Final MW-87 Area Investigation Work Plan

Defense Depot Memphis, Tennessee
U.S. EPA I.D. Number TN4210020570

February 2020

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Department of the Army

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Acronyms and Abbreviations

µg/L	micrograms per liter
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	chloroform
COPC	constituents of potential concern
CT	carbon tetrachloride
CVOC	chlorinated volatile organic compound
DDMT	Defense Depot Memphis, Tennessee
DO	dissolved oxygen
DoD	Department of Defense
DPT	direct push technology
DQO	data quality objective
ELAP	environmental laboratory accreditation program
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
FOST	Finding of Suitability for Transfer
ft	foot/feet
ID	inside diameter
IDW	Investigative Derived Waste
ISTD	in situ thermal desorption
LTM	long-term monitoring
MCL	maximum contaminant level
mg/L	milligrams per liter
MI	Main Installation
MIP	membrane interface probe
ml/min	milliliter per minute
NTU	nephelometric turbidity unit
ORP	oxidation reduction potential
PCE	tetrachloroethene
PID	photoionization detector
QAPP	Quality Assurance Project Plan
QC	quality control
RA	remedial action

RDI	Remedial Design Investigation
RG	remedial goal
RI	Remedial Investigation
ROD	Record of Decision
RSL	Regional Screening Level
SCHD	Shelby County Health Department
SL	screening level
SOP	Standard Operating Procedure
SVE	soil vapor extraction
TC	target concentration
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TeCA	1,1,2,2-Tetrachloroethane
TM	technical memorandum
UFP	Uniform Federal Policy
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
VI	vapor intrusion
VISL	Vapor Intrusion Screening Level
VMP	vapor monitoring point
VOA	volatile organic analysis
VOC	volatile organic compound

1 Introduction

This *MW-87 Area Investigation Work Plan* (Work Plan) was prepared by HDR, Inc. under Contract Number W91278-16-D-0061-W9127819F0090 to the United States Army Corps of Engineers (USACE), Mobile District. This Work Plan presents procedures for sampling, analysis and evaluation of soil, soil vapor and groundwater on Dunn Field at the former Defense Depot Memphis, Tennessee (DDMT). Project personnel are listed on Table 1 with their contact information and the project schedule is shown on Table 2.

The environmental restoration program at DDMT is directed by the Department of the Army (Army), Office of the Assistant Chief of Staff for Installation Management, Base Realignment and Closure Division. Army is planning transfer of their remaining DDMT property, which consists of approximately 26 acres along the western and northern boundary of Dunn Field, shown as DF West on Figure 1. This investigation of increased chlorinated volatile organic compounds (CVOCs) concentrations at long-term monitoring (LTM) well MW-87 in the west central portion of Dunn Field is being conducted to aid the planned transfer.

1.1 Location and Site History

DDMT is located in southeastern Memphis, Tennessee, and consists of approximately 634 acres at the Main Installation (MI) and Dunn Field. The MI contains approximately 567 acres with open storage areas, warehouses, former military family housing, and outdoor recreational areas. Dunn Field, which is located across Dunn Avenue from the northwest section of the MI, contains approximately 67 acres with former mineral storage and waste disposal areas.

DDMT originated as a military facility in the early 1940s to provide stock control, materiel storage, and maintenance services for the U.S. Army. It was selected for closure under Base Realignment and Closure (BRAC) in 1995; storage and distribution activities ceased in September 1997.

During operations from 1942 to 1997, DDMT received, warehoused, and distributed supplies to U.S. military services and civilian agencies. The supplies included hazardous substances; textile products; food products; electronic equipment; construction materials; and industrial, medical, and general supplies.

1.2 Site Description

Approximately two-thirds of Dunn Field is grassed, and the remaining area is covered with crushed rock and paved surfaces. Dunn Field is zoned for light industrial use, but is currently undeveloped.

The surrounding area has mixed residential, commercial and industrial land uses. Dunn Field is bordered on the south by Dunn Avenue and the MI, on the east by Hayes Road and residential property, on the north by a railroad line and East Person Avenue with commercial and industrial uses including a construction materials recycling facility, and on the west by an electrical substation and commercial warehouses with residential properties further west.

1.2.1 Geology and Hydrogeology

The geologic units of interest on Dunn Field are (from youngest to oldest): loess, including surface soil; fluvial deposits; and the Jackson Formation/Upper Claiborne Group (Jackson/Upper Claiborne). The Memphis Sand, is located beneath the Jackson/Upper Claiborne formation. This investigation is limited to the loess and fluvial deposits.

The loess consists of wind-blown and deposited brown to reddish-brown, low-plasticity clayey silt to silty clay. The loess deposits to the northeast of Dunn Field are approximately 15 to 30 feet (ft) thick.

The fluvial (terrace) deposits of Dunn Field consist of two general layers. The upper layer is silty, sandy clay to clayey sand and ranges from about 2 to 30 ft thick. The lower layer is composed of interlayered sand, sandy gravel, and gravelly sand, and ranges from 30 to 70 ft thick. The uppermost aquifer is the unconfined Fluvial Aquifer, consisting of saturated sands and gravelly sands in the lower portion of the deposits.

The Upper Claiborne Group includes the Cockfield and Cook Formations, and the individual formations of the Jackson/Upper Claiborne consist of clays, silts, and sands deposited in lenses or individual beds that are not areally extensive. A clay layer at the top of the Jackson/Upper Claiborne forms the base of the Fluvial Aquifer throughout the area of this investigation.

1.3 Site Investigation and Remedial Action

1.3.1 Site Investigations

The Dunn Field Remedial Investigation (RI) (CH2MHILL, 2002) was performed to evaluate the nature and extent of contamination at Dunn Field and the associated risk to human health and the environment. The Dunn Field RI was organized by investigation of areas considered to have similar levels of contamination rather than individual sites. The three areas (Northeast Open Area, Disposal Area and Stockpile Area) are shown on Figure 2; the environmental sites within each area are also shown. MW-87 is located in the Disposal Area; there are no identified environmental sites in close proximity. The RI figure with locations of soil samples is provided in Appendix A-1. No RI soil samples were collected near MW-87.

A remedial design investigation (RDI) was conducted to refine the limits of soil contaminated with CVOCs in the four treatment areas along the west side of Dunn Field (CH2MHILL, 2007). The RDI included a membrane interface probe (MIP) with confirmatory soil sampling. The RDI figure showing locations for MIP survey points and soil samples is provided in Appendix A-2. MW-87 is located south of Treatment Area 3 and was outside the limits of the MIP survey.

1.3.2 Remedial Action

The remedial actions implemented on Dunn Field were soil excavation and off-site disposal; soil vapor extraction (SVE) in the coarse-grained fluvial soils; and in situ thermal desorption (ISTD) in the fine-grained loess. The remedial goal objectives established in the Dunn Field Record of Decision (ROD) (CH2MHILL, 2004) are shown on Table 3. The locations of the remedial actions on Dunn Field are shown on Figure 3.

The *Source Areas Interim Remedial Action Completion Report, Dunn Field, Revision 1* (HDR|e2M, 2009) was approved by United States Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC) in November 2009. All remedies implemented on Dunn Field met the remediation goals established in the Dunn Field ROD. The Fluvial SVE system was shut down in July 2012 based on confirmation soil sample results demonstrating that remedial action objectives had been met; approximately 4,000 pounds of volatile organic compounds (VOCs) were removed during the five years of operation.

Groundwater concentrations of CVOCs began decreasing shortly after startup of the Fluvial SVE system. CVOC concentrations in LTM wells on Dunn Field, away from the northern boundary, were reduced below maximum contaminant levels (MCLs) and target concentrations (TCs) in the Dunn Field ROD between April 2007 and April 2012. A figure showing the reduction in CVOC concentrations from 2007 to 2012 is provided in Appendix A-3.

1.3.3 Land Use Controls

Land use controls were established for Dunn Field to limit use of the Disposal Area to light industrial land uses, to prevent residential use of Dunn Field, and to prevent exposure to contaminated groundwater (CH2MHILL, 2008). The majority of the eastern section of Dunn Field was approved for unrestricted use in the Dunn Field ROD (Figure 3).

Approximately 41 acres on the east side of Dunn Field have been transferred, 39 acres to Dunn Field Business Park LLC in 2007 through competitive public sale and 2 acres to City of Memphis in 2005 through a public benefit conveyance for realignment of Hayes Road. The Dunn Field West property of approximately 26 acres was approved for transfer through Finding of Suitability for Transfer (FOST #5) in June 2010. As stated in Section 1, Army is preparing for the transfer of this remaining property. A FOST Amendment will be prepared by Army for review by EPA and TDEC prior to the transfer.

1.3.4 Groundwater Analytical Summary

Beginning with an initial investigation in 1982, 153 monitoring wells have been installed at Dunn Field. LTM currently includes 85 wells; the remainder have been abandoned because of damage, or a determination that the well was no longer needed or required abandonment to allow remedial action. Construction data for MW-87 and nearby wells are listed on Table 4 and their locations are shown on Figure 4.

The April 2019 analytical results for CVOCs in the existing wells are shown on Table 5. Only MW-87 exceeded an MCL or TC for a primary CVOC; chloroform (CF) and trichloroethene (TCE) were above MCLs at 93.4 micrograms per liter (µg/L) and 8.79 µg/L, respectively.

Historical groundwater analytical results for CVOCs in MW-87 and nearby wells are provided in Appendix B and summarized below. All the wells are screened in the Fluvial Aquifer, except abandoned wells MW-231 and MW-234, which were screened in the Intermediate Aquifer.

- MW-87: 24 samples since January 2001. Maximum pre-remedial action (RA) concentrations of 1,1,2,2-Tetrachloroethane (TeCA) 180 µg/L, carbon tetrachloride (CT) 32 µg/L and TCE 150 µg/L; CF was not reported above the TC or MCL in that period. All CVOC concentrations below MCLs and TCs in April 2011; increased concentrations began in 2013 and CF above TC in April 2014 and above MCL in April 2017; TCE above MCL in April 2016. Maximum concentrations since 2011 are CF 125 µg/L and TCE 11.9 µg/L in October 2018.
- MW-06: 32 samples since November 1993. Maximum pre-RA concentrations of TeCA 613 µg/L, CT 45 µg/L and TCE 260 µg/L. CF increased from previous high of 16 µg/L in 1997 to 84.7 µg/L in 2008. All CVOC concentrations below MCLs and TCs in April 2011. Increased concentrations of CF and TCE in 2014. CF at 15.3 µg/L exceeded TC in April 2017. Highest recent TCE 2.59 µg/L in April 2015. Concentrations have since decreased.
- MW-32: Offsite. 35 samples from November 1993 until abandoned in March 2013. Maximum pre-RA concentrations of 47.2 µg/L CT, 828 µg/L CF, 6.39 tetrachloroethene (PCE), and 238 µg/L TCE. All other CVOCs were less than their TC and MCL. Concentrations decreased for most CVOCs after startup of the RA.
- MW-37: Offsite. 16 samples from November 1993 until abandoned in March 2013. With the exception of TCE detected at 0.83 µg/L in April 2003, MW-37 did not have CVOCs greater than laboratory detection limits prior to the start of RA in July 2007. In October 2007, CT was detected at 4.12 µg/L, CF at 6.01 µg/L, and TCE at 2.71 µg/L. Subsequent sampling events did not yield CVOCs greater than their laboratory reporting limit.
- MW-71: Offsite. 33 samples since February 2000. Maximum pre-RA concentrations of TeCA 268 µg/L, CT 53.9 µg/L, CF 1,600 µg/L and TCE 390 µg/L. All CVOC concentrations below MCLs and TCs in April 2012; no increase since.
- MW-164: Offsite. 31 samples since October 2004. Maximum pre-RA concentrations of TeCA 32 µg/L, CT 24.8 µg/L, CF 247 µg/L and TCE 136 µg/L. All increased from initial concentration to maximum in April 2007. All CVOC concentrations below MCLs and TCs in October 2013; no increase since.
- MW-175: 5 samples from November 2005 to August 2008, abandoned in March 2013. No concentrations above MCLs or TCs.
- MW-176: 13 samples since November 2005. No concentrations above MCLs or TCs.
- MW-184: Offsite. 15 samples since November 2005. Maximum pre-RA concentrations of TeCA 5.06 µg/L, CT 13.4 µg/L, CF 117 µg/L and TCE 84 µg/L. All increased from initial concentration to max in October 2009. All CVOC concentrations below MCLs and TCs in April 2012; no increase since.

- MW-187: Upgradient. 14 samples since April 2006. No concentrations above MCLs or TCs.
- MW-231: Offsite, Intermediate Aquifer. 4 samples from April 2008 until abandoned in March 2013. No concentrations above laboratory reporting limits.
- MW-233: Offsite. Well was dry; no samples collected. Abandoned in July 2009.
- MW-234: Offsite, Intermediate Aquifer. 4 samples from April 2008 until abandoned in March 2013. No concentrations above laboratory reporting limits.

1.4 Preliminary Human Health Risk Evaluation

Potential human health risk to future residents and site workers from contamination in soil, soil vapor and groundwater could occur via ingestion, dermal contact and inhalation pathways. The existing land use controls (Section 1.3.3) prevent residential land use or other child-occupied facilities on Dunn Field and the production/consumptive use of groundwater or drilling groundwater wells within the groundwater plume or one-half mile of the plume boundaries. The western boundary of Dunn Field is approximately 50 ft from MW-87. The off-site property adjacent to the western Dunn Field boundary is zoned Industrial-EMP, which includes light industrial uses; the area is available for development, subject to City of Memphis/Shelby County zoning restrictions and Shelby County Health Department groundwater well restrictions.

An initial risk evaluation was conducted using groundwater analytical results for LTM samples collected in April and October 2018 and April 2019; the analytical results were from MW-87 and seven wells in the same approximate groundwater flow path (MW-06, MW-71, MW-157, MW-164, MW-176, MW-184 and MW-187). The maximum detected concentrations were identified by CVOC, and exposure point concentrations (EPCs) were calculated for TCE and CF since these CVOCs had elevated concentrations at MW-87 in the April 2018 sample event. The EPCs calculated, using EPA ProUCL software, were 5.442 µg/L for TCE and 50.49 µg/L for CF. Preliminary cancer risks and hazards were calculated for a commercial/industrial worker and resident. For a future commercial/industrial worker's exposure to these two CVOCs in tapwater via dermal contact and ingestion, the draft cancer risks were in the range of 1E-07 to 1E-06, and the draft hazard quotients are slightly less than 1. For a future resident's exposure to TCE and CF in tapwater via ingestion, dermal contact and inhalation pathways, the draft cancer risks were in the range of 1E-06 to 1E-04 and the draft hazard quotients were 2 or less.

The Vapor Intrusion Screening Level (VISL) calculator was used to calculate groundwater screening levels (SLs) protective of the vapor intrusion (VI) risk for the Main Installation based on commercial land use with a target risk of 1E-06 and a target hazard quotient of 1 (HDR, 2017); the SLs are considered applicable to Dunn Field based on similar geologic conditions and prospective land use. Comparison of the SLs to the April 2019 LTM results for the well listed above show that concentrations exceed the CF SL (3.6 µg/L) at MW-06 and MW-87, and the TCE SL (7.4 µg/L) at MW-87, as shown on the following table.

	Analyte	TCE	CF
	MCL	5	80
	TC	5	12
	VISL	7.4	3.6
Well ID	Date	µg/L	µg/L
MW-06	4/6/2019	0.340 J	7.19
MW-87	4/6/2019	8.79	93.4
MW-164	4/7/2019	0.891 J	0.914
MW-176	4/6/2019	-	0.137 J
MW-187	4/7/2019	-	-

2 Data Quality Objectives

The data quality objectives (DQOs) were established in accordance with *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

2.1 Problem Statement

CVOC concentrations in groundwater, and possibly in soil and soil vapor, in the area of MW-87 present a potential human health risk for future use of the property.

MW-87 is located between two treatment areas for previous remedial action on Dunn Field. CVOC concentrations in the well decreased below remediation goals in April 2011 but began to increase in 2013. Maximum concentrations since 2011 are CF 125 µg/L and TCE 11.9 µg/L in October 2018. Soil samples were not collected in the vicinity of MW-87 during the RI (CH2MHILL, 2002) or the RDI (CH2MHILL, 2007), as noted in Section 1.3.2.

Residual CVOC concentrations in soil are likely present in the fine-grained soils (loess and upper fluvial deposits) near MW-87. Prior to RA, contaminants in the loess on Dunn Field leached through the soil and impacted groundwater. The SVE system, operated on Dunn Field from 2007 to 2012, halted contaminant migration through the fluvial deposits and ISTD removed CVOCs from the loess in the treatment areas. Contaminant migration through the loess was also halted at MW-87, but the location of MW-87 outside the ISTD treatment areas limited removal of contaminants from the loess in the surrounding area. After shutdown of the SVE system in 2012, contaminant migration from the loess through the fluvial deposits resumed and increased CVOC concentrations in LTM samples were observed in 2013.

2.2 Goals of the Study

The MW-87 area investigation is planned to address the following data gaps:

- Do CVOC concentrations in vadose zone soil present a continuing source for groundwater impacts?
- What is the extent of VOC contaminants in soil and soil vapor?
- What is the extent of VOC contaminants in groundwater, up-gradient and down-gradient of MW-87?
- Do VOC concentrations in soil, soil vapor and groundwater present unacceptable human health risk for allowable land uses on Dunn Field or for offsite property owners?
- Are VOC concentrations in soil vapor in the coarse-grained fluvial deposits sufficient for use of SVE for remedial action/mitigation?

2.3 Information Inputs

Ten initial soil borings will be advanced to coarse-grained fluvial deposits at depths of 35 to 45 ft below ground surface (bgs). Six additional soil borings will be advanced to further delineate soil contamination, if necessary. Two of the initial soil borings will be advanced up to 70 ft bgs to collect grab groundwater samples, if possible. Five shallow vapor monitoring points (VMPs) to 5 ft bgs, five deep VMPs to 40 ft bgs and three groundwater monitoring wells will be installed at locations selected based on observations and sample results from the soil borings.

Soil lithology will be determined using continuous soil cores from the soil borings and the borings for monitoring wells. The soil core will be screened in the field with a photoionization detector (PID).

Four soil samples from each of the 10 to 16 soil borings will be selected for laboratory analysis. Pressure and PID measurements and vapor samples will be collected at the VMPs during two sample events. All samples will be submitted for laboratory analysis of VOCs.

Location coordinates and elevations will be determined by a Tennessee-registered land surveyor for the soil borings, VMPs and monitoring wells.

Groundwater samples will be collected for laboratory analysis of VOCs from MW-87 and the three new monitoring wells during two sample events. Water level measurements will be made at the same four wells and at adjacent wells prior to sampling.

Analytical results for soil, soil vapor and groundwater samples will be compared to the remedial goal objectives from the Dunn Field ROD (Table 3).

2.4 Study Boundaries

The physical study area is bounded by the monitoring wells adjacent to MW-87 (Figure 4); only MW-87 has exceeded an MCL or TC in recent samples. The temporal boundaries are the initial groundwater sample dates for wells in the study area (November 1993) through collection of the final groundwater samples in July 2020. The schedule for the investigation is presented on Table 2. The VMPs and monitoring wells will remain in place for continued sampling, if warranted.

2.5 Analytical Approach

Soil, groundwater and vapor samples will be analyzed at Department of Defense (DoD) Environmental laboratory accreditation program (ELAP) laboratories for VOCs by EPA Method SW8260B (soil and groundwater) and by Method TO-15 (vapor).

Lithology at each boring will be described using the Unified Soil Classification System (American Society for Testing and Materials [ASTM] D2487-83). Field observations (e.g., odor, staining, and PID measurements) will be used to identify potential source areas and select soil sample depths where the PID or field observations identify VOCs.

Statistical analysis of soil, soil vapor and groundwater analytical results will be used to establish EPCs in accordance with the *Risk Assessment Guidance for Superfund* (EPA, 1989). EPCs will be used to estimate the human health risk to future on-site commercial receptors and potential off-site commercial and residential receptors.

Soil samples collected from 0 to 2 ft bgs and 2 to 10 ft bgs will be used for contaminant delineation and human health risk assessment. Soil samples collected from 10 ft bgs to boring termination will be used to delineate the extent of VOCs.

Grab groundwater samples, if successfully collected, will be used to evaluate contaminant extent and select monitoring well locations, with one well upgradient and two wells downgradient of MW-87.

Vapor samples from the shallow VMPs (5 ft bgs) will be used to evaluate potential vapor intrusion and human health risk. Vapor samples from the deep VMPs will be used to evaluate the source for vapor intrusion and to evaluate applicability of SVE for mitigation of vapor intrusion and protection of groundwater.

2.6 Performance or Acceptance Criteria

Soil, soil vapor and groundwater analytical results must meet EPA method-specified laboratory quality control (QC) criteria and be shown to be useful for the intended purpose through data verification and validation, consistent with the *DDMT Uniform Federal Policy (UFP) Quality Assurance Project Plan* (QAPP) (HDR, 2018).

A Tennessee-registered land surveyor will establish horizontal and vertical control for all new monitoring wells, VMPs and soil borings. Vertical control will be established to 0.01 ft and will be based on the North American Vertical Datum of 1988. Horizontal control will be established to 0.1 ft and will be based on the Tennessee State Plane Coordinate System.

Soil sampling, soil vapor sampling, well installation and development, groundwater sampling, laboratory analysis, and data validation will be conducted in accordance with:

- this Work Plan;
- DDMT Uniform Federal Policy – Quality Assurance Project Plan (DDMT UFP QAPP) (HDR, 2018);
- Low Stress Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells (EPA, 2017);
- DoD General Data Validation Guidelines (DOD, 2018); and
- Environmental Quality Guidance for Evaluating Performance-Based Chemical Data, EM 200-1-10 (USACE, 2005).

2.7 Plan for Obtaining Data

A phased approach with multiple mobilizations will allow sample collection, laboratory analysis, and data review to identify data gaps for subsequent mobilizations. A project schedule is included on Table 2; the planned activities are listed below. Additional information on investigation activities is provided in Section 3.

- Obtain site access from adjacent property owner, permits from Shelby County Health Department (SCHD), and notify Tennessee 811 prior to drilling.

Phase 1: Initial Soil Borings and Grab Groundwater Sampling

- Advance ten direct push technology (DPT) soil borings to upper sand in fluvial deposits (up to 45 ft bgs) on 80-ft square centered on well MW-87 and aligned with the groundwater flow (Figure 4). Record soil lithology and screen for VOCs with a PID.
- Select four samples from each of the DPT borings for analysis: surface (0 to 2 ft bgs), subsurface (2 to 10 ft bgs), and two deep (10 ft bgs to boring termination). Submit samples for VOC analysis on 3-day turnaround time.
- Advance SB-02 and SB-10 (Figure 4) to groundwater at approximately 70 ft bgs and collect a grab groundwater sample. Submit samples for VOC analysis on 3-day turnaround time.
- Abandon borings SB-02 and SB-10.
- Prepare data summary report with brief discussion of field activities, data tables with non-validated analytical results, figures, and recommendations for additional boring and groundwater monitoring well locations. Expedited Army review and discussion before Phase 2 mobilization.

Phase 2: Additional Borings and VMP Construction/Sampling

- Advance up to six additional DPT borings to further delineate VOC soil contamination. Same procedures as Phase 1.
- Construct five shallow VMPs adjacent to DPT borings and five deep VMPs in DPT borings. Collect pressure and PID measurements and soil vapor samples from each VMP. Submit soil vapor samples for VOC analysis on 1-week turnaround time.
- Abandon soil borings not used for VMPs.
- Prepare data summary report similar to Phase 1, include recommendations for monitoring well locations. Expedited Army review and discussion before Phase 3 mobilization.

Phase 3: Well Installation and Confirmation VMP Sampling

- Collect second round of pressure and PID measurements and soil vapor samples at VMPs. Submit samples for VOC analysis on 1-week turnaround time.
- Install and develop three groundwater monitoring wells at selected locations.
- Measure water levels in the new wells and nearby wells (Table 6). Collect groundwater samples from the new wells and MW-87. Submit samples for VOC analysis on 1-week turnaround time.
- Complete data validation for Phase 1 to 3 analytical results and conduct risk assessment.
- Collect and submit samples for investigation derived waste (IDW) analysis.

- Prepare Sampling Data Summary Technical Memorandum (TM) to document site investigation activities, present validated analytical results and results of the human health risk assessment.

Phase 4: Confirmation Groundwater Sampling

- Perform water level sweep at selected wells, and resample the new wells and MW-87. Submit samples for VOC analysis on 1-week turnaround time.
- Dispose of investigation derived waste.
- Prepare addendum to the TM with validated analytical results and update risk assessment.

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3 Site Investigation

The MW-87 area investigation will be conducted in accordance with the Statement of Work (USACE, 2020) and this Work Plan. Sampling and laboratory analysis will be performed in accordance with the DDMT UFP QAPP (HDR, 2018). Field activities will be conducted in accordance with Standard Operating Procedures (SOPs) in Appendix C and the Site Safety and Health Plan (SSHP) (HDR, 2019) prepared for this task order. Sample details are shown on Table 7, including media, analytical method, the number of field and QC samples, preservative, holding time, container, analytical turnaround time and laboratory. The investigation activities are summarized below.

3.1 Access, Permitting, and Utility Clearance

USACE is in discussion with the offsite property owner west of MW-87 to complete an access agreement for the two offsite wells. The final well locations will be selected following evaluation of soil and soil vapor sample analytical results.

The initial ten soil boring locations shown on Figure 4 will be field located and marked by HDR. The locations will be visually evaluated for access and overhead utilities; utilities are not expected to be a concern since the area is undeveloped and MW-87 is south of the overhead power lines that cross Dunn Field. Locations for additional soil borings and monitoring wells will be marked as the locations are selected following review of analytical results. The drilling contractor will obtain permits from SCHD and will have underground utilities located and marked at least 72 hours prior to drilling.

3.2 Soil and Grab Groundwater Sampling

3.2.1 Soil Boring

Residual contamination in the soil will be investigated by DPT soil borings through the loess and fine-grained soils in the upper section of the fluvial deposits and approximately 3 ft into the first sand layer in the lower section of the fluvial deposits; the approximate depth of the borings will be up to 45 ft bgs. Soil boring and sampling will be conducted in accordance with SOP 2.

DPT soil borings will be advanced at 10 locations initially: one boring approximately 5 ft from MW-87, eight borings at the mid-point and corners of an 80-ft square centered on MW-87 and one boring approximately 90 ft upgradient (southeast) of MW-87. The square will be aligned with the groundwater flow direction at MW-87; sample locations will be adjusted to remain on Dunn Field and to limit clearing of brush east of MW-87. The planned boring locations are shown on Figure 4.

After review of initial sample results, soil samples will be collected from up to six additional DPT borings to further delineate soil contamination. The soil borings will be left open for installation of VMPs after review of analytical results from all soil borings.

3.2.1 Soil Sampling and Analysis

At each boring location, continuous soil cores will be collected in 4-ft sections from the surface to boring termination. The soil core will be described using the Unified Soil Classification System (USCS) and screened for VOCs with a PID. Four samples from each boring will be submitted for laboratory analysis of VOCs. Two samples will be submitted from 0 to 10 ft for contaminant delineation and evaluation of human health risk, and two samples will be submitted from 10 ft to boring termination for contaminant delineation.

The samples will be collected at locations with the highest PID readings within the sample depth ranges (0 to 2 ft, 2 to 10 ft and 10 ft to boring termination). If elevated PID readings are not observed within the two shallow depth ranges, the samples will be collected at the mid-points (1 ft and 6 ft). As drilling progresses below 10 ft, samples will be collected from each 10-ft interval at the depth of the highest PID reading or the mid-point if elevated PID readings are not observed. After the boring is completed, two samples collected below 10 ft will be selected for analysis based on PID readings, soil type and depth. Sample selection will be biased toward fine-grained soil (silt and clay) since it is more likely to retain contaminants, and to provide samples from different depths in the sample area. Four samples from each boring will be submitted for analysis even if one or more samples do not have elevated PID readings; samples showing absence of contamination will provide confirmation for PID screening and aid delineation of contaminants.

Soil samples will be collected using Terracore samplers with three vials for each sample; two vials with water and one vial with methanol. Samples will be shipped at the end of each day for overnight delivery to Microbac Laboratories in Marietta, Ohio, via FedEx. The samples will be analyzed for VOCs by EPA Method 8260 with results provided three days after sample receipt. The project action limits for soil and the laboratory detection limits are shown on Table 8.

3.2.2 Grab Groundwater Sampling and Analysis

Borings SB-02 and SB-10 (Figure 4) will be advanced past the first sand layer to collect grab groundwater samples. The Fluvial Aquifer water table is expected to be approximately 65 ft bgs. The borings will be advanced in the same manner as the initial portion; continuous soil cores will be collected, described using the USCS and screened with a PID. Soil samples are not planned to be collected because the coarse-grained soils are considered a migration pathway, but not a source area, for the residual contamination.

After reaching groundwater, a stainless steel screen with expendable point will be lowered through the DPT casing and advanced at least 5 ft into the water table. The DPT drive rod will be retracted approximately 12 inches and a grab groundwater sample will be collected with stainless steel or Teflon® bailer.

The groundwater samples will be collected in laboratory-supplied 40-milliliter volatile organic analysis (VOA) vials preserved with hydrochloric acid. The two samples will be shipped for overnight delivery to Microbac Laboratories in Marietta, Ohio, via FedEx. The samples will be analyzed for VOCs by EPA Method 8260 with results provided one week after sample receipt.

The project action limits for groundwater and the laboratory detection limits are shown on Table 9.

3.3 Soil Vapor Sampling

Shallow soil vapor samples will be collected at a depth of 5 ft for use in human health vapor intrusion risk modeling and deep VMPs will be installed in the upper sand layer of the fluvial deposits, approximately 45 ft bgs, to evaluate the need for additional SVE. Shallow VMPs will be installed adjacent to five of the DPT soil borings with the greatest VOC concentrations in soil. Deep VMPs will be installed in five of the DPT borings with greatest VOC concentrations in soil.

3.3.1 VMP Construction

Five shallow VMPs will be installed adjacent to five of the previous DPT soil borings; borings with the highest CVOC concentrations from 0 to 10 ft bgs will be the primary factor but locations should also provide adequate coverage of the investigation area. DPT soil borings will be advanced by a Tennessee-licensed driller to 6.0 ft bgs. Continuous soil cores will be collected, described using the USCS and screened with a PID.

Deep VMPs will be constructed in five of the soil borings previously advanced to the upper sand layer of the fluvial deposits. Borings with the highest CVOC concentrations in samples collected below 10 ft bgs will be the primary factor, but locations should also provide adequate coverage of the investigation area. The shallow and deep VMPs may not be co-located at all locations, but that will also be a consideration in order to compare VOC concentrations at adjacent shallow and deep VMPs.

At each VMP, the bottom 0.5 ft of the boring will be backfilled with filter sand. A 1-ft section of #100 mesh stainless steel screen implant will be secured to ¼-inch inside diameter (ID) Teflon® tubing and lowered to the base of the boring as described in Appendix C, SOP 3. Filter sand will be placed in the annular space to 0.5 ft above the well screen.

A 2-ft thick bentonite seal will be placed above the filter sand and hydrated with potable water. The remainder of the boring annulus will be filled with bentonite crumbles and hydrated in 5-ft lifts. VMPs will have flush-mount completions with an 8-inch ID manhole set within a 2-ft by 2-ft by 0.5-ft thick concrete pad.

3.3.2 Soil Vapor Sampling

After construction, the VMPs will be allowed to cure for a minimum of 48 hours prior to vapor sampling. Samples will be collected in 1-liter Summa canisters using 200 milliliter per minute (ml/min) regulators in accordance with Appendix C, SOP 5. Two vapor samples will be collected from each VMP; the first after installation and a confirmation sample approximately 4 weeks later.

The samples will be shipped for overnight delivery to ALS in Simi Valley, California, via FedEx. The samples will be analyzed for VOCs by Method TO-15 with results provided one week after sample receipt. The project action limits for soil vapor and the laboratory detection limits are shown on Table 10.

3.4 Monitoring Well Construction

The extent of CVOCs in groundwater above TCs and MCLs will be investigated through installation and sampling of three monitoring wells, two offsite wells down-gradient of MW-87 and one on-site well upgradient of MW-87. The monitoring well locations will be selected following review of analytical results for the soil and grab groundwater samples. The wells are expected to be located on the groundwater flow direction at MW-87, which is toward MW-184 (Figure 4).

3.4.1 Soil Boring Methods

Borings will be advanced by a Tennessee-licensed driller using rotasonic drilling in accordance with Appendix C, SOP 2. A 6-inch diameter boring will be advanced at least 10 ft into the saturated zone of the Fluvial Aquifer at each location. Continuous soil cores will be collected from the ground surface to the termination depth of each boring. As the borings are advanced, the HDR geologist will classify the soil using the USCS and screen the soil core for VOCs with a PID. No soil samples are planned due to disturbance from heat generated by the drilling method. Borings terminated in a clay layer beneath the water table will be back-filled with bentonite chips to just below the top of clay.

3.4.2 Well Construction

Wells will be constructed in accordance with Appendix C, SOP 3. Well casings will be new, unused, 10-ft sections of 2-inch I.D. Schedule 40 PVC pipe with internal flush, threaded joints. Well screens will be one 10-ft section of Schedule 40 PVC continuous slotted 0.010-inch screen. A threaded PVC cap or point will be placed at the bottom of the screen. Centralizers will be used at the top of the screened section, and every 30 ft along the riser.

A filter pack of clean, inert, hard, well-rounded coarse sand will be installed from approximately 1 ft below to 5 ft above the well screen. A minimum 5-ft-thick bentonite seal will be placed above the filter pack and hydrated with potable water for at least one hour. Cement-bentonite grout will be placed in the annular space above the bentonite seal to approximately 6 inches bgs.

Wells will be set in aboveground steel sleeve completions and secured with a water-tight cap. The protective casing will be a steel sleeve placed over the casing and cap; the steel sleeve diameter will be at least 4 inches greater than the casing diameter or at least 8-inches diameter for nested wells. The protective casing will be set in a 3-ft by 3-ft by 4-inch concrete surface pad. Three 3-inch diameter concrete-filled steel bollards will be installed around each well. The grout will be allowed to cure for at least 24 hours before the surface pad and protective casing are installed.

3.4.3 Well Development

The wells will be developed by surging and pumping in accordance Appendix C, SOP 3. Well development will be initiated no sooner than 48 hours after grouting and 24 hours after installation of the well pad. Depending on the project schedule, wells may be developed prior to the well pad being installed.

