAPP guidance provides the following example table for data verification and validation inputs.

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
Planning Documents/Records			
1	Approved QAPP	X	
2	Contract	X	
3	Field SOPs	X	
4	Laboratory SOPs	X	
Field Records			
5	Field Logbooks and/or sample data forms	X	X
6	Equipment calibration records	X	X
7	Chain-of-Custody forms	X	X
8	Sampling diagrams/surveys	X	X
9	Drilling logs	X	X
10	Geophysics reports	X	X
11	Relevant correspondence	X	X
12	Change orders/deviations	X	X
13	Field audit reports	X	X
14	Field corrective action reports	X	X

QAPP Worksheet #34. Data Verification and Validation Inputs (Continued)

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
Analytical Data Package			
15	Cover sheet (laboratory identifying information)	X	X
16	Case narrative	X	X
17	Internal laboratory chain-of-custody	X	X
18	Sample receipt records	X	X
19	Sample chronology (i.e., dates and times of receipt, preparation, and analysis)	X	X
20	Communication records	X	X
21	Project-specific PT sample results	X	X
22	Limit of detection/limit of quantification establishment and verification	X	X
23	Standards Traceability	X	X
24	Instrument calibration records	X	X
25	Definition of laboratory qualifiers	X	X
26	Results reporting forms	X	X
27	QC sample results	X	X
28	Corrective action reports	X	X
29	Raw data	X	X
30	EDD	X	X

QAPP Worksheet #35. Data Verification Procedures

(UFP-QAPP Manual Section 5.2.2)
(EPA 2106-G-05 Section 2.5.1)

This worksheet documents procedures that will be used to verify project data. It applies to both field and laboratory records. Data verification is a completeness check to confirm that required activities were conducted, specified records are present, and the contents of the records are complete. As illustrated in the following example, verification often is performed at more than one step by more than one person.

Example taken from C-400 Complex RI/FS Project

Records Reviewed	Requirement Documents	Process Description	Responsible Person/Organization
Field logbook and/or sample data forms	QAPP, Field SOPs	Verify that records are present and complete for each day of field activities. Verify that all planned samples including field QC samples were collected and that sample collection locations are documented. Verify that meteorological data were provided for each day of field activities. Verify that changes/exceptions are documented and were reported in accordance with requirements. Verify that any required field monitoring was performed and results are documented.	Field Team Leader/FRNP— SMO/FRNP
Data deliverables, analytes, and holding times	QAPP, contract, and procedures	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*. Data assessment qualifiers and definitions are included in the data assessment package.	Laboratory PM/Contract Laboratory SMO/FRNP

QAPP Worksheet #35. Data Verification Procedures (Continued)

Records Reviewed	Requirement Documents	Process Description	Responsible Person/Organization
Chain-of-custody, sample handling, sampling methods and procedures, and field transcription	QAPP, contract, and procedures	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 Plans*. The documentation of this validation will be included in the data assessment packages.	SMO/FRNP
Analytical methods and procedures, laboratory data qualifiers, and standards	QAPP, contract, and procedures	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 qualifiers and definitions are listed in the procedures used for validation (see Worksheet #36).	Data Validation Subcontractor and SMO/FRNP
Audit reports, corrective action reports	QAPP and procedures	Verify that all planned audits were conducted. Examine audit reports. For any deficiencies noted, verify that corrective action was implemented according to plan.	CPAP Manager/FRNP
Deviations and qualifiers	QAPP and procedures	Any deviations and qualifiers resulting from process will be documented in the data assessment packages.	SMO/FRNP

QAPP Worksheet #36. Data Validation Procedures

(UFP-QAPP Manual Section 5.2.2)
(EPA 2106-G-05 Section 2.5.1)

This worksheet documents procedures that will be used to validate project data. Data validation is an analyte and sample-specific process for evaluating compliance with contract requirements, methods/SOPs, and MPC. The scope of data validation needs to be defined during project planning because it affects the type and level of documentation required for both field and laboratory activities. If data validation procedures are contained in an SOP or other document, the procedures should be referenced in this table and included as an attachment to the QAPP. The example below is taken from the RI/FS Work Plan for the C-400 Complex Operable Unit (DOE 2020).

Data Validator: A2RGC, LLC

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator* (Title and Organizational Affiliation)
Step IIa/IIb	Solid (Concrete), Soil, and Groundwater	All	All	National Functional Guidelines; Worksheets #12, #15, and #28; and CP2-ES-0026, CP2-ES-0811, CP2-ES-5102, CP2-ES-5105, CP2-ES-5103, and CP2-ES-5107	A2RGC, LLC
Step IIa/IIb	Air	VOCs	Very Low	National Functional Guidelines; Worksheets #12, #15, and #28; and CP2-ES-5105	A2RGC, LLC

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

QAPP Worksheet #37. Data Usability Assessment

(UFP-QAPP Manual Section 5.2.3 including Table 12)
(EPA 2106-G-05 Section 2.5.2, 2.5.3, and 2.5.4)

This worksheet documents procedures that will be used to perform the data usability assessment. The data usability assessment is performed at the conclusion of data collection activities, using the outputs from data verification and data validation. It is the data interpretation phase, which involves a qualitative and quantitative evaluation of environmental data to determine if the project data are of the right type, quality, and quantity to support the decisions that need to be made. It involves a retrospective evaluation of the systematic planning process, and, like the systematic planning process, involves participation by key members of the project team. The data usability assessment evaluates whether underlying assumptions used during systematic planning are supported, sources of uncertainty have been accounted for and are acceptable, data are representative of the population of interest, and the results can be used as intended, with the acceptable level of confidence.

Identify personnel (organization and position/title) responsible for participating in the data usability assessment:

Project Director
Characterization Manager
Risk Assessor
Data Validator
Sample Management Office
Field Team Leader

Describe how the usability assessment will be documented:

Data usability will be documented through validation reports as well as through the issuance of data quality assessment reports, which will summarize how the data reflect the specific criteria for the data quality indicators assigned to the project.

Summarize the data usability assessment process including statistics, equations, and computer algorithms that will be used to analyze the data:

Step 1. Review the project's objectives and sampling design

Review the key outputs defined during systematic planning (i.e., PQOs or DQOs and MPCs) to make sure they are still applicable. Review the sampling design for consistency with stated objectives. This provides the context for interpreting the data in subsequent steps.

QAPP Worksheet #37. Data Usability Assessment (Continued)

Step 2. Review the data verification and data validation outputs

Review available QA reports, including the data verification, data validation and data assessment, reports. Perform basic calculations and summarize the data (using graphs, maps, tables, etc.). Look for patterns, trends, and anomalies (i.e., unexpected results). Review deviations from planned activities (e.g., number and locations of samples, holding time exceedances, damaged samples, noncompliant PT sample results, and SOP deviations) and determine their impacts on the data usability. Evaluate implications of unacceptable QC sample results.

Step 3. Verify the assumptions of the selected statistical method

Verify whether underlying assumptions for selected statistical methods (if documented in the QAPP) are valid. Common assumptions include the distributional form of the data, independence of the data, dispersion characteristics, homogeneity, etc. Depending on the robustness of the statistical method, minor deviations from assumptions usually are not critical to statistical analysis and data interpretation. If serious deviations from assumptions are discovered, then another statistical method may need to be selected.

Step 4. Implement the statistical method

Implement the specified statistical procedures for analyzing the data and review underlying assumptions. For decision projects that involve hypothesis testing (e.g., "concentrations of lead in groundwater are below the action level") consider the consequences for selecting the incorrect alternative; for estimation projects (e.g., establishing a boundary for surface soil contamination), consider the tolerance for uncertainty in measurements.

Step 5. Document data usability and draw conclusions

Determine if the data can be used as intended, considering implications of deviations and corrective actions, following CP3-ES-5003. Discuss data quality indicators. 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. Assess the performance of the sampling design and identify limitations on data use. Update the CSM and document conclusions. Prepare the data usability summary report which can be in the form of text and/or a table.

3. REFERENCES

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

DOE (U.S. Department of Energy) 1995. *C-400 Process and Structure Review,* KY/ERWM-38, U.S. Department of Energy, Paducah, KY, May.

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1727&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2019. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, *Volume* 2. *Ecological,* DOE/LX/07-0107&D2/R3/V2, U.S. Department of Energy, Paducah, KY, April.

DOE 2020. *Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2433&D2/R1, U.S. Department of Energy, Paducah, KY, March.

DOE 2021a. *Paducah Gaseous Diffusion Plant Data Management Plan*, DOE/LX/07-2458&D2, U.S. Department of Energy, Paducah, KY, August.

DOE 2021b. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1. Human Health,* DOE/LX/07-0107&D2/R12/V1, U.S. Department of Energy, Paducah, KY, June.

DOE 2022a. *Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project Plan*, DOE/LX/07-2479&D1, U.S. Department of Energy, Paducah, KY, March.

DOE 2022b. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1. Human Health,* DOE/LX/07-0107&D2/R13/V1, U.S. Department of Energy, Paducah, KY, June.

EPA (U.S. Environmental Protection Agency) 2002. *Guidance for Quality Assurance Project Plans*, EPA QA/G-5, EPA/240/R-02/009, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC, December.

EPA 2009. *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*, EPA 540-R-08-005, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC, January.

EPA 2011. *Standard Operating Procedure for Sampling Porous Surfaces for Polychlorinated Biphenyls (PCBs)*, U.S. Environmental Protection Agency, Boston, MA, May.

EPA 2012. *Guidance on Quality Assurance Project Plans*, CIO 2106-G-05 QAPP, U.S. Environmental Protection Agency, Washington, DC, January.

EPA 2021a. Regional Screening Levels, May 2021: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

EPA 2021b. Vapor Intrusion Screening Level Calculator, May 2021: https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator

IDQTF (Intergovernmental Data Quality Task Force) 2005. *Uniform Federal Policy for Quality Assurance Project Plans Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs Part 1: UFP-QAPP Manual*, EPA: EPA-505-B-04-900A, DoD: DTIC ADA 427785, Intergovernmental Data Quality Task Force comprised of representatives from the U.S. Department of Defense, U.S. Department of Energy, and U.S. Environmental Protection Agency, Washington, DC, March.

IDQTF 2012. *Uniform Federal Policy for Quality Assurance Project Plans Optimized UFP-QAPP Worksheets*, Intergovernmental Data Quality Task Force comprised of representatives from the U.S. Department of Defense, U.S. Department of Energy, and U.S. Environmental Protection Agency, Washington, DC, March.

APPENDIX A

COMPARISON OF THE METHOD DETECTION LIMITS FOR WATER AND SOIL TO THE PROJECT ACTION LIMITS DEVELOPED USING 2020 CHILD RESIDENT NO FURTHER ACTION, BACKGROUND, AND MAXIMUM CONTAMINANT LEVEL CONCENTRATIONS

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COMPARISON OF THE METHOD DETECTION LIMITS FOR WATER AND SOIL TO THE PROJECT ACTION LIMITS DEVELOPED USING 2020 CHILD RESIDENT NO FURTHER ACTION, BACKGROUND, AND MAXIMUM CONTAMINANT LEVEL CONCENTRATIONS

The objective of data collection is to support project decision-making. The development of the data quality objectives (DQOs) for a project should include a determination of whether the method detection limits of the planned analytical methods will be sufficient to support the project decision-making. This appendix summarizes a comparison of the typically obtained method detection limits against potential project benchmarks. [This comparison has been updated using GEL Laboratories' method detection limit (MDLs) and the current project action limit (PALs).]

One benchmark for evaluating whether the method detection limit is low enough for a given project is the child resident no action limit (NAL). Analyses that are sensitive enough to detect constituents at or below their NAL often are sufficient to meet project objectives.

As noted in the charts below, most of the GEL MDLs are below the 2020 child resident NALs;[1] thus, they are low enough to support a risk assessment and meet most project DQOs. However, because there are some constituents that have MDLs that are above their respective NALs, the evaluation was extended to include a comparison against background levels (for soils and groundwater) and maximum contaminant levels (MCLs) [or U.S. Environmental Protection Agency's regional screening levels (RSLs) where MCLs are not available] (for groundwater) to support an evaluation of whether lower MDLs should be pursued for a given project. MDLs also are compared to background (BG) values, where appropriate.

The charts in the attachment summarize these comparisons. The comparison found the following.

SOILS

- The MDL was below the respective PAL for metals.
- The MDL was below the respective PAL for the polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs), except N-nitroso-di-n-propylamine. For most projects, the MDL should be sufficient; however, for projects with N-nitroso-di-n-propylamine as a constituent of concern, lower MDLs may be needed. This issue should be addressed in the project-specific quality assurance project plan (QAPP).

The minimum detectable activity (MDA) is above the PAL for cesium-137, neptunium-237, uranium-235, and uranium-238. This should be taken into account when developing a project-specific QAPP.

[1] *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 1. Human Health,* DOE/LX/07-0107&D2/R11/V1, U.S. Department of Energy, Paducah, KY, June 2020.

WATER

- Metals (in water): Antimony, arsenic, and thallium have NALs less than MDLs, but the MDLs are below the respective site background concentrations, so the MDLs are considered to be low enough to meet the project DQOs. In addition, the MDLs are below the MCLs for those constituents with MCLs. The NAL for chromium (VI) is less than the MDL and chromium (VI) does not have an established background level for the site and it does not have an MCL. California, however, has established an MCL at 0.010 mg/L. The MDL for chromium (VI) is below the California MCL; thus, it will be suitable for most projects.

- Uranium-235: The uranium isotope uranium-235 (U-235) has an NAL below the respective PAL and the interpreted MCL (the MCL is 0.030 mg/L total uranium). Because the mobility of uranium is not affected by isotopic composition and because U-235 cannot be separated quantitatively from other uranium isotopes, the standard PAL will be sufficient for many projects.

- PCBs: The Aroclors (except for Aroclor 1016) have PALs that are less than the MDL; however, the MDL is lower than the MCL for Total PCBs. NOTE: Even if all the MDLs were added together for all the Aroclors, the total MDL is less than the MCL for the total PCBs and would meet most project DQOs.

- Radionuclides: Radionuclide PALs are less than MDAs; however, MDAs are below the respective MCLs (except for U-235, calculated based upon normal isotopic composition). In evaluating water-based concentrations of alpha-emitting radionuclides, the alpha activity MCL of 15 pCi/L was evaluated. Thus, for most projects, routinely available MDAs likely will be sufficient.

- VOCs: A few VOCs have PALs less than their MDLs but also have MDLs below their respective MCL except for acrylonitrile (that does not have an MCL). Acrylonitrile is not detected in site groundwater; thus, the need for lower MDLs for acrylonitrile should be considered when setting project DQOs.

- SVOCs: Benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, dieldrin, hexachlorobenzene, indeno[1,2,3-cd]pyrene, naphthalene, and N-nitroso-di-n-propylamine have PALs less than the MDLs. The need for lower MDLs for these constituents should be considered when setting project DQOs.

In preparing a project-specific QAPP, the expected MDLs should be evaluated against project-specific DQOs (and the related PALs) to identify the need for lower MDLs to meet project objectives.

NOTE: For those constituents that have the PALs below the project quantitation limits, the laboratory will be directed to report to the MDL. Reporting to the MDL may not meet the PALs for some analytes.

ATTACHMENT

ACTION LIMITS VS. METHOD DETECTION LIMITS

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Comparison of Method Detection Limits to Project Action Limits and Background for Soil Samples

Metal	Project Action Limit (mg/kg) Child Resident NAL	Background (mg/kg) Surface	Background (mg/kg) Subsurface	GEL Laboratories	
				PQL (mg/kg)	MDL (mg/kg)
Aluminum	7,740	13,000	12,000	10	3
Antimony	3.13	0.21	0.21	1	0.33
Arsenic	0.356	12	7.9	1	0.2
Barium	1,530	200	170	0.4	0.1
Beryllium	15.6	0.67	0.69	0.1	0.02
Boron	1,560	N/A	N/A	3	0.8
Cadmium	5.28	0.21	0.21	0.2	0.02
Chromium (total)[a]	11,700	16	43	0.6	0.2
Chromium (VI)	0.301	N/A	N/A	0.4	0.12
Cobalt	2.34	14	13	0.2	0.06
Copper	313	19	25	0.2	0.066
Fluoride	313	N/A	N/A	TBD	TBD
Iron	5,480	28,000	28,000	20	6.6
Lead	400	36	23	0.4	0.1
Manganese	183	1,500	820	1	0.2
Mercury	2.35	0.2	0.13	0.01	0.004
Molybdenum	39.1	N/A	N/A	0.2	0.06
Nickel	155	21	22	0.4	0.1
Selenium	39.1	0.8	0.7	1	0.33
Silver	39.1	2.3	2.7	0.5	0.1
Thallium	0.0782	0.21	0.34	0.4	0.06
Uranium	1.56	4.9	4.6	0.04	0.013
Vanadium	39.3	38	37	0.5	0.1
Zinc	2,350	65	60	2	0.4

Comparison of Method Detection Limits to Project Action Limits and Background for Soil Samples (Continued)

PCB	Project Action Limit (mg/kg) Child Resident NAL	Background (mg/kg)	Background (mg/kg)	GEL Laboratories	
		Surface	Subsurface	PQL (mg/kg)	MDL (mg/kg)
Aroclor 1016	0.206	N/A	N/A	0.0033	0.0011
Aroclor 1221	0.0752	N/A	N/A	0.0033	0.0011
Aroclor 1232	0.0708	N/A	N/A	0.0033	0.0011
Aroclor 1242	0.0791	N/A	N/A	0.0033	0.0011
Aroclor 1248	0.0788	N/A	N/A	0.0033	0.0011
Aroclor 1254	0.0588	N/A	N/A	0.0033	0.0011
Aroclor 1260	0.0803	N/A	N/A	0.0033	0.0011
Total PCBs	0.0788	N/A	N/A	0.0033	0.0011

Comparison of Method Detection Limits to Project Action Limits and Background for Soil Samples (Continued)

Radionuclide	Project Action Limit (pCi/g) Child Resident NAL	Background (pCi/g)	Background (pCi/g)	GEL Laboratories
		Surface	Subsurface	MDA (pCi/g)
Americium-241	1.75	N/A	N/A	1
Cesium-137	0.0402	0.49	0.28	0.1
Neptunium-237	0.0911	0.1	N/A	1
Plutonium-238	4.27	0.073	N/A	1
Plutonium-239/240	3.77	0.025	N/A	1
Technetium-99	110.0	2.5	2.8	5
Thorium-230	4.93	1.5	1.4	1
Uranium-234	5.77	1.2	1.2	1
Uranium-235	0.148	0.06	0.06	1
Uranium-238	0.556	1.2	1.2	1

VOC	Project Action Limit (µg/kg) Child Resident NAL	Background (µg/kg)	Background (µg/kg)	GEL Laboratories	
		Surface	Subsurface	PQL (µg/kg)	MDL (µg/kg)
1,2-Dichloroethane	464	N/A	N/A	1	0.33
1,1-Dichloroethene	22,700	N/A	N/A	1	0.33
cis-1,2-Dichloroethene	15,600	N/A	N/A	1	0.33
trans-1,2-Dichloroethene	6,960	N/A	N/A	1	0.33
Acrylonitrile	255	N/A	N/A	5	1.7
Benzene	1,160	N/A	N/A	1	0.33
Bromodichloromethane	293	N/A	N/A	1	0.33
Carbon Tetrachloride	653	N/A	N/A	1	0.33
Chloroform	316	N/A	N/A	1	0.33
Ethylbenzene	5,780	N/A	N/A	1	0.33
Tetrachloroethene	8,100	N/A	N/A	1	0.33
1,1,1-Trichloroethane	815,000	N/A	N/A	1	0.33
1,1,2-Trichloroethane	150	N/A	N/A	1	0.33
Trichloroethene	412	N/A	N/A	1	0.33
Vinyl chloride	59.2	N/A	N/A	1	0.33
Total Xylenes	57,600	N/A	N/A	3	1.0
p-xylene	56,100	N/A	N/A	2	0.67
m-xylene	55,100	N/A	N/A	2	0.6
o-xylene	64,500	N/A	N/A	1	0.33

Comparison of Method Detection Limits to Project Action Limits and Background for Soil Samples (Continued)

SVOC	Project Action Limit (µg/kg) Child Resident NAL	Background (µg/kg)	Background (µg/kg)	GEL Laboratories	
		Surface	Subsurface	PQL (µg/kg)	MDL (µg/kg)
Acenaphthene	185,000	N/A	N/A	33.3	10
Acenaphthylene[a]	185,000	N/A	N/A	33.3	10
Anthracene	923,000	N/A	N/A	33.3	10
Benz[a]anthracene	475	N/A	N/A	33.3	10
Benzo[a]pyrene	47.8	N/A	N/A	33.3	10
Benzo[b]fluoranthene	478	N/A	N/A	33.3	10
Benzo[k]fluoranthene	4,780	N/A	N/A	33.3	10
Carbazole	10,400	N/A	N/A	33.3	10
Chrysene	47,800	N/A	N/A	33.3	10
Dibenz[a,h]anthracene	47.8	N/A	N/A	33.3	10
Dieldrin[b]	13.0	N/A	N/A	1.34	0.33
Fluoranthene	123,000	N/A	N/A	33.3	10
Fluorene	123,000	N/A	N/A	33.3	10
Hexachlorobenzene	212	N/A	N/A	333	100
Indeno[1,2,3-cd]pyrene	478	N/A	N/A	33.3	10
Naphthalene	1,040	N/A	N/A	33.3	10
2-nitroaniline	35,600	N/A	N/A	333	110
N-nitroso-di-n-propylamine	29.7	N/A	N/A	333	100
Pentachlorophenol	254	N/A	N/A	333	100
Phenanthrene[c]	185,000	N/A	N/A	33.3	10
Pyrene	92,300	N/A	N/A	33.3	10
Total PAHs (carcinogenic)	47.8	N/A	N/A	N/A	N/A

Constituent Name — Constituent MDL higher than considered potentially applicable benchmarks/PALs.

NOTE: Laboratories may not be able to meet PALs. In these cases, the project team will address this issue during scoping.

[a] The chromium (III) background value was used.

[b] GEL only reports dieldrin via method SW846-8081, not SW846-8270.

[c] Acenaphthylene and Phenanthrene use values for Acenaphthene as a surrogate.

