Fourth Five-Year Review

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

Revision 2
March 2018

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Department of the Army

Prepared for:

U.S. Army Corps of Engineers, Mobile District
Contract No. W90FYQ-09-D-0005
Task Order No. CK04

Prepared by:

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March 2018

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Defense Depot Memphis Tennessee		
EPA ID: TN4210020570		
Region: 4	**State:** TN	**City/County:** Memphis/Shelby

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** Army Base Realignment and Closure Division
Author name (Federal or State Project Manager): James C. Foster
Author affiliation: Department of the Army, Office of the Assistant Chief of Staff for Installation Management, Base Realignment and Closure Division
Review period: 15 March 2017 to 15 October 2017
Date of site inspection: July 2017
Type of review: Statutory
Review number: 4
Triggering action date: 23 January 2013
Due date *(five years after triggering action date)*: 22 January 2018

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU 1, Dunn Field

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): 2, 3 and 4, Main Installation	Issue Category: Remedy Performance			
	Issue: Selected remedy of enhanced bioremediation treatment and LTM has not shown expected progress toward the RAOs.			
	Recommendation: Complete SRI and FFS and determine appropriate revision to the selected remedy.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	12/3/2019

OU(s): 2, 3 and 4, Main Installation	Issue Category: Other			
	Issue: Additional lines of evidence are needed for a conservative assessment of VI risk.			
	Recommendation: Complete VI survey in accordance with DoD and USEPA guidance (TSERAWG, 2009 and USEPA, 2015).			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	8/6/2019

Protectiveness Statement(s)	
Operable Unit: 1 Dunn Field	*Protectiveness Determination:* Protective
Protectiveness Statement: The remedy at Dunn Field (OU 1) is protective of human health and the environment. RAs completed to date have met the RGs and the operating AS/SVE system is functioning as intended. Exposure pathways that could result in unacceptable risks are being controlled through LUCs. Long-term protectiveness will be verified by groundwater sampling performed during LTM and compliance monitoring.	
Operable Units: 2, 3 and 4 Main Installation	*Protectiveness Determination:* Short-term Protective
The remedy at the MI (OUs 2, 3 and 4) is currently protective of human health and the environment, because there is no current exposure to COCs in groundwater, and exposure pathways that could result in unacceptable risks are being controlled through LUCs. The VI information collected to date indicates that a complete VI pathway does not exist on the MI. However, additional lines of evidence are needed to provide a conservative assessment of the VI risk to human health. In order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness: 1. The selected remedy must be improved to reduce COC concentrations below MCLs throughout the MI in a reasonable period of time. An SRI and other studies (risk assessment, groundwater modeling and vapor intrusion) are underway; an FFS will be performed upon completion of the SRI to revise the enhanced bioremediation component of the remedy or select an alternative remedy, as appropriate. Long-term protectiveness will be verified by groundwater sampling performed during LTM and compliance monitoring. 2. The VI study must be completed in accordance with DoD and USEPA guidance, and with consideration of TDEC guidance, to evaluate whether there is a complete VI pathway.	

Sitewide Protectiveness Statement
Protectiveness Determination: Short-term Protective
Protectiveness Statement: Because the RAs at all DDMT OUs are currently protective, the site is currently protective of human health and the environment. However, in order for the remedy to be protective in the long-term the selected remedy for the MI must be revised to meet RAOs and the MI VI study must be completed.

Authorizing Signatures

22 MAR 18
Date

JAMES E. BRIGGS
Chief, Operations Branch
Base Realignment and Closure Division

4/5/18
Date

FRANKLIN E. HILL
Director, Superfund Division
U.S. EPA Region 4

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Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirement
AS/SVE	Air Sparging with Soil Vapor Extraction
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIL	community involvement line
COC	constituent of concern
COPC	constituent of potential concern
CSM	conceptual site model
CVOC	chlorinated volatile organic compound
DDMT	Defense Depot Memphis, Tennessee
DoD	Department of Defense
DQE	data quality evaluation
DRC	Depot Redevelopment Corporation
EBT	enhanced bioremediation treatment
EISR	Early Implementation of Selected Remedy
EPC	exposure point concentration
EPP	environmental protection provision
ET&D	Excavation, Transportation and Disposal
FFS	Focused Feasibility Study
FOST	Finding of Suitability to Transfer
FSVE	Fluvial Soil Vapor Extraction
FU	functional unit
FYR	Five-Year Review
HHRA	Human Health Risk Assessment
HI	hazard index
IAQ	Intermediate Aquifer
IC	Institutional Control
IRA	Interim Remedial Action
IRACR	Interim Remedial Action Completion Report
IW	injection well
JEM	Johnson Ettinger model
LTM	long-term monitoring
LUC	land use control
LUCIP	Land Use Control Implementation Plan
MAQ	Memphis Aquifer
MCL	maximum contaminant level
MI	Main Installation
MIP	membrane interface probe
MLGW	Memphis Light, Gas and Water
MMOA	mutagenic mode of action
MNA	monitored natural attenuation
MW	monitoring well

NPDWR	national primary drinking water regulations
OU	operable unit
PID	photoionization detector
PMW	performance monitoring well
PRB	permeable reactive barrier
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RG	remediation goal
ROD	Record of Decision
RW	recovery well
SL	screening level
SCHD	Shelby County Health Department
SLERA	Screening Level Ecological Risk Assessment
SRI	Supplemental Remedial Investigation
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
TA	treatment area
TBC	to be considered
TC	target concentration
TDEC	Tennessee Department of Environment and Conservation
TSERAWG	Tri-Service Environmental Risk Assessment Workgroup
TSVE	thermal soil vapor extraction
TTA	target treatment area
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UU/UE	unlimited use and unrestricted exposure
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound
ZVI	zero-valent Iron

1 Introduction

The purpose of this Five-Year Review (FYR) is to evaluate the implementation and performance of the selected remedies at the former Defense Depot Memphis Tennessee (DDMT) in order to determine if the remedies are and will continue to be protective of human health and the environment. The methods, findings, and conclusions of the FYR are documented in this report. In addition, this FYR report identifies issues found during the review and documents the recommendations to address them.

The lead agency for environmental restoration activities at DDMT is the Department of the Army (Army). The regulatory oversight agencies are United States Environmental Protection Agency (USEPA) Region 4 and the Tennessee Department of Environment and Conservation (TDEC). The site identification number for DDMT is TN4210020570.

HDR performed the review and prepared this report under Contract No. W90FYQ-09-D-0005, Task Order No. CK04 to the United States Army Corps of Engineers (USACE), Mobile District. The review was performed pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121, consistent with the National Contingency Plan (40 CFR Section 300.430(f)(4)(ii)).

This is the fourth FYR for DDMT. The triggering action for this statutory review is the completion date of the previous FYR. The FYR has been prepared due to the fact that hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure (UU/UE).

The site consists of operable units (OUs) 1 to 4, and all are addressed in this FYR:

- OU 1, Dunn Field is the only known and documented burial area on DDMT.
- OU 2, Southwestern Main Installation (MI) was an industrial area where maintenance and repair activities took place.
- OU 3, Southeastern MI contains the entire southeastern watershed and golf course.
- OU 4, North-Central MI area was a material storage area.

The DDMT FYR was led by Tom Holmes, Project Manager for HDR, the primary environmental contractor for DDMT since 2006. USEPA and TDEC were notified of the initiation of the FYR in monthly Site Management Team calls and by written notification. The review began on 15 March 2017.

Revision 0 of this FYR report was submitted to USEPA and TDEC on 25 September 2017. The report was revised in accordance with the approved responses to comments and Revision 1 was submitted on 9 December 2017. TDEC approved Revision 1 on 9 January 2018. Revision 2 was prepared to incorporate the responses to additional comments from USEPA. The responses to comments for Revision 1 and 2, and the approval letters from TDEC and USEPA are provided in Appendix A.

1.1 Site Background

DDMT is located in southeastern Memphis, Tennessee approximately 5 miles east of the Mississippi River and just northeast of Interstate 240 (Figure 1). The property consists of approximately 632 acres and includes two components: the MI and Dunn Field (Figure 2). 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 65 acres with former mineral storage and waste disposal areas. Approximately two-thirds of Dunn Field is grassed, and the remaining area is covered with crushed rock and paved surfaces.

From 1942 until closure in 1997, DDMT received, warehoused, and distributed supplies to U.S. military services and civilian agencies. The facility received a variety of materials including hazardous substances; textile products; food products; electronic equipment; construction materials; and industrial, medical, and general supplies. Types of past activities that could have resulted in the presence of hazardous materials in environmental media at the MI include hazardous substance repackaging for storage or shipment, pesticide application, painting and sandblasting, vehicle maintenance and hazardous material handling/storage. Other historical activities in open and enclosed storage areas included storing transformers with polychlorinated biphenyls (PCBs), storing and using pesticides/herbicides, and treating wood products with pentachlorophenol (PCP). These industrial activities resulted in the presence of metals, pesticides, and other less frequently detected chemicals in surface soil, surface water and sediment, and chlorinated volatile organic compounds (CVOCs) in groundwater.

All DDMT property was made available for transfer through six Findings of Suitability to Transfer (FOSTs). Property transfers through deed or letter of assignment have been completed for property in all FOSTs, except FOST 5; the FOST 5 property is expected to be transferred through a competitive public sale. The acreage, type of conveyance, type of transfer, receiving party and date of transfer are listed on Table 1. Prior to property transfer, Army leased the MI to the Depot Redevelopment Corporation (DRC) in 1997 and made properties available for reuse through sublease by the DRC.

DDMT is currently zoned for light industrial use. The MI is used for commercial warehousing and light manufacturing, except in in the southeast quadrant of the MI where the Airways police station, homeless shelter for veterans and golf course are located; Dunn Field is undeveloped (Figure 2). The current property owners, acreage and land use are listed on Table 2.

DDMT is located in an area of mixed residential, commercial and industrial land use. The surrounding area contains small commercial and manufacturing uses to the north and east and single-family residences to the south and west. Airways Boulevard, located on the east border of the MI, is the most heavily traveled thoroughfare in the vicinity and is developed with numerous small, commercial establishments, particularly in the area from DDMT south to the Interstate 240 interchange. A large electrical substation is located northwest of Dunn Field along Person Avenue. Rail lines border Dunn Field on the north with a number of large industrial and warehousing operations along the rail lines.

The groundwater in the water table aquifer (Fluvial Aquifer) is not a drinking water source for area residents and there is no current exposure to contaminated groundwater at DDMT. The deeper Memphis Aquifer (MAQ) is a regional confined aquifer and the primary source of water for the City of Memphis. The closest well field is the Allen Well Field operated by Memphis Light, Gas and Water (MLGW); individual extraction wells in the well field are 1 to 2 miles west of DDMT. The Jackson Formation/Upper Claiborne Group, which consists primarily of inter-fingering fine sand, silt and clay, is a regional confining unit between the Fluvial Aquifer and the MAQ. The Intermediate Aquifer (IAQ) is locally developed in sand units within the Upper Claiborne. Where clay units in the confining unit are thin or absent, a hydraulic connection or 'window' can be created between the Fluvial Aquifer and the MAQ.

A site chronology is provided in Appendix B. Additional background information is provided in the *2017 Site Management Plan, Revision 1* (HDR, 2017a).

2 Response Action Summary

2.1 Basis for Taking Action

2.1.1 Main Installation, OUs 2, 3 and 4

The MI Remedial Investigation (RI) (CH2M HILL, 2000) was conducted based on functional units (FUs) where human health exposure was generally uniform; the MI was divided into six FUs with groundwater under the MI being FU7. The FUs are described on Table 3 and the boundaries are shown on Figure 3. The MI RI included a baseline human health risk assessment (HHRA) and a screening level ecological risk assessment (SLERA) conducted for each FU.

The constituents of concern (COCs) identified for surface soil were two metals (lead and arsenic) and a chlorinated pesticide (dieldrin). Overall HHRA results indicated health risks to industrial workers were within acceptable levels for future industrial use of the property, except for lead in a limited surface soil area in FU3. However, the soil COCs were present at levels that do not allow for UU/UE.

The COCs identified in groundwater were tetrachloroethene (PCE) and trichloroethene (TCE). The groundwater contamination was considered to result from multiple, small volume, undocumented releases, which may have occurred until the end of operations in 1997.

Results from the HHRA indicated that direct exposures by human receptors to sediment and surface water in the ponds in FU2 did not present risks above the acceptable levels and thus no COCs were identified. The SLERA did not identify significant ecological impacts and no ecological COCs were identified.

2.1.2 Dunn Field, OU 1

The Dunn Field RI (CH2M HILL, 2002) was conducted based on past land use for the Northeast Open Area, Stockpile Area, and Disposal Area. The areas are described on Table 3 and the boundaries are shown on Figure 4. The Dunn Field RI included a baseline HHRA for each area and an SLERA for all of Dunn Field.

No soil COCs were identified in the Northeast Open Area or the Stockpile Area. In the Disposal Area, volatile organic compounds (VOCs) were identified as COCs in subsurface soil for industrial land use, and polycyclic aromatic hydrocarbons (PAHs), arsenic, antimony and CVOCs were identified as COCs in soil for residential land use.

Subsurface soils, including those from the disposal sites in the Disposal Area were considered to be principal threat wastes, which have significantly degraded groundwater quality in the shallow Fluvial Aquifer. The following CVOCs were detected at elevated concentrations in subsurface soils in the Disposal Area:

- PCE
- TCE
- 1,2-Dichloroethene (cDCE)
- Vinyl Chloride (VC)
- 1,1,2,2-Tetrachloroethane (TeCA)
- 1,1,2-Trichloroethane (TCA)
- Carbon Tetrachloride (CT)
- Chloroform (CF)

Groundwater samples were analyzed for explosives, herbicides, metals (total), pesticides, PCBs, semi-volatile organic compounds (SVOCs), and VOCs; samples were also analyzed for chemical warfare materiel breakdown products. Only CVOCs were selected as COCs for groundwater. Three CVOC plumes were identified in the Fluvial Aquifer: a northern plume, a central plume, and a southern plume, as stated in Section 14 of the Dunn Field RI (CH2M HILL, 2002). The plume along the northern boundary of the site was determined to have on-site sources from previous releases in the northwest section of the Disposal Area on Dunn Field and from undetermined off-site sources, based on CVOCs detected in off-site monitoring wells (MWs) upgradient of Dunn Field.

The SLERA indicated little potential for significant ecological impacts or adverse effects to wildlife; no ecological COCs were identified.

2.2 Initial Response

The following response actions were taken at the MI prior to completion of the Record of Decision (ROD) in 2001. The locations are shown on Figure 3.

- Approximately 602 cubic yards (CY) of soil from the PCP dip vat area (Building 737) in FU4 were removed by excavation, transport, and off-site disposal (ET&D) because of elevated levels of PCP (completed in 1985).
- Approximately 60,000 gallons of hazardous and petroleum/oil/lubricant materials from damaged drums were reclaimed and repackaged at Building 873 in 1985. Approximately 800 55-gallon drums were recouped in this open storage area and then returned to their original location for storage and distribution.
- Approximately 3,700 CY of soil in the Housing Area of FU6 were removed by ET&D because of the presence of dieldrin (completed in October 1998). The Housing Area is an exception to the overall industrial land use for the MI and is acceptable for residential reuse.
- Approximately 400 CY of surface soil surrounding the cafeteria (Building 274) in FU6 were removed by ET&D because of elevated levels of PCBs (completed in November 1998).
- Approximately 980 CY of surface and subsurface soil from near Buildings 1084, 1085, 1087, 1088, 1089 and 1090 were removed by ET&D because of elevated levels of metals and PAHs (completed in August 2000).

The following response actions were taken at Dunn Field prior to completion of the ROD in 2004. The locations are shown on Figure 4.

- Approximately 914 CY of soil contaminated with mustard degradation by-products, 19 CY of mustard-contaminated soil and 29 bomb casings were removed by ET&D (completed in March 2001).
- Approximately 930 CY of lead-contaminated surface soil from the former pistol range were removed by ET&D (completed in March 2003).

2.3 Remedy Selection

RODs have been completed for all OUs. The *Record of Decision for the Interim Remedial Action of the Groundwater at Dunn Field (OU 1)* (IRA ROD) (CH2M HILL, 1996) was the initial ROD. The *Main Installation Final Record of Decision, Revision 2* (MI ROD) (CH2M HILL, 2001) included OUs 2, 3, and 4. The *Dunn Field Final Record of Decision, Revision 2* (Dunn Field ROD) (CH2M HILL, 2004a) addressed OU 1. The Dunn Field ROD was modified through the *Dunn Field Record of Decision Amendment, Revision 3* (ROD Amendment) (engineering environmental Management, Inc. [e^2M], 2009a).

2.3.1 Interim Remedial Action

The IRA ROD was approved in April 1996. The IRA objectives were:

- Incrementally remove contamination from the Fluvial Aquifer,
- Decrease risk by mitigating the spread of contamination towards the Allen Well Field, and
- Create a hydraulic barrier to prevent contamination in the Fluvial Aquifer at Dunn Field from reaching the Allen Well Field.

The identified COCs were VOCs and metals. The final cleanup levels for groundwater were left to be addressed in the Dunn Field ROD. The major components of the selected IRA were:

- Evaluation of aquifer characteristics including installation of additional MWs and installation of recovery wells (RWs) along the leading edge of the plume,
- Obtaining discharge permit for disposal of recovered groundwater to the sanitary sewer and discharge monitoring in accordance with the discharge permit requirements, and
- Operation of the system of RWs until the risk associated with the contaminants is reduced to acceptable levels or until the final remedy is in place.

2.3.2 Main Installation

The MI ROD was approved in September 2001. The remedial action objectives (RAOs) for the MI are:

<u>Surface soil for protection of industrial workers</u>

- Prevent direct contact/ingestion of surface soils contaminated with lead in excess of industrial worker risk-based criteria.

Surface soil for protection of future on-site residents

- Prevent direct contact/ingestion of surface soils contaminated with dieldrin and arsenic in excess of HHRA criteria for residents; and
- Prevent direct contact/ingestion of surface soils contaminated with lead in excess of risk-based criteria for protection of residential children.

Groundwater

- Prevent ingestion of water contaminated with VOCs in excess of USEPA maximum contaminant levels (MCLs) from potential, future on-site wells;
- Restore groundwater to levels at or less than MCLs for TCE and PCE; and
- Prevent migration horizontally and vertically off-site of groundwater contaminants in excess of MCLs for TCE (5 micrograms per liter [µg/L]) and PCE (5 µg/L).

The major components of the selected remedy are:

- ET&D at a permitted landfill of an estimated 7,200 square feet (ft^2) of surface soil containing lead concentrations equal to or greater than 1,536 milligrams per kilogram (mg/kg) near the southeast corner of Building 949 in FU4.
- Deed restrictions and site controls, which include prevention of residential land use on the MI (except at the existing Housing Area); daycare restriction controls; production/consumptive use groundwater controls for the fluvial aquifer and for drilling into aquifers below the fluvial aquifer on the MI; and elimination of casual access by adjacent off-site residents through maintenance of a boundary fence surrounding FU2.
- Enhanced bioremediation of CVOCs in the most contaminated part of the groundwater plume.
- Long-term groundwater monitoring to document changes in plume concentrations and to detect potential plume migration to off-site areas or into deeper aquifers.

ET&D for lead contamination adjacent to Building 949 in FU4 was completed prior to final execution and was noted as a significant change in the MI ROD; the early completion effectively eliminated it as part of the selected remedy.

2.3.3 Dunn Field

The Dunn Field ROD was approved in April 2004. The RAOs for Dunn Field are:

Surface soil

- Limit use of the surface soil in the Disposal Area to activities consistent with Light Industrial use and prevent residential use through institutional controls (ICs).

Disposal sites

- Prevent groundwater impacts from a release of buried containerized hazardous liquids and the leaching of contaminants from buried hazardous solids; and
- Prevent unacceptable risk of direct contact with buried hazardous liquid and/or solids due to intrusive activities during future land use or site development.

Subsurface soil impacted with CVOCs

- Prevent direct inhalation of indoor air vapors from subsurface soils in excess of industrial worker criteria; and
- Reduce or eliminate further impacts to the shallow fluvial aquifer from the CVOCs in the subsurface soil.

Groundwater

- Prevent exposure to groundwater contaminated with VOCs in excess of protective target levels from potential future on-site wells;
- Prevent further off-site migration of VOCs in groundwater in excess of protective target levels; and
- Remediate fluvial aquifer groundwater to drinking water quality to be protective of the deeper MAQ.

The subsurface soils, primarily within the Disposal Area of Dunn Field, had residual CVOC levels that exceeded the soil-to-groundwater migration-based screening levels, and potential for vapor intrusion (VI) to indoor air under possible future land use conditions. Site specific target values calculated for the loess and fluvial deposits are shown on Table 4.

Since multiple CVOCs were detected in groundwater at the site and in the immediate downgradient area, targeting to meet the MCLs was not considered adequately protective of a potentially exposed receptor due to the possibility of cumulative toxicity exceeding the upper-bound limit of the acceptable risk or hazard index (HI). Upon completion of remedial action (RA), the residual risks are to be below target levels at points of compliance throughout the plume(s). The individual concentration of each CVOC will be below MCLs and combined concentration levels will not exceed a cumulative upper-bound target risk of 1 in 10,000 ($1X10^{-4}$) and a HI of 1.0 in any given plume.

CVOCs in groundwater and their respective target concentration (TC) levels are included on Table 4. The individual groundwater target goals will change with the number and concentrations of chemicals present in a plume during remediation; however, the target risk level (e.g. 1×10^{-4}) will remain fixed.

The components of the selected remedy for Dunn Field are:

- ET&D of soil and material contained within disposal sites based upon results of a pre-design investigation.

- Soil vapor extraction (SVE) to reduce VOC concentrations in subsurface soils to levels that are protective of the intended land use and groundwater.
- Injection of zero-valent iron (ZVI) within Dunn Field to treat CVOCs in the most contaminated part of the groundwater plume, and installation of a permeable reactive barrier (PRB) to remediate CVOCs within the off-site areas of the groundwater plume.
- Monitored natural attenuation (MNA) and long-term monitoring (LTM) of groundwater to document changes in plume concentrations, to detect potential plume migration to off site areas or into deeper aquifers, and to track progress toward remediation goals (RGs).
- Implementation of land use controls (LUCs), which consist of the following ICs: deed and/or lease restrictions; Notice of Land Use Restrictions; City of Memphis/Shelby County zoning restrictions and the Shelby County Health Department (SCHD) groundwater well restrictions.

The Dunn Field ROD identified the eastern portion of Dunn Field, including most of the Northeast Open Area and the Stockpile Area, as suitable for unrestricted use and unlimited exposure (Figure 4).

The selected remedies were modified through the ROD Amendment approved in March 2009. The fundamental change was the use of air sparging with soil vapor extraction (AS/SVE) instead of a PRB for the Off Depot groundwater plume. The ROD Amendment also revised the criteria for extent of the AS/SVE system and clarified the treatment objective. The AS/SVE system was selected to cross the core of the plume near the downgradient end and to reduce the individual CVOC concentrations in groundwater to 50 µg/L or less. The RGs for the COCs, shown on Table 4, were not changed from the Dunn Field ROD.

2.4 Status of Implementation

2.4.1 Interim Remedial Action

The interim groundwater extraction system began operation in November 1998 with seven RWs; groundwater was discharged without treatment to the city sewer system under Industrial Discharge Agreement S-NN3-097. An expanded system with four additional RWs was brought on-line in 2001.

Based on reduction of CVOC concentrations in groundwater following implementation of the Dunn Field ROD, all RWs were shut down by January 2009. Approximately 918 pounds of total VOCs were discharged by the IRA in just over 10 years of operation. The IRA system was removed and the RWs abandoned in July 2010. The final year of IRA groundwater monitoring and the closure activities were described in *2009 Operations and Closure Report, Dunn Field Groundwater Interim Remedial Action* (HDR, 2010).

2.4.2 Main Installation

The *Main Installation Final Remedial Design, Revision 1* (MI RD) (CH2M HILL, 2004b) was approved by USEPA in August 2004. Sodium lactate was chosen for injection in two target

treatment areas (TTA-1 and TTA-2) where PCE plus TCE exceeded 100 µg/L, and in TTA-2 where CT also exceeded 100 µg/L. The MI RD also included an LTM plan and a Land Use Control Implementation Plan (LUCIP).

2.4.2.1 Enhanced Bioremediation Treatment

The Enhanced Bioremediation Treatment (EBT) system consisted of 4-inch injection wells (IWs) and 2-inch performance monitoring wells (PMWs), the lactate-storage and transfer facility and two trailer-mounted injection systems. Sodium lactate was injected into the Fluvial Aquifer in the two areas from September 2006 through February 2009. Performance monitoring was conducted quarterly from October 2006 through March 2009. From 2006 to 2009, CVOC concentrations for parent compounds (PCE, TCE, CT and CF) were reduced over 90 percent in IWs and over 80 percent in MWs at locations with baseline concentrations above 100 µg/L.

The *Main Installation Interim Remedial Action Completion Report, Revision 1* (MI IRACR) (HDR|e^{2}M, 2010), including an operating properly and successfully determination, was approved by USEPA in March 2010. Although EBT did not achieve the goal of reducing concentrations below MCLs, additional field investigation, groundwater modeling and trend analysis indicated that additional RA was not necessary.

Following observed rebound in CVOC concentrations in 2010 LTM samples, the Army determined additional action was necessary to improve progress toward groundwater RAOs. A second round of EBT (EBT-2) was conducted in areas where individual CVOC concentrations of parent compounds PCE, TCE and CT exceeded 100 µg/L: TTA-1, TTA-2, the West-Central plume and the Building 835 plume. Quarterly injections were made from November 2012 to August 2014 and quarterly performance monitoring was conducted at all IWs and PMWs from February 2013 to November 2014. The final report for EBT-2, *Main Installation Year Four Enhanced Bioremediation Treatment Report, Revision 0* (HDR, 2015), was approved by USEPA and TDEC in May 2015. The CVOC concentrations in the final samples (November 2014) decreased from the baseline samples (December 2011) by an average of 80 percent for IWs and 28 percent for PMWs; the total number of EBT wells exceeding MCLs decreased from 55 wells to 17 wells over the same period.

While EBT-2 reduced CVOC concentrations, it was not sufficient to meet the groundwater RAOs for the MI. A Supplemental Remedial Investigation (SRI) is currently being performed to address data gaps identified through implementation of EBT and LTM. A Focused Feasibility Study (FFS) will be conducted upon completion of the SRI to update the remedial strategy for the MI. An explanation of significant differences or ROD Amendment will be prepared as necessary to document changes to the selected remedy. Further RA will be conducted after the FFS is completed and the selected remedy has been confirmed or revised.

2.4.2.2 MI Long-Term Monitoring

LTM is performed to document changes in plume concentrations, to detect potential plume migration to off-site areas or into deeper aquifers, and to track progress toward meeting RAOs. Recommendations for changes to LTM wells and sample frequency are made in annual LTM reports.

The *Annual Long-Term Monitoring Report – 2016, Revision 1* (HDR, 2017b) was approved by TDEC in June 2017 and by USEPA in October 2017. In 2016, MI LTM included 138 wells. Groundwater elevation contours and CVOC concentrations from October 2016 are shown for the Fluvial Aquifer on Figures 5–7, for the IAQ on Figures 8 and 9, and for the MAQ on Figure 10; CVOC concentrations are shown for all three aquifers along a cross-section on Figure 11. The number of wells with primary CVOCs exceeding an MCL in October 2016 and the maximum concentrations in each area are summarized by aquifer on Table 5.

Significant findings from MI LTM in 2016 are:

- Fluvial Aquifer groundwater elevation contours on the MI indicate a sink in the south-central MI with leakage to the IAQ. Groundwater flow appears to be onto the MI from all sides with flow off the MI through vertical leakage at the window in the northwest MI and the suggested sink in the south-central MI.
- Primary CVOC concentrations exceeded MCLs in 86 of 138 MI LTM wells in 2016. At wells sampled in both 2015 and 2016, 64 wells exceeded the MCL in 2015 and 66 wells in 2016.
- Reductive dechlorination is still active near some wells in areas where EBT was conducted. Other wells within the EBT areas have rebounding concentrations of PCE and/or TCE.
- CVOC concentrations in a number of LTM wells are consistently above MCLs and showed no impact from EBT indicating the areal extent of RA will need to be expanded to meet the RAO for concentrations below the MCLs throughout the MI.
- Migration of CVOCs onto the MI will also need to be addressed in planning additional RA. Off-site impacts have been confirmed at TTA-1 North and are likely at the North-Central plume.
- CVOCs in the Fluvial Aquifer have migrated vertically into the IAQ through the window in the northwestern area of the MI. CVOC concentrations remain below the MCL in the two wells screened in the Memphis Sand. PCE concentrations have increased in three wells screened in lower Upper Claiborne sands within the window.

2.4.2.3 MI Land Use Controls

The MI LUCIP was implemented in 2005. The Notice of Land Use Restrictions was recorded at the City of Memphis/Shelby County Register of Deeds Office on January 26, 2005 and deed restrictions have been included in property transfers. Annual inspections have been performed since 2005. The *Main Installation 2017 Annual Site Inspection Report, Revision 0* (HDR, 2017c) was submitted to USEPA and TDEC on 8 August 2017 (Appendix C-1). No deficiencies or violations of the LUCs have been identified since the last FYR.

2.4.3 Dunn Field

Three RAs were performed to implement the selected remedies for OU 1, Dunn Field: Disposal Sites RA, Source Areas RA; and Off-Depot Groundwater RA. Upon completion of the AS/SVE system for Off Depot groundwater in 2009, construction of the selected remedies for DDMT was

complete. Locations of the Disposal Sites, Source Areas and Off-Depot Groundwater RAs are shown on Figure 12.

2.4.3.1 Disposal Sites

Soil and debris including potential principal threat wastes (primarily drums and glass bottles) from five disposal sites were excavated and transported for off-site disposal in accordance with the *Dunn Field Disposal Sites Final Remedial Design, Revision 1* (CH2M HILL, 2004c). The *Dunn Field Disposal Sites Remedial Action Completion Report, Revision 1* (MACTEC, 2006), was approved by USEPA in August 2006.

The Disposal Sites RA was performed during two separate mobilizations in 2005 and 2006. Approximately 2,700 CY of non-hazardous materials were transported off-site and disposed at the BFI South Shelby County Landfill. Approximately 234 CY of hazardous materials from Disposal Site 3 was disposed at the Clean Harbors Lambton Secure Landfill in Canada. The confirmation samples met the RGs at each site.

2.4.3.2 Source Areas

The Source Areas RA included conventional SVE in the coarse-grained fluvial soils; ET&D for two shallow areas containing waste materials (TA-1F) and buried drums with residual petroleum hydrocarbons (TA-3); thermal SVE (TSVE) (in situ thermal desorption) in the fine-grained loess; and ZVI injection in the Fluvial Aquifer. The RA was performed in accordance with the *Memphis Depot Dunn Field Source Areas Final Remedial Design* (Dunn Field RD) (CH2M HILL, 2007).

The *Dunn Field Source Areas Interim Remedial Action Completion Report, Revision 1* (HDR|e^{2}M, 2009) was approved by USEPA and TDEC in November 2009. The *Dunn Field Operating Properly and Successfully Demonstration, Source Areas Remedial Action* (e^{2}M, 2009b), was approved by USEPA in October 2009.

The Fluvial SVE (FSVE) system was installed to remove CVOCs from the fluvial sands at Dunn Field through seven SVE wells with screened intervals at approximately 30 to 70 feet (ft) below ground surface (bgs). The FSVE system operated from July 2007 through July 2012, and removed approximately 4,000 pounds of VOCs. The FSVE system was shut down after confirmation soil sample results demonstrated that RAOs had been met. The final year of operations and monitoring was described in *Dunn Field Source Areas Fluvial Soil Vapor Extraction System Annual Operations Report, Year Five, Revision 0* (HDR, 2012a), which was approved by USEPA and TDEC in December 2012.

The initial excavations at TA-1F and TA-3 were performed October 2007 to January 2008. Further excavation was delayed in order to proceed with construction and operation of the TSVE system. The excavations were completed February to June 2009. Approximately 7,400 CY of waste material were disposed as non-hazardous waste at a CERCLA-approved facility. Soil confirmation samples met RGs in both areas.

TSVE treatment was performed in four areas with a total area of about 1.25 acres and a treatment interval of approximately 5 to 30 ft bgs. The system operated continuously from May to November 2008. The vapor extraction system was shut down on 4 December 2008.

Approximately 12,500 pounds of VOCs were removed during treatment. Confirmation soil samples, collected at various depths from 35 soil borings, demonstrated that clean-up standards were met.