Development will continue until clear, sand-free formation water is produced from the well and water quality parameters have stabilized. Stabilization of water quality parameters is achieved after three successive readings are within ± 0.1 for pH, ± 3% for specific conductance, ± 10% for dissolved oxygen (DO) values greater than 0.5 milligrams per liter (mg/L) or three successive DO values less than 0.5 mg/L, ± 10 millivolts for oxidation reduction potential (ORP), 3% for temperature, and 10% for turbidity values greater than 5 nephelometric turbidity units (NTU) or three successive values less than 5 NTU (EPA, 2017). If stabilization parameters are not met after four hours of development the PM will be contacted and a determination will be made whether or not to continue development.

3.4.4 Groundwater Sampling and Analysis

Water levels will be measured at the new wells and nearby LTM wells during a one-day sweep; the LTM wells selected for water level measurements are listed on Table 6. Measurements will be made at least 24 hours after well development or sampling.

Wells will be sampled no sooner than 24 hours after development is completed. Initial groundwater samples will be collected using bladder pumps and Teflon®-lined tubing for low flow sampling; if the saturated thickness or recharge is insufficient for a bladder pump, samples will be collected using disposable Teflon® bailers. Water quality parameters will be measured to confirm well stabilization prior to sampling in accordance with Appendix C, SOP 4. Passive diffusion bags will be installed after the initial sample if the saturated screened interval is 5 ft or greater.

The groundwater samples will be collected in laboratory-supplied 40-milliliter VOA vials preserved with hydrochloric acid. Samples will be shipped for overnight delivery to Microbac Laboratories in Marietta, Ohio, via FedEx. The samples will be analyzed for VOCs by EPA Method 8260 with results provided one week after sample receipt. Sample details are listed on Table 7. The project action limits for groundwater and the laboratory detection limits are shown on Table 9.

3.5 Boring Abandonment

Soil borings not used for monitoring well or VMP construction will be abandoned after receipt of sample results. Soil borings will be grouted to the surface with neat cement bentonite grout in accordance with Appendix C, SOP 2.

3.6 Equipment Decontamination

The purpose of decontamination and cleaning procedures during drilling, well installation, and sampling is to prevent foreign contamination of the samples and cross-contamination between sampling sites. Before use, drilling and sampling equipment will be decontaminated by steam-cleaning or pressure washing, or alternatively by washing with a non-phosphate detergent such as Liquinox or equivalent. A potable water rinse will follow the detergent washing. Specific decontamination procedures are described in Appendix C, SOP 9.

3.7 Management of Investigation Derived Waste

IDW, consisting of soil cuttings from the borings, wastewater from equipment decontamination and groundwater from well development, will be stored and analyzed prior to disposal.

Soil cuttings from the borings will be stored on Dunn Field; the soil will be placed on plastic sheeting in piles not to exceed 5 cubic yards; the cuttings will be covered by plastic sheeting held in place by perimeter weights. Soil cuttings with suspected contamination (e.g., stained soil or hydrocarbon or solvent odor) will be drummed or placed in piles separate from other soil cuttings. Upon completion of drilling, one soil sample will be collected from the central section of each soil pile. At each sample location, approximately 6 inches of surface soil will be removed and samples will be collected for VOC analysis by standard extraction and by toxicity characteristic leaching procedure (TCLP) extraction.

Soil samples for standard extraction will be collected with a Terracore sampler. Soil samples for TCLP extraction, which requires greater sample volume, will be collected by completely filling a 4-ounce jar for each location. If standard analysis demonstrates the VOC concentrations are less than the Dunn Field remedial goals (RGs), the soil cuttings will be spread on Dunn Field. If the soil concentrations exceed the RGs, TCLP VOC results will be reviewed to confirm the soil meets requirements for disposal as non-hazardous waste at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) approved facility.

Water IDW will be stored in an aboveground storage tank (AST) on Dunn Field. After well installation, development and sampling are completed, water samples will be collected for analysis in accordance with guidance from TDEC. The water will be discharged to the storm sewer on Dunn Field, if analytical results meet TDEC criteria. If criteria are not met, the water will be disposed at a CERCLA-approved facility. Documentation of sample analyses and discharge will be provided in the TM.

3.8 Soil Boring and Monitoring Well Survey

A Tennessee-registered land surveyor will establish horizontal and vertical control for new monitoring wells, soil borings, and VMPs. Vertical control will be established to 0.01 ft and will be based on the North American Vertical Datum of 1988. Horizontal control will be established to 0.1 ft and will be based on the Tennessee State Plane Coordinate System.

3.9 Quality Control

3.9.1 Field Location Identification

The MW-87 area investigation will include the advancement of temporary soil borings and construction of VMPs and monitoring wells. Field location identifications (IDs) for this investigation are listed below:

- Soil boring IDs (SB-01 through SB-10) and locations are shown on Figure 4. Additional boring locations have not been selected, but the boring IDs will continue in sequential order (SB-11 through SB-16).
- VMP IDs (VMP-01 through VMP-10)
- Monitoring well IDs (MW-319, MW-320 and MW-321) will continue in sequential order from the SRI Phase 4 well MW-318.

3.9.2 Sample Identification

Individual samples will be identified by a unique alphanumeric code (sample ID) which will be written on the sample label and recorded on the chain of-custody (CoC) form. The sample ID will include the type [well (MW), soil boring (SB) or VMP], location (xxx) and sampling event; the event designation will be DFW. The soil sample IDs will include the sample depth.

- Soil samples: SB-01-08-DFW for sample collected from SB-01 at 8 ft bgs.
- Groundwater Samples: MW-319-DFW.
- Soil Vapor Samples: VMP-01-DFW.

IDW samples will include the medium (S for soil and W for water), the sample sequence and sample event (IDW-Sxx-DFW).

Prefixes will replace the location for trip blanks (TB-xx-DFW) and rinse blanks (RB-xx-DFW) and suffixes will identify the locations of matrix spikes or matrix spike duplicates (MW-xxx-DFW-MS). Additional information is provided in Appendix C, SOP 7, *Sample Control and Documentation*.

3.9.3 Quality Control Samples

Field duplicate samples will be collected and equipment rinse blanks will be prepared in accordance with Table 7 for submittal with the groundwater; trip blanks provided by the analytical laboratory will be kept with the soil and groundwater field samples and submitted. The quality control samples will be analyzed at the frequencies shown below:

- Field duplicate: one for every ten field samples.
- Matrix spike/matrix spike duplicate: one for every 20 soil or groundwater samples.
- Trip blank: one for each shipping cooler containing soil or groundwater samples for VOC analysis.
- Equipment/rinse bank: one per day for reusable soil or groundwater sampling equipment.

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4 Risk Assessment

A human health risk screening will be performed to determine if there is unacceptable risk to future on-site and off-site receptors from exposure to constituents of potential concern (COPCs) in groundwater and surface and subsurface soil (0-10 ft bgs) via the ingestion, dermal contact and inhalation pathways as well as from exposure to COPCs in shallow soil vapor (to 5 ft bgs) via the inhalation pathway. The risk screening will include the following steps:

1. Identify the most useable and representative groundwater data set from MW-87 and nearby wells reflecting current (2018 to 2020) site conditions in a manner consistent with applicable guidance for risk screenings. Surface and subsurface soil (0-10 ft bgs) and soil vapor samples from the 2020 sampling event will also be reviewed.
2. Screen the data against applicable chemical-specific standards and risk-based screening levels to identify COPCs in each medium.
3. Identify potential receptors and exposure pathways:
    a. A future on-site commercial worker's exposure to COPCs in surface soil (0-2 ft bgs) via the incidental ingestion, dermal contact and inhalation exposure pathways, COPCs in groundwater limited to ingestion of and dermal contact with tapwater during the work day and COPCs in soil vapor via the inhalation pathway will be evaluated.
    b. A future construction worker's exposure to COPCs in the surface and subsurface soil (0-10 ft bgs) via the incidental ingestion, dermal contact and inhalation exposure pathways will be evaluated. A construction worker's exposure to groundwater seeping in to trenches is expected to be limited to small amounts of perched water within the clayey soils that extend to at least 20 ft bgs. The depth to water in the shallow Fluvial aquifer ranges from 55 to 80 ft bgs on Dunn Field. Therefore, a construction worker's exposure to COPCs in groundwater will not be evaluated. A construction worker's exposure to COPCs in soil vapor is covered by the more conservative scenario for a commercial worker's exposure.
    c. A future off-site resident's exposure to COPCs in surface soil (0-2 ft bgs) via the incidental ingestion, dermal contact and inhalation exposure pathways, COPCs in groundwater via ingestion of, dermal contact with and inhalation of tapwater and COPCs in soil vapor via the inhalation pathway will be evaluated.
4. Determine EPCs for each COPC in groundwater, surface and subsurface soil and soil vapor. EPA's ProUCL software will be used to calculate 95% Upper Confidence Limits (UCL) of the mean for all four data sets. If the 95% UCL of the mean is determined to be unreliable, or if it is greater than all values in the data set, the maximum detected concentration will be used.
5. Identify applicable cancer and non-cancer toxicological values for each COPC that will be used in the calculation of the risks and hazards.
6. Calculate human health cancer risks and hazards for each medium and receptor, which incorporates the EPCs, exposure factors and toxicological values:

a. Use the EPA VISL calculator and shallow soil vapor data to calculate risks and hazards for a commercial worker's and resident's (likely) exposure to COPCs in indoor air impacted via vapor intrusion.

b. Use standard risk and hazard quotient equations based on the EPA Regional Screening Level (RSL) equations (EPA, 2019a).

The risk assessment methodology and results for the commercial worker, construction worker and resident exposure scenarios will be summarized in the TM. Recommendations will be provided if the calculated risks and hazards are not within the acceptable risk and hazard limits. Following confirmation groundwater sampling (Phase 4), the risk assessment will be revised to incorporate the second round of groundwater samples and the findings and recommendations will be revised as necessary.

5 Reporting

Data reports will be prepared after each mobilization and submitted to the Army for review and comment prior to subsequent mobilizations. A description of the reports is presented below:

Phase 1 report: Brief summary of field activities with deviations from this work plan, if any; sample location map; tables with non-validated analytical results for initial soil samples and grab groundwater samples; recommendations for additional soil sample locations. Formal review with comment response is not planned; final decision on recommendations will be documented in an email following discussion with Army and USACE.

Phase 2 report: Same format as Phase 1 for additional soil samples and initial vapor samples; recommendations for well locations. Formal review with comment response is not planned; final decision on recommendations will be documented in an email following discussion with Army and USACE.

Phase 3 report: The TM shall be a more detailed report to be submitted after the first round of groundwater sampling. The TM will describe the field activities with deviations from this work plan; data quality evaluation; analytical results with final data validation flags; a risk assessment for soil, groundwater and vapor data with discussion of procedures, calculations including estimate of EPCs, cancer risks and hazards; and recommendations for further action if warranted. The complete laboratory reports will be included with electronic copies of the report. The report will be submitted for internal review by Army and USACE; responses to comments will be provided and a revised report will be submitted following resolution of the comments.

Phase 4 report: The TM will be amended to incorporate the second round of groundwater samples and to revise the risk assessment and the finding as necessary based on the analytical results. The report will be submitted for internal review by Army and USACE; responses to comments will be provided and a revised report will be submitted following resolution of the comments. The report will be submitted to EPA and TDEC for their information. Responses to agency comments are not in the SOW.

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6 References

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Tables

TABLE 1
PROJECT PERSONNEL AND CONTACT INFORMATION
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis Tennessee (DDMT)

Name	Organization	Role	Email	Office	Mobile
James Foster	DAIN-ODB	Program Manager	James.C.Foster10.civ@mail.mil	703-545-2541	
Joan Hutton	CALIBRE Systems, Inc.	BRAC Environmental Coordinator	joan.hutton@calibresys.com	571-403-3333	770-317-4323
Melissa Shirley	USACE-SAM	Contracting Officer’s Representative	Melissa.L.Shirley@usace.army.mil	251-690-2616	
Bob Beacham	USACE-SAM	Project Manager	robert.p.beacham@usace.army.mil	251-690-3077	251-581-2787
Laura Roebuck	USACE-SAM	Technical Manager	Laura.W.Roebuck@usace.army.mil	251-690-3480	251-455-5340
Diedre Lloyd	USEPA	Remedial Project Manager	lloyd.diedre@epa.gov	404-562-8855	
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Thomas Lyons	HDR	Health and Safety Manager	thomas.lyons@hdrinc.com	704-340-1350	405-420-9389
Lynn Lutz	HDR	Project Chemist	Lynn.Lutz@hdrinc.com	303-754-4266	720-633-2380
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Clayton Mokri	HDR	MW-87 Investigation Task Manager	clayton.mokri@hdrinc.com	916-679-8726	530-902-7106
Denise Cooper	HDR	Environmental Scientist	denise.cooper@hdrinc.com	901-268-2478	901-268-2478
Stephanie Mossburg	Microbac Laboratories, Inc.	Laboratory PM	stephanie.mossburg@microbac.com	740-885-5803	304-299-4976
Kate Kaneko	ALS Global	Laboratory Director	kate.kaneko@alsglobal.com	805-526-7161	

TABLE 2
PROJECT SCHEDULE
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

Task Name	**Start**	**Finish**
MW-87 Area Investigation Work Plan	21-Jan-20	6-Mar-20
MW-87 Area Investigation Work Plan (Draft)	21-Jan-20	5-Feb-20
MW-87 Area Investigation Work Plan (Final)	26-Feb-20	6-Mar-20
Site Access and Permitting	26-Feb-20	20-Mar-20
Phase 1. Initial Soil Borings and Grab Groundwater Sampling	23-Mar-20	3-Apr-20
Sampling and Laboratory Analysis	23-Mar-20	1-Apr-20
Prepare and Submit Data Report	1-Apr-20	2-Apr-20
Finalize Phase 2 Recommendations	3-Apr-20	3-Apr-20
Phase 2. Stepout Borings and VMP Construction/Sampling	6-Apr-20	1-May-20
Sampling and Laboratory Analysis	6-Apr-20	22-Apr-20
Prepare and Submit Data Report	22-Apr-20	27-Apr-20
Finalize Phase 3 Recommendations	28-Apr-20	1-May-20
Phase 3. Well Installation and Sampling, Confirmation VMP Sampling	11-May-20	2-Oct-20
Sampling and Laboratory Analysis	11-May-20	27-May-20
Final Laboratory Reports and Data Validation	27-May-20	19-Jun-20
Risk Assessment	22-Jun-20	7-Aug-20
Technical Memorandum (Draft)	10-Aug-20	21-Aug-20
Technical Memorandum (Final)	11-Sep-20	2-Oct-20
Phase 4. Confirmation Groundwater Sampling	9-Oct-20	2-Oct-20
Data Collection	20-Jul-20	24-Jul-20
Final Laboratory Report and Data Validation	24-Jul-20	21-Aug-20
Risk Assessment	21-Aug-20	4-Sep-20
Technical Memorandum Addendum (Draft)	4-Sep-20	11-Sep-20
Technical Memorandum Addendum (Final)	25-Sep-20	2-Oct-20

TABLE 3
DUNN FIELD REMEDIAL GOAL OBJECTIVES
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

	Remedial Goal Objectives				
	Site-Specific Soil Screening Levels to be Protective of Groundwater		Protective Soil Vapor Concentration		Groundwater Target Concentrations at 10-4 Target Risk Levels and Target HI=1.0 (µg/L)
Parameter	Loess Specific Values (mg/kg)	Fluvial Deposit Specific Values (mg/kg)	Loess Specific Values (ppbv)	Fluvial Deposit Specific Values (ppbv)	
Carbon Tetrachloride	0.2150	0.1086	28.14	14.22	3.0
Chloroform	0.9170	0.4860	61.57	32.63	12.0
Dichloroethane, 1,2-	0.0329	0.0189	1.12	0.64	—
Dichloroethene, 1,1-	0.1500	0.0764	57.00	29.03	7/340
Dichloroethene, cis-1,2-	0.7550	0.4040	73.86	39.52	35.0
Dichloroethene, trans-1,2-	1.5200	0.7910	256.53	133.50	50.0
Methylene Chloride	0.0305	0.0169	5.14	2.85	—
Tetrachloroethane, 1,1,2,2-	0.0112	0.0066	0.03	0.55	2.2
Tetrachloroethene	0.1806	0.0920	15.18	0.99	2.5
Trichloroethane, 1,1,2	0.0627	0.0355	0.84	2.03	1.9
Trichloroethene	0.1820	0.0932	10.56	2.06	5.0
Vinyl Chloride	0.0294	0.0150	28.94	14.77	—

Notes:
Source: Dunn Field Record of Decision, Table 2-21G (CH2MHILL, 2004)
HI: hazard index
mg/kg: milligrams per kilogram
ppbv: parts per billion per volume
µg/L: micrograms per liter
—: Not available for groundwater cleanup goals because of low number of detections or detected values consistently less than maximum contaminant levels.

TABLE 4
WELL CONSTRUCTION SUMMARY
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

Well	Aquifer	Area	Northing (ft)	Easting (ft)	Top of Casing Elevation (ft, NAVD)	Ground Elevation (ft, NAVD)	Top of Clay Depth (ft, bgs)	Top of Clay Elevation (ft, NAVD)	Total Boring Depth (ft, bgs)	Depth to Groundwater (ft, btoc)	Groundwater Elevation (ft, NAVD)	Riser Length (ft)	Screen Length (ft)	Total Well Depth (ft, btoc)
MW-06	Fluvial	DF West	280604	802069	289.11	288.10	-	-	70.0	57.11	232.00	51.0	20	71.0
MW-32	Fluvial	Off Depot	280834	801616	285.38	285.60	66.5	219.1	71.5	63.65	221.73	52.7	15	67.7
MW-37	IAQ	Off Depot	280831	801617	284.91	285.50	70.0	215.5	183.0	129.87	155.04	165.7	15	180.7
MW-71	Fluvial	DF West	280585	801805	294.40	291.90	76.0	215.9	77.7	63.59	230.81	65.5	10	75.5
MW-87	Fluvial	DF West	280696	802039	294.93	292.80	78.0	214.8	81.0	63.17	231.76	63.0	15	78.0
MW-164	Fluvial	Off Depot	280998	801497	287.48	287.71	72.0	215.7	86.0	61.14	226.34	55.3	20	75.5
MW-175	Fluvial	DF West	280618	802175	291.63	291.93	77.0	214.9	86.0	66.46	225.17	67.5	10	77.7
MW-176	Fluvial	DF West	280824	802032	299.68	299.92	86.5	213.4	96.0	67.95	231.73	76.0	10	86.0
MW-184	Fluvial	Off Depot	280903	801442	283.12	283.34	68.0	215.3	86.0	56.91	226.21	58.0	10	68.0
MW-187	Fluvial	Background	280563	802348	302.74	303.21	87.0	216.2	97.0	69.81	232.93	76.0	10	86.0
MW-231	IAQ	Off Depot	280944	801629	289.18	289.43	<70.0	>219.4	198.0	132.91	156.27	167.8	26	193.3
MW-233	Fluvial	Off Depot	280953	801629	289.53	289.68	90.0	199.7	68.7	Dry	-	57.8	10	68.0
MW-234	IAQ	Off Depot	281005	801631	291.50	291.71	71.4	220.3	187.0	135.87	155.63	166.6	10	176.8

Notes:
ft: feet
btoc: below top of casing
NAVD: North American Vertical Datum of 1988
1) MW-233 was abandoned in July 2009; MWs 32, 37, 175, 231, 234 were abandoned in March 2013.
2) Depths to groundwater are from April 2019, except abandoned MWs 32, 37,175, 231 and 234 which are from October 2008.

TABLE 5
ANALYTICAL RESULTS SUMMARY, APRIL 2019
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

	Well ID			MW-06	MW-71	MW-87	MW-164	MW-176	MW-184	MW-187
	Date			4/6/2019	4/7/2019	4/6/2019	4/7/2019	4/6/2019	4/7/2019	4/7/2019
Primary CVOCs	Units	MCL	TC							
1,1,2,2-Tetrachloroethane	µg/L	-	2.2	0.500 U	0.500 U	0.589	0.500 U	0.500 U	0.500 U	0.500 U
1,1,2-Trichloroethane	µg/L	5	1.9	1.00 U	1.00 U	1.73	1.00 U	1.00 U	1.00 U	1.00 U
1,1-Dichloroethene	µg/L	7	7	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-Dichloroethane	µg/L	5	-	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Carbon tetrachloride	µg/L	5	3	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	0.690 J	1.00 U
Chloroform	µg/L	80	12	7.19	0.844	**93.4**	0.914	0.137 J	1.33	0.500 U
cis-1,2-Dichloroethene	µg/L	70	35	1.28	1.00 U	6.67	1.00 U	1.00 U	0.480 J	1.00 U
Tetrachloroethene	µg/L	5	2.5	1.00 U	1.00 U	1.00 U	1.00 U	0.442 J	0.260 J	1.00 U
trans-1,2-Dichloroethene	µg/L	100	50	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Trichloroethene	µg/L	5	5	0.340 J	0.408 J	**8.79**	0.891 J	1.00 U	0.937 J	1.00 U
Vinyl chloride	µg/L	2	-	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U

Notes:
µg/L: micrograms per liter
MCL: Maximum Contaminant Level
TC: Target Concentration
LOQ: Limit of Quantitation
- : Not Listed
1) Results above MCL or TC shown in **bold**
2) Analytical results, whether non-detect or detected above or below the LOQ, are shown for the Primary CVOCs and for any Other VOCs (non-primary) that are detected above the LOQ in at least one sample.

DQE Flags:
J: Estimated
U: Not Detected

Method:
8260B: Volatile Organic Compounds

TABLE 6
WATER LEVEL MEASUREMENT FORM
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

Well ID	Aquifer	Top of Casing Elevation (ft, NAVD)	Top of Screen Elevation (ft, NAVD)	Date	Depth to Water (ft, btoc)	Groundwater Elevation ft NAVD
MW-06	Fluvial	289.11	238.11			
MW-13	Fluvial	300.01	234.01			
MW-70	Fluvial	304.99	224.18			
MW-71	Fluvial	294.40	228.90			
MW-87	Fluvial	294.93	231.93			
MW-91	Fluvial	291.99	236.99			
MW-164	Fluvial	287.48	232.18			
MW-176	Fluvial	299.68	223.68			
MW-184	Fluvial	283.12	225.12			
MW-187	Fluvial	302.74	226.74			
MW-225	Fluvial	304.52	229.54			
MW-226	Fluvial	303.19	228.97			
MW-319	Fluvial	NA	NA			
MW-320	Fluvial	NA	NA			
MW-321	Fluvial	NA	NA			

Notes:
ft, btoc: feet below top of casing
ft, NAVD: feet above North American Vertical Datum of 1988
NA: not available

TABLE 7
SAMPLE CONTAINERS, PRESERVATION AND HOLD TIMES
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

Media	Field Phase	Analytical Method	Field Samples	Field Duplicates	MS	MSD	Trip Blanks	Equipment Blanks	Total No. of Samples	Preservative	Holding Time	Container Size and Type	Turn Around Time	Analytical Laboratory
Soil	1	SW8260B	40	4	2	2	0	0	48	2xwater, 1xMeOH Chill to 4±2 degrees Celsius (°C)	14 days	2x40 mL glass VOA vials with water; 1x40 mL VOA vial with methanol; and 60g poly jar.	3 Days	Microbac
Water	1	SW8260B	0	0	0	0	8	1	9	HCl to pH<2 Chill to 4±2 °C	14 days	3x40 mL glass VOA vials with HCl to pH<2; Teflon lined septa	3 Days	Microbac
Soil	2	SW8260B	24	3	2	2	0	0	31	2xwater, 1xMeOH Chill to 4±2 degrees Celsius (°C)	14 days	2x40 mL glass VOA vials with water; 1x40 mL VOA vial with methanol; and 60g poly jar.	3 Days	Microbac
Water	2	SW8260B	0	0	0	0	5	1	6	HCl to pH<2 Chill to 4±2 °C	14 days	3x40 mL glass VOA vials with HCl to pH<2; Teflon lined septa	3 Days	Microbac
Vapor	2	TO-15	10	1	0	0	0	0	11	None	28 days	1 liter summa canister with 200-ml/min regulator	7 Days	ALS
Water	3	SW8260B	4	1	1	1	1	1	9	HCl to pH<2 Chill to 4±2 °C	14 days	3x40 mL glass VOA vials with HCl to pH<2; Teflon lined septa	7 Days	Microbac
Vapor	3	TO-15	10	1	0	0	0	0	11	None	28 days	1 liter summa canister with 200-ml/min regulator	7 Days	ALS
Water	4	SW8260B	4	1	1	1	1	0	8	HCl to pH<2 Chill to 4±2 °C	14 days	3x40 mL glass VOA vials with HCl to pH<2; Teflon lined septa	7 Days	Microbac

Notes: ml = milliliter
VOA = volatile organic analysis
HCl = hydrochloric acid
MeOH = methanol
g = gram
min = minute

MS = matrix spike
MSD = matrix spike duplicate
TICs = tentatively identified compounds
VOCs = volatile organic compounds
poly = polyethylene

TABLE 8
SOIL PROJECT ACTION LIMITS AND LABORATORY SPECIFIC DETECTION/QUANTITATION LIMITS
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

Analyte	Project Action Limit [1]		Project Quantitation Limit Goal	Achievable Laboratory Limits [2]		
	LSV	FDSV		DLs	LODs	LOQs
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Carbon tetrachloride	0.2150	0.1086	0.050	0.0005	0.001	0.005
Chloroform	0.9170	0.4860	0.050	0.0005	0.001	0.005
1,2-Dichloroethane	0.0329	0.0189	0.050	0.0005	0.001	0.005
1,1-Dichloroethene	0.1500	0.0764	0.050	0.0005	0.001	0.005
cis-1,2-Dichloroethene	0.7550	0.4040	0.050	0.0005	0.001	0.005
trans-1,2- Dichloroethene	1.520	0.7910	0.050	0.0005	0.001	0.005
Methylene chloride	0.0305	0.0169	0.100	0.001	0.002	0.005
1,1,2,2- Tetrachloroethane	0.0112	0.0066	0.050	0.0005	0.001	0.005
Tetrachloroethene	0.1806	0.0920	0.050	0.0005	0.001	0.005
1,1,2-Trichloroethane	0.0627	0.0355	0.050	0.0005	0.001	0.005
Trichloroethene	0.1820	0.0932	0.050	0.0005	0.001	0.005
Vinyl chloride	0.0294	0.0150	0.050	0.001	0.002	0.005

Notes:

1) Project Action Limits are Site-Specific Soil Screening Levels to be Protective of Groundwater from the Dunn Field ROD
2) Achievable DLs, LODs and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. Limits shown are for a 1-L Summa® canister.

LSV: Loess Specific Values
FDSV: Fluvial Deposit Specific Values.
mg/kg: milligrams per kilogram

TABLE 9
GROUNDWATER PROJECT ACTION LIMITS AND LABORATORY SPECIFIC DETECTION/QUANTITATION LIMITS
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

Analyte	Project Action Limit [1]		Project Quantitation Limit Goal	Achievable Laboratory Limits[2]		
	MCL	TC[3]		DLs	LODs	LOQs
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Carbon tetrachloride	5	3.0	1.00	0.250	0.500	1.00
Chloroform	80	12.0	1.00	0.125	0.250	1.00
1,2-Dichloroethane	5	NE	1.00	0.250	0.500	1.00
1,1-Dichloroethene	7	7/340	2.00	0.500	1.000	2.00
cis-1,2-Dichloroethene	70	35.0	1.00	0.250	0.500	1.00
trans-1,2-Dichloroethene	100	50.0	1.00	0.250	0.500	1.00
Methylene chloride	5	NE	1.00	0.250	0.500	1.00
1,1,2,2-Tetrachloroethane	NE	2.2	0.80	0.200	0.400	0.80
Tetrachloroethene	5	2.5	1.00	0.250	0.500	1.00
1,1,2-Trichloroethane	5	1.9	1.00	0.250	0.500	1.00
Trichloroethene	5	5.00	1.00	0.250	0.500	1.00
Vinyl chloride	2	NE	1.00	0.250	0.500	1.00

Notes:
1) Project Action Limits are USEPA Maximum Contaminant Levels and Target Concentrations from the Dunn Field ROD
2) Achievable DLs, LODs and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. Limits shown are for a 1-L Summa® canister.
3) Groundwater Target Concentrations at 10-4 Target Risk Levels and Target HI=1.0

MCL: Maximum Contaminant Level
TC: Target Concentration
ppbv: parts per billion by volume
NE: not established

TABLE 10
SOIL VAPOR PROJECT ACTION LIMITS AND LABORATORY SPECIFIC DETECTION/QUANTITATION LIMITS
MW-87 AREA INVESTIGATION WORK PLAN
Dunn Field, Defense Depot Memphis, Tennessee

Analyte	Project Action Limit [1]		Project Quantitation Limit Goal	Achievable Laboratory Limits[2]		
	LSV	FDSV		DLs	LODs	LOQs
	(ppbv)	(ppbv)	(ppbv)	(ppbv)	(ppbv)	(ppbv)
Carbon tetrachloride	28.14	14.22	0.21	0.029	0.068	0.21
Chloroform	61.57	32.63	0.28	0.036	0.090	0.28
1,2-Dichloroethane	1.12	0.64	0.33	0.036	0.11	0.33
1,1-Dichloroethene	57	29.03	0.34	0.047	0.11	0.34
cis-1,2-Dichloroethene	73.86	39.52	0.33	0.047	0.11	0.33
trans-1,2-Dichloroethene	256.53	133.50	0.33	0.047	0.11	0.33
Methylene chloride	5.14	2.85	0.39	0.11	0.23	0.39
1,1,2,2-Tetrachloroethane	0.03	0.55	0.19	0.027	0.062	0.19
Tetrachloroethene	15.18	0.99	0.20	0.025	0.063	0.20
1,1,2-Trichloroethane	0.84	2.03	0.25	0.025	0.078	0.25
Trichloroethene	10.56	2.06	0.25	0.034	0.080	0.25
Vinyl chloride	28.94	14.77	0.52	0.056	0.17	0.52

Notes:

1) Project Action Limits are Protective Soil Vapor Concentrations from the Dunn Field ROD
2) Achievable DLs, LODs and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. Limits shown are for a 1-L Summa® canister.

LSV: Loess Specific Values
FDSV: Fluvial Deposit Specific Values.
ppbv: parts per billion by volume

Figures

Path: W:\WorkPlans\MW8701_FOST Map.mxd

Figure 1

Property Transfer Map

MW-87 Area Investigation
Work Plan

Dunn Field, Defense Depot
Memphis, Tennessee

Legend

Property Boundary

Date of Quitclaim Deed(s)[1]

9/26/01

2/6/02 and 5/6/02

4/4/06 and 8/18/06

9/2/05 and 10/17/07

3/30/11

Note:
1) Date of signature by Army or other agency on deed.