Comparison of Method Detection Limits to Project Action Limits, Background, and MCLs for Groundwater Samples

Metal	Project Action Limit			RGA Background (mg/L)	MCL (mg/L)	GEL Laboratories	
	Tapwater RSL or MCL (mg/L)	RSL or MCL	Child Resident NAL (mg/L)			PQL (mg/L)	MDL (mg/L)
Aluminum	2.0	RSL	2.00	1.64	N/A	0.05	0.015
Antimony	0.0060	MCL	0.000779	0.060	0.0060	0.003	0.001
Arsenic	0.010	MCL	0.0000517	0.005	0.010	0.01	0.0017
Barium	2.0	MCL	0.377	0.202	2.0	0.206	0.0006
Beryllium	0.0040	MCL	0.00246	0.004	0.0040	0.0005	0.0002
Boron	0.40	RSL	0.399	N/A	N/A	0.015	0.004
Cadmium	0.0050	MCL	0.000922	0.010	0.0050	0.001	0.00011
Chromium (total)	0.10	MCL	2.25	0.134	0.10	0.01	0.002
Chromium (VI)	0.000035	RSL	0.0000350	N/A	N/A	0.01	0.0033
Cobalt	0.0006	RSL	0.000601	0.045	N/A	0.001	0.0001
Copper	1.3	MCL	0.0799	0.034	1.3	0.001	0.00035
Fluoride	4	MCL	0.0799	0.245	4	0.1	0.033
Iron	1.4	RSL	1.40	3.72	N/A	0.1	0.033
Lead	0.015	MCL	0.0150	0.25	0.015	0.002	0.0005
Manganese	0.043	RSL	0.0434	0.082	N/A	0.005	0.001
Mercury	0.0020	MCL	0.000566	0.0002	0.0020	0.0002	0.000067
Molybdenum	0.01	RSL	0.00998	0.050	N/A	0.0005	0.000165
Nickel	0.039	RSL	0.0392	0.530	N/A	0.002	0.0005
Selenium	0.050	MCL	0.00998	0.005	0.050	0.005	0.0015
Silver	0.0094	RSL	0.00941	0.011	N/A	0.001	0.0002
Thallium	0.0020	MCL	0.0000200	0.056	0.0020	0.002	0.00045
Uranium	0.030	MCL	0.00399	0.002	0.030	0.0002	0.000067
Vanadium	0.0086	RSL	0.00864	0.139	N/A	0.005	0.001
Zinc	0.60	RSL	0.600	0.025	N/A	0.01	0.0035

Comparison of Method Detection Limits to Project Action Limits, Background, and MCLs for Groundwater Samples (Continued)

PCB	Project Action Limit			RGA Background (µg/L)	MCL (µg/L)	GEL Laboratories	
	Tapwater RSL or MCL (µg/L)	RSL or MCL	Child Resident NAL (µg/L)			PQL (µg/L)	MDL (µg/L)
Aroclor 1016	0.5	MCL	0.140	N/A	0.5	0.1	0.033
Aroclor 1221	0.5	MCL	0.00471	N/A	0.5	0.1	0.033
Aroclor 1232	0.5	MCL	0.00471	N/A	0.5	0.1	0.033
Aroclor 1242	0.5	MCL	0.00785	N/A	0.5	0.1	0.033
Aroclor 1248	0.5	MCL	0.00785	N/A	0.5	0.1	0.033
Aroclor 1254	0.5	MCL	0.00785	N/A	0.5	0.1	0.033
Aroclor 1260	0.5	MCL	0.00785	N/A	0.5	0.1	0.033
Total (0.5 µg/L MCL total PCBs)	0.5	MCL	0.0436	N/A	0.5	0.1	0.033

Comparison of Method Detection Limits to Project Action Limits, Background, and MCLs for Groundwater Samples (Continued)

Radionuclide	Project Action Limit			RGA Background (pCi/L)	MCL[a] (pCi/L)	GEL Laboratories
	Tapwater RSL or MCL (pCi/L)	RSL or MCL	Child Resident NAL (pCi/L)			MDA (pCi/L)
Americium-241	15	MCL	0.504	N/A	15	1
Cesium-137	4 mRem/year-dose	MCL	1.71	N/A	200	10
Neptunium-237	15	MCL	0.763	0.21	15	1
Plutonium-238	15	MCL	0.398	N/A	15	1
Plutonium-239/240	15	MCL	0.387	0.03	15	1
Technetium-99[d]	4 mRem/year-dose	MCL	19	10.8	900	25
Thorium-230	15	MCL	0.572	0.54	15	1
Uranium-234	10.24	MCL	0.739	0.7	10.24	1
Uranium-235	0.466	MCL	0.728	0.3	0.466	1
Uranium-238	9.99	MCL	0.601	0.7	9.99	1

VOC	Project Action Limit			RGA Background (µg/L)	MCL (µg/L)	GEL Laboratories	
	Tapwater RSL or MCL (µg/L)	RSL or MCL	Child Resident NAL (µg/L)			PQL (µg/L)	MDL (µg/L)
Acrylonitrile	0.052	RSL	0.0523	N/A	N/A	5	1.5
Benzene	5.0	MCL	0.455	N/A	5.0	1	0.3
Bromodichloromethane	80.0	MCL	0.134	N/A	80.0	1	0.3
Carbon tetrachloride	5.0	MCL	0.455	N/A	5.0	1	0.3
Chloroform	80	MCL	0.221	N/A	80	1	0.3
1,2-Dichloroethane	5.0	MCL	0.171	N/A	5	1	0.3
1,1-Dichloroethene	7.0	MCL	28.5	N/A	7.0	1	0.3
cis-1,2-Dichloroethene	70	MCL	3.61	N/A	70	2	0.3
trans-1,2-Dichloroethene	100	MCL	6.78	N/A	100	1	0.3
Ethylbenzene	700	MCL	1.50	N/A	700	1	0.3
Tetrachloroethene	5.0	MCL	4.06	N/A	5.0	1	0.3
1,1,1-Trichloroethane	200.0	MCL	801	N/A	200.0	1	0.3
1,1,2-Trichloroethane	5.0	MCL	0.0415	N/A	5.0	1	0.3
Trichloroethene	5.0	MCL	0.283	N/A	5.0	1	0.3
Vinyl Chloride	2.0	MCL	0.0188	N/A	2.0	1	0.3
Total Xylenes	10,000	MCL	19.3	N/A	10,000	3	0.3
Xylene-o	19	RSL	19.3	N/A	N/A	1	0.3
Xylene-m	19	RSL	19.3	N/A	N/A	2	0.3
Xylene-p	19	RSL	19.3	N/A	N/A	2	0.3

Comparison of Method Detection Limits to Project Action Limits, Background, and MCLs for Groundwater Samples (Continued)

SVOC	Project Action Limit			RGA Background (µg/L)	MCL	GEL Laboratories	
	Tapwater RSL or MCL (µg/L)	RSL or MCL	Child Resident NAL (µg/L)		(µg/L)	PQL (µg/L)	MDL (µg/L)
Acenaphthene	53	RSL	53.5	N/A	N/A	1	0.3
Acenaphthylene[b]	53	RSL	53.5	N/A	N/A	1	0.3
Anthracene	180	RSL	177	N/A	N/A	1	0.3
Benz[a]anthracene	0.03	RSL	0.0298	N/A	N/A	1	0.3
Benzo[a]pyrene	0.2	MCL	0.0251	N/A	0.2	1	0.3
Benzo[b]fluoranthene	0.250	RSL	0.251	N/A	N/A	1	0.3
Benzo[k]fluoranthene	2.5	RSL	2.51	N/A	N/A	1	0.3
Carbazole	N/A	RSL	2.03	N/A	N/A	1	0.3
Chrysene	25	RSL	25.1	N/A	N/A	1	0.3
Dibenz[a,h]anthracene	0.025	RSL	0.0251	N/A	N/A	1	0.3
Dieldrin[c]	0.0018	RSL	0.00175	N/A	N/A	0.04	0.0125
Fluoranthene	80	RSL	80.2	N/A	N/A	1	0.3
Fluorene	29	RSL	29.4	N/A	N/A	1	0.3
Hexachlorobenzene	1.0	MCL	0.00976	N/A	1.0	10	3
Indeno[1,2,3-cd]pyrene	0.25	RSL	0.251	N/A	N/A	1	0.3
Naphthalene	0.12	RSL	0.117	N/A	N/A	1	0.3
2-nitroaniline	19	RSL	18.9	N/A	N/A	10	3
N-nitroso-di-n-propylamine	0.011	RSL	0.0108	N/A	N/A	10	3
Pentachlorophenol	1.0	MCL	0.0413	N/A	0.0413	TBD	TBD
Phenanthrene[b]	53	RSL	53.5	N/A	N/A	1	0.3
Pyrene	12	RSL	12.1	N/A	N/A	1	0.3

Constituent Name — Constituent MDL higher than all considered potentially applicable benchmarks/PALs

NOTE: Laboratories may not be able to meet PALs. In these cases, the project team will address this issue during scoping.

Even if EVERY Aroclor present at MDL, Total PCB concentration < MCL.

[a] Gross Alpha MCL = 15 pCi/L

Attributed uranium MCL — uranium MCL converted from 0.030 mg/L to pCi/L based upon natural composition and activity factors.

U-235 not seen alone (i.e., w/o U-238). Uranium-238 MDA < MCL (i.e., uranium issues in water will be detected at PAL with current isotopic MDAs).

[b] Acenaphthylene and Phenanthrene use values for Acenaphthene as surrogate.

[c] GEL only reports dieldrin via method SW846-8081, not SW846-8270.

[d] See Table A.9 of the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 1. Human Health*, DOE/LX/07-0107&D2/R11/V1, for technetium-99 dose-based groundwater screening levels resulting in a 4 mrem/yr dose based upon more recent dosimetry.

2019 RSLs from EPA regional screening levels (Target Risk = 1E-6, Hazard Quotient = 0.1) November 2019.

APPENDIX B

THE ROLE OF INDEPENDENT THIRD-PARTY DATA VALIDATION IN MEETING DATA QUALITY OBJECTIVES AT PADUCAH GASEOUS DIFFUSION PLANT

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THE ROLE OF INDEPENDENT THIRD-PARTY DATA VALIDATION IN MEETING DATA QUALITY OBJECTIVES

ISSUE

A balance must be struck and the associated uncertainties acknowledged over the appropriate level of independent third-party data validation that should be conducted for various types of Paducah Gaseous Diffusion Plant (PGDP) projects. In addition, there is uncertainty over how best to ensure that the appropriate level of independent third-party data validation is conducted.

Collected data are evaluated for usability by the project team. In addition, a fraction of these data is subjected to independent third-party validation. This briefing discusses the process by which the fraction of data subjected to independent third-party validation is specified.

BACKGROUND

Collected data are reviewed by the project team as part of a data assessment to ensure that collected data are usable for their intended purpose. This project-team assessment includes elements of data validation. This effort is supplemented further by subjecting a fraction of the data to independent third-party validation. All of the assessment and validation efforts are used to support the data usability assessment.

The cost of higher levels of independent third-party validation should be balanced against the incremental value in meeting project and programmatic data quality objectives (DQOs). Programmatic DQOs are related to the likelihood that collected data may be used to support issues that go beyond the needs of the individual project.

HISTORY

The level of independent third-party validation of data for a given PGDP project is set as part of developing DQOs for that project. This level has varied appropriately for different types of PGDP projects. The following discusses the role of independent third-party validation in the data quality process and discusses how project and programmatic considerations should be evaluated in setting the appropriate level of independent third-party validation for a given project.

FINDINGS

1. The level of independent third-party validation should be set for each project as part of the DQO process;

2. The project DQO process should anticipate (and incorporate where appropriate) programmatic considerations in setting the level of independent third-party validation;

3. Incorporation of programmatic considerations is required by the in-place Quality Assurance Program; this approach is consistent with the approach used at the Portsmouth Gaseous Diffusion Plant (PORTS);

4. Independent third-party validation, by design, duplicates many elements of the Four Rivers Nuclear Partnership, LLC, (FRNP) data assessment/verification/validation process;

5. The FRNP's *Quality Assured Data* procedure (CP3-ES-5003) identifies 5% as a minimum of definitive data that typically should be subjected to independent third-party validation;

6. Most PGDP data collection activities generate usable, valid, high-quality data with this approach;

7. There are a few data collection activities [e.g., supporting property transfer for unrestricted use under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 120h guidance] where a higher percentage of independent third-party validation may be appropriate (i.e., PORTS has identified some property transfer projects where 100% independent third-party validation is considered appropriate); and

8. Additional independent third-party data validation may be able to be performed at a later time should the DQOs of the project change.

DISCUSSION

Independent third-party validation is one tool used as part of an over-arching program to assure data quality. Per the current *Quality Assured Data* procedure, developed to be consistent with U.S. Environmental Protection Agency (EPA) guidance, 100% of collected definitive (i.e., not screening level) data are subjected to data assessment and verification (which includes elements of data validation) by the project team. However, only a fraction (minimum of 5%) of the definitive data collected for projects at PGDP are subjected to independent third-party validation that uses an external third party to repeat the data validation steps. As noted in EPA guidance, the principal use of independent third-party validation is to support the data assessment process and minimize the potential for fraud by providing detailed review of the data collection and analysis process. NOTE: Because this independent third-party validation does not introduce any additional data or information, this process does not increase the quality of the data.

Per the *Quality Assured Data* procedure, each project establishes a level of independent third-party validation needed to ensure project DQOs are met. The principal goal of a data collection process is to ensure that collected data meet the DQOs for the individual project, which helps assure the data will be considered usable to support decision-making. To support its Quality Assurance Program, FRNP has been subjecting landfill groundwater data to 100% independent third-party validation in support of the Environmental Monitoring Data Quality Program. By performing 100% independent third-party validation, these landfill groundwater data become a benchmark against which other groundwater data can be compared reliably.

For most other projects, independent third-party validation rates range from 5% to 20%. These levels are set in the project scoping process at levels that are considered sufficient to support the project data quality process. As noted above, the level of independent third-party data validation is a project-specific decision that should evaluate all data quality needs, including incorporating programmatic considerations. Attached is a White Paper that discusses in more detail the considerations that may drive the determination of the appropriate level of independent third-party data validation.

ATTACHMENT

WHITE PAPER ON THE USE OF INDEPENDENT THIRD-PARTY VALIDATION TO SUPPORT DATA QUALITY ASSURANCE AT PGDP

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WHITE PAPER ON THE USE OF INDEPENDENT THIRD-PARTY VALIDATION TO SUPPORT DATA QUALITY ASSURANCE AT PGDP

ISSUE

Independent third-party validation of laboratory data is one of the tools used to support the data quality assurance program at the Paducah Gaseous Diffusion Plant (PGDP), the Portsmouth Gaseous Diffusion Plant (PORTS), and other Superfund sites. Because there are multiple procedures that are used routinely to evaluate laboratory data quality; the manner in which these reviews are communicated to decision-makers also may vary. Because of this potential variability and because of the complex nature of commonly used analytical data verification and validation procedures, it is important to minimize ambiguity in communicating the nature of these procedures to data users. This White Paper seeks to summarize the tools Four Rivers Nuclear Partnership, LLC, (FRNP) uses to ensure data quality and its approach to the use of independent third-party validation to support its Quality Assurance Program.

BACKGROUND

There are several considerations that factor into the use of independent third-party validation as well as other tools used in the quality assurance program with the overall goal to ensure that the data meet the data quality objectives (DQOs) of the individual project. The data should be of sufficient quality as to ensure data usability to support environmental decision-making. The different objectives of that decision-making (e.g., ranging from simple survey sampling to property transfer) are the largest considerations driving the application of independent third-party validation.

Summary of the FRNP Data Quality Assurance Program

FRNP maintains a graduated program to ensure data quality assurance and usability, as described by CP3-ES-5003, *Quality Assured Data*, which is as follows.

Data Verification is performed on 100% of laboratory data. Data verification is the process for comparing a data set against a standard or contractual requirement. Data verification includes ***laboratory contractual screening***, which is the process of evaluating a set of data against the requirements in the analytical statement of work (SOW) to ensure that all requested information is received. The SOW requirements include required analytes, methods, units, and required reporting limits. Data verification includes comparison of newly received data to historical results, permit limits, maximum contaminant levels (MCLs), background values, and evaluates the results of field quality control samples, etc. The goal of data verification is to identify if submitted samples were analyzed appropriately, properly reported, and the results are consistent with historical information.

Data Assessment is performed on 100% of the data to ensure data meet the DQOs of the project and to ensure that data are usable for their intended purpose. Data assessment is used to determine if the data are suitable to make a decision with the desired level of confidence. Data assessment follows data verification/validation. Data qualifiers are taken into consideration during data assessment.

Data Validation is a data review process performed by a qualified individual, independent from sampling, laboratory, project management, or other decision-making personnel. Data validation evaluates the laboratory adherence to analytical method requirements. The percentage and level of data validation for a given project is defined in project work plans and quality assurance project plans and is performed in conjunction with data assessment. There are several levels of data validation that are performed by review of data packages as defined below:

- **Level I data packages** are comprised of sample results, methods, and data qualifiers.
- **Level II data packages** include the Level I information plus quality control (QC) information and surrogate results when applicable.
- **Level III data packages** include the Level II information plus calibration information, internal standard results, special instrumentation analysis requirements (i.e., bromofluorobenzene tune data or post digestion spike results).
- **Level IV data packages** include the Level III information plus all the raw data and certificates for standards.

An excerpt from EPA 2009 is reproduced below to clarify how the guidance defines the terms *verification* and *validation.*

> **5.1 Analytical Data Verification and Validation Stages**
>
> (1) A verification and validation based only on completeness and compliance of sample receipt condition checks should be called a Stage 1 Validation.
>
> (2) A verification and validation based on completeness and compliance checks of sample receipt conditions and ONLY sample-related QC results should be called a Stage 2A Validation.
>
> (3) A verification and validation based on completeness and compliance checks of sample receipt conditions and BOTH sample-related and instrument-related QC results should be called a Stage 2B Validation.
>
> (4) A verification and validation based on completeness and compliance checks of sample receipt conditions, both sample-related and instrument-related QC results, AND recalculation checks should be called a Stage 3 Validation.
>
> (5) A verification and validation based on completeness and compliance checks of sample receipt conditions, both sample-related and instrument-related QC results, recalculation checks, AND the review of actual instrument outputs should be called a Stage 4 Validation.
>
> The recommended minimum baseline checks conducted for each stage of analytical data verification and validation are described in more detail in Appendix A of the EPA 2009 guidance.

Independent Third-Party Data Validation is a data validation process performed by a party that is independent of sampling, the laboratory analyzing the sample, and other project decision-making personnel. The principal purpose for an independent third-party validation is to minimize the potential for fraud (EPA 2002). With that as its purpose, a random (5%) check may be as effective as greater levels of independent validation for many projects [think 5% validation of random drug test results compared to 100% validation of random drug test results; you achieve your goal (for the independent evaluation) of evaluating the performance of the drug-testing laboratory]. Note: EPA 2002 states that independent third-party validation alone is not sufficient to meet this goal (of combatting fraud); rather laboratory audits, etc. should be used with validation to identify and correct fraud.

As noted in EPA 2009:

> Note: Using higher stages of analytical verification and validation does not typically result in higher data quality. However, the quality of the analytical data becomes more transparent as more stages of verification and validation are conducted.

Appropriateness of Independent Third-Party Validation. Although the use of 100% independent third-party validation may be appropriate for a few types of data collection efforts at PGDP, the majority of the collected data will meet the project and programmatic DQOs with only a percentage of the results subjected to independent third-party validation. One example of a situation where 100% independent third-party validation may be appropriate would be if DOE were collecting data to support transfer of a parcel of property for unrestricted use and each of the samples (depending upon the sampling protocol) would be uniquely representative of a portion of that land. In that case, independent third-party validation of all the data is prudent to ensure that the data support the land transfer, given that DOE will have no recourse if the data were in error.

Similarly, if a project were collecting data in support of litigation and each of these data points were to be evaluated alone, having every data point subjected to independent third-party validation may have value even though the DQOs would have been met without the additional third-party validation.

Most PGDP data collection efforts will meet project DQOs with only a fraction of the data subjected to independent third-party validation, as follows:

- Time-series groundwater monitoring is conducted at PGDP to identify adverse impacts to groundwater. This type of monitoring typically requires several sample results to identify a trend. Thus, any individual sample does not need to be subjected to independent third-party validation as long as the Quality Assurance Program can confirm the quality and data usability of the groundwater data set to a reasonable certainty.

- Site investigation results often are grouped for evaluation and used to support risk assessments. Thus, any individual result is not uniquely important; rather, the mean and range of results are used to identify unacceptable risks requiring remedial action. Thus, if sufficient independent third-party validation is used to minimize the potential for fraud, the entire data set will be usable for its intended purpose. Note: Post-remedy ***confirmation samples*** may properly be subjected to a greater percentage of independent third-party validation if the decision rules for the site future use depend upon individual results. But even confirmation sampling results may be aggregated to support calculation of an exposure point concentration used in decision-making and thus, less independent third-party validation would be defensible.

The appropriate level of independent third-party validation should be established in the project-specific QAPP for each project and developed to ensure that the DQOs of the project will be met and the data will be considered usable. However, the degree of independent third-party validation should consider the entire PGDP Quality Assurance Program efforts.

In general, 100% independent third-party validation should not be considered necessary for CERCLA projects or solid waste projects where:

1. The entire data set is evaluated to support decision-making;

2. The analyses can be repeated (or are part of a continuing monitoring program to identify trends);

3. The decision is not dependent upon a single result at a single well at a single time [but rather some different form of evaluation (e.g., upgradient versus downgradient results)]; or

4. The decision is not dependent upon a single result at a location at a single time [but rather from combining multiple results (e.g., an exposure point concentration)].

For these types of projects, independent third-party validation would not increase data usability; however, the cost of collecting the data would increase markedly.

FRNP's Quality Assurance Program's Use of Independent Third-Party Validation. As noted above, all of FRNP's laboratory data are subjected to data verification and data assessment that includes elements of data validation. These processes typically are sufficient to ensure data usability for most projects. FRNP's program also subjects some data for independent third-party validation to support its Quality Assurance Program.

For example, all the groundwater monitoring data collected for the C-746-S&T, C-746-U, and C-404 Landfills are subjected to 100% independent third-party validation (at a Stage 3 Level), because FRNP believes that these samples are representative of the broad range of analyses conducted at PGDP. Performing 100% independent third-party validation of these samples effectively supports the FRNP Environmental Monitoring Quality Assurance Program by evaluating laboratory results from a broad spectrum of analyses. Independent third-party validation of groundwater samples is also more appropriate because these types of samples are not subject to as many heterogeneity issues as other sample matrices.

For most other projects, independent third-party validation rates range from 5% to 20%. These levels are set in the project scoping process at levels that are considered sufficient to support the project data quality process. As noted above, the level of independent third-party data validation to be conducted is a project-specific decision that should evaluate all data quality needs, including incorporating programmatic considerations.

FRNP recognizes that should DQOs for a project change, additional third-party data validation could be conducted on the project data. The value of this additional third-party validation will depend, in part, on how old are the collected data. Although there is no theoretical limit on the time that can elapse before independent third-party validation is conducted, the representativeness and usability of any data may be called into question after several years (whether or not those data were subjected to independent third-party validation).

REFERENCES

EPA (U.S. Environmental Protection Agency) 2002. *Guidance on Environmental Data Verification and Data Validation*, EPA/240/R-02/004, U.S. Environmental Protection Agency, Washington, DC, November.

EPA 2009. *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*, OSWER No. 9200.1-85, EPA 540-R-08-005, U.S. Environmental Protection Agency, Washington, DC, January.

APPENDIX C

DISCUSSION OF THE QUALITY ASSURANCE CRITERIA TO BE APPLIED TO FIELD ANALYTICAL METHODS

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QUALITY ASSURANCE CRITERIA TO BE APPLIED TO FIELD ANALYTICAL METHODS

Field analytical methods, like X-ray fluorescence (XRF) spectroscopy are used at Paducah Gaseous Diffusion Plant. These methods typically are performed in accordance with a procedure that includes quality assurance criteria associated with instrument calibration and standard result reproducibility, often based upon manufacturer's specifications. In addition, the quality of the results from field analyses may be further confirmed by subjecting a fraction of the samples to analysis at a fixed-based laboratory.

Although XRF and other field methods typically are used for screening or semiquantitative evaluation, under certain, well-defined circumstances, their use may be extended and used in a definitive analysis if the results can be shown to meet the project data quality objectives. In order to meet project data quality objectives, some data verification or validation may be needed in addition to the comparison of the field data to laboratory analyses.

As part of planning for a project that includes the use of a field method, the quality assurance requirements needed to support the data quality objective should be outlined in the plan or procedure, including a description of how calibration and field data will be collected, logged, and recorded. This process should also anticipate the steps that will be taken as part of the data verification/validation process. For example, the procedure may identify what data/information will be presented in the report, including logbook pages, etc. An example of this approach is presented in *The Standard Operating Procedure for Elemental Analysis Using the X-Met 920 Field X-Ray Fluorescence Analyzer* (EPA 1996).

Depending upon the types of data that are collected and the forms in which these data are recorded, a data review and validation process may be developed for use by the project team and/or an independent third-party validator. The *Standard Operating Procedure for the X-Ray Fluorescence Analysis of Particulate Matter Deposits on Teflon Filters* (RTI International 2009) has an outline of the types of activities that could be included to support quality control activities. This type of verification process, when coupled with the comparability evaluation of the field data to laboratory analyses, can bound the range of results and provide verification of whether the results meet the project data quality objectives.

REFERENCES

EPA (U.S. Environmental Protection Agency) 1996. *Standard Operating Procedure for Elemental Analysis Using the X-MET 920 Field X-ray Fluorescence Analyzer*, SOP #: X-MET 920, U.S. Environmental Protection Agency, Region I—New England, Boston, MA, October.

RTI International 2009. *Standard Operating Procedure for the X-Ray Fluorescence Analysis of Particulate matter Deposits on Teflon Filters*, RTI International, Environmental and Industrial Measurements Division, research Triangle Park, NC, August 19.

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APPENDIX D

CONCEPTUAL SITE MODEL
(FROM THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN FOR THE C-400 COMPLEX OPERABLE UNIT)

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Information in this appendix is taken primarily from the Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit (DOE 2020). This information provides an example conceptual site model (CSM).

D.1 CONCEPTUAL SITE MODEL

In general, the C-400 Cleaning Building rests on an approximate 16-inch concrete slab floor designed with four main pits and sumps and an east-side basement area that is 15 to 20 ft below grade. The east-side basement includes a plenum and fan room system to ventilate the building (Figure D.1). Some parts of the concrete slab in the basement and pits were constructed with a base slab and an overlying finished slab of differing construction materials (e.g., multiple discreet concrete layers, acid brick lining). For example, in the north fan room, plenum room, and trichloroethene (TCE) degreaser basement, original construction of the basement included a primary concrete floor with a slightly graded finished slab of concrete above to direct and control drainage to floor drains. Also, the compressor disassembly pit was constructed of an acid-proof brick floor with concrete below. In areas where multiple construction materials (e.g., multiple discreet concrete layers, acid brick lining) are located, the RI will collect additional samples at each interface to support characterization of the slab.

During original construction of the C-400 Building, the building footprint was excavated to allow for the installation of basements and building footers and gravel backfill (ranging from approximately 8 to 12 ft under the building grade slab) was used as the base, potentially creating a permeable zone for contaminant migration. This gravel backfill is anticipated to exist beneath the building grade slab, including most pits and basement areas. In pits, basements, etc., the gravel thickness is anticipated to be less than 8 to 12 ft thick and not present under some basement areas (e.g., North Fan Basement). In addition, footing drains were placed around the building footers in order to keep the footings dry and the area around the footers stable. Roof drains also are connected to the storm sewer lines that traverse beneath the building slab in some areas. Leaking and/or discharge from lines that traverse beneath the building slab periodically could flush contaminants into the subsurface.

Cleaning (clothes laundry and machinery parts), disassembly, and testing of cascade components are the primary activities the building was designed to support. The building also has housed many other activities, including recovery of precious metals and treatment of radiological waste streams.

As indicated in the *C-400 Process and Structure Review*, the tank bottom of the TCE degreaser rusted out, and the resulting leakage of solvents and other contaminants flowed to a sump near the unit. From the sump, they were discharged to the storm-water drain system via pipe. A hole in the underside of this pipe may have allowed solutions within the pipe to escape to surrounding media. In approximately 1973, the sump pump became inoperable and was tagged out. When sufficient liquid backed up, the liquid crossed the floor to the drains beneath the cleaning tanks. These floor drains were connected to the C-403 Neutralization Pit. The sump pump and degreaser body were replaced in approximately 1978. The C-400 Spray Booth (which was used to clean large radiologically contaminated items) originally was built out of common steel, and the unit's base degraded over time. During replacement of the original booth, it was found that the floor beneath was gravel, not concrete, and that this material had eroded or had undergone severe settling. Dye trace tests were performed in 1995 on the safety equipment sink and dissolver drain. Observations of the local storm sewer, sanitary sewer, and discard waste systems did not indicate the presence of dye. The general consensus among those involved at the time of the dye trace tests was that the volume of water/dye was not sufficient to flush out clear water in the lines or did not exceed leakage within the lines, or existing blueprints were incorrect and solutions actually are conveyed in a manner presently not identified (DOE 1995a).