ZVI injections were not required because groundwater objectives for the Source Areas remedy were achieved through the subsurface soil remedies.

2.4.3.3 Off Depot Groundwater

2.4.3.3.1 Early Implementation

An Early Implementation of Selected Remedy (EISR) using ZVI was performed to reduce contaminant mass downgradient of the planned PRB in order that the portion of the plume slated for MNA in the ROD was not unduly extensive or high in concentration. ZVI injections were made November 2004 to January 2005. Injections were made in 14 borings spaced approximately 60 to 80 ft apart at depths of approximately 70 to 100 ft bgs. The *EISR Interim Remedial Action Completion Report, Revision 1* (MACTEC, 2005) noted that the injections did not achieve the goal of 90 percent or greater reduction of TCE and TeCA and the report included recommendations for decreased spacing between injection locations to achieve increased reduction in CVOCs. The report was approved by USEPA in September 2005.

2.4.3.3.2 Air Sparge/Soil Vapor Extraction

The Off Depot Groundwater RA included installation of an AS/SVE system across the core of the plume near the downgradient end; MNA and long-term groundwater monitoring to document remedy performance and/or changes in the lateral or vertical extent of the CVOC plume; and ICs to prevent access to contaminated groundwater. The RA was performed in accordance with the *Memphis Depot Dunn Field Off Depot Groundwater Final Remedial Design, Revision 1* (Off Depot RD) (CH2M HILL, 2008), which also included an LTM plan and a LUCIP.

The AS/SVE system with 90 AS points and 12 SVE wells (Figure 13) began operation in December 2009. The *Dunn Field Off Depot Groundwater Interim Remedial Action Completion Report, Revision 1* (Off Depot IRACR) (HDR, 2011a) was approved by USEPA in August 2011.

The latest annual report, *Off Depot Air Sparge-Soil Vapor Extraction System Annual Operations Report, Year Six, Revision 0* (HDR, 2017d), was submitted to USEPA and TDEC on 28 August 2017. The AS/SVE system will continue to operate until the upgradient concentrations from the Dunn Field plume do not exceed 50 µg/L for individual CVOCs for 12 months. Only one well in the AS/SVE area, MW-159, has exceeded the treatment goal since 2012; the TCE concentration was 171 µg/L in October 2016. Additional AS wells will be installed near MW-159 to reduce CVOC concentrations upon completion of an access agreement.

2.4.3.4 Dunn Field Long-Term Monitoring

LTM is performed to document changes in plume concentrations, to detect potential plume migration to off-site areas or into deeper aquifers, and to track progress toward meeting RAOs. Recommendations for changes to LTM wells and sample frequency are made in annual LTM reports.

Reduction in CVOC concentrations from the RAs on Dunn Field and the Off Depot area began shortly after operations began for the Dunn Field FSVE system in July 2007. The overall reduction is shown in total CVOC plume maps for April 2007 and April 2016 on Figure 14.

The *Annual Long-Term Monitoring Report – 2016, Revision 1* (HDR, 2017b) was approved by TDEC in June 2017 and by USEPA in October 2017. In 2016, Dunn Field LTM included 85 wells. Groundwater elevations and concentrations of TCE and TeCA in October 2016 are shown for the Fluvial Aquifer on Figures 15 and 16. The number of wells with primary CVOC concentrations exceeding an MCL in October 2016 and the maximum concentrations in each area are summarized by aquifer on Table 6.

Significant findings from Dunn Field LTM in 2016 are:

- The Dunn Field North plume is the most obvious feature on Dunn Field concentration maps (Figure 15); eight wells in the plume exceeded MCLs for PCE, TCE and/or 1,1-dichloroethene (DCE) in 2016. The plume is considered to result from a suspected, off-site source(s) upgradient of Dunn Field.
- Smaller isolated plumes with CVOC concentrations above MCLs or TCs are located in the Dunn Field West area extending west from MW-87, and in the Off Depot area at MW 144/MW-190 and at MW-159/MW-246.

2.4.3.5 Land Use Controls

The Dunn Field LUCIP was implemented in 2009. The Notice of Land Use Restrictions for Dunn Field was recorded at the City of Memphis/Shelby County Register of Deeds on 11 June 2009. Annual inspections have been performed since 2009 and reports have been distributed in accordance with the LUCIP. The *Dunn Field 2017 Annual Site Inspection Report, Revision 0* (HDR, 2017c) was submitted to USEPA and TDEC on 8 August 2017 (Appendix C-1). No deficiencies or violations of the LUCs have been identified since the last FYR.2System Operation and Maintenance

The Off Depot AS/SVE system is the only currently operating remediation system.

The AS/SVE system (Figure 13) is currently operated in alternate months. During full operation, the AS wells are operated 12 hours per day to remove VOCs from groundwater, and the SVE blowers and wells are operated 24 hours per day to remove soil vapor with VOCs from the vadose zone. During limited operations in the alternate months, the AS manifold is closed and the compressor is in stand-by mode except for brief operation during system inspections, and the SVE blowers and wells are operated 12 hours per day.

The only significant change in operations since the previous FYR is reduction in AS operations to limit plume diversion around the system. The change has not impacted system effectiveness in removing CVOCs from groundwater. In February 2014, the AS/SVE system shut down due to extensive equipment damage from a power surge during a thunderstorm; system repairs and testing were completed and operations resumed in March 2015.

The latest annual report, *Off Depot Air Sparge-Soil Vapor Extraction System Annual Operations Report, Year Six, Revision 0* (HDR, 2017d), was submitted to USEPA and TDEC on 28 August

2017. System inspections are performed weekly and equipment maintenance performed semiannually. System operating time has exceeded 90 percent since operations began, except during the equipment failure and repair in 2014 and 2015.

System monitoring includes photoionization detector (PID) readings at SVE wells and system effluent to assess VOC capture effectiveness, and vacuum and PID measurements at vapor monitoring points to assess the vacuum radius of influence and vapor extraction effectiveness. Vapor samples of the system discharge are analyzed via EPA TO-15 for VOCs to estimate VOC mass removal and verify compliance with SCHD air regulations. AS/SVE operations were incorporated in SCHD Permit #01030-01P issued for FSVE on Dunn Field. Permit conditions included maintaining VOC emissions below 5.71 pounds per hour (lb/hr) as documented in an annual emissions report. In May 2016, SCHD cancelled the permit and exempted the AS/SVE system based on emissions consistently below the de minimus limit of 0.1 lb/hr.

The overall effectiveness of AS/SVE operations are evaluated based on LTM results for wells located upgradient and downgradient of the AS/SVE system. As noted in Section 2.4.3.3.2, only one of these wells, MW-159, currently exceeds the treatment goal (50 µg/L). Additional AS wells will be installed near MW-159 to reduce CVOC concentrations; installation will proceed upon completion of an access agreement.

3 Progress Since the Last Five-Year Review

The *Third Five-Year Review, Revision 1* (HDR, 2012b) was completed in January 2013 and concluded that because the RAs at all OUs for DDMT were protective, the site was protective of human health and the environment. All selected remedies had been implemented, attainment of RGs had been documented in subsurface soils at Dunn Field and attainment of cleanup goals in groundwater would be achieved through active treatment and natural attenuation. In the interim, exposure pathways that could result in unacceptable risks were being controlled. Long-term protectiveness would be verified by groundwater sampling performed during LTM and compliance monitoring at the MI and Dunn Field.

The third FYR identified the following issues regarding groundwater contamination in the fluvial and intermediate aquifers on the MI and progress toward RAOs:

- Rebound in groundwater concentrations of CVOCs on the MI in TAs and concentrations above MCLs in IAQ wells.
- Time required to achieve RAOs on the MI.

The issues did not affect current protectiveness because there was no current exposure to COCs in groundwater and did not affect future protectiveness because the remedies were shown to be effective in the IRACRs. The follow-up actions have been completed as shown on Table 7.

3.1 Actions Taken

Implementation of the selected remedies continued on the MI and Dunn Field.

- Additional EBT was performed on the MI from 2012 to 2014. (Section 2.4.2.1)
- AS/SVE system operations and monitoring continued in the Off Depot Area. (Section 2.4.3.3.2)
- LTM was conducted during semiannual sample events. (Sections 2.4.2.2 and 2.4.3.4)
- Annual LUC inspections were performed. (Sections 2.4.2.3 and 2.4.3.5)
- Annual reports for monitoring and RA were submitted for each activity and were approved by USEPA and TDEC.

In addition to ongoing RA and monitoring, additional investigations were initiated on the MI and in the northeast corner of Dunn Field.

3.1.1 Additional MI Investigation and Studies

3.1.1.1 Supplemental Remedial Investigation

As noted in Section 2.4.2.1, additional EBT was not sufficient to meet the groundwater RAOs for the MI. An SRI is currently being performed to address identified data gaps in order to update the remedial strategy for the MI. The SRI includes document review to re-examine the basis for the selected remedy and additional field investigation to improve the site hydrogeological model

and delineation of contaminant plumes and to evaluate potential off-site impacts to groundwater. The *SRI Phases 1 and 2 Report, Revision 0* (HDR, 2017e) was submitted to USEPA and TDEC on 3 November 2017.

The SRI report presented findings from document review and additional monitoring well installation from April 2015 to April 2017. Conclusions from the document review addressed hydraulic connections between the Fluvial Aquifer and the MAQ in the Memphis area and at DDMT; limits to natural attenuation of CVOCs in groundwater at DDMT due to low natural carbon and high dissolved oxygen in groundwater; and findings of groundwater modeling for the MI in 2009. Conclusions from the new monitoring wells addressed site hydrogeology and plume delineation.

Additional investigation is planned in 2018. The *SRI Phase 3 Quality Assurance Project Plan (QAPP), Revision 0* (HDR, 2017f) was submitted to USEPA and TDEC on 7 November 2017. The SRI Phase 3 QAPP addresses data gaps developed from the SRI report and the 2016 and April 2017 LTM reports. The data gaps include groundwater flow direction in the Fluvial Aquifer and Intermediate Aquifer in some areas of the MI; potential source areas in locations with relatively quick rebound of CVOC concentrations following EBT or consistently high concentrations of parent compounds (PCE, TCE and CT); plume delineation and potential off-site impacts; and potential groundwater impacts from vertical migration of groundwater to the IAQ and MAQ.

3.1.1.2 Risk Assessment

The groundwater component of the MI RI HHRA (CH2M HILL, 2000) is being updated to comply with current guidance and address technical and policy changes since its completion.

In addition to the groundwater HHRA update, the soil component of the HHRA and the SLERA in the MI RI is being reviewed. Soil contaminants (lead, PCP, dieldrin, PCBs and metals/ PAHs) were addressed in removal actions prior to completion of the MI ROD. There has been no change in the site's development for light industrial use nor has there been an increase in suitable ecological habitat since the MI RI was completed in 2000. The review will evaluate the impact of changes to toxicity factors and risk assessment protocols for the identified soil contaminants and for ecological risk in order to determine if an update to the soil component of the HHRA and/or the SLERA is warranted.

3.1.1.3 Groundwater Modeling

An updated groundwater model is being developed to incorporate site information obtained since the previous groundwater modeling in 2009 and to utilize a more detailed flow and transport model. The modeling update includes data collection and compilation, conceptual site model (CSM) development, and groundwater flow and transport model construction, calibration and predictive scenarios. The updated CSM will consider groundwater flow directions and velocities within the site, off-site and towards the Allen Well Field in the Memphis Sand Aquifer; identification of potential source areas based on current PCE and TCE plume maps and establishment of boundary conditions for the model domain.

The model will focus on flow and transport in the Fluvial Aquifer with simplifying assumptions for Intermediate and Memphis Aquifers based on available information. A technical memorandum documenting the CSM, modeling objectives and data limitations, and planned model construction will be submitted for review and concurrence by USEPA and TDEC. A second technical memorandum will document the final model construction, calibration and predictive scenarios. The memoranda will be incorporated in the final SRI report.

Data for the Allen Well Field has been requested from MLGW, to include monthly pumping data for supply wells and monthly water level data for supply and monitoring wells at Allen Well Field. Based on review of the existing data from DDMT, the Allen Well Field data are needed to update the 2009 model results.

3.1.1.4 Vapor Intrusion

Potential VI issues at the MI are being evaluated through a study performed in accordance with Department of Defense (DoD) and USEPA guidance, and with consideration of TDEC guidance. The primary guidance documents are:

- *DoD Vapor Intrusion Handbook* (Tri Service Environmental Risk Assessment Workgroup [TSERAWG], 2009)
- *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air* (USEPA, 2015) (https://www.epa.gov/vaporintrusion/technical-guide-assessing-and-mitigating-vapor-intrusion-pathway-subsurface-vapor)
- *Vapor Intrusion Process and Flowchart* (TDEC, 2014)

VI monitoring for DDMT was conducted in 2009 for the Dunn Field area to evaluate the potential risks from groundwater contamination and implementation of the AS/SVE remedy; CVOC concentrations in groundwater were an order of magnitude higher than currently reported on the MI. CVOC concentrations in the loess vapor samples were below then-current residential vapor screening values. The results indicated the loess provides a barrier to vertical migration of soil vapor and prevents vapor intrusion problems above the groundwater plume in that area (HDR, 2011a). Additional information on the 2009 vapor sampling activities and results are presented in Attachment A of the responses to USEPA comments on Revision 1 of this FYR report (Appendix A-2).

The DoD Guidance provides a 5-step approach for VI investigations. DoD Steps 1 and 2, which evaluate the presence of site contaminants which are sufficiently volatile and toxic to present a potential VI risk and the potential for immediate risk to human health, were completed based on past site investigation activities. The groundwater plumes, and potentially soil contamination, are present beneath commercial/industrial buildings at the site resulting in a potential VI human exposure pathway. There have been no reports of suspected VI from the businesses operating at the Memphis Depot Industrial Park, and no immediate VI risk to building occupants is indicated.

A VI screening level (VISL) assessment was conducted in accordance with DoD Step 3 and documented in a memorandum submitted to USEPA and TDEC on 11 August 2017 (HDR,

2017g). Constituents of potential concern (COPCs) were identified from the primary CVOCs targeted for groundwater remediation on the MI; the May 2016 Vapor Intrusion Screening Level (VISL) calculator was used to determine the groundwater screening level (SL) and the October 2016 LTM results were used to show where groundwater concentrations exceeded the SLs (Figure 17). In addition, the VISL Calculator and the Johnson Ettinger model (JEM) were used to estimate the potential VI human health risk from COPCs at three wells which had the highest groundwater concentrations in October 2016 and are located adjacent to occupied buildings. The VISL calculator estimated excess cancer risk based on COPC concentrations at the three wells to be less than of $1x10^{-4}$ and the non-cancer HI above 1 at two locations with a maximum of 6.8. JEM, incorporating depth to water and soil type at the same locations, estimated excess cancer risk at less than of $1x10^{-5}$ and the non-cancer HI below 1 at all three locations. The VISL assessment memorandum is provided in Appendix D.

Since the assessment identified potential cancer risks greater than the $1x10^{-6}$ and non-cancer risk greater than 1.0, further VI pathway evaluation is planned. Soil gas samples will be collected in open areas and beneath building sub-slabs at locations considered most likely to contain VOCs in soil and/or groundwater at concentrations that may present a VI human health risk. The *Main Installation Vapor Intrusion Soil Gas Sampling QAPP* (HDR, 2017h) was submitted to USEPA and TDEC on 23 October 2017. Depending on soil gas sample results, samples of indoor air may be collected and options for mitigation and/or remediation will be evaluated as needed. A detailed report describing VI study activities, analytical results with data validation and laboratory reports, conclusions and recommendations will be prepared upon completion.

In summary, the VI evaluation performed to date indicates that a complete VI pathway does not exist on the MI. However, further sampling and evaluation is planned to provide a conservative assessment of the VI risk to human health in accordance with current DoD and USEPA guidance. Additional information for the VI evaluation is provided in Attachment A of Appendix A-2.

3.1.2 Off-Site Plume, Northeast Dunn Field

CVOC concentrations above MCLs in Fluvial Aquifer wells on the north end of Dunn Field are considered to result from contaminant migration from a suspected, off-site source(s) upgradient of Dunn Field. Concentrations of DCE, PCE and TCE above MCLs have been detected at the north end of Dunn Field since 1993. DCE has not been commonly detected in soil samples on Dunn Field or in groundwater samples, except at wells along the northern boundary. Groundwater concentrations have exceeded MCLs for DCE, PCE, and TCE in off-site, upgradient wells (MW-129 and MW-130) since installation in 2003.

TDEC conducted preliminary assessments and site investigations upgradient of Dunn Field to identify an off-site source(s). During investigations at the Wabash Avenue and Cintas/Production Specialties sites from 2005 to 2008, TDEC installed 11 monitoring wells (Figure 18). Elevated concentrations of CVOCs were detected at the Cintas site, but TDEC did not consider it a source for the plume migrating on to Dunn Field.

Army conducted a membrane interface probe (MIP) survey with confirmation soil sampling at the northeast corner of Dunn Field in March and April 2017 (Figure 18). The purpose of the survey was to determine if previously unidentified contaminant source areas exist in this area of Dunn Field and contribute to the persistent groundwater contamination migrating across Dunn Field. The investigation was limited to the unsaturated loess zone, as previous investigations in the Source Areas on Dunn Field have shown the fine-grained soil and organic matter in that zone retard migration of CVOCs and act as a long-term source area.

The *Membrane Interface Probe Survey Report, Dunn Field* (Trinity, 2017) was submitted to USEPA and TDEC on 26 July 2017. The report stated there were no MIP locations where the data indicated elevated levels of contaminants and only one soil sample with an estimated detection of PCE below the laboratory reporting limit (RL). The report concluded there was no indication of source materials on current or former Army-owned property contributing to elevated CVOC concentrations in groundwater in the northeast portion or upgradient of Dunn Field.

Following the MIP survey, Army collected additional data from the TDEC wells installed from 2005 to 2008. The 11 wells were located and their condition assessed for further use. Well WB-04 had a damaged pad and casing, and no visible well vault or manhole cover; TDEC was notified of the well's condition and will take necessary action. The remaining wells were redeveloped; water level measurements were recorded and groundwater samples were collected for analysis of VOCs.

Data Collection at TDEC Wells, Dunn Field, Defense Depot Memphis, Tennessee (HDR, 2017i) was submitted to USEPA and TDEC on 4 December 2017. The memorandum stated the TDEC wells provide a good network for off-site delineation of the CVOC plume migrating on to Dunn Field and the analytical results were consistent with previous TDEC sample events. The following CVOCs were detected above the RL in one or more wells: DCE, CT, CF, PCE, TCE and 1,1-dichloroethane. The only CVOC reported above an MCL was DCE in CS-02 at 16.3 µg/L. CVOC concentration maps were prepared for the TDEC wells and Dunn Field LTM wells sampled at the same time; the maps show the upgradient limits of the off-site plumes for TCE and DCE are located on the Cintas site. The highest concentrations for this sample event were in Cintas well CS-02 for DCE and in LTM well MW-130 for TCE. The scope for further investigation, including repeat sampling of the TDEC wells and additional locations for soil and groundwater sampling, is being reviewed by Army.

4 Five-Year Review Process

4.1 Community Notification, Involvement and Site Interviews

Ongoing community involvement is maintained through the Community Involvement Line (CIL); publication of an annual newsletter, *EnviroNews*; and maintenance of the information repository at the TDEC Memphis field office.

- The CIL (901-774-3683) is checked at least weekly with response to callers.
- *EnviroNews* is distributed by mail to approximately 4,000 addresses, primarily in the area surrounding DDMT.
- The information repository (TDEC, 8383 Wolf Lake Drive, Bartlett, TN) is updated with new documents semiannually.

The community was initially informed of the FYR through an announcement in the Winter 2016/2017 *EnviroNews*. A notification letter for the FYR was sent to former DDMT Restoration Advisory Board members and local elected officials on 10 March 2017. Notice of the review was also published in the Memphis *Commercial Appeal* on 15 March 2017. The notice and letter invited recipients to call the CIL to comment on the protectiveness of the selected remedy or the RAs at DDMT; the comment period ended 15 May 2017. Copies of the advertisement and the letter are included in Appendix E. No comments regarding the FYR were received.

The community will be notified by public notice in the Memphis *Commercial Appeal* when the report is final and an electronic copy will be placed in the information repository.

Site interviews were not conducted for this FYR for the following reasons:

- Neither comments nor questions were received following the public notice and notification letter. There has been little community interest in the environmental restoration activities since the previous FYR.
- Monthly Site Management Team calls are held to discuss activities with the remedial project managers at USEPA and TDEC.
- The HDR Project Manager leading this FYR has managed site activities and data review since before the previous FYR.

4.2 Data Review

This FYR consisted of a review of relevant documents including the previous FYR, decision documents and work plans/reports completed since the third review:

- Current Site Management Plan;
- Final annual report (Year 4) for additional EBT;
- Current annual operations and monitoring report (Year 5) for the AS/SVE system;
- Current annual LTM and LUC inspection reports (2016) for the MI and Dunn Field; and

- SRI work plans and reports.

A complete list of references is provided in Section 9.

Success of the RAs at DDMT is determined through comparison of analytical results with RGs established in the RODs. Analytical results presented in all RA and annual LTM reports have been qualified relative to the project data quality objectives. The data quality evaluation (DQE) consisted of review of laboratory quality control (QC) data and field QC parameters, and flagging of the data as usable, usable with qualification, or unusable in accordance with the DQE standard operating procedures using the criteria for each analytical method performed.

Groundwater samples collected at the MI for performance monitoring and LTM are compared to the MCLs. Additional EBT injections at the MI did not reduce CVOC concentrations below MCLs; however, concentrations were reduced an average of 80 percent in IWs and 28 percent in MWs. Additional RA is planned once the selected remedy for the MI is confirmed or revised. During biennial sampling of all MI LTM wells in October 2016, concentrations for one or more of the primary CVOCs exceeded the MCL in 86 of 138 MI LTM wells.

The Dunn Field ROD noted that MCLs might not be adequately protective of a potentially exposed receptor when multiple CVOCs are present. TCs were developed for groundwater at Dunn Field based on assumptions about the CVOCs that may be present (Table 3). Groundwater samples collected for LTM at Dunn Field are compared to the MCLs and the TCs. In October 2016, concentrations for one or more of the primary CVOCs exceeded the MCL or TC in 13 of 85 LTM wells. The majority of the exceedances (8) were in the northern area of Dunn Field, which is impacted by a suspected, off-site plume, as described in Section 3.1.2. The number of wells with CVOCs above an MCL or TC in the remaining area of Dunn Field decreased to five wells from eight wells in 2015.

4.3 Site Inspection

Site inspection was performed with the annual LUC inspection in July 2017. The inspection form is provided in Appendix F.

Weekly inspections have been made at Dunn Field since 2006. Regular mowing of Dunn Field and maintenance of the perimeter fence are performed to maintain site appearance and security. The golf course fence at the MI is regularly inspected by the lessee, Memphis Athletic Ministries. Repairs are made as problems are observed. As stated in Sections 2.4.2.3 and 2.4.3.5, no deficiencies or violations of the LUCs have been identified since the last FYR.

5 Technical Assessment

5.1 Is the Remedy Functioning as Intended by the Decision Documents?

The review indicates that the Dunn Field AS/SVE remedy is functioning as intended and should meet treatment goals following a minor expansion of the system. The MI EBT remedy reduced CVOC concentrations in the treatment areas (TAs) but not to levels below MCLs, and natural attenuation outside the TAs has been less than projected in the MI ROD. In addition, understanding of site hydrogeology and contaminant extent on the MI has changed based on data collected from MWs installed since the last FYR. The LTM and LUC remedies are functioning as intended.

Opportunities for optimization of system operations and LTM are considered during evaluation of system operating parameters and monitoring results, and recommendations are presented in annual reports. Operational and monitoring changes since the last review have included:

- Additional air sparge wells are planned for the one area exceeding the AS/SVE treatment goal (50 µg/L for individual CVOCs). The wells will be installed upon completion of an access agreement.
- Revised LTM well classification based on aquifer and location were recommended in the 2016 LTM report with updated criteria for sample frequency.

The selected remedies are listed below with their status.

Main Installation (OUs 2, 3 and 4)

Remedy	*Deed restrictions and site controls, including prevention of residential land use on MI (except at existing Housing Area); Daycare restrictions; production/consumptive use groundwater controls for the fluvial aquifer and for drilling into aquifers below the fluvial aquifer on the MI; and elimination of casual access by off-site residents through maintenance of a boundary fence surrounding FU2.*
Status	Notice of land use restrictions was recorded; restrictions were incorporated in deeds; annual inspections have not identified deficiencies or violations. All parcels have been transferred.
Remedy	*Enhanced bioremediation of CVOCs in the most contaminated part of the groundwater plume.*
Status	EBT implemented from 2006 to 2009 and 2012 to 2014 reduced CVOC concentrations in TAs and downgradient but CVOC concentrations in the majority of LTM wells exceed MCLs. Natural attenuation outside the TAs has been less than projected.
Remedy	*Long-term groundwater monitoring to document changes in plume concentrations and to detect potential plume migration to off-site areas or into deeper aquifers.*
Status	LTM is being performed with 148 wells monitored on a semiannual to biennial basis and meets the goals established in the remedy. Wells installed for the SRI are incorporated in LTM after initial sampling.

Dunn Field (OU 1)

Remedy	*ET&D of soil and material contained within disposal sites based upon results from a pre-design investigation.*
Status	ET&D of disposal sites completed in March 2006; soil confirmation samples met the RGs.
Remedy	*SVE to reduce VOC concentrations in subsurface soils to levels that are protective of the intended land use and groundwater with conventional SVE in the fluvial soils from roughly 30 to 70 ft bgs and TSVE (in situ thermal desorption) in the loess at 0 to 30 ft.*
Status	TSVE and FSVE met RGs and operations were completed. The FSVE system remains in place while rebound is monitored through LTM. The time since FSVE shutdown (2012) exceeds the estimated time for rebound through migration of residual contaminants in the vadose zone. One well on Dunn Field (MW-87) has demonstrated limited rebound since shutdown of the FSVE system.
Remedy	*Injection of ZVI within Dunn Field to treat CVOCs in the most contaminated part of the groundwater plume and reduce individual concentrations to <50 µg/L for CVOCs.*
Status	ZVI injections were not required because groundwater objectives were achieved through subsurface soil remedies.
Remedy	*AS/SVE to reduce CVOCs within the off-site areas of the groundwater plume to <50 µg/L for individual CVOCs.*
Status	AS/SVE has operated since December 2009 and removed 86 pounds of VOCs through May 2017. Only one upgradient well (MW-159) exceeds the concentration required for system shut down. Limited expansion of air sparge wells is planned upon completion of an access agreement.
Remedy	*MNA and LTM of groundwater to document changes in plume concentrations, to detect potential plume migration to off-site areas or into deeper aquifers, and to track progress toward RGs.*
Status	LTM is being performed with 85 wells monitored on a semiannual to biennial basis and meets the goals established in the remedy. LTM results have demonstrated the success of RAs. LTM wells have documented groundwater impacts at the north end of Dunn Field from a suspected off-site source(s); additional investigation to confirm an off-site source has begun.
Remedy	*Implementation of LUCs, which consist of the following ICs: deed and/or lease restrictions; Notice of Land Use Restrictions; City of Memphis/Shelby County zoning restrictions and the SCHD groundwater well restrictions.*
Status	Notice of land use restrictions was recorded; annual inspections have not identified deficiencies or violations. One parcel remains to be transferred.

5.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Used at the Time of the Remedy Selection Still Valid?

The applicable or relevant and appropriate requirements (ARARs) identified in the MI and Dunn Field RODs (CH2M Hill, 2001 and 2004a) and the Dunn Field ROD Amendment (e^2M, 2009a) are listed on Table 8, which includes the applicable requirements and citation for each established ARAR. An online search of the citations was made to review pertinent updates of

laws, regulations, or guidance. Numerous regulations formerly under Tennessee Rule 1200-1-11 are now covered in Rule 0400-12-01-.01 (taken largely from 40 Code of Federal Regulations [CFR] 260 Subpart A). The ground water quality standards have been moved from 1200-3-8-.01 and the underground inspection control regulations have moved from 1200-4-6-.14. It appears these are not substantive changes and should not affect the protectiveness of this remedy.

5.2.1 Changes in Standards and TBCs

A review of the COCs in the previous FYRs, the RIs and the RODs identified 42 soil and groundwater COCs. Concentrations of most of these COCs were reduced below RGs through the completed RAs at Dunn Field. The list of current COCs (Table 9) has been refined to the 12 groundwater CVOCs present at the MI and/or Dunn Field. These CVOCs are carried through in the individual evaluations in this section. Additional risk assessment for the MI is currently being performed as described in Section 3.1.1.2. The groundwater component of the HHRA is being updated, and the soil component of the HHRA and the SLERA are being reviewed to evaluate whether they require updates as well. The larger COC list will be reviewed during the update/review. The report is in preparation and will be submitted to USEPA and TDEC in early 2018.

The federal national primary drinking water regulations (NPDWR), also known as MCLs, which were the basis for the remedial goals in the MI and Dunn Field RODs, have not been updated since the RODs were completed. USEPA's third Six-Year Review for the NPDWR, from 2010 to 2016, evaluated 76 MCLs and identified eight additional chemicals as candidates for regulatory revision (https://www.epa.gov/dwsixyearreview); however, none are COCs for DDMT. As noted in the Third FYR for DDMT, USEPA announced in 2011 its plans to develop one MCL covering up to 16 carcinogenic VOCs (Regulatory Information Number 2040-AF29); the notice of proposed rule making has been re-scheduled from October 2013 to February 2018.

5.2.2 Changes in Toxicity

Several changes to toxicity factors for the 12 current COCs have been identified by comparing the toxicity values in the original risk assessments to the current May 2016 toxicity values in the USEPA Regional Screening Levels summary table (https://www.epa.gov/risk/regional-screening-levels-rsls). The current toxicity values have either become less stringent, more stringent or no change has been seen. For those COCs and exposure pathways having more stringent toxicity values, the cancer risks, and/or non-cancer hazard quotients in the original risk assessments may underestimate the potential risk to industrial and residential receptors. Table 10 summarizes changes in toxicity values for each COC. Of the 12 current COCs, 8 have more stringent toxicity values.

5.2.3 Changes in Risk Assessment Methods

USEPA has published new risk assessment guidance documents since the 2000 MI Risk Assessment and the 2002 Dunn Field Risk Assessment were prepared, as follows:

- *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual – Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004)*
- *Framework for Determining a Mutagenic Mode of Action for Carcinogenicity: Using USEPA's 2005 Cancer Guidelines* and *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, External Peer Review Draft (USEPA, 2005a & 2005b)*
- *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual - Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009)*
- *Exposure Factors Handbook: 2011 Edition (USEPA, 2011)*
- *Memorandum - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors (USEPA, 2014a)*
- *Memorandum - Determining Groundwater Exposure Point Concentrations, Supplemental Guidance (USEPA, 2014b)*

These guidance documents include changes to EPA's risk assessment methodology as it relates to exposure factors, evaluation of inhalation risks, the effects of chemicals, now being identified as having a mutagenic mode of action (MMOA), and the calculation of groundwater exposure point concentrations (EPCs).

The USEPA *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual – Part E, Supplemental Guidance for Dermal Risk Assessment* updated its specific dermal absorption factors from soil, soil adherence values and exposure factors (USEPA, 2004).

The USEPA *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* ("Supplemental Guidance", 2005), assesses the mode of action of a chemical to determine potential impact via mutagenesis when exposure occurs at younger ages (USEPA, 2005b). The Supplemental Guidance provides information on using age-dependent adjustment factors and age-specific exposure factors in developing default risk estimates if there is evidence of a MMOA. If chemical-specific data are available, those data shall be used in determining risk from childhood (or earlier, e.g., prenatal) exposures. Of the 12 current COCs, methylene chloride, TCE and VC have been identified as "mutagens". In the larger COC list, seven other COCs are identified as mutagens, which will be further evaluated when the HHRA is updated.

In 2009, USEPA released the *Risk Assessment Guidance for Superfund (RAGS), Part F* that revised the method for calculating inhalation risks (2009). RAGS states that the risk assessment should assess the duration of exposure (i.e., acute, sub-chronic, or chronic); the exposure pattern, a comparison of the site-specific exposure time and frequency to a typical sub-chronic or chronic timeframe; and the exposure scenario-specific exposure concentration, using the exposure concentration equation from RAGS that best matches the site-specific exposure scenario. As the inhalation risks are meant to be site-specific, they will vary depending on site conditions and potential receptors, which may impact the calculated risk and protectiveness of

the remedy. The guidance also notes update of its inhalation risk paradigm to be compatible with the "Inhalation Dosimetry Methodology", which represents USEPA's current methodology for inhalation dosimetry and derivation of inhalation toxicity values. This methodology recommends using the concentration of the chemical in air as the exposure metric (e.g., milligrams per cubic meter), rather than inhalation intake of a contaminant in air based on ingestion rate and body weight (e.g., mg/kg-day). The DDMT risk assessments apply the older form of inhalation toxicity values; comparison of these toxicity values to current toxicity values that use the new methodology is provided in Table 10.