Buildings *490 - DDMT Assigned Number*

Roads

N W E S

0 500 1,000
Feet

Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet, NAVD88

Date: 1/30/2020
Edition: Rev 0

HDR

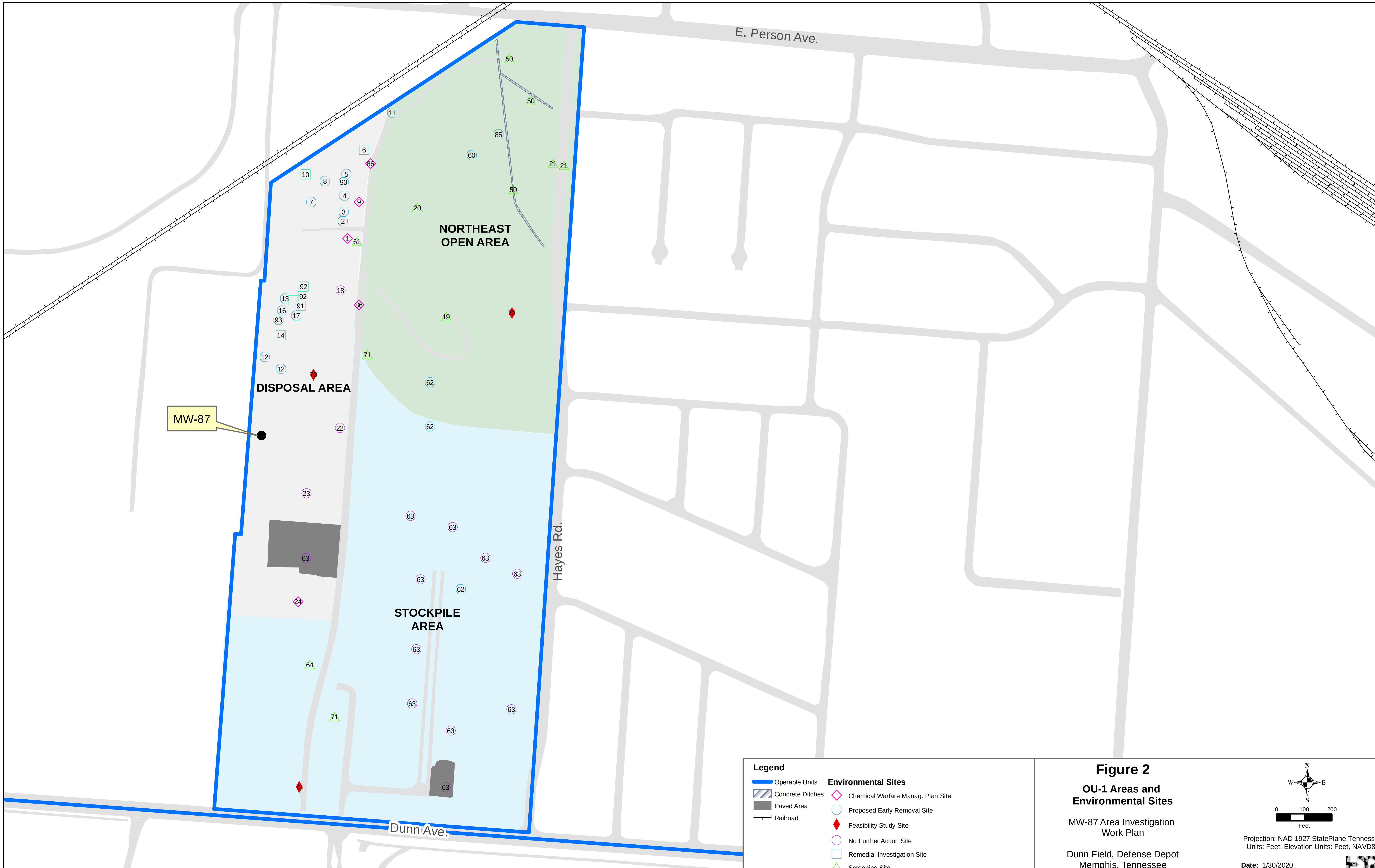

Figure 2

OU-1 Areas and Environmental Sites

MW-87 Area Investigation Work Plan

Dunn Field, Defense Depot
Memphis, Tennessee

Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet, NAVD88

Date: 1/30/2020
Edition: Rev 0

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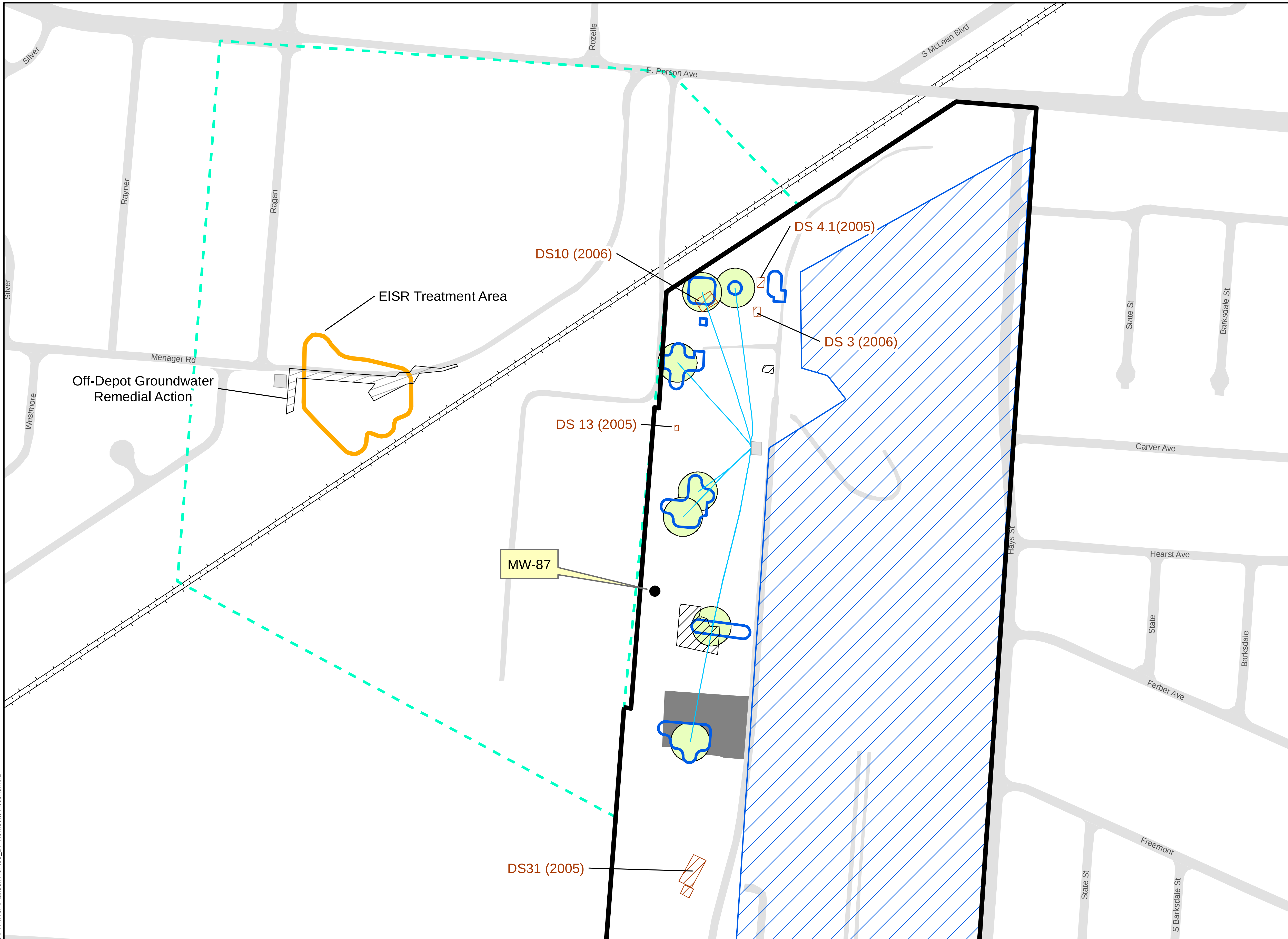

Figure 3

Disposal Sites, Source Areas and Off-Depot Groundwater Remedial Actions

MW-87 Area Investigation Work Plan

Dunn Field, Defense Depot
Memphis, Tennessee

Legend

- Original Dunn Field Boundary
- Fluvial SVE Conveyance Line
- Disposal Sites Excavation Area
- Off Site Treatment Areas
- Off Depot Air Sparge Area
- EISR Treatment Area
- *Loess Excavation Areas*
- *Loess Thermal-Enhanced SVE Treatment Areas*
- Fluvial SVE Well 60-foot radius of influence
- Unrestricted Use Area from ROD
- Buildings
- Paved Area
- Roads
- Railroad

N
W E
S

0 250 500
Feet

Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet, NAVD88

Date: 1/30/2020
Edition: Rev 0

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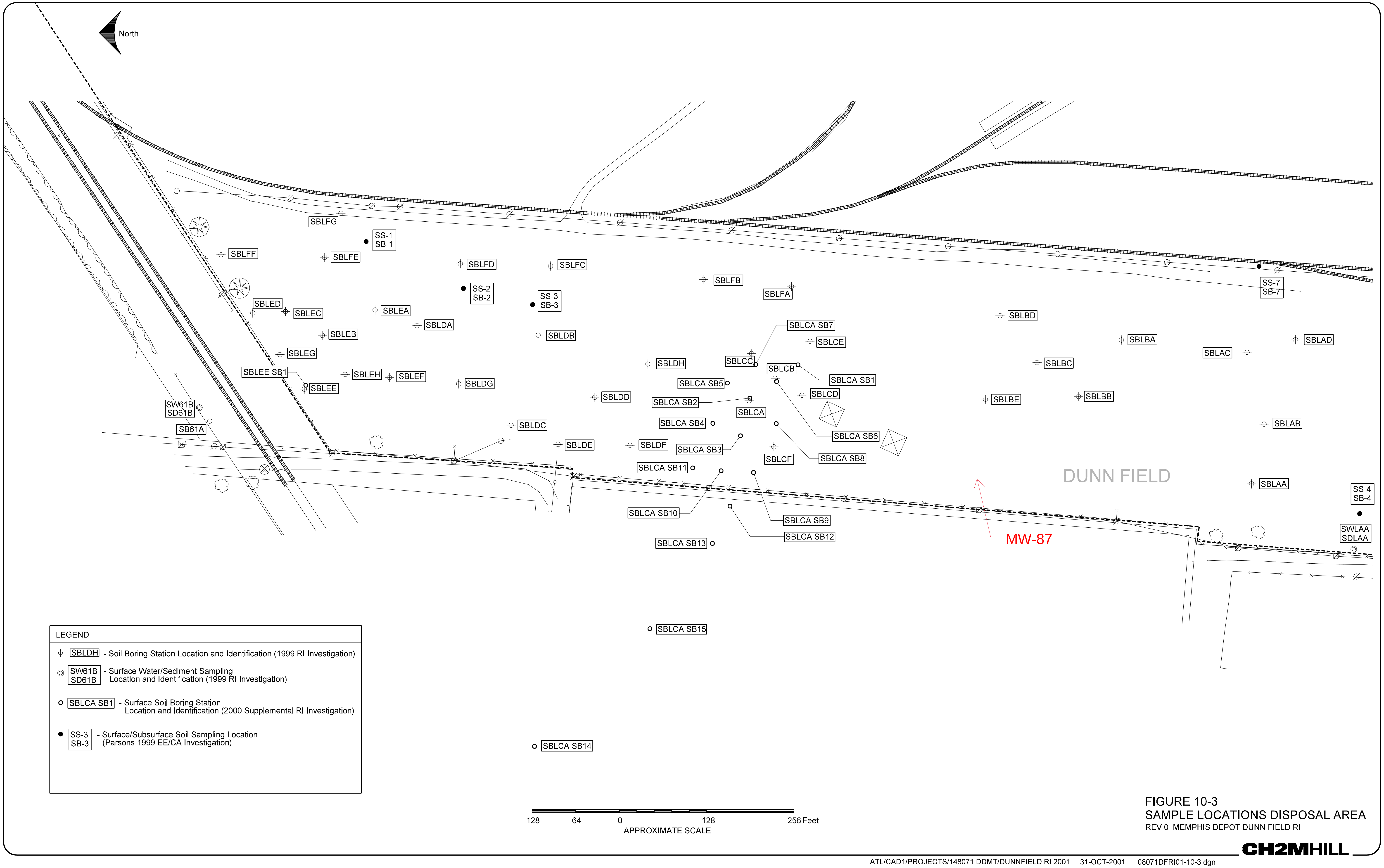
MW-157
MW-164
MW-184
Rozelle St.
MW-70
MW-134
MW-224
MW-13
MW-222
MW-225
MW-226
MW-223
MW-176
SB-03
SB-04
SB-05
SB-02/GW-01
SB-01
MW-87
SB-06
SB-10/GW-02
SB-09
SB-08
SB-07
MW-06
MW-71
MW-187
MW-91
232
Legend
Aquifer
Fluvial
Intermediate/Upper Claiborne
Memphis/ Upper Claiborne (Deep)
Proposed Soil Boring
Groundwater Grab Sample
Abandoned Wells
Area
Background
DF North
DF West
Off Depot
Potentiometric surface of the Fluvial Aquifer 1-ft. contour
Potentiometric surface of the Fluvial Aquifer 5-ft. contour
Potentiometric surface extrapolation
Original Dunn Field Boundary
Railroad
Fence
Air Sparge System
Buildings
Figure 4
Initial Sample Locations
MW-87 Area Investigation
Work Plan
Dunn Field, Defense Depot
Memphis, Tennessee
N
W
E
S
0
25
50
Feet
Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet, NAVD88
Date: 1/30/2020
Edition: Rev 0

A

Appendix A

Supplemental Information


North
SBLFG
SS-1
SB-1
SBLFF
SBLFE
SBLFD
SBLFC
SBLFB
SBLFA
SS-2
SB-2
SS-3
SB-3
SS-7
SB-7
SBLED
SBLEC
SBLEA
SBLDA
SBLEB
SBLDB
SBLEG
SBLCA SB7
SBLCE
SBLBD
SBLBA
SBLAD
SBLAC
SBLDH
SBLCC
SBLCB
SBLCA SB1
SBLBC
SBLEE SB1
SBLEH
SBLEF
SBLEE
SBLDG
SBLCA SB5
SBLCD
SBLBE
SBLBB
SBLDD
SBLCA SB2
SBLCA
SW61B
SD61B
SB61A
SBLDC
SBLCA SB4
SBLCA SB6
SBLAB
SBLDE
SBLDF
SBLCA SB3
SBLCA SB8
SBLCF
SBLCA SB11
DUNN FIELD
SBLAA
SS-4
SB-4
SBLCA SB10
SBLCA SB9
SBLCA SB12
MW-87
SWLAA
SDLAA
SBLCA SB13
SBLCA SB15
SBLCA SB14
LEGEND
SBLDH - Soil Boring Station Location and Identification (1999 RI Investigation)
SW61B SD61B - Surface Water/Sediment Sampling Location and Identification (1999 RI Investigation)
SBLCA SB1 - Surface Soil Boring Station Location and Identification (2000 Supplemental RI Investigation)
SS-3 SB-3 - Surface/Subsurface Soil Sampling Location (Parsons 1999 EE/CA Investigation)
128 64 0 128 256 Feet
APPROXIMATE SCALE
FIGURE 10-3
SAMPLE LOCATIONS DISPOSAL AREA
REV 0 MEMPHIS DEPOT DUNN FIELD RI
CH2MHILL
ATL/CAD1/PROJECTS/148071 DDMT/DUNNFIELD RI 2001 31-OCT-2001 08071DFRI01-10-3.dgn

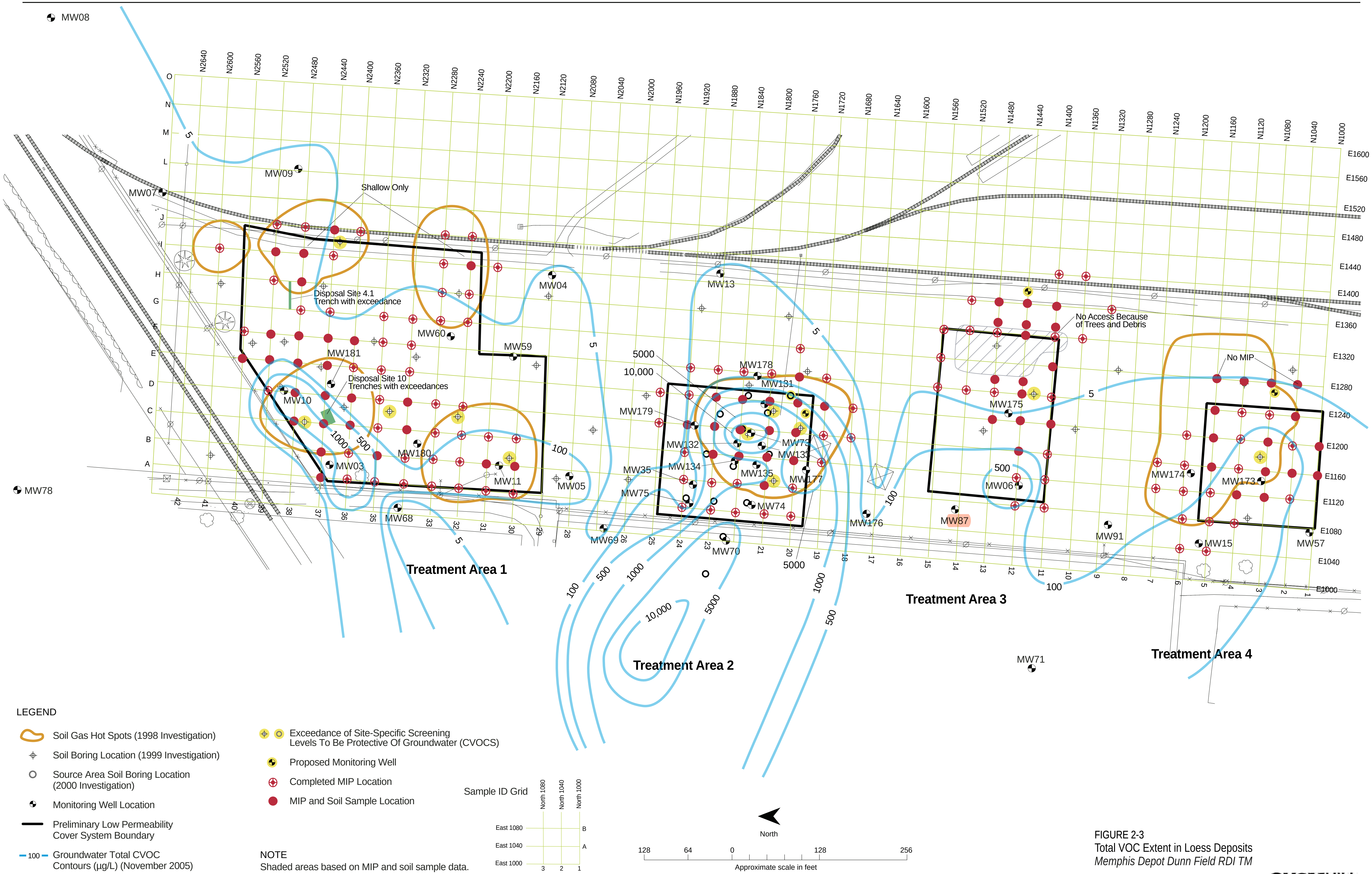
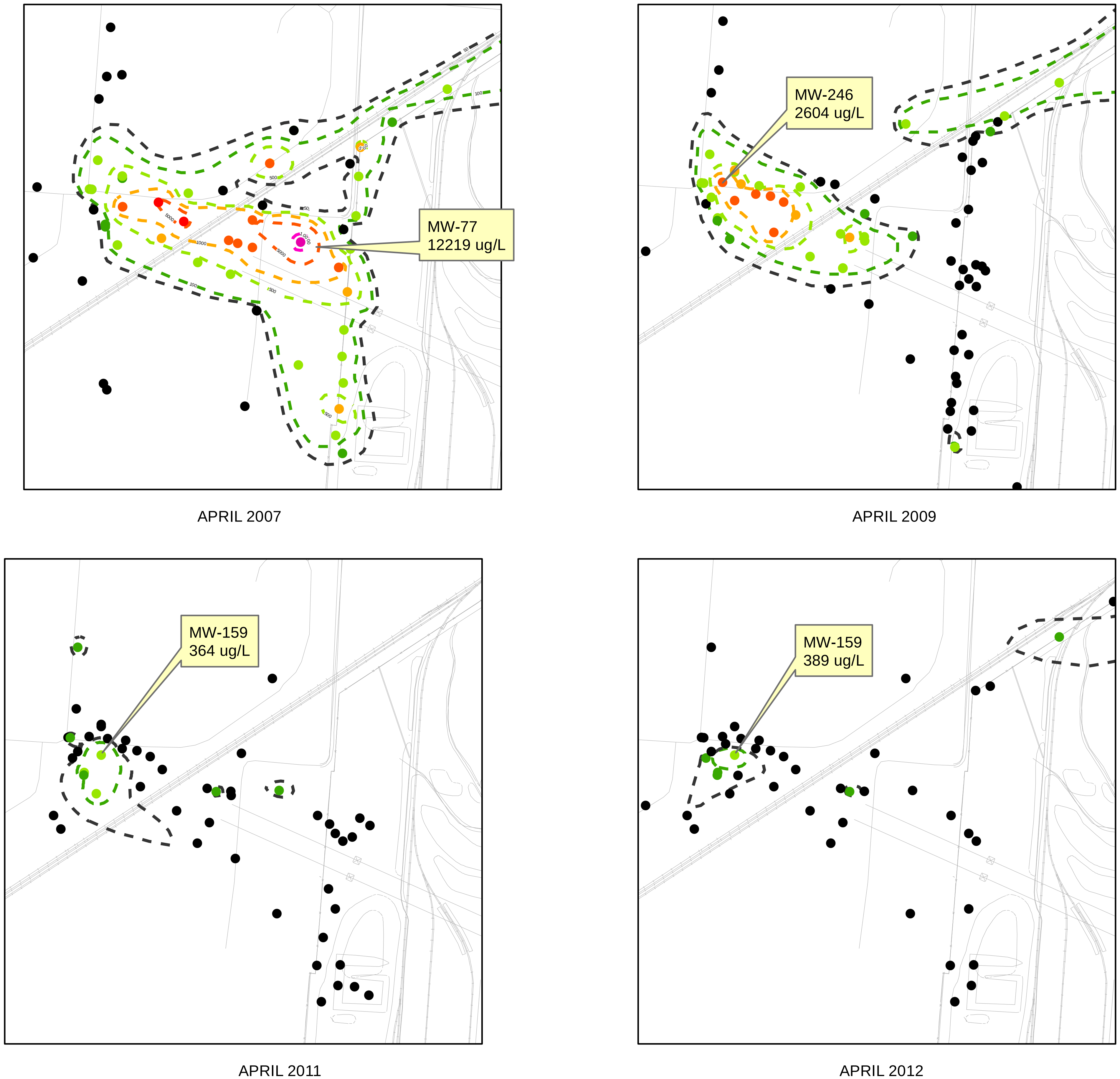


FIGURE 2-3
Total VOC Extent in Loess Deposits
Memphis Depot Dunn Field RDI TM



N
W E
S

Figure 13

DUNN FIELD TOTAL CVOC CONCENTRATIONS, 2007 - 2012

2013 SITE MANAGEMENT PLAN

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Legend

Total CVOC Isopleth (ug/L)

- 50
- 100
- 500
- 1000
- 5000
- 10000

Total CVOC Ranges (ug/L)

- 0 - 50
- 50 - 100
- 100 - 500
- 500 - 1000
- 1000 - 5000
- 5000 - 10000
- 10000 - 50000

0 200 400 600 800
Feet

Installation Location
Memphis, Tennessee

Date: October 2012
Edition: Rev 0

Path: G:\DDMT\2013 SMP\GIS\Figure 13.mxd

B

Appendix B

Historic Groundwater Analytical Results

MW-06

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW6	11/18/1993	219	9.1	ND	43.7	14.3	--	3.06	20.8	198	ND
MW062	6/21/1997	110	7 J	<20	45	16 J	--	4 J	--	260	<20
MW063	9/27/1997	220	9 J	<20	37	14 J	--	3 J	--	240	<20
MW064	3/30/1998	130	5 J	<10	15	6 J	--	1 J	--	94	<10
MW065	10/15/1998	220	8 J	<20	23	10 J	--	2 J	--	160	<20
MW06RD67	10/27/2004	613	20.9 J	<1	31.2 J	15.4 J	436	1.9 J	25.4 J	236	1.59 J
MW06-67	11/21/2005	237	10.1	<1	26.5	10.2	295	1.84	16.8	171	1.35 J
MW-06-SARA-GW01	5/16/2007	41	3.9	<1	16	6.2	200	1.4	11	120	0.68
MW6-69	11/7/2007	18.4	2.32	<1	13.8	8.55	150	1.14	6.33	78.1	0.484
MW-6-IS-4	4/15/2008	8.89	1.02	<1	3.78	84.7	36.2	1.07	1.45	32.5	<1
MW-06-TSVE-GW	8/19/2008	8.1	0.972	<1	1.35	29.4	23.1	0.365	0.926	14.2	<1
MW-6-IS-5	10/17/2008	5.57	0.674 J	<1	0.793 J	21.2	15	<1	0.458 J	8.6	<1
MW-6-IS-6	4/22/2009	3.23	<1	<1	0.463 J	6.17	4.91	0.254 J	<1	2.53	<1
MW-06-IS-7	10/13/2009	3.96	<1	<1	<1	5.48	3.78	<1	<1	2.44	<1
MW-006-ODLA-1	3/26/2010	2.67	<1	<1	<1	5.4	1.62	<1	<1	2.29	<1
MW-06	4/26/2011	0.807	<1	<1	<1	8.73	0.637 J	0.304 J	<1	3.34	<1
MW-06	7/19/2011	0.614	<1	<1	<1	4.88	0.41 J	<1	<1	1.75	<1
MW-06	4/19/2012	0.497 J	<1	<1	<1	2.9	0.311 J	<1	<1	1.06	<1
MW-06	10/17/2012	0.486 J	<1	<1	<1	2.72	0.569 J	<1	<1	0.938 J	<1
MW-06	4/12/2013	<0.5	<1	<1	<1	2.21	<1	<1	<1	0.707 J	<1
MW-06	10/10/2013	<0.5	<1	<1	<1	2.38	0.572 J	<1	<1	0.848 J	<1
MW-06	4/25/2014	0.201 J	<1	<1	<1	4.2	0.983 J	<1	<1	0.929 J	<1
MW-06	10/18/2014	<0.5	<1	<1	<1	9.05	3.59	<1	<1	1.32	<1
MW-06	4/10/2015	<0.5	<1	<1	<1	11	12.8	<1	<1	2.59	<1
MW-06	10/6/2015	<0.5	<1	<1	<1	4.03	3.35	<1	<1	0.89 J	<1
MW-06	4/25/2016	<0.5	<1	<1	<1	7.39	3.15 J	<1	<1	1.02	<1
MW-06	10/16/2016	<0.5	<1	<1	<1	7.4	2.5	<1	<1	0.66 J	<1
MW-06	4/22/2017	<0.5	<1	<1	<1	15.3	3.4	<1	<1	0.876 J	<1 U
MW-06	10/6/2017	<0.5	<1	<1	<1	8.03	2.08	<1	<1	0.375 J	<1
MW-06	4/7/2018	<0.5	<1	<1	<1	7.16	1.7	<1	<1	0.468 J	<1
MW-06	10/5/2018	<0.5	<1	<1	<1	7.1	1.45	<1	<1	0.299 J	<1
MW-06	4/6/2019	<0.5	<1	<1	<1	7.19	1.28	<1	<1	0.340 J	<1

MW-32

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-32	11/18/1993	162	7.69	ND	33	11.3	--	2	--	137	ND
MW-32	2/6/1996	66	4 J	ND	22	7 J	--	1 J	--	68	ND
MW-32	6/21/1997	91	5 J	<10	25	8 J	--	2 J	--	93	<10
MW-32	9/29/1997	110	5 J	<10	16	6 J	--	1 J	--	76	<10
MW-32	3/27/1998	140	6 J	<10	20	7 J	--	1 J	--	100	<10
MW-32	2/3/1999	5.67	1.54	<1	25.2	7.89	30.5	1.16	3.82	31.9	<1
MW-32	5/25/1999	4.42	<1	<1	14.2	32.2	16.7	1.28	1.76	28.1	<1
MW-32	8/26/1999	0.92 J	<1	<1	17.3	76.9	4.64	2.22	0.99 J	34.6	<1
MW-32	11/3/1999	<1	<1	<1	25.2	73	4.59	2.63	1.01	36.8	<1
MW-32	2/15/2000	<1	<1	<1	25.5	77.2	5.07	2.34	1.12	41.8	<1
MW-32	5/16/2000	<1	<1	<1	37	117	6.61	3.94	2	58.2	<1
MW-32	8/24/2000	2.12	<1	<1	47.2	171	5.66	5.9	2.68	89.2	<1
MW-32	11/9/2000	21.5	0.61 J	<1	61.3	372 J	8.55	6.39 J	4.53	94.8	<1
MW-32	2/20/2001	68.2	<1	<1	19.7	434	9.44	3.74	2.42	71.9	<1
MW-32	10/3/2001	216	<1	<1	42.7	828	12.6 J	<1	5.82 J	238	<1
MW-32	4/10/2002	24	0.59 J	<1	12.1	102	4.21	0.82 J	1.26	37.9	<1
MW-32	10/1/2002	14	<1	<1	12.3	91.5	3.49	1.41	0.72 J	34.8	<1
MW-32	4/8/2003	11	0.52	<1	1.18	50.2	9.16	<1	<1	13.5	<1
MW-32	10/28/2003	7.82	<1	<1	<1	50.9	7.97	<1	<1	13.4	<1
MW-32	4/29/2004	8.1	<1	<1	8.2	37	2	0.37 J	0.36 J	14	<1
MW-32	8/13/2004	21	<2.5	<2.5	7.6	68	2.8	0.97 J	<2.5	24	<2.5
MW-32	10/20/2004	3.6	<1	<1	2.3 J	17	1.7	<1	0.23 J	7.3	<1
MW-32	10/28/2004	17.1 J	0.379 J	<1 U	9.56 J	64.7 J	3.3 J	0.937 J	0.491 J	22 J	<1 U
MW-32	6/14/2005	3.72	<1	<1	2.83	11.5	1.65	<1	<1	4.1	<1
MW-32	11/16/2005	32.7	1.06	<1	12.3	131	4.99	1.55	<1	55	<1
MW-32	4/12/2006	46	1.28	<1	17.4	154	7.62	2.58	1.25	70	<1
MW-32	10/19/2006	21.7	0.594 J	<1	12.3	86	3.53	1.63	0.613 J	38	<1
MW-32	4/9/2007	1.59	<1	<1	3.95	8.63	1.14	0.82 J	<1	6.47	<1
MW-32	10/8/2007	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-32	4/11/2008	<0.5	<1	<1	<1	4.07	0.263 J	<1	<1	2.47	<1
MW-32	10/17/2008	<0.5	<1	<1	<1	0.2 J	2.09	<1	<1	3.65	<1
MW-32	4/15/2009	<0.5	<1	<1	<1	0.593	3.03	<1	<1	4.41	0.495 J
MW-32	10/14/2009	16.2	0.873 J	<1	20.2	176	10.3	5.41	1.97	113	<1
MW-32	3/26/2010	9.16	0.434 J	<1	6.71	60	6.27	2.43	0.926 J	38.3	<1
MW-32	4/26/2011	3.39	<1	<1	1.21	10.9	3.6	0.45 J	<1	6.92	<1

MW-37

Sample	Primary CVOCs MCL TC Date	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-37	11/18/1993	ND	ND	ND	ND	ND	--	ND	ND	ND	ND
MW-37	9/29/1996	<10	<10	<10	<10	<10	--	<10	--	<10	<10
MW-37	6/18/1997	<10	<10	<10	<10	<10	--	<10	--	<10	<10
MW-37	3/27/1998	<10	<10	<10	<10	<10	--	<10	--	<10	<10
MW-37	2/20/2001	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-37	4/10/2002	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-37	10/1/2002	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-37	4/8/2003	<1	<1	<1	<1	<1	<1	<1	<1	0.83	<1
MW-37	10/28/2003	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-37	4/29/2004	<1	<1	<1	<1	<1	<1	<1	<1 J	<1	<1
MW-37	10/21/2004	<1	<1	<1	<1 J	<1	<1	<1	<1	<1	<1
MW-37	6/14/2005	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-37	11/16/2005	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-37	4/12/2006	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-37	10/19/2006	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-37	4/9/2007	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-37	10/8/2007	0.788	<1	<1	4.12	6.01	0.29 J	0.637 J	<1	2.71	<1
MW-37	4/14/2008	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-37	10/17/2008	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-37	4/15/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-37	10/14/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-37	4/28/2011	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1

MW-71

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-71-Y2Q1	2/15/2000	97.7	3.21	<1	53.9	996	11.5	10	4.7	330	<1
MW71NA	3/24/2000	180	5 J	<10	47	1600	14	15	5 J	390	<10
MW-71	5/18/2000	181	4.54	<1	34	1080	9.98	7.35	3.72	239	<1
MW-71-Y2Q3	8/23/2000	168	4.04	<1	32.9	989	8.94	7.02	2.94	247	<1
MW-71-Y2Q4	11/9/2000	78.4	2.99	<1	26.5	605 J	6.49	4.09 J	2.29	95.6	<1
MW-71-Y3S2-B	10/3/2001	268	5.17 J	<1	22.6	857	9.09 J	<1	2.91 J	186	<1
MW-71-2_020410	4/10/2002	68.1	6	<1	20.3	828	9.64	1.96	3.36	70.9	<1
MW-71-2_021002	10/2/2002	9.49	<1	<1	11.2	8.89	1.12	<1	<1	27	<1
MW-71-2	4/8/2003	7.62	0.66	<1	17.6	35.4	1.59	1.31	0.52	44.5	<1
MW-71-2_031028	10/28/2003	27	<1	<1	6.87	88.8	1.59	<1	<1	17.4	<1
MW71 (74.4-76.4)	4/29/2004	3.8	<2	<2	8.2	56	0.98 J	0.54 J	<2	6.9	<2
MW71 73.86-75.86	10/21/2004	6	<1	<1	5.6 J	28	0.7 J	0.4 J	<1	12	<1
MW71RD73	10/28/2004	4.27	<1	<1	9.9	17.5	0.59 J	0.61 J	<1	6.95	<1
MW-71	6/14/2005	25.8	0.634 J	<1	12.8	103	1.86	1.58	0.532 J	34.9	<1
MW-71	11/16/2005	27.6	0.924 J	<1	14	94.2	10.6	2.1	<1	47.9	<1
MW-71	4/12/2006	26.3	0.766 J	<1	16.3	73.5	10.6	2.65	0.977 J	54	<1
MW-71	10/20/2006	22.9	1.16	<1	37.8	303	11.7	7.34	3.07	158 J	<1
MW-71-72.3-IS-2	4/11/2007	4.66	<1	<1	16.5	59.2	1.89	3.03	0.59 J	36.2	<1
MW-71-72.3-IS-3	10/8/2007	2.21	<1	<1	12.6	32.6	1.65	1.52	0.36 J	21	<1
MW-71-72.3-IS-4	4/14/2008	1.72	<1	<1	7.66	17.3	0.523 J	0.715 J	<1	9.37	<1
MW-71-74.28-IS-5	10/17/2008	5.32	<1	<1	5.94	27.2	0.717 J	0.856 J	<1	12.7	<1
MW-71-74.28-IS-6	4/15/2009	4.42	<1	<1	0.683 J	8.79	0.262 J	0.265 J	<1	3.93	<1
MW-71-IS-7	10/14/2009	7.97	<1	<1	0.301 J	3.79	<1	<1	<1	2.23	<1
MW-071-ODLA-1	3/26/2010	8.26	<1	<1	<1	1.47	<1	<1	<1	0.612 J	<1
MW-71	4/26/2011	0.892	<1	<1	<1	29.3	0.531 J	<1	<1	4.48	<1
MW-71	4/19/2012	0.953	<1	<1	0.53 J	10.6	<1	0.264 J	<1	3.02	<1
MW-71	4/13/2013	0.58	<1	<1	0.452 J	8.06	<1	<1	<1	2.39	<1
MW-71	4/25/2014	0.362 J	<1	<1	0.445 J	7.05	<1	0.323 J	<1	2.47	<1
MW-71	4/10/2015	<0.5	<1	<1	0.442 J	5.59	0.35 J	0.372 J	<1	3.05	<1
MW-71	4/24/2016	<0.5	<1	<1	0.252 J	5.08	0.599 J	0.367 J	<1	1.98	<1
MW-71	4/23/2017	<0.5	<1	<1	<1	2.13	<1	0.308 J	<1	1.03	<1
MW-71	4/7/2018	<0.5	<1	<1	<1	1.95	<1	0.326 J	<1	0.93 J	<1
MW-71	4/7/2019	<0.5	<1	<1	<1	0.844	<1	<1	<1	0.408 J	<1