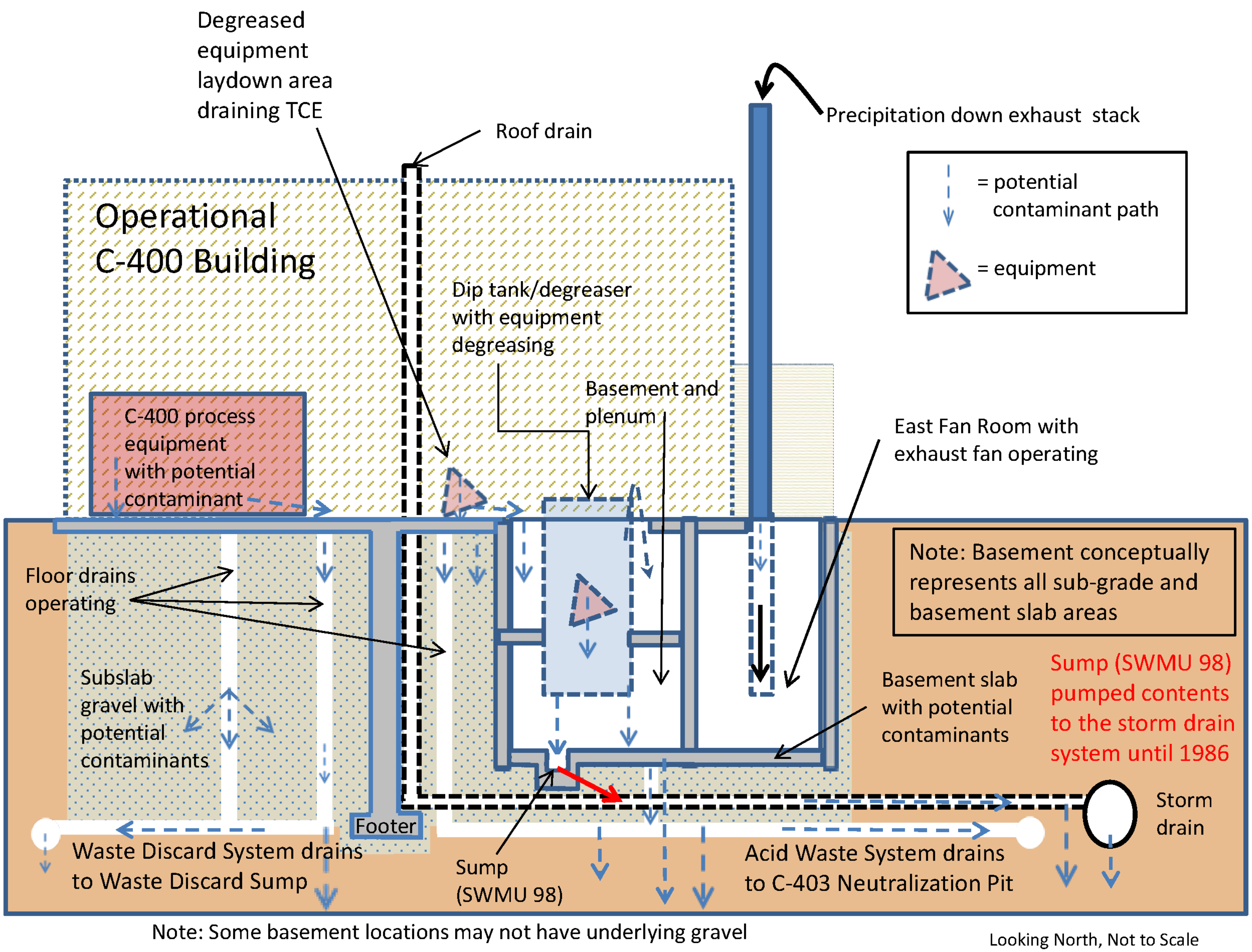


Figure D.1. Historical C-400 Building Operational and Contaminant Release CSM

Potential contaminant source areas include a TCE off-loading pump station, spills, overfill from sumps, and releases from tanks or underground piping. Releases from these sources would directly impact soils below or adjacent to the source and/or sediments and surface water in nearby drainage ways. Continuing transport processes also may result in secondary releases that may impact larger areas or affect additional environmental media. Transport processes likely to be active at the site include vertical infiltration in soil, lateral and vertical migration in groundwater, soil erosion and surface runoff, volatilization, and mobilization of dust particles. Figure D.2 illustrates the hydrogeologic setting for the CSM.

D.1.1 CONTAMINANT SOURCES, RELEASE MECHANISMS, AND MIGRATION PATHWAYS

In accordance with historical process knowledge and the findings of sampling and analysis performed during the Waste Area Grouping (WAG) 6 Remedial Investigation (RI), several contaminant sources have been identified. Detections of chemicals in soil and groundwater confirm potential for media-specific chemical transport. The following migration pathways discussed appear to be the most viable exposure routes.

- Contaminant migration through construction bedding (gravel) around building footers and/or below building concrete slabs, pits, and basements
- Leaching of contaminants through soil to groundwater
- Migration of groundwater to downgradient receptors
- Migration of vapors to on-site receptors

The C-400 Complex is the source of many types of potential contaminants, including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, and radionuclides. Examples of contaminant sources, release mechanisms, and pathways for migration are illustrated in Figure D.3. In this example, primary sources are related to the following processes:

- TCE: truck and railroad delivery and pump and transfer system, storage tank systems, and vapor degreasers;
- Polychlorinated biphenyls (PCBs): leaks of electrical transformers, leaks of gaskets and degradation of building wiring, and wall and floor coatings;
- Technetium-99 (Tc-99): radionuclide recovery and storage and spray booth and degreasing operations; and
- Uranium: pulverizing and screening of the diffusion process heels and hydrostatic testing of product cylinders.

Construction gravel of varying thicknesses (ranging from approximately 0–12 ft) was placed as base material under C-400 Complex building slabs, basements, and within pits. These subsurface gravel beds also housed an assortment of drain lines (e.g., discard waste, acid waste, sanitary sewer, and storm sewer systems) that potentially transported VOCs, SVOCs, metals, and radionuclides. Breaches in the building slab and or drain lines potentially allowed chemicals (or radionuclides) of potential concern (COPCs) to enter into these gravel zones and disperse laterally and downward, eventually migrating to the soil interface below.

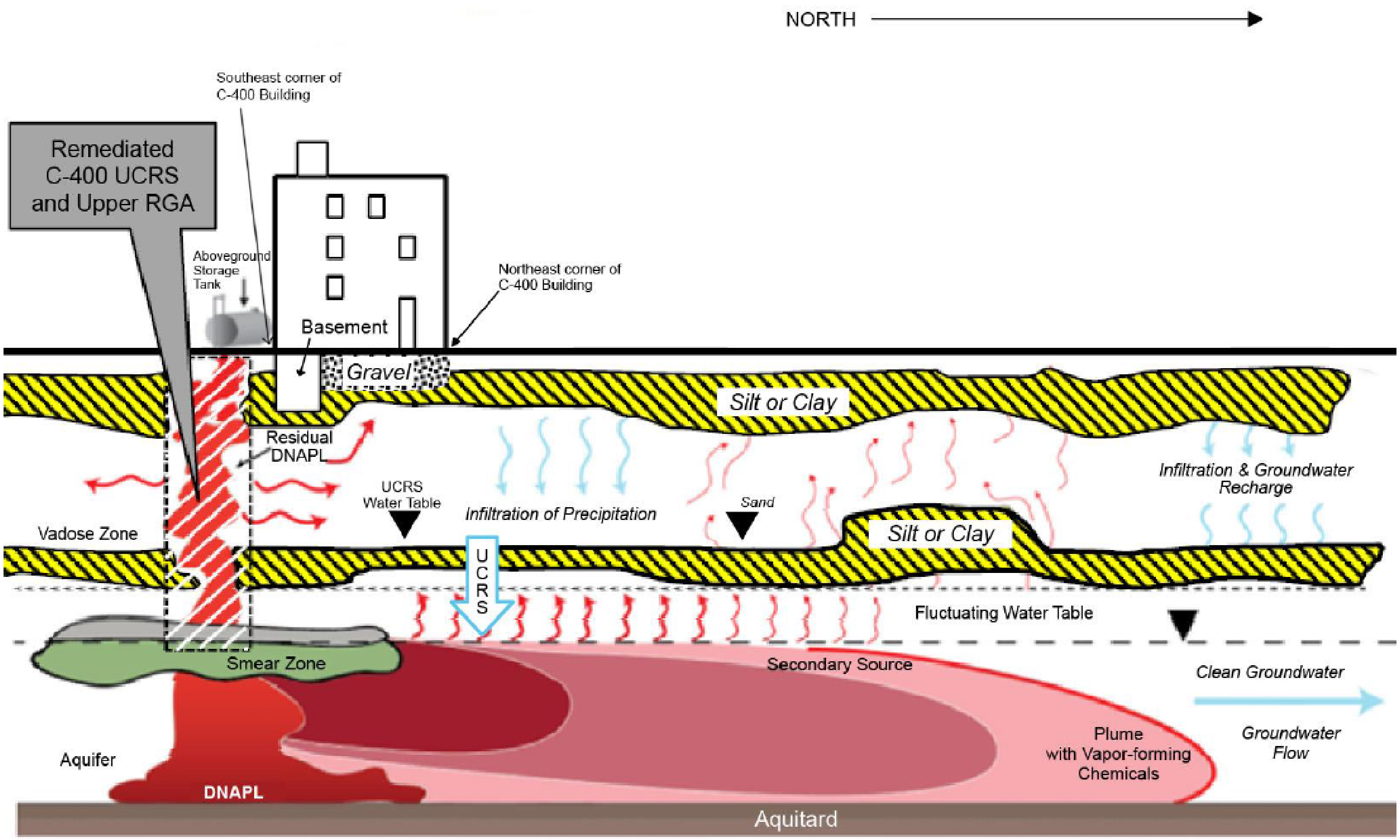


Figure D.2. Hydrogeologic Setting for Conceptual Site Model

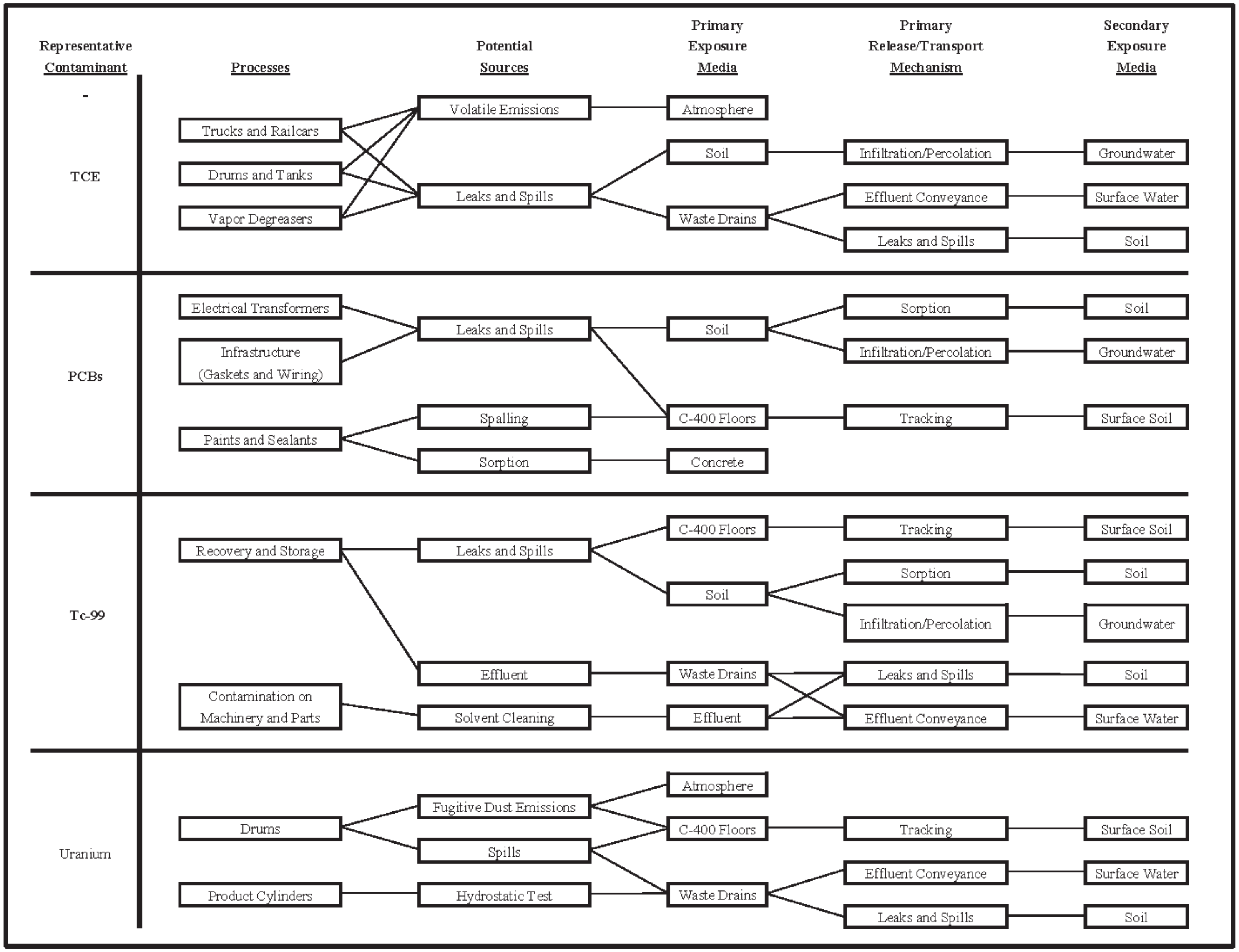


Figure D.3. Pathway Network Diagram for Representative Contaminants

Extensive areas of soil surrounding the C-400 Cleaning Building have been impacted by releases of TCE and other contaminants into the shallow subsurface soil. Due to the dense nonaqueous-phase liquid (DNAPL) characteristics of TCE, the dominant dispersal pattern through the vadose soil to the top of the RGA is gravity-driven. Within the Regional Gravel Aquifer (RGA), where spill volumes were sufficiently large, vertical DNAPL migration has penetrated to the base of the RGA. Lateral transport of dissolved-phase contaminants within the RGA follows groundwater flow paths established by the regional groundwater gradient. Releases of TCE at the C-400 Complex are the source for the downgradient, off-site Northwest Plume and may be related to the Northeast Plume.

Because large releases of TCE likely occurred and TCE is expected to have penetrated the thickness of the RGA as a DNAPL, TCE DNAPL likely pooled at the top of the McNairy Formation. Where TCE pools obtained enough height to overcome the interfacial tension between the RGA and McNairy Formation soils, TCE may have migrated to greater depths in the McNairy Formation. These migration depths could be significantly greater if faulting is present beneath C-400.

D.1.2 MIGRATION PATHWAYS

D.1.2.1 Soil to Groundwater Pathway—Upper Continental Recharge System

Contaminants present in surface and subsurface soils may leach to the underlying aquifer. Several factors influence the dissolution of COPCs in soils and the rate of contaminant movement through soils. These include the physical/chemical properties of the contaminants [e.g., solubility, density, viscosity, distribution coefficient (K_d)] and the physical/chemical properties of the environment (e.g., rainfall, percolation rate, soil permeability, porosity, particle size, and amount of organic carbon). Contaminants migrate to groundwater through infiltration, leaching, and the movement of subsurface water within the capillary fringe.

Generally, the groundwater is relatively deep at the C-400 Complex, and many of the potential source areas have been present for a long time; therefore, leaching potential is indicated by the observed groundwater concentrations. The depth to the water table in many areas is approximately 50 ft, suggesting a long travel time from the surface to the water table. In areas beneath pavement or other low permeability zones, less infiltration would occur. Adjacent to paved areas, higher rates of recharge may occur as runoff increases infiltration in localized areas. It is obvious that vertical migration has occurred at a much higher rate than indicated by advection/leaching, primarily because of diffusion. Diffusion can increase the rate of contaminant migration significantly as the chemical moves to counteract concentration gradients, which are estimated to be quite significant at the C-400 Complex. It appears that the dominant driving force for chemical migration in the Upper Continental Recharge System (UCRS) is diffusion.

Chemicals can attenuate in the vadose zone. Chemicals that strongly sorb to soils, including most polycyclic aromatic hydrocarbon (PAH) compounds, tend to remain in or near the point of release. The retardation factors for these constituents indicate that they would be expected to migrate much more slowly than water in some instances. In addition to their strong tendency to adsorb, these compounds biodegrade during the slow transport, limiting the impacted area. Other constituents such as VOCs tend to volatilize in the unsaturated zone, decreasing their persistence in that medium.

The cosolvent effect may apply where there are two types of organic contaminants present in the waste: one type that is hydrophobic and sparingly soluble, (e.g., PAHs and PCBs), and another type that may function as a cosolvent for the sparingly soluble contaminant or moderately to highly soluble in water (Huling 1989). In order for a substance to behave as a cosolvent, it must be miscible with water, even to a small degree. The cosolvent effect is such that the solubility of the hydrophobic compounds increases due to co-mixing with the organic cosolvent, particularly if the latter is fully miscible with water (e.g., ethanol or methanol) (Suresh et al. 1990; Li and Andren 1994). Nonspecific hydrophobic partitioning to solid phase materials also is understood to decline in the presence of an organic cosolvent.

The main cosolvency effect at the C-400 Complex is anticipated to be PCBs and/or PAHs in TCE. If DNAPL is present or if a small amount of DNAPL is captured in a sample, a "nugget effect" in the concentration levels of PAHs, PCBs, or other cosolved constituents may be observed in the analytical data—this would be evidenced by a higher than expected concentration of the cosolved constituent. Conversely, a higher than expected concentration of a constituent that could be cosolved may be the result of several factors, but could indicate that a small amount of DNAPL was captured in the sample. Cosolvency also may be evidenced during DNAPL remediation, where PCB or PAH concentrations in water and air may increase as the DNAPL is removed/remediated. Raoult's Law can be used to predict this effect. Uncertainties due to the effects of cosolvency will need to be considered during the evaluation of remedial alternatives in the RI/FS Report.

D.1.2.2 Groundwater Migration—Regional Gravel Aquifer

The contaminants of concern (COCs) from the WAG 6 RI reported in RGA groundwater include arsenic, beryllium, iron, chromium, lead, manganese, thallium, silver, TCE, *cis*-1,2-dichloroethene (DCE), *trans*-1,2-DCE, vinyl chloride, 1,1-DCE, 1,1,1-trichloroethane (TCA), 1,1,2-TCA, and several radionuclides. VOCs are the most widespread of the COCs. The highest concentrations of VOCs were reported in the southeast area of the C-400 Complex. DCE is formed from anaerobic biodegradation of TCE, TCA, or the DCE intermediates. It subsequently degrades to ethene and/or ethane. The current data indicate that anaerobic biodegradation (e.g., TCE to DCE) is not a major process in the hydrogeological/geochemical environment at the C-400 Complex.

Once in the groundwater, COCs generally move through the RGA via advection. COCs spread both horizontally and vertically due to the process of dispersion, while adsorption retards the movement of chemicals in groundwater. Dispersion generally causes chemicals to migrate from 10 to 20% farther than migration caused by advection alone. Adsorption, which retards the movement of chemicals, counteracts the advection and dispersion processes. Adsorption generally is described by a chemical's K_d.

In accordance with the COCs identified in the WAG 6 RI, the most mobile constituents include the chlorinated VOCs. Other constituents, including PAHs and metals (such as lead and vanadium), are not readily transported in groundwater. Consistent with these properties, PAHs were not detected in the groundwater. The widespread occurrence of unfiltered metals in the WAG 6 RI groundwater samples, such as iron, is the result of highly turbid groundwater samples and is not a result of migration or site-related activities.

D.1.2.3 Groundwater Migration—McNairy

The following text summarizes the site data available for the Cretaceous McNairy Formation, relative to groundwater migration.

Stratigraphy Overview

The McNairy Formation includes an upper silt and sand member, a middle silt and clay member (known as the Levings Member), and a lower sand member at the Paducah Site. Laterally extensive, smaller scale, bedding has not been identified in the McNairy members in the proximity of the Paducah Site.

McNairy Upper Member: The upper member of the McNairy Formation primarily consists of interlensing, fine-grained, silt and sand. In the area of the Paducah Site, the Paleocene age Clayton Formation and upper member of the Cretaceous age McNairy Formation are indistinguishable based on soil textures and are referred to collectively as the McNairy upper member. Sand units comprise less than one-half of the thickness of the McNairy upper member at the Paducah Site. The top of the McNairy upper member underlies the Porters Creek Clay under the south portion of the Paducah Site at an elevation of approximately 240 ft amsl. The irregular erosional surface of the ancestral Tennessee River basin, at an approximate elevation of 250 to 280 ft amsl is the top of the McNairy upper member under the north portion of the Paducah Site.

McNairy Levings Member: A common interval of generally finer-grained clastic sediments exists beneath the Paducah Site and adjacent areas. The lithologic character and stratigraphic position is consistent with description of the Levings Member by Pryor and Ross (1962). In the area of the Paducah Site, the contact of the upper member and Levings Member appears relatively planar, at an approximate elevation of 215 to 220 ft amsl.

McNairy Lower Member: The lower member of the McNairy Formation predominately consists of well-sorted, fine sand with lesser silt and clay interbeds. As noted by regional studies (Moneymaker and Grant 1954; Pryor 1960; and Davis, Lambert, and Hansen, Jr. 1973), the McNairy Formation sands are characteristically fine-grained. Sands of the lower member are uniquely well-sorted. Beneath the industrial complex of the Paducah Site, the top of the McNairy lower member occurs at an approximate elevation of 110 to 130 ft amsl, and the base is at an approximate elevation of -5 to 90 ft amsl.

McNairy/RGA Interface

The low hydraulic conductivity of the fine-grained sediments of the McNairy Formation (interbedded fine sands, silts, and clays) sharply contrasts with the high hydraulic conductivity of the coarse grained sediments of the overlying RGA (gravelly sands and sandy gravels). This contrast of hydraulic conductivity within a low vertical, hydraulic gradient field,[1] results in a dominant lateral flow regime in the RGA with little vertical flow between the RGA and the McNairy Formation. Although the lower McNairy member is an aquifer capable of producing residential supplies, the upper McNairy Formation in the area of the Paducah Site functions as a lower aquitard to the RGA.

McNairy Formation Data of the Paducah Site

Characterization of the McNairy Formation at the Paducah Site can be summarized utilizing three types of data: lithologic descriptions, aquifer properties, and groundwater elevations.

Lithologic Descriptions of the C-400 Area: While numerous Paducah Site investigations provide lithologic logs of the upper McNairy member, relatively few soil borings transect all (or most) of the McNairy Formation. Deep McNairy Formation lithology and geophysical logs include the following:

- The 2 deep Z-series locations, Z-9/Z-12 and Z-14/Z-16, on the north and west sides of the Paducah Site (ERCE 1990),
- The P4F8 soil boring of the Groundwater Monitoring Phase IV Investigation, located in the north central area of the industrial complex (DOE 1995b), and

[1] At the C-400 Complex, the vertical hydraulic gradient of both the RGA and McNairy formation is approximately +1 × 10-2 ft/ft.

- The DB01 soil boring from the siting investigation for a potential Comprehensive Environmental Response, Compensation, and Liability Act waste disposal facility, located immediately south of the industrial complex (DOE 2004).

The WAG 6 RI provides lithologic logs of the upper McNairy member in the C-400 area for 11 deeper soil borings, with total depths ranging from 104 to 147 ft. The predominant soil textures that are described range from clay to fine sand (DOE 1999). No upper McNairy member lithologic units can be correlated across the C-400 area.

Hydrogeologic Properties: Several area investigations contribute measurements of aquifer properties of the McNairy Formation at the Paducah Site. Appendix B includes a figure that shows the historical McNairy Formation sample locations. Table D.1 summarizes measurements of natural moisture content and specific gravity of McNairy Formation soil samples and the derived porosity for the samples. Direct measurements of McNairy Formation porosity as part of the WAG 6 RI, as summarized in Table D.2, are similar to the area-wide results (DOE 1999).

Four Paducah Site investigations have measured hydraulic conductivity of the McNairy Formation. The Phase I SI (CH2M HILL 1991) measured horizontal hydraulic conductivity with slug tests in three McNairy monitoring wells (MWs). Results ranged from 2.88×10^{-5} to 1.84×10^{-4} cm/sec (Table D.3) with a median value of 9.69×10^{-5} cm/sec. Tests for siting investigations of the Northwest Plume Capture System and the C-746-U Landfill measured vertical hydraulic conductivity with permeameters from 18 soil borings and 20 discrete sample depths (Table D.4). Vertical hydraulic conductivity values ranged from 1.80×10^{-8} to 5×10^{-4} cm/sec with a median value of 3.67×10^{-7} cm/sec.

Table D.1. Porosity of McNairy Formation Samples

Soil Boring ID	Sample Number	Depth (ft bgs)	Elevation (ft AMSL)	Grain Size Description	Natural Moisture Content (%)	Specific Gravity (gm/cm^3)	Calculated Porosity (%)
S-7	27	135.0–137.5	244.8–247.3	SILT, sandy	42	2.65	65
Z-1	30	124.0–125.5	254.8–256.3	SAND, silty	23	2.56	43
Z-5	33	133.5–135.0	244.9–246.4	SAND, silty	30	2.56	52
Z-12	1	137.8–139.2	211.9–213.3	CLAY, silty	30	2.59	53
	4	197.8–199.2	151.9-153.3	CLAY, sandy	10	2.60	23
	7	257.8–258.9	92.2–93.3	SILT, sandy	19	2.62	38
	10	317.8–318.2	32.9–33.3	SAND, clayey	27	2.75	51
Z-14	31	123.5–125.0	246.5–248.0	CLAY, silty	27	2.70	49
Z-16	2	137.0–139.0	231.9–33.9	SAND, clayey	33	2.62	56
	5	167.7–169.2	201.7–03.2	CLAY, sandy	26	2.66	48
	6	177.7–179.2	191.7–193.2	SAND, silty	25	2.65	47
	8	197.7–199.2	171.7–173.2	CLAY, silty	24	2.63	46
	11	227.7–228.1	142.8–143.2	SAND, silty	27	2.67	50
	14	257.7–258.8	112.1–113.2	CLAY, silty	25	2.65	46
	17	287.7–288.2	82.7–83.2	SAND, silty	31	2.65	55
	19	307.7–308.2	62.7–63.2	SAND	28	2.66	51
					Average Porosity:		**48**

Table D.2. Measurements of McNairy Formation Samples as Part of the WAG 6 Remedial

Soil Boring ID	Depth (ft bgs)	Elevation (ft AMSL)	Percentage			Porosity (%)
			Clay	Silt	Sand	
026001SA120	127–130	246.0–249.0	1.9	5.0	93.1	41
400036SA110	109*	269.3	4.0	3.3	92.7	51
400036SA120	120*	258.3	27.5	15.3	57.2	52
400036SA140	141*	237.3	7.8	22.5	69.7	48
400038SA120	120–120.5*	258.4–258.9	54.0	37.7	8.3	45
400038SA140	141–143.5	235.4–237.9	27.8	58.6	13.6	32
400208SA140	126–128*	246.4–248.4	15.2	73.0	11.8	42
400210SA110	115.5–116*	261.4–261.9	16.0	33.8	50.2	56
400212SA100	117–119.5*	256.3–258.8	20.0	45.4	34.6	46
					Average Porosity:	**46**

*Depth of associated analytical sample.