USEPA updated its overall default exposure factors in the *Exposure Factors Handbook – 2011 Edition* (2011) and in the February 2014 OSWER (now Office of Land and Emergency Management) Directive 9200.1-120 (USEPA, 2014c), which provided program-specific recommendations on the use of exposure parameters to characterize exposures to human populations for HHRAs. Several of the recommended parameters differ from the exposure factors used in the DDMT risk assessments; some exposure scenarios were developed on a site-specific basis, not reflected in the more generic scenarios included in the guidance. The changes include increasing the adult body weight from 70 kg to 80 kg, reducing the residential adult exposure duration from 30 years to 26 years and increasing the skin surface area for contact with soil. Taken alone, without considering potential changes in COC concentrations or other revisions to how risk is calculated, the changes can result in either an increase or decrease in the calculated risk for the COCs. Table 11 provides a comparison of the exposure factors applied in the DDMT risk assessments with the recommended exposure factors in the 2014 OSWER Directive. These changes to exposure factors will be incorporated in the current update to the groundwater component of the HHRA and the review of the HHRA soil component and the SLERA.

The USEPA *Determining Groundwater Exposure Point Concentrations, Supplemental Guidance* (USEPA, 2014b) provides a recommended approach to improve the quality and consistency in calculating groundwater EPCs. The approach involves evaluating data from the "core/center of the plume," which is defined as the three-dimensional core/center zone of highest concentrations of each constituent within a delineated groundwater plume. Application of this guidance would result in higher COC concentrations incorporated in the risk assessments, which implies that the original risk assessments may have underestimated the potential cancer risks and/or hazards. This change in methodology will be reflected in the updated HHRA groundwater component.

5.2.4 Changes in Exposure Pathways

There have been no changes in the physical condition of the site or the current and planned land use that would change the exposure assumptions and no new exposure pathways have been identified.

5.2.5 Vapor Intrusion

As noted in Section 3.1.1.4, a VI study is being performed in accordance with DoD and USEPA guidance (TSERAWG, 2009 and USEPA, 2015) to evaluate whether there is a complete VI

pathway. The guidance includes a screening level VI human health assessment of VOCs based on comparison of current site data (e.g., groundwater, soil gas, indoor air) to conservative risk-based screening values. .

The initial VISL assessment utilized the May 2016 VISL calculator to determine the groundwater SLs and recent LTM results to show where groundwater concentrations exceeded the SLs. The VISL Calculator and the JEM were used to estimate the potential VI human health risk from COPCs at three locations with the highest groundwater concentrations from October 2016 LTM and adjacent to occupied buildings. The VISL Calculator estimated excess cancer risk was less than $1x10^{-4}$ and the non-cancer HI was above 1 at two locations with a maximum of 6.8. The JEM, which incorporates depth to water and soil type at the same locations, estimated excess cancer risk at less than of $1x10^{-5}$ and the non-cancer HI below 1. The VISL assessment memorandum (HDR, 2017g) is provided in Appendix D.

The VI evaluation performed to date indicates that a complete VI pathway does not exist on the MI, based on depth to groundwater greater than 80 feet, 20 to 30 feet of clayey soil (loess) at the ground surface, relatively low estimated risk levels, and results from previous (2009) soil gas sampling. Additional information for the VI evaluation is provided in Attachment A of Appendix A-2.

However, further sampling and evaluation is planned to provide a conservative assessment of the VI risk to human health in accordance with current DoD and USEPA guidance. Upon approval of the QAPP (HDR, 2017h), soil gas samples will be collected at locations considered most likely to contain VOCs in soil and/or groundwater at concentrations that may present a VI human health risk.

5.3 Has Any Other Information Come to Light that Could Call Into Question the Protectiveness of the Remedy?

There is no other new information that calls into question the protectiveness of the remedy.

5.4 Technical Assessment Summary

Based on the data reviewed, the remedies are functioning as intended by the RODs with the exception of EBT on the MI. To date, EBT has not reduced CVOC concentrations in the TAs below MCLs, and LTM has not demonstrated significant reduction in CVOC concentrations outside the TAs.

There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy. There have been no substantive changes to the ARARs cited in the ROD that would call into question the protectiveness of the remedy.

There have been changes to the standardized risk assessment methodology, including updates to exposure factors and toxicity values, evaluation of inhalation risks, identification of chemicals with a MMOA and the calculation of groundwater EPCs.

On the MI, the RGs for groundwater are the MCLs, which have not changed. The RGs for soil were site-specific, risk-based target levels for removal actions conducted prior to completion of the ROD. An update of the HHRA for groundwater is in progress for the MI, incorporating current groundwater concentrations and risk-based factors to confirm the RAOs are protective. In addition, the soil component of the HHRA and the SLERA are being reviewed to determine if updates are warranted.

The initial VISL assessment estimated potential cancer risks greater than the target $1x10^{-6}$ and non-cancer risk greater than 1.0; soil gas sampling is planned as the next step in the VI study. Previous soil gas sampling in the Off Depot area indicated the loess provides a good barrier to vapor migration from groundwater contamination in the deeper Fluvial aquifer (Attachment A of Appendix A-2).

Performance monitoring for EBT has shown CVOC concentrations can be reduced over time, but not that concentrations can be reduced below MCLs in a reasonable period. In addition, the expected reduction through natural attenuation outside the TAs has not been observed; therefore, the TAs will have to be expanded to meet the RAOs throughout the MI. The selected remedy and schedule to meet RAOs will be revised during the FFS to be performed after the SRI. The SRI will continue in 2018; the SRI Phases 1 and 2 Report (HDR, 2017e) and the SRI Phase 3 QAPP (HDR, 2017f) were submitted to USEPA and TDEC in November 2017.

On Dunn Field, the RGs for groundwater incorporate a comparison to both MCLs and calculated, site-specific, risk-based target levels, with adjustments made to reflect site conditions. As noted in Section 2.3.3, the Dunn Field ROD states the individual concentration of each groundwater COC will be below the MCL and combined risk will not exceed a cumulative upper-bound target of $1X10^{-4}$ and HI of 1.0 within the plumes.

Continued progress has been made toward achieving groundwater RAOs at Dunn Field. Rebound in CVOC concentrations on Dunn Field following shutdown of FSVE operations in July 2012 has been limited; only one well (MW-87) has had increased CVOC concentrations, with TCE slightly above the MCL and CF above the TC but not the MCL. Vadose zone leaching model results, presented in the FSVE Year Four report (HDR, 2011b), estimated the maximum groundwater impact due to leachate from the loess would occur up to four years after FSVE shutdown (2016).

AS/SVE performance objectives continue to be met and reduction in upgradient CVOC concentrations from the Source Areas RA have continued. Only one well in the AS/SVE area has not met the treatment objective since April 2012 and a limited expansion of AS wells is planned upon approval of the access agreement with MLGW. The AS/SVE system is in the seventh year of operation, which is longer than the estimate of five years but is not considered an issue for the RA. The number of wells upgradient of the AS/SVE system, not impacted by the off-site plume, with CVOC concentrations above the MCL or TC decreased from 15 wells in 2013 to 5 wells in 2016.

CVOC concentrations above MCLs in Fluvial Aquifer wells on the north end of Dunn Field are considered to result from contaminant migration from a suspected, off-site source(s) upgradient of Dunn Field. The MIP survey report (Trinity, 2017) concluded there was no indication of source materials on current or former Army-owned property contributing to elevated CVOC concentrations in groundwater in the northeast portion or upgradient of Dunn Field. Groundwater samples from several wells previously installed by TDEC upgradient of Dunn Field contained CVOCs above RLs, but the only CVOC reported above an MCL was DCE in well CS-02. CVOC concentration maps based on analytical results from the TDEC wells and Dunn Field LTM wells showed the upgradient limits of the off-site plumes for DCE and TCE were located on the Cintas site (HDR, 2017i). Army continues to evaluate whether it has any obligation with respect to the off-site plume but is working with USEPA and TDEC to determine the investigation necessary to confirm the groundwater contamination is not related to past activities at DDMT and to determine what remedial action, if any, is necessary to remediate groundwater in the northern area of Dunn Field.

6 Issues/Recommendations

Issues/Recommendations
OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU 1, Dunn Field

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): 2, 3 and 4, Main Installation	**Issue Category: Remedy Performance**			
	Issue: Selected remedy of EBT and LTM has not shown expected progress toward the RAOs			
	Recommendation: Complete SRI and FFS, and determine appropriate revision to the selected remedy EBT			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	12/3/2019

The milestone date is the planned date for completion of the FFS report, assuming the SRI is completed at Phase 4.

OU(s): 2, 3 and 4, Main Installation	**Issue Category: Other**			
	Issue: Additional lines of evidence are needed for a conservative assessment of VI risk.			
	Recommendation: Complete VI survey in accordance with DoD and USEPA guidance (TSERAWG, 2009 and USEPA, 2015).			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	8/6/2019

The milestone date is the planned date for completion of the Comprehensive VI Study report, assuming indoor air sampling and evaluation of mitigation/remediation options are required.

6.1 Other Findings

In addition, the following recommendation was identified during the FYR but does not affect current and/or future protectiveness:

- Additional investigation of the suspected off-site source for the groundwater plume migrating on to the northeast section of Dunn Field is necessary to evaluate whether the Army has any responsibility for remedial action of the plume on Dunn Field and its impact on site closure for Dunn Field.

7 Protectiveness Statement

All selected remedies have been implemented at DDMT and the site status is construction complete.

Protectiveness Statement	
Operable Unit: 1, Dunn Field	*Protectiveness Determination:* Protective
Protectiveness Statement: RAs completed to date have met the RGs and the operating AS/SVE system is functioning as intended. Exposure pathways that could result in unacceptable risks are being controlled through LUCs. Long-term protectiveness will be verified by groundwater sampling performed during LTM and compliance monitoring.	

Protectiveness Statement	
Operable Units: 2, 3 and 4, Main Installation	*Protectiveness Determination:* Short-term Protective
Protectiveness Statement: There is no current exposure to COCs in groundwater and exposure pathways that could result in unacceptable risks are being controlled through LUCs. The VI information collected to date indicates that a complete VI pathway does not exist on the MI. However, additional lines of evidence are needed to provide a conservative assessment of the VI risk to human health. In order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness: 1. The selected remedy must be improved to reduce COC concentrations below MCLs throughout the MI in a reasonable period of time. An SRI and other studies (risk assessment, groundwater modeling and vapor intrusion) are underway; an FFS will be performed upon completion of the SRI to revise the enhanced bioremediation component of the remedy or select an alternative remedy, as appropriate. Long-term protectiveness will be verified by groundwater sampling performed during LTM and compliance monitoring. 2. The VI study must be completed in accordance with DoD and USEPA guidance, and with consideration of TDEC guidance, to evaluate whether there is a complete VI pathway.	

Sitewide Protectiveness Statement
Protectiveness Determination: Short-term Protective
Protectiveness Statement: Because the RAs at all DDMT OUs are currently protective, the site is currently protective of human health and the environment. However, in order for the remedy to be protective in the long-term the selected remedy for the MI must be revised to meet RAOs and the MI VI study must be completed.

8 Next Review

The next FYR for DDMT is required 5 years from the completion date of this review.

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Tables

TABLE 1
PROPERTY TRANSFER STATUS
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

FOST No.	Area	Date FOSTsigned	Acres	Type of Conveyance	Type of Transfer (Transferee)	Date of Transfer/Deed
1	MI	23-Feb-01	6.52	PBC	Deed (Alpha Omega Veterans)	18-Sep-01
2	MI	27-Sep-01	4.67	PBC	Deed (Memphis Police Department)	6-Feb-02
			13.36	EDC	Deed (DRC)	6-May-02
3	MI	1-Jul-04	302.48	EDC	Deed (DRC)	4-Apr-06
			46.74	PBC	Letter of Assignment (DOI/NPS)	29-Sep-05
4	DF	4-Mar-05	1.57	PBC	Deed (Memphis)	2-Sep-05
			39.35	CPS	Deed (Dunn Field Business Park, LLC)	24-Oct-07
5	DF	12-Jul-10	24.5	CPS	Not transferred	
6	MI	2-Aug-10	193.0	EDC	Deed (DRC)	30-Mar-11

Notes:
CPS: Competitive Public Sale
DF: Dunn Field
DOI/NPS: Department of Interior/National Parks Service
DRC: Depot Redevelopment Corporation
EDC: Economic Development Conveyance
MI: Main Installation
PBC: Public Benefit Conveyance

TABLE 2
PROPERTY OWNERSHIP AND USE
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Property Owner	Acreage	Use
Main Installation		
Mayfield Properties, LP	250.6	Warehousing/logistics – Memphis Depot Industrial Park managed by Colliers International. Buildings are leased to multiple tenants.
Barnhart Crane & Rigging	143.8	Engineering, construction and maintenance of complex lifting and transportation equipment for heavy industry.
Economic Development Growth Engine of Memphis/Shelby Co.	69.9	Primarily undeveloped property for future warehousing/logistics or light industrial development.
City of Memphis	46.7	Recreation - Golf Course operated by Memphis Athletic Ministries.
Depot Owners Association	35.6	Memphis Depot Parkway and stormwater basins.
Supply Chain Solutions, LLC	8.2	Warehousing/logistics.
Alpha Omega Veterans Services	6.5	Homeless shelter.
		Approved for unrestricted use.
Memphis Police Department	4.7	Airways Police Station.
Dunn Field		
Dunn Field Business Park, LLC	39.35	Undeveloped property for future warehousing/ logistics or light industrial development.
		Approved for unrestricted use.
Army	24.5	Undeveloped.
City of Memphis	1.6	Realignment of Hayes Road.

TABLE 3
FUNCTIONAL UNIT AND AREA DESCRIPTIONS
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Main Installation

Functional Unit	Name	Size[1] (Acres)	Common Past Land Use	Description
1	Twenty Typical Warehouses	89	Transportation to and storage in closed warehouses	Located in the northeastern area of the MI, consisting of about 20 large warehouses, with interspersed roadways and railroad tracks.
2	Southeast Golf Course/ Recreational Area	53	Golf, other recreation	Located in the southeastern corner of the MI, consisting of golf course (Parcel 3). This FU also includes a baseball field and a small playground in the southeastern corner. This FU includes two constructed ponds and two concrete-lined drainage ditches from the ponds leading to the off-site area.
3	Southwest Open Area	92	Transportation to and storage in open-sided warehouses, painting and sandblasting, open storage	Located in the southwestern corner of the MI, consisting of varied type of parcels and sites.
4	Northern and Open Areas	193	Open storage, and transportation to and storage in closed warehouses	Located in the north-central to northwest area of the MI, covering a large area.
5	Newer Warehouses	109	Transportation to and storage in closed warehouses	Located in the south-central area of the MI and includes 10 large warehouse buildings.
6	Administrative and Residential Areas	33	Offices, equipment storage and maintenance, on-base housing	Located along the property boundary of the Depot along the Airways Boulevard. This FU includes the old Residential Unit Area, parking lots, and other asphalt-paved areas.
7	Groundwater at the Main Installatiion	-	No past use of groundwater	Includes all groundwater beneath the Main Installation.

Dunn Field

Area	Size[1] (Acres)	Description
Northeast Open Area	20	Land in the northeast quadrant of Dunn Field, mostly grass covered with some lightly wooded areas.
Disposal Area	14	Open land in the northwest quadrant of Dunn Field, where the majority of disposal sites are located.
Stockpile Area	30	Open land in the southern half of Dunn Field. Area of former bauxite and fluorspar stockpiles (removed in 1999) and burial areas in the eastern and southwestern portions of Dunn Field.

Notes:
1) Acreage is approximate
FU: Functional Unit
MI: Main Installation

TABLE 4
DUNN FIELD REMEDIATION GOALS
FOURTH FIVE-YEAR REVIEW
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
Chloroform	0.9170	0.486	61.57	32.63	12
Dichloroethane, 1,2-	0.0329	0.0189	1.12	0.64	--
Dichloroethene, 1,1-	0.1500	0.0764	57	29.03	7/340
Dichloroethene, cis-1,2-	0.7550	0.404	73.86	39.52	35
Dichloroethene, trans-1,2-	1.5200	0.791	256.53	133.5	50
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	0.092	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
Vinyl Chloride	0.0294	0.015	28.94	14.77	--

Notes:
mg/kg: milligrams per kilogram
µg/L: micrograms per liter
ppbv: parts per billion per volume
MCL: maximum contaminant level
HI: hazard index
-- : Not available for groundwater cleanup goals because of low number of detections or detected values consistently less than MCLs.

TABLE 5
MAIN INSTALLATION MCL EXCEEDANCE SUMMARY, OCTOBER 2016
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

	Analyte		PCE		TCE		cDCE		VC		CT	
	MCL (µg/L)		5		5		70		2		5	
Area	No. of Wells	No. of Wells >MCL	No. of Wells >MCL	Maximum Concentration (µg/L)	No. of Wells >MCL	Maximum Concentration (µg/L)	No. of Wells >MCL	Maximum Concentration (µg/L)	No. of Wells >MCL	Maximum Concentration (µg/L)	No. of Wells >MCL	Maximum Concentration (µg/L)
Fluvial												
TTA-1N	13	9	6	*293*	3	*122*	2	*135*	1	*101*	0	-
TTA-1S	20	12	10	*54.1*	2	*18.5*	0	-	3	*12.2*	0	-
TTA-2	24	18	15	*208*	9	*35.9*	1	*92.1*	7	*59*	5	*57.9*
West-Central	14	14	11	*85*	9	*31.7*	0	-	0	-	0	-
Building 835	8	5	0	-	4	*59.8*	0	-	1	*6.5*	0	-
North-Central	9	5	2	*26.6*	5	*60.6*	0	-	0	-	0	-
South-Central	5	2	0	-	2	*57.4*	0	-	0	-	0	-
Southeastern MI	2	2	1	*6.73*	1	*53.7*	0	-	0	-	0	-
Background	10	0	-	-	-	-	-	-	-	-	-	-
Fluvial Subtotal	**105**	**67**	**45**	***293***	**35**	***122***	**3**	***135***	**12**	***101***	**5**	***57.9***
IAQ/UC												
Window	15	7	7	*81.9*	2	*8.51*	0	-	0	-	0	-
TTA-2	1	0	-	-	-	-	-	-	-	-	-	-
West-Central	8	7	6	*20.6*	6	*27.8*	0	-	0	-	0	-
Building 835	2	2	0	-	2	*8.6*	0	-	0	-	0	-
North-Central	4	2	2	*5.21*	0	-	0	-	0	-	0	-
IAQ/UC Subtotal	**30**	**18**	**15**	***81.9***	**10**	***27.8***	**0**	**-**	**0**	**-**	**0**	**-**
MAQ												
Window	3	1	1	*5.85*	0	-	0	-	0	-	0	-
MI Total	**138**	**86**	**61**	***293***	**45**	***122***	**3**	***135***	**12**	***101***	**5**	**57.9**

Notes:
MCL: maximum contaminant level
µg/L: micrograms per liter

TABLE 6
DUNN FIELD MCL EXCEEDANCE SUMMARY, OCTOBER 2016
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

	Analyte		**TeCA**		**TCA**		**PCE**		**TCE**	
	MCL (µg/L)		**-**		**-**		**5**		**5**	
	TC (µg/L)		**2.2**		**1.9**		**2.5**		**5**	
Area	No. of Wells	No. of Wells >TC or MCL	No. of Wells >TC	Maximum Concentration (µg/L)	No. of Wells >TC or MCL	Maximum Concentration (µg/L)	No. of Wells >TC or MCL	Maximum Concentration (µg/L)	No. of Wells >TC or MCL	Maximum Concentration (µg/L)
Fluvial										
DF North	15	8	0	-	0	-	8	*39.2*	8	*39.8*
DF West	19	1	1	*2.41*	1	*2.3*	0	-	1	*5.3*
Off Depot	34	4	4	*9.86*	1	*3.1*	1	-	3	*171*
Background	12	0	-	-	-	-	-	-	-	-
Fluvial Subtotal	**80**	**13**	**5**	***9.86***	**2**	***3.1***	**9**	***39.2***	**12**	***171***
IAQ/UC										
Off Depot	3	0	-	-	-	-	-	-	-	-
Background	1	0	-	-	-	-	-	-	-	-
IAQ/UC Subtotal	**4**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
MAQ										
Background	1	0	-	-	-	-	-	-	-	-
MI Total	**85**	**13**	**5**	***9.86***	**2**	***3.1***	**9**	***39.2***	**12**	***171***

Notes:
MCL: maximum contaminant level
TC: target concentration
µg/L: micrograms per liter

TABLE 6
DUNN FIELD MCL EXCEEDANCE SUMMARY, OCTOBER 2016
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

	Analyte		**DCE**		**cDCE**		**VC**		**CF**	
	MCL (µg/L)		**7**		**70**		**2**		**80**	
	TC (µg/L)		**7**		**35**		**-**		**12**	
Area	No. of Wells	No. of Wells >TC or MCL	No. of Wells >TC or MCL	Maximum Concentration (µg/L)	No. of Wells >TC or MCL	Maximum Concentration (µg/L)	No. of Wells >MCL	Maximum Concentration (µg/L)	No. of Wells >TC or MCL	Maximum Concentration (µg/L)
Fluvial										
DF North	15	8	6	*15*	0	-	0	-	0	-
DF West	19	1	0	-	0	-	0	-	1	*70.1*
Off Depot	34	4	0	-	0	-	1	*4.7*	0	-
Background	12	0	-	-	-	-	-	-	-	-
Fluvial Subtotal	**80**	**13**	**6**	***15***	**0**	***0***	**1**	***4.7***	**1**	***70.1***
IAQ/UC										
Off Depot	3	0	-	-	-	-	-	-	-	-
Background	1	0	-	-	-	-	-	-	-	-
IAQ/UC Subtotal	**4**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
MAQ										
Background	1	0	-	-	-	-	-	-	-	-
MI Total	**85**	**13**	**6**	***15***	**0**	***0***	**1**	***4.7***	**1**	***70.1***

Notes:
MCL: maximum contaminant level
TC: target concentration
µg/L: micrograms per liter

TABLE 7
FOLLOW-UP ACTIONS FROM THIRD FIVE-YEAR REVIEW
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Issues	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)		Completion Date	Action/Document
					Current	Future		
Rebound in groundwater concentrations of CVOCs on the MI in TAs and concentrations above MCLs in IAQ wells	Restart EBT	DAIM	USEPA/TDEC	11/15/2012	N	N	11/6/2012	Additional EBT injections conducted November 2012 through August 2014.
Time required to achieve RAOs on the MI	Re-evaluate in annual report following one year of additional EBT	DAIM	USEPA/TDEC	3/11/2014	N	N	4/4/2014	Year Three EBT Report submitted to USEPA/TDEC concluded "it is not likely that contaminant concentrations will be reduced to MCLs throughout the MI by December 2015". A supplemental remedial investigation and focused feasibility study is being performed to develop a remedial strategy to achieve RAOs throughout the MI.

Notes:
CVOCs: chlorinated volatile organic compounds
DAIM: Office of the Assistant Chief of Staff for Installation Management
EBT: enhanced bioremediation treatment
IAQ: intermediate aquifer
MCLs: maximum contaminant levels
MI : Main Installation
RAOs: Remedial Action Objectives
TAs: treatment areas
TDEC: Tennesse Department of Environment and Conservation
USEPA: United States Environemtnal Protection Agency

TABLE 8
ARARS AND TBC GUIDANCE
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Action/ Medium	Requirements	Prerequisite	Original Citation(s)	New Citation
Chemical-Specific				
Restoration of groundwater to its designated uses(s)	May not exceed MCLs and MCLGs above zero established under the Safe Drinking Water Act for public water systems	Presence of contaminants in ground water of the State designated as *General Use* as defined in TDEC 1200-4-3-.07(4)(b) **- relevant and appropriate**	TDEC 1200-5-1-.06 40 CFR 141 *et seq.*	TDEC 0400-40-03.07(4)(b)
	Except for naturally occurring levels, shall not contain constituents that exceed those levels specified in Rules 1200-04-03-.03(1)j and k; and		TDEC 1200-4-3-.08(2)(a)	TDEC 0400-40-03-.08(2)(a): Except for naturally occurring levels, General Use Ground Water: shall not contain constituents that exceed those levels specified in subparagraphs (1)(j) and (k) of Rule 0400-40-03-.03
	Except for naturally occurring levels, shall contain no other constituents at levels and conditions which pose an unreasonable risk to the public health or the environment.		TDEC 1200-4-3-.08(2)(b)	TDEC 0400-40-03-.08(2)(b): shall contain no other constituents at levels and conditions which pose an unreasonable risk to the public health or the environment.
Action-Specific	***General Construction standards - all land-disturbing activities (i.e., excavation, trenching, clearing, etc.)***			
Activities causing fugitive dust emissions	Shall take reasonable precautions to prevent particulate matter from becoming airborne; reasonable precautions shall include, but are not limited to, the following:	Fugitive emissions from demolition of existing buildings or structures, construction operations, grading of roads, or the clearing of land **-applicable**	TDEC 1200-3-8-.01(1)	Not Applicable; see https://tn.gov/environment/article/apc-air-pollution-control-regulations
	• use, where possible, of water or chemicals for control of dust; and		TDEC 1200-3-8-.01(1)(a)	See above
	• application of asphalt, oil, water, or suitable chemicals on dirt roads, materials stock piles, and other surfaces which can create airborne dusts.		TDEC 1200-3-8-.01(1)(b)	See above
	Shall not cause or allow fugitive dust to be emitted in such a manner as to exceed 5 minute/hour or 20 minute/day beyond property boundary lines on which emission originates.		TDEC 1200-3-8-.01(2)	See above
Activities causing storm water runoff (e.g., clearing, grading, excavation)	Implement good construction management techniques (including sediment and erosion controls, vegetative controls, and structural controls) in accordance with the substantive requirements of General Permit No. TNR10-0000 Appendix F, (see updated requirements at http://www.state.tn.us/environment/wpc/stormh2o/TNR100000.pdf) to ensure that storm water discharge	Dewatering or storm water runoff discharges from land disturbed by construction activity - disturbance of ≥5 acres total **-applicable**; <5 acres - **relevant and appropriate**	TCA 69-3-108(j) TDEC 1200-4-10-.03(2)	TCA 69-3-108(j) Not Applicable - not updated since 2010, see http://law.justia.com/codes/tennessee/2010/title-69/chapter-3/part-1/69-3-108/ TDEC 1200-4-10-.03(2) - appears to be an error in new citation listed. TDEC web site refers to Lexis Nexis, no such citation found. Original link is broken.

TABLE 8
ARARS AND TBC GUIDANCE
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Action/ Medium	Requirements	Prerequisite	Original Citation(s)	New Citation
	• does not violate water quality criteria as stated in TDEC 1200-4-3-.03, including but not limited to prevention of discharges that causes a condition in which visible solids, bottom deposits, or turbidity impairs the usefulness of waters of the state for any of the designated uses for that water body by TDEC 1200-4-4;	Storm water discharges from construction activities – **TBC**	*General Permit No. TNR10-0000* Part III D.2.a	Cannot confirm - moved; appears to be an error in new citation listed; see http://tnepsc.org/tnr100000.pdf
	• does not contain distinctly visible floating scum, oil, or other matter;		*General Permit No. TNR10-0000* Part III D.2.b	See above
	• does not cause an objectionable color contrast in the receiving stream; and		*General Permit No. TNR10-0000* Part III D.2.c	See above
	• results in no materials in concentrations sufficient to be hazardous or otherwise detrimental to humans, livestock, wildlife, plant life, or fish and aquatic life in the receiving stream.		*General Permit No. TNR10-0000* Part III D.2.d	See above
Action-Specific	***Underground injection well construction and operation***			
Injection of nutrients (or other treatments) into groundwater	Wells shall be designed, constructed, and operated in such a manner that does not present a hazard to existing or future use of groundwater and may not cause a violation of either drinking water or water quality standards.	Class V injection well for innovative or experimental technologies – **relevant and appropriate**	TDEC 1200-4-6-.14(1)(b)	Cannot confirm - repealed, appears there is no transfer.
Action-Specific	***Groundwater Monitoring well installation and closure***			
Installation and maintenance of groundwater monitoring well(s) and soil borings	All wells shall be constructed in a manner that will guard against contamination of the groundwater aquifers underlying Shelby County.	Construction, modification, and repair of groundwater monitoring well(s) and boreholes - **relevant and appropriate**	*Rules and Regulations of Wells* in Shelby County Section 6 and Section 7 et. seq.	No revisions to county rules since 1980; see http://www.shelbycountytn.gov/DocumentCenter/View/768; TN rules last revised 2005; see ? http://www.ngwa.org/Documents/States/1200-04-06%20Con.pdf
Closure of groundwater monitoring well(s)	Well shall be completely filled and sealed in such a way as to prevent vertical movement of water from one aquifer to another.	Permanent plugging and abandonment of a well - **relevant and appropriate**	*Rules and Regulations of Wells* in Shelby County Section 9 *et. seq.*	See above
Action-Specific	***SVE treatment system -*** *air emissions control*			
Emissions from SVE treatment system	Discharge of air contaminants must be in accordance with the appropriate provisions of Rules of the TDEC Chapter 1200-3 et seq., any applicable measures of control strategy and provisions of the Tennessee Air Quality Act.	Emissions of air pollutants from new air contaminant sources - **applicable**	TDEC 1200-3-9-.01(1)(d) Memphis Code 16-77	Cannot confirm if there are changes - appears to be an error in citation listed; Memphis Code 16-77 not updated since 2000, see http://www.shelbycountytn.gov/DocumentCenter/View/777

TABLE 8
ARARS AND TBC GUIDANCE
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Defense Depot Memphis, Tennessee

Action/ Medium	Requirements	Prerequisite	Original Citation(s)	New Citation
Action-Specific	***Waste generation, characterization, segregation, and storage - primary remediation wastes (excavated contaminated soil, disposal pit materials) and secondary wastes (wastewaters, spent treatment media, etc.)***			
Characterization of solid waste	Must determine if solid waste is hazardous waste or if waste is excluded under 40 CFR 261.4; and	Generation of solid waste as defined in 40 CFR 261.2 and which is not excluded under 40 CFR 261.4(a) -**applicable**	40 CFR 262.11(a) TDEC 1200-1-11-.03(1)(b)(1)	40 CFR 262.11 last updated in 2016. See https://www.ecfr.gov/cgi-bin/text-idx?SID=cb303aa6b9b66c6d63494f0cdb39820f&mc=true&node=pt40.28.262&rgn=div5#se40.28.262_111 Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.
	Must determine if waste is listed as a hazardous waste in subpart D of 40 CFR Part 261; or		40 CFR 262.11(b) TDEC 1200-1-11-.03(1)(b)(2)	See above
	Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used.		40 CFR 262.11(c) TDEC 1200-1-11-.03(1)(b)(3)	See above
	Must refer to Parts 261, 264, 265, 266, 267, 268, and 273 of Chapter 40 for possible exclusions or restrictions pertaining to management of the specific waste.	Generation of solid waste which is determined to be hazardous – **applicable**	40 CFR 262.11(d); TDEC 1200-1-11-.03(1)(b)(4)	See above
Characterization of hazardous waste	Must obtain a detailed chemical and physical analysis of a representative sample of the waste(s), which at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with pertinent sections of 40 CFR 264 and 268.	Generation of RCRA-hazardous waste for storage, treatment or disposal - **applicable**	40 CFR 264.13(a)(1) TDEC 1200-1-11-.06(2)(d)(1)	See above
	Must determine the underlying hazardous constituents [as defined in 40 CFR 268.2(i)] in the waste.	Generation of RCRA characteristic hazardous waste (and is not D001 non-wastewaters treated by CMBST, RORGS, or POLYM of Section 268.42 Table 1) for storage, treatment or disposal – **applicable**	40 CFR 268.9(a) TDEC 1200-1-11-.10(1)(i)(1)	See above
	Must determine if the waste is restricted from land disposal under 40 CFR 268 et seq. by testing in accordance with prescribed methods or use of generator knowledge of waste.		40 CFR 268.7 (a) TDEC 1200-1-11-.10(1)(g)(1)(i)	See above
	Must determine each EPA Hazardous Waste Number (Waste Code) to determine the applicable treatment standards under subpart D of CFR 268.9.		40 CFR 268.9(a) TDEC 1200-1-11-.10(1)(i)(1)	See above