MW-87

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW87-80.3FT	1/8/2001	140	6	0.2 J	32	6	210	2	17	150	0.9 J
MW87RD74	10/27/2004	10.2 J	0.799 J	<1	18.7 J	6.03 J	49.5 J	1.45 J	5.40 J	105 J	<1
MW87-77	11/21/2005	86.6	3.59	<1	8.18	3.88	65.4	0.95 J	3.49	64.2	<1 UJ
MW87-68	11/9/2007	180	6.67	<1	7.16	6.25	91.2	0.676	4.6	91.4	0.272
MW-87-IS-6	4/23/2009	0.939	<1	<1	<1	0.148 J	<1	<1	<1	<1	<1
MW-87-IS-7	10/13/2009	7.09	<1	<1	<1	0.471	0.391 J	<1	<1	0.778 J	<1
MW-087-ODLA-1	3/26/2010	12	0.653 J	<1	<1	1.04	1.38	<1	<1	2	<1
MW-87	4/26/2011	1.49	<1	<1	<1	3.04	0.398 J	<1	<1	0.985 J	<1
MW-87	7/19/2011	1.54	<1	<1	<1	3.05	0.547 J	<1	<1	0.897 J	<1
MW-87	4/19/2012	0.207 J	<1	<1	<1	0.53	<1	<1	<1	<1	<1
MW-87	10/17/2012	<0.5	<1	<1	<1	0.377	<1	<1	<1	<1	<1
MW-87	4/12/2013	<0.5	<1	<1	<1	0.254 J	0.32 J	<1	<1	<1	<1
MW-87	10/10/2013	<0.5	<1	<1	<1	3.46	<1	<1	<1	0.677 J	<1
MW-87	4/25/2014	<0.5	<1	<1	<1	19.3	2.01	0.273 J	<1	2.74	<1
MW-87	10/18/2014	0.671	0.287 J	<1	<1	56.2 J	6.71	0.379 J	<1	4.16	<1
MW-87	4/11/2015	0.904	0.578 J	<1	<1	63.1	8.82	0.358 J	<1	4.16	<1
MW-87	10/6/2015	1.5	0.713 J	<1	<1	49.5	4.91	0.345 J	<1	3.38	<1
MW-87	4/24/2016	1.91	1.19	<1	<1	59.8	5.81	0.421 J	<1	7.04	<1
MW-87	10/16/2016	2.41	2.29	<1	<1	70.1	5.84	0.286 J	<1	5.3	<1
MW-87	4/22/2017	1.18	1.55	<1	<1	100	7.57	0.463 J	0.293 J	7.32	<1
MW-87	10/6/2017	1.89	2.4	<1	<1	110	9.48	0.432 J	0.298 J	8	<1
MW-87	4/7/2018	4	4.33	<1	<1	97.9	8.28	0.325 J	<1	7.2	<1
MW-87	10/5/2018	3.75	6.4	<1	<1	125	11.8	0.274 J	0.365 J	11.9	<1
MW-87	4/6/2019	0.589	1.73	<1	<1	**93.4**	6.67	<1	<1	**8.79**	<1

MW-164

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-164	10/15/2004	<2.5	<2.5	<2.5	4	9.1	6.3	<2.5	0.97 J	60	<2.5
MW-164	6/15/2005	4.65 B	<1	<1	3.66	8.82	7.86	<1	1.22	53.3	<1
MW-164	11/14/2005	2.14	<1	<1	5.44	8.44 B	8.05	0.576	0.599 J	75.5	<1
MW-164	4/12/2006	2.6	<1	<1	2.99	9.56	6.87	0.637 J	0.974 J	62.9 J	<1
MW-164	10/19/2006	3.05	<1	<1	16.8	52.6	8.79	2.03	1.49	92.6	<1
MW-164	4/10/2007	45	1.75	<1	24.8	247	18.1	3.62	2.66	136 J	<1
MW-164	10/8/2007	17.7	0.719 J	<1	9.87	126	4.38	2.13	1.39	61.1	<1
MW-164	4/14/2008	13.4	0.517 J	<1 J	3.42 J	37.1	2.71	0.894	0.57 J	24.9 J	<1
MW-164	10/17/2008	6.83	0.403 J	<1	4.43	32.2	2.91	0.728 J	0.41 J	27	<1
MW-164	4/14/2009	20.8	1.07	<1	10.4	76.1	17.4	1.89	1.61	93.3	<1
MW-164	7/30/2009	26.3	1.27	<1	8.71	79.5	20.2	1.52	1.99	98.2	<1
MW-164	10/15/2009	32	1.41	<1	7.78	79.3	18.6	1.33	1.91	89.1	<1 UJ
MW-164	3/25/2010	21.3	1.07	<1	6.74	56.5	15	1.49	1.57	75.5	<1
MW-164	6/22/2010	21	0.909 J	<1	6.26	52.7	13.2	1.15	1.25	58.5	<1
MW-164	9/22/2010	11.9	0.524 J	<1	4.32	29.5	8.57	0.962 J	0.703 J	39.7	<1
MW-164	1/26/2011	5.48	0.284 J	<1	2.53	15.6	4.74	0.637 J	0.381 J	23.5	<1
MW-164	3/28/2011	4.08	<1	<1	2.06	13.9	3.8	0.383 J	0.357 J	17.8	<1
MW-164	9/27/2011	2.64	<1	<1	1.62	9	2.25	0.385 J	<1	12.1	<1
MW-164	4/19/2012	1.47	<1	<1	0.957 J	5.3	1.36	0.284 J	<1	6.97	<1
MW-164	10/17/2012	0.826	<1	<1	1.03	5.15	0.925 J	<1	<1	5.86	<1
MW-164	4/13/2013	0.578	<1	<1	0.9 J	4.65	0.905 J	0.306 J	<1	5.36	<1
MW-164	10/10/2013	0.35 J	<1	<1	0.454 J	2.03	0.474 J	<1	<1	2.75	<1
MW-164	4/26/2014	0.305 J	<1	<1	0.596 J	2.26	0.536 J	<1	<1	3.08	<1
MW-164	10/19/2014	<0.5	<1	<1	0.36 J	1.4	0.383 J	<1	<1	2.49	<1
MW-164	4/10/2015	<0.5	<1	<1	0.614 J	1.98	0.41 J	0.27 J	<1	2.78	<1
MW-164	10/6/2015	<0.5	<1	<1	0.5 J	1.85	0.497 J	<1	<1	2.44	<1
MW-164	5/23/2016	<0.5	<1	<1	<1	0.924	<1	<1	<1	1.25	<1
MW-164	10/17/2016	<0.5	<1	<1	<1	1.08	<1	<1	<1	1.39	<1
MW-164	4/23/2017	<0.5	<1	<1	<1	1.16	<1	<1	<1	1.21	<1
MW-164	4/7/2018	<0.5	<1	<1	<1	1.2	<1	<1	<1	1.01	<1
MW-164	4/7/2019	<0.5	<1	<1	<1	0.914	<1	<1	<1	0.891 J	<1

MW-175

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW175-73	11/19/2005	<1	<1	<1	<1	1.78	<1 U	0.52 J	<1	2.2	<1 UJ
MW-175-SARA-GW01	5/15/2007	<0.5	<1	<1	<1	0.48	<1	0.3	<1	0.39	<1
MW175-77	11/9/2007	<1	<1	<1	0.361	2.55	<1	<1	<1	1.17	<1
MW-175-IS-4	4/14/2008	<0.5	<1	<1	0.383 J	0.489	<1	0.317 J	<1	0.874 J	<1
MW-175-TSVE-G	8/18/2008	<0.5	<1	<1	<1	0.496	<1	0.28	<1	0.438	<1

MW-176

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW176-81	11/18/2005	<1	<1	<1	<1	0.21 J	<1	0.44 J	<1	0.73 J	<1 UJ
MW176-85	11/8/2007	<1	<1	<1	0.415	0.246	<1	0.287	<1	3.07	<1
MW-176-IS-6	4/23/2009	<0.5	<1	<1	<1	0.166 J	<1	<1	<1	0.579 J	<1
MW-176-IS-7	10/13/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-176-ODLA-1	3/26/2010	<0.5	<1	<1	<1	0.147 J	<1	<1	<1	<1	<1
MW-176	4/26/2011	<0.5	<1	<1	<1	0.208 J	<1	<1	<1	<1	<1
MW-176	4/18/2012	<0.5	<1	<1	<1	0.187 J	<1	<1	<1	<1	<1
MW-176	4/13/2013	<0.5	<1	<1	<1	0.275 J	<1	<1	<1	0.3 J	<1
MW-176	4/25/2014	<0.5	<1	<1	<1	0.193 J	<1	0.334 J	<1	<1	<1
MW-176	4/11/2015	<0.5	<1	<1	<1	<0.3	<1	0.279 J	<1	<1	<1
MW-176	4/24/2016	<0.5	<1	<1	<1	0.179 J	<1	0.328 J	<1	<1	<1
MW-176	4/22/2017	<0.5	<1	<1	<1	<0.3	<1	0.273 J	<1	<1	<1
MW-176	4/6/2019	<0.5	<1	<1	<1	0.137 J	<1	0.442 J	<1	<1	<1

MW-184

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW184-67	11/18/2005	1.74	<1	<1	8.08	32.6	1.43	0.69 J	0.33 J	12.6	<1 UJ
MW184-68	11/9/2007	<1	<1	<1	4.19	7.79	1.2	<1	0.27	9.47	<1
MW-184-IS-6	4/23/2009	<0.5	<1	<1	4.52	2.94	0.424 J	0.393 J	<1	2.27	<1 UJ
MW-184-IS-7	10/14/2009	5.06	<1	<1	13.4	117	5.61	4.98	1.63	84	<1
MW-184	4/28/2011	2.36	<1	<1	2.23	13.3	1.06	0.729 J	<1	7.77	<1
MW-184	4/19/2012	0.716	<1	<1	1.31	4.67	0.642 J	0.397 J	<1	2.83	<1
MW-184	5/9/2013	0.353 J	<1	<1	0.923 J	5.03	0.587 J	0.261 J	<1	2.7	<1
MW-184	10/10/2013	0.344 J	<1	<1	0.879 J	4.61	0.442 J	0.366 J	<1	2.29	<1
MW-184	4/26/2014	<0.5	<1	<1	1.01	2.67	0.528 J	0.355 J	<1	1.61	<1
MW-184	10/19/2014	0.211 J	<1	<1	0.958 J	3.17	0.633 J	0.429 J	<1	1.99	<1
MW-184	4/10/2015	<0.5	<1	<1	0.784 J	2.79	0.545 J	0.327 J	<1	1.79 B	<1
MW-184	5/23/2016	<0.5	<1	<1	0.62 J	1.83	0.431 J	<1	<1	1.17	<1
MW-184	4/23/2017	<0.5	<1	<1	0.542 J	1.4	0.396 J	0.272 J	<1	0.994 J	<1
MW-184	4/7/2018	<0.5	<1	<1	0.653 J	1.47	0.445 J	<1	<1	1.02	<1
MW-184	4/7/2019	<0.5	<1	<1	0.690 J	1.33	0.480 J	0.260 J	<1	0.937 J	<1

MW-187

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW187-84_060425	4/25/2006	<1	<1	<1	<1	0.13 J	<1	<1	<1	0.26 J	<1 UJ
MW-187-SARA-GW01	5/16/2007	<0.5	<1	<1	0.8	0.29	0.4	0.36	<1	3.7	<1
MW187-81	11/8/2007	0.141	<1	<1	<1	<1	<1	<1	<1	<1	<1
MW-187-IS-4	4/16/2008	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-187-TSVE-G	8/20/2008	<0.5	<1	<1	<1	0.139	<1	<1	<1	<1	<1
MW-187-IS-5	10/16/2008	<0.5	<1	<1	<1	0.183 J	<1	<1	<1	<1	<1
MW-187-IS-6	4/21/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-187-IS-7	10/15/2009	<0.5	<1	<1	<1	0.162 J	<1	0.253 J	<1	<1	<1
MW-187-ODLA-1	3/26/2010	<0.5	<1	<1	<1	0.149 J	<1	<1	<1	<1	<1
MW-187	4/28/2011	<0.5	<1	<1	<1	0.265 B	<1	0.312 J	<1	<1	<1
MW-187	4/12/2013	<0.5	<1	<1	<1	0.166 J	<1	0.267 J	<1	<1	<1
MW-187	4/10/2015	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-187	4/22/2017	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-187	4/7/2019	<0.5	<1	<1	<1	<0.5	<1	<1	<1	<1	<1

MW-231

Sample	Primary CVOCs MCL TC Date	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-231	4/14/2008	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-231	10/22/2008	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-231	4/17/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-231	10/14/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-231	4/28/2011	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1

MW-234

Sample	Primary CVOCs	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethene	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride
	MCL	-	5	7	5	80	70	5	100	5	2
	TC	2.2	1.9	7	3	12	35	2.5	50	5	-
Sample	Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-234	4/14/2008	0.469 J	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-234	10/22/2008	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-234	4/17/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-234	10/14/2009	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1
MW-234	4/28/2011	<0.5	<1	<1	<1	<0.3	<1	<1	<1	<1	<1

C

Appendix C

Field SOPs

STANDARD OPERATING PROCEDURE 1 - GENERAL PROCEDURES FOR FIELD PERSONNEL

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose

This Standard Operating Procedure (SOP) provides guidance for the general field practices to be followed during field activities at Defense Depot Memphis, Tennessee (DDMT); review is mandatory prior to the start of each field event. This SOP provides general guidance; the project-specific work plan must be reviewed for specific project requirements.

2 Health and Safety

Each individual assigned to field work must participate in the HDR Medical Monitoring Program, must have taken the Occupational Safety and Health Administration (OSHA) 40-Hour course (updated with the 8-Hour OSHA Refresher, when necessary), and must be certified as able to wear respiratory protection.

Each individual is required to have read and understood the project Site Safety and Health Plan (SSHP) for the specific project activity. Upon arrival at the site, each person shall sign the acknowledgement sheet confirming their review of the SSHP. Personal protective equipment (PPE) and other provisions for site safety requirements are discussed in the project specific Health and Safety plan.

All equipment will only be used by properly trained personnel. Only personnel that have received forklift operator safety training are permitted to use the forklift. Proper tools will be made available to each employee as necessary. Any questions should be addressed to the Field Team Leader (FTL).

3 Personnel Qualifications and Responsibilities

Field activities will be directed by the FTL, an environmental professional (engineer, geologist or scientist) with experience in performing and directing the planned activities. Field staff will be junior to mid-level environmental professionals or environmental technicians. Field work will be conducted by persons with experience in performing the planned activities. At least one person on each team will have a current certification in first aid and CPR.

The FTL will provide direction to field staff to ensure work is performed in accordance with the project documents (Quality Assurance Project Plan [QAPP], project work plan and SOPs). The field staff will carefully review the project documents, conduct the work as planned, seek direction from the FTL when questions or problems arise, and carefully complete field documentation.

4 Equipment and Supplies

The required equipment and supplies will be identified in the SOPs for the specific field activities to be performed and in the project work plan. Field activities should not proceed until the proper tools and equipment are available and in good working order.

Each team will have use of a truck/van during field activities. An initial safety check should be performed at the start of each shift to confirm the vehicle is in good working condition. The vehicle should then be checked daily for damage or required maintenance. For each HDR owned vehicle, mileage will be recorded on the vehicle mileage log at the start and end of each field event.

5 Procedure

5.1 Start-Up Activities

5.1.1 Office

Prior to leaving the office for field work, personnel will perform the following actions:

1. The Project Manager (PM) will assign an FTL to direct field activities and coordinate with project personnel. Task specific responsibilities of the FTL will be addressed in the appropriate SOP; general responsibilities include:
   a. Review project work plan, SSHP, and QAPP.
   b. Work with PM to properly staff the field activity.
   c. Coordinate sampling activities with the project chemist and analytical laboratory.
   d. Confirm availability and condition of DDMT-owned equipment and order additional equipment/supplies for delivery prior to the start of each event.
   e. Prepare field forms and other documentation for the planned event.
   f. If work is to be subcontracted, review the subcontract agreement, work plan, and SSHP.
   g. Confirm that field staff have Driver's License (or other picture identification) and current OSHA Certification in their possession prior to leaving the office.

5.1.2 Field

After arrival on site, but prior to commencement of operations, the following activities will be performed:

- Complete equipment and supply checklists and verify that required documentation and equipment for field activities are on site.
- Review condition of DDMT-owned and rental equipment; inventory field supplies and laboratory-provided sampling supplies.

- Review locations for planned field activities for hazards, determine requirements for site preparation and clearance, and select location for the storage of purge and decontamination waters.
- Conduct team safety meetings as required by the SSHP.
- Conduct team review of the project documents including SOPs to be utilized.
- Complete the Field Event Startup Report and submit to PM (Attachment 1-1).

5.2 Field Operations

Field staff responsibilities are project-specific. At a minimum, field personnel will perform the following activities:

1. Document field activities in a log book for each team and/or field records as required by the work plan or SOPs.
2. Record the following additional information for field measurements:
    a. The identification number and calibration results for each field instrument
    b. The numerical value and units of each measurement
    c. A description of any unexpected delays or problems observed during purging or sampling activities
3. Complete required data collection/sample control forms (e.g., Chain-of-Custody, Field Sampling Report, etc.).
4. Communicate with the PM regarding site conditions and out of scope work to be performed.
5. Perform following activities daily before leaving the site:
    a. Decontaminate and check condition of field equipment.
    b. Provide log books and other field documentation to FTL for review and scanning.
    c. Properly dispose of trash, debris and used PPE.
    d. Safely store purge and decontamination water, or transfer to large storage tanks at Dunn Field.
    e. Make arrangements for shipment of samples (if applicable) and follow-up with the analytical laboratory to confirm samples arrived in good condition.
    f. Complete activity-specific field reports as required by applicable SOPs.
    g. Complete the Daily Field Report and submit to PM (Attachment 1-2).

5.3 Field Log Books and Documentation

Dedicated log books will be used by each field team in addition to documentation required by activity-specific SOPs.

- The first page of each log book will list the following information:
    - Site Name: Former Defense Depot Memphis Tennessee

- EPA ID (TN4210020570)
- Project Location: 2241 Truitt Street, Memphis, TN 38114

- The first entry for each field event will list the following information: log books:
  - Project Name and Number
  - FTL (full name) and initials
  - Sample team leader and members (full names) and initials
- At minimum, the log book will describe general activities performed, date and time, personnel and weather conditions. All field equipment calibration and maintenance records will be documented in the logbook. Communications with the FTL, PM or project chemist regarding field activities will be documented. Additional field data will be recorded in the log book if other field records are not used.
- Any deviations from the QAPP or work plan will be noted in the log books.
- Errors will be crossed out with a single line, the correction added and the entry initialed.
- Each page will be numbered and dated. A diagonal line will be drawn through any unused portion of a page containing an entry. To indicate the end of an entry, personnel are required to initial and date the page at the conclusion of each day.

5.4 Closeout

Upon the completion of field activities, the FTL will view each site to verify the area has been cleared and restored as closely as possible to its prior condition. Trash will be removed from the site, and surface damage, including ruts caused by vehicles, will be repaired.

Confirm all equipment is accounted for and properly decontaminated and in good working condition. Notify PM if repairs are needed. Properly package and ship all rental equipment to the vendor. When shipping equipment, use the proper HDR FedEx number and insure the package for the cost of the equipment. Follow manufacturer’s instructions on long and short term storage when storing government and/or HDR equipment.

Rental trucks should be fueled and returned to the rental company as soon as possible. HDR leased trucks should also be fueled and cleaned prior to storing at the shop.

Work areas should be cleaned with tools and equipment properly stored.

The FTL will make a final check of all logbooks and other field records to ensure there are no blanks or missing data and the entries are legible. FTL will organize scanned forms in proper order and transmit to PM.

The FTL will complete Field Event Closeout Report and submit to PM (Attachment 1-3).

6 Data and Records Management

All field forms and log book entries will be scanned and copied to the project folder on the HDR network file share drive within one week of the field event completion. All photographs taken during the field event will be uploaded along with a typed photograph log (date, project and subject) to the HDR network file share drive. The photographs will then be erased from the camera. All original forms will be stored on site in Memphis in the filing cabinet in the proper folder labeled for the project. The PM, project chemist and project administrator will be sent a link for the data.

7 Quality Control and Quality Assurance

All work will be performed in accordance with the QAPP, the specific work plan, and applicable SOPs. All field activities will be recorded in the log books in sufficient detail to reconstruct the events. No erasures or mark outs will be made on field forms or log books. A single line will be used to strike out errors and will be annotated with the initials and date of the editor.

8 References

HDR, 2017a. *2017 Uniform Federal Policy-Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 0*. Prepared for the U.S. Army Corps of Engineers, Mobile District. May 2017.

USEPA Region 4 SESD Guidance, *Soil Sampling* (SESDPROC-010-4). October, 2010.

Field Event Startup Report

Prepared by: Date:

Event Name:

Project-Activity Number:

Summary of Planned Event:

Planned Performance Period: _______to___________

Project Documents - Title, Date

Work Plan:

Health and Safety Plan:

Other SOPs – List number/revision and title:

Field Event Staffing

Position	Name	OSHA Cert. (Y/N)	First Aid/ CPR (Y/N)	Driver's License (Y/N)	Proj. Plans reviewed (Y/N)	Experience (Hi-Med-Low-None)
Field Team Leader						

DDMT Field Equipment

Name/Use	Mfr./Model No.	Condition	Calibration Req'd.(Y/N)	Calibration supplies	Other supplies (batteries, etc.)

Rental Equipment

Name/Use	Mfr./Model No.	Condition	Calibration Req'd.(Y/N)	Calibration supplies	Other supplies (batteries, etc.)

Lab-provided Sampling Supplies

Sample Type	Number	Supplies

Additional Tools/Supplies

Camera
Field forms (list):
Sample supplies (list):
Water/Ice cooler
Sample cooler

Final Check

1. All required equipment/tools received and condition checked

Yes ___ No ___ Comment:

2. Initial equipment calibration completed

Yes ___ No ___ Comment:

3. Vehicles inspected

Yes ___ No ___ Comment:

4. Field locations reviewed

Yes ___ No ___ Comment:

5. Weather forecast checked

Yes ___ No ___ Comment:

6. Staff documents (OSHA, DL) checked

Yes ___ No ___ Comment:

7. Review of project plans confirmed and activities discussed

Yes ___ No ___ Comment:

8. Initial Safety Meeting held and SSHP signed

Yes ___ No ___ Comment:

Daily Field Report

Project Number/Activity:	**Date:**
Project Name:	**Field Team Leader:**
Brief Work Description:	

Weather:	**Temp:**

Previous Day's Samples received at laboratory – Y / N Comment:

Time	Description

Name/Organization of Field Staff, Subcontractors and Site Visitors	

Samples Collected

Problems or Deviations from Work Plan

Tasks to be completed next workday

Name ______ **Signature** ______ **Date** ______

Field Event Close-Out Report

Prepared by: Date:

Event Name:

Project-Activity Number:

Performance Period: ________to__________

Field Team Leader:

Field Staff:

Summary of Completed Event:

Field problems and/or changes from planned activities:

Change in number/type of samples collected:

Health and Safety problems/Injuries:

Close-out Checklist

1. Log book and field forms scanned and originals placed in project file

Yes ___ No ___ Comment:

2. Equipment/tools decontaminated

Yes ___ No ___ Comment:

3. Rental equipment shipped to supplier

Yes ___ No ___ Comment:

4. Rental vehicles returned

Yes ___ No ___ Comment:

5. DDMT equipment and tools properly stored

Yes ___ No ___ Comment:

6. List damaged equipment

Yes ___ No ___ Comment:

7. Replacement supplies ordered

Yes ___ No ___ Comment:

8. Field locations inspected and trash/debris removed

Yes ___ No ___ Comment:

9. Field shop/office cleaned

Yes ___ No ___ Comment:

STANDARD OPERATING PROCEDURE 2 – DRILLING AND SAMPLING

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

This Standard Operating Procedure (SOP) provides guidance for drilling and soil sampling operations in support of investigative activities at Defense Depot Memphis, Tennessee (DDMT). Drilling activities will enable collection of subsurface samples and allow the installation of monitoring wells. This SOP provides general guidance; the project-specific work plan must be reviewed for specific project requirements.

2 Overview

There are several methods by which drilling operations may be conducted including manual (hand) augering, power augering with hollow-stem augers, direct push technology (DPT), sonic drilling, and cable tool or mud rotary drilling with installation of surface casing. Generally, hand augering is useful only for surficial soil sampling while the other methods are used for deeper, subsurface investigations, sampling and installation of monitoring wells. Sonic drilling is the recommended drilling method for well installation at DDMT; it has proven to be the most effective method for boring advancement and well installation based on the depth to water (i.e. 75-105 feet below ground surface [ft bgs]) and geologic characteristics of the fluvial aquifer (i.e. tight sands mixed with gravel up to cobble size).

Drilling activities that require the use of a truck-mounted drill rig will be conducted by a Tennessee-licensed subcontractor with experience on similar projects. The drilling subcontractor will advance boring to the target depth using the selected drilling technology and provide equipment sufficient to carry out the work as specified. Drilling and sampling will be overseen by the field team leader (FTL), an environmental professional (engineer, geologist or scientist), with support staff if required. HDR personnel will prepare soil boring logs with lithologic descriptions and observations relevant to investigative activities, collect samples for field, geotechnical or laboratory analysis and monitor compliance with the project Site Safety and Health Plan (SSHP).

3 Health and Safety

Proper safety precautions must be observed during drilling activities and when collecting samples in accordance with the SSHP. Each individual assigned to field work must: (1) participate in the HDR Medical Monitoring Program, or subcontractor medical surveillance program, as applicable, (2) must have taken the Occupational Safety and Health Administration (OSHA) 40-Hour course (updated with the 8-Hour OSHA Refresher, when necessary), and (3) must be certified as able to wear respiratory protection.

Each individual is required to have read and understood the SSHP for the specific project activity. Upon arrival at the site, each person shall sign the acknowledgement sheet confirming their review of the SSHP. Personal protective equipment (PPE) and other provisions for site safety requirements are discussed in the SSHP. At a minimum for drilling, personnel will wear a hard hat, steel toe shoes, safety glasses, hearing protection, and a high visibility outer garment.

Equipment will only be used by properly trained personnel. In particular, the use of a photoionization detector (PID) will only be performed by personnel familiar with the equipment. Proper tools will be made available to each employee as necessary. Questions should be addressed to the FTL.

Drilling locations will be cleared for underground and above ground utilities prior to beginning drilling activities. Prior to setting up on the drilling location, the FTL will confirm the location has been cleared with the appropriate utility companies and the property owner/tenant. Drilling will only proceed where no aboveground or subsurface obstructions exist. Locations will be offset if these obstructions are identified prior to drilling, or encountered after drilling has begun. The new locations will be as close as possible to the originally proposed locations; utility clearance will be performed again as necessary.

If drilling is to occur in the vicinity of overhead utilities, HDR personnel will measure utility line height from the ground surface using a clinometer (or similar device) to ensure a minimum safe clearance distance is maintained between on-site equipment and overhead utility lines. As needed, the appropriate utility company will be contacted in order to determine a recommended safe clearance distance from aboveground or underground on-site utilities.

Prior to the start of drilling activities, the drilling subcontractor will hand clear each drilling location to a depth of at least 4 ft bgs, in order to verify that underground utilities or other hazards are not present.

4 Personnel Qualifications and Responsibilities

Field activities will be directed by the FTL, an engineer/geologist with experience in the planned drilling activities; junior to mid-level geologists will assist, if necessary. Field activities will be overseen by a Tennessee-licensed geologist or engineer. Drilling will be conducted by a licensed driller and crew familiar with planned activities, the project-specific work plan and SSHP. At least one person on each team will have a current certification in first aid and CPR. Operation of fork lifts on site will be limited to personnel that have documentation for forklift operator safety training.

The FTL will provide direction to field staff to ensure work is performed in accordance with the project documents (Quality Assurance Project Plan [QAPP], project-specific work plan, SSHP, and SOPs). The field staff will carefully review the project documents, conduct the work as planned, seek direction from the FTL when questions or problems arise, and carefully complete field documentation.

5 Equipment and Supplies

The required equipment and supplies will be identified in the project-specific work plan. Field activities should not proceed until the proper tools and equipment are available and in good working order. Usual equipment/supplies for a drilling project will include: a PID, tape measure, Munsell color chart, knife, PPE, field drill log forms, camera, sample containers and work table.

Each team will have use of a truck/van during field activities. An initial safety check should be performed at the start of each shift to confirm the vehicle is in good working condition. The vehicle should then be checked daily for damage or required maintenance.

6 Procedures

6.1 Start-Up Activities

6.1.1 Office

Prior to leaving the office for field work, personnel will perform the following actions:

1. The Project Manager (PM) will assign a FTL to direct field activities and coordinate with project personnel. Task specific responsibilities of the FTL will be addressed in the appropriate SOP; general responsibilities include:
    a. Review project-specific work plan, SSHP, QAPP, and for subcontracted work, review of the subcontract agreement.
    b. Work with PM to properly staff the field activity.
    c. Arrange site access with the property manager (Colliers International-Memphis Depot Industrial Park), tenants and/or property owners.
    d. Locate the proposed drilling locations, and mark each location with a wooden stake and white flagging or white paint.
    e. Notify the Tennessee One Call underground utility location and, if necessary, a private utility location service.
    f. Provide drilling subcontractor with proposed boring location and depth for well permits from Shelby County Health Department (SCHD); confirm receipt of permits.
    g. Coordinate sampling activities and supplies with the project chemist and analytical laboratory.
    h. Confirm availability and condition of DDMT-owned equipment and order additional equipment/supplies for delivery prior to the start of each event.
    i. Prepare field forms and other documentation for the planned event.
    j. Provide all HDR and subcontracted field personnel with time and location for personnel to meet prior to beginning field activities.
    k. Confirm that field staff have a valid Driver's License (or other picture identification) in their possession prior to leaving the office and current OSHA Certification.

6.1.2 Field

After arrival on site, but prior to commencement of operations, the following activities will be performed:

- Complete equipment and supply checklists and verify that required documentation and equipment for drilling and soil sampling activities are on site.
- Notify SCHD prior to start of drilling activities in accordance with permit requirements.
- Review condition of DDMT-owned and rental equipment; inventory field supplies and laboratory-provided sampling supplies.
- Confirm drilling and soil sampling locations are clearly marked and review locations for hazards; determine if the utility locators have adequately marked utilities on the site. Check for overhead dangers such as power lines, and make necessary height measurements to ensure safe clearance distances are maintained.
- Determine requirements for site preparation and clearance, and select location for the placement of the decontamination area, storage of decontamination waters, and soil cuttings.
- Confirm locations and requirements for each sample to be collected.
- Conduct site set up activities to include posting of signage (if applicable) and delineation of work zones as required in the SSHP.
- Calibrate field equipment.
- Conduct team safety meetings as required by the SSHP.
- Conduct team review of the project documents including SOPs to be utilized.
- Complete the Field Event Startup Report (SOP 1 *General Procedures for Field Personnel*) and submit to PM.

6.2 Field Operations

Field staff responsibilities are project-specific. At a minimum, field personnel are required to ensure the following items are completed as part of field operations during drilling and soil sampling activities.

6.2.1 Field Documentation

Field activities will be documented in a bound logbook for each team and in field records as required by the project-specific work plan or SOPs. At minimum, the logbook will describe general activities performed, date and time, personnel performing the activity, and weather conditions.

For field measurements, the following additional information will be required:

- The numerical value and units of each measurement
- The identity of and calibration results for each field instrument

For sampling activities, the following additional information will be required:

- Sampling type and method
- The identity of each sample and the depth(s) from which it was obtained
- The amount of each sample
- Sample description (e.g., color, odor, clarity)
- Identification of sampling devices
- Identification of conditions that might reflect representativeness of a sample (e.g., refueling operations, damaged well casings)

Field personnel will complete required data collection/sample control forms (e.g., Chain-of-Custody [COC], Drill logs, Field Sampling Report, etc.).

6.2.2 Drilling Logs

The geologist/engineer will log the subsurface conditions encountered in the boring, and record the information on the drilling log and/or the logbook. Additional pertinent information will be recorded on the drilling log, including, but not limited to, the following:

- Drilling date
- Drilling method
- Geologist name
- Location of boring/Boring identification
- Driller's name/Drilling subcontractor name/Type of drill rig
- Diameter of inner and outer drill casings
- Diameter of surface casing, casing type and method of installation
- Types of drilling fluids and depths at which they were used
- Weather conditions
- Start and completion time for each boring
- Standard Penetration Test blow counts per six inch advance, if applicable
- Recovery length of each sample
- Visual description of soil using the Unified Soil Classification System (USCS) (ASTM-D-2488-00)
- Depths at which each soil sample was collected for chemical or physical analysis
- Total number of samples taken
- Total depth of boring
- Boring refusal
- Water losses (if applicable)
- Water bearing strata (depth and thickness)

- Depth at which saturated conditions were first encountered
- Lithologic descriptions and depths of lithologic boundaries
- Zones of caving or heaving
- Depths at which drilling fluid was lost and amount lost
- Drilling rate
- Drill rig reactions such as chatter, rod drops, or bouncing
- Location of the boring relative to an easily identifiable landmark.

6.2.3 Drilling Procedures

Generally, drilling activities will be completed in accordance with the planned activities presented in project work plan. Additionally, the following requirements will apply to drilling activities at DDMT:

- Drilling will conform to Shelby County rules and regulations, and Rules of Tennessee Department of Environment and Conservation (TDEC), Division of Water Supply, Chapter 12-4-10.
- All necessary precautions will be taken to prevent leakage of hydraulic oil or other contaminants from the drilling rig into the borehole or onto equipment that is placed in the hole.
- The only acceptable drilling fluid to be used while advancing the borehole is water. However, water will be used only when necessary as approved by the FTL, and will be from an approved potable water source, if the onsite subcontractor and HDR personnel determine drilling fluid additives (e.g. sodium bentonite) are necessary for drilling operations. PM authorization must be obtained prior to their use.
- During drilling of boreholes with a sonic rig, soil will be collected continuously as 10-foot sections of soil core. These cores will be deposited from the drill casing into 10-foot polyethylene liners.
- During drilling of boreholes with DPT, soil core will be collected continuously in 4-foot sections in clear plastic liners. .
- The HDR geologist/engineer will maintain visual and verbal communication with the onsite subcontracted driller in order to maintain awareness of any changes in subsurface conditions, amount of water used (if any) during drilling, quantities of materials used during drilling and well installation, or any mechanical problems with the drill rig or support equipment.
- The HDR geologist/engineer will carefully and thoroughly complete all required field documentation in order to provide a complete record of drilling activities, including drill rig maintenance and repairs, subcontractor down time, subsurface conditions and geologic materials encountered.
- The HDR geologist/engineer will determine and record the depth to groundwater observed during drilling.

- When the HDR geologist/engineer is finished with visual logging and sampling soil core, the drilling subcontractor will place the core in an approved container for disposal of soil cuttings.
- During drilling activities, the drilling subcontractor will notify the onsite HDR geologist/engineer of any significant changes in lithology encountered, significant changes in amount of water being used, and any mechanical problems with the drill rig.
- The HDR geologist/engineer will monitor the breathing zone for organic vapors in accordance with the procedures contained in the SSHP. The tops of the boreholes will be monitored for organic vapors using a PID.
- The HDR geologist/engineer collect soil samples at specified intervals in borings for soil classification and/or chemical analysis or field screening as specified in the project-specific work plan.
- Drilling equipment will be decontaminated prior to drilling activities in accordance with SOP 9 *Equipment Decontamination*.
- Investigative-derived waste (i.e., drill cuttings, drilling fluid) will be characterized and disposed as specified in the project work plan.
- Soil cuttings will be examined (e.g. olfactory, PID, and visual inspection) for contamination. If contamination is suspected, the finding will be noted on the boring log form and the contaminated soil cuttings will be segregated.
- The HDR geologist/engineer will communicate with the PM regarding site conditions and out of scope work to be performed.