Table D.3. Slug Tests of McNairy Formation Monitoring Wells from the Phase I Site Investigation

Monitoring Well	Screen Interval		Lithologies of the Screen Interval	Hydraulic Conductivity (cm/sec)
	Depth (ft)	Elevation (ft AMSL)		
MW120	155–170	214–229	CLAY, silty and SAND	1.84×10^{-4}
MW121	198–210	162–174	SILT and SAND, silty	2.88×10^{-5}
MW122	144–158	205–219	SAND, medium and CLAY, sandy	9.69×10^{-5}
			Average:	$\mathbf{1.03 \times 10^{-4}}$
			Median:	$\mathbf{9.69 \times 10^{-5}}$

Table D.4. Permeameter Tests of McNairy Formation Samples outside the C-400 Vicinity

Soil Boring ID	Depth (ft bgs)	Elevation (ft AMSL)	Lithology	Hydraulic Conductivity (cm/sec)
GB-01D	86–88 #2	272.2–274.2	CLAY with sand interbeds	2.75×10^{-7}
	86–88#3			3.67×10^{-7}
GB-02D	88–90 #2	272.3–274.3	CLAY with silt interbeds	4.09×10^{-8}
	88–90 #3			7.25×10^{-8}
GB-03D	88–90 #2	271.9–273.9	CLAY with sand interbeds	4.66×10^{-6}
	88–90 #3			2.67×10^{-6}
GB-04D	83–85 #2	279.9–281.9	SAND, very fine	4.71×10^{-5}
	83–85 #3			4.12×10^{-6}
GB-05D	83–85 #2	278.4–280.4	CLAY, sandy	1.25×10^{-6}
	83–85 #3			2.05×10^{-6}
MW239	124–126	244.1–246.1	no description	2.10×10^{-7}
MW245	95–97	272.2–274.2	GRAVEL, sandy, silty	5.00×10^{-4}
MW247	118–120	247.0–249.0	no description	5.90×10^{-6}
MW248	98–100	268.5–270.5	no description	9.80×10^{-5}
MW250	95–97	270.8–272.8	SAND and CLAY, silty	1.20×10^{-7}
SB-28	114–116	253.9–255.9	SAND, fine above/CLAY below	4.10×10^{-6}
SB-29	114–116	253.8–255.8	CLAY with sand above/CLAY below	3.90×10^{-8}
SB-30	114–116	251.5–253.5	CLAY above/SAND and CLAY below	2.50×10^{-7}
SB-31	114–116	252.3–254.3	CLAY above/CLAY below	1.60×10^{-7}

Table D.4. Permeameter Tests of McNairy Formation Samples outside the C-400 Vicinity (Continued)

Soil Boring ID	Depth (ft bgs)	Elevation (ft AMSL)	Lithology	Hydraulic Conductivity (cm/sec)
SB-33	98–100	267.2–269.2	SAND and CLAY, interbedded	1.80×10^{-8}
	174–176	191.2–193.2	CLAY	1.30×10^{-7}
SB-36	118–120	246.3–248.3	no description	1.50×10^{-4}
SB-37	88–90	279.9–281.9	CLAY with little sand	4.80×10^{-7}
	114–116	253.9–255.9	CLAY	3.30×10^{-7}
SB-38	118–120	248.1–250.1	CLAY with sand	5.40×10^{-8}
			Average:	**3.29×10^{-5}**
			Median:	**3.67×10^{-7}**

The WAG 6 RI measured the vertical hydraulic conductivity of 9 McNairy Formation soil samples from the C-400 area (DOE 1999). Values ranged from 8.2×10^{-8} to 1.09×10^{-3} cm/sec with a median of 1.33×10^{-5} cm/sec (Table D.5).

Table D.5. Permeameter Tests of McNairy Formation Samples from the C-400 area

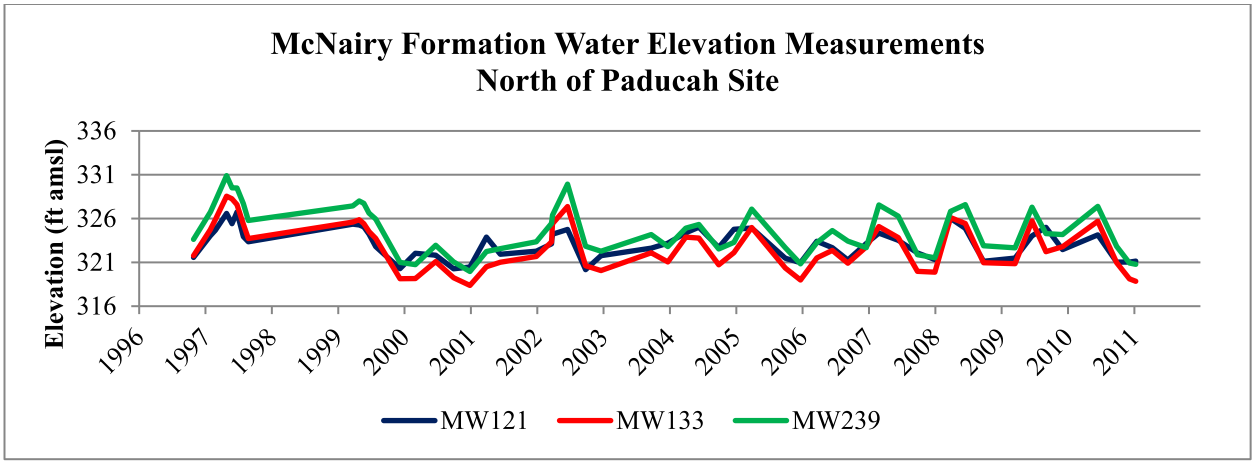
Soil Boring ID	Depth (ft bgs)	Elevation (ft AMSL)	Lithology	Hydraulic Conductivity (cm/sec)
026001SA120	127–130	246.0–249.0	SAND	1.09×10^{-3}
400036SA110	109*	269.3	SAND, silty	3.62×10^{-4}
400036SA120	120*	258.3	SAND, clayey, silty	8.20×10^{-8}
400036SA140	141*	237.3	SAND, silty	2.11×10^{-6}
400038SA120	120–120.5*	258.4–258.9	CLAY, silty	4.73×10^{-6}
400038SA140	141–143.5	235.4–237.9	SILT, clayey	1.52×10^{-5}
400208SA140	126–128*	246.4–248.4	SILT, clayey	7.36×10^{-5}
400210SA110	115.5–116*	261.4–261.9	SAND, clayey, silty	1.33×10^{-5}
400212SA100	117–119.5*	256.3–258.8	SILT, clayey, sandy	1.32×10^{-6}
			Average:	**1.74×10^{-4}**
			Median:	**1.33×10^{-5}**

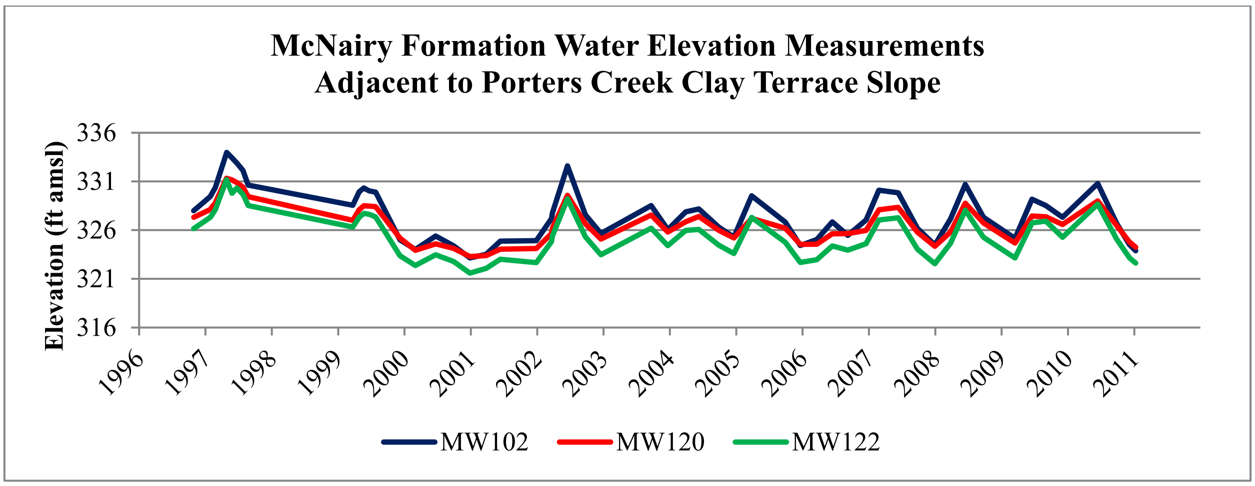
*Depth of associated analytical sample.

Water Level Measurements

The regional potentiometric surface of the McNairy groundwater flow system dips from an outcrop recharge area at Kentucky Lake westward and northward to the Ohio River (Davis, Lambert, and Hansen, Jr., 1973). Local groundwater flow in the McNairy Formation discharges to the Ohio River. Potentiometric trends of the RGA and the McNairy Formation are similar at the Paducah Site.

The Paducah Site has 7 McNairy MWs with an extensive record of water level measurements, including 54 synoptic water level measurements during the period 1996 through 2011. (Six of these McNairy wells have neighboring RGA wells with synoptic water level measurements.) These synoptic measurements constitute a robust data set for analysis that documents similar McNairy water level trends in all 7 MWs (Figure D.4).





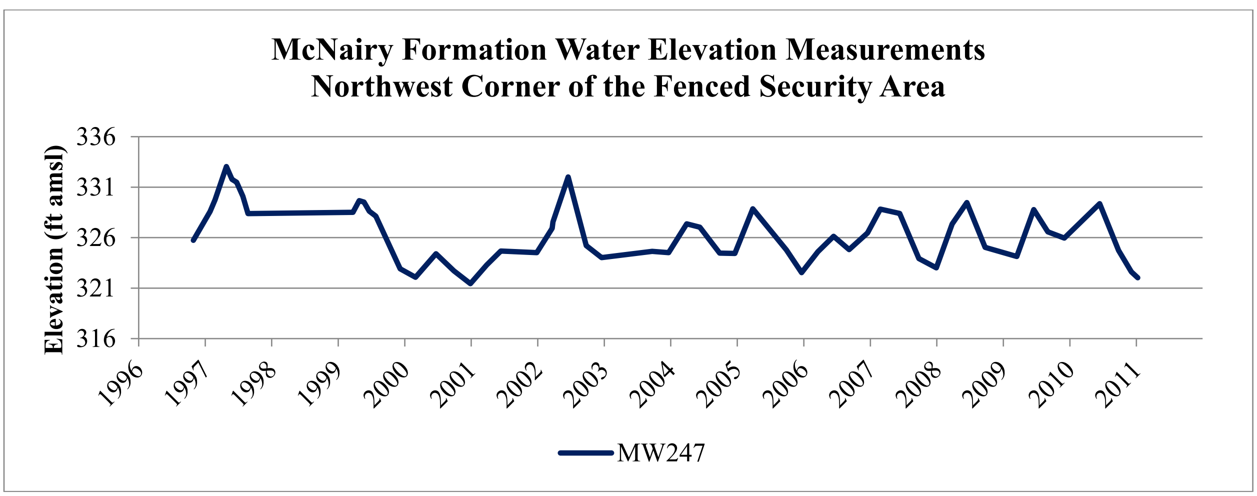


Figure D.4. McNairy Formation Synoptic Water Elevation Measurements

Three of the McNairy MWs (MW122, MW239, and MW247) are located in close vicinity of extraction wells. The remaining four McNairy wells (MW102, MW120, MW121, and MW133) are located distal to extraction wells and provide opportunity for assessment of the vertical and horizontal gradients in the McNairy Formation.

The measured vertical gradients (using the water level in the adjacent RGA well as the water level at the base of the RGA) range between -0.013 (at MW121) and +0.014 ft/ft (at MW133). Horizontal gradients measured between two upgradient McNairy wells (MW102 and MW120) and downgradient McNairy wells (MW121 and MW133) are 4.65×10^{-4} ft/ft (at N24°E)[2] and 4.2×10^{-4} ft/ft (at N21°E),[2] respectively, (based on the median of water elevations in each well and corrected to a reference screen midpoint elevation of 219 ft amsl) (Figure D.5).

Groundwater Flow Rates

The product of hydraulic conductivity (*K*) and gradient (*i*) divided by porosity (*n*) determine the groundwater flow rate of the McNairy Formation. Using the median horizontal hydraulic conductivity based on slug test data (Table D.3) and assuming maximum horizontal hydraulic gradient, the horizontal groundwater flow rate in the McNairy Formation beneath C-400 is calculated as follows.

$$(K_{median} \times i)_{\text{horizontal}} \div n = (9.69 \times 10^{-5} \text{ cm/sec} \times 4.65 \times 10^{-4}) \div 0.46 = 9.80 \times 10^{-8} \text{ cm/sec} = 1.01 \times 10^{-1} \text{ ft/yr}$$

Using the median horizontal hydraulic conductivity based on permeameter test data (Table D.5) and assuming the vertical gradient for the C-400 area is the same as MW121, the vertical groundwater flow rate in the McNairy Formation beneath C-400 is calculated as follows.

$$(K_{median} \times i)_{\text{vertical}} \div n = (1.33 \times 10^{-5} \text{ cm/sec} \times 1.3 \times 10^{-2}) \div 0.46 = 3.76 \times 10^{-7} \text{ cm/sec} = 3.89 \times 10^{-1} \text{ ft/yr}$$

Travel time for vertical advective flow across the 125-ft thickness of the Upper and Levings Members of the McNairy beneath C-400 is approximately 321 years.

Contaminant Migration

The rate of transport of dissolved contamination in the McNairy Formation by advective flow is much less than the rate of advective transport in the RGA. Diffusion may be a more important process promoting contaminant migration. The upper and middle McNairy Formation members have significant organic carbon content. Horizons of lignite are reported in some soil cores. Partitioning, biological transformation, and abiotic transformation likely are important processes of retardation and degradation of contaminants in the upper and middle members.

Analyses of grab samples of McNairy Formation groundwater samples beneath the TCE plumes from previous Paducah Site investigations [notably the Groundwater Monitoring Phase IV Investigation (DOE 1995b) and the WAG 6 RI (DOE 1999)] indicate the vertical limit of TCE migration into the McNairy Formation is approximately 50 ft. Figure D.6 summarizes the combined results.

[2] Bearings are relative to the Paducah Site coordinate system.

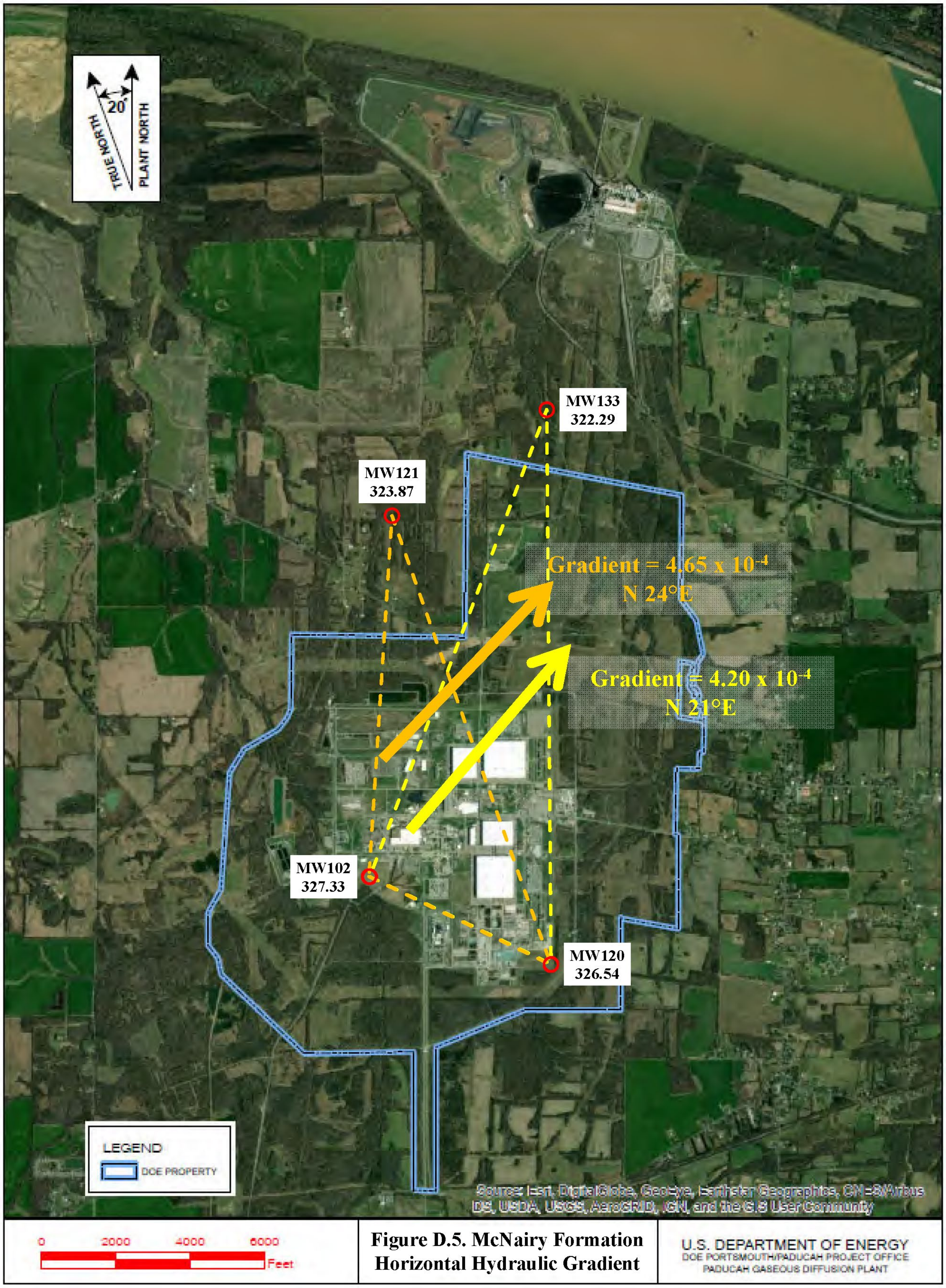


Figure D.5. McNairy Formation Horizontal Hydraulic Gradient

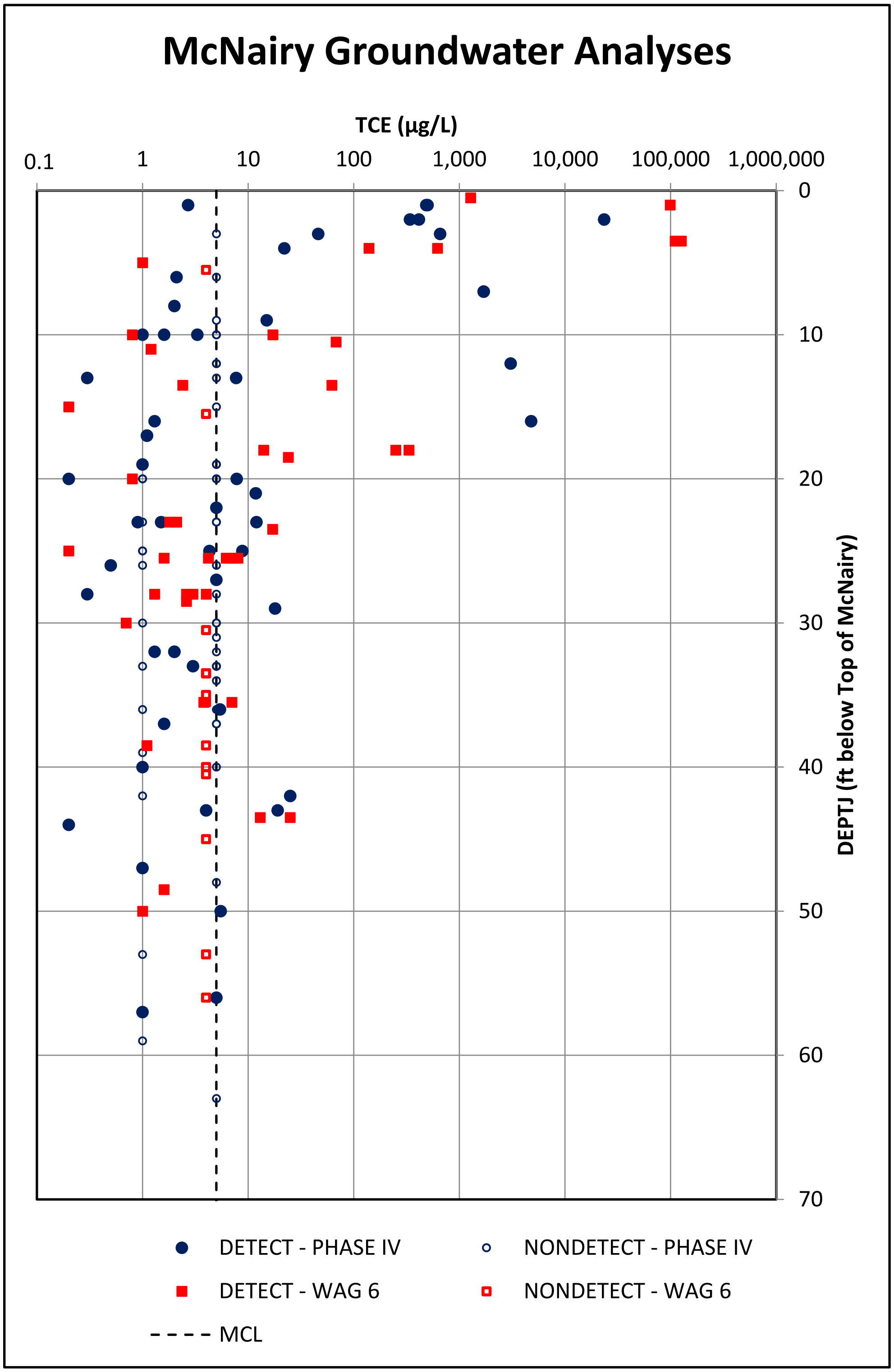


Figure D.6. McNairy Formation Groundwater Sample TCE Analyses from the Groundwater Monitoring Phase IV Investigation and the WAG 6 RI

Because large releases of TCE likely occurred and TCE is expected to have penetrated the thickness of the RGA as a DNAPL, TCE DNAPL likely pooled at the top of the McNairy Formation. Where TCE pools obtained enough height to overcome the interfacial tension between the RGA and McNairy Formation soils, TCE may have migrated to greater depths in the McNairy Formation. These migration depths could be significantly greater if faulting is present beneath C-400. Unless the contaminated, fine-grained sediments of the McNairy Formation are remediated, they will be a long-term source of dissolved TCE to the RGA through back diffusion.

D.1.3 VAPOR INTRUSION

A vapor intrusion (VI) study was conducted for the C-400 Cleaning Building, and the report was submitted to EPA and KDEP for review and approval on May 29, 2018 (*Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1289&D2/R1/A3/R1), was approved by KDEP and EPA on November 21, 2018, and December 4, 2018, respectively.

TCE-contaminated groundwater and soil adjacent to and under the C-400 Cleaning Building are considered sources of vapors. Subslab vapor sampling at the C-400 Cleaning Building detected primarily TCE, but also detected *cis*-1,2-DCE. Subsurface conditions in the C-400 Complex are considered to allow vapor transport toward the building. Although TCE concentrations in the RGA near the C-400 Cleaning Building have decreased, groundwater concentrations still exceed EPA's groundwater Vapor Intrusion Screening Level (VISL). Similarly, remedial actions have achieved greater than 95% reduction in soil concentrations, though post remedial residual concentrations remain. Vapor concentrations associated with the remaining TCE contamination in groundwater and soil are expected to be orders of magnitude higher than the commercial soil gas and subslab TCE VISL screening level of 100 $\mu g/m^3$ (micrograms per m^3).

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 the C-400 Complex, as well as the presence of gravel immediately beneath the building. The presence of gravel under the slab was documented by the drilling of subslab soil gas ports, which encountered gravel at six of the seven subslab probe locations. A possible explanation for why TCE vapors were not present in Location 3 (i.e., North Fan Basement) is that material beneath the slab is clay, rather than the anticipated gravel that was present at the other probe locations. The large number of utilities present in the vicinity of the building also may serve as preferential pathways for vapor migration.