TABLE 8
ARARS AND TBC GUIDANCE
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Action/ Medium	Requirements	Prerequisite	Original Citation(s)	New Citation
Temporary storage of hazardous waste in containers	A generator may accumulate hazardous waste on-site for 90 days or less without a permit or without having interim status, provided that:	Accumulation of RCRA hazardous waste on site as defined in 40 CFR 260.10 - **applicable**	40 CFR 262.34(a); TDEC 1200-1-11-.03(4)(e)	40 CFR 262.11 last updated in 2016. See https://www.ecfr.gov/cgi-bin/text-idx?SID=0c6b768dee958f03e0a53e77bc9ec860&mc=true&node=se40.28.262_111&rgn=div8 Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.
	• waste is placed in containers that comply with applicable requirements of subparts I, AA, BB, and CC of 40 CFR part 265; and/or		40 CFR 262.34(a)(1)(i); TDEC 1200-1-11-.03(4)(e)(2)(i)(I)	See above
	• the date upon which each period of accumulation begins is clearly marked and visible for inspection on each container;		40 CFR 262.34(a)(2); TDEC 1200-1-11-.03(4)(e)(2)(ii)	See above
	• container is marked clearly with the words “hazardous waste” or		40 CFR 262.34(a)(3) TDEC 1200-1-11-.03(4)(e)(2)(iii)	See above
	• container may be marked with other words that identify the contents.	Accumulation of 55 gal. or less of RCRA hazardous waste at or near any point of generation - **applicable**	40 CFR 262.34(c)(1)(ii) TDEC 1200-1-11-.03(4)(e)(5)(i)(II)	See above
Use and management of hazardous waste in containers	If container is not in good condition (e.g. severe rusting, structural defects) or if it begins to leak, must transfer waste into container in good condition.	Storage of RCRA hazardous waste in containers – **applicable**	40 CFR 265.171 TDEC 1200-1-11-.05(9)(b)	See above
	Use container made or lined with materials compatible with waste to be stored so that the ability of the container is not impaired.		40 CFR 265.172 TDEC 1200-1-11-.05(9)(c)	See above
	Keep containers closed during storage, except to add/remove waste.		40 CFR 265.173(a) TDEC 1200-1-11-.05(9)(d)(1)	See above
	Open, handle and store containers in a manner that will not cause containers to rupture or leak.		40 CFR 265.173(b) TDEC 1200-1-11-.05(9)(d)(2)	See above
Storage of hazardous waste in container area	Area must have a containment system designed and operated in accordance with 40 CFR 264.175(b).	Storage of RCRA-hazardous waste in containers with free liquids – **applicable**	40 CFR 264.175(a) TDEC 1200-1-11-.06(9)(f)(1)	See above
	Area must be sloped or otherwise designed and operated to drain liquid from precipitation, or	Storage of RCRA-hazardous waste in containers that do not contain free liquids - **applicable**	40 CFR 264.175(c)(1) TDEC 1200-1-11-.06(9)(f)(3)(i)	See above
	Containers must be elevated or otherwise protected from contact with accumulated liquid.		40 CFR 264.175 (c)(2); TDEC 1200-1-11-06(9)(f)(3)(ii)	See above

TABLE 8
ARARS AND TBC GUIDANCE
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Defense Depot Memphis, Tennessee

Action/ Medium	Requirements	Prerequisite	Original Citation(s)	New Citation
Action-Specific Treatment/disposal of wastes - primary and secondary wastes				
Disposal of RCRA-hazardous waste in a land-based unit	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 CFR 268.40 before land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted RCRA waste - **applicable**	40 CFR 268.40(a) TDEC 1200-1-11-.10(3)(a)(1)	40 CFR 268.40 last updated 1994. See https://www.ecfr.gov/cgi-bin/text-idx?SID=1fa0b08eb41cf6cb5a28dd740aeddda8&mc=true&node=pt40.29.268&rgn=div5#se40.29.268_140 Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.
	Must be treated according to the alternative treatment standards of 40 CFR 268.49(c) or according to the UTSs [specified in 40 CFR 268.48 Table UTS] applicable to the listed and/or characteristic waste contaminating the soil prior to land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted hazardous soils - **applicable**	40 CFR 268.49(b) TDEC 1200-1-11-.10(3)(j)(2)	40 CFR 268.49 last updated in 2006. See https://www.ecfr.gov/cgi-bin/text-idx?SID=87d53a6ed29e208bd2f414a81fbce878&mc=true&node=pt40.29.268&rgn=div5#se40.29.268_149 Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.
Disposal of RCRA wastewaters in an CWA wastewater treatment unit	Are not prohibited, unless the wastes are subject to a specified method of treatment other than DEACT in 40 CFR 268.40, or are D003 reactive cyanide.	Restricted RCRA characteristic hazardous wastewaters managed in a wastewater treatment system which is NPDES permitted - **applicable**	40 CFR 268.1(c)(4) TDEC 1200-1-11-.10(1)(a)(3)(iv)	40 CFR 268.1 last updated in 2016. See https://www.ecfr.gov/cgi-bin/text-idx?SID=81c0ca77a15c2ca17d82b57e486a7664&mc=true&node=se40.29.268_11&rgn=div8 Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.
Action-Specific	***Transportation***			
Transportation of hazardous materials	Shall be subject to and must comply with all applicable provisions of the HMTA and HMR at 49 CFR 171-180.	Any person who, under contract with a department or agency of the federal government, transports "in commerce," or causes to be transported or shipped, a hazardous material - **applicable**	49 CFR 171.1(c)	49 CFR 171 updated 2017, see https://www.ecfr.gov/cgi-bin/text-idx?SID=a30c7d01bd28721df8259723b008b865&mc=true&node=pt49.2.171&rgn=div5
Transportation of hazardous waste off site	Must comply with the generator requirements of 40 CFR 262.20–23 for manifesting, Sect. 262.30 for packaging, Sect. 262.31 for labeling, Sect. 262.32 for marking, Sect. 262.33 for placarding and Sect. 262.40, 262.41(a) for record keeping requirements and Sect. 262.12 to obtain EPA ID number.	Off-site transportation of RCRA hazardous waste – **applicable**	40 CFR 262.10(h) TDEC 1200-1-11-.03(1)(a)(8)	40 CFR 262.10 not in ECFR, see https://www.ecfr.gov/cgi-bin/text-idx?SID=91f9f8640697841a9fb3f3a15a856f51&mc=true&node=se40.28.262_110&rgn=div8 Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.

TABLE 8
ARARS AND TBC GUIDANCE
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Defense Depot Memphis, Tennessee

Action/ Medium	Requirements	Prerequisite	Original Citation(s)	New Citation
	Must comply with the requirements of 40 CFR 263.11–263.31.	Transportation of hazardous waste within the United States requiring a manifest – **applicable**	40 CFR 263.10(a) TDEC 1200-1-11-.04(1)(a)(1)	40 CFR 263 not in ECFR, see https://www.ecfr.gov/cgi-bin/text-idx?SID=e2eac371903a6f84721c18ceafa4ff36&mc=true&node=pt40.28.263&rgn=div5 Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.
	A transporter who meets all applicable requirements of 49 CFR 171–179 and the requirements of 40 CFR 263.11 and 263.31 will be deemed in compliance with 40 CFR 263.			40 CFR 263 not in ECFR, see https://www.ecfr.gov/cgi-bin/text-idx?SID=a9bb39f84d6eb1cbba562b3b74666bed&mc=true&tpl=/ecfrbrowse/Title49/49cfr262_main_02.tpl
Management of treatability samples (i.e., contaminated soils, wastewaters)	Are not subject to any requirements of 40 CFR Parts 261 through 263, nor are such samples included in the quantity determinations of 40 CFR 261.5 and 262.34(d) when:	Generation of samples of hazardous waste for purpose of conducting treatability studies as defined in 40 CFR 260.10 -**applicable**	40 CFR 261.4(e)(1) TDEC 1200-1-11-.02(1)(d)(5)(i)	40 CFR 261.4 last updated 1980, see https://www.gpo.gov/fdsys/pkg/CFR-2016-title40-vol28/pdf/CFR-2016-title40-vol28-sec261-4.pdf Cannot confirm if there are changes in TDEC 400 series; see http://share.tn.gov/sos/rules/0400/0400-01/0400-01.htm, shows corresponding 400 series citation numbers as repealed. However, they do not correspond to program of interest.
	• The sample is being collected and prepared for transportation by the generator or sample collector;		40 CFR 261.4(e)(1)(i) TDEC 1200-1-11-.02(1)(d)(5)(i)(I)	See above
	• The sample is being accumulated or stored by the generator or sample collector prior to transportation to a laboratory or testing facility; or		40 CFR 261.4(e)(1)(ii) TDEC 1200-1-11-.02(1)(d)(5)(i)(II)	See above
	• The sample is being transported to the laboratory or testing facility for purpose of conducting a treatability study.		40 CFR 261.4(e)(1)(iii) TDEC 1200-1-11-.02(1)(d)(5)(i)(III)	See above

ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
NPDES = National Pollutant Discharge Elimination System
CWA = Clean Water Act of 1972
DEACT = deactivation
HMR = Hazardous Materials Regulations
HMTA = Hazardous Materials Transportation Act
MCLs = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goals
RCRA = Resource Conservation and Recovery Act of 1976
TBC = to be considered
TCA = Tennessee Code Annotated
TDEC = Tennessee Department of Environment and Conservation
UTS = Universal Treatment Standard

TABLE 9
CURRENT CONSTITUENT OF CONCERN LIST
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

COC Group	COC	CAS	Location	Medium
VOC	1,1,2,2,-Tetrachloroethane	79-34-5	DF	Soil, Groundwater
VOC	1,1,2-Trichloroethane	79-00-5	DF	Soil, Groundwater
VOC	1,1-Dichloroethene	75-35-4	DF	Soil, Groundwater
VOC	1,2-Dichloroethane	107-06-2	DF	Soil, Groundwater
VOC	1,2-Dichloroethylene, cis	156-59-2	MI, DF	Soil, Groundwater
VOC	1,2-Dichloroethylene, trans	156-60-5	DF	Soil, Groundwater
VOC	Carbon tetrachloride	56-23-5	MI, DF	Soil, Groundwater
VOC	Chloroform	67-66-3	MI, DF	Soil, Groundwater
VOC	Methylene chloride	75-09-2	DF	Soil, Groundwater
VOC	Tetrachloroethylene	127-18-4	MI, DF	Soil, Groundwater
VOC	Trichloroethylene	79-01-6	MI, DF	Soil, Groundwater
VOC	Vinyl chloride	75-01-4	MI, DF	Soil, Groundwater

Notes:
CAS: Chemical Abstracts Service registry number assigned to each chemical
COC: Constituent of concern
DF: Dunn Field
FYR: Five Year Review
MI: Main Installation

TABLE 10
REVIEW OF TOXICITY VALUES
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

					Toxicity Values from DDMT RIs						Toxicity Values from May 2016 USEPA RSLs				Comparison of DDMT RI Toxicity Values to May 2016 USEPA RSL Toxicity Values			
					Cancer			Noncancer			Cancer		Noncancer		Cancer		Noncancer	
					(mg/kg-d)$^{-1}$	(mg/kg-d)$^{-1}$	(ug/m^3)$^{-1}$	mg/kg-d	mg/kg-d	mg/m^3	(mg/kg-d)$^{-1}$	(ug/m^3)$^{-1}$	mg/kg-d	mg/m^3	(mg/kg-d)$^{-1}$	(ug/m^3)$^{-1}$	mg/kg-d	mg/m^3
COC Group	COC	CAS	Location	Medium	SF_o	Original Inhalation SF	Inhalation SF Converted to IUR	RfD_o	Original Inhalation RfD	Inhalation RfD Converted to RfC_i	SF_o	IUR	RfD_o	RfC_i	SF_o	IUR	RfD_o	RfC_i
VOC	1.1.2.2.-Tetrachloroethane	79-34-5	DF	Soil, Groundwater	2.00E-01	2.03E-01	5.80E-05	6.00E-02	NV	NV	2.00E-01	5.80E-05	2.00E-02	NV	No Change	No Change	More Stringent	--
VOC	1.1.2-Trichloroethane	79-00-5	DF	Soil, Groundwater	5.70E-02	5.60E-02	1.60E-05	4.00E-03	NV	NV	5.70E-02	1.60E-05	4.00E-03	2.00E-04	No Change	No Change	No Change	--
VOC	1.1-Dichloroethene	75-35-4	DF	Soil, Groundwater	6.00E-01	1.75E-01	5.00E-05	9.00E-03	NV	NV	NV	NV	5.00E-02	2.00E-01	--	--	Less Stringent	--
VOC	1.2-Dichloroethane	107-06-2	DF	Soil, Groundwater	9.10E-02	9.10E-02	2.60E-05	3.00E-02	1.40E-03	4.90E-03	9.10E-02	2.60E-05	6.00E-03	7.00E-03	No Change	No Change	More Stringent	Less Stringent
VOC	1.2-Dichloroethylene, cis	156-59-2	MI, DF	Soil, Groundwater	NV	NV	NV	1.00E-02	1.00E-02	3.50E-02	NV	NV	2.00E-03	NV	--	--	More Stringent	--
VOC	1.2-Dichloroethylene, trans	156-60-5	MI, DF	Soil, Groundwater	NV	NV	NV	NV	NV	NV	NV	NV	2.00E-02	NV	--	--	--	--
VOC	Carbon tetrachloride	56-23-5	MI, DF	Soil, Groundwater	1.30E-01	5.25E-02	1.50E-05	7.00E-04	5.71E-04	2.00E-03	7.00E-02	6.00E-06	4.00E-03	1.00E-01	Less Stringent	Less Stringent	Less Stringent	Less Stringent
VOC	Chloroform	67-66-3	MI, DF	Soil, Groundwater	6.10E-03	8.10E-02	2.31E-05	1.00E-02	8.60E-05	3.01E-04	3.10E-02	2.30E-05	1.00E-02	9.80E-02	More Stringent	No Change*	No Change	Less Stringent
VOC	Methylene chloride	75-09-2	DF	Soil, Groundwater	7.50E-03	1.65E-03	4.71E-07	6.00E-02	8.57E-01	3.00E+00	2.00E-03	1.00E-08	6.00E-03	6.00E-01	Less Stringent	Less Stringent	More Stringent	More Stringent
VOC	Tetrachloroethylene	127-18-4	MI, DF	Soil, Groundwater	5.20E-02	2.00E-03	5.71E-07	1.00E-02	1.71E-01	5.99E-01	2.10E-03	2.60E-07	6.00E-03	4.00E-02	Less Stringent	Less Stringent	More Stringent	More Stringent
VOC	Trichloroethylene	79-01-6	MI, DF	Soil, Groundwater	1.10E-02	6.00E-03	1.71E-06	6.00E-03	NV	NV	4.60E-02	4.10E-06	5.00E-04	2.00E-03	More Stringent	More Stringent	More Stringent	--
VOC	Vinyl chloride	75-01-4	MI, DF	Soil, Groundwater	1.90E+00	3.00E-01	8.57E-05	3.00E-03	1.10E-01	3.85E-01	7.20E-01	4.40E-06	3.00E-03	1.00E-01	Less Stringent	Less Stringent	No Change	More Stringent

Notes:
NV -- No value available
The 2000 Main Installation (MI) Remedial Investigation (RI) and 2002 Dunn Field (DF) RI utilized toxicity values from USEPA Integrated Risk Information System (IRIS), the USEPA Health Effects Assessment Summary Tables (HEAST) and those provided by the USEPA Superfund Technical Support Center.
The inhalation cancer slope factors (SF, in units of (mg/kg-d)$^{-1}$) from the original RIs are converted to the same units as in the May 2016 USEPA RSLs (ug/m^3)$^{-1}$ by using the former default USEPA body weight of 70 kg and inhalation rate of 20 m^3/d (USEPA 1997, 2016).
The inhalation reference concentrations (RfC, in units of (mg/kg-d)$^{-1}$) from the original RIs are converted to the same units as in the May 2016 USEPA RSLs ((mg/m^3)$^{-1}$) by using the former default body weight of 70 kg and inhalation rate of 20 m^3/d (USEPA 1997, 2016).
A comparison of the toxicity values is performed to determine whether current toxicity values (source being May 2016 USEPA RSLs) have become more stringent than those applied in the Memphis Depot RIs. Based on the risk and hazard equations, current cancer toxicity values that are greater than the previous toxicity values are considered more stringent whereas current noncancer toxicity values that are smaller than the previous toxicity values are considered more stringent.
*Comparisons identified as "No Change" with a star (*) indicates the toxicity values are similar but slightly different due to rounding in the conversions.
** The toxicity values for cadmium in diet from the May 2016 USEPA RSL table are compared, as opposed to cadmium in water.

Abbreviations:
CAS -- Chemical Abstracts Service registry number assigned to each chemical
COC -- Constituent of concern
DDMT -- Defense Depot Memphis Tennessee
IUR -- Inhalation unit risk
RfC_i -- Inhalation reference concentration
RfD_o -- Oral reference dose
RI -- Remedial Investigation
RSLs -- USEPA Regional Screening Levels
SF_o -- Oral slope factor

References:
CH2M HILL, 2000. Memphis Depot Main Installation Remedial Investigation Report. Prepared for the Defense Logistics Agency and presented to U.S. Army Engineering and Support Center, Huntsville, Alabama. January 2000.
CH2M HILL, 2002. Memphis Depot Dunn Field Remedial Investigation Report - Volumes I through III. Prepared for the Defense Logistics Agency and presented to U.S. Army Engineering and Support Center, Huntsville, Alabama. July 2002.
USEPA, 2007. Exposure Factors Handbook. EPA/600/P-95/002Fa. August. Available online: https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=12464
USEPA, 2016. Regional Screening Levels (RSLs) - Generic Tables. May. Available online: https://www.epa.gov/risk/regional-screening-levels-rsls

TABLE 11
REVIEW OF EXPOSURE FACTORS
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

			Exposure Factors from Memphis Depot Risk Assessments					Exposure Factors from USEPA 2014 Exposure Factors Memo			
Medium	**Exposure Factor**	**Units**	**Maintenance Worker**	**Industrial Worker**	**Resident Adult / Recreator Adult**	**Resident Child / Recreator Youth**		**Outdoor Worker** (to compare to Maintenance Worker)	**Indoor Worker** (to compare to Industrial Worker)	**Resident Adult**	**Resident Child**
All	Body Weight	kg	70	70	70	15		80	80	80	15
All	Averaging Time - Cancer	day	25,550	25,550	25,550	25,550		25,550	25,550	25,550	25,550
Soil	Incidental Soil Ingestion Rate	mg/day	50	50	100	200		100	50	100	200
Soil	Skin Surface Area	cm^2	2,679	2,679	5,049	2,351		3,527	3,527	6,032	2,373
Soil	Adherence Factor	mg/cm^2	0.03	0.03	0.03	0.15		0.12	0.12	0.07	0.2
Soil	Exposure Time	hour/day	8	8	4	4			8	24	24
Soil	Exposure Frequency	day/year	50	250	350	350		225	250	350	350
Soil	Exposure Duration	year	25	25	30	6		25	25	20	6
Surface Water	Skin Surface Area (Wading)	cm^2	2,679	2,679	N/A	N/A		N/A	N/A	19,652	6,365
Surface Water	Skin Surface Area (Swimming)	cm^2	N/A	N/A	20,000	13,118		N/A	N/A	19,652	6,365
Surface Water	Exposure Time	hour/day	4 for MI / 2 for DF	4 for MI / 2 for DF	6 for MI / 2 for DF	6 for MI / 2 for DF		N/A	N/A	24	24
Surface Water	Exposure Frequency	day/year	12	250 for MI / 50 for DF	45	45		225	250	350	350
Surface Water	Exposure Duration	year	25	25	30	10		25	25	20	6
Sediment	Exposure Time	hour/day	4 for MI / 2 for DF	4 for MI / 2 for DF	6 for MI / 2 for DF	6 for MI / 2 for DF		N/A	N/A	24	24
Sediment	Exposure Frequency	day/year	12	250 for MI / 50 for DF	45	45		225	250	350	350
Sediment	Exposure Duration	year	25	25	30	10		25	25	20	6
Groundwater	Ingestion Rate of Water	L/day	N/A	1	2	1		N/A	N/A	2.5	0.78
Groundwater	Exposure Time	hour/day	N/A	0.007	0.007	0.007		N/A	N/A	24	24
Groundwater	Exposure Duration	year	N/A	25	30	6		25	25	20	6

Notes:
N/A -- Not available
Only exposure factors from the Memphis Depot Main Installation (MI) and Dunn Field (DF) Risk Assessments for which there are comparison values from the USEPA 2014 Exposure Factors Memorandum are presented.

References:
CH2M HILL, 2000. Memphis Depot Main Installation Remedial Investigation Report. Prepared for the Defense Logistics Agency and presented to U.S. Army Engineering and Support Center, Huntsville, Alabama. January 2000.
CH2M HILL, 2002. Memphis Depot Dunn Field Remedial Investigation Report - Volumes I through III. Prepared for the Defense Logistics Agency and presented to U.S. Army Engineering and Support Center, Huntsville, Alabama. July 2002.
USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. Memorandum. OSWER Directive 9200.1-120.

Figures

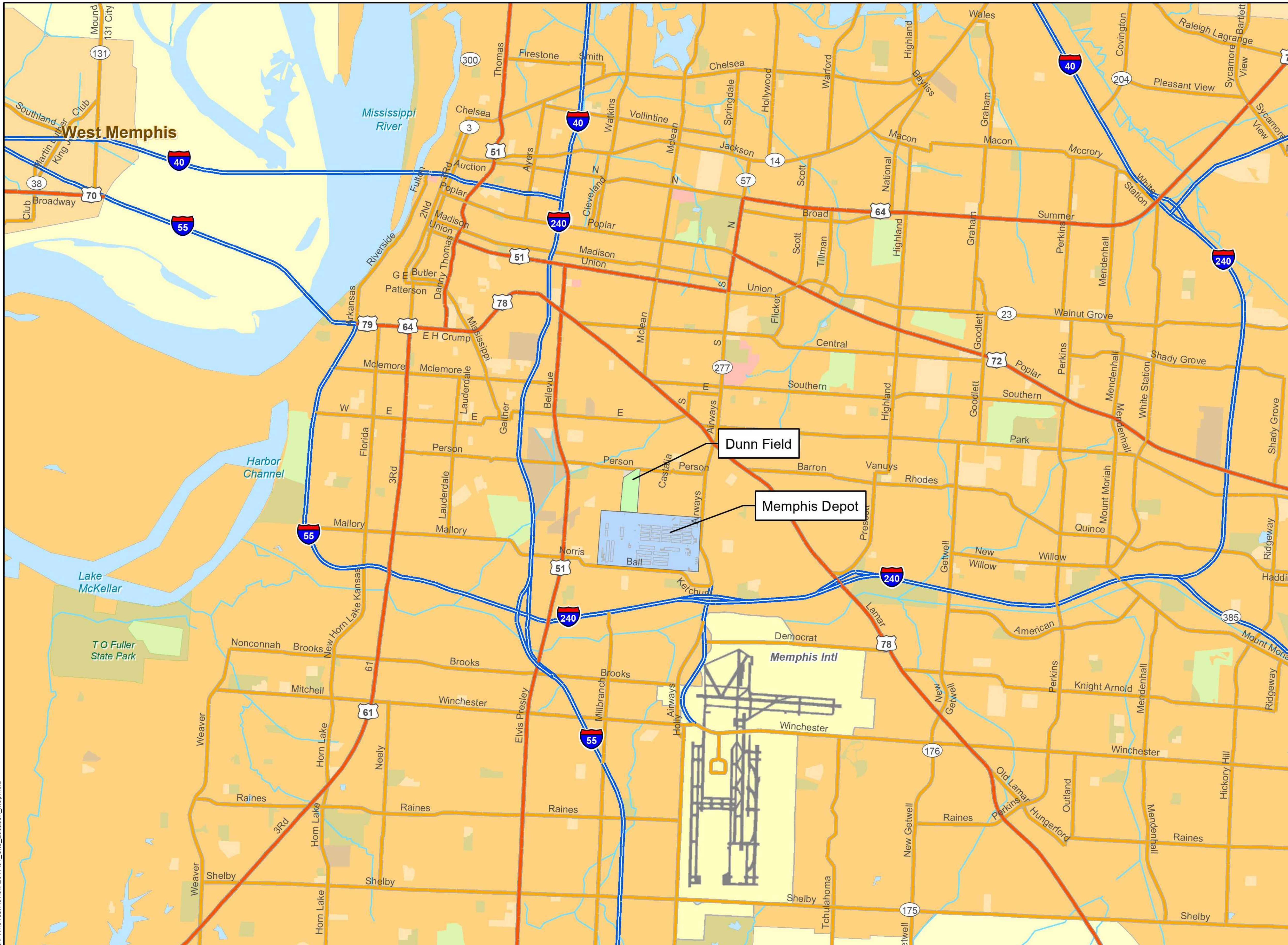

Figure 1

Site Location Map

Fourth Five-Year Review

Defense Depot
Memphis, Tennessee

N
W E
S

0 1 2
Miles

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

Date: 5/15/2017
Edition: Rev 0

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Figure 2

Site Aerial Photograph

Fourth Five-Year Review

Defense Depot
Memphis, Tennessee

N
W E
S

0 500 1,000
Feet

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

Date: 5/17/2017
Edition: Rev 0

HDR

Figure 3

Main Installation Unit Boundaries and Response Actions

Fourth Five-Year Review

Defense Depot
Memphis, Tennessee

OU-1

OU-2

OU-3

OU-4

FU-1

FU-2

FU-3

FU-4

FU-5

FU-6

Bldg. 949 Surface Soil Removal Action (2001)

Former PCP Dip Vat Soil Removal Action (1985)

Cafeteria (Bldg 274) Surface Soil Removal Action (1998)

BRAC Parcels 35 & 28 Surface Soil Removal Action (2000)

Building 873 Soil Removal Action (1985)

Housing Area Surface Soil Removal Action (1998)

925
949
835
865
720
737
629
630
649
650
529
530
549
550
429
430
449
450
319
329
330
349
350
210
229
230
249
250
144
756
770
560
468
469
360
263
260
265
274
270
271
970
972
1089
1086
1088
1087
1091
995
670
689
685
690
470
489
490
Memphis Depot Pkwy
Amido
Ball
Perry
Rozelle
Vista
Stiller
Castalia
Hays
Airways
Dunn
G
L

Legend

- Operable Units (OU-#)
- Past Response Actions
- Functional Unit Boundary (FU-#)
- Area Available for Unrestricted Use
- 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: 6/21/2017
Edition: Rev 0

HDR

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CHEMICAL WARFARE MATERIAL REMOVAL ACTION (2001)

PISTOL RANGE REMOVAL ACTION (2003)

GROUNDWATER INTERIM REMEDIAL ACTION (2009)

CHEMICAL WARFARE MATERIAL REMOVAL ACTION (2001)

NORTHEAST OPEN AREA

DISPOSAL AREA

STOCKPILE AREA

McLean

Person

Carver

Hearst

Hays

State

Ferber

Perry

Dunn

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Figure 4

Dunn Field Area Designations, Removal Actions and Interim Remedial Action

Fourth Five-Year Review

Defense Depot Memphis, Tennessee

Legend

- IRA Recovery Well
- Railroad
- IRA Discharge Conveyance Line
- Area Designations
- Original Dunn Field Boundary
- Removal Actions
- Unrestricted Use Area
- Paved Area
- Roads

N
W E
S

0 250 500
Feet

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

Date: 6/21/2017
Edition: Rev 0

HDR

Note:
1. Color-coded wells symbols are based on the most recent analytical result at each well. Results are from the October 2016 LTM event.
2. Groundwater contours are from the October 2016 LTM event.

Legend

PCE Range (µg/L)
- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 300

PCE Isopleth (ug/L)
- 5
- 10
- 50
- 100

- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Potentiometric surface of the Intermediate Aquifer 5-ft. contour
- Property Boundary
- Groundwater Flow Direction
- Clay Elevation Exceeds Groundwater Elevation

Figure 5

Main Installation Fluvial Aquifer PCE Concentrations, October 2016

Fourth Five-Year Review

Defense Depot Memphis, Tennessee

0 250 500 Feet

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

Date: 6/21/2017
Editilion: Rev 0

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Figure 6
Main Installation Fluvial Aquifer TCE Concentrations, October 2016

Fourth Five-Year Review

Defense Depot Memphis, Tennessee


MW-55 <1
MW-19 <1
MW-213 <5
MW-143 <1
MW-62 <1
MW-142 <1
MW-212 <1
MW-198 <1
MW-199B <1
MW-209B <1
MW-207B 3.73
MW-99 <1
MW-208B <1
MW-39 <1
MW-210B <1
MW-205B <1
MW-206A <1
MW-206B <1
MW-200 <1
MW-197B <1
MW-98 <1
MW-203B <1
MW-204B <1
MW-204A <1
MW-94A <1
MW-53 <1
MW-263 <1
MW-16 <1
MW-103 <1
MW-104 <1
MW-260 <1
MW-63A <1
MW-63B <1
MW-258
MW-265 <1
MW-215B 1.39
MW-64 1.94
MW-218 7.76
MW-267 29.6
MW-266 1.44
MW-88 3.53
MW-85 0.861 J
MW-113 <1
MW-26 2.96
MW-96 0.73 J
MW-50 <1
MW-25A 1.15
MW-66A <1
MW-269 <1
MW-219 <1
MW-21 <1
MW-100B <1
MW-101 T: <1 B: <1
MW-22 <1
MW-102B <1
MW-23 <1
MW-216 <1
MW-97 <1
MW-261 <1
PZ-03 <1
MW-271 <1
MW-259 4.7
MW-272 <1
MW-24 <1
MW-93 <1
MW-270 <1
MW-52 <1
DR1-8 <1
DR1-7 <1
DR1-2 <1
DR1-3 <1
DR1-1 <1
DR1-1A <1
DR1-4 <1
DR1-5 <1
DR1-5A <1
DR1-6 <1
DR1-6A <1
PMW21-01 <1
PMW21-02 <1
PMW21-03 <1
PMW21-04 <1
PMW21-05 <1
PMW101-02 A: <1 B: <1
PMW101-03 A: <1 B: <1
PMW101-04 A: <1 B: <1
PMW101-06 A: <1 B: <1
PMW101-07 A: <1 B: <1
DR2-5 <1
PMW85-01 <1
PMW85.05 25.6
DR2-1 32
DR2-2 <1
DR2-6 <1
DR2-3 2.37
DR2-4 1.92
PMW92-03 <5
PMW92-02 <1
MW-92 <1
925
949
835
865
737
720
629
630
649
650
530
529
549
550
429
430
449
450
319
329
330
349
350
210
229
230
249
250
144
756
770
560
468
469
360
670
470
689
489
685
690
490
1089
1086
1088
1087
1090
972
970
995
274
270
271
260
261
263
265
Hayde
Cole
L Davis
Third
Troyer
Alley
Lloyd
Memphis Depot Pkwy
Behnke
Amido
Dickson
Fifth
Twenty Fifth
Twenty Seventh
Twenty Third
Spicer
W.E Freeman
Dunn
Ledger
Cincinnati
Silver
Raven
Corry
Warren
Sparks
Merlin
Cane
Starr
Elliston
Rayner
Eloise
Mallory
Dempster
Norris
Dottie
Giusco
Whitmore
Arizona
Ferber
Leitner
Freemont
Hays
Slade
Barksdale
Lapsley
Murkey
Cordell
Custer
Fillmore
Flower
Ansonia
Frisco
Dwight
Ball
Gladney
Kingsview
Carbondale
Fairmeade
Manchester
Rozelle
Vista
Ventura
Lausanne
Thames
Jovanne
Perry
Gause
Legend
CT Range (µg/L)
0-5
5-10
10-50
50-100
CT Isopleth (ug/L)
5
10
50
Potentiometric surface of the Fluvial Aquifer 5-ft. contour
Potentiometric surface of the Fluvial Aquifer 1-ft. contour
Potentiometric surface of the Intermediate Aquifer 5-ft. contour
Property Boundary
Groundwater Flow Direction
Clay Elevation Exceeds Groundwater Elevation
Figure 7
Main Installation
Fluvial Aquifer
CT Concentrations,
October 2016
Fourth Five-Year Review
Defense Depot
Memphis, Tennessee
N
W
E
S
0
250
500
Feet
Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet, NAVD88
Date: 6/29/2017
Edition: Rev 0
FDR
Note:
1. Color-coded wells symbols are based on the most recent analytical result at each well. Results are from the October 2016 LTM event.
2. Groundwater contours are from the October 2016 LTM event.
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Note:
1. Color-coded wells symbols are based on the most recent analytical result at each well. Results are from the October 2016 LTM event.
2. Groundwater contours are from the October 2016 LTM event.