6.2.4 Boring Diameter

Soil boring diameter and drilling method shall be established in a project specific work plan and selected based on the boring purpose. Shallow borings advanced for the purpose of soil or soil vapor sampling may only need to 1.25 inch in diameter while borings advanced to construct monitoring wells in conductor casings may be 12 inches in diameter. Some drilling methods and their respective boring diameter are listed below.

6.2.4.1 Sonic Drilling

The boring diameter is based on a minimum of 2 inches of annular space between the outside diameter of the well casing and the borehole wall. The majority of borings at DDMT are advanced via sonic drilling methods for monitoring well construction in the fluvial aquifer, which is underlain by the uppermost clay of the Jackson Formation/Upper Claiborne Group. For these borings, a 6-inch diameter borehole is advanced 5-10 feet into the clay; after the depth to the clay is confirmed, the boring is back-filled to just below the top of clay with bentonite chips. A borehole diameter of 6 inches allows proper installation of a nominal 2-inch outside diameter well casing.

For wells to be installed in the deeper intermediate or Memphis aquifer, a surface casing is typically installed into the uppermost clay of the Jackson Formation/Upper Claiborne Group in order to prevent cross contamination between formations. For the deeper borings, a 12-inch diameter borehole will be advanced 10 feet into the uppermost clay and an 8-inch diameter surface casing will be installed, either welded sections of carbon steel or threaded Schedule 80 polyvinyl chloride

(PVC). After placing the surface casing, the driller will lower a tremie pipe connected to a grout pumping unit through the outer annulus of the casing. The driller will pump grout through the tremie pipe until the grout returns to the ground surface. The grout will cure for 24 hours before continuing to advance the borehole. Water present in the inner annulus of the casing will be pumped to a holding tank before the borehole is advanced to the target depth. A 6-inch diameter borehole will then be advanced to the target depth for installation of a 2-inch diameter well.

6.2.4.2 DPT Drilling

DPT drilling at DDMT is performed for the purpose of soil, groundwater and soil vapor sampling using the Geoprobe dual tube system. The dual tube system uses a 2.25-inch outer diameter (OD) drive rod and cutting shoe attached to the leading edge of the rod string. As the drive rod is advanced into the subsurface, the cutting shoe shears a 1.125-inch OD soil core which is collected in a clear plastic liner inside the drive rod.

6.2.5 Soil Sampling Procedures

During drilling of boreholes with a sonic rig, soil samples will be collected continuously as 10-foot sections of soil cores. These cores are deposited from the drill casing into 10-foot polyethylene liners, and the liners laid out for visual logging, and to obtain samples for headspace readings and laboratory analysis, if required by the project work plan.

During drilling of boreholes with DPT, soil samples are collected continuously as 4-foot sections of soil cores. The cores are sheared by the soil cutting shoe and deposited into the clear plastic liner as the drive rod is advanced. The plastic liners are cut lengthwise and laid out for visual logging, and to obtain samples for headspace readings and laboratory analysis, if required by the project work plan.

During advancement of the soil borings, the following sampling devices with sand catchers to retain loose material may also be used:

- Chemical Sample Collection (undisturbed): 2 or 3-inch diameter carbon steel California modified split spoon sampler lined with brass rings or stainless steel liners.
- Geotechnical Sample (undisturbed) Collection: 2-inch diameter carbon steel split-barrel sampler with brass or stainless steel liners.
- Geotechnical Sample (undisturbed) Collection: 3-inch diameter “Shelby Tube” or thin-walled tube sampler

6.2.5.1 Soil Description

Soils will generally be described in accordance with the 1990 ASTM D-2488-90, *Standard Practice for Description and Identification of Soils* (Visual-Manual Procedure). Descriptive information to be recorded in the field will include:

- Identification of the predominant particle size and range of particle sizes
- Percent of gravel, sand, fines, or all three
- Description of grading and sorting of coarse particles

- Particle angularity and shape
- Maximum particle size or dimension

The plasticity of fines description will include:

- Color using Munsell Color System
- Moisture (dry, wet, or moist)
- Consistency of fine grained soils
- Structure of consolidated materials
- Cementation (weak, moderate, or strong)

The USCS group symbols will be used for identification. Additional information to be recorded includes: depth to the water table, caving or sloughing of the borehole, changes in drilling rate, depths of laboratory sample collection, presence of organic materials, presence of fractures or voids in consolidated materials, and other noteworthy observations or conditions, such as the locations of geologic boundaries.

6.2.5.2 Headspace Sampling

At five-foot intervals within the soil cores, the headspace will be screened with a PID. The headspace samples will be collected and analyzed using the following procedure:

- From the sampling location within the soil core, remove the top 1 to 2 inches of soil using a decontaminated stainless steel spoon or gloved hand.
- Partially fill one decontaminated 16-ounce container or zip top bag with soil using the stainless steel spoon or gloved hand.
- Cover the jar immediately with aluminum foil and fasten the jar lid or seal the zip top bag.
- Allow the sample vapors to equilibrate (approximately 5 minutes). If necessary, the headspace samples will be brought to a temperature of 20 degrees Celsius (°C) (68 degrees Fahrenheit [°F]) to 32°C (90°F) by placing in sunlight.
- Collect a reading from the first sample jar by puncturing the aluminum foil or inserting the tip of a calibrated PID into the bag and recording the highest reading.
- If the reading is > 10 parts per million, collect a second reading with the activated charcoal filter on the calibrated PID. Determine corrected hydrocarbon measurement of the sample by subtracting the filtered reading from the unfiltered reading.

6.2.5.3 Soil Sample Collection for Laboratory Analysis

Selected soil samples may be collected for laboratory analysis based upon the results of the headspace screening. At these selected locations, samples for volatile organic compound (VOC) analysis will be collected using an Encore or Terracore sampler, or acceptable equivalent. (Note: There is no difference in field criteria for the two samplers. Different laboratories supply different devices and there is a difference in cost). Samples collected for VOC analysis should be collected from the soil cores in a manner that minimizes disturbance of the sample.

The following items should be considered when collecting soil samples:

- A clean pair of new, non-powdered, disposable gloves will be worn each time a sample is collected.
- Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned in accordance with SOP 9 *Equipment Decontamination*.
- Document field sampling, including field conditions, problems encountered during sampling and sample appearance, in the field logbook. Samples collected will also be noted on the drilling log sheet at the corresponding depth.
- Place unused sample material into the approved transport/disposal containers along with other drill cuttings generated during sonic drilling activities.
- When soil sampling is completed or when time permits, transfer samples to site office for final packaging. Complete COC documentation and shipping procedures in accordance with relevant SOPs. The completed COC will remain with the samples until custody is relinquished.
- Note problems encountered during sampling in the Field Sampling Report Form and Daily Quality Control Report Form.

6.2.5.3.1 Encore ™ Sampler Procedure

The procedure for collection of VOC samples using an Encore ™ Sampler are as follows:

- Remove sampler and cap from package and attach T-handle to the sampler body.
- Quickly push the sampler into a freshly exposed surface of soil until the sampler is full.
- Carefully wipe the exterior of the sampler head with a clean disposable paper towel so that the cap can be tightly attached.
- Push cap on with a twisting motion to attach and seal the sampler.
- Attach the label onto the sampler body, place the sampler into a plastic Ziploc™ bag and place into a cooler with ice.
- Repeat steps through for the remaining sampler(s) as necessary.
- Collect a bulk soil sample for screening and moisture determination in a 2 or 4-ounce wide mouth glass or polyethylene jar. Fill the jar completely allowing no headspace. Place the sample in a cooler containing ice.
- Thoroughly mix remaining soil and place into specified labeled containers for remaining parameters.
- Place sample bottles into Ziploc™ or bubble bag and in an iced cooler.
- Complete COC documentation and shipping procedures in accordance with relevant SOPs.

6.2.5.3.2 Terracore Sampler Procedures

The procedure for collection of VOC samples using a Terracore Sampler are as follows:

- Label appropriate laboratory containers
- Quickly push the sampler (Terracore or equivalent) into a freshly exposed surface of soil to collect 5 grams (+ 0.5g) of sample. Also collect a bulk aliquot container for moisture content analysis in the laboratory supplied 4 ounce container.
- Carefully wipe the exterior of the sampler head with a clean disposable paper towel.
- Empty sampler into appropriate laboratory container. The cored samples must be extruded from the selected coring tool to a volatile organic analysis (VOA) vial in accordance with collection and preservation methods described in EPA method 5035A. The extruded core is transferred into a laboratory pre-weighed (tared) VOA vial. The VOA threads should be wiped with a new paper towel to remove soil and the VOA capped with septum cap. Unpreserved VOA vials must be analyzed within 48 hours of collection, VOA vials preserved with sodium bisulfate or methanol must be analyzed within 14 days of collection.
- Place the sample into a plastic Ziploc™ bag and place into a cooler with ice.
- Complete COC documentation and shipping procedures in accordance with relevant SOPs.

6.2.5.4 Grab Groundwater Sample Collection for Laboratory Analysis

The Geoprobe® Screen Point 15/16 Groundwater Sampler is a discrete interval ground water sampling device that can be pushed to pre-selected sampling depths in saturated, unconsolidated materials. Once the target depth has been reached, the screen is opened and groundwater can be sampled as a temporary monitoring well, which yields a representative, uncompromised sample from that depth. Methods to install and operate the SP 16 in accordance with SESDGUID-101-R1 are listed below:

- Attach drive cap to top of sampler and slowly drive it into the ground. Raise the hammer assembly, remove the drive cap and place an O-ring* in the top groove of the drive head. Add a probe rod and continue to push the rod string.
- Continue to add probe rods until the desired sampling depth is reached.
- When the desired sampling depth is reached, re-position the probe derrick and position either the casing puller assembly or the rod grip puller over the top of the top probe rod.
- Thread a screen push adapter on an extension rod and attach sufficient additional extension rods to reach the top of the Screen Point® 15/16 sampler. Add an extension handle to the top of the string of extension rods and run this into the probe rod, resting the screen push adapter on top of the sampler.
- To expose the screened portion of the sampler, exert downward pressure on the sampler, using the extension rod and push adapter, while pulling the probe rod upward. To expose the entire open portion of the screen, pull the probe rod upward approximately 41 inches.
- At this point, the Screen Point® 15/16 Groundwater Sampler has been installed as a temporary well and may be sampled using appropriate ground water sampling methodology.

6.2.6 Post Run Tubing Boring Construction

Post run tubing (PRT) drill rod will be advanced into the subsurface to the target depth via DPT. After reaching the desired depth, the PRT rod will be retracted approximately 6 inches exposing the soil interval to be sampled. Teflon® tubing will be threaded into the PRT adaptor through the center of the PRT rod and capped to prevent soil gas venting. The annulus around the PRT rod where it penetrates ground surface will be packed with bentonite crumbles and hydrated. The boring will not be disturbed or sampled for a minimum of 2 hours to allow the bentonite crumbles to seal the annulus and allow soil gas to equilibrate. After the soil gas sample has been collected, the PRT drill rod and tubing will be removed from the boring and the boring will be filled to ground surface with neat cement.

6.3 Soil Boring Abandonment

Vadose zone soil borings advanced to 15-feet bgs or less can be abandoned by filling the boring with neat cement from the ground surface. Borings advanced greater than 15 ft bgs shall be grouted from the bottom up as the drill string is removed. A tremie pipe will be lowered through the drill string to the base of the boring. Type II Portland cement with 3 to 5 percent bentonite powder will be mixed at a ratio of 7.2 to 8.5 gallons of potable water to one sack (94 pounds) of dry cement. The grout shall be thoroughly mixed to a smooth, uniform consistency, with no lumps or balls. The bentonite grout will be pumped through the tremie pipe to displace groundwater as the drill string is removed. The bentonite grout shall fill the boring to within 2 ft of ground surface and rechecked for settlement after at least 12 hours. If grout has settled, the boring shall be topped off and the ground surface restored to match adjacent conditions.

6.4 Closeout

6.4.1 Daily Closeout

Perform following activities daily before leaving the site:

- Decontaminate and check condition of field equipment.
- Provide logbooks and other field documentation to FTL for review.
- Properly dispose of trash, debris and used PPE.
- Make arrangements for shipment of samples (if applicable) and follow-up with the analytical laboratory to confirm samples arrived in good condition.
- Secure the site for the night and/or weekend.
- Prepare the daily field report as required by the project-specific work plan or SOPs and submit report to the PM. Note any problems or deficiencies in field activities.

6.4.2 Field Event Closeout

Upon completion of field activities, the FTL will view each site to verify the area has been cleared and restored as closely as possible to its prior condition. The following activities will be performed prior to the completion of each field event:

- All trash will be removed from site and disposed of appropriately
- Any damage to the ground surface, including ruts, will be repaired
- All equipment is accounted for, properly decontaminated, and in good working condition. The FTL will be notified if repairs are needed
- Rental equipment has been properly cleaned, packaged, and shipped to the appropriate vendor
- Shipments are made using the correct HDR FedEx number and packages insured for the cost of the rental item
- Manufacturer's instructions are followed regarding long and short term storage for all equipment
- Rental vehicles are refueled and returned to the rental company
- HDR leased vehicles are cleaned and refueled
- All work areas have been cleaned, and tools and equipment have been stored properly

The FTL will make a final check of all drilling logs, logbooks and other field records to ensure there are no blanks or missing data and the entries are legible. The FTL will complete Field Event Closeout Report and submit to PM.

7 Data and Records Management

All field forms and logbook entries will be scanned and copied to the project folder on the network file share drive within one week of the field event completion. All photographs taken during the field event will also be uploaded along with a typed photograph log (date, project and subject) to the network file share. All uploaded photographs will then be erased from the camera. All original forms will be stored on site at the field office in Memphis in the appropriate project-specific filing cabinet and task-specific labeled folder.

8 Quality Control and Quality Assurance

All work will be performed in accordance with the QAPP, the project-specific work plan, and applicable SOPs. All field activities will be recorded in the logbooks in sufficient detail to reconstruct the events. No erasures or mark outs will be made on field forms or logbooks. A single line will be used to strike out errors and will be annotated with the initials and date of the editor. Boring logs will be typed into a spreadsheet provided by the CAD operator for the inclusion into computerized drill logs.

9 References

HDR, 2018a. DDMT Uniform Federal Policy-Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 1. Prepared for the U.S. Army Corps of Engineers, Mobile District. March 2018.

Shelby County Health Department, Pollution Control Section, Water Quality Branch, <http://www.shelbycountytn.gov/DocumentCenter/Home/View/767>.

USEPA Region 4 SESD Guidance, *Design and Installation of Monitoring Wells* (SESDGUID-101-R1), January, 2013.

USEPA Region 4 SESD Guidance, *Field Equipment Cleaning and Decontamination* (SESDPROC-205-R2), December, 2011.

USEPA Region 4 SESD Guidance, *Soil Sampling* (SESDPROC-300-R3), August, 2014.

STANDARD OPERATING PROCEDURE 3 – WELL INSTALLATION, DEVELOPMENT AND ABANDONMENT

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

This Standard Operating Procedure (SOP) provides guidance for installation, development and abandonment of monitoring wells at Defense Depot Memphis, Tennessee (DDMT). This SOP provides general guidance; the project-specific work plan must be reviewed for specific project requirements.

2 Overview

Monitoring wells will be installed, developed and abandoned by a Tennessee-licensed subcontractor and supervised by an HDR geologist/engineer. Well installation and development will occur immediately after drilling and preparations should be made prior to beginning drilling operations, which are described in SOP 2 *Drilling and Soil Sampling*. This SOP incorporates past practice at DDMT as described in work and test procedures (WTPs) from the RA SAP (MACTEC, 1995) and SOPs prepared by United States Environmental Protection Agency (USEPA) Region 4.

3 Health and Safety

Proper safety precautions must be observed during drilling activities and when collecting soil samples in accordance with the site-specific Health and Safety Plans (HASPs). Each individual assigned to field work must: (1) participate in the HDR Medical Monitoring Program, or subcontractor medical surveillance program, as applicable, (2) must have taken the OSHA 40-Hour course (updated with the 8-Hour OSHA Refresher, when necessary), and (3) must be certified as able to wear respiratory protection.

Each individual is required to have read and understood the HASP for the specific project activity. Upon arrival at the site, each person shall sign the acknowledgement sheet confirming their review of the HASP. Personal protective equipment (PPE) and other provisions for site safety requirements are discussed in the HASP. At a minimum for drilling all personnel will wear a hard hat, steel toe shoes, safety glasses, hearing protection, and a high visibility outer garment.

All equipment will only be used by properly trained personnel. In particular, the use of a photoionization detector (PID) will only be performed by personnel familiar with the equipment. Proper tools will be made available to each employee as necessary. Any questions should be addressed to the Field Team Leader (FTL).

4 Personnel Qualifications and Responsibilities

Field activities will be directed by the FTL, a mid- or senior level engineer/geologist with experience in monitoring well installation, development and abandonment; junior to mid-level geologists will assist, if necessary. The well installation, development and/or abandonment will be conducted by a TN-licensed driller and crew familiar with planned activities, the project-specific work plan and HASP. At least one person on each team will have a current certification in first aid and CPR. If a fork lift is used on site the person driving the fork lift will have the proper Occupational Safety and Health Administration (OSHA) training.

The FTL will provide direction to field staff to ensure work is performed in accordance with the project documents (Quality Assurance Project Plan [QAPP], project-specific work plan HASP, and SOPs). The field staff will carefully review the project documents, conduct the work as planned, seek direction from the FTL when questions or problems arise, and carefully complete field documentation.

5 Equipment and Supplies

The required equipment and supplies will be identified in the project-specific work plan or quality assurance project plan (QAPP). Field activities should not proceed until the proper tools and equipment are available and in good working order. Usual equipment/supplies for a monitoring well installation, well development, and well abandonment will include: a PID, tape measure, knife, nitrile gloves, well pump, compressor, grout mixer, grout pump, bleach, sand, bentonite, Portland cement, well construction forms, well abandonment forms, camera, and development water containers.

Each team will have use of a truck/van during field activities. An initial safety check should be performed at the start of each shift to confirm the vehicle is in good working condition. The vehicle should then be checked daily for damage or required maintenance.

6 Procedures

6.1 Start-Up Activities

6.1.1 Office

Prior to leaving the office for field work, personnel will perform the following actions:

1. The Project Manager (PM) will assign a FTL to direct field activities and coordinate with project personnel. Task specific responsibilities of the FTL will be addressed in the appropriate SOP; general responsibilities include;
   a. Review project project-specific work plan, HASP, and QAPP and for subcontracted work, review of the subcontract agreement.
   b. Work with PM to properly staff the field activity.

c. Arrange site access with the Memphis Depot Associates, tenants and/or property owners.

d. Confirm availability and condition of on-site equipment and order additional equipment/supplies for delivery prior to the start of each event.

e. Prepare field forms and other documentation for the planned event.

f. Prepare the required Shelby County Health Department (SCHD) well installation and abandonment forms.

g. Provide all HDR and subcontracted field personnel with time and location for personnel to meet prior to beginning field activities.

h. Confirm that field staff have a valid Driver's License (or other picture identification) and current OSHA Certification in their possession prior to leaving the office.

6.1.2 Field

After arrival on site, but prior to commencement of operations, the following activities will be performed:

- Complete equipment and supply checklists and verify that required documentation and equipment for field activities are on site.
- Review condition of DDMT-owned and rental equipment, and inventory field supplies.
- Review locations for planned field activities for hazards, including overhead dangers such as power lines, and select location for the placement of the decontamination area, storage of decontamination and development waters.
- Confirm the exact locations of the wells to be abandoned and that the correct well is being abandoned.
- Confirm the location and length of the screened interval and the total depth of the well to be installed and developed.
- Conduct site set up activities to include posting of signage (if applicable) and delineation of work zones as required in the HASP.
- Calibrate field equipment.
- Conduct team safety meetings as required by the HASP.
- Conduct team review of the project documents including SOPs to be utilized.
- Complete the Field Event Startup Report and submit to PM.

6.2 Field Operations

Field activities will be documented in a logbook for each team and in field records as required by the project-specific work plan or SOPs. At minimum, the logbook will describe general activities performed, date and time, personnel and weather conditions. Additional information will be recorded in the log book if other field records are not used.

The following information will be required as part of the field documentation.

- The length of risers, screens, and end caps for each monitoring well including adjustments to riser sections during installation.
- The type, manufacturer, and gradation of the filter sand, and the volume used for each well.
- The type and manufacturer of the Portland cement and bentonite and the volume used for the bentonite seal and grout at each well.
- Surface completion details including: completion type, number of bollards installed, and a description of surface completion materials.

6.2.1 Monitoring Well Installation and Materials

Monitoring well installation will be completed in a manner consistent with relevant sections of USEPA Region 4 SESD Guidance, *Design and Installation of Monitoring Wells* (SESDGUID-101-R1), and applicable state/local requirements. Monitoring well installation will be conducted by a licensed driller and well installation subcontractor. A qualified geologist/engineer will oversee well installation activities.

Borings for monitoring wells will be advanced using sonic drilling. The following procedure will be used to install the well casing and screen:

- If the boring is drilled deeper than the total depth of the well, backfill the boring to approximately 1 foot below the planned well depth in accordance with the work plan, either with bentonite or by allowing the formation material to collapse as the casing is raised.
- Remove the new polyvinyl chloride (PVC) or stainless steel screen and riser from manufacturer packaging.
- Install a section of minimum 2-inch (I.D.), threaded, flush jointed, pre-manufactured PVC or stainless steel screen inside the steel drill casing; screen length will be 10 feet unless a different length is specified in the work plan..
- Install solid riser to ground surface, plus stick-up (if required).
- Install the filter pack using the gravity method through the annular opening between drill casing and well screen as the drill casing is removed. Continue removing drill casing and installing filter pack until at least 5 feet above the top of the well screen. Use the sonic drilling head to vibrate the steel casing as it is slowly withdrawn to distribute and compact the filter pack around the screen and to prevent bridging. Measure the thickness of the filter pack as it is placed.
- Install a minimum 5-foot bentonite seal. If bentonite is gravity fed in dry form, the seal will be hydrated with potable water. Allow the bentonite seal a minimum of 1 hour of hydration time before grouting the annulus. If the seal is in the saturated section of if potential for bridging is an issue, a bentonite slurry can be installed using a side-discharge tremie pipe.
- The remaining annulus will be filled with bentonite grout via tremie pipe to within 6-inches of the ground surface. Once the boring has been filled, the casing is removed and additional grout added as necessary.

- Wait at least 24 hours after grout installation to develop the well.

Well Construction Materials

Well risers will consist of material durable enough to retain their long-term stability and structural integrity and be relatively inert to minimize alteration of groundwater samples. Selection of PVC or stainless steel for the monitoring wells is based on the primary purpose of the well, which is the detection of potential contaminants, and site-specific conditions, such as planned remedial actions.

Well materials will consist of new, threaded, flush joint PVC or stainless steel pipe, with a minimum inside diameter of 2 inches. If PVC is used, the riser pipe will conform to ASTM D 1785, Standards for Schedule 40 Pipe; deeper wells installed in the intermediate or Memphis aquifers require Schedule 80 Pipe. Materials will be new, unused and joined with compatible welds or couplings that do not interfere with the primary purpose of the well. Use of solvent or glue will not be permitted.

Monitoring well screens will consist of new, commercially fabricated, threaded, flush joint, minimum 2-inch inside diameter (ID), factory slotted or continuous wrap PVC or stainless steel screen. Screen slot size will be based on previously available soil information, but will be generally sized to prevent 90 percent of the filter pack from entering the well. The screen slot size will be adjusted if site geologic conditions significantly differ from the expected conditions. Previous well installation at DDMT have generally used factory-slotted or wire-wrapped screens with 0.010-inch openings,

Silt traps will not be used in monitoring wells. A notch will be cut in the top of the casing to be used as a measuring point for water levels.

6.2.1.1 Well Design

Monitoring wells will be designed and installed in a manner to accomplish the following objectives: to collect representative water levels and groundwater samples; to prevent contamination of the aquifer by the drilling equipment; to prevent vertical seepage of surface water or inter-aquifer contamination.

Well design includes placement of the screen and the type and amount of filter pack, bentonite seal, and grout seal. The FTL and PM will collectively make decisions on well depths, locations, screened intervals, etc. If the borings are advanced into the clay unit at the base of the aquifer, bentonite chips will be used to backfill the boring to the top of the clay and allowed to hydrate for one hour prior to placing the filter pack or screen.

The well pipe assembly will be hung in the borehole, prior to placement of the filter pack, and will not be allowed to rest on the bottom of the hole in order to keep the well assembly straight and plumb. Centralizers will be installed at the top of the screened section and at 30-foot intervals.

6.2.1.1.1 Screen Location

The screened intervals will be selected for each proposed well, based on visual observations of aquifer materials encountered and objectives in the project work plan.

6.2.1.1.2 Filter Pack

A filter pack will be installed in the annular space between the boring and the well screen. The filter pack will consist of clean, inert, well rounded silica sand and contain less than 2 percent flat particles. The filter pack will be certified as free of contaminants by the supplier and have a grain size distribution compatible with the formation materials and the screen.

A filter pack size of 8-16 or 10-20 grade is typically used for monitoring wells at DDMT. If the site conditions show significant change (i.e. more gravelly, or more fine-grained soil) from those previously encountered, a grain-size analysis will be completed and the filter pack selected based on those results.

The filter pack will be placed from the bottom of the hole to a minimum of 5 feet above the top of the well screen. The filter pack will not extend across more than one water-bearing unit.

Prior to installation of the well screen and casing, the total depth of the borehole depth will be measured from the top of the 6-inch steel drill casing by the drilling contractor to verify that the target depth has been reached. The sand filter pack will be gravity-placed through the 6-inch steel casing in lifts of approximately 1 foot. Care will be taken to prevent bridging by frequently measuring the thickness of the filter pack as it is placed. As the steel casing is slowly withdrawn between lifts, it will be vibrated with the sonic drilling head to compact the sand filter pack.

6.2.1.1.3 Bentonite Seal

A minimum 5-foot thick bentonite seal will be installed above the filter pack in the annular space of the well. Only 100 percent sodium bentonite (pellets or chips) will be used and care will be taken to prevent bridging by frequently measuring the thickness of the bentonite as it is gravity placed. When the seal is installed above the water table, the bentonite will be hydrated with water from an approved water source. At least 5 gallons of water will be added after each 24 to 30 inches of bentonite is placed. The bentonite seal will be allowed to hydrate for a minimum of one hour prior to placement of the grout collar around the wells. When the seal is placed below the water table, a bentonite slurry may be installed using a side-discharge tremie pipe.

6.2.1.1.4 Grout Seal

A non-shrinking cement-bentonite grout mixture will be placed in the annular space from the top of the bentonite seal to approximately 6-inches below the ground surface. Concrete will be added in the remaining annular space during installation of the protective casing and concrete pad.

The cement-bentonite mixture will consist of 94 pounds of neat Type I Portland or American Petroleum Institute (API) Class A Cement, not more than four pounds of 100 percent sodium bentonite powder, and not more than 8 gallons potable water. The cement-bentonite mixture may be modified to reduce the heat generated during curing. A side discharge tremie pipe will be used to place the grout mixture into the annular space. The tremie pipe will be located a maximum of 10 feet from the top of the bentonite seal in deep wells to ensure even placement of grout in the annular space. Pumping will continue until undiluted grout is visible at the surface.

6.2.2 Nested Monitoring Well Construction and Materials

Nested monitoring well installation will be conducted by a TN-licensed driller overseen by a qualified geologist/engineer. Borings will be advanced via sonic drilling utilizing a 6-inch inner casing and an 8-inch diameter outer casing. After reaching the desired depth, the 6-inch casing will be removed and the nested well will be constructed.

Each nested well will consist of up to four 1-inch inside diameter wells constructed within a single boring. The 1-inch wells will be constructed with Schedule 80 PVC well casing and screen for increased rigidity and strength, and will have one 2.5-feet long, pre-packed screen with a 2-inch diameter centralizer placed approximately one foot above the screen. The 8-inch boring will be filled with filter sand around the pre-packed screen; the screened intervals will be separated by a minimum 5-foot thick bentonite seal. Schedule 80 PVC well casing will extend from each screen interval to the ground surface. The annulus will be filled with a neat cement grout mixture from the uppermost bentonite seal to the surface. A diagram of a nested well is included as Attachment 1. The well construction steps are listed below:

- After reaching the desired depth with the 8-inch diameter casing, place one foot of filter sand in the base of the boring; confirm the depth to the top of the sand by tape measure.
- Insert a PVC plug in the bottom of the prepacked well screen, connect Schedule 80 PVC casing to the top of the screen and attach a 2-inch centralizer approximately one foot above the well screen.
- Lower the screen and casing to the sand at the bottom of the boring; suspend the well casing and maintain tension on the casing throughout construction in order to minimize bowing.
- Place filter sand through the 8-inch casing in lifts while measuring the depth to the top of the sand. Sand should extend two feet above the top of the screen interval.
- Raise the 8-inch sonic casing to the top of the filter pack while vibrating. Measure the depth to the top of the filter pack and add additional sand as necessary.
- Slowly pour bentonite chips and raise the 8-inch diameter casing while vibrating until bentonite is at least 5-feet thick and two feet below the next screen interval. Allow the bentonite to hydrate for at least one hour.
- Place two feet of sand on top of the bentonite seal. Confirm the thickness of the sand and install the next 1-inch well following the steps listed above.
- Continue this process until each of the nested wells has been constructed.
- After a 5-foot thick bentonite seal has been placed and hydrated above the shallowest screened interval, place a neat cement/bentonite grout mixture in the annulus via tremie pipe to within 6-inches of the ground surface.
- Develop the well at least 24 hours after grout installation.

6.2.2.1 Well Construction Materials

Well materials will consist of new, threaded, flush joint schedule 80 PVC, with an inside diameter of approximately 1-inch and conform to ASTM D 1785, where applicable. Casing will only be joined with compatible welds or couplings that do not interfere with the primary purpose of the well. Use of solvent or glue will not be permitted.

To ensure well screen separation from the borehole wall and adjacent well casings, Geoprobe pre-packed well screens will be utilized. The Geoprobe screens are constructed from PVC, slotted to 0.010 inch, measure 2.5-feet in length and include 20/40 mesh sand enclosed within a stainless steel screen.

A notch will be cut in the top of the casing to be used as a measuring point for water levels.

6.2.2.1.1 Screen Location

The screened intervals will be selected for each proposed well, based on visual observations of aquifer materials encountered and objectives in the project work plan.

6.2.2.1.2 Filter Pack

A filter pack will be installed in the annular space between the borehole wall and the Geoprobe pre-packed well screen. The filter pack will consist of clean, inert, well rounded silica sand and contain less than 2 percent flat particles. The filter pack will be certified as free of contaminants by the supplier and have a grain size distribution compatible with the formation materials and the screen.

A filter pack size of 8-16 or 10-20 grade sand will be used based on past practice at DDMT. If the site conditions show significant change (i.e. more gravelly, or more fine-grained soil) from those previously encountered a grain-size analysis will be completed and the filter pack selected based on those results. The filter pack will be placed from two feet below to two feet above the well screen, except at the deepest well screen where the filter pack will extend 1 foot below the well screen.

Prior to installation of the well casing, the total depth of the borehole depth will be measured from the top of the 8-inch steel drill casing by the drilling contractor to verify that the target depth has been reached. Care will be taken to prevent bridging by frequently measuring the thickness of the filter pack as it is placed. As the steel casing is slowly withdrawn between lifts, it will be vibrated with the sonic drilling head to compact the sand filter pack.

6.2.2.1.3 Bentonite Seal

A minimum 5-foot thick bentonite seal will be installed in the annular space of the well above each filter pack to separate the nested well screens. Only 100 percent sodium bentonite (pellets or chips) will be used and care will be taken to prevent bridging by frequently measuring the thickness of the bentonite as it is gravity placed. When the seal is installed above the water table, the bentonite will be hydrated with water from an approved water source. At least 5 gallons of water will be added after each 24 to 30 inches of bentonite is placed. The bentonite seal will be allowed to hydrate for a minimum of one hour prior to construction of overlying filter pack or placement of the grout collar around the wells.

6.2.2.1.4 Grout Seal

A non-shrinking cement-bentonite grout mixture will be placed in the annular space from the top of the uppermost bentonite seal to approximately 6-inches below the ground surface. Concrete will be added in the remaining annular space during installation of the protective casing and concrete pad.

The cement-bentonite mixture will consist of 94 pounds of neat Type I Portland or American Petroleum Institute (API) Class A Cement, not more than four pounds of 100 percent sodium bentonite powder, and not more than 8 gallons potable water. A side discharge tremie pipe will be used to place the grout mixture into the annular space. The tremie pipe will be located a maximum of 10 feet from the top of the bentonite seal in deep wells to ensure even placement of grout in the annular space. Pumping will continue until undiluted grout is visible at the surface.

6.2.3 Vapor Monitoring Point

VMPs will be constructed in soil borings advanced using direct push technology or sonic drilling methods. Each VMP borehole will be drilled approximately 0.5 foot below the target depth and backfilled with filter sand before installing the VMP. A 12-inch section of #100 mesh stainless steel screen implants will be installed to the surface with ¼-inch ID Teflon tubing. Well screen and tubing will be new, unused, decontaminated, material.

Filter pack will be placed in the annular space around the well screen. The filter pack material will be washed and bagged sand with a grain size distribution curve that meets the gradation specification. The filter pack will be gravity-placed through the hollow stem auger drill casings in lifts of one to two feet. Care will be taken to prevent bridging by measuring the thickness of the filter pack as it is placed. The drill casing will be withdrawn between lifts to place the sand filter pack against the native soil. The filter pack will extend from the bottom of the borehole below the screen interval to approximately one foot above the top of the well screen.

A seal of hydrated bentonite with a thickness of approximately one foot will be placed above the filter pack at each well. The 100 percent sodium bentonite seal will consist of ¼-inch or ⅜-inch diameter dry bentonite pellets or chips. The bentonite seal will be placed using gravity methods, or by the tremie method if the pellets or chips bridge in the borehole annulus. Because the bentonite seal will be placed above the water table, sufficient water will be added to allow complete hydration of the bentonite.

A bentonite-cement grout seal will be placed in the annular space above the bentonite seal. The grout will be placed using a side discharge tremie pipe and will be continuously pumped until grout returns to within one foot of the ground surface. The grout will be allowed to cure for a minimum of eight hours before further grouting or well construction.