The spatial association between elevated indoor air and subslab soil gas concentrations is consistent with a conclusion that the VI pathway is complete, particularly in the southern portion of the building. The presence of *cis*-1,2-DCE in subslab vapor in some locations shows there is an underlying groundwater source of TCE. *Cis*-1,2-DCE is a common breakdown product of TCE dissolved in groundwater, where groundwater conditions support reductive dechlorination. It is rarely present in commercial products, and it generally is not associated with TCE off-gassing from contaminated vadose zone soil because soils typically are sufficiently oxygenated to preclude reductive dechlorination of TCE (Rivett et al. 2011). In the northern portion of C-400 Cleaning Building, at Locations 2, 3, and 4, *cis*-1,2-DCE was not detected in subslab soil gas, and TCE concentrations in subslab soil gas ranged from 14 to 200 $\mu g/m^3$, which is consistent with an absence of subsurface sources of TCE (in groundwater) that are significant to the VI pathway. (Vadose zone sources of TCE are present, however.) In the southern portion of C-400 Cleaning Building, near Locations 1, 6, and 7, TCE concentrations in subslab soil gas ranged from 75 to 77,000 $\mu g/m^3$, and *cis*-1,2-DCE was detected in subslab soil gas, consistent with a groundwater source of TCE and a complete VI pathway. A recommendation of the VI study was that, based on the presence of TCE in subslab soil gas above the EPA subslab soil gas screening level, periodic air monitoring be conducted and worker access be restricted. Additionally, increased ventilation may be appropriate if it is anticipated workers will spend substantial time in Locations 5, 6, and 8, the C-400 east basement area or former southeast office area until the building is decommissioned or the source is remediated.

D.2. REFERENCES

CH2M HILL 1991. *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant*, KY/ER-4, CH2M HILL Southeast, Inc., Oak Ridge, TN, March.

Davis, R. W., T. W. Lambert, and A. J. Hansen, Jr. 1973. "Subsurface Geology and Groundwater Resources of the Jackson Purchase Region, Kentucky," U.S. Geological Survey Water-Supply Paper 1987, U.S. Geological Survey.

DOE (U.S. Department of Energy) 1995a. *C-400 Process and Structure Review*, KY/ERWM-38, U.S. Department of Energy, Paducah, KY, May.

DOE 1995b. *Northeast Plume Preliminary Characterization Support Report*, DOE/OR/07-1339/V1&D2, U.S. Department of Energy, Paducah, KY, July.

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 6 (C-400) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1727&D2.

DOE 2004. *Final Report Six-Phase Heating Treatability Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2113&D2, U.S. Department of Energy, Paducah, KY, March.

DOE 2019. *Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2433&D2, U.S. Department of Energy, Paducah, KY, October.

ERCE 1990. Recommended Soil Columns for Use in Amplification Studies, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, ERCE File No. B672, November.

Huling, S. G. 1989. "Facilitated Transport," Superfund Groundwater Issue, U.S. Environmental Protection Agency, ORD-OSWER, EPA/540/4-89-003.

Li, A. and A. W. Andren 1994. "Solubility of Polychlorinated Biphenyls in Water/Alcohol Mixtures, 1. Experimental Data," ES&T 28:47-52.

Moneymaker, B. C. and L. F. Grant 1954. "Cretaceous and Pleistocene Section in Northern End of Mississippi Embayment," American Association of Petroleum Geologists Bulletin 38(8) 1741-1747.

Pryor, W. A. 1960. "Cretaceous Sedimentation in Upper Mississippi Embayment," American Association of Petroleum Geologists Bulleting 44(9), 1473-1504.

Rivett, M. O., G. P. Wealthall, R. A. Dearden, T. A. McAlary 2011. "Review of unsaturated-zone transport and attenuation of volatile organic compound (VOC) plumes leached from shallow source zones," *Journal of Contaminant Hydrology*, 123 (2011) pp.130–156.

Suresh, P., C. Rao, L. S. Lee, and R. Pinal 1990. “Cosolvency and Sorption of Hydrophobic Organic Chemicals,” ES&T 24:647-654.

APPENDIX E

COLLECTION OF FIELD DUPLICATES AT THE C-404 HAZARDOUS WASTE LANDFILL

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COLLECTION OF FIELD DUPLICATES AT THE C-404 HAZARDOUS WASTE LANDFILL

The monitoring well network at the C-404 Hazardous Waste Landfill is sampled twice a year as required by the Hazardous Waste Management Facility Permit (Permit). Results are reported in a semiannual groundwater report. During development of the May 2018 semiannual groundwater report, the use of field duplicate data was discussed. Upon review of the Permit, it was identified that duplicate samples taken for the C-404 Hazardous Waste Landfill groundwater monitoring were not being collected as described in the Permit.

SAMPLE COLLECTION METHODS

The Permit describes field duplicates as two aliquots of a sample (i.e., the primary sample and its duplicate) that are aliquoted into two containers from a single sample collection container or sample mixing container and shipped to the same laboratory for analysis. Data generated by duplicate samples collected and analyzed in this manner can be used to assess sampling and analytical variability (precision).

Current in-house procedure describes field duplicates being collected by taking separate samples as close to each other in time and space as practical. The description of field duplicates in the Permit is identified as replicate samples within the current in-house procedure. Data from a duplicate sample collected in this manner may be used to assess sampling variability.

In reviewing other guidance, U.S. Environmental Protection Agency's SW846 describes collocated samples as a type of field duplicate where independent samples are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently by the same method and laboratory. These types of duplicates are useful in documenting the precision of the sampling process. The SW846 guidance also identifies a field split sample as another type of field duplicate. A field split sample is described as a type of field duplicate where the sample is homogenized and then divided into two or more aliquots so that variability can be evaluated, (i.e., often between laboratories or methods). The guidance goes on to state that homogenization may have an impact on sample integrity for some sample types [e.g., volatile organic compounds (VOCs) in soil] and, in these cases, collocated samples may be more appropriate. The SW846 guidance states that field duplicates (both collocated samples and split samples) are useful in documenting the precision of the sampling process. As defined in the SW846 guidance, precision measures the agreement among a set of measurements.

BACKGROUND

Field duplicate samples historically have been collected using a collocated duplicate approach because VOCs are a contaminant of concern at the Paducah Site. The collocated duplicate sampling method was implemented to prevent the potential loss of a sample's volatile concentrations during mixing or transferring from a single sample container. Additionally, this collection method is an acceptable practice under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and it is the type of duplicate sampling utilized in CERCLA sampling events at the Paducah Site.

A teleconference with the U.S. Department of Energy (DOE) and Kentucky Division of Waste Management (KDWM) was held May 23, 2018, to discuss the method used to collect duplicate samples from monitoring wells at the C-404 Landfill. In the teleconference, KDWM agreed that the collocated duplicate collection method was appropriate for precision monitoring at the C-404 Landfill.

CURRENT COLLECTION METHOD-

In order to comply with the current Permit requirement, two field duplicates have been collected since the November 2018 semiannual reporting period. A groundwater sample is collected from a monitoring well, along with a field duplicate sample prescribed by the Permit. Additionally, a separate groundwater sample is collected from the same monitoring well, along with a duplicate sample using the collocated duplicate collection method prescribed by the in-house procedure. All data are being reported in the semiannual groundwater reports.

DATA ANALYSIS

Table E.1 provides a comparison of the analytical data for the samples collected to date. A *duplicate (Permit)* sample is a duplicate collected in accordance with the Permit and a *duplicate (procedure)* sample is a duplicate collected in accordance with the in-house procedure. The qualifiers provided in Table E.1 include laboratory qualifiers and any validation qualifier that is not the same as the laboratory qualifier.

Table E.1. Field Duplicate Data Comparison

August 2018		MW85		MW85 Duplicate (Permit)		MW85-2		MW85-2 Duplicate (Procedure)	
Analysis	**Units**	**Result/ Qualifiers**		**Result/ Qualifiers**		**Result/ Qualifiers**		**Result/ Qualifiers**	
Arsenic	mg/L	0.00992		0.0101		0.0104		0.0106	
Arsenic, Dissolved	mg/L	0.005	U	0.005	U	0.005	U	0.00206	J
Cadmium	mg/L	0.001	U	0.001	U	0.001	U	0.001	U
Cadmium, Dissolved	mg/L	0.001	U	0.001	U	0.001	U	0.001	U
Chromium	mg/L	0.00963	J	0.0105		0.0049	J	0.00611	J
Chromium, Dissolved	mg/L	0.00337	J	0.01	U	0.01	U	0.01	U
Iron	mg/L	1.02	N,J	1.08	N,J	0.321	N,J	0.397	N,J
Lead	mg/L	0.000917	J	0.000924	J	0.002	U	0.000554	J
Lead, Dissolved	mg/L	0.002	U	0.002	U	0.002	U	0.002	U
Manganese	mg/L	0.00845	N,J	0.00921	N,J	0.00336	N,J	0.00362	JN,J
Mercury	mg/L	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Mercury, Dissolved	mg/L	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Selenium	mg/L	0.005	U	0.005	U	0.005	U	0.005	U
Selenium, Dissolved	mg/L	0.005	U	0.005	U	0.005	U	0.005	U
Technetium-99	pCi/L	52.6		64		50.5		64.3	
Total Organic Carbon (TOC)	mg/L	0.919	J	0.909	J	0.941	J	0.915	J
Trichloroethene	µg/L	1.24		0.41	J	1	U	1	U
Uranium	mg/L	0.000367		0.000372		0.000299		0.000301	
Uranium, Dissolved	mg/L	0.000276		0.000251		0.000241		0.000224	
Uranium-234	pCi/L	0.0486	U	-0.39	U	0.315	U	0.545	U
Uranium-235	pCi/L	0.201	U	-0.0572	U	0.0548	U	0	U
Uranium-238	pCi/L	0.0913	U	-0.185	U	0.12	U	0.233	U

Table E.1 Field Duplicate Data Comparison (Continued)

January 2019		MW84		MW84 Duplicate (Permit)		MW84-2		MW84-2 Duplicate (Procedure)	
Analysis	**Units**	**Result/ Qualifiers**		**Result/ Qualifiers**		**Result/ Qualifiers**		**Result/ Qualifiers**	
Arsenic	mg/L	0.0243		0.0246		0.0275		0.0247	
Arsenic, Dissolved	mg/L	0.00234	J	0.00239	J	0.0024	J	0.00233	J
Cadmium	mg/L	0.000415	J	0.000325	J	0.001	U	0.001	U
Cadmium, Dissolved	mg/L	0.001	U	0.001	U	0.001	U	0.001	U
Chromium	mg/L	0.0251		0.0225		0.0216		0.0209	
Chromium, Dissolved	mg/L	0.01	U	0.01	U	0.01	U	0.01	U
Iron	mg/L	5.55		5.03		4.62		4.26	
Lead	mg/L	0.00204		0.00187	J	0.00169	J	0.00163	J
Lead, Dissolved	mg/L	0.002	U	0.002	U	0.002	U	0.002	U
Manganese	mg/L	0.726	J	0.541	J	0.483		0.457	
Mercury	mg/L	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Mercury, Dissolved	mg/L	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Selenium	mg/L	0.005	U	0.005	U	0.005	U	0.005	U
Selenium, Dissolved	mg/L	0.005	U	0.005	U	0.005	U	0.005	U
Sulfate	mg/L	6.33		6.31		6.3		6.33	
Technetium-99	pCi/L	25.6		28.8		27.8		23.1	
Total Organic Carbon (TOC)	mg/L	0.814	J	0.914	J	0.957	J	0.955	J
Trichloroethene	µg/L	4670		5060		5580		5570	
Uranium	mg/L	0.000186	J	0.000172	J	0.000193	J	0.00016	J
Uranium, Dissolved	mg/L	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Uranium-234	pCi/L	0.305	U	0.944	U	-0.147	U	0.609	U
Uranium-235	pCi/L	0.172	U	-0.201	U	1.25	U	0.517	U
Uranium-238	pCi/L	0.6	U	0.724	U	1.24	U	0.0908	U

July 2019		MW85		MW85 Duplicate (Permit)		MW85-2		MW85-2 Duplicate (Procedure)	
Analysis	**Units**	**Result/ Qualifiers**		**Result/ Qualifiers**		**Result/ Qualifiers**		**Result/ Qualifiers**	
Arsenic	mg/L	0.00954		0.00929		0.00879		0.00912	
Arsenic, Dissolved	mg/L	0.00255	BJ, U	0.00313	BJ,U	0.005	U	0.00263	BJ, U
Cadmium	mg/L	0.001	U	0.001	U	0.001	U	0.001	U
Cadmium, Dissolved	mg/L	0.001	U	0.001	U	0.001	U	0.001	U
Chromium	mg/L	0.00338	J	0.00326	J	0.00441	J	0.00416	J
Chromium, Dissolved	mg/L	0.00318	J	0.00331	J	0.0042	J	0.00408	J
Iron	mg/L	0.148		0.14		0.183		0.144	
Lead	mg/L	0.002	U	0.002	U	0.002	U	0.002	U
Lead, Dissolved	mg/L	0.00084	J, U	0.00092	J, U	0.00077	J, U	0.0009	J, U
Manganese	mg/L	0.00186	JE, U	0.0018	JE, U	0.00268	JE, U	0.00259	JE, U
Mercury	mg/L	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Mercury, Dissolved	mg/L	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Selenium	mg/L	0.005	U	0.005	U	0.005	U	0.005	U
Selenium, Dissolved	mg/L	0.005	U	0.005	U	0.005	U	0.005	U
Sulfate	mg/L	9.5		9.53		9.29		9.26	
Technetium-99	pCi/L	57.4		55.1		53.6		54	
Total Organic Carbon (TOC)	mg/L	1.2		1.2		1.19		1.7	
Trichloroethene	µg/L	1.06	Y1	0.85	JY1	2.21	Y1	2.55	Y1

Table E.1 Field Duplicate Data Comparison (Continued)

July 2019		MW84	MW84 Duplicate (Permit)	MW84-2	MW84-2 Duplicate (Procedure)
Analysis	**Units**	**Result/ Qualifiers**	**Result/ Qualifiers**	**Result/ Qualifiers**	**Result/ Qualifiers**
Uranium	mg/L	0.00026	0.00025	0.00027	0.00027
Uranium, Dissolved	mg/L	0.00025 J	0.00024 J	0.00026 J	0.00026 J
Uranium-234	pCi/L	0.382 U	2.12	-0.0342 U	2.35
Uranium-235	pCi/L	0.339 U	1.26 U	0.152 U	0.201 U
Uranium-238	pCi/L	0.411 U	0.363 U	0.718 U	1.19 U

B = analyte found in the associated blank
E = results estimated due to matrix interferences
J = estimated quantity
N = sample spike (MS/MSD) recovery not within control limits
U = analyte analyzed for but not detected at or below the lowest concentration reported
Y1 = MS/MSD recovery outside acceptance criteria

CONCLUSION

For all analyses except TCE, the two sampling methods give very similar results. For TCE, the collocated samples are more consistent than the field split samples, which show loss of TCE in the sample when the sample is split.

This process of collecting two field duplicates will be incorporated into future sampling events until such time that the field duplicate collection method can be changed through a Permit modification. Data in the Oak Ridge Environmental Information System will be flagged to distinguish between the two types of field duplicates. A field duplicate collected as described in the Permit will be identified as REP in the SMP_TYPE field. A field duplicate collected as described in the in-house procedure will be identified as FR in the SMP_TYPE field. These flags also will be reflected in Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System under Sample Type.

Collection of field duplicates for all other environmental monitoring, environmental remediation, waste management, and characterization sampling events at the Paducah Site will be according to the in-house procedure, unless otherwise noted in project specific sampling plans and/or quality assurance project plans.

APPENDIX F

SUMMARY OF SURVEY ACTIVITIES ASSOCIATED WITH UPDATING THE REFERENCE MEASURING POINT ELEVATIONS FOR THE GROUNDWATER MONITORING WELL NETWORK AT THE PADUCAH SITE, PADUCAH, KENTUCKY

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FRNP-RPT-0165

Summary of Survey Activities Associated with Updating the Reference Measuring Point Elevations for the Groundwater Monitoring Well Network at the Paducah Site, Paducah, Kentucky

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

This document is approved for public release per review by:

JACK C THOMPSON — 01-06-2021

FRNP Classification Support — Date

Summary of Survey Activities Associated with Updating the Reference Measuring Point Elevations for the Groundwater Monitoring Well Network at the Paducah Site, Paducah, Kentucky

Date Issued—January 2021

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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FIGURES

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ACRONYMS

amsl	above mean sea level
BM	benchmark
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DL	differential leveling
DOE	U.S. Department of Energy
DQO	data quality objective
GPS	Global Positioning System
LA	limited area
LL	level loop
MW	monitoring well
OREIS	Oak Ridge Environmental Information System
PDOP	position dilution of precision
PEGASIS	Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System
PEMS	Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
SMO	Sample Management Office
TBM	temporary bench mark
TIC	top of inner casing
TOC	top of casing
WWP	well wizard plate
WWR	well wizard rim

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1. INTRODUCTION

This white paper documents the activities associated with updating the reference measuring point elevations for the groundwater monitoring well (MW) network located at the U.S. Department of Energy (DOE) Paducah Site. References in this report to the Paducah Site generally mean the property, programs, and facilities at or near Paducah Gaseous Diffusion Plant (PGDP). This update resulted from the discovery of discrepancies between temporal potentiometric maps developed for the Paducah Site. This survey update is one element of the Monitoring Well Survey Study (Activity 17) being conducted under the Groundwater Strategy Project discussed during the April 10, 2019, Groundwater Modeling Working Group meeting (DOE 2020) and provides the basis for subsequent elements of the Monitoring Well Survey Study, including well installation and replacement, well inspection and maintenance, water level monitoring, data management, and data use. The following are the data quality objectives (DQOs) for the Monitoring Well Survey Study (Activity 17) (Table 1).

Table 1. DQOs for the Monitoring Well Survey Study

1. State the Problem	In 2018, an issue with selection of MW measurement point(s) was identified as part of C-404 Landfill permit required reporting. Additionally, a review of 2017 MW survey data performed during the Northeast (NE) Plume Optimization Project and compared to previous MW survey data indicated a need for additional review of MW elevation data.	
2. Identify the Decision	Is the current survey information for the MWs of appropriate tolerance for decision making and required reporting, and are measurement points understood?	
3. Identify Inputs to the Decision	• Current and historical MW survey data in the Oak Ridge Environmental Information System (OREIS) and working databases or files maintained by staff • History of repairs made to MWs that would affect survey data • Scopes, activities, and reports that are sensitive to the measurement and are being used for decision making or to demonstrate compliance • Procedures for collecting and managing MW survey data • Groundwater plume maps	
4. Define the Study Boundaries	• Spatial: Paducah Site • Temporal: less than one year	• Regulatory: environmental permits, CERCLA projects, Groundwater Modeling Working Group
5. Develop a Decision Rule	**IF** survey tolerances for MWs are not acceptable for the decisions and reporting, **THEN** define actions to resolve the tolerances and audit the use of the survey data.	
6. Specify Limits on Decision Errors	• Groundwater flow direction • Groundwater recharge • Groundwater plume maps	
7. Optimize the Design for Obtaining Data	• Review available MW survey data and techniques used to obtain the data. • Identify scopes, activities, and reports that are sensitive to the measurement and are being used for decision making or to demonstrate compliance. • Identify significant differences, attempt to understand root cause of differences, and evaluate impact of difference. • Understand structure and data available in OREIS. • Review tools/files used to qualify the usefulness of the survey data.	

The survey effort documented in this white paper addresses the procedures for collecting and managing MW survey data, a component of the DQO decision inputs, and provides the foundation for subsequent elements required to complete the DQO process. A separate white paper will discuss the results of the survey effort and any impacts to the use and management of water elevation information.

1.1 BACKGROUND

In 2018, differences between temporal potentiometric maps for the C-404 Landfill were discovered, and an issue with selection of MW measurement point(s) was identified. Additionally, a review of 2017 MW survey data performed during the NE Plume Optimization Project and compared to previous MW survey data indicated a need for additional review of elevation data. An initial review of water level measurement reference point elevations indicated multiple survey methods and inconsistent water level data collection procedures employed at the Paducah Site potentially contributed to inaccuracies in calculated groundwater elevations. For example, recommended Global Positioning Systems (GPS) instrument hold times may not have been adhered to consistently, potentially compromising the quality of survey data collected. Additionally, reference measuring point locations used to measure water level depths in the field were not always consistent between gaging events, potentially introducing inaccuracies in the calculated groundwater elevations. These factors have contributed to uncertainty regarding groundwater level elevation analyses that relied on these data.

In 2013, all Paducah Site MWs were resurveyed in an attempt to standardize well elevation data. A standard procedure for conducting these surveys was not established, however, leading to inaccuracies and inconsistencies in the data collected. Starting in 2016, MWs were resurveyed using improved GPS survey methods; and in 2019, a comprehensive sitewide survey plan was developed that included use of the differential leveling (DL) method for MWs within and adjacent to the Limited Area (LA).

2. DATA COLLECTION

Two technologies, GPS and DL, are used to collect MW survey data at the Paducah Site. The following sections provide details about each survey technology and the methods used at the site during MW survey data collection efforts from 2013 to present.

2.1 SURVEY METHODOLOGIES

GPS measurements at the Paducah Site are collected using the Trimble 8s, a global navigation satellite system that can produce measurement results with precisions of about +/- 0.02 ft to +/-0.04 ft in the horizontal plane (coordinates) and +/- 0.04 ft to +/- 0.06 ft in the vertical plane (Trimble, Inc. 2020). The small error in the precision is related to the number of satellites acquired, the random orbit of the satellite positions, and the elliptical shape of the earth. To achieve the greatest accuracy from satellite signals, a minimum setup time of 3 minutes is recommended to help process the accumulated data from the satellites. Based on field observations, shorter initial setup times can result in precision inaccuracies in the vertical plane ranging from +/- 0.10 ft to +/-0.20 ft, due to insufficient processing time. Other factors affecting precision are the number of satellites and the relative spread of the satellites referred to as position dilution of precision (PDOP). These factors are integrated into the GPS system, and measurements will be reported by the instrument only when these factors are within an acceptable range. Based on field experience, higher precision is observed when the number of satellites is between 10 and 12, but measurements are reported with as low as 8. The PDOP observed in the field was between approximately 2 and 5. In general, better precision is obtained with lower PDOP values, and no measurements are reported by the instrument when the PDOP is above 5. Based on field observations, the PDOP typically is lower before 10 a.m. and after 2 p.m.; when possible, GPS surveys are conducted in the early or late part of the day. For the GPS surveys at the site, the actual precision recorded in the vertical plane was +/- 0.012 ft to +/- 0.085 ft.

Two methods using the GPS technology have been used at the Paducah Site. One method (referred to herein as GPS Method 1) obtained a GPS measurement for each reference point (e.g., ground surface, inner casing, outer casing) by using multiple GPS set ups. This method, illustrated in Figure 1, Detail 1, introduces potential error associated with multiple physical set ups and GPS readings. A second GPS method (GPS Method 2) used at the Paducah Site is depicted in Figure 1, Detail 2; and it relies on a single GPS elevation measurement of a brass monument installed in the well pad called a benchmark (BM). The remaining MW reference points were determined by measuring the vertical distance from the BM to the reference point.

The DL technology [also referred to as the level loop (LL) method] uses an engineering level and level rod(s) to measure the vertical distances from a known elevation point, referred to as a BM, to determine elevations of unknown points. The DL technique is demonstrated in Figure 1, Detail 3. The process is conducted over an LL to ensure the measurement precision is within acceptable closure criteria. Based on LL closures for survey data collected at the Paducah Site, the precision of the DL method is +/- 0.02 ft in the vertical plane. The DL surveys conducted at the site relied on a single BM, ACCU-AIR No. 21, located along the LA eastern boundary (Figure 2). The elevations of the ACCU-AIR monuments were measured by a Commonwealth of Kentucky licensed surveyor in 2010 using a static GPS system, a GPS method using extended hold times that provides higher accuracy than handheld GPS devices.

2.2 SURVEY SUMMARY—2013 to 2016

The sitewide GPS surveys began in 2013 and continued through 2014. These surveys included all MWs located on DOE property and West Kentucky Wildlife Management Area. Wells located on privately owned lands were not resurveyed. The wells surveyed are listed in Appendix A. Review of field reports indicated that many of these wells were surveyed using GPS Method 1 (described above), with a setup time of seconds instead of minutes.

In 2016, several changes to the MW survey methods were made to improve the reliability of the data.

- A standardized point was established on each well for measuring water levels to resolve inconsistencies between water level reference point locations. A mark was cut into the tops of both inner and outer casings to establish this point. This mark serves as a reference point for samplers to use while recording their measurements. All wells in the current monitoring network at that time were marked.[1]

- The GPS setup time was standardized to a minimum of 3 minutes or more to minimize measurement inaccuracies.

- For each well, the brass monument located in the well pad, or the top of the outer casing if a brass monument was missing, was established as a single reference point of elevation or BM, and GPS Method 2 was used exclusively.

- The distances from the BM to the top of the outer casing, from the outer casing to the inner casing, well wizard rim, and well wizard plate were measured using a tape and level.

[1] This procedure has been applied to all MWs installed subsequently.