Legend

PCE Range (ug/L)
- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 100

PCE Isopleth (ug/L)
- 5
- 10
- 50

- Potentiometric surface of the Intermediate Aquifer 5-ft. contour
- Property Boundary
- Groundwater Flow Direction
- Clay Elevation Exceeds Groundwater Elevation

Figure 8

Main Installation Intermediate Aquifer PCE Concentrations, October 2016

Fourth Five-Year Review

Defense Depot
Memphis, Tennessee

N
W E
S

0 250 500
Feet

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

Date: 6/21/2017
Edition: Rev 0

FDR

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Figure 9
Main Installation Intermediate Aquifer TCE Concentrations, October 2016
Fourth Five-Year Review
Defense Depot
Memphis, Tennessee

Path: W:\5YearReview\2017\09_MI_IUC_TCE_October_2016.mxd

Figure 10
Main Installation Memphis Aquifer CVOC Concentrations, October 2016

Fourth Five-Year Review

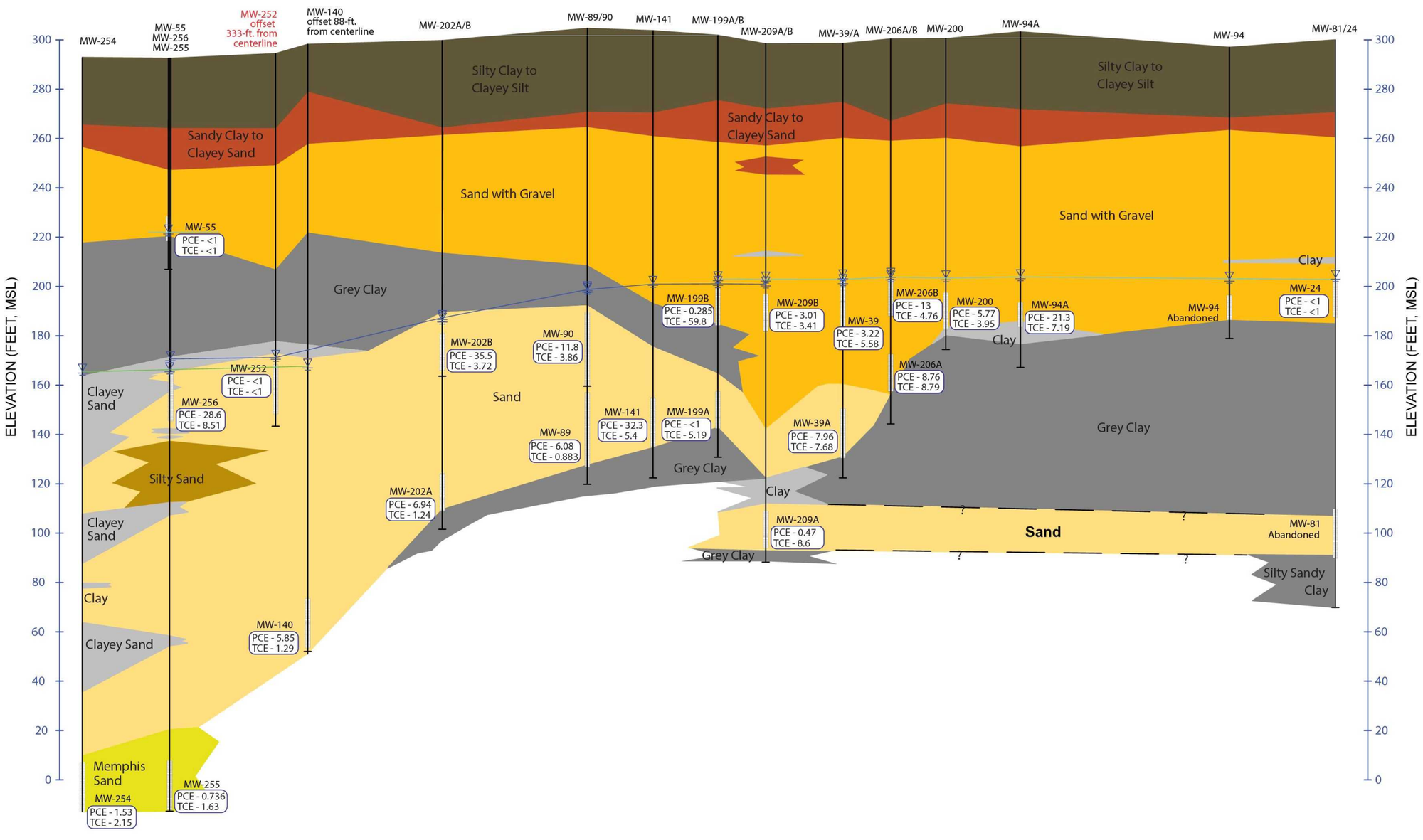
Defense Depot
Memphis, Tennessee

Figure 11

Main Installation Cross Section A with PCE and TCE Concentrations October 2016

Fourth Five-Year Review

DEFENSE DEPOT
MEMPHIS, TENNESSEE



- Silty Clay to Clayey Silt
- Sandy Clay to Clayey Sand
- Fluvial Sand or Sand with Gravel
- Clayey Sand to Silty Clay
- Silty Sand-Sandy Silt
- Intermediate Sand
- Clay
- Memphis Sand
- Groundwater Elevation
- Fluvial Aquifer Groundwater Elevation 10/11/2016
- Intermediate Aquifer Groundwater Elevation 10/11/2016
- Memphis Aquifer Groundwater Elevation 10/11/2016
- Well Screen Interval

Note: PCE and TCE concentrations in µg/L for LTM samples collected in October 2016.

20
0
200

Date: 3/16/2016
Edition:Rev 0

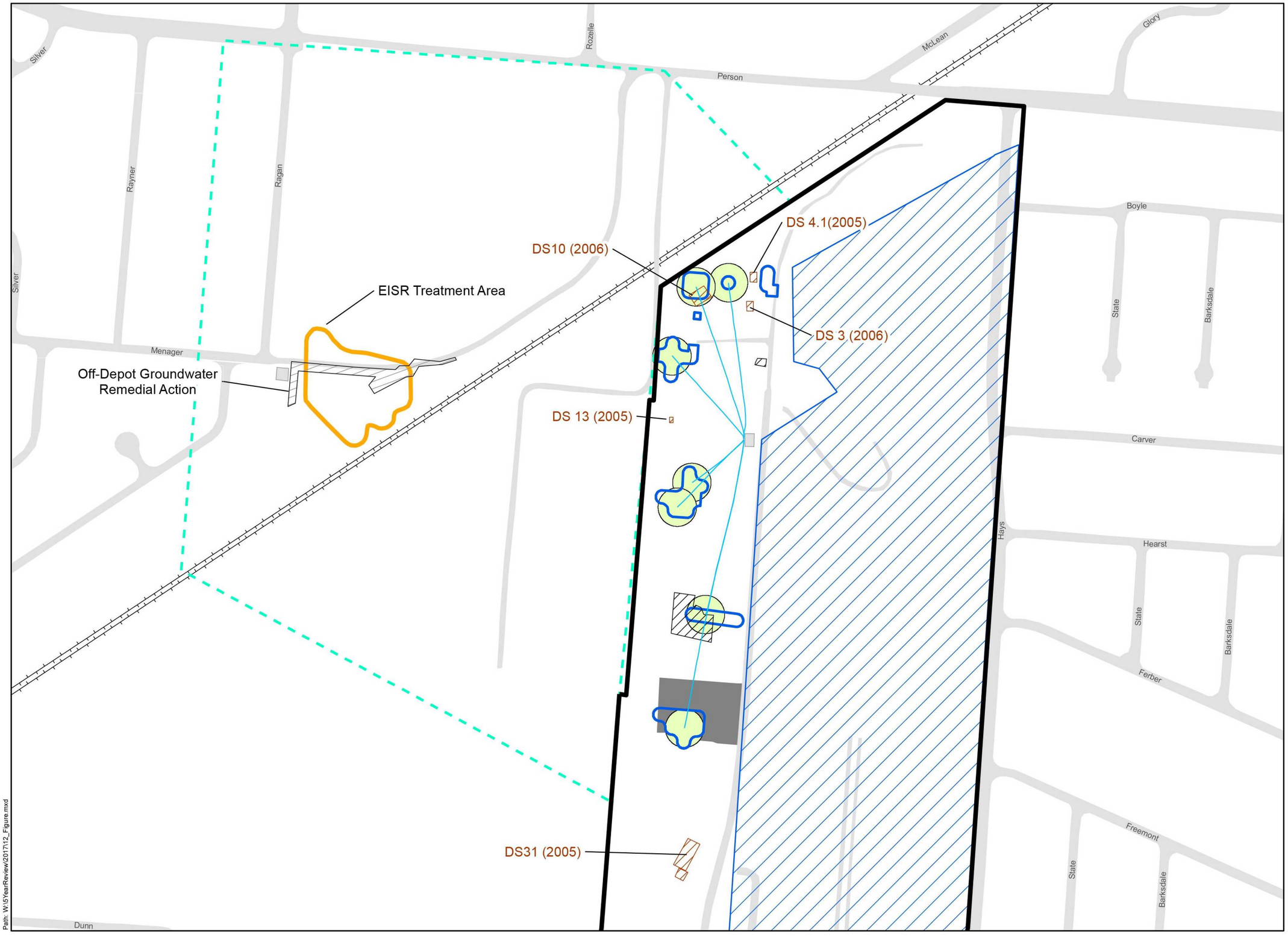


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Figure 12

Dunn Field
Remedial Actions

Fourth Five-Year Review

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: 6/21/2017
Edition: Rev 0

Figure 13

AS/SVE System

Fourth-Five Year Review

Defense Depot
Memphis, Tennessee

Legend

TCE Range (ug/L)
- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 300

TCE Isopleth (ug/L)
- 5
- 10
- 50
- 100
- AS Location (1/2 time)
- AS Location (full time)
- AS Location (closed)
- New AS Location
- VMP Location
- SVE Location
- Conveyance Lines
- New Conveyance Line
- SVE Compound
- Roads
- Railroad
- Parcel Boundary

N
W E
S

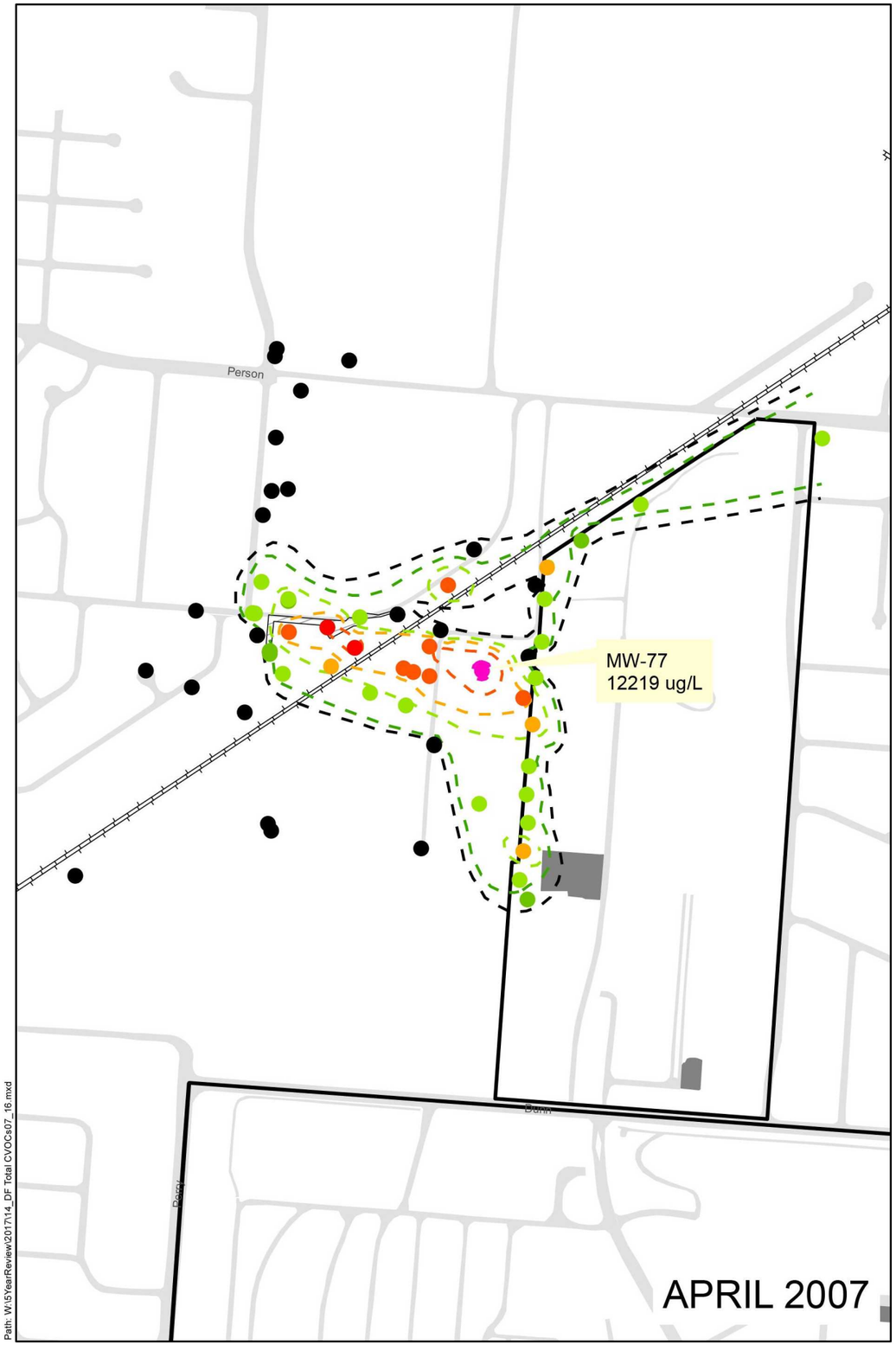
0 25 50
Feet

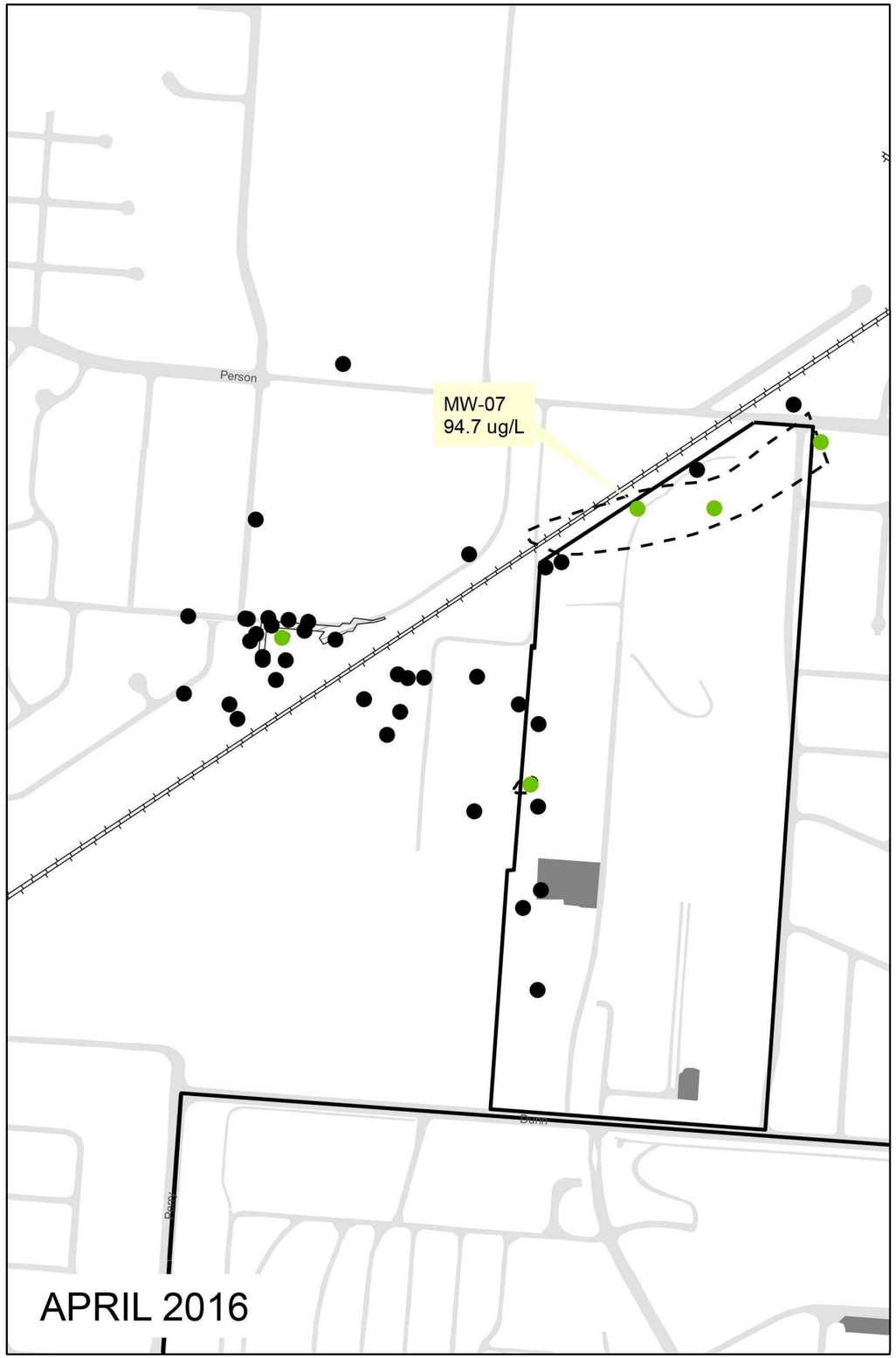
Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet, NAVD88

Date: 6/21/2017
Edition: Rev 0

Notes:
1. Color-coded wells symbols are based on the TCE concentration in the most recent analytical results at each well. Analytical results are from the April 2015, April 2016 and October 2016 LTM events. Only total TCE concentrations from the October 2016 LTM event are shown below the well ID.
2. Highest concentration at well pairs used for contour.

Path: W:\5YearReview\2017\13_ASSVESystem.mxd





Path: W:\5YearReview\2017\14_DF Total CVOCs07_16.mxd

Figure 14

Dunn Field Total CVOC Concentrations, 2007 - 2016

Fourth Five-Year Review

Defense Depot
Memphis, Tennessee

Legend

Total CVOC Isopleth (ug/L)

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

Total CVOC Ranges (ug/L)

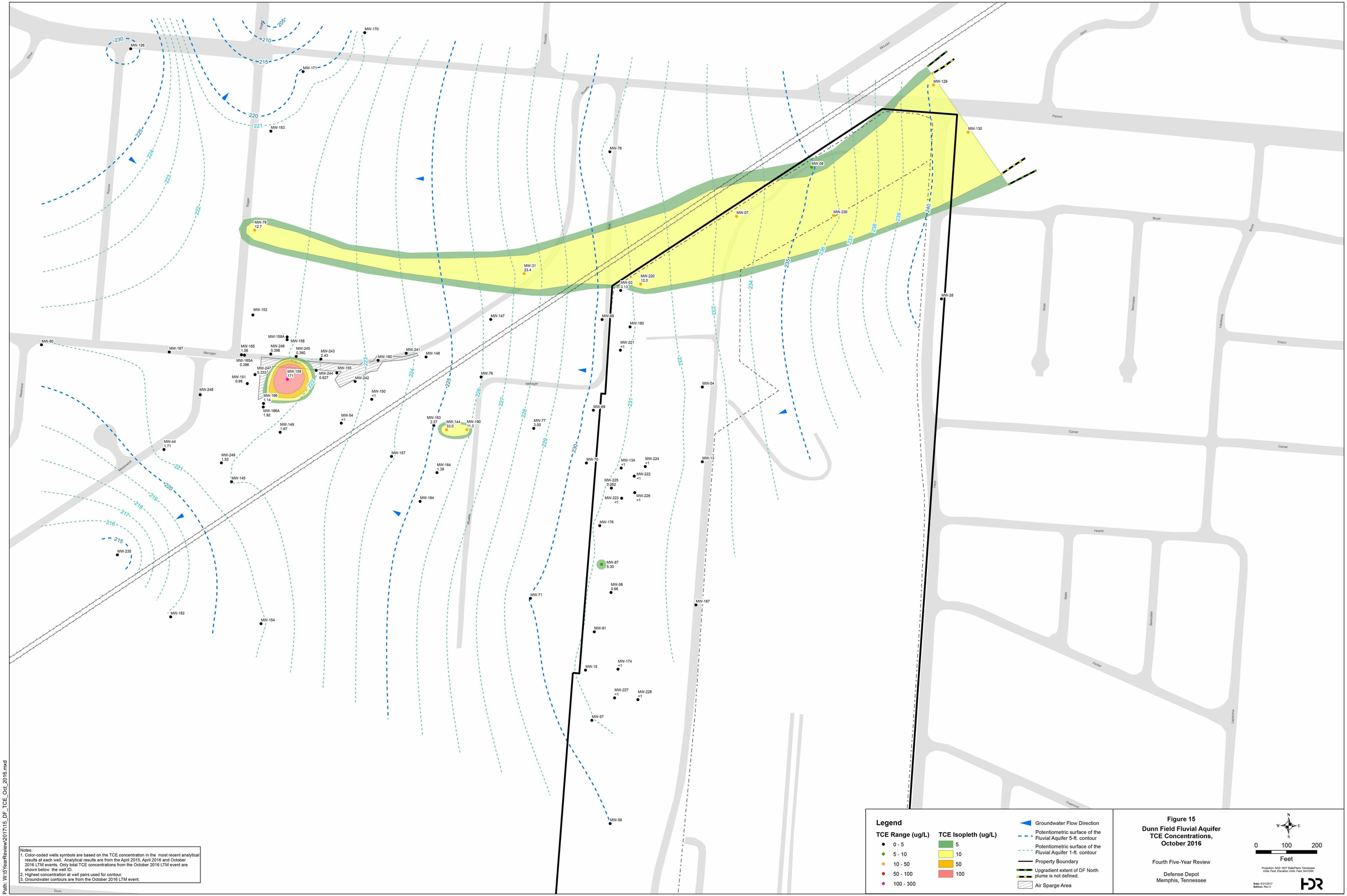
- 50
- 100
- 500
- 1000
- 5000
- 10000
- Original Property Boundary
- Off Depot Air Sparge Area
- Paved Area
- Roads
- Railroad

N
W E
S

0 250 500
Feet

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

Date: 6/21/2017
Edition: Rev 0



Notes:
1. Color-coded wells symbols are based on the TCE concentration in the most recent analytical results at each well. Analytical results are from the April 2015, April 2016 and October 2016 LTM events. Only total TCE concentrations from the October 2016 LTM event are shown below the well ID.
2. Highest concentration at well pairs used for contour.
3. Groundwater contours are from the October 2016 LTM event.

Legend

TCE Range (ug/L)
- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 300

TCE Isopleth (ug/L)
- 5
- 10
- 50
- 100

- Groundwater Flow Direction
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Property Boundary
- Upgradient extent of DF North plume is not defined.
- Air Sparge Area

Figure 15
Dunn Field Fluvial Aquifer TCE Concentrations, October 2016

Fourth Five-Year Review

Defense Depot
Memphis, Tennessee

N W E S

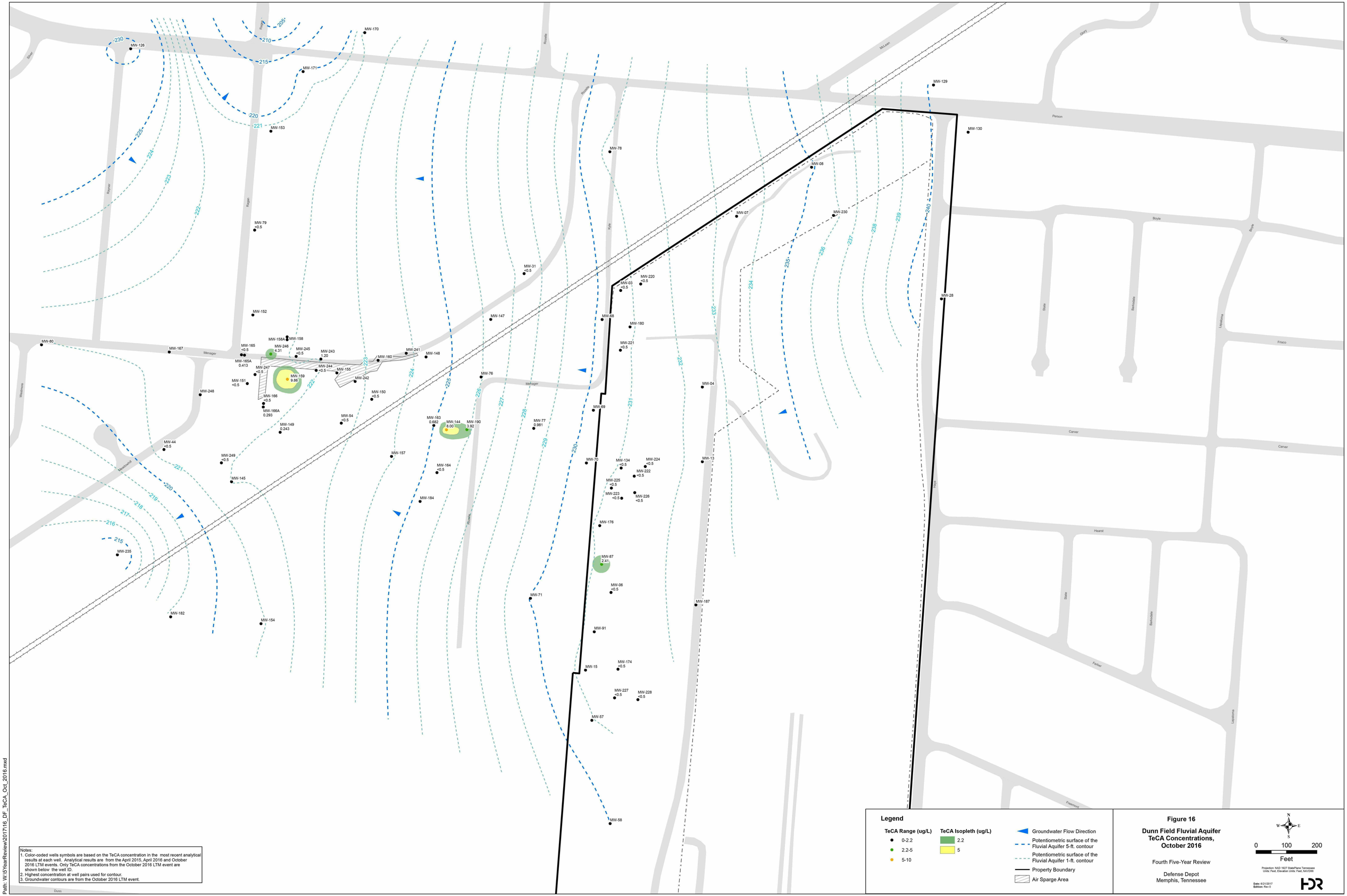
0 100 200
Feet

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

Date: 6/21/2017
Edition: Rev 0

HDR

Path: W:\5YearReview\2017\15_DF_TCE_Oct_2016.mxd



Notes:
1. Color-coded wells symbols are based on the TeCA concentration in the most recent analytical results at each well. Analytical results are from the April 2015, April 2016 and October 2016 LTM events. Only TeCA concentrations from the October 2016 LTM event are shown below the well ID.
2. Highest concentration at well pairs used for contour.
3. Groundwater contours are from the October 2016 LTM event.

Legend

TeCA Range (ug/L)
- 0-2.2
- 2.2-5
- 5-10

TeCA Isopleth (ug/L)
- 2.2
- 5

- Groundwater Flow Direction
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Property Boundary
- Air Sparge Area

Figure 16

Dunn Field Fluvial Aquifer TeCA Concentrations, October 2016

Fourth Five-Year Review

Defense Depot Memphis, Tennessee

N W E S

0 100 200

Feet

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

Date: 6/21/2017
Edition: Rev 0

HDR

Path: W:\5YearReview\2017\16_DF_TeCA_Oct_2016.mxd

Notes:
1. Groundwater contours from October 2016.
2. CVOC contours from October 2016.

Path: W:\5YearReview\2017\17_MI\Vmap.mxd

Legend

- PCE Commercial Vapor Intrusion Screening Level (65 ug/L)
- TCE Commercial Vapor Intrusion Screening Level (7.4 ug/L)
- CT Commercial Vapor Intrusion Screening Level (1.8 ug/L)
- CF Commercial Vapor Intrusion Screening Level (3.6 ug/L)
- VC Commercial Vapor Intrusion Screening Level (2.5 ug/L)
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Fluvial Aquifer Well
- Intermediate Aquifer Well
- Property Boundary
- Area Available for Unrestricted Use
- Roads
- Building with Number and Lessee(s)
- Clay Elevation Exceeds Groundwater Elevation

Figure 17

Main Installation Comprehensive Vapor Intrusion Screening Map

Fourth Five-Year Review

Defense Depot Memphis, Tennessee

0 250 500 Feet

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

Date: 12/5/2017
Edition: Rev 0

Legend

Aquifer
- Fluvial
- Intermediate/Upper Claiborne
- Memphis
- Cintas Monitoring Well
- Wabash Monitoring Well
- Original Dunn Field Boundary
- MIP Study Area

LTM Well Classifications
- Background
- DF North
- DF West
- Off Depot

Note:
Well WB-04 is not usable; TDEC has been notified and will take necessary action.

Figure 18

MIP Survey, TDEC and LTM Well Locations

Fourth Five-Year Review

Defense Depot
Memphis, Tennessee

N
W E
S

0 100 200
Feet

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

Date: 12/5/2017
Edition: Rev 0

HDR

Path: W:\5YearReview\2017\18_MIPSurvey_TCEC Well Locations.mxd

A

Appendix A.

Responses to Regulatory Agency Comments

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

April 09, 2018

UPS NEXT DAY AIR
RETURN RECEIPT REQUESTED

Mr. James Foster
Base Realignment and Closure Division (ACSIM-ODB)
2530 Crystal Drive (Taylor Building) Room 5000
Arlington, VA 22202-3940

Dear Mr. Foster:

A five-year review (FYR) of remedial actions is required under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) at CERCLA sites where the selected remedies allow concentrations of hazardous substances, pollutants or contaminants to remain at concentrations that do not allow for unrestricted use and unlimited exposure. As lead Agency for CERCLA at the former Memphis Depot, the Department of the Army (DA) submitted the Fourth Five Year Review (FYR), Revision 2, for EPA review on March 27, 2018.

All EPA comments on previously submitted draft documents have been acceptably incorporated into the above mentioned and revised final document. EPA concurs with the findings by DA and hereby approves the 4th Five Year Review document. Should you have any questions or concerns, please feel free to call me at on my cell number 404-229-9509.

Sincerely,

Diedre Lloyd
Remedial Project Manager
Restoration & Sustainability Branch
Superfund Division

cc: Mr. James Foster, (Signed Original) United Parcel Service, Return Receipt
Mr. Jamie A. Woods, PG, Tennessee, Department of Environment and Conservation, Memphis Environmental Field Office, 8383 Wolf Lake Drive, Bartlett, TN 38133-4119
Ms. Joan Hurton, CALIBRE, 3898 Mountain View Road, Kennesaw, GA 30152
Mr. Thomas Holmes, HDR Environmental, P.O. Box 728, Highlands, NC 28741

Responses to Comments from
U.S. Environmental Protection Agency (EPA) Region 4 on:
Fourth Five-Year Review, Revision 0
Defense Depot Memphis, Tennessee
22 September 2017

EPA Comments:

1. The first paragraph in Section 3.1.1.4, Vapor Intrusion, Page 17, indicates potential vapor intrusion (VI) issues at the Main Installation (MI) are being evaluated to determine if groundwater plumes, and potentially soil contamination, are present beneath commercial/industrial buildings at the site resulting in a potential VI human exposure pathway. As such, it appears the VI exposure pathway has not been characterized at the MI. Additionally, the potential for an unacceptable VI exposure pathway was not identified as an issue or was discussed in the protectiveness statement presented for the MI. As this is an issue that potentially impacts the protectiveness statement prepared for the MI, the Fourth Five-Year Review, Revision 0, dated September 22, 2017 should be revised to address this issue.

Response: Army agrees that further investigation of the potential VI risk on the MI is needed. The *Fourth Five-Year Review, Revision 0* was submitted prior to completion of the initial assessment of the MI VI study. Discussion of the initial assessment and planned soil gas sampling have been added in Sections 3.1.1.4, 5.25 and 5.4. VI has been added as an issue with recommendation in Section 6 and noted in the Protectiveness statement in Section 7.