6.2.4 Soil Vapor Extraction Well

The SVE wells are to be constructed in 6-inch diameter soil borings advanced using sonic drilling methods. SVE soil borings will be advanced to first encountered groundwater. The borehole will be backfilled with filter sand at least five feet above the first encountered groundwater. 10-foot sections of 0.010-inch slot size 2-inch diameter Schedule 40 polyvinyl chloride (PVC) screen will be installed from 5 feet bgs above groundwater to the top of the fluvial sands. Schedule 40 PVC riser will extend to approximately 6 inches bgs. Centralizers will be used at the top of the screened section, and every 30 feet along the riser. Well screen and riser will be new, unused, decontaminated, 2-inch inside-diameter Schedule 40 PVC with internal flush-jointed threaded joints.

Filter pack will be placed in the annular space around the well screen. The filter pack material will be washed and bagged sand with a 15/18 or 10/20 grain size distribution. The filter pack will be gravity-placed through the center of the sonic drill casings in lifts of one to two feet. Care will be taken to prevent bridging by measuring the thickness of the filter sand as it is placed. The drill casing will be withdrawn between lifts to place the sand filter pack against the native soil. The filter pack will extend from the bottom of the borehole below the screen interval to approximately three feet above the top of the well screen.

A seal of hydrated bentonite with a thickness of approximately five foot will be placed above the filter pack. The 100 percent sodium bentonite seal will consist of ¼-inch or ⅜-inch diameter dry bentonite pellets or chips. The bentonite seal will be placed using gravity methods, or by the tremie method if the pellets or chips bridge in the borehole annulus. Because the bentonite seal will be placed above the water table, sufficient water will be added to allow complete hydration of the bentonite.

A bentonite-cement grout seal will be placed in the annular space above the bentonite seal. The grout will be placed using a side discharge tremie pipe and will be continuously pumped until grout returns to within 6-inches of the ground surface. The grout will be allowed to cure for a minimum of 24-hours before further grouting or well construction.

6.2.5 Surface Completion

Surface completion (flush-mount or stick-up) will be selected by the PM based on well location and planned land use. For flush-mount completions, the well casing(s) will be cut approximately 3 inches below ground surface and secured with a water-tight locking cap to prevent surface water from entering the well. The casing will be covered by a bolted manhole cover set in a 3-foot by 3-foot by 4-inch thick concrete pad that slopes away from the manhole.

If an aboveground surface completion is used, the well casing will be extended 2 or 3 feet above ground surface and secured with a water-tight cap. The protective casing will be a steel sleeve placed over the casing and cap; the steel sleeve diameter will be at least 4 inches greater than the casing diameter or at least 8-inches diameter for nested wells. The protective casing will be set in a 3-foot by 3-foot by 4-inch concrete surface pad. A vent hole will be drilled in the steel sleeve about 1 inch above the top of the well pad. The pad will be sloped away from the well sleeve and a lockable cap or lid will also be installed. Three 3-inch diameter concrete-filled steel guard posts will be installed around each well unless the well is located in an area receiving vehicular traffic. These guard posts will be 5 feet in total length and installed radially from the well head. The guard posts will be installed approximately 2 feet into the ground and set in concrete just outside the concrete pad. The protective sleeve and guard posts will be brush-painted yellow or orange.

Wells will be secured immediately after well completion. Corrosion-resistant locks will be provided for both flush and aboveground surface completions. A brass survey marker will be installed in each concrete pad and the well ID will be stamped in the marker. A reference point will be marked on the well casing for use in groundwater level and well depth measurements. This reference point will marked by the HDR geologist/engineer using a permanent marker for PVC wells, or by notching the top of casing for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing.

6.2.6 Location Survey

Following installation of the surface completion for each well, the wells will be surveyed for horizontal locations and elevations at top of casing, ground surface and well pad by a Tennessee-licensed surveyor. The top of casing elevation will be made at the reference point on the north side of the top of casing; the surveyor will not mark the wells in any way. Vertical coordinates will be based on the North American Datum, 1927 used for all survey data at DDMT. Horizontal coordinates will be provided in the Tennessee State Plane coordinate system. Accuracy for well locations will be within 0.01 foot for elevations and within 0.1 feet for horizontal coordinates.

6.2.7 Well Installation Diagrams

The HDR geologist/engineer will maintain suitable logs detailing drilling and well construction practices. Well dimensions, amount, type and manufacture of materials used to construct each well will be recorded in the logbook. Additional information to be recorded in the field for the well installation diagram will include:

- Well identification.
- Drilling method.
- Installation date(s).
- Total boring depth.
- Lengths and descriptions of the screen(s) and riser(s).
- Thickness and descriptions of filter pack, bentonite seal, annular grout, and any backfilled material.
- Quantities of all well construction materials used.

6.2.8 Well Development

The purpose of well development is to create good hydraulic contact between the well and the aquifer and to remove accumulated sediments from the well. Each newly installed monitoring well will be developed no sooner than 24 hours after installation to allow for adequate grout curing time. The water volume purged during development will exceed the volume of potable water or other drilling fluids used during drilling and well installation.

The wells will be developed with a surge block in conjunction with a pump sized to effectively develop the well. No detergents, soaps, acids, bleaches, or additives will be used during well development. Development will continue until clear, sand-free formation water is produced from the well and until pH, conductivity, turbidity, and temperature measurements have stabilized. Stabilization is defined when the pH is within + or - 0.1, the conductivity is + or - 5%, and the turbidity is less than 10 nephelometric turbidity units (NTUs).

The monitoring well development protocol is as follows:

- Measure the static water level (SWL) and the depth to the top of sediment in the well.
- Record the total depth of the well (from the Well Installation Diagram).

- Calculate the volume of water in the well and saturated annulus.
- Begin developing the well using a combination of surging and pumping. Continue pumping and periodically surging until each the following criteria have been met:
  - Fluids lost to the formation during drilling and well installation have been removed (this is a minimum requirement where conditions permit).
  - pH, temperature, turbidity, and specific conductance have stabilized. In general, field parameters are stable when NTUs are less than 10, pH is within 0.1 on consecutive readings, and temperature and specific conductance are within 10 percent of previous readings. Natural turbidity levels in ground water may exceed 10 NTU.
  - If feasible, monitor the SWL during purging. Adjust the purge rate to keep the SWL from dropping more than 0.3 meter from the initial SWL.
  - No sediment remains in the bottom of the well. However, it can be accepted if the sediment thickness remaining within the well is less than 1 percent of the screen length.
- In the event that the above criteria have not been met after six hours of pumping, surging, and bailing (including recharge time for poorly recharging wells), development activities will be temporarily discontinued at that well. The FTL and PM will decide whether or not to continue development.
- In the event of slowly recharging wells that will not sustain pumping or bailing, the field staff will advise the FTL as soon as a determination of estimated recharge time has been made.
- Physical characteristics of the water (suspended sediment, turbidity, temperature, pH, EC, purge rate, odor, etc.) will be recorded throughout the development operation. At a minimum, they will be recorded initially and after each well volume has been removed, or every 30 minutes, whichever comes first.
- The total quantity of water removed and final depth to the top of sediment (total depth of well) will be recorded.
- Well development equipment will be decontaminated prior to use in each newly-installed monitoring well.

6.2.8.1 Well Development Records

Well development data will be recorded on Well Development Data Sheets, which should include the following information:

- Method of development.
- The model number and type of water quality instruments.
- The model and type of water pump used for development.
- The flow rate of the pump.
- The type and technique used for surging of the well.
- Final water quality description (e.g., color, odor, clarity).

- Identification of conditions that might reflect the results of the development if it was successful or why it was not.
- Volume of water removed from the well.

6.2.8.2 Well Development Water

Development water will be drummed or stored in bulk containers. The containers will be clearly labeled with site name, well name, date, and contents. The development water will be properly disposed in accordance with investigation derived waste (IDW) procedures set forth in the project work plan.

6.2.9 Well Abandonment

Monitoring wells at DDMT are reviewed annually with regard to classification, sample frequency and utility. Wells are recommended for abandonment based on the following criteria:

1. The well is redundant: duplicates information; not in the flow pathway of on-coming plumes and not required to establish background; or analytical data will have no clear, reasonable use in future decision making.
2. The monitoring well (MW) has sustained damage and cannot be repaired, or an object that cannot be removed has become lodged in the MW.
3. The MW was installed for a specific reason that no longer applies.

Wells are scheduled for abandonment after recommendations are approved by USEPA and Tennessee Department of Environment and Conservation (TDEC).

Well abandonment will be completed in accordance with SCHD requirements following issuance of a fill and abandonment construction permit from SCHD. Well abandonment will be conducted by a TN-licensed well contractor. An HDR geologist/engineer will oversee well abandonment activities. The following procedure will be used for well abandonment:

- Total well depths will be measured and compared to depths recorded during well installation to determine if obstructions are present in the well.
- One-half gallon of bleach will be poured into the well as a disinfectant.
- The well screen and casing will be filled with grout (Portland type II cement with 5 percent bentonite) from the bottom up using a tremie pipe. After allowing the grout time to settle, additional grout will be added to fill the well casing to approximately 6 inches below ground surface (bgs).
- Surface completions including well pads and manholes will be removed at wells located in grassed or graveled areas. If necessary, the well casing will be cut off a few inches below the ground surface. The pad areas will be recovered with either topsoil/grass seed or gravel. At wells located in concrete or asphalt-paved areas, the manhole covers will be removed and the manholes filled with concrete. Bollards will be removed at all abandoned wells.
- Surface completion materials including manholes, bollards, well lids and wells casings will be placed in a roll-off and properly disposed.

The following information will be recorded to document the well abandonment:

- The total depth of the abandoned wells and whether obstructions had to be removed.
- The amount and type of Portland and bentonite used for grouting.
- The volume of grout used to fill the well casing and the volume of water recovered during grouting.
- Disposal of surface completion materials removed during well abandonment.

6.3 Closeout

6.3.1 Daily Closeout

Perform following activities daily before leaving the site:

- Decontaminate and check condition of field equipment.
- Provide log books and other field documentation to FTL for review.
- Properly dispose of trash, debris and used PPE.
- Secure the site for the night and/or weekend.
- Prepare daily report as required by the project-specific work plan or SOPs and submit report to the PM. Note any problems or deficiencies in field activities.

6.3.2 Field Event Closeout

Upon completion of field activities, the FTL will view each site to verify the area has been cleared and restored as closely as possible to its prior condition. Trash will be removed from the site, and surface damage including ruts caused by vehicles, will be repaired.

Confirm all equipment is accounted for and properly decontaminated and in good working condition. Notify FTL if repairs are needed. Properly package and ship all rental equipment to the vendor. When shipping equipment, use the proper HDR FedEx number and insure the package for the cost of the equipment. Follow manufacturer's instructions on long and short term storage when storing government and/or HDR equipment.

Rental trucks should be fueled and returned to the rental company as soon as possible. HDR leased trucks should also be fueled and cleaned prior to storing at the shop.

Work areas should be cleaned with tools and equipment properly stored.

The FTL will make a final check of all logbooks and other field records to ensure there are no blanks or missing data and the entries are legible.

The FTL will complete Field Event Closeout Report and submit to PM.

7 Data and Records Management

All field forms and logbook entries will be scanned and copied to the project folder on the network file share drive within one week of the field event completion. All photographs taken during the field event will also be uploaded along with a typed photograph log (date, project and subject) to the network file share. All uploaded photographs will then be erased from the camera. All original forms will be stored on site at the field office in Memphis in the appropriate project-specific filing cabinet and task-specific labeled folder.

Well logs and sample results for new wells will be submitted to the SCHD in accordance with permit requirements.

8 Quality Control and Quality Assurance

All work will be performed in accordance with the QAPP, the project-specific work plan, and applicable SOPs. All field activities will be recorded in the logbooks in sufficient detail to reconstruct the events. No erasures or mark outs will be made on field forms or logbooks. A single line will be used to strike out errors and will be annotated with the initials and date of the editor. Well completion diagrams will be typed into a spreadsheet provided by the CAD operator for the inclusion into computerized well diagrams.

9 References

MACTEC, *RA SAP Volume I: Field Sampling Plan, Defense Depot Memphis, Tennessee, Revision 1*, *WTP-3 Well Installation, Development and Sampling*. November, 2005.

Shelby County Health Department, Pollution Control Section, Water Quality Branch, <http://www.shelbycountytn.gov/DocumentCenter/Home/View/767>.

USEPA Region 4 SESD Guidance, *Design and Installation of Monitoring Wells* (SESDGUID-101-R1), January, 2013.

STANDARD OPERATING PROCEDURE 4 – GROUNDWATER SAMPLE COLLECTION

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

This Standard Operating Procedure (SOP) provides guidance for groundwater sample collection at Defense Depot Memphis, Tennessee (DDMT). The project work plan must be reviewed for specific requirements.

2 Health and Safety

General Information on Health and Safety requirements are provided in SOP 1. Each individual is required to have read and understood the Health and Safety Plan (HASP) for the specific project activity and signed the acknowledgement sheet confirming their review.

Health and safety concerns for groundwater sampling include the use of lead-acid batteries with bladder pumps, contact with contaminated groundwater, and contact with sample container preservatives. Material safety data sheets (MSDS) will be available on site for each chemical to be utilized during sampling activities. Staff will wear appropriate personal protective equipment (PPE), as outlined in the site safety health plan. Many of the wells are located in or near streets and parking lots with traffic; field staff should wear vests with reflective stripes or other high visibility clothing while sampling. Some wells may be located in areas with biological threats such as spiders, fire ants, snakes, and wasp nests; the wells should be checked for hazards before starting sampling activities.

3 Personnel Qualifications and Responsibilities

Groundwater sampling will be directed by a Field Team Leader (FTL), a mid- or senior level environmental professional (engineer, geologist or scientist) with appropriate experience. Field staff will be junior to mid-level environmental professionals or environmental technicians overseen by the FTL. Sampling will be performed by two-person teams and at least one person on each team will have a current certification in first aid and CPR.

4 Equipment and Supplies

The required equipment and supplies will be identified in the work plan for the specific field activities to be performed. Field activities should not proceed until the proper tools and equipment are available and in good working order. Usual equipment/supplies for groundwater sampling will include: a photoionization detector (PID), nitrile gloves, pump controller, portable bladder pump, compressor, water quality meter, water level indicator tape, camera, and purge water containers.

Each team will have use of a truck/van during field activities. An initial safety check should be performed at the start of each shift to confirm the vehicle is in good working condition. The vehicle should then be checked daily for damage or required maintenance.

5 Procedure

5.1 Start-Up Activities

5.1.1 Office

The Project Manager (PM) will assign a FTL to direct field activities and coordinate with project personnel. General responsibilities are described in SOP 1. Task specific responsibilities include:

- Coordinate sampling activities with the PM, project chemist (PC) and analytical laboratory.
- PC will prepare the sampling plan detail (SPD) listing the wells and sample bottles for planned analyses. FTL will review the SPD, discuss any questions with PC and confirm shipment of laboratory-supplied sample containers and equipment for arrival prior to the start of sampling.
- The FTL will update the list of wells to be included in the water level sweep. An example list is provided in **Attachment 4-1**.
- Confirm availability and condition of DDMT-owned equipment and order additional equipment/supplies for delivery prior to the start of sampling event.
- Obtain well location maps and prepare tables showing screened interval and previous water level measurements to confirm planned sample depths.
- Prepare field forms and other documentation for the planned event.
- Schedule time and location for the initial meeting with field staff to review project information and begin work.

5.1.2 Field

After arrival on site, but prior to commencement of operations, the following activities will be performed:

- Complete equipment and supply checklists and verify that required documentation and equipment for field activities are on site.
- Review condition of DDMT-owned and rental equipment.
- Inventory field supplies.
- View well locations and confirm the wells are accessible and well IDs are clearly marked.

- Review locations for planned field activities for hazards. Determine requirements for site preparation and clearance, and select location for storage of decontamination and purge waters. Confirm sufficient storage capacity for wastewater.
- Confirm the location and length of the screened interval and the total depth of the well to be sampled if not equipped with a diffusion bag.
- Conduct site set up activities to include posting of signage (if applicable) and delineation of work zones as required in the HASP.
- Review sampling activities and assignments with field staff.
- Prior to groundwater sampling, visually inspect laboratory supplied trip blanks (TBs) for headspace. TBs without headspace will be placed into the refrigerator at DDMT and chilled overnight. Visually inspect the TBs for headspace the following day and discard TBs with headspace. Have the laboratory provide new TBs as necessary.

5.2 Field Operations

Field records will be prepared in accordance with SOP 7 – Sample Control and Documentation. Each sampling site will be characterized by the following factors:

- Location of work
- Weather conditions: rainfall, temperature, and wind direction
- Ongoing activities that may influence or disrupt sampling efforts
- Accessibility to the sampling locations (e.g., rough terrain, fallen trees, flooding, etc.)

5.2.1 Water Level Sweep and Monitoring Well Inventory

Prior to sampling, a water level sweep will be made at listed monitoring wells to produce an accurate potentiometric map.

1. Determine if the water level probes are working properly by using two or more in one well to confirm the same depth is measured. If the depths differ by more than 0.1 feet, determine which one is malfunctioning and replace it for the project.
2. Arrive at the monitoring wells and inspect the surroundings for hazards (e.g., traffic, wasps, trip hazards)
3. Using the water level sweep list proceed to the wells requiring water level readings. Confirm the well location by checking the well ID on the pad.
4. Assess the well condition and note cracks in the pad, missing bolts, missing caps, etc. on the well inventory (**Attachment 4-2**).
5. Remove water or debris from the well box as necessary and remove the monitoring well cap. Note appearance of positive or negative pressure in casing when cap is removed (air pressure lifting cap or suction on cap). Multiple wells within an area can be inspected and opened to make efficient use of field time, but each open well must be within clear sight of field staff or within a secured area.

6. Allow the water level to equilibrate for at least 3 minutes after removing the well cap prior to measurement. If pressure is noted, re-measure water level at least 3 minutes after the initial measurement; if the two measurements vary by more than 0.05 feet, make a third measurement.
7. Turn the water level indicator on and slowly lower it into the well until it alerts to the water level.
8. Bring up the probe slowly until the beeping stops and slowly lower it again until it beeps; do this three times and record the average level recorded. All readings should be taken at the location marked on top of the casing; if no mark is present, use the north side of the casing.
9. Record depth measurement to the nearest 0.01 feet.
10. Put the cap and lock back on the well casing and then close the well box.
11. Decontaminate the water level probe before proceeding to the next well. The decontamination procedure for the water level indicator is: Hand wash the calibrated tape and probe with Alconox solution (or equivalent) and rinse with deionized (Reagent Grade II) water.

5.2.2 Monitoring Well Sampling

Field measurements of groundwater parameters are used for groundwater sampling and for independent measurements during remedial actions. At the beginning of each day, field equipment will be properly calibrated per manufacturer's instructions and throughout the day as necessary if abnormal readings are observed. Calibration activities will be recorded on **Attachment 4-3**.

5.2.2.1 Sampling Using a Passive Diffusion Bag (PDB) Sampler

Groundwater samples will be collected for VOC analyses using PDB sampling from most monitoring wells. A typical PDB sampler consists of a low-density polyethylene tube closed at both ends and filled with deionized water. The PDB is positioned in the well screen interval at the desired target depth by attaching it to a weighted tether. The water within the PDB is allowed to equilibrate with the ambient groundwater for at least 14-days before retrieval. The PDB water is decanted into 40 mL volatile organic analysis (VOA) vials and sent to the lab for analysis. Detailed procedures for using PDB samplers in wells can be found in "User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells" (USGS, 2001). The following is a generalized summary of PDB sampling:

1. The top and bottom of the PDB sampler will be attached to 3/16" polyester or similar non-buoyant rope strong enough to support the weight of the sampler and subject to minimal stretch. The PDB will be suspended within the well screen at selected depths based on the depth to water, location of the screen and total depth of the well. Weights will be attached to the bottom of the sampler to keep it in place in the well. The sampler will be allowed to equilibrate for at least two weeks before being carefully retrieved with the attached line and the sample collected.
2. The PDBs will carefully be withdrawn from the well and inspected. Evidence of algae or other coatings on the bag or tears in the membrane will be noted in the field book. If there are tears, the sample will be rejected.

3. The contents of the intact bag will then be transferred to pre-preserved VOA vials causing as little agitation of the sample as possible.
4. A new PDB will be filled with deionized water, attached to the tether with zip ties, then carefully lowered into the well. The well cap, lock, and cover will be securely fastened once the PDB is in place.

5.2.2.2 Sampling Using a Bladder Pump

The sampling protocol will be as follows for the collection of groundwater samples using low-flow sampling with a portable bladder pump.

1. Wells should be sampled in order of increasing contamination (i.e. - samples that are expected to be least contaminated will be collected before those that are more highly contaminated).
2. The bladder pump will be decontaminated prior to use in each well.
3. Slowly and carefully lower the pump inlet to the mid-point of the screened interval. In cases where the entire screen is not saturated, place the pump inlet near the middle of the saturated screen, keeping in mind the limitations stated below.
4. Do not place pump inlet less than 2 feet above the bottom of the well, as this may cause the mobilization of bottom sediments. If saturated screen length is 3 feet or less, collect sample using disposable bailer.
5. Place pump inlet at least 1-foot below the water level so there is little risk of entrainment or air in the sample.
6. Begin purging the well at a rate of 200 to 500 milliliters per minute (mL/min). Purge water will be containerized as investigation derived waste (IDW). The appropriate purge rate will be determined by monitoring groundwater drawdown.
7. The discharge during purging and sampling should flow with minimal turbulence or agitation.
8. The water level should stabilize and the pump rate should allow water to recharge the well so that little or no water level drawdown is observed. Adjust discharge rate to limit drawdown.
9. Record groundwater level frequently until water level stabilization occurs. After stabilization, measure water levels at regular intervals.
10. If drawdown is greater than 0.3 feet, decrease the discharge rate of the pump and repeat discharge and water level measurements. Repeat until the water level stabilizes to closely match the recharge rate. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging (USEPA, 2017). Record pumping rates and depths to water on the Sample Collection Data sheet (**Attachment 4-4**).
11. An in-line multi-probe flow-through cell will be used to monitor water quality parameters. During purging, water quality indicator parameters (pH, turbidity, temperature, ORP, specific conductivity, and DO) will be measured every 5-10 minutes until the parameters have stabilized. Measurement should be recorded on **Attachment 4-4**. A minimum of 5 sets of water quality indicator parameters should be recorded.
12. Stabilization of water quality parameters is achieved after three successive readings are within ± 0.1 for pH, ± 3% for specific conductance, ± 10% for dissolved oxygen (DO) values greater than 0.5 milligrams per liter (mg/L) or three successive DO values less than 0.5

mg/L, ± 10 millivolts for oxidation reduction potential (ORP), 3% for temperature, and 10% for turbidity values greater than 5 nephelometric turbidity units (NTU) or three successive values less than 5 NTU (USEPA, 2017)

13. Specific conductance and DO usually take the longest to stabilize. Up to 2 hours of purging may be required to reach stabilization. Stabilized purge indicator trends are generally obvious and follow either an exponential or asymptotic change to stable parameter values during purging.
14. The pump will not be turned off between the purging and sampling processes.
15. If stabilization does not occur within 2 hours the FTL should be contacted for direction.
16. Groundwater samples will be collected by gently filling the sample bottles with minimum turbulence once equilibrium is established. Lower the flow rate to 100 mL/min and fill sample containers as described in Section 5.2.3.4.

5.2.2.3 Sampling using a Disposable Bailer

Wells will be sampled with bailers where necessary due to small diameter casing in piezometers, slow groundwater recharge or thin saturated layer in wells. A new disposable Teflon bailer will be used for sampling at each well. Purging and sampling will be conducted in a manner that minimizes the agitation of sediments in the well and formation; the bailer will not be allowed to free fall into a well.

The sampling protocol will be as follows for the collection of groundwater samples using a disposable Teflon bailer:

1. Measure the static water level prior to purging using a decontaminated electronic water level indicator. The probe of the water level indicator will be lowered into the well casing and the water level will be recorded.
2. Calculate the saturated well volume.
3. Lower the bailer into the well using new nylon twine, until it contacts the water surface. Allow the bailer to sink and fill with a minimum of water surface disturbance. Slowly withdraw the bailer from the well, preventing the bailer and bailing line from touching the ground.
4. The well should be purged until a minimum of three well volumes is removed from the well, and the water quality indicators of pH, DO, and specific conductivity have stabilized and turbidity is less than 10 NTU. At a minimum, readings will be taken after each well volume is removed or more frequently if sufficient purge volume is removed and recorded on the Sample Collection Data sheet (**Attachment 4-4**). Stabilization is achieved after three successive readings are within ± 0.1 for pH, ± 5% for specific conductance, ± 10% saturated or ± 0.2 mg/L for DO, and <10 NTU for turbidity. Temperature and ORP will also be measured and recorded, but will not be used as stabilization parameters. Sampling may begin once the minimum well volume has been removed and water quality indicators have stabilized. If stabilization does not occur or turbidity cannot be reduced below 10 NTU after three well volumes have been removed, additional purging (up to five well volumes), should be performed. If the parameters have not stabilized within five volumes, the FTL should be contacted for direction.

5. If the well is purged dry, a sample will be collected as soon as sufficient recharge has occurred and within 24 hours. Temperature, specific conductance, turbidity, pH, and DO will also be measured and recorded, along with a notation that the well was bailed dry and the conditions did not stabilize; however, stabilization of these parameters is not required.
6. After water quality indicators stabilize or the well recharges, collect samples by pouring the water from the bailer into the appropriate sample containers. This process will be repeated as necessary to fill each container.
7. After samples have been collected, replace the well cap and lock the security casing.

5.2.2.4 Sample Collection

Groundwater samples will be collected by gently filling the sample bottles with minimum turbulence. Fill the sample bottles in the following order, as needed for the required analyses:

- Volatile organic compounds (VOCs) (no headspace)
- Carbon Dioxide, Methane, Ethane, Ethene (no headspace)
- Metabolic fatty acids (MFAs) (no headspace)
- Total organic carbon (TOC) (no headspace)

Collect the samples to be analyzed for volatile organics first, leaving zero headspace. Once the VOC sample is filled, carefully secure the cap to the vial. Turn the container upside down, tap the container against the palm of a hand, and look for any bubbles inside the vial. If bubbles are observed, gently remove the cap and carefully add a small amount of sample water to the container until a meniscus forms above the rim of the vial. Gently place the cap over the meniscus and secure to the vial. Re-inspect the container for any air bubbles. If air bubbles are observed again, repeat the sample process using a new clean VOC container. Proceed with the collection of samples for the remaining analyses, collecting the more volatile parameters first.

At the end of each day, as sample containers are placed into the refrigerator or cooler for shipment to the laboratory, containers will be inspected for headspace. Samples with excessive headspace may be discarded after discussion with the project manager, laboratory, and project chemist. The samples may need to be recollected.

5.3 Closeout

Perform following activities daily before leaving the site:

- Decontaminate and check condition of field equipment.
- Provide log books and other field documentation to FTL for review.
- Properly dispose of trash, debris and used PPE.
- Store purge water in the designated area.
- Make arrangements for shipment of samples (if applicable) and follow-up with the analytical laboratory to confirm samples arrived in good condition in accordance with SOPs 7 and 8.
- Complete the Daily Field Report (SOP 1, Attachment 1-2) and submit to PM.

Upon the completion of groundwater sampling activities, the FTL will perform closeout activities per SOP 1 and complete Closeout Report (SOP 1, Attachment 1-3) and submit to PM.

6 Data and Records Management

All field forms and log book entries will be scanned and copied project folder on the “Z” drive within one week of the field event completion. All photographs taken during the field event will be uploaded along with a typed photograph log (date, project and subject) to the “Z” drive.

7 Quality Control and Quality Assurance

All work will be performed in accordance with the QAPP, the specific work plan, and applicable SOPs.

8 References

HDR, 2018. DDMT Uniform Federal Policy-Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 1. Prepared for the U.S. Army Corps of Engineers, Mobile District. March 2018

United States Environmental Protection Agency (USEPA) 2017. Low Stress Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. September 2017.

USEPA Region 4 Science and Ecosystem Support Division (SESD) 2013. SESDPROC-301-R3, *Operating Procedure: Groundwater Sampling*. January 2013.

USEPA Region 4 SESD 2013. SESDPROC-105-R2, *Operating Procedure: Groundwater Level and Well Depth Measurement*. January 2013.

United States Geological Survey, 2001. *User’s Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells*. Water-Resources Investigations Report 2001-4060.

Attachment 4-1

Water Level Measurement and Well Assessment Record

Well ID	Aquifer	Area	Measurement Date	Depth to Water (ft, btoc)	Northing (ft)	Easting (ft)	Screen Length (ft)	Total Well Depth (ft, btoc)	April 2018 Depth to Water (ft, btoc)	Oct. 2018 Depth to Water (ft, btoc)
DR1-1	Fluvial	TTA-1S			276300	800856	20	141.7	84.34	83.08
DR1-1A	Fluvial	TTA-1S			276307	800863	20	109.2	84.09	82.81
DR1-2	Fluvial	TTA-1N			276537	801153	20	117.7	81.91	80.58
DR1-3	Fluvial	TTA-1S			276527	801416	20	129.7	83.78	82.50
DR1-4	Fluvial	TTA-1S			276231	801400	20	126.3	84.51	83.14
DR1-5	Fluvial	TTA-1S			276080	800828	20	144.7	85.50	84.18
DR1-5A	Fluvial	TTA-1S			276087	800835	20	110.0	85.39	84.21
DR1-6	Fluvial	TTA-1S			276044	801103	20	134.4	84.35	82.85
DR1-6A	Fluvial	TTA-1S			276035	801104	20	110.9	84.50	82.94
DR1-7	Fluvial	TTA-1N			276791	801441	20	128.3	82.20	80.96
DR1-8	Fluvial	TTA-1N			276752	800875	20	112.7	81.48	80.21
DR2-1	Fluvial	TTA-2			276772	806498	20	93.9	86.23	85.82
DR2-2	Fluvial	TTA-2			276771	806659	15	93.4	75.81	75.76
DR2-3	Fluvial	TTA-2			276539	806203	20	113.0	91.52	90.66
DR2-4	Fluvial	TTA-2			276456	806633	20	108.1	89.10	88.59
DR2-5	Fluvial	TTA-2			276831	806180	15	99.5	92.45	91.89
DR2-6	Fluvial	TTA-2			276644	805861	20	114.6	94.56	93.51
MW-16	Fluvial	Background			278838	807100	15	72.6	55.74	55.42
MW-19	Fluvial	Background			278946	800782	10	93.1	79.12	78.32
MW-21	Fluvial	TTA-1N			276473	800602	15	107.1	84.84	84.08
MW-22	Fluvial	TTA-1S			275912	800702	10	105.4	87.77	87.06
MW-23	Fluvial	Background			275791	801817	10	111.2	89.78	89.25
MW-24	Fluvial	Background			275616	803539	15	112.3	94.42	94.00
MW-25A	Fluvial	TTA-2			275975	805521	10	83.0	62.96	62.01
MW-26	Fluvial	TTA-2			276508	805962	10	107.6	93.07	92.02
MW-34	Intermediate	Window			279411	801918	20	156.6	117.97	119.47
MW-38	Intermediate	Window			279141	802450	15	154.9	115.80	115.29
MW-39	Fluvial	W-C			277281	802598	20	115.5	92.40	92.01
MW-39A	Upper Claiborne	W-C			277278	802608	20	168.1	92.74	92.33

Attachment 4-1

Well ID	Aquifer	Area	Measurement Date	Depth to Water (ft, btoc)	Northing (ft)	Easting (ft)	Screen Length (ft)	Total Well Depth (ft, btoc)	April 2018 Depth to Water (ft, btoc)	Oct. 2018 Depth to Water (ft, btoc)
MW-50	Fluvial	TTA-2			276456	807065	10	125.0	81.14	80.26
MW-52	Fluvial	SE			275372	805897	10	104.0	71.57	70.55
MW-53	Fluvial	Background			279177	805136	10	82.5	72.94	72.21
MW-55	Fluvial	Background			279301	801205	10	74.0	69.15	69.52
MW-62	Fluvial	B-835			278290	801858	10	96.1	86.12	85.38
MW-63A	Fluvial	N-C			278200	803573	10	140.0	94.80	93.91
MW-63B	Fluvial	N-C			278201	803558	10	125.0	94.48	93.54
MW-64	Fluvial	TTA-2			276952	805006	10	112.0	98.60	97.64
MW-66A	Fluvial	TTA-1N			276626	799793	20	94.6	72.53	71.14
MW-85	Fluvial	TTA-2			276704	806065	15	110.9	92.46	92.99
MW-88	Fluvial	TTA-2			276879	806513	15	97.0	77.11	76.89
MW-89	Intermediate	Window			278287	802555	30	177.0	102.60	102.68
MW-90	Intermediate	Window			278284	802540	30	145.0	103.22	103.33
MW-92	Fluvial	TTA-2			276614	806490	15	108.0	90.81	90.32
MW-93	Fluvial	Background			275542	804440	15	107.0	89.68	89.31
MW-94A	Fluvial	W-C			276806	803086	10	119.6	97.61	97.31
MW-96	Fluvial	TTA-2			276310	806320	20	95.5	76.58	75.62

Notes:
ft, btoc: feet below top of casing
ft, NAVD: feet above North American Vertical Datum of 1988
NM: Not measured
--: Well not installed

Attachment 4-2

Water Maintenance Inspection Form

Site: ____________________ Date: ____________________

Client: ____________________ Technician: ____________________ Page: ______ of ______

		Entry Indicates Deficiency													
Inspection Point	Well Inspected - No Corrective Action Required	Cap non-functional	Lock Non Functional	Lock Missing	Bolts Missing (# missing / # total tabs)	Tabs Stripped (# stripped / # total tabs)	Tabs Broken (# broken / # total tabs)	Annular seal incomplete	Apron damaged	Rim / Lid broken	Trip Hazard	Below grade	Other (explain in notes)	Well not inspected (explain in notes)	**Notes** (Note repairs made onsite)

Attachment 4-3

Meter Calibration Log

EQUIPMENT MAKE	EQUIPMENT MODEL	SERIAL NUMBER	DATE	TIME	TEMP OF CALIBRATION STANDARD (ºC or ºF)	pH STANDARD	pH STANDARD	pH STANDARD	SPECIFIC CONDUCTANCE	ORP	DISSOLVED OXYGEN
						4	7	10	______ µs/cm	_____ mV	_____ mg/L or %

Attachment 4-4

Purging and Sampling Data Sheet

Job#:	**Sampler(s):**		**Site:**
Well ID:	**Date:**	**Sample Event:**	
Well diam: 1/4" 2" 3" 4" 6" Other:		**DTW:**	**Total Depth:**

Purge equip (circle): Bladder-pump Peri-pump DC-pump PE bailer Teflon bailer Other: _____________
Tubing (circle): New Dedicated **Tubing Type (circle):** Teflon lined HDPE Other:________________

Purge Method (Circle): 3-5 Case Volume Micro/Low-Flow Extraction Well Other:_________________

Pump intake depth (ft):	**Multipliers:** 1"=0.04 2"=0.16 3"=0.37 4"=0.65 5"=1.02 6"=1.47 $Radius^2$ x 0.163
{TD-DTW X Multiplier = 1 Volume	80% Recovery {TD - DTW X 0.20 + DTW}

1 Volume =__________X **3** =___________(Total Purge) 80% =

Time	Temp (°C / °F)	pH	Cond (µS/cm)	Turb. (NTU)	DO (mg/L)	ORP (mv)	Vol. Removed (gal / L)	Notes

Did well dewater? YES NO		Total volume removed: _____________ (gal / L)
Sample method: Disp Bailer Ded. Tubing New Tubing Ext. Port Other:		
Sample date:	Sample time:	DTW at sample:
Sample ID:		Number of bottles:
QC Sample IDs:		Analysis:

Stabilization Parameters: ± 0.1 for pH, ± 3% for specific conductance, ± 10% for DO > 0.5 mg/L or three readings < 0.5 mg/L, ± 10mv for ORP, ±3% for temperature, and 10% for turbidity > 5 NTU or three successive values < 5 NTU

Attachment 4-4

Purging And Sampling Data Sheet (continued)

Job#:	**Sampler(s):**		**Site:**
Well ID:	**Date:**	**Sample Event:**	

Time	**Temp** (°C / °F)	**pH**	**Cond** (µS/cm)	**Turb.** (NTU)	**DO** (mg/L)	**ORP** (mv)	**Vol. Removed** (gal / L)	**Notes**

Stabilization Parameters: ± 0.1 for pH, ± 3% for specific conductance, ± 10% for DO > 0.5 mg/L or three readings less than 0.5 mg/L, ± 10mv for ORP, ±3% for temperature, and 10% for turbidity greater than 5 NTU or three successive values less than 5 NTU

STANDARD OPERATING PROCEDURE 5 – VAPOR SAMPLE COLLECTION

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

This Standard Operating Procedure (SOP) provides guidance for vapor sample collection at Defense Depot Memphis, Tennessee (DDMT). The project work plan must be reviewed for specific requirements.