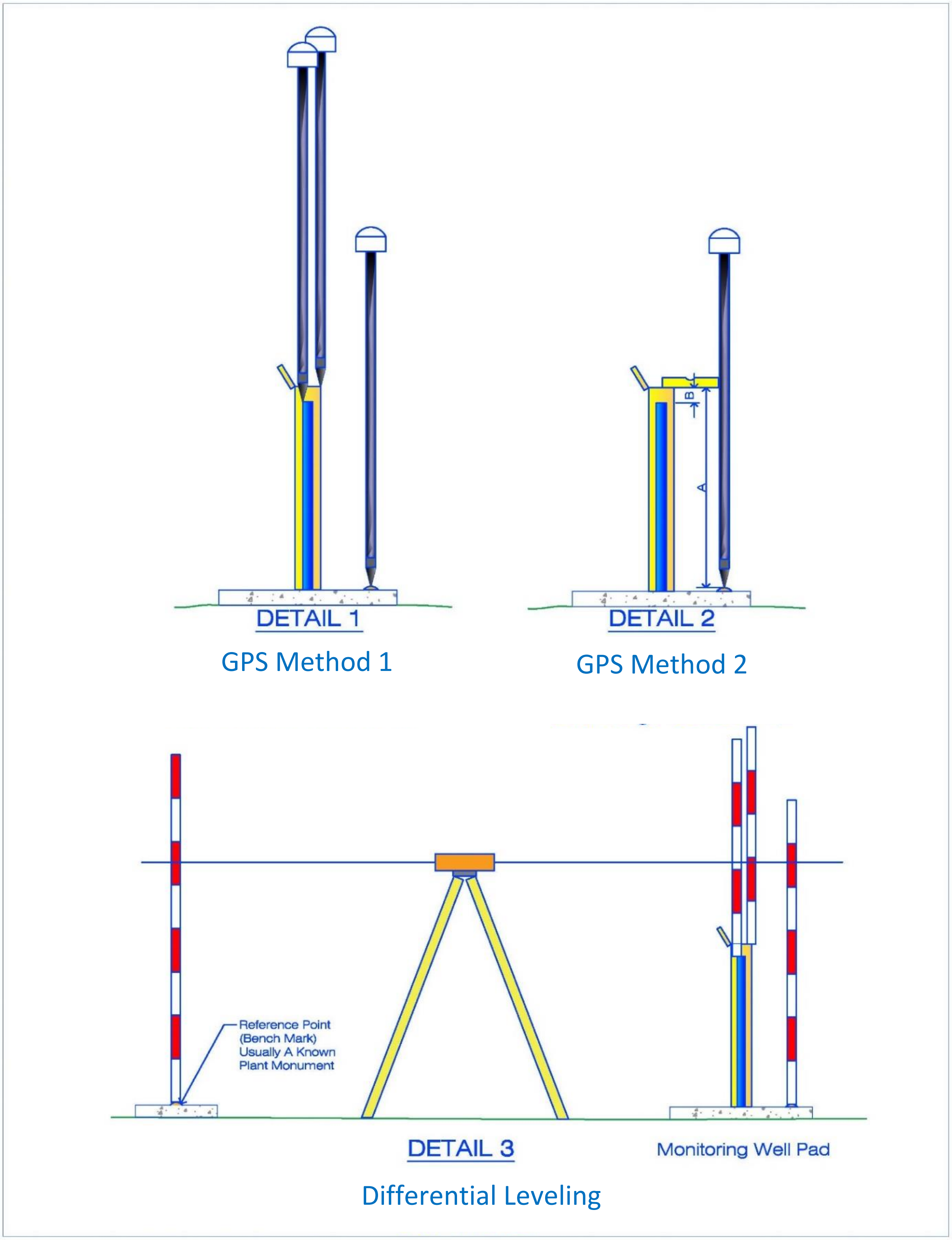

Figure 1. Schematics of Surveying Methods

Legend

- Differential Leveling Elevation Reference Point
- Bench Mark established from ACCU-AIR No. 21
- Limited Area Boundary

20°
True North
Plant North

Notes:
1. The ACCU-AIR No. 21 elevation was measured by a Commonwealth of Kentucky licensed surveyor in 2010 using a static GPS system.
2. Monitoring well bench marks are tied to the ACCU-AIR No. 21 bench mark to provide conveniently located points of reference for future surveys.
3. The monitoring well bench mark is the brass monument located in the monitoring well concrete pad.

1,000 500 0 1,000 Feet

Location of ACCU-AIR No. 21 and Other Bench Mark Locations

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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

December 2020

Figure 2

MAP SOURCE INFORMATION:

LAYER: limited_area_proposed_C100_mod; SOURCE: G:\GIS\SHAPES\BOUNDS\limited_area_proposed_C100_mod.shp.
AERIAL IMAGE LOCATION: ArcGIS World Imagery Map Service (World View-3 Image collected on 11/08/2019 by Maxar).

Document Path: Q:\GISProjects\KX6467A_Paducah\MXDs\Acton_2020\Location of ACCUAIR 21.mxd

Figure 2. Location of ACCU-AIR No. 21 and Other Bench Mark Locations

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The wells that were resurveyed in 2016 using this revised method are indicated in Appendix A.

2.3 SURVEY UPDATE—2019 to 2020

Since the 2016 GPS surveys were completed, a separate source of uncertainty in the data was identified for the NE Plume Optimization Project MWs, and it was attributed to ghosting effects caused by GPS signal interferences from nearby structures. It also was recognized that, due to smaller changes in the potentiometric surface in this area of more closely spaced MWs, a finer precision and accuracy was necessary to interpret better the groundwater gradients between wells. To address ghosting effects and increase the level of precision, the DL technique was recommended for the NE Plume Project MWs in the LA. To help reduce inconsistencies even further, a single BM, an existing plant monument, ACCU-AIR No. 21, was established so that all survey data would be tied in relationship to a single reference point. Use of a single BM addresses inconsistency in the vertical plane caused by using multiple reference datums.

In 2017, the NE Plume Project MWs were surveyed using the DL method using the ACCU-AIR No. 21 as the single BM. This method was used again in 2019 to survey the remaining MWs inside and adjacent to the LA and wells located at the C-746-S&T and C-746-U Landfills. The MWs resurveyed using the DL method are listed in Appendix A.

In addition, several point of reference elevations were established on the well pad brass monuments of select MWs throughout the LA and landfill areas. These monuments will provide conveniently located points of reference for future surveys that are tied to the master BM (ACCU-AIR No. 21). A list of these monuments is included in Table 2 and their locations are shown on Figure 2.

Table 2. Established Benchmarks Using ACCU-AIR No. 21

Line Item	Well Name	Elevation (ft amsl)	Location Datum
1	MW63	369.954	BM
2	MW91A	372.924	BM
3	MW100	370.370	BM
4	MW171	372.779	BM
5	MW172	370.884	BM
6	MW174	371.569	BM
7	MW186	371.849	BM
8	MW187	370.209	BM
9	MW190	371.114	BM
10	MW211	375.004	BM
11	MW214	375.659	BM
12	MW217	374.989	BM
13	MW219	377.294	BM
14	MW223	390.903	BM
15	MW225	382.703	BM
16	MW243	368.774	BM
17	MW245	369.614	BM

Table 2. Established Benchmarks Using ACCU-AIR No. 21 (Continued)

Line Item	Well Name	Elevation (ft amsl)	Location Datum
18	MW247	367.674	BM
19	MW329	373.239	BM
20	MW340	371.999	BM
21	MW343	375.039	BM
22	MW353	372.389	BM
23	MW359	366.428	BM
24	MW362	359.378	BM
25	MW365	365.783	BM
26	MW368	366.903	BM
27	MW371	362.393	BM
28	MW374	357.403	BM
29	MW375	368.563	BM
30	MW376	368.103	BM
31	MW377	363.483	BM
32	MW386	363.003	BM
33	MW393	364.098	BM
34	MW428	371.179	BM
35	MW431	371.284	BM
36	MW464	366.210	BM
37	MW478	381.634	BM
38	MW500	370.389	BM
39	MW525	381.229	BM
40	MW526	381.529	BM
41	MW538	382.129	BM
42	MW543	374.919	BM
43	MW548	374.764	BM
44	MW549	375.499	BM
45	MW534 (PZ)	381.609	BM

In early 2020, a third-party review of the current survey data was conducted. The findings of the review identified two deficiencies in the current survey data. One deficiency affected 18 MWs surveyed with the DL method, and it was based on issues with the BMs used. The other deficiency affected 68 MWs surveyed using GPS Method 1, and it was based on unacceptable accuracy of the hand measurement method used to measure the distance from the BM to the top of the outer casing and inner casing reference point [top of casing (TOC); top of inner casing (TIC), well wizard rim (WWR), well wizard plate (WWP)]. In August 2020, a new round of surveys was initiated to address these issues. The 18 wells were resurveyed using the DL method to address the BM issues. For the 68 wells measured with the GPS method, the distance from the BM to the top of the outer casing and inner casing reference points (TIC, WWR, WWP) were measured using a surveyor rod. These wells are listed in Appendix A. Four other wells were included in the 2020 resurvey (MW98, MW155, MW156, and MW294A).

3. DATA MANAGEMENT

MW survey data is maintained in OREIS, a centralized environmental data management system that fulfills the environmental information management obligations of DOE for PGDP under an enforceable Federal Facility Agreement. The objectives of OREIS are to maintain data that are complete, consistent, and fully qualified as to their usability and to provide ease of accessibility of environmental data that support environmental planning, analysis, and decision making. Access to the database is limited to approved users; however, the data is uploaded periodically to the publicly available database, Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System (PEGASIS).

The following survey data are stored in the OREIS system for each MW location.

- Coordinates
- Reference point elevations
- Reference point measurement method
- Reference point datum

These data currently are entered manually and checked for quality control in the Project Environmental Measurements System (PEMS) database before upload to OREIS. Water level data uploads from PEMS to OREIS (and from OREIS to PEGASIS) occur quarterly. Other updates to OREIS can be made at any time. A list of the well location data fields and descriptions and a list of data codes and descriptions are included in Appendix B (OREIS Location Table). Site coordinates are stored using several coordinate systems including these.

- Data received (RCVD_X, RCVD_Y, currently in the plant coordinates)
- Administration (ADMIN_EAST, ADMIN_WEST, currently equivalent to RCVD)
- Longitude and Latitude
- Kentucky State Plane (SPLANE_EAST, SPLANE_WEST, stored as meters)

Coordinates received for entry to the database (RCVD_X, RCVD_Y) typically are reported by the surveyors in plant coordinates, and a conversion system is used to calculate the values in the other coordinate systems. Elevation data reported to the Sample Management Office (SMO) are stored in OREIS such that records reflect the most recent survey data. Some changes to survey data were tracked in a change log that documented the previous values and date of change. Currently, no systems are in place to ensure that new survey data is reported to the SMO. Consequently, changes recorded in the log are limited to those that are reported to the SMO and do not reflect a comprehensive record of all changes documented in historical survey reports.

4. CONCLUSIONS AND RECOMMENDATIONS

Recent discovery of discrepancies between temporal potentiometric maps developed for the Paducah Site resulted in a review of existing survey data and methods. Based on the findings of the review, a revised survey method was developed for implementing MW surveys across the Paducah Site. The revised survey method included standardization of GPS survey methods and use of the more precise DL method for areas with more closely spaced MWs (i.e., the LA and the landfill areas). In addition, a unique water level measurement reference point location was marked on each MW. An effort to survey all Paducah Site MWs with the updated survey method was initiated in 2019 and was completed in November 2020. These data provide a reliable data set with acceptable survey tolerances to meet the Monitoring Well Survey Study (Activity 17) DQOs. These data will be stored in OREIS and will serve as the basis for future water level elevation calculations and for evaluating historical water level elevation data. A datasheet with the updated elevation data is included in Appendix C.

To ensure the integrity of future survey data, it is recommended that a MW survey control procedure be developed to document the current survey methodology and for collecting and reporting survey data to the SMO.

The survey control procedure should include the following information.

- Detailed procedures for GPS data collection
- Detailed Procedures for DL data collection
- Standardized documentation of data collection and measurements
- Identification of wells or areas where GPS or DL methods apply
- Procedure for quality control review of data collection and measurements
- Procedure for reporting data to SMO

The following include recommendations for data management of the survey data.

- Adding new fields to OREIS to store the survey date and the data source;
- Establishing a procedure to retain historical survey data (starting with the current sitewide survey); and
- Developing a procedure to generate a standard format report for site practitioners to facilitate water level elevation calculations for all site activities.

Using the data from the surveys conducted through November 2020, a comprehensive elevation data set for all Environmental Monitoring Plan MWs will be compiled and the review of the other elements specified in the Groundwater Strategy Project Plan Monitoring Well Survey Study (Activity 17) will be completed and documented in a comprehensive white paper. These elements include well inspection, water-level monitoring, data management, and data use. Recommendations will include specific revisions to existing control procedures for well installation, well maintenance, and data collection; and development of a survey control procedure to ensure accuracy and consistency of water level elevation calculations for historical and future groundwater studies.

5. REFERENCES

DOE (U.S. Department of Energy) 2020. *Compilation of Meeting Summaries and White Papers (2019-July 2020), A Product of the Paducah Gaseous Diffusion Plant Site Groundwater Modeling Working Group*, DOE/LX/07-2451&D1, U.S. Department of Energy, Paducah, KY, December.

Trimble, Inc. 2020. Trimble R8s GNSS System Datasheet, accessed from https://geospatial.trimble.com/sites/geospatial.trimble.com/files/2020-10/Datasheet%20-%20Trimble%20R8s%20GNSS%20-%20English%20US%20-%20Screen.pdf, October 26, 2020.

APPENDIX A

SUMMARY OF SURVEY ACTIVITIES FROM 2013 TO 2020

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Table A.1. Summary of Survey Activities from 2013 to 2020

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
PZ5G			X		
PZ5S			X		
MW20[a]					
MW63		X	X		
MW64		X	X		
MW65		X	X		
MW66			X		
MW67			X		
MW68			X		
MW69			X		
MW71			X		
MW72	X	X	X		
MW73		X	X		
PZ74		X	X		
MW75		X	X		
MW76 (PZ)	X	X	X		
MW77 (PZ)	X	X	X		
MW78			X		
MW79	X		X		
MW80			X		
MW81			X		
MW82			X		
MW83			X		
MW84[b]	X	X	X		
MW84A			X		
MW85	X	X	X		
MW86	X	X	X		
MW87[b]	X		X		
MW87A			X		
MW88	X		X		X
MW89	X		X		
MW90A	X	X	X		
MW91[b]	X				
MW91A		X	X		
MW92	X	X	X		
MW93[b]	X		X		
MW93A			X		
MW94	X		X		
MW95A	X		X		
MW96	X		X		
MW98	X	X	X		
MW99		X		X	

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW100	X		X		
PZ101	X				
MW102[a]					
MW103[a]					
MW106[b]	X				
MW106A	X		X		
PZ107		X		X	
MW108	X	X	X		
PZ109	X		X		
PZ110	X		X		
PZ111	X		X		
PZ112[b]	X				
PZ113[b]	X				
PZ114	X		X		
PZ115	X		X		
PZ117			X		
PZ118	X		X		
MW120	X				
MW121	X				
MW122	X				
MW123[a]					
MW124	X				
MW125	X				
MW126	X				
MW127[b]	X				
MW132	X				
MW133	X				
MW134	X				
MW135	X				
MW137	X				
MW138	X				
MW139	X				
MW144	X				
MW145	X		X		
MW146	X				
MW147	X				
MW148		X		X	
MW149		X		X	
MW150		X		X	
MW151		X		X	
MW152[b]		X			
MW153[b]		X			

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW154	X	X	X		
MW155	X		X		
MW156	X		X		
MW157	X		X		X
MW161	X	X	X		
MW162	X		X		
MW163	X		X		
MW164	X		X		
MW165[b]	X				
MW165A	X		X		
MW166	X		X		
MW167	X		X		
MW168	X		X		
MW169	X		X		
MW170	X		X		
MW171	X		X		
MW172	X		X		
MW173	X	X	X		
MW174	X	X	X		
MW175	X	X	X		
MW176	X		X		
MW177		X	X		
MW178		X	X		
MW180	X				
MW182	X				
MW185	X		X		
MW186	X		X		
MW187	X		X		
MW188	X		X		
MW189	X		X		
MW190	X		X		
MW191	X				
MW192	X				
MW193	X				
MW194	X				
MW196	X				
MW197	X				
MW198	X				
MW199		X		X	
MW200	X				
MW201	X				
MW202	X				
MW203	X		X		

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW204	X		X		
MW205	X		X		
MW206[b]	X				
MW207	X		X		
MW209[b]	X				
MW210		X	X		
MW211	X		X		
MW212	X		X		
MW213	X		X		
MW214	X		X		
MW215	X		X		X
MW216	X		X		
MW217	X		X		
MW218	X		X		
MW219	X		X		
MW220	X		X		
MW221	X		X		
MW222	X	X	X		
MW223	X		X		
MW224	X	X	X		
MW225	X		X		
MW226	X		X		
MW227	X		X		
MW233	X				
MW236			X		
MW237	X		X		
MW238			X		
MW239	X		X		
MW240			X		
MW241A			X		
MW242			X		
MW243	X		X		
MW244	X		X		
MW245	X	X	X		
MW246		X	X		
MW247		X	X		
MW248	X	X			
MW249		X	X		
MW250	X	X	X		
PZ251	X		X		
MW252		X		X	
MW253[b]		X			

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW253A		X		X	
MW255	X	X	X		
MW256	X	X	X		
MW257	X		X		
MW258	X	X	X		
MW260	X	X	X		
MW261	X		X		
MW262	X		X		
MW283	X				
MW284	X				
PZ287	X				
MW288	X				
PZ289	X				
PZ290	X				
MW291	X				
MW292	X				
MW293A	X				
MW294A	X				
MW300	X	X		X	
MW301[b]	X				
MW302	X	X		X	
MW304	X				X
MW305[b]	X	X		X	
MW306[b]	X				
MW307[b]	X	X		X	
MW308[b]	X	X		X	
MW309[b]	X				
MW310[b]	X				
MW311[b]	X				
MW312[b]	X				
MW313	X	X		X	
MW314[b]	X				
MW315	X	X	X		X
MW316	X	X			X
MW317	X				
MW325	X		X		X
MW326	X		X		X
MW327	X	X	X		X
MW328	X		X		
MW329	X		X		
MW330	X	X	X		X
MW333	X		X		

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
PZ334[c]	X	X	X		
PZ335	X	X	X		
PZ336	X	X	X		
MW337	X	X	X		
MW338	X	X	X		
MW339		X	X		
MW340	X		X		
MW341	X		X		
MW342	X		X		
MW343	X	X	X		
MW344	X		X		
MW345	X		X		
MW346	X				
MW347	X				
PZ348	X				
PZ349	X				
PZ350	X		X		
PZ351	X		X		
MW353	X		X		
MW354	X		X		
MW355	X		X		
MW356	X		X		
MW357	X		X		
MW358	X		X		
MW359	X		X		
MW360	X		X		
MW361	X		X		
MW362	X		X		
MW363	X	X	X		
MW364	X	X	X		
MW365	X		X		
MW366	X		X		
MW367	X		X		
MW368	X		X		
MW369	X		X		
MW370	X		X		
MW371	X		X		
MW372	X		X		
MW373	X		X		
MW374	X		X		
MW375	X		X		
MW376	X		X		
MW377	X		X		

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW380			X		
MW381[a]					
MW384	X		X		
MW385	X		X		
MW386	X		X		
MW387	X		X		
MW388	X		X		
MW389	X		X		
MW390	X		X		
MW391	X		X		
MW392	X		X		
MW393	X		X		
MW394	X		X		X
MW395	X		X		X
MW396	X		X		X
MW397	X		X		
MW401	X				
MW402	X				
MW403	X				
MW404	X				
MW405		X	X		
MW406		X	X		
MW407		X	X		
MW408		X	X		
MW409		X		X	
MW410		X		X	
MW411		X		X	
MW414	X		X		
MW415	X		X		
MW416	X		X		
MW417	X		X		
MW418	X		X		
MW419	X		X		
MW420	X	X	X		
MW421	X	X	X		
MW422	X	X	X		
MW423	X	X	X		
MW424	X	X	X		
MW425	X	X	X		
MW426	X	X		X	
MW427	X	X		X	
MW428	X	X	X		
MW429[b]	X				

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW429A		X	X		
MW430	X	X	X		
MW431	X	X	X		
MW432	X	X	X		
MW433	X	X		X	
MW435	X	X		X	
MW439	X	X		X	
MW440	X	X		X	
MW441	X	X		X	
MW442	X	X		X	
MW443	X	X		X	
MW444	X	X		X	
MW445	X	X		X	
MW447	X	X		X	
MW448	X	X		X	
MW450	X	X		X	
MW451	X	X		X	
MW452	X	X		X	
MW453	X	X		X	
MW454	X	X		X	
MW455	X	X		X	
MW456	X	X		X	
MW457	X	X		X	
MW458	X	X		X	
MW459	X	X		X	
MW460	X	X		X	
MW461	X	X		X	
MW462	X	X		X	
MW463	X		X		
MW464	X		X		
MW465	X		X		
MW466	X		X		
MW467		X	X		
MW468		X	X		
MW469		X	X		
MW470		X	X		
MW471		X	X		
MW472		X	X		
MW473		X		X	
MW474		X		X	
MW475		X		X	
MW476	X	X		X	
MW477		X		X	

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW478	X				
MW479	X	X		X	
MW480	X		X		
MW481	X	X		X	
MW482	X	X		X	
MW483		X		X	
MW484		X		X	
MW485		X		X	
MW486[b]		X		X	
MW486A		X		X	
MW487		X		X	
MW488		X		X	
MW489	X	X		X	
MW490	X	X		X	
MW491	X	X		X	
MW492	X	X		X	
MW493	X	X		X	
MW494	X	X		X	
MW495	X		X		
MW496	X		X		
MW497	X	X	X		
MW498	X	X	X		
MW499	X	X	X		
MW500	X	X	X		
MW501	X	X		X	
MW502	X	X		X	
MW503	X	X	X		
MW504	X	X	X		
MW505		X			X
MW506		X			X
MW507		X			X
MW508[b]	X				
MW509[b]	X				
MW510[b]	X				
MW511[b]	X	X	X		
MW512[b]	X	X	X		
MW513[b]	X	X	X		
MW514	X	X	X		
MW515	X	X	X		
MW516	X	X	X		
MW517 (PZ)			X		
MW518 (PZ)			X		

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
MW519 (PZ)			X		
MW520 (PZ)			X		
MW521 (PZ)			X		
MW522 (PZ)			X		
MW523 (PZ)			X		
MW524		X	X		
MW525		X	X		
MW526		X	X		
MW527		X	X		
MW528		X	X		
MW529		X	X		
MW530		X	X		X
MW531			X		
MW532 (PZ)			X		
MW533			X		
MW534 (PZ)		X	X		
MW535 (PZ)			X		
MW536			X		
MW537			X		
MW538			X		
MW539			X		
MW540 (PZ)			X		
MW541 (PZ)			X		
MW542		X	X		
MW543		X	X		
MW544		X	X		
MW545		X	X		
MW546		X	X		
MW547		X	X		
MW548		X	X		
MW549		X	X		
MW550		X	X		
MW551		X	X		
MW553 (PZ)			X		
MW554 (PZ)			X		X
MW555 (PZ)			X		
MW556			X		
R2[a]					
R9[a]					
R13[a]					
R14[a]					
R20[a]					

Table A.1. Summary of Survey Activities from 2013 to 2020 (Continued)

Well Name	2013/2014 GPS	2016 GPS	Dif Leveling 2017 or 2019	GPS 2020 (68 Wells)	Dif Leveling 2020 (18 BMs)
R21[a]					
R26[a]					
R53[a]					
R83[a]					
R90[a]					
R114[a]					
R245[a]					
R302[a]					

[a] Survey status pending.
[b] Location abandoned.
[c] Listed as MW334 in Appendix C.