2. In Table 7, ARARs and TBC Guidance, the following "New Citation" column reference website addresses are incorrect. Update the correct website addresses accordingly.

   1) Page 2 of 6, Installation and maintenance of groundwater monitoring well(s) and soil borings:
      - Incorrect: http://www.shelbycountytn.gov/DocumentCenter/Home/View/768
      - Correct: http://www.shelbycountytn.gov/DocumentCenter/View/768

   2) Page 2 of 6, Emissions from SVE treatment:
      - Incorrect: http://www.shelbycountytn.gov/DocumentCenter/Home/View/777
      - Correct: http://www.shelbycountytn.gov/DocumentCenter/View/777

   3) Page 3 of 6, Characterization of Solid Waste and Page 4 of 6, Temporary storage of hazardous waste in containers (40 CFR 262.11):
      - Incorrect: https://www.ecfr.gov/cgi-bin/textidx?SID=0c6b768dee958f03e0a53e77bc9ec860&mc=true&node=se40.28.262_111&rgn=div8
      - Correct: https://www.ecfr.gov/cgi-bin/text-idx?SID=cb303aa6b9b66c6d63494f0cdb39820f&mc=true&node=pt40.28.262&rgn=div5#se40.28.262_111

   4) Page 5 of 6, Disposal of RCRA-hazardous waste in a land-based unit 40 CFR 268.40:
      - Incorrect: https://www.ecfr.gov/cgi-bin/textidx?SID=4732e17a82f8f891b9df89c13d82afd4&mc=true&node=se40.29.268_140&rgn=div8
      - Correct: https://www.ecfr.gov/cgi-bin/text-idx?SID=1fa0b08eb41cf6cb5a28dd740aedda8&mc=true&node=pt40.29.268&rgn=div5#se40.29.268_140

40 CFR 268.49:

- Incorrect: https://www.ecfr.gov/cgi-bin/textidx?SID=4424a0ed5d96150946af1c2db75d0b85&mc=true&node=se40.29.268_149&rgn=div8
- Correct: https://www.ecfr.gov/cgi-bin/text-idx?SID=87d53a6ed29e208bd2f414a81fbce878&mc=true&node=pt40.29.268&rgn=div5#se40.29.268_149

5) Page 5 of 6, Disposal of RCRA wastewaters in an CWA wastewater treatment unit (40 CFR 268.1):
   - Incorrect: https://www.ecfr.gov/cgibin/retrieveECFR?gp=&SID=4424a0ed5d96150946af1c2db75d0b85&mc=true&n=pt40.29.268&r=PART&ty=HTML#se40.29.268_11
   - Correct: https://www.ecfr.gov/cgi-bin/text-idx?SID=81c0ca77a15c2ca17d82b57e486a7664&mc=true&node=se40.29.268_11&rgn=div8

6) Page 5 of 6, Transportation of hazardous materials (49 CFR 262.10):
   - Incorrect: https://www.ecfr.gov/cgibin/textidx?SID=a9bb39f84d6eb1cbba562b3b74666bed&mc=true&node=se49.2.171_11&rgn=div8
   - Correct: https://www.ecfr.gov/cgi-bin/text-idx?SID=a30c7d01bd28721df8259723b008b865&mc=true&node=pt49.2.171&rgn=div5

7) Page 5 of 6, Transportation of hazardous waste off site (40 CFR 262.10):
   - 40 CFR 262.10 can be found at the following address: https://www.ecfr.gov/cgi-bin/text-idx?SID=91f9f8640697841a9fb3f3a15a856f51&mc=true&node=se40.28.262_110&rgn=div8

8) Page 6 of 6, Transportation of hazardous waste off site (40 CFR 263):
   - 40 CFR 263 can be found at the following address: https://www.ecfr.gov/cgi-bin/text-idx?SID=e2eac371903a6f84721c18ceafa4ff36&mc=true&node=pt40.28.263&rgn=div5

Response: Army will incorporate the corrected website addresses in the FYR.

Responses to Comments from
U.S. Environmental Protection Agency (EPA) Region 4 on:
Fourth Five-Year Review, Revision 1
Defense Depot Memphis, Tennessee
8 December 2017

EPA Comments, Y. Jones, Received 31 January 2018

1. Page iii, Summary Form, Protectiveness Statement: Highlighted text (Main Installation) "Short-term Protective"

   Comment: Pursuant to the guidance document: Clarifying the Use of Protectiveness Determinations for CERCLA Five-Year Reviews, September 2012 (https://semspub.epa.gov/work/11/174829.pdf), with the type of issues (e.g. a full VI evaluation is required) resulting from this review, it may be more appropriate to 'defer the protectiveness statement' until sufficient data is available to make this determination. Please review and revise accordingly.

   Same comment included in Section 7 Protectiveness Statement.

   Response: Army believes the VI exposure pathway is not complete at the MI and the determination of "Short-term Protective" is appropriate. Protectiveness Statement revised to support the determination. Additional discussion of the VI evaluation to date and protectiveness determination for the Main Installation (MI) is provided in Attachment A to these responses.

2. Page v, Highlighted text "Table of Contents"

   Comment: Please include the FYR Site Inspection Forms. In addition, it would be helpful to include the VI Screening results.

   Response: The FYR Site Inspection Checklist will be added as Appendix F to the FYR.

   Results of the vapor intrusion study are presented in Section 3.1.1.4. Additional VI information is provided in Attachment A to these responses. The VISL Assessment memorandum will be added as Appendix D to the FYR.

   Per Section 4.3, "The site inspection was performed with the annual LUC inspection in July 2017. Weekly inspections have been made at Dunn Field since 2006." The annual LUC inspection reports are submitted to USEPA upon completion. The 2017 LUC inspection reports for the MI and Dunn Field will be added as Appendix C to the FYR.

3. Page 2 Highlighted text: "DDMT is currently zoned for light industrial use. The MI is used for commercial warehousing and light manufacturing, except in in the southeast quadrant of the MI where the Airways police station, homeless shelter for veterans and golf course are located; Dunn Field is undeveloped"

   Comment: Is there a potential for people to be exposed via the VI exposure pathway?

   Response: Army believes the VI exposure pathway is not complete at the MI. See Attachment A for discussion of the VI evaluation to date.

4. Page 10 Highlighted text: "OPS"

   Comment: Please define and include in the List of Acronyms and Abbreviations.

   Response: This was the only use of the acronym; it will be replaced with the full spelling, "operating properly and successfully".

5. Page 18, 3.1.1.4 Highlighted text "Recent USEPA"

Comment: I am assuming the recent VI Screening conducted used the OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air. U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. June 2015.

This information can be access as the following websites: https://www.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf Latest VISL: https://www.epa.gov/vaporintrusion

Response: The referenced sentence will be revised to "…in accordance with Department of Defense (DoD) and USEPA guidance, and with consideration of TDEC guidance." The VI Screening followed the process in the DoD Vapor Intrusion Handbook and was consistent with requirements in the OSWER June 2015 guidance; work plans will be submitted to USEPA and TDEC for review and will be implemented following approval. The screening assessment used the May 2016 VISL calculator to calculate screening levels and calculate risk based on contaminant concentrations at specific locations.

Additional VI information is provided in Attachment A to these responses. The VISL Assessment memorandum will be added as Appendix D included as appendices to the FYR.

6. Page 18, 3.1.1.4 Highlighted text "In addition, the VISL Calculator and the Johnson Ettinger model (JEM) were used to estimate the potential VI human health risk from COPCs at three wells which had the highest groundwater concentrations in October 2016 and are located adjacent to occupied buildings. The assessment identified potential cancer risks greater than the target 1x10-6 and non-cancer risk greater than 1.0.

   Site-specific VI pathway evaluation is planned in accordance with DoD Step 4. Soil gas samples will be collected in open areas and beneath building sub-slabs at locations considered most likely to contain VOCs in soil and/or groundwater at concentrations that may present a VI human health risk."

   Comment: With the type of issues (e.g. a full VI evaluation is required) resulting from this review, it may be more appropriate to 'defer the protectiveness statement' until sufficient data is available to make this determination. Please review the Protectiveness Determination and revise accordingly.

   Response: Army believes the VI exposure pathway is not complete at the MI and the determination of "Short-term Protective" is appropriate. See Attachment A for discussion of the VI evaluation to date and protectiveness determination for the MI.

7. Page 31 Section 6 Issues/Recommendations, Main Installation Category Other.

   Affect Current Protectiveness: No Affect Future Protectiveness: Yes

   Comment : Is sufficient data available to make this determination?

   Response: Army believes the VI exposure pathway is not complete at the MI and the determination of "Short-term Protective" is appropriate. See Attachment A for discussion of the VI evaluation to date and protectiveness determination for the MI.

EPA Comments, M. Brock, Received 2 February 2018

1. OU(s) 2, 3 and 4 (Main Installation). Issues/Recommendations. Issue Category: Other. The "recommendation" should identify the specific DoD guidance and should also state that the VI survey will be conducted in accordance with EPA guidance at

https://www.epa.gov/vaporintrusion/technical-guide-assessing-and-mitigating-vapor-intrusion-pathway-subsurface-vapor. As noted at CERCLA §120(a)(2), all guidelines, rules, regulations, and criteria applicable to remedial actions are applicable at federal facilities in the same manner and extent as at non-federal facilities. This section states, further, that no department, agency or instrumentality of the United States may adopt or utilize any guidelines, rules, regulations, or criteria which are inconsistent with the guidelines, rules, regulations, and criteria established by the Administrator under CERCLA.

Response: Will revise statement to "… in accordance with DoD and USEPA guidance (TSERAWG, 2009 and USEPA, 2015)." Full titles for the guidance will be provided in the document, Sections 3.1.1.4, Vapor Intrusion and 9, References.

2. OU(s) 2, 3, and 4 (Main Installation). Protectiveness Statement. Protectiveness Determination. Per EPA guidance, *Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation and Liability Act Five-Year Reviews,* September 13, 2012, OSWER 9200.2.111, a determination of "Protectiveness Deferred" is generally used where the available information does not provide sufficient data and documentation to conclude that all human and ecological risks are currently under control and no unacceptable exposures are occurring. As noted in the recommendation, "[a]dditional lines of evidence are needed to assess VI risk." The appropriate determination is, therefore, "Protectiveness Deferred."

   Response: Army believes the VI exposure pathway is not complete at the MI and the determination of "Short-term Protective" is appropriate. Protectiveness Statement revised to support the determination. Additional discussion of the VI evaluation to date and protectiveness determination for the Main Installation (MI) is provided in Attachment A to these responses.

3. OU(s) 2, 3 and 4(Main Installation), Protectiveness Statement. Please revise the statement regarding EPA guidance to reflect that remediation work under CERCLA, including the VI evaluation, must be conducted consistent with EPA guidance. For your convenience, it could be phrased, ". . . completed in accordance with DoD and USEPA guidance, and with consideration of TDEC guidance . . ." See comment above.

   Response: Text will be revised per the comment.

4. OU(s) 2, 3 and 4(Main Installation), Protectiveness Statement. Number 2 states that a VI study will be done to "confirm there is not a complete VI pathway or to implement appropriate mitigation/remediation requirements." The use of the word "confirm" may be misleading to the reader of this Five-Year Review. Please use less leading wording, such as "evaluate whether there is a complete VI pathway." The Army need not follow with the "mitigation/remediation" clause, because that will be driven by the results of the evaluation.

   Response: Text will be revised per the comment.

5. Sitewide Protectiveness Statement. Given that the appropriate determination for OU(s) 2, 3 and 4 (Main Installation) is "Protectiveness Deferred," the entire site cannot be "Protective" and should also be "Protectiveness Deferred."

Response: The Sitewide Protectiveness Statement will match the statement for the least protective OU following further review of the Protectiveness Statement for OUs 2, 3 and 4 (see Attachment A).

6. Throughout the document and during the conduct of the VI evaluation, please ensure that both the document and the evaluation are prepared and conducted consistent with EPA guidance (e.g., Section 5.2.5).

   Response: Text in Sections 3.1.1.4 and 5.2.5 will be revised to note consistency with EPA guidance. Protectiveness statements will be revised as necessary for consistency with guidance following further evaluation by Army and USEPA. Otherwise, the document and the evaluation are considered to be consistent with EPA guidance.

7. Section 5.3. Please note that since the appropriate category is "Protectiveness Deferred," a short statement that additional information is being gathered in order to evaluate whether there is an unacceptable risk due to a vapor intrusion exposure.

   Response: Protectiveness statements are still being evaluated by Army and USEPA. The statement will be added if necessary following final decision on protectiveness.

8. Section 6. Please revise consistent with the above comments.

   Response: Section 6 will be revised per above responses, pending acceptance by USEPA.

Attachment A
VI Evaluation and OUs 2, 3 and 4 Protectiveness Determination
Fourth Five-Year Review, Revision 1
Defense Depot Memphis, Tennessee

Comments received from USEPA on the *Fourth Five-Year Review, Revision 1* for the former Defense Depot Memphis, Tennessee (DDMT) stated that the appropriate protectiveness determination for the Main Installation (MI) was Protectiveness Deferred, rather than Short-term Protective as stated in the subject document. The recommended change in protectiveness was based on the ongoing vapor intrusion study for the MI and USEPA guidance (OSWER 9200.2.111). The guidance states a determination of protectiveness deferred "is generally used when the available information … does not provide sufficient data and documentation to conclude that all human and ecological risks are currently under control and no unacceptable exposures are occurring". As an example, the guidance lists "a new exposure pathway (e.g., vapor intrusion) has been identified and additional data are required to determine if an unacceptable risk is occurring."

Vapor intrusion is not a new exposure pathway at DDMT, although it was given more consideration at Dunn Field (OU 1) than at the MI (OUs 2, 3 and 4). Groundwater contamination at Dunn Field resulted from waste disposal activities, while contamination on the MI is considered to result from multiple, small volume, undocumented releases. Chlorinated volatile organic compounds (CVOCs) are the contaminants of concern in groundwater at all DDMT OUs. The Dunn Field Record of Decision (CH2MHILL, 2004) includes a remedial action objective to "Prevent direct inhalation of indoor air vapors from subsurface soils in excess of industrial worker criteria"; the MI Record of Decision does not address vapor intrusion.

Sampling performed at DDMT prior to the current five-year review indicates there is not a complete pathway. However, the sampling was performed in 2009 prior to the current USEPA guidance for assessing the VI pathway. The Army chose to perform the current VI study out of an abundance of caution and to provide a study conforming to current DOD and USEPA guidance.

2009 Vapor Sampling

As noted in FYR Section 3.1.1.4, previous soil gas sampling at the AS/SVE treatment system near Dunn Field was performed prior to implementation of the Off Depot Groundwater remedial action (HDR, 2011a).

Soil gas samples were collected at nine locations near the Off Depot air sparge/soil vapor extraction (AS/SVE) treatment system to evaluate potential VI risk to nearby residents. The samples were collected prior to start-up of the AS/SVE system. Samples were collected at depths of 5 feet (B) and 15 feet (A) below ground surface (bgs) at each location. CVOC concentrations in the soil gas samples were below then-current residential vapor screening values.

All the vapor sample points were installed in loess, which is the surficial geologic layer in the Memphis area. The loess deposits consist of wind-blown and deposited brown to reddish-brown, low-plasticity clayey silt to silty clay, are about 20 to 30 feet (ft) thick, and are continuous throughout DDMT (HDR, 2017b).

Eight vapor sample points were located on residential properties, which were near the edge of the groundwater plume, and one vapor sample point (VI-2) was placed in the core of the plume adjacent to an AS/SVE vapor monitoring point (VMP-4) installed in the fluvial sand-gravel beneath the loess. VMP-4 has two screened intervals, 4A at 63 feet bgs and 4B at 44 feet bgs. The initial vapor samples were collected in September 2009. Depth to water at VMP-4 was approximately 74 feet bgs.

Trichloroethene (TCE) and 1,1,2,2-tetrachloroethane (TeCA) were the CVOCs with the highest concentrations in the Dunn Field plume. Baseline groundwater samples in the AS/SVE area were collected in July 2009. Groundwater concentrations at two wells near VI-2 and VMP-4 had the following concentrations, 1280 micrograms per liter (µg/L) (TCE) and 366 µg/L (TeCA) at MW-159 and 346 µg/L (TCE) and 1620 µg/L (TeCA) at MW-244.

Vapor concentrations in the fluvial sand-gravel at VMP-4 were 6830 micrograms per cubic meter (µg/m^3) (TCE) and 1420 µg/m^3 (TeCA) at VMP-4A and 2950 µg/m^3 (TCE) and 133 µg/m^3 (TeCA) at VMP-4B. TCE and TeCA were not detected in the loess at either depth in VI-2; the reporting limits (RLs) were 0.86 µg/m^3 (TCE) and 5.5 µg/m^3 (TeCA).

A second round of VI samples was collected in March 2010 following start-up of the AS/SVE system in December 2009. Vapor concentrations at VMP-4 were 11 µg/m^3 (TCE) and <5.5 µg/m^3 (TeCA) at VMP-4A and 28 µg/m^3 (TCE) and <5.5 µg/m^3 (TeCA) at VMP-4B. TCE and TeCA were not detected above the reporting limit at either depth in VI-2, although TCE was detected below the RL at 0.75 µg/m^3 in VI-2B; the RLs were 0.86 µg/m^3 (TCE) and 5.5 µg/m^3 (TeCA).

Based on CVOC concentrations below RLs in the loess vapor samples and the greatly reduced concentrations in the fluvial sand-gravel, abandonment of the VI sample points was recommended. The recommendation was approved by DoD, USEPA and TDEC, and the sample points were abandoned in September 2010 (HDR, 2011a).

Groundwater Concentrations

CVOC concentrations in groundwater at the Off Depot Area in the June 2009 samples were much higher than currently observed on the MI. The 2016 annual LTM report (HDR, 2017b) stated CVOC concentrations exceeded an MCL in 86 of 138 LTM wells, but individual CVOC concentrations exceeded 100 µg/L in only eight wells. The maximum CVOC concentrations were 293 µg/L for tetrachloroethene (PCE), 122 µg/L for TCE, 135 µg/L for cis-1,2-dichloroethene and 101 µg/L for vinyl chloride (VC). High concentrations of cis-1,2-dichloroethene and vinyl chloride result from implementation of enhanced bioremediation, the active component of the selected remedy for groundwater.

MI Vapor Intrusion Screening Level Assessment

The MI Vapor Intrusion Study is being performed using the process outlined in the DoD Vapor Intrusion Handbook but the work is in accordance with USEPA and TDEC guidance; work plans are submitted to USEPA and TDEC for review and implemented following approval.

The initial step was a Vapor Intrusion Screening Level (VISL) Assessment for the MI. The memorandum report (HDR, 2017c) was submitted to USEPA and TDEC in August 2017; comments were provided by USEPA on 29 November and responses were submitted by Army on 15 December 2017. The VISL Assessment memorandum has been added in Appendix D of the Fourth FYR.

The assessment included use of the May 2016 VISL Calculator (USEPA, 2016) to determine screening levels for the contaminants of concern; a comprehensive vapor intrusion map for the MI (Figure 1 attached) was then prepared to show the area of the CVOC plumes above the screening levels, CVOC concentrations at individual wells, groundwater elevation contours, and the locations of existing buildings with the building number and current tenant/owner name. The groundwater elevations and analytical results shown are from the October 2016 LTM report (HDR, 2017b).

The figure shows contaminant concentrations in groundwater above the SLs are present beneath some buildings on the MI. To further evaluate the VI risk, the May 2016 VISL Calculator (USEPA, 2016) and the Johnson and Ettinger model (JEM) (USEPA, 2003) were used to estimate VI risk at three locations, which had the highest concentrations of the contaminants of concern and were located adjacent to occupied buildings. The VISL Calculator used default values for commercial exposure endpoints, while JEM used site-specific information. The input parameters are noted below.

Table 1. Input Parameters

	Well DR2-1	Well MW-100B	Well PMW21-04
Depth to Water (feet/centimeters)	84.97/2,590	82.87/2,526	83.49/2,545
Soil Type (depth in feet below ground surface)	Clay (0-30), Sand (26-85)	Clay (0-18.5) Sand (18.5-83)	Clay (0-26), Sand (26-83.5)
Chloroform (µg/L)	4.97	0.3 U	0.157
CT (µg/L)	32	1.0 U	1.0 U
PCE (µg/L)	208	1.09	293
TCE (µg/L)	5.92	0.306	122
VC (µg/L)	1.0 U	101	1.0 U

The calculated combined risks for the contaminants of concern at the three locations are shown below.

Table 2. VI Risk Results

Well	Cancer Risk		Non-Cancer Risk	
	VISL	*JEM*	*VISL*	*JEM*
DR2-1	**$2.4x10^{-5}$**	**$3.5x10^{-6}$**	**1.2163**	0.162
MW-100B	**$4.2x10^{-5}$**	**$8.1x10^{-6}$**	0.2812	0.0531
PMW21-04	**$2.2x10^{-5}$**	**$2.6x10^{-6}$**	**6.8053**	0.971

The combined CVOC carcinogenic risk from the groundwater contaminants at each well are less than the target level of $1x10^{-4}$ using both VISL and JEM. The non-cancer HI is a maximum of 6.8 using VISL, but the HI did not exceed 1 at any location using JEM.

Land Use

The MI is zoned for light industrial use. The property is used for commercial warehousing and light manufacturing, except in the southeast quadrant of the MI where the Airways police station, a homeless shelter for veterans and a golf course are located. The current property owners and use are listed on Table 3.

Fourteen of approximately fifty buildings on the MI are above or adjacent to the core of a groundwater plume (Figure 1). Information on building size, height and use is provided in Attachment A-1 and photographs of building exteriors and interiors are provided in Attachment A-2.

The buildings are relatively large, open warehouses with high ceilings. A few of the buildings (970, 972 and 1089) are partially or completely open on one side. The buildings are generally used for storage and shipment of materials within Memphis Depot Industrial Park and for storage and equipment maintenance on the Barnhart Crane property.

Table 3. Property Ownership and Use

Property Owner	Acreage	Use
Ares Management, LLC	250.6	Warehousing/logistics – Memphis Depot Industrial Park managed by Colliers International. Buildings are leased to multiple tenants.
Barnhart Crane & Rigging	143.8	Engineering, construction and maintenance of complex lifting and transportation equipment for heavy industry.
Economic Development Growth Engine of Memphis/Shelby Co.	69.9	Primarily undeveloped property for future warehousing/logistics or light industrial development.
City of Memphis	46.7	Recreation – Golf Course operated by Memphis Athletic Ministries.
Depot Owners Association	35.6	Memphis Depot Parkway and stormwater basins.
Supply Chain Solutions, LLC	8.2	Warehousing/logistics.
Alpha Omega Veterans Services	6.5	Homeless shelter, on the eastern MI.
Memphis Police Department	4.7	Airways Police Station, on the eastern MI.

Summary

The VI evaluation performed to date indicates that a complete VI pathway does not exist on the MI. However, further sampling and evaluation is planned to provide a conservative assessment of the VI risk to human health in accordance with DoD and USEPA guidance. Army considers the available information to support a protectiveness determination of Short-term Protective for the MI.

The exposure pathway for vapor intrusion at the MI is volatilization of CVOCs from the water table and vapor migration through soil and into buildings.

Depth to groundwater on the MI is greater than 80 feet. Loess (clayey silt to silty clay) is present throughout the DDMT area from the surface to a depth of 20 to 30 feet bgs.

Screening level assessment using VISL calculator at three locations with maximum CVOC concentrations estimated excess cancer risk at less than of $1x10^{-4}$ and the non-cancer HI above 1 at two locations with a maximum of 6.8. JEM, incorporating depth to water and soil type at the same locations, estimated excess cancer risk at less than of $1x10^{-5}$ and the non-cancer HI below 1 at all three locations. The latest versions of the VISL calculator and JEM will be used for risk estimates as additional sample data is gathered.

The groundwater contaminants present at the highest concentrations (TCE and TeCA) were not detected above RLs in the 2009 vapor samples collected above the core of the off-site plume west of Dunn Field indicating the loess provides an effective barrier to vertical migration of soil gas.

Notes:
1. Groundwater contours from October 2016.
2. CVOC contours from October 2016.

Path: W:\5YearReview\2017\17_MI\Vmap.mxd

Legend

- PCE Commercial Vapor Intrusion Screening Level (65 ug/L)
- TCE Commercial Vapor Intrusion Screening Level (7.4 ug/L)
- CT Commercial Vapor Intrusion Screening Level (1.8 ug/L)
- CF Commercial Vapor Intrusion Screening Level (3.6 ug/L)
- VC Commercial Vapor Intrusion Screening Level (2.5 ug/L)
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Fluvial Aquifer Well
- Intermediate Aquifer Well
- Property Boundary
- Area Available for Unrestricted Use
- Roads
- Building with Number and Lessee(s)
- Clay Elevation Exceeds Groundwater Elevation

Figure 17

Main Installation Comprehensive Vapor Intrusion Screening Map

Fourth Five-Year Review

Defense Depot Memphis, Tennessee

0 250 500 Feet

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

Date: 12/5/2017
Edition: Rev 0

Attachment A-1
VI Evaluation – Building Information
Defense Depot Memphis, Tennessee
February 2018

Building(s)	Tenant	Area (square feet)	Ceiling Height (feet)	Use/Employees
429, 430 &529	Cargill Cotton	109,994 per building	14	Cotton Storage/ not available
530	United Way (partial)	109,994	14	Four bays vacant; one bay used periodically for forklift training/ not available
649 & 650	Supply Chain Solutions	109,994 per building	14	Storage of solar panels/ No regular employees
360	Avery Outdoors	207,272	25	Storage of hunting gear and equipment for retail sale/ approximately 34 employees 40 hours per week
470	Nickey Warehouse	207,921	20	Logistics; storage of client products to be shipped/ 56 employees for this and 3 other buildings
260/261	Colliers	11,838	14	Storage for tools and equipment/ 1 employee 40 hrs per week & 1 part-time as needed
	HDR	3,926	14	Equipment and file storage; office space for semiannual LTM sampling and other infrequent field activities
265	Tylur French	4,107	14	Artist studio/ 4-5 employees with variable hours
970	Barnhart Crane	276,000	20	Construction, maintenance and storage/ 5 employees intermittently, 25-30 hrs per week. Sourthern section of 970 open on one side.
972	Barnhart Crane	276,000	20	Construction, maintenance and storage/ 50 employees, 40 hrs per week. 972 has numerous bay doors which are often open.
1089	Barnhart Crane	39,600	20	Construction, maintenance and storage/ No regular employees. 1089 is open one one side.

Attachment A-2
VI Evaluation – Building Photographs
Defense Depot Memphis, Tennessee
February 2018

Buildings 429, 430, 529, 530, 649 and 650 are among the 'Typical Twenty' warehouses constructed at DDMT. They are all of similar, size and construction. All have slab foundations with floor at loading dock height, approximately 3 feet above ground surface. None have sumps or a basement. See Building 530 for interior photos.

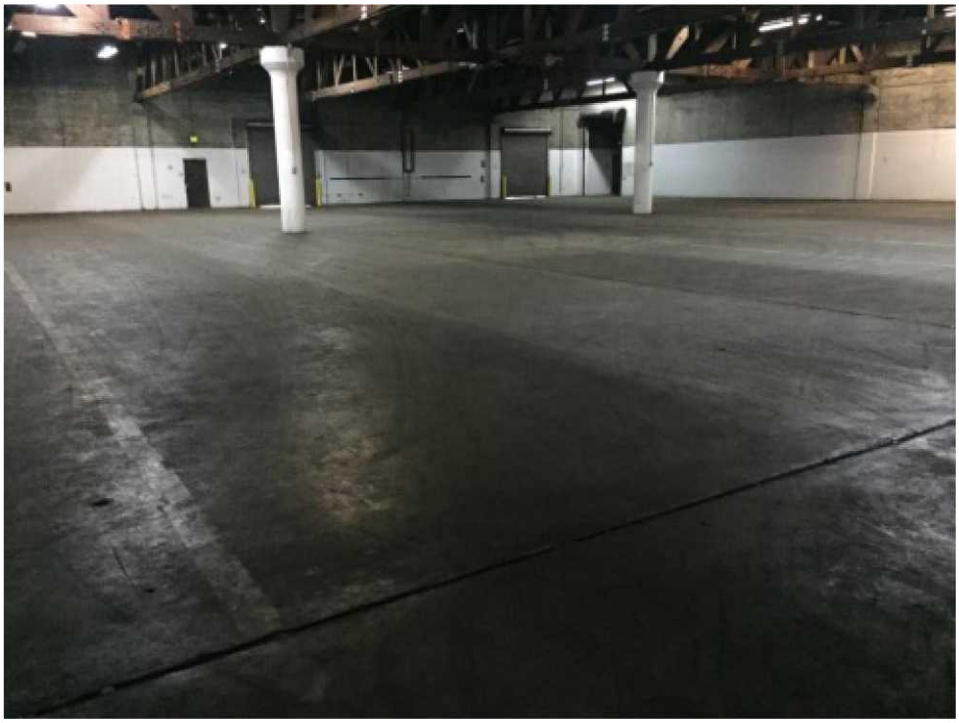
Location 1 - Building 429

Attachment A-2
VI Evaluation – Building Photographs
Defense Depot Memphis, Tennessee
February 2018

Location 2 – Building 430

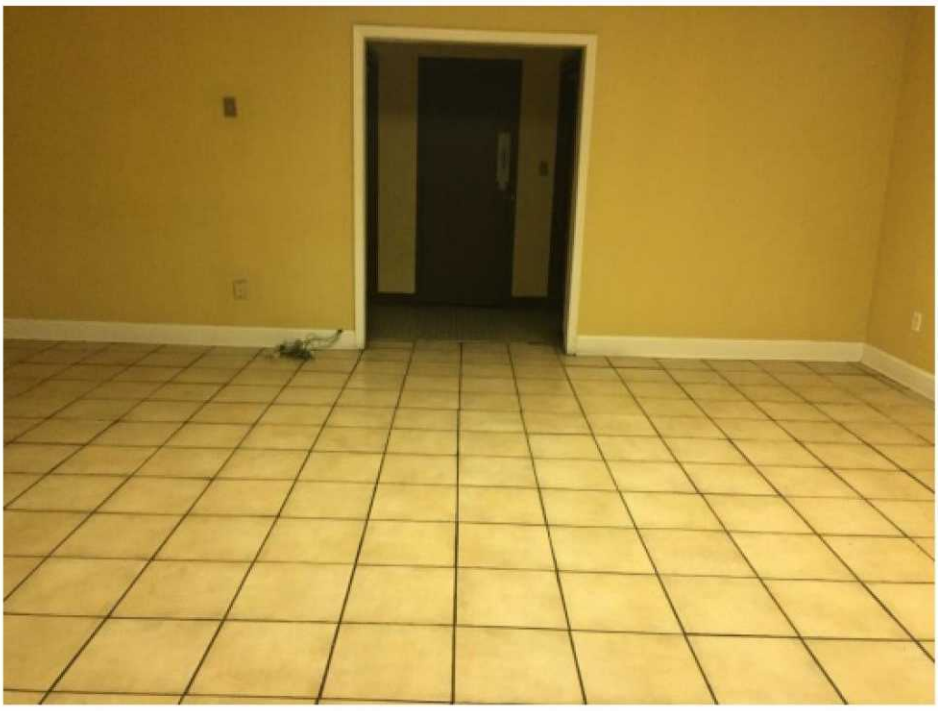
Location 3 – Building 529

Location 4 – Building 530



Building 530 – Typical Twenty warehouse support columns and floor.

Building 530 - Typical Twenty warehouse office area.



Building 530 - Typical Twenty warehouse office flooring is tile or carpet.