2 Health and Safety

General Information on health and safety requirements are provided in SOP 1. Each individual is required to have read and understood the Site Safety and Health Plan for the specific project activity and signed the acknowledgement sheet confirming their review.

Health and safety concerns for vapor sampling include the use of lead-acid batteries, pressurized tubing, hot surfaces, and biological hazards. Batteries should be handled and transported properly to avoid acid spills. Some vapor samples locations are under positive pressure, and safety glasses should be worn at all times. Equipment in the machine rooms, including metal piping, can be very hot and care should be taken to not come in contact with the hot surfaces. Biological hazards include spiders, wasps, bees, and possibly snakes; care should be taken when reaching into areas that cannot be visually inspected.

3 Personnel Qualifications and Responsibilities

Vapor sampling will be directed by a Field Team Leader (FTL), an environmental professional (engineer, geologist or scientist) with appropriate experience. Field staff will be junior to mid-level environmental professionals or environmental technicians.

4 Equipment and Supplies

The required equipment and supplies will be identified in the project work plan for the specific field activities to be performed. Field activities should not proceed until the proper tools and equipment are available and in good working order. Usual equipment/supplies for a vapor sampling will include: a photoionization detector (PID), a vacuum pump, a set of tedlar bags, 6-liter Summa canisters and Summa canisters wrenches.

Each sampler will have use of a truck/van during field activities. An initial safety check should be performed at the start of each shift to confirm the vehicle is in good working condition. The vehicle should then be checked daily for damage or required maintenance.

5 Procedure

5.1 Start-Up Activities

5.1.1 Office

The Project Manager (PM) will assign a FTL to direct field activities and coordinate with project personnel. General responsibilities are described in SOP 1. Task specific responsibilities include:

- Coordinate sampling activities with the project chemist (PC) and analytical laboratory; prepare a sampling plan detail listing the sample locations and schedule shipment of laboratory-supplied Summa canisters and equipment for arrival prior to the start of sampling.
- Confirm availability and condition of DDMT-owned equipment and order additional equipment/supplies (tubing and Tedlar bags) for delivery prior to the start of sampling event.
- Prepare field forms and other documentation for the planned event.

5.1.2 Field

After arrival on site, but prior to commencement of operations, the following activities will be performed:

- Complete equipment and supply checklists and verify that required documentation and equipment for field activities are on site.
- Review condition of DDMT-owned and rental equipment; inventory field supplies and laboratory-provided sampling supplies. Sample tubing and Tedlar bags should be replaced every three months.
- Confirm the exact locations of the samples to be collected.
- Check that monitoring equipment is functioning properly, and calibrated as needed.
- Due to the limited field activities for vapor sampling, completion of the Field Event Startup Report (SOP 1, Attachment 1-1) is not required.

5.2 Field Operations

Prior to sampling, a field station will be established. The station will contain equipment, supplies, safety gear, and instrumentation necessary for the collection of samples. Environmental conditions will also be noted. Each sampling site will be characterized by the following factors:

- Location of work
- Weather conditions including precipitation, temperature and wind direction
- Ongoing activities that may influence or disrupt sampling efforts

- Accessibility to the sampling locations

All laboratory sampling will be documented in the field logbook. The logbook will summarize sampling events include sampling locations and times, field conditions and other significant information.

5.2.1 Sample Locations

Field screening and laboratory vapor samples are collected from individual soil vapor extraction (SVE) wells, the SVE system effluent (vapor stream from all SVE wells), and vapor monitoring points (VMPs), sub-slab vapor ports, and soil borings. Samples for field measurements will be collected using an oil-less vacuum pump and captured in Tedlar bags for photoionization detector (PID) and/or helium detector readings. Laboratory vapor samples will be collected via Summa canisters.

5.2.2 Sample Containers

Laboratory samples will be collected by field personnel in accordance with the project work plan and at the direction of the PM. Sample collection will follow United States Environmental Protection Agency (USEPA) TO-15 volatile organic compounds (VOCs) procedures. Laboratory samples from the SVE system effluent will be collected in 6-liter Summa canisters; a 200 milliliter/minute (mL/min) regulator for laboratory analysis will be used when collecting samples from VMPs. Laboratory samples from sub-slab sample ports and soil borings will be collected in 1-liter Summa canisters restricted with a 200 mL/min regulator. Standard turnaround time (TAT) for laboratory results is 15 workdays.

Summa canisters will be delivered from the analytical laboratory; a pressure gauge and a flow regulator (if needed) for each canister should be included. Arrangement for delivery will be coordinated by the PC.

5.2.3 SVE Wells and System Effluent

Field measurements and samples for laboratory analysis will be collected to monitor system performance and VOC concentrations in emissions.

5.2.3.1 Field Measurements

Field measurements will be collected from individual SVE wells and the system effluent. While online, the SVE system is continuously pulling vapor from the subsurface; thus, no purging of wells or the system is required prior to field (PID) sample collection. Ensure all wells to be sampled are online for a minimum of two hours prior to sample collection. Field measurement procedures are as follows:

- Connect sampling pump inlet hose to SVE well sample port located on SVE manifold.
- Open appropriate well sample port ball valve.
- Turn on sampling pump and allow it to run for five seconds to purge the pump and tubing.
- Connect tedlar bag to discharge of sampling pump by inserting nipple of bag into pump discharge tube.

- Allow tedlar bag to fill (approximately 20 seconds).
- Once filled, disconnect tedlar bag from sampling pump.
- Close SVE well sample port ball valve.
- Connect calibrated PID Meter to tedlar bag.
- Allow PID Meter to measure VOC concentration. Ensure reading on PID meter stabilizes before recording VOC concentration. This usually takes 10 to 15 seconds.
- Record peak VOC concentration and time.

5.2.3.2 Laboratory Samples

Procedures for sample collection from the SVE wells and system effluent are as follows:

- Fill out Summa canister tag with sampling information using a pen with blue or black waterproof ink.
- Remove the Summa canister valve cap.
- Run dedicated tubing from SVE manifold to canister by connecting swagelock.
- Open appropriate SVE well/effluent sample port ball valve.
- Record starting Summa canister pressure on chain-of-custody (COC). The starting Summa canister pressure should be at least -25 inches of mercury (in. Hg) or greater. If not, the canister has leaked and should not be used for sampling.
- Open Summa canister valve located at top of sampling canister.
- Record sampling start time on COC.
- Allow Summa canister to fill until pressure gauge reads -5 in. Hg. (approximately 2 minutes with a 6-liter canister).
- Close sampling port ball valve at SVE well.
- Disconnect Summa canister from regulator.
- Record time of sample collection, date, and Summa canister serial and regulator numbers on COC form.

5.2.4 Vapor Monitoring Points

Field measurements and samples for laboratory analysis will be collected from VMPs to evaluate system performance and determine SVE well vacuum influence. It is necessary to purge VMPs prior to sample collection. Procedure will be repeated for the ‘A’ and ‘B’ screens at each VMP.

<u>Purging:</u>

- Unlock VMP well casing (secured by padlock).
- Attach regulator to “quick connect” on well cap, run line to a “T” connection.
- Run one line out from the “T” to the pump.

- Attach second line to the Summa canister via swagelock.
- Turn on sampling pump and allow lines to purge for approximately five minutes. Purge time is based on tubing diameter and length and is intended to remove three tubing volumes.

Field (PID) Measurements:

- Attach tedlar bag to discharge of sampling pump by inserting nipple of bag into pump discharge tube.
- Allow tedlar bag to fill (approximately 20 seconds).
- Once filled, disconnect tedlar bag from sampling pump.
- Connect calibrated PID Meter to tedlar bag.
- Allow PID Meter to measure VOC concentration. Ensure reading on PID meter stabilizes before recording VOC concentration. This usually takes 10 to 15 seconds.
- Record peak VOC concentration and time.
- Open valve on tedlar bag to completely deflate bag.
- Collect additional PID readings following the previous steps until three consecutive readings are within 10% of each other.

5.2.4.1 Laboratory Samples

Procedures for sample collection from the Dunn Field VMPs are as follows:

- Attach the vacuum pump and its dedicated tubing to the VMP well quick connect fitting.
- Close the valve to the “T” fitting and open the valve to the pump and start the pump.
- Each VMP has a purge time determined and it is on the VMP sample collection sheet for each VMP; run the vacuum pump for the allotted time.
- Attach a tedlar bag to the output from the vacuum pump and allow it to fill.
- Read the tedlar bag with a PID and record the result; repeat this procedure until three readings are within 10%.
- Fill out the Summa canister tag with sampling information using a pen with blue or black waterproof ink.
- Remove the Summa canister valve cap.
- Attach regulator to 6-liter Summa canister. An individual regulator should be provided by the laboratory for each Summa canister to be used for VMPs.
- Connect the Summa canister to the “T” tubing that was used to purge the VMP tubing. The Summa canister is connected before the vacuum pump, because the Summa canister is under its own vacuum.
- Open appropriate VMP sample port ball valve.

- Record starting Summa canister pressure on COC. The starting Summa canister pressure should be at least -25 in. Hg or greater. If not, the canister has leaked and should not be used for sampling.
- Open Summa canister valve located at top of sampling canister.
- Record sampling start time on COC.
- Allow Summa canister to fill until pressure gauge on regulator reads -5 in. Hg (approximately 30 minutes with a 6-liter canister and a 200 mL/min flow regulator).
- Close sampling port ball valve at VMP cap.
- Disconnect Summa canister from regulator.
- Record time of sample collection, date, and Summa canister serial and regulator numbers on COC form.

5.3 Sub-Slab and Soil Boring Vapor Sampling

Sub-slab sample ports and temporary soil borings will be installed to evaluate VOC concentrations beneath or adjacent to impervious surfaces. VaporPin, or equivalent device, will be constructed in accordance with manufacture specifications to allow for collection of sub-slab samples. Shallow soil gas samples will be collected from soil borings via the post run tubing (PRT) method. Procedures for these sampling methods are presented below.

Leak Check

Leak check should be performed prior to sample train purging and sampling to verify the integrity of the sub-slab sample port (Water Dam Procedures) and PRT annular seal (Tracer Test) and to identify the presence of leaks in the sample train (Shut-In Test).

5.3.1 Water Dam Procedure

Leak testing of the Vapor Pin annular seal will be performed with a water dam in accordance with the method prescribed in the Vapor Intrusion Technical Guidance (NJDEP, 2016). The water dam will be constructed from PVC and surround the sub-slab sample port. The water dam will be sealed to the concrete floor with modeling clay or other VOC free inert material. The water dam will be filled with distilled/deionized water so that it is covering the sub-slab sample port annular seal. The water level will be briefly observed to verify that the water level is not receding. If the water level remains stable the sample train will be purged and a sample will be collected while continuing to observe the water level. Should the water level decrease, the sampling will be stopped, a new sub-slab sample port will be installed and the process repeated.

5.3.2 Tracer Test

A tracer test is used to determine whether ambient air is introduced into the soil gas sample during the collection process. The tracer test and well purging will be performed simultaneously by the steps described below:

1. Connect aboveground sample train to PRT tubing and place a shroud over the drive rod and sample train;

2. Inject He gas under the shroud to achieve a target shroud concentration of two orders of magnitude greater than the He meter minimum detection limit;
3. Purge three casing volumes from the sample train with a syringe or pump, at a flow rate of 100 to 200 ml/min and contain the purged gas in a Tedlar bag;
4. Use the He detector to measure the He concentration in the Tedlar bag and beneath the shroud;
5. If the He concentration in the Tedlar bag is less than 5 percent (%) of the concentration beneath the shroud then a sample can be collected; and
6. If the He concentration in the Tedlar bag is greater than 5% of the concentration beneath the shroud than the annular seal may be compromised. A sample can still be collected, but the technician will note that the He test failed and the result will be flagged.

5.3.3 Shut-In Test

A shut-in test will be performed prior to purging and sampling soil gas and sub-slab aboveground sampling trains to locate leaks. This test is performed by assembling the sample train, as if a sample was being collected, and a vacuum of at least 100 inches of water (7.4 inches of mercury) is applied. At this point, the sample train should be isolated from the sub-slab sample port either by a valve or disconnected and plugged so that the vacuum can be applied without evacuating soil gas. After the vacuum is applied, the field technician will observe the vacuum gauge on the sample train for any change in vacuum. If the vacuum in the sample train dissipates then the leak will be located, corrected, and the test will be repeated until the sample train can hold a vacuum for at least thirty seconds.

Sampling

After the field technician has completed the shut-in test, tracer test, and purged three casing volumes, the soil gas sample will be collected. This will be performed by opening the valve on the top of the 1-liter Summa canister and allowing the canister vacuum to remove one liter of soil gas at a 200 ml/min flow rate. The Summa canister will be labeled with the sample identification, starting vacuum, ending vacuum, sampler's initials, sample date, and sample time.

Field records will be maintained that detail site activities and observations so that an accurate, factual account of field procedures may be reconstructed. At a minimum, the field records will contain sample identification, collection time, location description, methods used, daily weather conditions, field measurements, name of sampler(s), names of contractor/subcontractor personnel, and other site-specific observations including any deviations from the project work plan. HDR will periodically record the precipitation, temperature, and barometric pressure from a nearby weather station during and 72 hours prior to sample collection.

5.4 Closeout

5.4.1 Field

Following sample collection, the following procedures will be performed by on-site personnel:

- Decontaminate all field equipment.

- Ensure all field documentation is completely filled out. This includes the COC and Summa sampling tag. Unless revised by the project manager, standard turn-around time (15 days) will be used. Retain copy of COC for the project file.
- Package Summa canisters in sturdy cardboard boxes with packing material to prevent any potential puncture of the canister. In most cases, the boxes and packing material used by the laboratory to ship the Summa canisters to the site can be reused.
- Affix a custody seal across the top taped seam of the canister shipping carton and elsewhere as necessary to ensure security.
- Ship Summa canisters to laboratory for analysis. Ensure copy of COC is included in shipment.
- Complete logbook, making notations as to site conditions, anomalous readings, etc.
- Ensure that equipment and associated supplies have been shipped back to the office or supplier.
- Ensure that all IDW/trash has been disposed in accordance with the project work plan and QAPP.

5.4.2 Office

Upon return to the office, field personnel will perform the following:

- Submit logbook and any original forms to Project/Task Manager for review
- Completion of the Field Event Closeout Report (Attachment 1-3) is not required.

6 Data and Records Management

All field forms and log book entries will be scanned and copied to the project folder on the "Z" drive within one week of the field event completion. All photographs taken during the field event will be uploaded along with a typed photograph log (date, project and subject) to the "Z" drive. All original forms will be stored on site in Memphis in the filing cabinet in the proper folder labeled for the project. The PM and PC will be sent a link for the data.

7 Quality Control and Quality Assurance

All work will be performed in accordance with the Quality Assurance Project Plan (HDR, 2017a), the project work plan, and applicable SOPs. All field activities will be recorded in the log books in sufficient detail to reconstruct the events. No erasures or mark outs will be made on field forms or log books. A single line will be used to strike out errors and will be annotated with the initials and date of the editor.

8 References

HDR, 2017a. *2017 Uniform Federal Policy-Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 0*. Prepared for the U.S. Army Corps of Engineers, Mobile District. May 2017.

New Jersey Department of Environmental Protection (NJDEP), 2016. *Vapor Intrusion Technical Guidance,* August 2016.

STANDARD OPERATING PROCEDURE 7 – SAMPLE CONTROL AND DOCUMENTATION

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

This Standard Operating Procedure (SOP) provides guidance for sample control and identification, data recording, and proper completion of Chain-of-Custody (COC) forms.

2 Health and Safety

General Information on health and safety requirements are provided in SOP 1. Each individual is required to have read and understood the Site Safety and Health Plan for the specific project activity and signed the acknowledgement sheet confirming their review.

Health and safety concerns for sample handling include potential for exposure to contaminants, sample container preservatives, and injury from breakage of sample containers. Contamination levels at Defense Depot Memphis, Tennessee (DDMT) are relatively low but care should be taken to avoid exposure. Sample containers should be handled carefully; nitrile gloves and safety glasses should be used.

3 Personnel Qualifications and Responsibilities

Sample control activities will be directed by the Field Team Leader (FTL), an environmental professional (engineer, geologist or scientist) with experience in sampling activities. The field staff, environmental professionals or technicians, are responsible for proper sample handling and documentation of the sample collection.

4 Equipment and Supplies

The field staff will use a pen with blue or black waterproof ink to record field activities and document sample handling in a field logbook and on field data sheets. A laptop computer with laboratory-provided software may also be used for sample documentation.

5 Procedure

Proper field sampling and documentation help ensure sample authenticity and data integrity. These procedures describe sample collection documentation and sample handling, tracking, and custody procedures to ensure that sample integrity and custody are maintained.

If the computer is being used to scan the samples as they are collected the data recorded by the computer should be checked for correctness. The date and time on the computer should be checked prior to scanning of any samples. The sample label should be completed when the sample is collected. If a hand written COC will be used, all information should be recorded in a log book as to the type of sample, date and time collected and number of sample containers. The COC can then be filled out back at the field office in a quiet environment without disturbances to avoid errors.

Corrections to the COC, field logbook or field data forms will be made by a single line to strike out errors annotated with the initials and date of the editor; the correct information will be inserted as appropriate.

The number of sample containers on the COC should be physically checked against the number of containers collected. Once this is confirmed the sample crew can properly store the samples for shipment.

5.1 Start-Up Activities

5.1.1 Office

The FTL will work with the project chemist (PC) to:

- Prepare the sampling plan detail (Attachment 7-1).
- Coordinate with the analytical laboratory and ensure that sample forms including chain of custody forms and custody seals are shipped to the site.

5.1.2 Field

After arrival on site, but prior to commencement of operations, the FTL will confirm that required documentation and equipment for field activities are on site.

5.2 Field Operations

5.2.1 Sample Identification

Individual samples will be identified by a unique alphanumeric code (also referred to as a sample ID number or field number) which will be written on the sample label and recorded on the COC form. The sample ID will include the location and sampling event as described in Worksheet #17 of the Quality Assurance Project Plan (QAPP). Additional information to be written on the label includes sample ID, time and date of sample, sampler's initials, and the analytical methods to be performed, as described in Section 5.2.3 of this SOP.

Field Quality Control (QC) samples to be collected at DDMT include trip blanks, rinsate blanks, field (ambient) blanks, and field duplicates. The ID for trip blanks, rinsate blanks and field blanks will consist of the prefix TB, RB or FB, respectively, followed by a number, followed by the sampling event, as shown below:

TB-1-ODPM-9	first Trip Blank for event ODPM-9
TB-2-ODPM-9	second Trip Blank for event ODPM-9
RB-1-ODPM-9	Rinsate Blank for event ODPM-9
FB-1-ODPM-9	Field Blank for event ODPM-9

Matrix spike and matrix spike duplicate samples will also be collected. The ID for these samples will consist of the location ID, followed by the sampling event, followed by the suffix matrix spike (MS) or matrix spike duplicate (MSD), as shown below:

MW-315-ODPM-9-MS	Matrix Spike sample for well MW-315
MW-315-ODPM-9-MSD	Matrix Spike Duplicate sample for well MW-315

The identity of field duplicate samples will be concealed from the laboratory by using a consecutively numbered duplicate identifier, followed by the sampling event, as shown below:

DUP-1-ODPM-9	first field duplicate for event ODPM-9
DUP-2-ODPM-9	second field duplicate for event ODPM-9

The location of field duplicates will be recorded on the sampling plan detail (SPD) and field notebook. The final SPDs will be maintained in the project file and copies will be kept at the on-site field office. At the end of the sampling event, the FTL will send the PM and PC the final SPD with changes to field duplicate or MS/MSD sample IDs, additional blanks collected, and any other changes.

5.2.2 Field Documentation

5.2.2.1 Logbook

The logbook is a written record of sampling activities to be completed in the field during sampling. The purpose is to document field conditions or procedural exceptions that may aid in the analysis of data generated from sampling activities. The log book will have with sequentially numbered pages and information will be recorded in blue or black waterproof ink. The recorder will sign and date each entry.

Information pertaining to environmental conditions at the site during the field investigation will be noted in the field log book for each day. The following information will be recorded for each activity:

1. Activity
2. Location
3. Date and time
4. Weather conditions

For field sampling activities, the following information will be recorded, if a sampling form is not used:

1. Sample type and sampling method

2. The identity of each sample and the depth(s) from which it was collected
3. Sample description (e.g., color, odor, clarity)
4. Identification of sampling devices used
5. Identification of sampling conditions that might affect the representativeness of a sample (i.e., refueling operations, damaged casings)

5.2.2.2 Daily Field Reports

Each day the FTL will prepare a Daily Field Report (SOP 1, Attachment 1-2). The report will include daily weather, time and description of field activities, samples collected, and any problems or changes in scope that occurred that day. The report also lists field staff, subcontractors and site visitors.

5.2.2.3 Photographs

Photographs taken for the purpose of project documentation will be noted in the field logbook. The sequential number of the photograph, photographer, date, time, location, description, and orientation of the photograph will be recorded in the logbook as the photographs are taken. The photographs and documentation will be loaded on the HDR network project file.

5.2.3 Sample Labels/Tags

Sample labels will be filled out for each sample with an indelible pen. The label will be protected from water and solvents with clear label protection tape. Any change in the pre-prepared label information will be initialed by the sampler.

5.2.3.1 Labels for Groundwater Samples

Pre-printed labels from the laboratory for groundwater sampling events contain the following information:

- Sample ID
- Preservative
- Date the bottle was prepared
- Matrix
- Tests
- Laboratory name
- Bar code

The sample collector will write in the following information:

- Date of collection
- Time of collection
- Name or initials of collector

5.2.3.2 Sample Tags for Air Samples

Sample tags from the laboratory for air sampling events contain the following information:

- Laboratory name, address, phone number and fax number

The sample collector will write in the following information:

- Client name (HDR)
- Sample ID
- Analysis (TO-15)
- Date and time of sample collection
- Sampler's initials
- Comments

5.2.4 Sample Custody

Sample custody is a part of a quality field or laboratory operation. Custody of a sample is defined as:

1. Having physical possession
2. Being in view, after being in possession
3. Having possession, then being placed in a secure area
4. Being maintained in a secure area by the person who had possession last

These custody practices will be observed in the field. They will be performed according to the procedures described in the following subsections.

5.2.4.1 COC Records

A hand-written three-part COC will be fully completed, in triplicate. The first two pages will accompany the cooler to the laboratory, and the bottom copy will be retained in the files at the field office after it is scanned into the computer file.

A computer-generated COC will have one copy printed that will accompany the cooler to the laboratory. The data used to generate the COC will be transmitted via E-mail to the laboratory and a PDF copy of the COC will be saved on the computer in the sampling file.

The information specified on the COC record will contain the same level of detail found in the site log book, with the exception that on-site measurement data will not be recorded. The custody record will include at least the following information:

- Name of person collecting the samples
- Date samples were collected
- Type of sampling conducted (composite/grab)
- Location of sampling station (including the site location)
- Number and type of containers used

- Signature of the HDR person relinquishing samples to a non-HDR person (such as a FedEx agent), with the date and time of transfer noted, and the cooler designation
- Airbill Number

If samples will require rapid turnaround in the laboratory because of project time constraints or analytical concerns such as extraction time or sample retention period limitations, these constraints will be noted in the remarks section of the custody record. The FTL or designee will contact the laboratory to confirm the turnaround time can be achieved. The computer generated COC is for use with Microbac Laboratories only. Other laboratories will provide COCs for use.

It is not practicable to seal the sample coolers or cartons at a FedEx office; they will be sealed beforehand. The custody record will, therefore, have the signature of the relinquishing field technician with the date and time, but the “relinquished to” box will not be completed.

The duplicate custody record will then be placed in a plastic bag, taped to the underside of the cooler lid, and the cooler closed. COCs for air samples will be included in the carton. The container will be tightly bound with filament tape. Finally, custody seals will be signed by the individual relinquishing custody and affixed in such a way that the cooler or carton cannot be opened without breaking the seals.

The original and duplicate custody records and the airway bill or delivery note together constitute a complete record. The FTL will email a copy of the airbill and the COC to the PC, who will maintain the custody records as part of the analytical data file.

Custody Seals: Custody seals will be preprinted, adhesive-backed seals designed to break if disturbed. For groundwater samples, affix custody seals on the sample shipping containers (coolers) in as many places as necessary to ensure security. For vapor samples affix a custody seal across the top, taped seam of the canister shipping carton and additional locations as necessary. Seals will be signed and dated before application.

Laboratory custody procedures are described in the laboratory sample handling and storage SOPs, included in Appendix C of this QAPP.

5.3 Closeout

Before leaving the site daily, the following procedures will be performed by on-site personnel:

- Maintain custody of samples, maintaining them as specified for the analyses to be performed.
- Prepare samples for shipment to the laboratory.
- Complete the COC forms.
- Contact the laboratory to inform them that samples will be shipped and also remind them of any special requirements for the sample analyses.
- Verify completion of logbook, ensuring that required information has been recorded.

Upon the completion of sample collection and shipment, copies of the COCs will be scanned and sent to interested parties to include the PM and PC. The FedEx tracking numbers will be checked each day to confirm the samples were delivered and the laboratory will be contacted to check on problems with the samples or COCs.

6 Data and Records Management

All field forms, COCs, and log book entries will be scanned and copied project folder on the HDR network project file within one week of the field event completion. All original forms will be stored on site in Memphis in the filing cabinet in the proper folder labeled for the project. The PM and PC will be sent a link for the data.

7 Quality Control and Quality Assurance

Work will be performed in accordance with the QAPP, the specific work plan, and applicable SOPs. Field activities will be recorded in the log books in sufficient detail to reconstruct the events and forms provided with the SOP will be completed. No erasures or mark outs will be made on field forms or log books. A single line will be used to strike out errors and will be annotated with the initials and date of the editor; the correct information will be inserted as appropriate.

8 References

HDR, 2018. DDMT Uniform Federal Policy-Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 1. Prepared for the U.S. Army Corps of Engineers, Mobile District. March 2018.

USEPA Region 4 Science and Ecosystem Support Division (SESD) 2011. SESDPROC-209-R2, *Operating Procedure: Packing, Marking, Labeling and Shipping of Environmental and Waste Samples*. April 2011.

Attachment 7-1

EXAMPLE: Sample Plan Detail

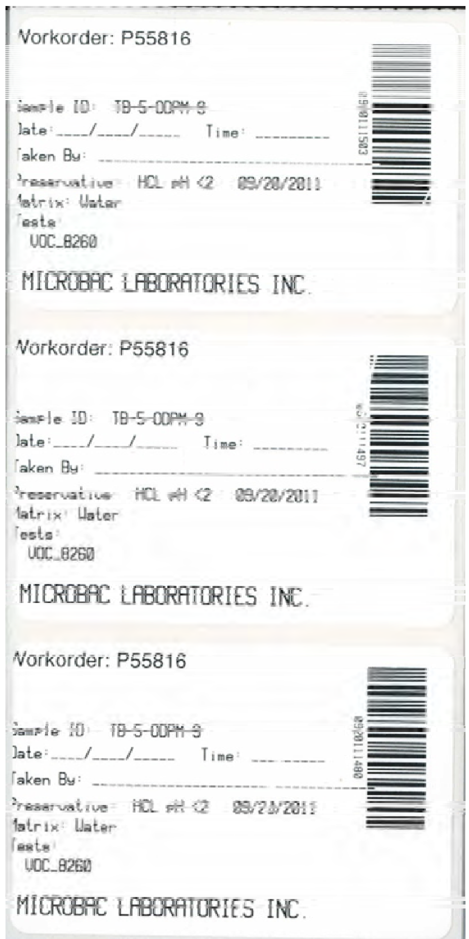
SAMPLING PLAN DETAIL (OFF DEPOT PM WELLS September 2011) - ODPM-9

Parameter	**VOCs**
Method	**8260B**
Container	**40 mL VOA**
Preservative	**HCl to pH<2**
	Cool to 4°C

#	Well ID	Sample ID	Additional	No. of Containers
1	MW-54	MW-54-ODPM-9		3
2	MW-70	MW-70-ODPM-9		3
3	MW-76	MW-76-ODPM-9		3
4	MW-77	MW-77-ODPM-9		3
5	MW-79	MW-79-ODPM-9	DUP-1	3
6	MW-148	MW-148-ODPM-9		3
7	MW-149	MW-149-ODPM-9		3
8	MW-150	MW-150-ODPM-9		3
9	MW-151	MW-151-ODPM-9		3
10	MW-152	MW-152-ODPM-9		3
11	MW-155	MW-155-ODPM-9		3
12	MW-157	MW-157-ODPM-9		3
13	MW-158	MW-158-ODPM-9		3
14	MW-158A	MW-158A-ODPM-9		3
15	MW-159	MW-159-ODPM-9	DUP-2	3
16	MW-160	MW-160-ODPM-9		3
17	MW-161	MW-161-ODPM-9		3
18	MW-162	MW-162-ODPM-9		3
19	MW-163	MW-163-ODPM-9		3
20	MW-164	MW-164-ODPM-9		3
20	MW-164	MW-164-ODPM-9-MS	MS	3
20	MW-164	MW-164-ODPM-9-MSD	MSD	3
21	MW-165	MW-165-ODPM-9		3
22	MW-165A	MW-165A-ODPM-9		3
23	MW-166	MW-166-ODPM-9		3
24	MW-166A	MW-166A-ODPM-9		3
25	MW-241	MW-241-ODPM-9		3
26	MW-242	MW-242-ODPM-9		3
27	MW-243	MW-243-ODPM-9		3
28	MW-244	MW-244-ODPM-9		3
29	MW-245	MW-245-ODPM-9		3
30	MW-246	MW-246-ODPM-9		3
31	RB	RB-ODPM-9		3
32	DUP-1	DUP-1-ODPM-9		3
33	DUP-2	DUP-2-ODPM-9		3
34	TB-1	TB-1-ODPM-9		3
35	TB-2	TB-2-ODPM-9		3

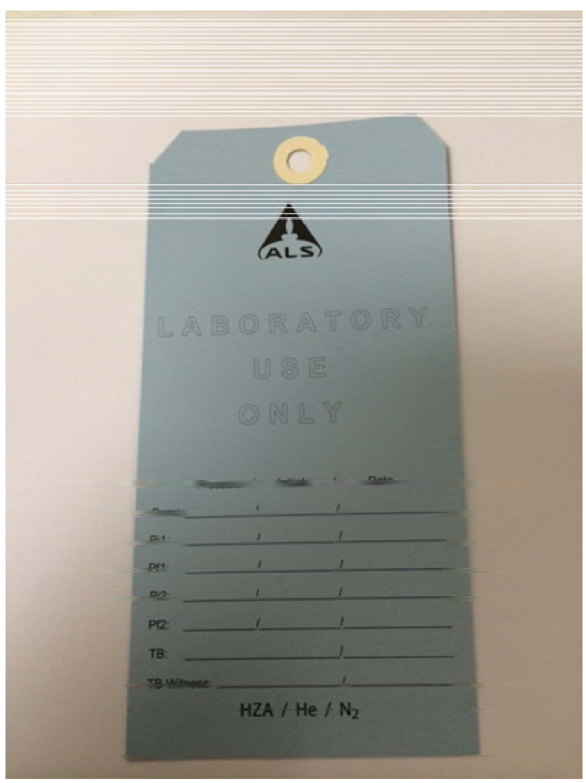
Attachment 7-2

EXAMPLE: Sample Labels for Groundwater Samples



Attachment 7-3

<u>EXAMPLE:</u> Sample Labels for Air Samples



Attachment 7-4

EXAMPLE: Microbac Chain-of-Custody Form (Computer)

Microbac

Chain of Custody

Chain #: 1001
Printed at : 04/26/2011 08:46

Barcode	Client ID	Tests	Collect Date	Beg. Depth	End. Depth	Notes
~~0420111~~	~~MW-91-ODLB-3~~	~~VOC_8260~~	~~04/25/2011 10:09~~	[illegible]		
~~0420112~~	~~MW-91-ODLB-3~~	~~VOC_8260~~	~~04/25/2011 10:09~~	[illegible]		
~~0420113~~	~~MW-91-ODLB-3~~	~~VOC_8260~~	~~04/25/2011 10:09~~	[illegible]		
0420111	04/25/11-TB-1-ODPM-8	VOC_8260	04/25/2011 10:09			
0420112	04/25/11-TB-1-ODPM-8	VOC_8260	04/25/2011 10:09			
0420113	04/25/11-TB-1-ODPM-8	VOC_8260	04/25/2011 10:09			
0420114	DUP-1-ODPM-8	VOC_8260	04/25/2011 11:32			
0420115	DUP-1-ODPM-8	VOC_8260	04/25/2011 11:32			
0420116	DUP-1-ODPM-8	VOC_8260	04/25/2011 11:32			
0420117	MW-250-ODPM-8	VOC_8260	04/25/2011 10:30			
0420118	MW-250-ODPM-8	VOC_8260	04/25/2011 10:30			
0420119	MW-250-ODPM-8	VOC_8260	04/25/2011 10:30			
04201110	MW-251-ODPM-8	VOC_8260	04/25/2011 10:42			
04201111	MW-251-ODPM-8	VOC_8260	04/25/2011 10:42			
04201112	MW-251-ODPM-8	VOC_8260	04/25/2011 10:42			
04201113	MW-54-ODPM-8	VOC_8260	04/25/2011 11:32			
04201114	MW-54-ODPM-8	VOC_8260	04/25/2011 11:32			
04201115	MW-54-ODPM-8	VOC_8260	04/25/2011 11:32			
04201116	MW-70-ODPM-8	VOC_8260	04/25/2011 13:23			
04201117	MW-70-ODPM-8	VOC_8260	04/25/2011 13:23			
04201119	MW-70-ODPM-8-MS	VOC_8260	04/25/2011 13:23			
04201120	MW-70-ODPM-8-MS	VOC_8260	04/25/2011 13:23			
04201122	MW-70-ODPM-8-MSD	VOC_8260	04/25/2011 13:23			
~~04201123~~	~~MW-70-ODPM-8-MSD~~	~~VOC_8260~~	~~04/25/2011 13:23~~	ks 4/26		
04201125	MW-76-ODPM-8	VOC_8260	04/25/2011 13:07			
04201126	MW-76-ODPM-8	VOC_8260	04/25/2011 13:07			
04201127	MW-76-ODPM-8	VOC_8260	04/25/2011 13:07			
04201128	MW-77-ODPM-8	VOC_8260	04/25/2011 13:14			
04201129	MW-77-ODPM-8	VOC_8260	04/25/2011 13:14			
04201130	MW-77-ODPM-8	VOC_8260	04/25/2011 13:14			
04201131	MW-79-ODPM-8	VOC_8260	04/25/2011 11:17			
04201132	MW-79-ODPM-8	VOC_8260	04/25/2011 11:17			

Microbac OVD 221000014398
Received: 04/27/2011 12:56
By: BRENDA GREENWALT
(signed)

Barcode	Client ID	Tests	Collect Date	Beg. Depth	End. Depth	Notes
04201133	MW-79-ODPM-8	VOC_8260	04/25/2011 11:17			

Samples Collected on: 04/25/2011 by jbsperry
(signed)

Attachment 7-4

EXAMPLE: Microbac Chain-of-Custody Form (Hand)

COC No. A 23953

158 Starlite Drive
Marietta, OH 45750

Microbac

CHAIN-OF-CUSTODY RECORD

Phone: 740-373-4071
Fax: 740-373-4835

Company Name:

Project Contact: | Contact Phone #:

Turn Around Requirements: | Location:

Project ID:

Sampler (print): | Signature:

Sample I.D. No.	Comp	Grab	Date	Time	Matrix*	NUMBER OF CONTAINERS	Hold															TOTAL # (LAB USE)	Program: ☐ CWA ☐ RCRA ☐ DOD ☐ NPDES ☐ Other ____ ADDITIONAL REQUIREMENTS

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Relinquished by: (Signature)	Date	Time	Received for Laboratory by: (Signature)	Date:	Time	Remarks:	

*Water (W), Soil (S), Solid Waste (SD), Unknown (X)

Page ________ of________

Attachment 7-5

EXAMPLE: ALS Chain-of-Custody Form

Air - Chain of Custody Record & Analytical Service Request

Page ______ of ______

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10 Day-Standard

ALS Project No.