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APPENDIX B

OREIS SURVEY DATA FIELDS

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OREIS Survey Data Fields

FIELD NAME	FIELD DESCRIPTION
ADMIN_EAST	X-value of the distance in ft of a sampling or measuring location from the reference location based on the administrative coordinate grid system.
ADMIN_NORTH	Y-value of the distance in ft of a sampling or measuring location from the reference location based on the administrative coordinate grid system.
DATUM	Coded value that represents the method by which reference points were established (e.g., NAD27, NAD83). Datum should be associated with the state plane coordinate system. It is not valid for administrative grid. See CODE table where CODE_TYPE = DATUM for a list of valid values and their descriptions.
ELV_ERROR	Elevation measurement error in ft.
ELV_METHOD	Coded value that represents the elevation measurement method. See CODE table where CODE_TYPE = ELV_METHOD for a list of valid values and their descriptions.
GRND_ELV	Elevation of ground surface (for groundwater, soil, or sediment sampling) at a sampling or measuring location in ft above mean sea level (msl).
LATITUDE	Geographic position of a station in degrees north of the equator.
LOC_METHOD	Coded value that represents the method used for locating the station. See CODE table where CODE_TYPE = LOC_METHOD for a list of valid values and their descriptions.
LONGITUDE	Geographic position of a station in degrees west of the Prime Meridian. Must be in the format DDD.XXXXXX, where DDD represents degrees and XXXXXX represents decimal degrees.
MPE_CODE	Coded value that represents the reference point from which measurements are being taken. Examples are top of casing (TOC) and ground surface (GS). See CODE table where CODE_TYPE = MPE_CODE for a list of valid values and their descriptions.
MPE_VAL	The measuring point elevation in ft above mean sea level, required for water level measurements.
RCVD_COORD_SYS	Coded value that represents the coordinate system which defines units used for RCVD_X and RCVD_Y. See CODE table where CODE_TYPE = RCVD_COORD_SYS for a list of valid values and their descriptions.
RCVD_X	Received X-value of the distance in ft or decimal degrees, of a sampling or measuring location from the reference location.
RCVD_Y	Received Y-value of the distance in ft or decimal degrees, of a sampling or measuring location from the reference location.
SPLANE_EAST	X-value of the distance in meters of a sampling or measuring location from the reference location based on the state plane coordinate grid system.
SPLANE_NORTH	Y-value of the distance in meters of a sampling or measuring location from the reference location based on the state plane coordinate grid system.
DATUM Codes	
NAD27	State Plane Grid-NAD27
NAD83	State Plane Grid-NAD83
NAVD88	North American Vertical Datum of 1988
UNKN	Unknown
ELV_METHOD Codes	
ECM	Estimated from Contour Map
GPS	Global Positioning System
SURVEY	Survey Method
UNKNOWN	Unknown

OREIS Survey Data Fields (Continued)

LOC_METHOD Codes	
AVG	Average calculated from multiple sample coordinates
ESTIMATED	Estimated from map or other method
GPS	Global Positioning System
GPS_AVG	Average calculated from multiple sample coordinates
PRELIM_EST	Preliminary estimate. Used with initial transmittal of EST location data.
SURVEY	Survey Method
UNKNOWN	Unknown
MPE_CODE Codes	
GS	Ground Surface
TIC	Top of Inner Casing
TOC	Top of Casing
TOP	Top of Pad
TOWW	Top of Well Wizard
TPC	Top of Protective Casing
UNKN	Unknown
WWP	Top of the Well Wizard Platform
WWR	Well Wizard Rim
RCVD_COORD_SYS Codes	
ADMIN	Administrative Grid
LATLON	Latitude/Longitude
PAD	Paducah Grid
PGDP	Received Coordinate System
STATE	State Plane
UNKN	Unknown

APPENDIX C

2019 MONITORING WELL SURVEY UPDATE

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Table C.1. 2019 Monitoring Well Survey Update

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW63	369.95	NAVD88	BM	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW63	370	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW63	371.89	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW63	372.61	NAVD88	WWP	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW63	372.75	NAVD88	WWR	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW64	370.24	NAVD88	BM	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW64	370.15	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW64	371.86	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW64	372.61	NAVD88	WWP	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW64	372.75	NAVD88	WWR	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW65	370.61	NAVD88	BM	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW65	370.3	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW65	371.88	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW65	372.75	NAVD88	WWR	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW66	368.72	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW66	370.37	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW66	371.08	NAVD88	WWP	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW66	371.22	NAVD88	WWR	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW67	372.18	NAVD88	BM	Differential Leveling	3/27/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW67	372	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW67	374.16	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW67	374.89	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW67	375.02	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW68	377.04	NAVD88	BM	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW68	377	NAVD88	Grade	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW68	379.01	NAVD88	TOC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW68	379.75	NAVD88	WWP	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW68	379.87	NAVD88	WWR	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW69	376.91	NAVD88	BM	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW69	376.99	NAVD88	Grade	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW69	379.05	NAVD88	TOC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW69	379.87	NAVD88	WWR	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW71	376.92	NAVD88	Grade	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW71	378.94	NAVD88	TOC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW71	379.76	NAVD88	WWP	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW71	379.88	NAVD88	WWR	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW75	373.46	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW75	375.97	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW75	375.61	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW78	372.76	NAVD88	BM	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW78	372.64	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW78	375.53	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW78	375.03	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW79	373.6	NAVD88	BM	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW79	373.49	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW79	376.45	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW79	375.91	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW80	373.65	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW80	373.62	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW80	376.39	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW80	375.88	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW81	373.55	NAVD88	BM	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW81	373.52	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW81	376.4	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW81	375.9	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW82	373.67	NAVD88	BM	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW82	373.54	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW82	376.44	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW82	375.9	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW83	373.76	NAVD88	BM	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW83	373.74	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW83	376.47	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW83	375.92	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW84	372.61	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW84	375.03	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW84	375.82	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW84	375.93	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW84A	372.9	NAVD88	BM	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW84A	372.12	NAVD88	Grade	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW84A	374.93	NAVD88	TIC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW84A	375.29	NAVD88	TOC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW85	372.74	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW85	375.03	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW85	375.81	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW85	375.93	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW86	373.01	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW86	375.08	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW86	375.82	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW86	375.93	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW87	373.04	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW87	374.99	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW87	375.73	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW87	375.85	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW87A	372.88	NAVD88	BM	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW87A	372.27	NAVD88	Grade	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW87A	374.89	NAVD88	TIC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW87A	375.3	NAVD88	TOC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW89	372.83	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW89	374.88	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW89	375.61	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW89	375.73	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW90A	372.31	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW90A	372.05	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW90A	374.15	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW90A	374.36	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW91A	372.92	NAVD88	BM	Differential Leveling	3/27/19	TBM = Temporary Bench Mark; TBM and BM used synonomously per Steve Tilley.	DAC-ENV-FA5480-0010
MW91A	372.55	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW91A	375.37	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW91A	375.9	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW92	371.73	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW92	373.71	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW92	374.44	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW92	374.57	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW93	375.09	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW93	376.85	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW93	377.6	NAVD88	WWP	Differential Leveling	3/27/19	WWP measured from WWR using pocket rod. Well Wizard Plate (WWP) = Well Wizard Rim (WWR) - 0.13 = 377.734 - 0.13 = 377.604	DAC-ENV-FA5480-0010
MW93	377.73	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW93A	375.74	NAVD88	BM	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW93A	375.16	NAVD88	Grade	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW93A	378.2	NAVD88	TIC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW93A	378.67	NAVD88	TOC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW94	375.14	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW94	376.89	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW94	377.63	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW94	377.75	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW95A	375.55	NAVD88	BM	Differential Leveling	3/27/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010
MW95A	375.24	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW95A	376.96	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW95A	377.33	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW96	375.71	NAVD88	BM	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW96	375.4	NAVD88	Grade	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW96	377.42	NAVD88	TIC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW96	377.42	NAVD88	TOC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW99	366.78	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW100	370.37	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	2/5/19		DAC-ENV-FA5480-0010
MW100	370.04	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	2/5/19		DAC-ENV-FA5480-0010
MW100	373.08	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	2/5/19		DAC-ENV-FA5480-0010
MW100	373.25	NAVD88	WWP	Differential Leveling based on beginning BM set with GPS	2/5/19		DAC-ENV-FA5480-0010
MW100	373.39	NAVD88	WWR	Differential Leveling based on beginning BM set with GPS	2/5/19		DAC-ENV-FA5480-0010
MW106A	366.66	NAVD88	BM	Differential Leveling	5/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most southern brass monument.	DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW106A	366.27	NAVD88	Grade	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW106A	369.25	NAVD88	TIC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW106A	369.52	NAVD88	TOC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW145	378.06	NAVD88	BM	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW145	380.07	NAVD88	TIC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW145	380.73	NAVD88	TOC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW148	371.32	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW149	371.49	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW150	374.66	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW151	380.58	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW154	371.81	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW154	371.76	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW154	374.45	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW154	375.04	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW155	379.16	NAVD88	BM	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW155	381.28	NAVD88	TIC	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW155	381.57	NAVD88	TOC	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW156	379.56	NAVD88	BM	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW156	382.09	NAVD88	TIC	Differential Leveling	12/6/16	DAC correction—TOC corrected to TIC, confirmed with field notes	DAC-ENV-FA5480-0010
MW156	382.41	NAVD88	TOC	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW161	371.68	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW161	371.52	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW161	373.57	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW161	373.85	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW162	371.72	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW162	371.62	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW162	374.19	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW162	374.54	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW163	383.78	NAVD88	BM	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW163	386.15	NAVD88	TIC	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010
MW163	386.42	NAVD88	TOC	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010
MW164	383.59	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW164	383.57	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW164	386.28	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW164	386.64	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW165A	378.03	NAVD88	BM	Differential Leveling	12/8/16		DAC-ENV-FA5480-0010
MW165A	380.75	NAVD88	TIC	Differential Leveling	12/8/16		DAC-ENV-FA5480-0010
MW165A	380.94	NAVD88	TOC	Differential Leveling	12/8/16		DAC-ENV-FA5480-0010
MW166	378.15	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW166	377.91	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW166	380.04	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW166	380.42	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW167	374.89	NAVD88	BM	Differential Leveling	3/12/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW167	374.59	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
MW167	376.35	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
MW167	376.7	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
MW168	374.89	NAVD88	BM	Differential Leveling	3/12/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW168	374.55	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
MW168	377.41	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
MW168	377.69	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
MW169	370.45	NAVD88	BM	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW169	370.3	NAVD88	Grade	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW169	373.46	NAVD88	TIC	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW169	373.71	NAVD88	TOC	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW170	370.89	NAVD88	BM	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW170	370.75	NAVD88	Grade	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW170	374.05	NAVD88	TIC	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW170	374.26	NAVD88	TOC	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW171	372.78	NAVD88	BM	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW171	372.6	NAVD88	Grade	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW171	374.62	NAVD88	TIC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW171	374.94	NAVD88	TOC	Differential Leveling	6/24/19		DAC-ENV-FA5480-0010
MW172	370.88	NAVD88	BM	Differential Leveling	5/20/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW172	370.74	NAVD88	Grade	Differential Leveling	5/20/19		DAC-ENV-FA5480-0010
MW172	373.8	NAVD88	TIC	Differential Leveling	5/20/19		DAC-ENV-FA5480-0010
MW172	374.11	NAVD88	TOC	Differential Leveling	5/20/19		DAC-ENV-FA5480-0010
MW173	371.45	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW173	371.26	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW173	373.32	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW173	373.63	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW174	371.57	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW174	371.26	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW174	373.31	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW174	373.63	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW175	378.49	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW175	381.13	NAVD88	TIC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW175	381.46	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW176	378.75	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW176	381.23	NAVD88	TIC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW176	381.59	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW177	377.38	NAVD88	BM	Differential Leveling	5/14/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW177	377	NAVD88	Grade	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW177	379.8	NAVD88	TIC	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW177	380.08	NAVD88	TOC	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW178	376.81	NAVD88	BM	Differential Leveling	5/14/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW178	376.6	NAVD88	Grade	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW178	378.83	NAVD88	TIC	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW178	379.14	NAVD88	TOC	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW185	371.76	NAVD88	BM	Differential Leveling	4/10/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW185	371.69	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW185	373.66	NAVD88	TIC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW185	373.94	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW186	371.85	NAVD88	BM	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW186	371.72	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW186	373.64	NAVD88	TIC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW186	374.03	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW187	370.21	NAVD88	BM	Differential Leveling	4/10/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW187	370.17	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW187	373.26	NAVD88	TIC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW187	373.49	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW188	371.76	NAVD88	BM	Differential Leveling	3/19/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW188	371.36	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW188	374.3	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW188	374.49	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW189	372.4	NAVD88	BM	Differential Leveling	3/19/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW189	372.06	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW189	375.55	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW189	375.85	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW190	371.11	NAVD88	BM	Differential Leveling	4/10/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW190	371.35	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW190	373.22	NAVD88	TIC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW190	373.61	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW199	354.01	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW203	374.93	NAVD88	BM	Differential Leveling	3/18/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW203	374.65	NAVD88	Grade	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW203	377.53	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW203	377.87	NAVD88	TOC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW204	374.81	NAVD88	BM	Differential Leveling	3/18/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW204	374.5	NAVD88	Grade	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW204	377.69	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW204	378.01	NAVD88	TOC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW207	375.76	NAVD88	BM	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW207	375.61	NAVD88	Grade	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW207	379.02	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW207	379.16	NAVD88	TOC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW210	382.73	NAVD88	BM	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW210	382.63	NAVD88	Grade	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW210	385.63	NAVD88	TIC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW210	385.8	NAVD88	TOC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW211	375	NAVD88	BM	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW211	374.45	NAVD88	Grade	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW211	378.05	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW211	378.2	NAVD88	TOC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW212	376.14	NAVD88	BM	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW212	375.8	NAVD88	Grade	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW212	379.19	NAVD88	TIC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW212	379.31	NAVD88	TOC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW213	377.43	NAVD88	BM	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW213	377.28	NAVD88	Grade	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW213	380.44	NAVD88	TIC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW213	380.63	NAVD88	TOC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW214	375.66	NAVD88	BM	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW214	375.49	NAVD88	Grade	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW214	378.77	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW214	378.9	NAVD88	TOC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW216	376.81	NAVD88	BM	Differential Leveling	3/18/19	Change WM to MW (DAC Sect 6.2.84)	DAC-ENV-FA5480-0010
MW216	376.64	NAVD88	Grade	Differential Leveling	3/18/19	Change WM to MW (DAC Sect 6.2.84)	DAC-ENV-FA5480-0010
MW216	379.61	NAVD88	TIC	Differential Leveling	3/18/19	Change WM to MW (DAC Sect 6.2.84)	DAC-ENV-FA5480-0010
MW216	379.77	NAVD88	TOC	Differential Leveling	3/18/19	Change WM to MW (DAC Sect 6.2.84)	DAC-ENV-FA5480-0010
MW217	374.99	NAVD88	BM	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW217	374.9	NAVD88	Grade	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW217	378.08	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW217	378.22	NAVD88	TOC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW218	371.68	NAVD88	Grade	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW218	371.68	NAVD88	Grade	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW218	371.12	NAVD88	TIC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW218	371.77	NAVD88	TOC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW219	377.29	NAVD88	BM	Differential Leveling	3/13/19	TBM = Temporary Bench Mark; TBM and BM used synonomously per Steve Tilley.	DAC-ENV-FA5480-0010
MW219	377.05	NAVD88	Grade	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW219	379.6	NAVD88	TIC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010
MW219	379.76	NAVD88	TOC	Differential Leveling	3/13/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW220	378.74	NAVD88	BM	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW220	378.65	NAVD88	Grade	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW220	381.24	NAVD88	TIC	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW220	382.06	NAVD88	TOC	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW221	387.8	NAVD88	BM	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW221	387.89	NAVD88	Grade	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW221	390.81	NAVD88	TIC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW221	391.43	NAVD88	TOC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW222	392.38	NAVD88	BM	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW222	391.98	NAVD88	Grade	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW222	394.83	NAVD88	TIC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW222	395.32	NAVD88	TOC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW223	390.9	NAVD88	BM	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW223	390.95	NAVD88	Grade	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW223	393.94	NAVD88	TIC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW223	394.43	NAVD88	TOC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW224	392.32	NAVD88	BM	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW224	392.08	NAVD88	Grade	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW224	395.38	NAVD88	TIC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW224	395.74	NAVD88	TOC	Differential Leveling	8/19/19		DAC-ENV-FA5480-0010
MW225	382.7	NAVD88	BM	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW225	382.46	NAVD88	Grade	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW225	385.43	NAVD88	TIC	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW225	385.78	NAVD88	TOC	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW226	375.54	NAVD88	BM	Differential Leveling	3/27/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010
MW226	375.33	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW226	378.36	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW226	378.66	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW227	375.61	NAVD88	BM	Differential Leveling	3/27/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010
MW227	375.38	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW227	378.61	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW227	378.81	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW236	370.14	NAVD88	BM	GPS	4/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most southern brass monument. TBM = Temporary Bench Mark; TBM and BM used synonomously per Steve Tilley.	DAC-ENV-FA5480-0010
MW236	369.34	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW236	372.31	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW236	372.76	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW237	370.95	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most northern brass monument.	DAC-ENV-FA5480-0010
MW237	369.94	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW237	372.98	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW237	373.42	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW238	371.45	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most northern brass monument.	DAC-ENV-FA5480-0010
MW238	370.35	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW238	373.65	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW238	374.09	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW239	370.86	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most northern brass monument.	DAC-ENV-FA5480-0010
MW239	369.94	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW239	373.14	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW239	373.58	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW240	370.98	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most northern brass monument.	DAC-ENV-FA5480-0010
MW240	370.54	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW240	373.4	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW240	373.85	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW241A	370.35	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	1/16/20	BM established on east side of flush mount well vault rim by GPS. Sequential well components collected by Differential Leveling.	DAC-ENV-FA5480-0010
MW241A	369.34	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	1/16/20		DAC-ENV-FA5480-0010
MW243	368.77	NAVD88	BM	Differential Leveling	4/30/19	TBM = Temporary Bench Mark; TBM and BM used synonomously per Steve Tilley.	DAC-ENV-FA5480-0010
MW243	368.5	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW243	371.33	NAVD88	TIC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW243	371.73	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW244	366.68	NAVD88	BM	Differential Leveling	4/30/19	BM = Top of Lid for flush mount well	DAC-ENV-FA5480-0010
MW244	366.52	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW244	364.37	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW244	365.42	NAVD88	WWP	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW244	365.54	NAVD88	WWR	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW245	369.61	NAVD88	BM	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW245	368.73	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW245	367.93	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW245	368.71	NAVD88	WWP	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW245	368.83	NAVD88	WWR	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW246	367.44	NAVD88	BM	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW246	367.08	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW246	370.35	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW246	370.04	NAVD88	WWP	Differential Leveling	4/30/19	WWP measured from WWR using pocket rod. Well Wizard Rim (WWR) = Well Wizard Plate (WWP) + 0.12 = 370.044 + 0.12 = 370.164	DAC-ENV-FA5480-0010
MW246	370.16	NAVD88	WWR	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW247	367.67	NAVD88	BM	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW247	367.22	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW247	370.51	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW247	370.21	NAVD88	WWP	Differential Leveling	4/30/19	WWP measured from WWR using pocket rod. Well Wizard Rim (WWR) = Well Wizard Plate (WWP) + 0.12 = 370.214 + 0.12 = 370.334	DAC-ENV-FA5480-0010
MW247	370.33	NAVD88	WWR	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW248	368.97	NAVD88	BM	Differential Leveling	4/30/19	Originally thought to be excluded from the 2019 EMP. "Do not use" comment is recinded.	DAC-ENV-FA5480-0010
MW248	368.6	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW248	366.9	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW248	367.88	NAVD88	WWP	Differential Leveling	4/30/19	WWP measured from WWR using pocket rod. Well Wizard Rim (WWR) = Well Wizard Plate (WWP) + 0.14 = 367.88 + 0.14 = 368.02	DAC-ENV-FA5480-0010
MW248	368.02	NAVD88	WWR	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW249	367.61	NAVD88	BM	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW249	367.25	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW249	370.51	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW249	370.23	NAVD88	WWP	Differential Leveling	4/30/19	WWP measured from WWR using pocket rod. Well Wizard Rim (WWR) = Well Wizard Plate (WWP) + 0.11 = 370.23 + 0.11 = 370.34	DAC-ENV-FA5480-0010
MW249	370.34	NAVD88	WWR	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW250	368.31	NAVD88	BM	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW250	367.95	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW250	371.21	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW250	370.87	NAVD88	WWP	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW250	370.99	NAVD88	WWR	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW252	371.82	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW253	364.14	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW253A	366.16	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW255	381.71	NAVD88	BM	Differential Leveling	12/8/16		DAC-ENV-FA5480-0010
MW255	384.61	NAVD88	TOC	Differential Leveling	12/8/16		DAC-ENV-FA5480-0010
MW255	384.22	NAVD88	WWR	Differential Leveling	12/8/16	TWW = WWR, confirmed with field notes	DAC-ENV-FA5480-0010
MW256	383.85	NAVD88	BM	Differential Leveling	12/8/16		DAC-ENV-FA5480-0010
MW256	385.72	NAVD88	TOC	Differential Leveling	12/8/16		DAC-ENV-FA5480-0010
MW256	385.31	NAVD88	WWR	Differential Leveling	12/8/16	TWW = WWR, confirmed with field notes	DAC-ENV-FA5480-0010
MW257	371.02	NAVD88	BM	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW257	371.08	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW257	373.87	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW257	373.29	NAVD88	WWP	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW257	373.41	NAVD88	WWR	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW258	381.18	NAVD88	BM	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW258	383.8	NAVD88	TIC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW258	384.17	NAVD88	TOC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW260	381.76	NAVD88	BM	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010
MW260	384.54	NAVD88	TOC	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010
MW260	384.06	NAVD88	WWP	Differential Leveling	12/7/16	TWWP = WWPp, confirmed with field notes	DAC-ENV-FA5480-0010
MW261	371.05	NAVD88	BM	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW261	371.08	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW261	374.04	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW261	373.48	NAVD88	WWP	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW261	373.6	NAVD88	WWR	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW262	372.55	NAVD88	BM	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW262	371.95	NAVD88	Grade	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW262	374.15	NAVD88	TOC	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW262	373.77	NAVD88	WWP	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW262	373.66	NAVD88	WWR	Differential Leveling	6/19/19		DAC-ENV-FA5480-0010
MW300	370.11	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW302	381.31	NAVD88	BM	GPS	4/11/19		DAC-ENV-FA5480-0010
MW305	413.08	NAVD88	BM	GPS	4/11/19		DAC-ENV-FA5480-0010
MW307	415.33	NAVD88	BM	GPS	4/11/19		DAC-ENV-FA5480-0010
MW308	416.25	NAVD88	BM	GPS	4/11/19		DAC-ENV-FA5480-0010
MW313	369.6	NAVD88	BM	GPS	4/11/19		DAC-ENV-FA5480-0010
MW328	365.7	NAVD88	BM	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW328	365.62	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW328	368.22	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW328	368.04	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW329	373.24	NAVD88	BM	Differential Leveling	5/7/19	TBM = Temporary Bench Mark; TBM and BM used synonomously.	DAC-ENV-FA5480-0010
MW329	373.27	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW329	375.1	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW329	375.02	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW333	374.47	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW333	374.37	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW333	377.25	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW333	377.09	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW334	375.21	NAVD88	BM	Differential Leveling	N/A		DAC-ENV-FA5480-0010
MW334	374.84	NAVD88	Grade	Differential Leveling	N/A		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW334	377.41	NAVD88	TIC	Differential Leveling	N/A		DAC-ENV-FA5480-0010
MW334	377.64	NAVD88	TOC	Differential Leveling	N/A		DAC-ENV-FA5480-0010
MW337	371.52	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW337	371.55	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW337	374.31	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW337	374.39	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW337	374.53	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW338	372.17	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW338	371.84	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW338	374.74	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW338	374.71	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW339	-	NAVD88	BM	Differential Leveling	5/14/19	MW 339 located in contamination area and well pad covered with earth. Unable to disturb dirt.	DAC-ENV-FA5480-0010
MW339	371.81	NAVD88	Grade	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW339	374.02	NAVD88	TIC	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW339	373.86	NAVD88	TOC	Differential Leveling	5/14/19		DAC-ENV-FA5480-0010
MW340	372	NAVD88	BM	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW340	371.4	NAVD88	Grade	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW340	374.49	NAVD88	TOC	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW340	374.54	NAVD88	WWP	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW340	374.6	NAVD88	WWR	Differential Leveling	4/10/19		DAC-ENV-FA5480-0010
MW341	377.95	NAVD88	BM	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW341	380.02	NAVD88	TIC	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW341	380.52	NAVD88	TOC	Differential Leveling	12/6/16		DAC-ENV-FA5480-0010
MW342	377.39	NAVD88	BM	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW342	376.91	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW342	379.61	NAVD88	TIC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW342	380.07	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW343	375.04	NAVD88	BM	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW343	374.91	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW343	377.03	NAVD88	TIC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW343	377.41	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW345	378.44	NAVD88	BM	Differential Leveling	5/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most northern brass monument.	DAC-ENV-FA5480-0010
MW345	378.17	NAVD88	Grade	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW345	380.68	NAVD88	TIC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW345	381.14	NAVD88	TOC	Differential Leveling	5/8/19		DAC-ENV-FA5480-0010
MW353	372.39	NAVD88	BM	Differential Leveling	9/10/19		DAC-ENV-FA5480-0010
MW353	372.32	NAVD88	Grade	Differential Leveling	9/10/19		DAC-ENV-FA5480-0010
MW353	374.71	NAVD88	TIC	Differential Leveling	9/10/19		DAC-ENV-FA5480-0010
MW353	375.09	NAVD88	TOC	Differential Leveling	9/10/19		DAC-ENV-FA5480-0010
MW354	371.12	NAVD88	BM	Differential Leveling	5/7/19	Multiple brass monuments in concrete well pad. Elevation recorded on most southern brass monument.	DAC-ENV-FA5480-0010
MW354	371.09	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW354	373.29	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW354	373.48	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW356	379.84	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW356	379.55	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW356	382.67	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW356	382.8	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW357	366.68	NAVD88	BM	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW357	366.13	NAVD88	Grade	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW357	368.82	NAVD88	TIC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW357	368.79	NAVD88	TOC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW358	366.43	NAVD88	BM	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW358	366.11	NAVD88	Grade	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW358	368.97	NAVD88	TIC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW358	368.95	NAVD88	TOC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW359	366.43	NAVD88	BM	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW359	366.18	NAVD88	Grade	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW359	368.96	NAVD88	TIC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW359	368.98	NAVD88	TOC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW360	359.79	NAVD88	BM	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW360	359.12	NAVD88	Grade	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW360	362.12	NAVD88	TIC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW360	362.04	NAVD88	TOC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW361	359.22	NAVD88	BM	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW361	358.59	NAVD88	Grade	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW361	361.37	NAVD88	TIC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW361	361.32	NAVD88	TOC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW362	359.38	NAVD88	BM	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW362	358.78	NAVD88	Grade	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW362	361.9	NAVD88	TIC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW362	361.87	NAVD88	TOC	Differential Leveling	10/15/19		DAC-ENV-FA5480-0010
MW363	366.08	NAVD88	BM	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW363	365.33	NAVD88	Grade	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW363	368.61	NAVD88	TIC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW363	368.63	NAVD88	TOC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW364	365.78	NAVD88	BM	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW364	365.1	NAVD88	Grade	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW364	367.57	NAVD88	TIC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW364	368.22	NAVD88	TOC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW365	365.78	NAVD88	BM	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW365	365.26	NAVD88	Grade	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW365	368.19	NAVD88	TIC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW365	368.02	NAVD88	TOC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW366	366.74	NAVD88	BM	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW366	365.88	NAVD88	Grade	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW366	369	NAVD88	TIC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW366	369.03	NAVD88	TOC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW367	367.23	NAVD88	BM	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW367	366.32	NAVD88	Grade	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW367	369.42	NAVD88	TIC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW367	369.35	NAVD88	TOC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW368	366.9	NAVD88	BM	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW368	366.2	NAVD88	Grade	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW368	369.03	NAVD88	TIC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW368	369.06	NAVD88	TOC	Differential Leveling	10/29/19		DAC-ENV-FA5480-0010
MW369	361.59	NAVD88	BM	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW369	361.27	NAVD88	Grade	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW369	364.28	NAVD88	TIC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW369	364.17	NAVD88	TOC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW370	362.86	NAVD88	BM	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW370	362.17	NAVD88	Grade	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW370	365.17	NAVD88	TIC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW370	365.13	NAVD88	TOC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW371	362.39	NAVD88	BM	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW371	361.67	NAVD88	Grade	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW371	364.69	NAVD88	TIC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW371	364.58	NAVD88	TOC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW372	357.22	NAVD88	BM	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW372	356.47	NAVD88	Grade	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW372	359.47	NAVD88	TIC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW372	359.49	NAVD88	TOC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW373	357.89	NAVD88	BM	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW373	357.36	NAVD88	Grade	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW373	359.78	NAVD88	TIC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW373	359.78	NAVD88	TOC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW374	357.4	NAVD88	BM	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW374	356.61	NAVD88	Grade	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW374	359.49	NAVD88	TIC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW374	359.44	NAVD88	TOC	Differential Leveling	8/21/19		DAC-ENV-FA5480-0010
MW375	368.56	NAVD88	BM	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW375	367.85	NAVD88	Grade	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW375	370.41	NAVD88	TIC	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW375	370.31	NAVD88	TOC	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW376	368.1	NAVD88	BM	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW376	367.84	NAVD88	Grade	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW376	370.44	NAVD88	TIC	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW376	370.44	NAVD88	TOC	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW377	363.48	NAVD88	BM	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW377	362.91	NAVD88	Grade	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW377	365.79	NAVD88	TIC	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW377	365.71	NAVD88	TOC	Differential Leveling	10/9/19		DAC-ENV-FA5480-0010
MW380	370.4	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/8/19	Multiple brass monuments in concrete well pad. Elevation recorded on most northern brass monument.	DAC-ENV-FA5480-0010
MW380	369.82	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW380	372.84	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW380	373.26	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/8/19		DAC-ENV-FA5480-0010
MW384	363.03	NAVD88	BM	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW384	362.45	NAVD88	Grade	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW384	364.95	NAVD88	TIC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW384	365.34	NAVD88	TOC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW385	363.33	NAVD88	BM	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW385	363.11	NAVD88	Grade	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW385	365.43	NAVD88	TIC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW385	365.79	NAVD88	TOC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW386	363	NAVD88	BM	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW386	362.43	NAVD88	Grade	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW386	365.09	NAVD88	TIC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW386	365.37	NAVD88	TOC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW387	361.38	NAVD88	BM	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW387	360.73	NAVD88	Grade	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW387	363.11	NAVD88	TIC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW387	363.53	NAVD88	TOC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW388	360.91	NAVD88	BM	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW388	360.53	NAVD88	Grade	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW388	363.09	NAVD88	TIC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW388	363.5	NAVD88	TOC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW389	361.82	NAVD88	BM	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW389	361.67	NAVD88	Grade	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW389	363.74	NAVD88	TIC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW389	364.16	NAVD88	TOC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW390	358.1	NAVD88	BM	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW390	357.69	NAVD88	Grade	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW390	360.24	NAVD88	TIC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW390	360.44	NAVD88	TOC	Differential Leveling	8/20/19		DAC-ENV-FA5480-0010
MW391	364.32	NAVD88	BM	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW391	363.8	NAVD88	Grade	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW391	366.4	NAVD88	TIC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW391	366.72	NAVD88	TOC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW392	363.64	NAVD88	BM	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW392	363.06	NAVD88	Grade	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW392	365.54	NAVD88	TIC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW392	365.9	NAVD88	TOC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW393	364.1	NAVD88	BM	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW393	363.69	NAVD88	Grade	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW393	366.45	NAVD88	TIC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW393	366.67	NAVD88	TOC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW397	384.87	NAVD88	BM	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW397	384.42	NAVD88	Grade	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW397	386.8	NAVD88	TIC	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW397	387.05	NAVD88	TOC	Differential Leveling	8/15/19		DAC-ENV-FA5480-0010
MW405	379.43	NAVD88	TOC	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW405	378.54	NAVD88	WWP	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW406	379.18	NAVD88	TOC	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW406	378.24	NAVD88	WWP	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW407	379.37	NAVD88	TOC	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW407	378.47	NAVD88	WWP	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW408	379.83	NAVD88	TOC	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW408	378.09	NAVD88	WWP	Differential Leveling	6/20/17		DAC-ENV-FA5480-0010
MW409	373.53	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW410	372.89	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW411	365.91	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW414	371.01	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW414	371.05	NAVD88	Grade	Differential Leveling	3/19/19	Change WM to MW—see DAC Sect 6.2.64.	DAC-ENV-FA5480-0010
MW414	373.6	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW414	373.91	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW415	371.07	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW415	371.2	NAVD88	Grade	Differential Leveling	3/19/19	Change WM to MW—see DAC Sect 6.2.64.	DAC-ENV-FA5480-0010
MW415	373.44	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW415	374.02	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW416	374.6	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW416	374.7	NAVD88	Grade	Differential Leveling	3/19/19	Change WM to MW—see DAC Sect 6.2.64.	DAC-ENV-FA5480-0010
MW416	377.02	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW416	377.53	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW417	374.4	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW417	374.6	NAVD88	Grade	Differential Leveling	3/19/19	Change WM to MW—see DAC Sect 6.2.64.	DAC-ENV-FA5480-0010
MW417	376.94	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW417	377.62	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW418	364.25	NAVD88	BM	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW418	364.11	NAVD88	Grade	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW418	366.63	NAVD88	TIC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW418	367.26	NAVD88	TOC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW419	364.08	NAVD88	BM	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW419	364.07	NAVD88	Grade	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW419	366.53	NAVD88	TIC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW419	367.1	NAVD88	TOC	Differential Leveling	8/27/19		DAC-ENV-FA5480-0010
MW420	375.49	NAVD88	BM	Differential Leveling	3/27/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010
MW420	374.99	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW420	377.55	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW420	378.18	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW421	375.71	NAVD88	BM	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW421	375.64	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW421	378.88	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW421D	378.36	NAVD88	TIC	Differential Leveling	N/A	TIC West; top of well flange labeled D3.	DAC-ENV-FA5480-0010
MW421M	378.37	NAVD88	TIC	Differential Leveling	N/A	Steve Tilley confirmed Location = TIC from field notes; top of well flange labeled M2.	DAC-ENV-FA5480-0010
MW421S	378.35	NAVD88	TIC	Differential Leveling	N/A	TIC East; top of well flange labeled S1.	DAC-ENV-FA5480-0010
MW422	375.37	NAVD88	BM	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW422	375.25	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW422	378.44	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW422D	377.95	NAVD88	TIC	Differential Leveling	N/A	TIC West; top of well flange labeled D3.	DAC-ENV-FA5480-0010
MW422M	377.96	NAVD88	TIC	Differential Leveling	N/A	TIC East; top of well flange labeled M2.	DAC-ENV-FA5480-0010
MW422S	377.96	NAVD88	TIC	Differential Leveling	N/A	TIC South; top of well flange labeled S1.	DAC-ENV-FA5480-0010
MW423	375.14	NAVD88	BM	Differential Leveling	3/11/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010
MW423	375.02	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW423	378.21	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW423D	377.73	NAVD88	TIC	Differential Leveling	N/A	TIC East; top of well flange labeled D3.	DAC-ENV-FA5480-0010
MW423M	377.72	NAVD88	TIC	Differential Leveling	N/A	TIC West; top of well flange labeled M2x	DAC-ENV-FA5480-0010
MW423S	377.73	NAVD88	TIC	Differential Leveling	N/A	TIC South; top of well flange labeled S1.	DAC-ENV-FA5480-0010
MW424	376.83	NAVD88	BM	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW424	376.79	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW424	379.71	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW424D	379.13	NAVD88	TIC	Differential Leveling	N/A	TIC North; Top of well flange labeled D3	DAC-ENV-FA5480-0010
MW424M	379.18	NAVD88	TIC	Differential Leveling	N/A	TIC South - confirmed Location = TIC from field notes; Top of well flange labeled M2	DAC-ENV-FA5480-0010
MW424S	379.21	NAVD88	TIC	Differential Leveling	N/A	TIC East; Top of well flange labeled S1	DAC-ENV-FA5480-0010
MW425	377.09	NAVD88	BM	Differential Leveling	3/11/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW425	376.96	NAVD88	Grade	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW425	380.27	NAVD88	TOC	Differential Leveling	3/11/19		DAC-ENV-FA5480-0010
MW425D	379.77	NAVD88	TIC	Differential Leveling	N/A	TIC North; Top of well flange labeled D3.	DAC-ENV-FA5480-0010
MW425M	379.79	NAVD88	TIC	Differential Leveling	N/A	TIC West; Top of well flange labeled M2.	DAC-ENV-FA5480-0010
MW425S	379.77	NAVD88	TIC	Differential Leveling	N/A	TIC East; Top of well flange labeled S1.	DAC-ENV-FA5480-0010
MW426	357.57	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW427	357.16	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW428	371.18	NAVD88	BM	Differential Leveling	5/7/19	Multiple brass monuments in concrete well pad. Elevation recorded on most northern brass monument.	DAC-ENV-FA5480-0010
MW428	371.14	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW428	373.5	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW428	373.98	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW429A	371.69	NAVD88	BM	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW429A	371.54	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW429A	373.96	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW429A	374.4	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW430	371.28	NAVD88	BM	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW430	371.19	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW430	373.7	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW430	374.23	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW431	371.28	NAVD88	BM	Differential Leveling	5/7/19	Multiple brass monuments in concrete well pad. Elevation recorded on most southern brass monument.	DAC-ENV-FA5480-0010
MW431	371.12	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW431	373.34	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW431	373.89	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW432	369.36	NAVD88	BM	Differential Leveling	5/7/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010
MW432	369.18	NAVD88	Grade	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW432	371.53	NAVD88	TIC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW432	371.94	NAVD88	TOC	Differential Leveling	5/7/19		DAC-ENV-FA5480-0010
MW433	357.2	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW435	357.6	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW439	327.69	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW440	327.75	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW441	327.98	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW442	353.61	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW443	353.51	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW444	353.87	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW445	354.86	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW447	354.3	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW448	353.28	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW450	352.4	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW451	364.56	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW452	364.79	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW453	365.65	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW454	365.63	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW455	367.95	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW456	367.95	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW457	368.31	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW458	368.5	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW459	366.85	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW460	367.34	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW461	368.49	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW462	368.3	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW463	365.94	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW463	365.41	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010
MW463	367.77	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010
MW463	368.3	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010
MW464	366.21	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010
MW464	365.59	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010
MW464	368.19	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010
MW464	368.61	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	2/4/19		DAC-ENV-FA5480-0010
MW467	369.6	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW467	367.87	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW467	371.73	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW467	372.55	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW468	369.39	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW468	368.32	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW468	372.04	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW468	372.24	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW469	370.66	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW469	369.77	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW469	373.3	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW469	373.72	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW470	370.84	NAVD88	BM	GPS	4/22/19	TBM = Temporary Bench Mark; TBM and BM used synonomously.	DAC-ENV-FA5480-0010
MW470	369.95	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW470	373.43	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW470	373.83	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW471	368.01	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/22/19	BM is southern BM. Also MW471 is north of MW472.	DAC-ENV-FA5480-0010
MW471	367.72	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW471	370.57	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW471	370.99	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW472	367.95	NAVD88	BM	Differential Leveling based on beginning BM set with GPS	4/22/19	BM is southern BM. Also MW472 is north of MW471.	DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW472	367.59	NAVD88	Grade	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW472	370.33	NAVD88	TIC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW472	370.76	NAVD88	TOC	Differential Leveling based on beginning BM set with GPS	4/22/19		DAC-ENV-FA5480-0010
MW473	365.06	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW474	365.31	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW475	363.57	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW476	363.37	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW477	367.11	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW478	381.63	NAVD88	BM	Differential Leveling	N/A		DAC-ENV-FA5480-0010
MW479	380.79	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW480	380.78	NAVD88	BM	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW480	382.85	NAVD88	TIC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW480	383.38	NAVD88	TOC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW481	376.58	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW482	376.74	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW483	368.23	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW484	368.52	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW485	370.47	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW486	370.15	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW486A	371.07	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW487	372.21	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW488	372.14	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW489	367.68	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW490	367.68	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW491	365.81	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW492	365.79	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW493	367.84	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW494	368.03	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW495	379.11	NAVD88	BM	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW495	381.4	NAVD88	TIC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW495	382.12	NAVD88	TOC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW496	377.94	NAVD88	BM	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW496	380.08	NAVD88	TIC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW496	380.41	NAVD88	TOC	Differential Leveling	12/14/16		DAC-ENV-FA5480-0010
MW497	369.46	NAVD88	BM	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW497	369.48	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW497	371.8	NAVD88	TIC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW497	372.03	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW498	369.46	NAVD88	BM	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW498	369.36	NAVD88	Grade	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW498	371.88	NAVD88	TIC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW498	372.18	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW499	370.38	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW499	370.27	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW499	372.78	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW499	372.99	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW500	370.39	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW500	370.28	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW500	372.8	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW500	373.13	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW501	368.05	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
MW502	368.15	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW503	370.51	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW503	370.31	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW503	373.19	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW503	373.5	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW504	370.7	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW504	370.33	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW504	373.14	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW504	373.38	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
MW511	373.91	NAVD88	BM	Differential Leveling	3/18/19	MW511 & 513, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW511	373.75	NAVD88	Grade	Differential Leveling	3/18/19	MW511 & 513, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW511	376.44	NAVD88	TIC	Differential Leveling	3/18/19	TIC North, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW511	376.67	NAVD88	TOC	Differential Leveling	3/18/19	MW511 & 513, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW512	374.55	NAVD88	BM	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW512	374.35	NAVD88	Grade	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW512	377.01	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW512	377.49	NAVD88	TOC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW513	373.91	NAVD88	BM	Differential Leveling	3/18/19	MW511 & 513, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW513	373.75	NAVD88	Grade	Differential Leveling	3/18/19	MW511 & 513, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW513	376.47	NAVD88	TIC	Differential Leveling	3/18/19	TIC South, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW513	376.67	NAVD88	TOC	Differential Leveling	3/18/19	MW511 & 513, two wells in one casing, 511 is north and 513 is south.	DAC-ENV-FA5480-0010
MW514	372.69	NAVD88	BM	Differential Leveling	3/18/19	Multiple brass monuments in concrete well pad. Elevation recorded on most eastern brass monument.	DAC-ENV-FA5480-0010
MW514	372.52	NAVD88	Grade	Differential Leveling	3/18/19	MW514/515/516, three wells in casing	DAC-ENV-FA5480-0010
MW514	375.25	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW514	375.6	NAVD88	TOC	Differential Leveling	3/18/19	MW514/515/516, three wells in casing	DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW515	372.68	NAVD88	BM	Differential Leveling	3/18/19	Multiple brass monuments in concrete well pad. Elevation recorded on center brass monument.	DAC-ENV-FA5480-0010
MW515	372.52	NAVD88	Grade	Differential Leveling	3/18/19	MW514/515/516, three wells in casing	DAC-ENV-FA5480-0010
MW515	375.23	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW515	375.6	NAVD88	TOC	Differential Leveling	3/18/19	MW514/515/516, three wells in casing	DAC-ENV-FA5480-0010
MW516	372.66	NAVD88	BM	Differential Leveling	3/18/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
MW516	372.52	NAVD88	Grade	Differential Leveling	3/18/19	MW514/515/516, three wells in casing	DAC-ENV-FA5480-0010
MW516	375.22	NAVD88	TIC	Differential Leveling	3/18/19		DAC-ENV-FA5480-0010
MW516	375.6	NAVD88	TOC	Differential Leveling	3/18/19	MW514/515/516, three wells in casing	DAC-ENV-FA5480-0010
MW524	379.28	NAVD88	BM	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW524	381.58	NAVD88	TIC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW524	382.02	NAVD88	TOC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW525	381.23	NAVD88	BM	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW525	383.45	NAVD88	TIC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW525	383.8	NAVD88	TOC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW526	381.53	NAVD88	BM	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW526	383.84	NAVD88	TIC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW526	384.29	NAVD88	TOC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW527	381.8	NAVD88	BM	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW527	384.09	NAVD88	TIC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW527	384.51	NAVD88	TOC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW528	381.81	NAVD88	BM	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW528	384.14	NAVD88	TIC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW528	384.57	NAVD88	TOC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW529	381.23	NAVD88	BM	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW529	383.34	NAVD88	TIC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW529	383.95	NAVD88	TOC	Differential Leveling	12/5/16		DAC-ENV-FA5480-0010
MW531	381.02	NAVD88	BM	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW531	383.62	NAVD88	TIC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW531	383.98	NAVD88	TOC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW533	381.57	NAVD88	BM	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW533	384.17	NAVD88	TIC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW533	384.54	NAVD88	TOC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW536	383.08	NAVD88	BM	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW536	385.71	NAVD88	TIC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW536	386.05	NAVD88	TOC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW537	383.6	NAVD88	BM	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW537	386	NAVD88	TIC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW537	386.32	NAVD88	TOC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW538	382.13	NAVD88	BM	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW538	384.85	NAVD88	TIC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW538	385.22	NAVD88	TOC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW539	382.1	NAVD88	BM	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW539	384.66	NAVD88	TIC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW539	385.03	NAVD88	TOC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW542	372.53	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW542	372.17	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW542	375.12	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW542	375.45	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW543	374.92	NAVD88	BM	Differential Leveling	3/19/19	TBM = Temporary Bench Mark; TBM and BM used synonomously.	DAC-ENV-FA5480-0010
MW543	374.52	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW543	377.36	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW543	377.67	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW544	374.82	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW544	374.27	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW544	377.33	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW544	377.64	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW545	372.64	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW545	372.32	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW545	375.04	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW545	375.43	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW546	374.87	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW546	374.4	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW546	377.33	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW546	377.64	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW547	373.85	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW547	373.42	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW547	376.38	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW547	376.67	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW548	374.76	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW548	374.43	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW548	377.34	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW548	377.62	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW549	375.5	NAVD88	BM	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW549	375.11	NAVD88	Grade	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW549	377.86	NAVD88	TIC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW549	378.14	NAVD88	TOC	Differential Leveling	3/19/19		DAC-ENV-FA5480-0010
MW550	377.3	NAVD88	BM	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW550	376.93	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW550	379.91	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW550	380.07	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW551	375.07	NAVD88	BM	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW551	374.78	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW551	377.51	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW551	377.71	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW556	379.87	NAVD88	BM	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW556	382.53	NAVD88	TIC	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
MW556	382.94	NAVD88	TOC	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
PZ5G	379.14	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ5G	378.93	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ5G	381.88	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ5G	381.97	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ5S	379.03	NAVD88	BM	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ5S	378.8	NAVD88	Grade	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ5S	382.04	NAVD88	TIC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ5S	382.15	NAVD88	TOC	Differential Leveling	5/6/19		DAC-ENV-FA5480-0010
PZ72	371.7	NAVD88	Grade	Differential Leveling	N/A		DAC-ENV-FA5480-0010
PZ72	374.56	NAVD88	TIC	Differential Leveling	N/A		DAC-ENV-FA5480-0010
PZ72	374.14	NAVD88	TOC	Differential Leveling	N/A		DAC-ENV-FA5480-0010
PZ73	372.57	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
PZ73	374.47	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
PZ73	374.42	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
PZ74	372.09	NAVD88	Grade	Differential Leveling	3/27/19	TW = Temporary Well; well renamed PZ74 (DAC description = MW TW 74 Gr)	DAC-ENV-FA5480-0010
PZ74	374.82	NAVD88	TIC	Differential Leveling	3/27/19	TW = Temporary Well; well renamed PZ74 (DAC description = MW TW 74 TIC)	DAC-ENV-FA5480-0010
PZ74	374.45	NAVD88	TOC	Differential Leveling	3/27/19	TW = Temporary Well; well renamed PZ74 (DAC description = MW TW 74 TOC)	DAC-ENV-FA5480-0010
PZ76	373.5	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ76	373.47	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ76	376.04	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ76	376.56	NAVD88	WWP	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ76	376.68	NAVD88	WWR	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
MW77 (PZ)	373.44	NAVD88	Grade	Differential Leveling	N/A		DAC-ENV-FA5480-0010
MW77 (PZ)	376.18	NAVD88	TIC	Differential Leveling	N/A		DAC-ENV-FA5480-0010
MW77 (PZ)	375.74	NAVD88	TOC	Differential Leveling	N/A		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
PZ107	382.78	NAVD88	BM	GPS	N/A		DAC-ENV-FA5480-0010
PZ108	382.81	NAVD88	BM	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ108	382.87	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ108	385.94	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ108	385.41	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ109	382.69	NAVD88	BM	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ109	383.05	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ109	385.71	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ109	385.28	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ110	383.14	NAVD88	BM	Differential Leveling	12/12/16		DAC-ENV-FA5480-0010
PZ110	385.92	NAVD88	TIC	Differential Leveling	12/12/16		DAC-ENV-FA5480-0010
PZ110	385.49	NAVD88	TOC	Differential Leveling	12/12/16		DAC-ENV-FA5480-0010
PZ111	382.76	NAVD88	BM	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ111	382.96	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ111	385.7	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ111	385.26	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ114	382.69	NAVD88	BM	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ114	382.87	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ114	385.63	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ114	385.21	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ115	382.61	NAVD88	BM	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ115	382.63	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ115	385.74	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ115	385.29	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ117	383.39	NAVD88	BM	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ117	383.39	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ117	386.47	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ117	386	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ118	382.71	NAVD88	BM	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
PZ118	382.74	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ118	385.78	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ118	385.32	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ251	374.16	NAVD88	BM	Differential Leveling	3/12/19	Multiple brass monuments in concrete well pad. Elevation recorded on most western brass monument.	DAC-ENV-FA5480-0010
PZ251	374.14	NAVD88	Grade	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ251	376	NAVD88	TIC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ251	376.98	NAVD88	TOC	Differential Leveling	3/12/19		DAC-ENV-FA5480-0010
PZ335	373.91	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ335	373.84	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ335	376.05	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ335	376.21	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ336	376.71	NAVD88	BM	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ336	376.11	NAVD88	Grade	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ336	378.83	NAVD88	TIC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ336	378.99	NAVD88	TOC	Differential Leveling	3/27/19		DAC-ENV-FA5480-0010
PZ350	369.71	NAVD88	Grade	Differential Leveling	4/30/19	Concrete pad, no BM	DAC-ENV-FA5480-0010
PZ350	371.88	NAVD88	TIC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
PZ350	372.06	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
PZ351	369.66	NAVD88	Grade	Differential Leveling	4/30/19	Concrete pad, no BM	DAC-ENV-FA5480-0010
PZ351	372.12	NAVD88	TIC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
PZ351	372.3	NAVD88	TOC	Differential Leveling	4/30/19		DAC-ENV-FA5480-0010
MW517 (PZ)	373.73	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW517 (PZ)	376.68	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW517 (PZ)	376.28	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW518 (PZ)	374.15	NAVD88	Concrete Pad	Differential Leveling	4/3/19	Concrete Pad Only—No Brass Monument—No reference point on concrete pad—Information only	DAC-ENV-FA5480-0010
MW518 (PZ)	374.15	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW518 (PZ)	377.1	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW518 (PZ)	376.73	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW519 (PZ)	377.29	NAVD88	Concrete Pad	Differential Leveling	4/3/19	Concrete Pad Only—No Brass Monument—No reference point on concrete pad—Information only	DAC-ENV-FA5480-0010
MW519 (PZ)	377.27	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW519 (PZ)	380.26	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW519 (PZ)	379.89	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW520 (PZ)	375.3	NAVD88	Concrete Pad	Differential Leveling	4/3/19	Concrete Pad Only—No Brass Monument—No reference point on concrete pad—Information only	DAC-ENV-FA5480-0010
MW520 (PZ)	375.28	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW520 (PZ)	378.18	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW520 (PZ)	377.87	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW521 (PZ)	378.26	NAVD88	Concrete Pad	Differential Leveling	4/3/19	Concrete Pad Only—No Brass Monument—No reference point on concrete pad—Information only	DAC-ENV-FA5480-0010
MW521 (PZ)	378.3	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW521 (PZ)	381.22	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW521 (PZ)	380.83	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW522 (PZ)	375.93	NAVD88	Concrete Pad	Differential Leveling	4/3/19	Concrete Pad Only - No Brass Monument - No reference point on concrete pad -Information only	DAC-ENV-FA5480-0010
MW522 (PZ)	375.93	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW522 (PZ)	378.85	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW522 (PZ)	378.47	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW523 (PZ)	374.75	NAVD88	Concrete Pad	Differential Leveling	4/3/19	Concrete Pad Only—No Brass Monument—No reference point on concrete pad—Information only	DAC-ENV-FA5480-0010
MW523 (PZ)	374.47	NAVD88	Grade	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW523 (PZ)	377.55	NAVD88	TIC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW523 (PZ)	377.37	NAVD88	TOC	Differential Leveling	4/3/19		DAC-ENV-FA5480-0010
MW532 (PZ)	382.37	NAVD88	BM	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW532 (PZ)	385.17	NAVD88	TIC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW532 (PZ)	385.43	NAVD88	TOC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010