Location 5 – Building 649

Location 6 – Building 650

Location 7 – Building 360

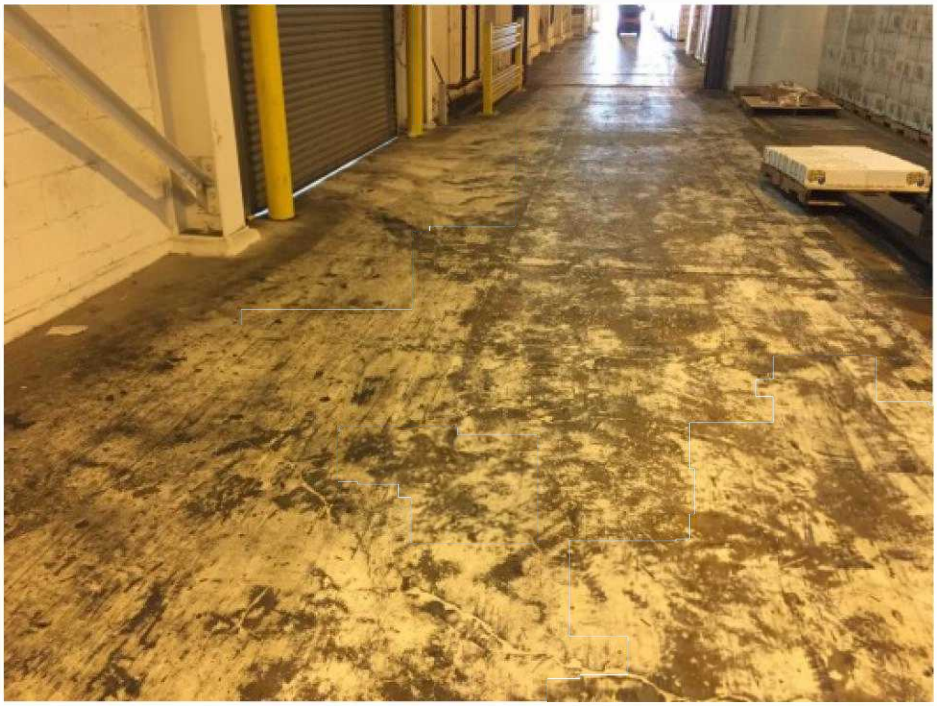
Building 360 is a slab foundation with floor at loading dock height with no sump or basement.

Building 360 has concrete warehouse floors.

Building 360 office has carpet and tile floors.

Location 8 – Building 470

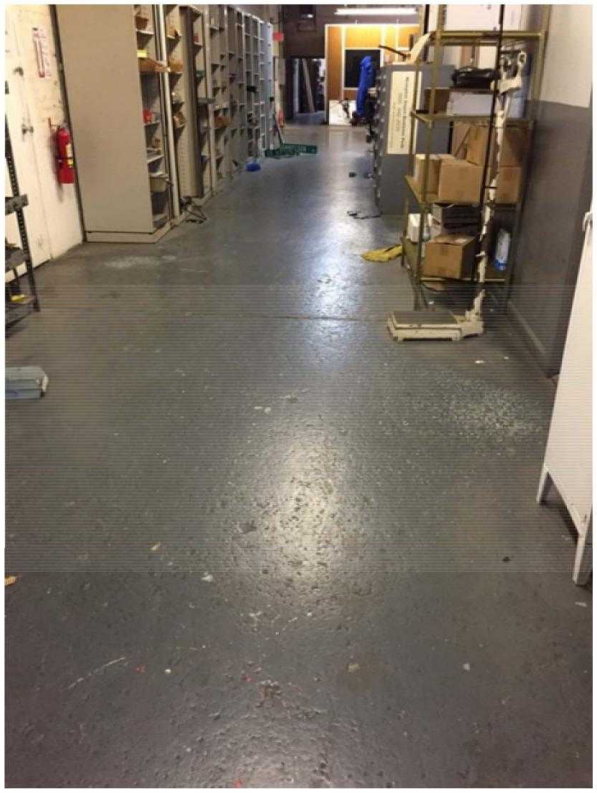
Building 470 is a slab foundation with floor at loading dock height with no sump or basement.



Building 470 floors are concrete. The Building 470 office area floors are similar to Building 360 – tile and carpet.

Location 9 – Building 260/261

Building 260/261 foundation is slab on grade with no sumps or basement.



Building 260/261 has concrete floors throughout.

Storage overhang connected to south side of Building 260/261. This section shed was added after property transfer and is not part of the original structure.

Location 10 – Building 265

Building 265. Foundation is slab on grade and has no sumps or basement.

Building 265 shop/warehouse areas have concrete floors.

Building 265 has tiled office floors.

Location 11 – Building 970

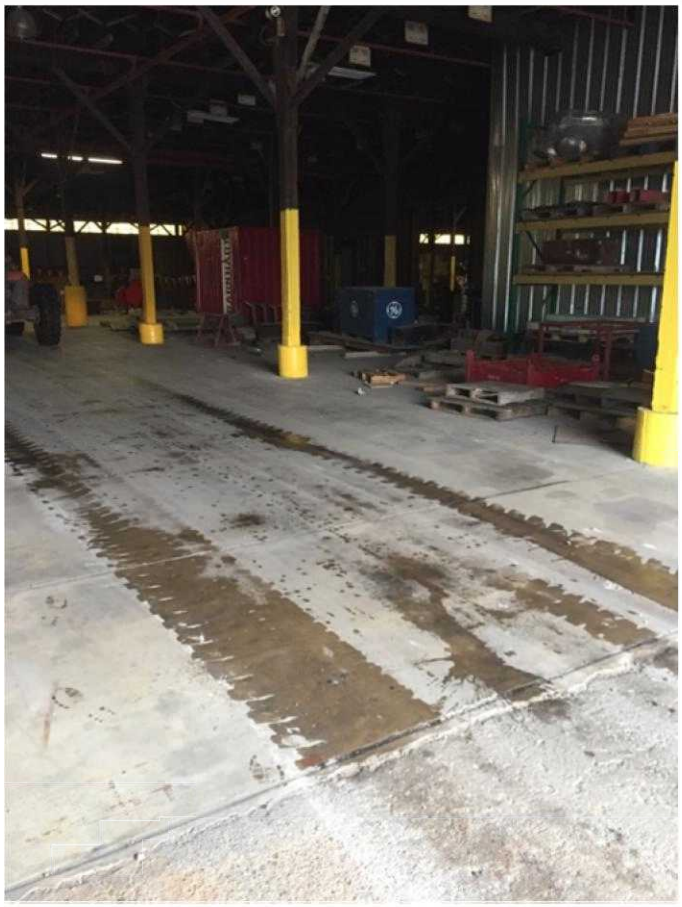
Building 970 has a concrete foundation slab on grade with no sump or basement. The area located over the plume is open warehouse.

Building 970 North of the plume the building is enclosed.

Building 970 Coated concrete floor in enclosed portion of Building 970.

Location 12 – Building 972

Building 972 has a concrete foundation slab on grade with no sumps or basement.



Location 13 – Building 1089

Building 1089 is concrete slab foundation on grade with no sumps or basements, open on one side


TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
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January 9, 2018

James C. Foster
BRAC Program Manager
Headquarters Department of the Army,
Assistant Chief of Staff for
Installation Management (DAIM-ODB)
Army Pentagon,
2530 Crystal Drive,
Arlington, VA 22202-3934

Subject: **Fourth 5-Year Review Report, Revision 1**
Defense Depot Memphis, Tennessee
TDoR ID # 79-736

Mr. Foster,

TDEC-DoR has reviewed the contents of the **Fourth 5-Year Review Report (Revision 1)** for the Memphis Defense Depot, as compiled by T. Holmes (HDR Inc), and approves the revised document. If there are questions or concerns, please contact me at (901) 371-3041 or at jamie.woods@tn.gov .

Regards,

Jamie A. Woods, P.G.
Project Manager
Division of Remediation
Memphis Environmental Field Office

cc: Tom Holmes (HDR Inc)
D. Lloyd (EPA-PM)
Joan Hutton (CALIBRE)
TDoR NCO: file 79-736
TDoR MEFO: file 79-736

Responses to Comments from
Tennessee Department of Environment and Conservation on:
Fourth Five-Year Review, Revision 0
Defense Depot Memphis, Tennessee
22 September 2017

TDEC Comments:

1. Protectiveness Statement, Page 4. Should the up-gradient plume be referenced here?

Response: No. The Land Use Control (LUC) restricting groundwater use is protective for the off-site plume on Dunn Field. Also, that level of detail is not necessary in this protectiveness statement.

2. Page 12, 3rd paragraph – Table 1 acknowledged, please clarify that portions of the Main Installation have been in reuse since 2001.

Response: Will replace the subject sentence with the following:

Prior to property transfer, Army leased the MI to the Depot Redevelopment Corporation (DRC) in 1997 and made properties available for reuse through subleases by the DRC. The property is zoned for light industrial use. The MI is currently used for commercial warehousing and light manufacturing, except for the Airways police station, homeless shelter for veterans and golf course located in the southeast quadrant of the MI; Dunn Field is undeveloped (Figure 2). The current property owners, acreage and land use are listed on Table 2.

The following will be added in a new Table 2. (The existing tables will be renumbered.)

Property Owner	Acreage	Use
Main Installation		
Mayfield Properties, LP	250.6	Warehousing/logistics – Memphis Depot Industrial Park managed by Colliers International. Buildings are leased to multiple tenants.
Barnhart Crane & Rigging	143.8	Engineering, construction and maintenance of complex lifting and transportation equipment for heavy industry.
Economic Development Growth Engine of Memphis/Shelby Co.	69.9	Primarily undeveloped property for future warehousing/logistics or light industrial development.
City of Memphis	46.7	Recreation - Golf Course operated by Memphis Athletic Ministries.
Depot Owners Association	35.6	Memphis Depot Parkway and stormwater basins.
Supply Chain Solutions, LLC	8.2	Warehousing/logistics.
Alpha Omega Veterans Services	6.5	Homeless shelter. Approved for unrestricted use.
Memphis Police Department	4.7	Airways Police Station.
Dunn Field		
Dunn Field Business Park, LLC	39.4	Undeveloped property for future warehousing/ logistics or light industrial development. Approved for unrestricted use.
Army	24.5	Undeveloped.
City of Memphis	1.6	Realignment of Hayes Road.

Responses to Comments from
Tennessee Department of Environment and Conservation on:
Fourth Five-Year Review, Revision 0
Defense Depot Memphis, Tennessee
22 September 2017

3. Page 12, 5th paragraph – Please clarify that MLGW's Allen Well Field is the one being referenced.

Response: Will revise to "The closest well field is the Allen Well Field operated by Memphis Light, Gas and Water; the individual extraction wells are 1-2 miles west of DDMT."

4. Page 14, 1st paragraph – Should a historical figure be included for the referenced Dunn Field North, South, and Central contaminant plumes?

Response: Will add reference for the statement that three plumes are present "... and a southern plume, as stated in Section 14 of the Dunn Field RI (CH2M HILL, 2002)." Details of historical data are not necessary for the FYR as the focus is protectiveness under current conditions. Figure 14 introduced later compares total CVOC plume extent for 2007 and 2017.

5. Page 14, 1st paragraph – Please clarify potential sources on-site and off-site sources for the current northern plume.

Response: Will revise to "... to have on-site sources from previous releases in the northwest section of the Disposal Area on Dunn Field and from undetermined off-site sources, based on CVOCS detected ..."

6. Page 17, 3rd paragraph – Please omit original pdf comment.

Response: Noted.

7. Page 17, 3rd paragraph – Initial feedback on why TDEC's HI is less than 1.0 is due to the fact that it is for individual contaminants, but when summed with other COC's, should be no greater than 1.0.

Response: The target risk and HI cited here are from the Dunn Field ROD and were based on EPA requirements at that time. These will guide site restoration unless an amendment is required. No change to the FYR is necessary here.

8. Section 2.4.2.1, Page 19, 3rd paragraph - Please clarify the time frame of observed CVOC rebound in relation to the previous paragraph, 2010 vs 201X.

Response: Will revise to "... concentrations in 2010 LTM samples, ...". Will also revise following sentence to note action taken, not simply proposed.

9. Section 2.4.2.1, Page 19, end of 5th paragraph – Please estimate the time frame (if possible) in which additional remedial action will occur, post FFS.

Response: This section is a summary of response actions taken. The timing of additional remedial action on the MI is not known at this time; it depends on completion of the SRI, the FFS and an amendment to the MI ROD or explanation of significant differences. The timing for recommended actions to address the issues identified in this FYR is noted in Section 6.

10. Page 26, 2nd paragraph – Please omit original pdf comment.

Response: Noted.

11. Page 26, 2nd paragraph – Not sure the word "regarding" was intended here.

Response: Will delete "regarding".

Responses to Comments from
Tennessee Department of Environment and Conservation on:
Fourth Five-Year Review, Revision 0
Defense Depot Memphis, Tennessee
22 September 2017

12. Issues/Recommendations – Please reference OU's in these tables for ease of review, similar to the initial tables on page 4.

Response: Will add "Dunn Field" and "Main Installation" as in the Five-Year Review Summary Form at the beginning of this FYR report.

B

Appendix B.
Site Chronology

APPENDIX B
SITE CHRONOLOGY
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Year	Activity
1944 - 1997	Supply Distribution activities
1980s	Initial Installation Assessment completed in 1981. Compliance programs established for U.S. Army and Department of Defense (DoD) regulations and local, state, and federal regulatory programs including the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, Resource Conservation and Recovery Act (RCRA), and the Toxic Substances Control Act.
1990	On 28 September 1990, USEPA Region 4 and TDEC issued the Memphis Depot (Depot) a RCRA Part B permit for the storage of hazardous waste (No. TN4 210-020-570). The Hazardous and Solid Waste Amendment (HSWA) portion of the permit issued by USEPA included requirements for the identification and, if necessary, corrective action of Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs). 49 SWMUs and 8 AOCs identified during a RCRA Facility Assessment (A.T. Kearney, 1990). Subsequent to issuing the permit, and in accordance with Section 120(d)(2) of CERCLA, and Title 42, Section 9620(d)(2), of the United States Code (USC), USEPA prepared a final Hazard Ranking System (HRS) Scoring Package for the facility.
1992	In October 1992, USEPA added the Depot to the National Priorities List (NPL) (57 Federal Register 47180 No. 199).
1995	On 6 March 1995, USEPA, TDEC, and the Depot entered into a Federal Facilities Agreement (FFA) under CERCLA, Section 120, and RCRA, Sections 3008(h) and 3004(u) and (v). The FFA outlines the process for investigation and cleanup of the Depot sites under CERCLA. The parties agreed that investigation and cleanup of releases from the sites (including formerly identified SWMUs/AOCs) would satisfy any RCRA corrective action obligation under the USEPA HSWA permit and Tennessee Code -Annotated, Section 68-212-101 *et seq.* The Generic Remedial Investigation/Feasibility Study (RI/FS) Work Plan was prepared to indicate how the RI and FS would be accomplished. USEPA and TDEC approved RI/FS Field Sampling Plans for each operable unit (OU) and screening site. In July 1995, the Depot was identified for closure under the BRAC process, which requires environmental restoration to comply with the requirements for property transfer. The City of Memphis and Depot Redevelopment Corporation (DRC) were given the responsibility of planning and coordinating the reuse of the Depot.
1996	USEPA and TDEC approved the Record of Decision (ROD) for Groundwater IRA at Dunn Field.
1997	Sampling at RI, screening, and BRAC sites was conducted on the Main Installation (MI).
1997 - 1998	Storage and distribution operations at DDMT ended in September 1997. During 1997 and 1998, the Depot requested and received closure of its air permits, underground storage tank permits, storm water discharge permit, and Nuclear Regulatory Agency storage permit. On 22 October 1998, TDEC terminated the RCRA Part B permit because the proposed storage unit was never constructed or operated.
1998	The Depot completed a dieldrin-contaminated soil removal action at the military family housing units and a polychlorinated biphenyl (PCB)-contaminated soil removal action at Bldg 274. Phase 1 of the IRA was completed with the installation of seven recovery wells (RWs) and the discharge piping system; the system was expanded in 2001, with four additional RWs.
1999	The Depot completed a lead-contaminated soil removal project at the old paint shop and maintenance area (Parcels 35 and 28). Regular groundwater monitoring for the Dunn Field IRA began in February 1999. Additional RWs for the IRA system were approved by the BRAC Cleanup Team (BCT) and installed in 1999. The Depot completed RI fieldwork at the MI and started RI fieldwork at Dunn Field.

APPENDIX B
SITE CHRONOLOGY
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Year	Activity
2000	The Depot began the removal action for chemical warfare material (CWM) disposal locations at Dunn Field. The Depot completed and provided to the public the MI RI Report, FSs for Soil and Groundwater, and the MI Proposed Plan (PP).
2001	The Depot completed the CWM removal action at Dunn Field. DLA signed the MI ROD on 22 February 2001; TDEC signed it on 1 March 2001; and USEPA signed it on 6 September 2001. Prior to final execution of the MI ROD, DLA exercised its removal authority under CERCLA Section 104, as delegated in Executive Order 12580, and removed lead-contaminated soil at the south end of Bldg 949. The Depot completed RI fieldwork and additional groundwater sampling at Dunn Field.
2002	The Depot began the Enhanced Bioremediation Treatability Study at the MI for use in the MI Remedial Design (RD). The Depot completed the early removal of lead in soil at the former pistol range (Site 60) on Dunn Field. The Depot completed a soil vapor extraction (SVE) treatability study at Dunn Field.
2003	The Depot provided the Dunn Field RI Report, FS, and PP to the public. DLA signed the Dunn Field Five-Year Review on 17 January 2003 and USEPA concurred on 22 January 2003. Dunn Field PP public comment period held 8 May to 6 June 2003 and public meeting held 15 May 2003.
2004	DLA signed the Dunn Field ROD on 22 March 2004; TDEC signed it on 6 April 2004; and USEPA signed it on 12 April 2004. MI Final RD with Long-Term Monitoring (LTM) Plan and Land Use Control Implementation Plan (LUCIP) approved August 2004. LTM on the MI began in March 2004. Dunn Field Disposal Sites Final RD approved 10 August 2004. Chlorinated volatile organic compound (CVOC) concentrations above 500 micrograms per liter (µg/L) in downgradient monitoring wells (MWs) northwest of Dunn Field prompted the BCT to conduct Early Implementation of Selected Remedy (EISR) to reduce contamination levels in groundwater downgradient of Dunn Field. EISR Work Plan was completed and zero-valent iron (ZVI) injections began November 2004.
2005	MI Notice of Land Use Restrictions filed with Shelby County Registrar on 26 January 2005. Post-ROD Community Involvement Plan approved 10 February 2005. Notice of Dunn Field Disposal Sites mobilization provided 14 March 2005. ZVI injections completed January 2005 and EISR Interim Remedial Action Completion Report (IRACR) approved in August 2006. TDEC denied renewal of the Depot's Hazardous Waste Corrective Action Permit terminating Defense Distribution Center's requirement to continue corrective action under the hazardous waste regulations, as all correction action activities shall continue to be performed under CERCLA authority. MI Remedial Action Work Plan (RAWP) approved by USEPA on 12 September 2005.

APPENDIX B
SITE CHRONOLOGY
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Year	Activity
2006	The Depot completed the Disposal Sites Remedial Action (RA) in March 2006 and received USEPA approval of the Disposal Sites Remedial Action Completion Report (RACR) on 25 August 2006. Dunn Field Source Areas RD Investigation completed in March 2006. Construction for the ZVI Permeable Reactive Barrier (PRB) implementation study completed in June 2006. DLA provided Notice of MI RA mobilization on 2 May 2006. Enhanced bioremediation treatment (EBT) system construction was completed and MI RA operations began in September 2006.
2007	Off Depot ZVI PRB study completed in January 2007. Dunn Field Source Areas RD approved in April 2007. Source Areas Fluvial SVE (FSVE) RAWP approved in July 2007. DLA provided Notice of Dunn Field Source Areas RA mobilization on 15 May 2007. FSVE RA construction completed and operations began in July 2007. TDEC amended the Notice of Hazardous Substance Site deleting the Dunn Field property in Finding of Suitability to Transfer (FOST) 4 on 12 September 2007.
2008	DLA signed the Second Five-Year Review for DDMT on 13 December 2007 and USEPA signed it on 22 January 2008. MI Source Area Evaluation to propose compliance well networks and additional soil investigation to assess potential source areas for the identified groundwater plumes completed in March 2008. Dunn Field Loess/Groundwater RAWP approved for construction and operation in October 2007, with final approval in July 2008. Loess Thermal-enhanced SVE RA construction completed and operations began in May 2008. Dunn Field Off-Depot Groundwater Final RD with LTM Plan and LUCIP approved October 2008. Final Dunn Field Revised PP was approved by USEPA on 24 October 2008 and by TDEC on 6 November 2008; 30-day public comment period held 27 October to 25 November 2008.
2009	MI Source Area Investigation to identify soil contamination impacting shallow groundwater was completed February 2009. Initial EBT on the MI completed February 2009. DLA signed the Dunn Field ROD Amendment on 5 February 2009; TDEC signed it on 3 March 2009; and USEPA signed it on 19 March 2009. Dunn Field Notice of Land Use Restrictions filed with the Shelby County Registrar on 11 June 2009. Off Depot Groundwater RAWP approved in March 2009. DLA provided Notice of Off Depot RA mobilization on 17 June 2009. Air Sparging/SVE (AS/SVE) construction completed in October 2009 and operations began in December 2009. DDMT Restoration Advisory Board (RAB) passed a motion to adjourn at the 29 October 2009 meeting. Dunn Field Source Areas IRACR approved by USEPA on 2 November 2009 and Operating Properly And Successfully (OPS) demonstration approved on 21 October 2009.

APPENDIX B
SITE CHRONOLOGY
FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Year	Activity
2010	BCT concurred to adjourn at the 11 February 2010 meeting. MI IRACR approved by USEPA on 23 March 2010 and OPS demonstration approved on 15 March 2010. IRA groundwater monitoring replaced by Dunn Field LTM in March 2010. USEPA approved the Preliminary Close Out Report for all OUs effective 10 May 2010 and the NPL site status revised to Construction Complete. Superfund Property Reuse Evaluation Checklist for Reporting the Site-wide Ready for Anticipated Use was effective 26 May 2010. IRA system removed and RWs abandoned in July 2010 based on reduction in groundwater CVOC concentrations.
2011	Dunn Field IRA 2009 Operations and Closure Report approved April 2011. Off Depot Groundwater IRACR approved by USEPA in August 2011.
2012	FSVE operations were shut down 24 July 2012 based on reduced CVOC concentrations in vapor effluent and soil remediation goals (RGs) being met. FSVE Year 5 report documenting shutdown approved December 2012. EBT RAWP Addendum approved in January 2013. Additional EBT at five areas on the MI began in November 2012 due to rebound in groundwater CVOC concentrations.
2013	DAIM signed the Third Five-Year Review for DDMT on 27 November 2012 and USEPA signed it on 23 January 2013.
2014	AS/SVE shut down due to extensive equipment damage from lightning-caused power surge in February 2014. Final sodium lactate injections for additional EBT on the MI made in August 2014; final performance monitoring event in November 2014.
2015	AS/SVE equipment repairs completed and system re-started in March 2015. MI Year 4 EBT report approved in May 2015. Supplemental Remedial Investigation (SRI) Phase 1Work Plan approved in April 2015.
2016	SRI Phase 2 Work Plan approved in August 2016.
2017	AS/SVE operations in the Off Depot area continue. LTM for the MI and Dunn Field continue. Annual Site Inspections for LUCs continue.

C

Appendix C.

2017 Annual Site Inspection Reports

Defense Depot Memphis, Tennessee
Main Installation
Annual Site Inspection Report

Pursuant to the Land Use Control Implementation Plan (LUCIP) dated February 2004 (Appendix C of Final Main Installation Remedial Design, Revision 1, July 2004) for the former Defense Depot Memphis, Tennessee – Main Installation (Memphis Depot), an inspection of property was conducted by HDR Environmental, Operations and Construction, Inc. on 17 July 2017.

A summary of the land use restrictions is as follows:

- No residential land use or other child-occupied facilities including daycare on the Main Installation (except Parcels 1 and 2 of Functional Unit [FU] 6).
- No production/consumptive use of groundwater or drilling groundwater wells on the Main Installation.

Table 1 Summary of Land Use Controls and Monitoring Requirements, Figure 1 Land Use Restrictions Map and Figure 2 Groundwater Use Restrictions from the Main Installation LUCIP are attached.

Verification that land use restrictions are being accomplished and LUCs remain effective

- Verify that boundary fence surrounding golf course area in FU2 remains intact.
    - Visual inspection conducted on 17 July 2017. No deficiencies or required repairs were identified.
    - Interviewed Vince Alfonso of Memphis Athletic Ministries (MAM) who manages the golf course (26 June 2017). He confirmed that MAM was responsible for maintaining the fence around the golf course. In the past year, he has repaired one large break in the fence. He indicated that repairs are usually made within 24 hours of identification of a break.
- Verify that no residential housing/development or child daycare activities are occurring at the site (except Parcels 1 and 2 of FU6).
    - Visual inspection conducted on 17 July 2017. No deficiencies identified.
    - Interviewed the following property owners/managers: Ms. Anita Bunn of Colliers International – the property management firm for the Memphis Depot Industrial Park (26 June 2017); Mr. Greg Ward of Barnhart Crane (26 June 2017); Mr. Robert Keskey of Supply Chain Solutions LLC (6 July 2017); and Mr. Randy Richardson for the Memphis/Shelby County Economic Development Growth Engine (26 June 2017). All confirmed no residential housing/development or child daycare activities are occurring at their property on the site.
    - Obtained current tenant list from Colliers International on 29 June 2017. No residential housing/development or child daycare activities are listed at the Memphis Depot Industrial Park.
- Verify that no groundwater wells have been installed at the site (except for monitoring and injection wells that were installed as part of the remedy) and that no production/consumptive use of groundwater is occurring.
    - Visual inspection conducted on 17 July 2017. No deficiencies identified.
    - Interviewed Mr. Greg Parker, Memphis/Shelby County Health Department Pollution Control Division, Water Quality Control on 26 June 2017. Mr. Parker confirmed that

no permits have been issued for construction of consumptive use/production groundwater wells at the Main Installation.

- Interviewed the following property owners/managers: Ms. Anita Bunn of Colliers International – the property management firm for the Memphis Depot Industrial Park (26 June 2017); Mr. Greg Ward of Barnhart Crane (26 June 2017); Mr. Robert Keskey of Supply Chain Solutions LLC (6 July 2017); and Mr. Randy Richardson for the Economic Development Growth Engine of Memphis/Shelby County (26 June 2017). All confirmed no groundwater extraction wells have been installed at their property on the site and no production/consumptive use of groundwater is occurring.

Description of any deficiency or violation of the land use restrictions

No deficiencies or violations identified.

Description of any proposed measures or corrective actions taken to remedy the deficiency or violation

No proposed measures or corrective actions are necessary.

Certification Statement

I, the undersigned, do document that the inspection was performed as indicated above, and that the above information is true and correct to the best of my knowledge, information, and belief.

Date:	25 July 2017
Name/Title:	Thomas Holmes/Project Manager
Organization:	HDR Environmental, Operations and Construction, Inc.
Signature:	

Completed annual inspection forms shall be sent within thirty (30) days of the inspection to:

HQ Department of the Army
Assistant Chief of Staff for Installation Management
Attn: BRAC Division (DAIM-ODB) (James C. Foster, PM)
2530 Crystal Drive (Taylor Bldg), Room 5000
Arlington, VA 22202-3940

U. S. Environmental Protection Agency, Region 4
Caroline Freeman, Chief
Restoration & Sustainability Branch, Superfund Division
61 Forsyth Street, SW
Atlanta, GA 30303

Tennessee Department of Environment and Conservation
Division of Remediation
Memphis Field Office
Attn: Jordan English
8383 Wolf Lake Drive
Bartlett, TN 38133-4199

Table 1

Summary of Land Use Controls and Monitoring Requirements From Main Installation Land Use Control Implementation Plan

Table 1. Summary of Land Use Controls and Monitoring Requirements
Main Installation - Memphis Depot, Tennessee

Type of control	Purposes of control	Duration	Implementation	Monitoring Frequency/Responsibility[1]	Affected area
1. Lease Restrictions A. Land Use B. Groundwater	A. Prevent residential use or daycare activities on property. B. Prevent production/ consumptive use of groundwater or drilling of groundwater wells.	The term of the Master Lease ending on August 31, 2052, or the term specified in any sublease.	Master Lease entered into by the Army and the DRC includes EPP. DRC subleases are required to include Master Lease EPP that restrict land use and groundwater use.	Site Inspection – Annual. The Army will verify adherence to the LUC. LUC verification -- Every 5 years as part of the required remedy review under CERCLA. The Army will verify with the DRC that all subleases contain required EPP.	All of the MI property, except Parcels 1 and 2 in FU6.
2. Deed Restrictions A. Land use B. Groundwater	A. Prevent residential use or daycare activities on property. B. Prevent production/ consumptive use of groundwater or drilling of groundwater wells.	Until the concentration of hazardous substances in the soil and the groundwater have been reduced to levels that allow for unlimited exposure and unrestricted use.	Drafted by Army property disposal agent in accordance with Tennessee law and recorded at the Shelby County Register of Deeds office.	Site Inspection – Annual. The Army will verify adherence to the LUC. LUC verification -- Every 5 years as part of the required remedy review under CERCLA. The Army will verify information properly recorded at Shelby County Register of Deeds office(s).	All of the MI property except Parcels 1 and 2 in FU6.
3. Notice of Land Use Restriction A. Land Use B. Groundwater	A. Prevent residential use or daycare activities on property. B. Prevent production/ consumptive uses of groundwater or drilling of groundwater wells.	Until the concentration of hazardous substances in the soil and the groundwater have been reduced to levels that allow for unlimited exposure and unrestricted use.	Drafted by Army property disposal agent in accordance with Tennessee law and recorded at the Shelby County Register of Deeds office.	Site Inspection – Annual. The Army will verify adherence to the LUC. LUC verification -- Every 5 years as part of the required remedy review under CERCLA . The Army will verify information properly recorded at Shelby County Register of Deeds office(s).	All of the MI property except Parcels 1 and 2 in FU6.
4. Zoning Restrictions	Allow only certain uses of the property per designation as a Light Industrial zoning district.	Until zoning district designation changes.	Zoning districts designated by City of Memphis and Shelby County LUC Board.	Site Inspection – Annual. The Army will verify adherence to the LUC. LUC verification -- Every 5 years as part of the required remedy review under CERCLA. The Army will verify with the City of Memphis and Shelby County the current zoning designation.	All of the MI property.

5. Groundwater Well Restrictions	Prohibit installation of drinking water well within half-mile of the site and the off-site contaminated groundwater.	Until the site is no longer a Federal Superfund site, or MSCHD determines that the drilling of a well does not pose a threat to a local aquifer.	Groundwater Well Construction Code administered by MSCHD, Water Quality Branch.	Site Inspection – Annual. The Army will verify adherence to the LUC. LUC verification -- Every 5 years as part of the required remedy review under CERCLA. The Army will verify with the MSCHD on the implementation of its regulation.	All of the MI property except Parcels 1 and 2 in FU6.
6. Fence	Restrict public access to prevent unauthorized uses.	Until the concentration of hazardous substances in the soil and the groundwater have been reduced to levels that allow for unlimited exposure and unrestricted use.	Erected by the Army and maintained by the City of Memphis.	Site Inspection – Annual. The Army will verify adherence to the LUC. LUC verification -- Every 5 years as part of the required remedy review under CERCLA.	The golf course area located in FU2.

Notes

[1] Prior to transfer of any Depot property, the Army or its representatives will perform the monitoring. After transfer, the Army may arrange to have TDEC, the City of Memphis, or some independent third party representative conduct any required monitoring. [See Section 5 below].