ALS Contact:

Company Name & Address (Reporting Information)	Project Name
	Project Number
Project Manager	P.O. # / Billing Information
Phone / Fax	
Email Address for Result Reporting	Sampler (Print & Sign)

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method		Comments e.g. Actual Preservative or specific instructions

Report Tier Levels - please select
Tier I - Results (Default if not specified) ____
Tier II (Results + QC Summaries) ____
Tier III (Results + QC & Calibration Summaries) ____
Tier IV (Data Validation Package) 10% Surcharge ____

EDD required Yes / No
Type: ______________ Units: __________

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:	Cooler / Blank Temperature ____°C

STANDARD OPERATING PROCEDURE 8 – SAMPLE PACKING AND SHIPPING

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for packing and shipping environmental samples to the laboratory for analysis. The goals for sample packing and shipping are that: 1) the integrity of the sample is maintained, and 2) no exposure to the sample contents occurs during transit. These goals should be met regardless of the method by which the samples were shipped.

Samples will usually be shipped as either environmental samples or as hazardous materials based on the expected contaminant concentrations. While the concentration of constituents in the sample is not generally known prior to shipment of the sample, inferences can be made based on the site location and knowledge of past activities, observations during collection, and past sample results. Hazardous materials are generally considered to be samples of highly contaminated media collected at or near an observed release and can consist of pure product or a mixture. Environmental samples are generally media with low-level contamination.

Relevant regulations include Department of Transportation (DOT) regulations for ground transportation (49 Code of Federal Regulations [CFR]) and the International Air Transport Association (IATA) regulations for air transportation. Common carriers (e.g., FedEx, and UPS etc.) must abide by these regulations. This SOP provides specific guidance on how to package and ship samples to achieve the stated objectives and remain in compliance with shipping regulations. If field personnel are unsure regarding current shipping regulations, they will immediately contact the selected carrier (e.g., FedEx, UPS, etc.) for guidance.

2 Health and Safety

General Information on Health and Safety requirements are provided in SOP 1. Each individual is required to have read and understood the Health and Safety Plan (HASP) for the specific project activity and signed the acknowledgement sheet confirming their review.

Health and safety concerns for sample shipment include potential for exposure to contaminants, sample container preservatives, and injury from breakage of sample containers. Contamination levels at Defense Depot Memphis, Tennessee (DDMT) are relatively low but care should be taken to avoid exposure. Sample containers should be handled carefully; nitrile gloves and safety glasses should be used.

3 Personnel Qualifications and Responsibilities

Sample packing and shipping activities will be directed by the Field Team Leader (FTL), a mid- or senior level environmental professional (engineer, geologist or scientist) with experience in sampling activities. Field staff, environmental professionals or technicians, are responsible for proper sample handling and compliance with these guidelines.

4 Equipment and Supplies

The required equipment and supplies will consist of ice chests from the laboratory, clear tape, filament tape, gallon size Ziploc bags, trash bags, custody seals, bubble bags, cushion for bottom of cooler, and FedEx handle label hangers.

5 Procedure

5.1 Start-Up Activities

5.1.1 Office

The FTL will work with the project chemist (PC) to:

- Ensure that sufficient sample containers, shipping containers/coolers and packing material are shipped to the site based on the analytical parameters, total number of samples and average number of samples to be collected per day.
- Develop guidelines on the number/type of samples per shipper based on sample type and past analytical results (i.e. volatile organic compounds [VOCs] in one cooler to limit the number of trip blanks needed and samples from high concentration wells packed in separate cooler to prevent cross contamination)
- Coordinate sample shipments to ensure laboratory personnel will be available to receive the samples if weekend or holiday shipments are planned.

5.1.2 Field

After arrival on site, but prior to commencement of operations, the FTL will confirm that the required sample containers, sample coolers, packing material and ice are available on-site.

5.2 Field Operations

On specific projects, protocols for sample shipment will be specified in the work plan. This SOP provides general guidelines for sample packing and shipping.

- Samples will be shipped to the laboratory by an overnight courier service.
- Samples will not remain on site for more than 24 hours after collection, unless samples were collected on a weekend or there were not enough samples to make a shipment. These

samples will be stored in the refrigerator at 4 degrees Celsius (°C) in a locked office until the next shipment.

- Glass sample containers will be placed inside sealed plastic bubble wrap bags or wrapped in bubble wrap and placed in plastic bags as a precaution against cross-contamination due to leakage or breakage.
- Sample bottles will be placed in coolers in a manner to limit the breakage and/or leakage during shipment. All coolers will have a bottom cushion/absorbent placed in prior to placing the samples in the cooler.
- Coolers will be lined with a heavy duty plastic garbage bag.
- Segregate highly contaminated samples, if known, by placement in a separate cooler or in separate plastic zip-lock bags.
- All coolers will have the drain plug taped closed, if present.
- Sufficient ice in plastic bags (double-bagged) will be placed in the coolers to keep the samples at 4°C throughout shipment.
- The top of the garbage bag, lining the cooler and containing the samples and ice, will be tied or adequately sealed as to prevent leakage.
- Chain-of-Custody (COC) documents will be placed in zip-lock bags and taped to the inside lid of each cooler.
- Cooler lids will be secured by wrapping with filament tape.
- The air bill will be secured to the handle of the cooler for the shipment label.
- Place Fragile and perishable stickers on all coolers. If shipping for Saturday delivery, place multiple Saturday Delivery stickers on each cooler and contact the laboratory to confirm receiving staff will be present.
- Confirm arrangements with the laboratory point-of-contact for Saturday delivery samples so that hold times and/or sample preservation are not compromised.

Custody seals will be used for sample shipments in accordance with SOP 7, Sample Control and Documentation. Custody seals are adhesive labels that are placed in such a manner that they will be visibly disturbed upon opening the shipping container or cooler. The seals will be initialed and dated upon placement. Upon receipt at the laboratory, the sample custodian will note the condition of custody seals and will also check the sample temperature, recording these items on the laboratory receipt form.

5.3 Closeout

Before leaving the site daily, the following procedures will be performed by the FTL or designated field staff:

- Ensure that the sample transport containers are properly packed and are in compliance with DOT and IATA regulations.
- Complete the Sample Handling, Packing & Shipping Checklist (Attachment 8-1).

6 Data and Records Management

All field forms and log book entries will be scanned and copied project folder on the "Z" drive within one week of the field event completion.

7 Quality Control and Quality Assurance

Work will be performed in accordance with the Quality Assurance Project Plan (QAPP), the specific work plan, and applicable SOPs. The Sample Handling, Packing & Shipping Checklist will be completed each day that samples are shipped. No erasures or mark outs will be made on the checklist. A single line will be used to strike out errors and will be annotated with the initials and date of the editor.

8 References

HDR, 2018a. DDMT Uniform Federal Policy-Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 1. Prepared for the U.S. Army Corps of Engineers, Mobile District. March 2018.

SESDPROC-209-R2, *Operating Procedure: Packing, Marking, Labeling and Shipping of Environmental and Waste Samples,* 2011.

Attachment 8-1

Sample Handling, Packing & Shipping Checklist

When preparing samples for shipment to the laboratory, complete this checklist to ensure that samples, documents, and materials are properly packed in the sample shipper.

Sample Event: ______________________

Date: ______________

PROJECT SAMPLES

□ All samples, duplicates, MS/MSDs, equipment blanks, ambient blanks, and trip blanks should be included in the cooler that are listed on the COC.

□ Verify that the proper number of bottles with appropriate preservative(s) were collected for each sample

□ Verify that samples were checked for pH (except volatile samples)

DOCUMENTS

□ **Chain-of-Custody (COC)** generated for *each* cooler

□ COC reviewed for completeness, including appropriate signature(s) and date(s), and include the **courier tracking/shipping number** on the COC

□ **COC** placed in a Ziploc bag and taped to the underside of the cooler lid

□ **Custody seals** placed on the front and back of each cooler, or across the sealing tape for Summa canister cartons.

□ Coolers for Saturday delivery have “Saturday Delivery” stickers and “Saturday Delivery” box checked on the airbill

□ Shipments are insured

PACKING MATERIALS

□ Ice is “double-bagged” and is sufficient to maintain a temperature of 4°C

□ Glass bottles placed in a bubble bag to prevent breakage and leakage

□ All coolers have a bottom cushion in place prior to placing samples in the cooler.

□ Highly contaminated samples (if known) placed together

□ **Trip blank** placed in each cooler that contains samples for VOC analyses at beginning of day

□ All VOC samples placed in same cooler to minimize the number of trip blanks,

□ Each cooler contains a **temperature blank**

Comments: (special handling or delivery requirements, highly contaminated samples, etc.)
____
____

Number of coolers shipped: ________________

Checklist Completed By: ______________________________ Date: ____________

Note: Place the completed checklist in the project file with the associated COCs and airbill.

STANDARD OPERATING PROCEDURE 9 – EQUIPMENT DECONTAMINATION

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Field Team Leader: Clayton Mokri
Project QA Officer: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

This Standard Operation Procedure (SOP) provides guidance for proper decontamination of equipment used in sampling and collection of equipment rinsates to evaluate effectiveness of decontamination procedures.

2 Health and Safety

General Information on Health and Safety requirements is provided in SOP 1. Each individual is required to have read and understood the Site Safety and Health Plan for the project and signed the acknowledgement sheet confirming their review.

Health and safety concerns for equipment decontamination include exposure to contaminants from sampling equipment. Nitrile gloves and safety glasses should be used during decontamination.

3 Personnel Qualifications and Responsibilities

Sampling equipment decontamination and rinsate sample collection will be directed by the Field Team Leader (FTL), an environmental professional (engineer, geologist or scientist) with experience in equipment decontamination and sampling activities. The field staff, environmental professionals or technicians, are responsible for following these procedures and seeking direction from the FTL when questions or problems arise.

4 Equipment and Supplies

The required equipment and supplies will consist of Alconox soap, deionized water (DI), tap water, paper towels, foil, and sample containers.

5 Procedure

Proper equipment decontamination will prevent cross-contamination of samples due to residual contamination from previous sample locations and spread of contamination via sampling equipment. Proper decontamination also supports the legal defensibility of data generated during site activities.

Decontamination procedures will be evaluated by the collection of equipment rinsate samples. These samples consist of reagent water collected from final rinse of sampling equipment after the decontamination procedure has been performed. The samples are analyzed with the environmental sample to assess the adequacy of the decontamination performed.

5.1 Start-Up Activities

5.1.1 Office

The FTL will confirm that sufficient equipment and supplies are available at the site based on the number of samples and estimated field days.

5.1.2 Field

After arrival on site, but prior to commencement of operations, the FTL will confirm that decontamination supplies and equipment are available on site and review procedures with field staff.

5.2 Field Operations

5.2.1 Decontamination Area

The location of the decontamination area, used primarily for larger pieces of equipment, will be determined in consultation with subcontractor personnel. The decontamination pad will include a sump lined with 6-mil polyethylene sheeting to collect the decontamination water. The sump will be constructed by either excavating a small area to create a depression or by elevating the edges of the sheeting. Existing concrete pads with containment areas can be used for large equipment like drill rigs. Small handheld equipment will be decontaminated in 5-gallon buckets in order to contain the water.

5.2.2 Decontamination Water Source

Potable water from the municipal water system will be used as a rinse in the decontamination procedure. The FTL will be responsible for coordinating with the subcontractor personnel to secure an adequate supply of potable water for decontamination procedures. If large quantities of water are to be used, the subcontractor will rent a water meter from Memphis Light Gas and Water (MLGW). For smaller amounts, the field office water supply can be used.

5.2.3 Decontamination Procedures

The required decontamination procedure for large pieces of equipment such as drill rigs, auger flights, and drilling and well casing is:

1. Wash the external surface of equipment or materials with high pressure hot water and Alconox or equivalent, and scrub with brushes if necessary until all visible dirt, grime, grease, oil, loose paint, rust flakes, etc., have been removed from the equipment.
2. Air dry.
3. Decontamination waste water will be stored at the site and analyzed prior to disposal.

The required decontamination procedure for sampling equipment except the water level indicator probe is:

1. Wash and scrub with Alconox solution (or equivalent) and nylon brushes.
2. Double tap water rinse.
3. Rinse with American Society for Testing and Materials (ASTM) Type II Reagent - Grade Water
4. Wrap in oil free aluminum foil for transport.
5. Collect all decontamination rinse water in 5 gallon buckets. Rinse water will be combined with other wastewater generated during sampling activities and disposed of according to the work plan.

During water level sweeps and measurements in low-flow sampling, the water level tape and indicator in contact with groundwater will be decontaminated before initial use and before moving to a new location. The decontamination procedure for the water level indicator is:

1. Hand wash the calibrated tape and probe with Alconox solution (or equivalent).
2. Rinse with deionized (Reagent Grade II) water.

5.2.4 Equipment Rinsate Collection

When non-dedicated sampling equipment is used, the equipment will be decontaminated before initial use and after each sample is collected. An equipment rinsate sample will be collected for equipment type (bladder pump or bailer). At least one equipment rinsate will be collected for each sampling protocol (i.e. soil sampling, bladder pumps used for groundwater sampling) during each week of sampling. Equipment rinsate samples will be collected to be representative of field decontamination procedures.

Sampling Equipment: Equipment rinsate samples will be obtained from decontaminated bladder pumps, bailers, stainless steel split-spoons, hand augers, and stainless steel bowls with ASTM Type II water or better.

The equipment rinsate protocol will be as follows:

a. Label Sample Container - Label the sample container as outlined in SOP 7 – Sample Control and Documentation.
b. Collect Sample - After sample collection and equipment has been decontaminated as described above, an equipment rinsate will be collected. ASTM Type II water (or better) will be poured over and through the sampling equipment into a cleaned stainless steel bowl (preferably the equipment and bowl to be used on a specifically identifiable sample location). The collected water will be poured into the appropriate sample container. Repeat the process as necessary to fill each container to the required volume. Vials for volatile analysis and bottles for total organic carbon (TOC) analysis will be completely filled, leaving no air space above the liquid portion (to minimize volatilization). Check that the Teflon on the Teflon- lined silicone septum is toward the sample in the caps and secure the cap tightly. If semi-volatile compounds are to be sampled for, collect these samples next. Proceed to the collection of

samples for the remaining analyses. Be careful of all pre-preserved bottles. If acids are present, open the bottle downwind and away from the body.

c. Custody, Handling and Shipping - Complete the procedures as outlined in SOP 7 – Sample Control and Documentation and SOP 8 - Sample Packing and Shipping.

5.3 Closeout

Before leaving the site daily, the following procedures will be performed by the FTL or designated field staff:

- Confirm all equipment is decontaminated and properly stored all equipment.
- Add decontamination rinse water to the wastewater storage tank
- Note equipment decontamination activities and rinsate sample collection on the Daily Field Report (SOP 1, Attachment 1-2).

6 Data and Records Management

All field forms and log book entries will be scanned and copied project folder on the "Z" drive within one week of the field event completion.

7 Quality Control and Quality Assurance

Work will be performed in accordance with the Quality Assurance Project Plan (QAPP), the specific work plan, and applicable SOPs.

8 References

HDR, 2018. DDMT Uniform Federal Policy-Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 1. Prepared for the U.S. Army Corps of Engineers, Mobile District. March 2018.

SESDPROC-205-R2, *Operating Procedure Field Equipment Cleaning and Decontamination,* 2011.

STANDARD OPERATING PROCEDURE 10 – DATA VERIFICATION, VALIDATION, QUALIFICATION AND USABILITY ASSESSMENT

Lead Organization: Department of the Army (DA)
Preparing Organization: HDR
SOP Approved by: Project Chemist: Lynn Lutz
Project Manager: Tom Holmes

1 Purpose and Summary

This Standard Operating Procedure (SOP) provides guidance for the data verification, validation and usability assessment (hereafter called "data review" to denote all three stages) performed for analytical data generated for groundwater and vapor samples collected at Defense Depot Memphis, Tennessee (DDMT).

2 Health and Safety

There are no health and safety issues associated with the activities described in this SOP.

3 Personnel Qualifications and Responsibilities

Data review will be performed by the DDMT Project Chemist (PC), who will be familiar with the sampling areas and data requirements at DDMT and experienced in data review.

4 Equipment and Supplies

A computer loaded with Microsoft Excel, Microsoft Word and Adobe Acrobat (reader level or higher) is required.

5 Procedure

This section describes the data qualifiers that will be applied to the data during the verification and validation steps of the data review, and how the determination of usability will be performed. General guidelines for final qualification are provided; individual circumstances for data packages or specific samples may result in different qualification.

To maintain comparability among data sets for the entire DDMT project, the data validation guidelines from these documents have been incorporated:

- Appendix E, Data Quality Evaluation SOPs, of the previous version of the DDMT Quality Assurance Project Plan (QAPP) (MACTEC, 2005);

- Project Quality Assurance Project Plan (QAPP) (*DDMT Uniform Federal Policy – Quality Assurance Project Plan, Environmental Restoration Support at Former Defense Depot Memphis, Tennessee, Revision 1* [HDR, March 2018])
- *General Data Validation Guidelines* (United States Department of Defense [DoD] Environmental Data Quality Workgroup [EDQW], February 09, 2018);
- *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual* (Intergovernmental Data Quality Task Force, 2005);
- United States Environmental Protection Agency (USEPA) National Functional Guidelines (USEPA, 2017); and
- Quality Systems Manual (QSM) 5.1..

Refer to Sections 1 and 2 and Worksheets #12, #19, #24 and #28 of the QAPP for the quality control limits to be used for data validation.

Final qualifiers will be:

- No qualification
- Non-detect (U)
- Detected and estimated (J)
- Detected and estimated with possible low bias (J-)
- Detected and estimated with possible high bias (J+)
- Non-detect and estimated (UJ)
- Rejected (R)

5.1 Chain-of-Custody

If the chain-of-custody (COC) form was not received by the laboratory with the sample, was not signed with date and time by the sampler in the “relinquished by” box, and/or was not signed with date and time by the lab’s sample receipt personnel in the “received by” box, the legal trail of custody may be compromised. A copy of the COC will be sent to the lab and the PC by the Field Team Leader (FTL) following sample shipment. The PC will examine sample receipt documentation and call or email the lab when discrepancies are identified. Custody seals should be noted as unbroken.

5.2 Sample Receipt

5.2.1 Water Samples

Water samples should arrive at the lab between 0 degrees Celsius (ºC) and 6ºC. If water samples were received warm, the lab will contact the PC immediately. The PC and Project Manager (PM) will determine whether samples should be analyzed or re-collected. If samples are analyzed and reported, generally all results will be qualified as estimated (J), estimated with possible low bias (J-), or non-detect estimated (UJ).

5.2.2 Air Samples

Air samples have no temperature requirements.

5.3 Holding Times and Preservation

For samples analyzed past their holding time, generally all results will be qualified as estimated with possible low bias (J-) or non-detect estimated (UJ) unless holding times are grossly exceeded.

5.4 Method Identification, Analyte List, and RLs/MDLs

The correct methods used for analysis must be identified on the sample result pages. If an incorrect method was used, the lab may be instructed to reanalyze samples using the correct method.

If the list of reported analytes is incorrect, or incorrect limits of quantitation (LOQ), limits of detection (LOD), or detection limits (DL) are reported, the lab will be requested to report the correct analyte list or the correct LOQs, LODs, and DLs.

5.5 Gas Chromatography/Mass Spectrometry Tuning and Analytical Sequence

If tuning requirements were not met, the lab should not have proceeded with sample analysis. If samples were analyzed and reported after an unacceptable tune with 4-bromofluorobenzene (BFB), this will be brought to the attention of the lab PM, and it should have been mentioned in the Case Narrative.

For volatile organic compounds (VOCs) in water and air the critical ion abundance criteria for BFB are the m/z 95/96, 174/175, 174/176, and 176/177 ratios. The relative abundances of m/z 50 and 75 are of lower importance. Samples reported after an unacceptable tune may be rejected (R), or qualified as estimated (J) and non-detect estimated (UJ), according to the reviewer's judgment.

Analysis of all field and QC samples must begin within 12 hours (for waters) or within 24 hours (for air samples) of a valid BFB tune. If sample analysis began later than required, sample results will be qualified as estimated (J) or non-detect estimated (UJ). If analysis began only a short time (within 15 minutes) after the required interval, the results need not be qualified.

5.6 Initial Calibration

Initial calibration Relative Response Factors (RRFs) and % Relative Standard Deviations (RSDs) will be examined to determine whether they met required control limits.

5.6.1 Water Samples

VOC analytes with a %RSD greater than 15% should have had a linear curve fit with an r value of at least 0.995 or a quadratic curve fit with an r^2 value of at least 0.990, or the average %RSD of all analytes in the calibration curve must be 15% or less. Calibration check compounds (CCCs) must have %RSDs less than or equal to 30%. Analytes outside these limits will be qualified as estimated (J) or non-detect estimated (UJ).

A number of VOC analytes (shown below) are considered poor responders and have less stringent requirements for minimum RRF.

Poor Responders		
Acetone	Chloroethane	1,2-Dibromoethane (EDB)
2-Butanone	Chloromethane	1,2-Dibromo-3-chloropropane
2-Hexanone	Dichlorodifluoromethane	cis-1,2-Dichloroethene
4-Methyl-2-pentanone	Trichlorofluoromethane	trans-1,2-Dichloroethene
Carbon disulfide	Methyl tert-butyl ether (MTBE)	1,2-Dichloropropane
	Isopropylbenzene	Methylene chloride

All VOC analytes except the poor responders should have an RRF of at least 0.05. The poor responders should have an RRF of at least 0.01. System performance check compounds (SPCCs) must have RRFs of at least 0.1 or 0.3 as required by the method. Analytes outside these limits will be qualified as estimated (J) or non-detect estimated (UJ).

Initial calibrations for other analytes that do not meet requirements will be qualified in a similar manner as VOCs.

5.6.2 Air Samples

Analytes with a %RSD greater than 30% will be qualified as estimated (J) or non-detect estimated (UJ).

5.7 Initial Calibration Verification (Second Source Standard)

A second source standard must be analyzed after every initial calibration. An LCS can serve as a second source standard for VOCs or dissolved gases as long as it can be determined from the standard prep sheets of instrument run logs that a different standard than those used for the calibration curve was used.

5.7.1 Water Samples

Any analyte with a %D (difference or drift) greater than the control limit compared to the initial calibration will be qualified as estimated (J) or non-detect estimated (UJ).

5.7.2 Air Samples

Any analyte with a %D (difference or drift) greater than 30% compared to the initial calibration will be qualified as estimated (J) or non-detect estimated (UJ).

5.8 Continuing Calibrations

5.8.1 Water Samples

VOC CCCs must have %D values less than or equal to 20%. Other analytes should have %D values less than or equal to 20%. Analytes outside these limits with lower responses than the initial calibration will be qualified as estimated with possible low bias (J-) or non-detect estimated (UJ).

Detected analytes outside these limits with higher responses than the initial calibration will be qualified as estimated with possible high bias (J+).

All VOC analytes except the poor responders should have an RRF of at least 0.05. The poor responders should have an RRF of at least 0.01. SPCCs must have RRFs of at least 0.1 or 0.3 as required by the method. Analytes outside these limits will be qualified as estimated (J) or non-detect estimated (UJ).

Any other analyte with a %D (difference or drift) greater than the control limit compared to the initial calibration will be qualified as estimated with possible low bias (J-) , estimated with possible high bias (J+), or non-detect estimated (UJ), as in Section 5.8.1 above.

5.8.2 Air Samples

All analytes must have %D values less than or equal to 30%. Analytes outside these limits with lower responses than the initial calibration will be qualified as estimated with possible low bias (J-) or non-detect estimated (UJ). Detected analytes outside these limits with higher responses than the initial calibration will be qualified as estimated with possible high bias (J+).

5.9 Blanks

5.9.1 Method Blank

There must be a method blank associated with each sample. Method blanks should contain no COCs above one-half the LOQ. Analytes detected above the LOQ should be discussed in the Case Narrative.

Analytes detected in the samples as well as the method blank will be qualified as non-detect (U) or will not be qualified, in accordance with the qualification as discussed in the applicable National Functional Guidelines (USEPA, 2017).

5.9.2 Trip Blank

A trip blank must accompany all VOC water samples during sampling and shipment, in the same cooler. Trip blanks are not required for air samples.

Analytes detected in the samples as well as the trip blank will be qualified as for a method blank.

5.9.3 Rinsate Blank

A rinsate blank must be collected periodically when non-dedicated sampling equipment is used to collect water samples. Rinsate blanks are not required for air samples.

Analytes detected in the associated samples as well as the rinsate blank will be qualified as for a method blank.

5.10 Laboratory Control Sample and Duplicate

There must be a laboratory control sample (LCS) associated with each sample. There may also be a laboratory control sample duplicate (LCSD), although this is not required. LCSs must be spiked with all COCs.

Analytes with recoveries above the control limits may be biased high and will be qualified as estimated with possible high bias (J+) when detected; non-detect results will not be qualified. Analytes with recoveries below the control limits may be biased low and will be qualified as estimated with possible low bias (J-) or non-detect estimated (UJ). If an LCSD is also analyzed, analytes with relative percent difference (RPD) values greater than 20% (30% for VOCs in air) will be qualified as estimated (J) when detected; non-detect results will not be qualified. All samples associated with the LCS will be qualified.

5.11 Matrix Spike and Matrix Spike Duplicate

MS/MSD samples will be indicated on the COC. Matrix spike/matrix spike duplicate (MS/MSD) samples must be spiked with all COCs.

5.11.1 Water Samples

One set of MS/MSD samples will be collected for every 20 field samples. Recovery limits are the lab's in-house control limits. Analytes with higher recoveries may be biased high and will be qualified as estimated (J) when detected; non-detect results will not be qualified. Analytes with lower recoveries may be biased low and will be qualified as estimated with possible high bias (J+) or non-detect estimated (UJ). Analytes with RPD values greater than 20% will be qualified as estimated (J) when detected; non-detect results will not be qualified. Only the parent sample will be qualified.

5.11.2 Air Samples

MS/MSD samples are not collected for air samples.

5.12 Field Duplicates

Field duplicate samples will be sent blind to the laboratory. They will be designated on the COC but not identified with a specific sample location. One field duplicate sample will be collected for every 10 field samples.

Analytes detected above the LOQ should agree within the RPD control limit. Sample results outside this control limit will be qualified as estimated (J). Results detected below the LOQ will not be assessed. If one result is above the LOQ and the other result is below the LOQ, both results will be qualified as estimated (J). If one result is above the LOQ and the other result is non-detect, the detected result will be qualified as estimated (J) and the non-detect result will be qualified as non-detect estimated (UJ).

5.13 Laboratory Duplicates

5.13.1 Water Samples

Laboratory duplicates may be analyzed for metals in water samples. Control limits and qualification are the same as for a field duplicate.

5.13.2 Air Samples

A laboratory duplicate of an air sample must be analyzed daily. Laboratory duplicate results are assessed only if the duplicate was on a DDMT sample. Control limits and qualification are the same as for a field duplicate.

5.14 Surrogates

Surrogates are spiked into every field sample, quality control (QC) sample, and standard for VOCs in water and air.

Surrogates with recoveries above the control limits may indicate a high bias in detected sample results; all detected analytes in the sample will be qualified as estimated with possible high bias (J+). Surrogates with recoveries below control limits may indicate a low bias in sample results; all analytes in the sample will be qualified as estimated with possible low bias (J-) or non-detect estimated (UJ). Samples will not be qualified if only one surrogate out of three or four has a high or low recovery.

5.15 Internal Standards

Internal Standards are spiked into every field sample, QC sample, and standard for VOCs in water and air.

Internal standards with recoveries or retention times outside control limits may indicate interferences in the sample matrix or poor purging.

All analytes associated with an internal standard that has an area outside control limits will be qualified as estimated (J) or non-detect estimated (UJ).

If an internal standard has a retention time outside control limits, the chromatogram and quantitation report will be examined to determine possible impact on the detected or non-detected sample results. Retention times outside control limits may lead to false positive or false negative results for other analytes.

5.16 Usability Assessment

The HDR PC will assess the Precision, Accuracy/bias, Representativeness, Comparability, Completeness, and Sensitivity (PARCCS) parameters and determine overall usability of the data. In general, non-rejected data will be considered usable. Measurement error will be deemed within acceptable limits when project data quality objectives (DQOs) as assessed by PARCCS parameters are met. The PC will write a brief assessment of data usability for each data package.

6 Data and Records Management

This section details the distribution of data files from the laboratories to HDR and the project files.

6.1 Data Files from Laboratories

The laboratories will email to the HDR PC the Level IV data package in PDF format and an electronic data deliverable (EDD) file in Excel to the PC. The PC will save these files to the appropriate folders on the HDR network drive, to be retained in perpetuity.

Hardcopy (paper) data files are not required for this project.

6.2 Data Files from HDR

The HDR PC will email the PDF Level IV data package and the Excel EDD to the HDR Project Manager (PM) and the EDD to the project database manager. The database manager will prepare preliminary tables of results to be used in reports.

6.3 Data Files at HDR

The PC will save the report and EDD file to the appropriate folders on the HDR network drive. The PC will make a copy of the EDD file, with the same name plus "-final".

The PC will prepare a final validation report and note any qualifiers.

The PC will open the "final" file and add a column before the analytes column, called "Report?"; all entries will default to "Y(es)", and will be changed to "N(o)" in the event of multiple runs and/or dilution runs of a sample, so that there is only one reportable result per analyte in all samples. The PC will also add a field named "Final Qualifier" at the end of the fields and record final qualifiers as described in Section 5.6.1 of this SOP.

When all the EDDs have been completed for a sampling event, the PC will email the PM and the database manager the files, to create final result tables to be used in reports.

7 Quality Control and Quality Assurance

All work will be performed in accordance with the QAPP, the specific work plan, the specific sampling plan details (SPD) and applicable SOPs.

8 References

Intergovernmental Data Quality Task Force, 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual* (2005).

MACTEC Engineering and Consulting, Inc. (MACTEC), 2005. *Remedial Action Sampling and Analysis Plan, Volume II: Quality Assurance Project Plan, Defense Depot Memphis, Tennessee, Revision 1*. November 2005.

United States Department of Defense (DoD), 2018. *General Data Validation Guidelines* (Environmental Data Quality Workgroup [EDQW]. February 09, 2018).

United States Environmental Protection Agency (USEPA), 2017a. *National Functional Guidelines for Organic Superfund Methods Data Review (EPA-540-R-2017-002).* January 2017.

USEPA, 2017b. *National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA-540-R-2017-001).* January 2017.