Table C.1. 2019 Monitoring Well Survey Update (Continued)

Well Name	Elevation (ft)	Elevation Datum	Location Datum	Survey Method	Survey Date	Comment	Data Source
MW534 (PZ)	381.61	NAVD88	BM	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010
MW534 (PZ)	383.94	NAVD88	TIC	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010
MW534 (PZ)	384.34	NAVD88	TOC	Differential Leveling	12/7/16		DAC-ENV-FA5480-0010
MW535 (PZ)	382.66	NAVD88	BM	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW535 (PZ)	385.32	NAVD88	TIC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW535 (PZ)	385.68	NAVD88	TOC	Differential Leveling	5/30/17		DAC-ENV-FA5480-0010
MW540 (PZ)	384.83	NAVD88	BM	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW540 (PZ)	387.53	NAVD88	TIC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW540 (PZ)	387.89	NAVD88	TOC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW541 (PZ)	381.73	NAVD88	BM	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
MW541 (PZ)	384.14	NAVD88	TIC	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
MW541 (PZ)	384.5	NAVD88	TOC	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
MW553 (PZ)	382.09	NAVD88	BM	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
MW553 (PZ)	384.61	NAVD88	TIC	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
MW553 (PZ)	385	NAVD88	TOC	Differential Leveling	6/1/17		DAC-ENV-FA5480-0010
MW555 (PZ)	383.11	NAVD88	BM	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW555 (PZ)	385.71	NAVD88	TIC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010
MW555 (PZ)	386.07	NAVD88	TOC	Differential Leveling	5/31/17		DAC-ENV-FA5480-0010

BM = benchmark
TIC = top of inner casing
TOC = top of outer casing
WWP = well wizard plate
WWR = well wizard rim

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