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
DRC = Depot Redevelopment Corporation of Memphis and Shelby County
EPP = Environmental Protection Provision
FU = Functional Unit
LUC = Land Use Control
MI = Main Installation [of the Memphis Depot]
MSCHD = Memphis Shelby County Division of Health Services
TDEC = Tennessee Department of Environment and Conservation

Figures 1 and 2

Land Use and Groundwater Use Restrictions
From Main Installation Land Use Control Implementation Plan

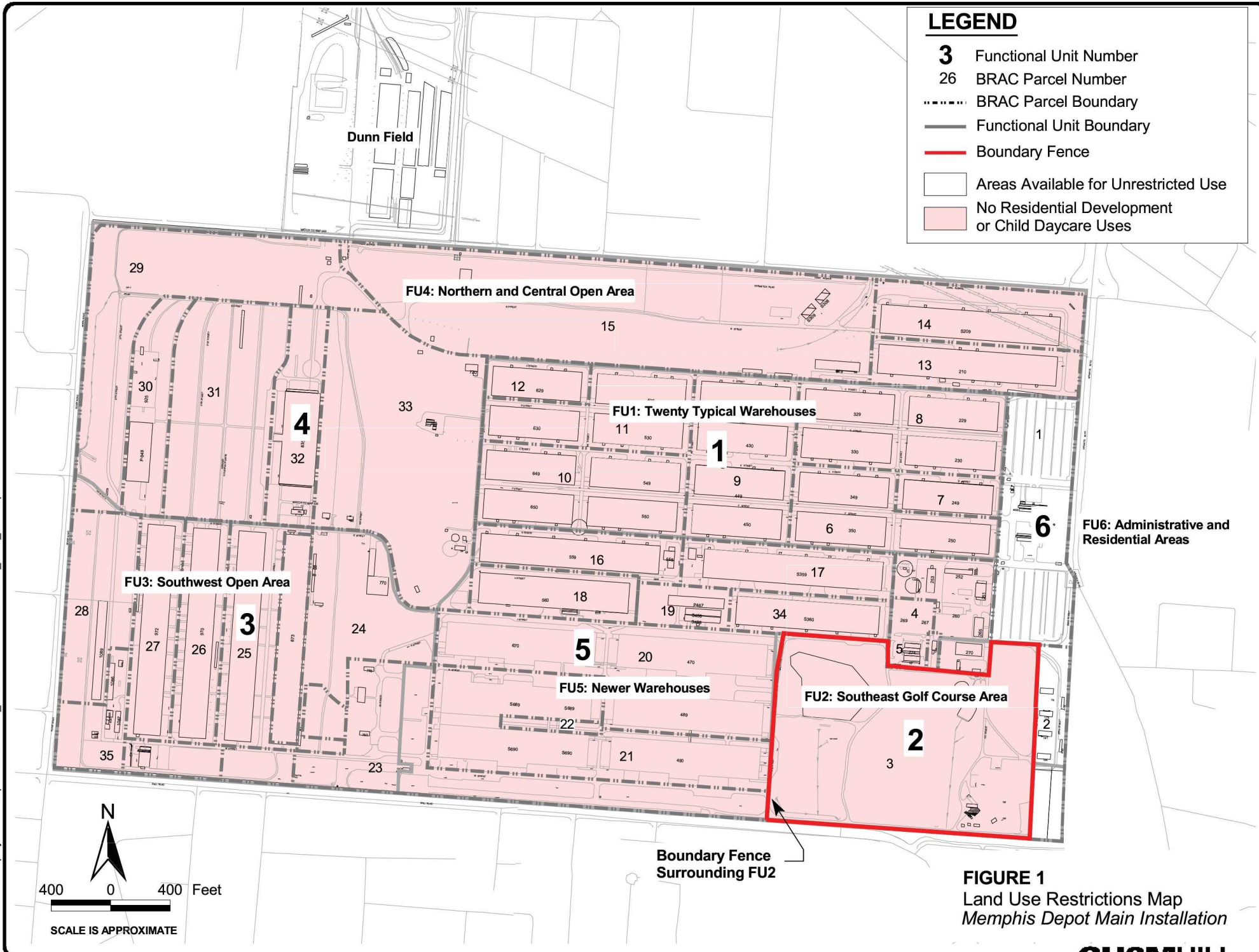


FIGURE 1
Land Use Restrictions Map
Memphis Depot Main Installation

CH2MHILL

ATL \\boomer\H:\projects3\Memphis\DDMT\RDD_data\DDMT\arcview\fssoilrod_ddmt_new2.apr 2/25/2004

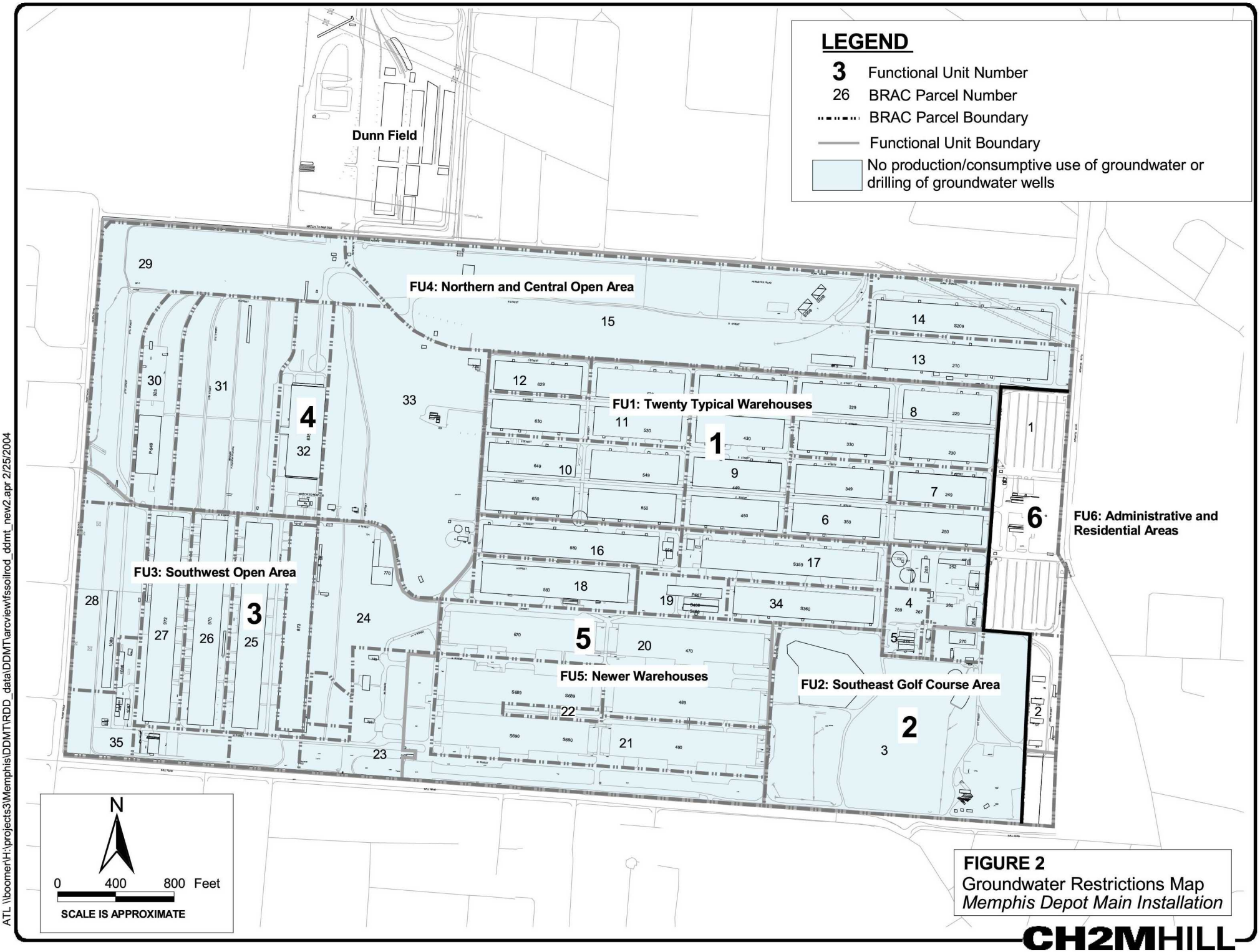


FIGURE 2
Groundwater Restrictions Map
Memphis Depot Main Installation

CH2MHILL

ATL \\boomer\H:\projects3\Memphis\DDMT\RDD_data\DDMT\arcview\fssoilrod_ddmt_new2.apr 2/25/2004

Defense Depot Memphis, Tennessee
Dunn Field
2017 Annual Site Inspection Report

Pursuant to the Land Use Control Implementation Plan (LUCIP) dated September 2008 (Appendix A of Final Dunn Field Off-Depot Groundwater Remedial Design, Revision 1, September 2008) for the former Defense Depot Memphis, Tennessee – Dunn Field (Memphis Depot), an inspection of property was conducted by HDR Environmental, Operations and Construction, Inc. on 18 July 2017.

A summary of the land use restrictions is as follows:

- No residential land use or other child-occupied facilities including daycare in the Disposal Area/western portion of Dunn Field.
- No production/consumptive use of groundwater or drilling groundwater wells in contaminated groundwater associated with Dunn Field.

Table 1 Summary of Land Use Controls and Monitoring Requirements, Figure 1 Land Use Restrictions and Figure 2 Groundwater Use Restrictions from the Dunn Field LUCIP are attached.

Verification that land use restrictions are being accomplished and LUCs remain effective

- Verify that no residential housing/development or child daycare activities are occurring in the Disposal Area/western portion of Dunn Field.
    - Visual inspection conducted on 18 July 2017. No structures or other development are present in the Disposal Area/western portion of Dunn Field. Access to Dunn Field is controlled by perimeter fence with locked gates. The Dunn Field fence was observed to be in good condition with no required repairs identified.
- Verify that no groundwater wells have been installed at the site (except for wells that were done as part of the remedy) and that no production/consumptive use of groundwater is occurring.
    - Visual inspection conducted on 18 July 2017. No deficiencies identified.
    - Interviewed Mr. Greg Parker, Memphis/Shelby County Health Department Pollution Control Division, Water Quality Control, on 26 June 2017. Mr. Parker confirmed that no permits have been issued for construction of consumptive use/production groundwater wells at Dunn Field or within contaminated groundwater down gradient of Dunn Field.

Description of any deficiency or violation of the land use restrictions

No deficiencies or violations identified.

Description of any proposed measures or corrective actions taken to remedy the deficiency or violation

No proposed measures or corrective actions are necessary.

Description of whether the use restrictions and controls referenced in Column 1 of Table 1 were communicated in the deed(s)

No deed(s) issued to date.

Describe whether the owners and state and local agencies were notified of the use restrictions and controls affecting the property

State environmental agencies were notified of use restrictions and controls via review/approval of the Rev. 1 Final Off-Depot Groundwater Remedial Design. The Notice of Land Use Restrictions was recorded on Thursday, 11 June 2009, in the Register of Deeds, Shelby County, TN; Document No. 09069308.

Certification Statement

I, the undersigned, do document that the inspection was performed as indicated above, and that the above information is true and correct to the best of my knowledge, information, and belief.

Date:	25 July 2017
Name/Title:	Thomas Holmes/Project Manager
Organization:	HDR Environmental, Operations and Construction, Inc.
Signature:	

Completed annual inspection forms shall be sent within thirty (30) days of the inspection to:

HQ Department of the Army
Assistant Chief of Staff for Installation Management
Attn: BRAC Division (DAIM-ODB) (James C. Foster, PM)
2530 Crystal Drive (Taylor Bldg), Room 5000
Arlington, VA 22202-3940

U. S. Environmental Protection Agency, Region 4
Caroline Freeman, Chief
Restoration & Sustainability Branch, Superfund Division
61 Forsyth Street, SW
Atlanta, GA 30303

Tennessee Department of Environment and Conservation
Division of Remediation
Memphis Field Office
Attn: Jordan English
8383 Wolf Lake Drive
Bartlett, TN 38133-4199

Table 1

Summary of Land Use Controls and Monitoring Requirements
From Dunn Field Land Use Control Implementation Plan

TABLE 1
Summary of Land Use Controls and Monitoring Requirements
Dunn Field - Memphis Depot, Tennessee

Type of control	Purposes of control	Duration	Implementation	Monitoring Frequency/Responsibility[1]	Affected area
1. Deed and/or Lease Restrictions A. Land use B. Groundwater	A. Prevent residential use or other child-occupied facilities (including daycare) B. Prevent production/ consumptive use of groundwater or drilling of groundwater wells.	Until the concentration of hazardous substances in the soil and the groundwater have been reduced to levels that allow for unlimited exposure and unrestricted use.	Drafted by Army property disposal agent Deed recorded at the Shelby County Register of Deeds office.	Site Inspection/ LUC verification -- Every 5 years as part of the required remedy review under CERCLA. The Army will verify information properly recorded at Shelby County Register of Deeds office(s). Groundwater well verification – No less than annually the DLA or the Army (or its authorized representative) will conduct field inspection to ensure no production/consumptive use well(s) have been installed.	A. The Disposal Area/western portion of Dunn Field B. The Disposal Area/western portion and the northern portion of the Northeast Open Area of Dunn Field.
2. Notice of Land Use Restriction A. Land Use B. Groundwater	A. Prevent residential use or other child-occupied facilities (including daycare) B. Prevent production/ consumptive uses of groundwater or drilling of groundwater wells.	Until the concentration of hazardous substances in the soil and the groundwater have been reduced to levels that allow for unlimited exposure and unrestricted use.	Drafted by Army property disposal agent in accordance with Tennessee law and recorded at the Shelby County Register of Deeds office.	Site Inspection/ LUC verification -- Every 5 years as part of the required remedy review under CERCLA . The Army will verify information properly recorded at Shelby County Register of Deeds office(s). Groundwater well verification – No less than annually the DLA or the Army (or its authorized representative) will conduct field inspection to ensure no production/consumptive use well(s) have been installed.	A. The Disposal Area/western portion of Dunn Field B. The Disposal Area/western portion and the northern portion of the Northeast Open Area of Dunn Field.
3. Zoning Restrictions	Allow only certain uses of the property per designation as Light Industrial zoning district. Not effective at preventing child-occupied uses including daycare, nursery school or schools K through 12.	Until zoning district designation changes.	Zoning districts designated by City of Memphis and Shelby County LUC Board.	Site Inspection/ LUC verification -- Every 5 years as part of the required remedy review under CERCLA. The Army will verify with the City of Memphis and Shelby County the current zoning designation.	All of the Dunn Field property (except the northeast area which has been sold to a private owner).

TABLE 1
Summary of Land Use Controls and Monitoring Requirements
Dunn Field - Memphis Depot, Tennessee

Type of control	Purposes of control	Duration	Implementation	Monitoring Frequency/Responsibility[1]	Affected area
4. Groundwater Well Restrictions	Prohibit installation of drinking water well within half-mile of the site and the offsite contaminated groundwater.	Until the site is no longer a Federal Superfund site, or MSCHD determines that the drilling of a well does not pose a threat to a local aquifer.	Groundwater Well Construction Code administered by MSCHD, Water Quality Branch.	Site Inspection/ LUC verification -- Every 5 years as part of the required remedy review under CERCLA. The Army will verify with the MSCHD on the implementation of its regulation. Groundwater well verification – No less than annually the DLA or the Army (or its authorized representative) will conduct field inspection to ensure no production/consumptive use well(s) have been installed.	A. The Disposal Area/western portion and the northern portion of the Northeast Open Area of Dunn Field.
5. Fencing	Restrict public access to prevent unauthorized uses while the site is not regularly occupied.	Until transfer and the site is occupied on a regular basis, pending approval by the Army, EPA and TDEC.	Erected by the Army and is maintained by DLA prior to transfer.	Site Inspection/ LUC verification -- Every 5 years as part of the required remedy review under CERCLA . The Army will verify that the fencing while present is in place and is being maintained,	All of the Dunn Field property (except the northeast area, which has been sold to a private owner).
6. Protocol	Restriction of groundwater use and denial of installation of groundwater wells within the site.	The Protocol will terminate and be superseded by the deed restriction upon property transference.	90 days after approval of the LUCIP.	Protocol will be provided to all personnel that are assigned to work on Dunn Field.	All of the Dunn Field property (except the northeast area, which has been sold to a private owner).

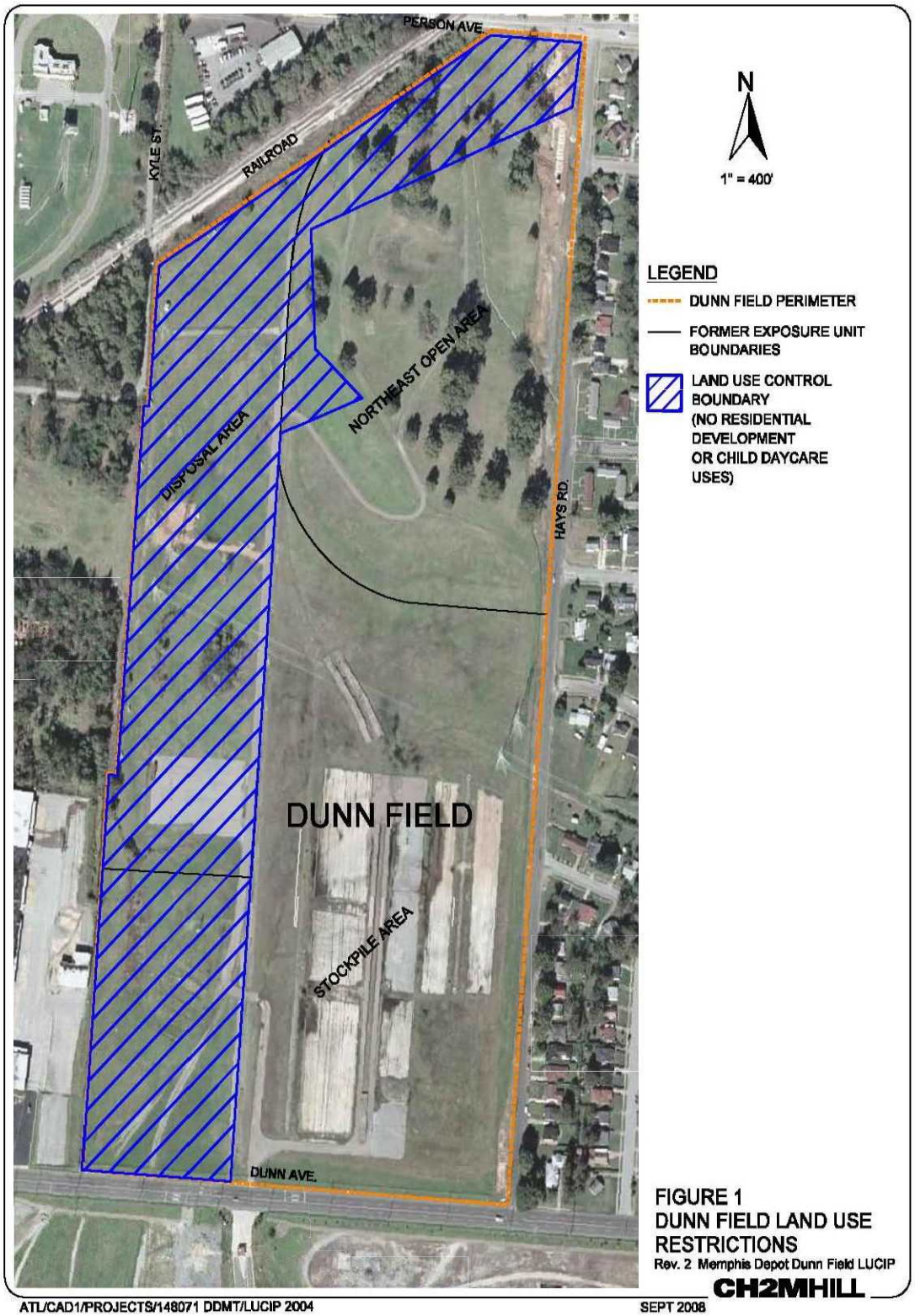
Notes

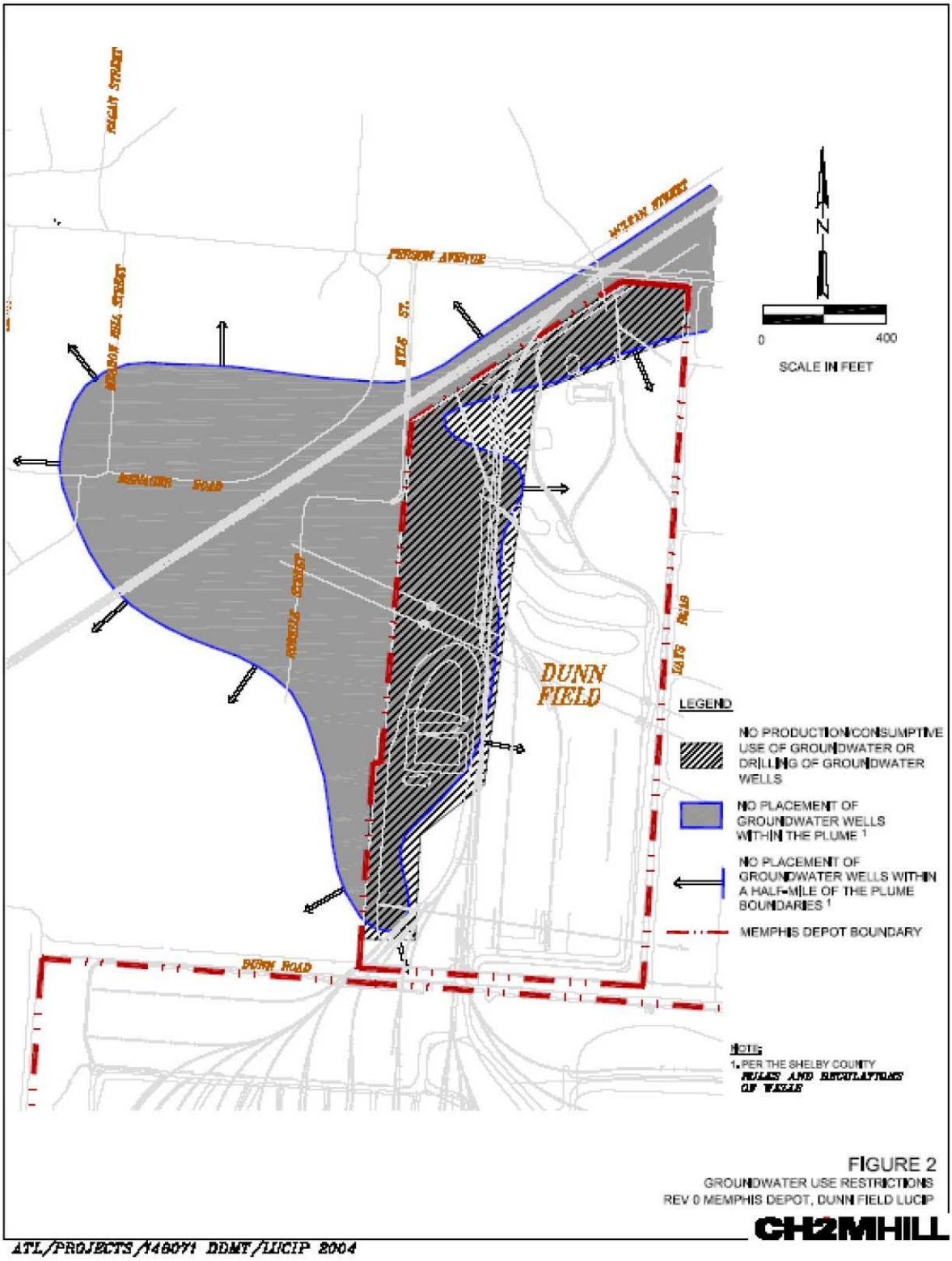
[1] Prior to transfer of any Memphis Depot property, the DLA or the Army (or its representatives) will perform the monitoring. After transfer, the Army may arrange to have TDEC, the City of Memphis, or some independent third party representative conduct any required monitoring. [See Section 5 below].

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
DLA = Defense Logistics Agency
EPA = US Environmental Protection Agency, Region 4
LUC = Land Use Control
MSCHD = Memphis Shelby County Division of Health Services
TDEC = Tennessee Department of Environment and Conservation

Figures 1 and 2

Land Use and Groundwater Use Restrictions
From Dunn Field Land Use Control Implementation Plan


PERSON AVE.
KYLE ST.
RAILROAD
NORTHEAST OPEN AREA
DISPOSAL AREA
HAYS RD.
DUNN FIELD
STOCKPILE AREA
DUNN AVE.
N
1" = 400'
LEGEND
DUNN FIELD PERIMETER
FORMER EXPOSURE UNIT BOUNDARIES
LAND USE CONTROL BOUNDARY (NO RESIDENTIAL DEVELOPMENT OR CHILD DAYCARE USES)
FIGURE 1
DUNN FIELD LAND USE RESTRICTIONS
Rev. 2 Memphis Depot Dunn Field LUCIP
CH2MHILL
ATL/CAD1/PROJECTS/148071 DDMT/LUCIP 2004
SEPT 2008


DUNN FIELD
N
0
400
SCALE IN FEET
LEGEND
NO PRODUCTION/CONSUMPTIVE USE OF GROUNDWATER OR DRILLING OF GROUNDWATER WELLS
NO PLACEMENT OF GROUNDWATER WELLS WITHIN THE PLUME 1
NO PLACEMENT OF GROUNDWATER WELLS WITHIN A HALF-MILE OF THE PLUME BOUNDARIES 1
MEMPHIS DEPOT BOUNDARY
NOTE:
1. PER THE SHELBY COUNTY RULES AND REGULATIONS OF WELLS
FIGURE 2
GROUNDWATER USE RESTRICTIONS
REV 0 MEMPHIS DEPOT, DUNN FIELD LUCIP
CH2MHILL
ATL/PROJECTS/146071 DDMT/LUCIP 2004

D

Appendix D.

VISL Assessment Memorandum

Memorandum

To: Laura Roebuck, USACE-Mobile
Joan Hutton, CALIBRE Systems, Inc.

From: Clayton Mokri, Vapor Intrusion Task Manager
Tom Holmes, Project Manager

Date: 18 October 2017

Re: **Vapor Intrusion Screening Level Assessment**
Main Installation, Defense Distribution Depot, Memphis

HDR Environmental, Operations and Construction, Inc. (HDR) has prepared this memorandum to present the screening level assessment of potential vapor intrusion (VI) risk from volatile organic compounds (VOCs) in groundwater beneath the Main Installation (MI) at the former Defense Depot Memphis, Tennessee (DDMT). The assessment utilized the United States Environmental Protection Agency (USEPA) Vapor Intrusion Screening Level Calculator (VISL) and the Johnson and Ettinger (J&E) VI model. This work was performed for the Office of the Assistant Chief of Staff for Installation Management, Base Realignment and Closure Division (ODB) under Contract W91278-16-D-0061, Task Order 0002 with the U.S. Army Corps of Engineers, Mobile District.

INTRODUCTION

DDMT is located in southeastern Memphis, Tennessee and consists of approximately 632 acres at the 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 65 acres with former mineral storage and waste disposal areas. Approximately two-thirds of Dunn Field is grassed, and the remaining area is covered with crushed rock and paved surfaces.

From 1942 until closure in 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. Types of past activities that could have resulted in the presence of hazardous materials in environmental media at the MI include hazardous substance repackaging for storage or shipment, pesticide application, painting and sandblasting, vehicle maintenance and hazardous material handling/storage. These activities resulted in the presence of metals, pesticides, and other less frequently detected chemicals in surface soil, surface water and sediment, and chlorinated volatile organic compounds (CVOCs) in groundwater.

DDMT was placed on the USEPA National Priorities List of contaminated sites in 1992. Numerous remedial investigations and remedial actions have been performed at DDMT resulting in a significant dataset for site lithology and extent of contamination, which is suitable for use in this assessment.

Environmental restoration at the MI includes remedial action and monitoring for specific CVOCs, which are listed as 'primary CVOCs' in site documents, such as *Annual Long-Term Monitoring Report – 2016, Revision 0* (2016 LTM Report) (HDR, 2017). The primary CVOCs consist of tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene, vinyl chloride (VC), carbon tetrachloride (CT) and chloroform (HDR, 2017). All six CVOCs are listed as being sufficiently volatile and toxic to be considered for potential VI risk in Appendix A of the *DoD Vapor Intrusion Handbook* (DoD, 2009), which is taken from USEPA guidance (USEPA530-D-02-004, 2002). The CVOCs are present in groundwater at concentrations up to 300 micrograms per liter (µg/L). The groundwater plumes, and potentially soil contamination, are present beneath commercial/industrial buildings at the site presenting a potential VI risk to current and future building occupants.

METHODS

Groundwater Data

As an initial step, HDR prepared a comprehensive vapor intrusion map for the MI (Figure 1) to show the location of the CVOC plumes, CVOC concentrations at individual wells, groundwater elevation contours, and the locations of existing buildings with the building number and current tenant/owner name. The groundwater elevations and validated analytical results are from the October 2016 sampling event, as presented in *Annual Long-Term Monitoring Report – 2016, Revision 0* (HDR, 2017). The October 2016 analytical results and water level measurements are consistent with historical results.

Current and Future Land Use

Land use controls have been established for the MI that prevent the construction of residential development or child daycare facilities (CH2MHILL, 2004), except for the eastern parcel depicted on Figure 1, which is available for unrestricted use. Current building tenants or unoccupied buildings, where noted, were identified as documented on the February 2, 2016 site plan, *Memphis Depot Industrial Park, Tenant Locations*. The buildings are used for warehousing and light industrial use. This assessment evaluated the VI risk with commercial exposure assumptions.

Constituents of Potential Concern and Initial Exposure Assessment

The primary CVOCs detected in monitoring wells on the MI were evaluated to develop the list of constituents of potential concern (COPCs) in Table 1. One of the primary CVOCs for the MI (cis-1,2-dichloroethene) is not included as a COPC because the toxicity data (reference concentration and inhalation unit risk) used to calculate VI screening levels are not established (USEPA, 2017).

To evaluate whether a VI exposure pathway is complete, the COPCs listed above were selected in the VISL calculator to identify a groundwater screening level (SL) protective of the VI risk. VISL (USEPA, 2016) calculated the SL based on commercial land use, groundwater to indoor air attenuation factor of 0.001, 25 degree Celsius average groundwater temperature, Henry's law constant, and the indoor air regional screening level (RSL) with a target cancer risk of $1x10^{-6}$ and non-cancer hazard index of 1.0 (USEPA, 2017). The calculated SLs are listed in Table 1 and the VISL spreadsheet is included as Appendix A-1.

Table 1. Groundwater COPCs and Screening Levels

COPC	Screening Level (µg/L)
Carbon Tetrachloride (CT)	1.8
Chloroform	3.6
Tetrachloroethene (PCE)	65
Trichloroethene (TCE)	7.4
Vinyl Chloride (VC)	2.5

The October 2016 groundwater analytical results and the SLs were used to identify where groundwater concentrations of COPCs exceed the SLs. Generally, at properties where subsurface concentrations of vapor-forming chemicals (e.g. groundwater or "near source" soil gas concentrations) fall below SLs, no further action or study is warranted (USEPA, 2014). As illustrated on Figure 1, contaminants are present in groundwater greater than SLs and in many cases, are present beneath occupied commercial buildings; therefore, the VI pathway is complete (USEPA, 2015).

RISK CHARACTERIZATION

Where a complete VI exposure has been identified, preexisting and readily ascertainable data may be compared to recommended generic VI screening criteria to develop insights about the potential level of exposure and risk posed by VI (USEPA, 2015). To further evaluate the VI risk, HDR reviewed October 2016 groundwater analytical results. Wells DR2-1, MW-100B and PMW21-04 were selected as they had the highest concentrations of the most common COPCs (PCE, TCE and VC) among the wells sampled and are located adjacent to occupied buildings.

The VI risk was estimated using the May 2016 VISL Calculator (USEPA, 2016) commercial exposure endpoints, default 25 degree Celsius (C) groundwater temperature, and the COPC concentrations detected in groundwater at the selected wells during the October 2016 sampling (Table 2). To further evaluate the VI risk, the J&E model (USEPA, 2003) incorporated additional site specific information such as depth to water, approximate 22ºC groundwater temperature (HDR, 2017), and soil type(s). The VISL and/or J&E model input data used to estimate the potential for VI risk at the MI is presented on Table 2.

Table 2. Input Parameters

	Well DR2-1	Well MW-100B	Well PMW21-04
Depth to Water (feet/centimeters)	84.97/2,590	82.87/2,526	83.49/2,545
Soil Type (depth in feet below ground surface)	Clay (0-30), Sand (26-85)	Clay (0-18.5) Sand (18.5-83)	Clay (0-26), Sand (26-83.5)
Chloroform (µg/L)	4.97	0.3 U	0.157
CT (µg/L)	32	1.0 U	1.0 U
PCE (µg/L)	208	1.09	293
TCE (µg/L)	5.92	0.306	122
VC (µg/L)	1.0 U	101	1.0 U

The cancer and non-cancer risk from VI of COPCs in groundwater to indoor air were calculated using commercial exposure assumptions, the USEPA's June 2017 unit risk factors and reference concentrations to generate cancer and non-cancer risk estimates (USEPA, 2017). The VISL spreadsheets for each of the selected wells are provided in Appendix A (A-2 to A-4)

and the J&E model results are provided in Appendix B (B-1 to B-3). The calculated risk estimates are presented for wells DR2-1, MW-100B and PMW21-04 in Tables 3, 4, and 5, respectively.

Table 3. Well DR2-1 VI Risk Results

COPC	Cancer Risk		Non-Cancer Risk	
	VISL	J&E	VISL	J&E
Chloroform	**$1.4x10^{-6}$**	$2.6x10^{-7}$	0.0017	0.0003
CT	**$1.8x10^{-5}$**	**$2.6x10^{-6}$**	0.0820	0.0120
PCE	**$3.2x10^{-6}$**	$4.1x10^{-7}$	0.8600	0.1100
TCE	$8x10^{-7}$	$5.6x10^{-8}$	0.2700	0.0390
VC	$4.1x10^{-7}$	$1.3x10^{-7}$	0.0026	0.0007
Total	**$2.4x10^{-5}$**	**$3.5x10^{-6}$**	**1.2163**	0.1620

Table 4. Well MW-100B Risk Results

COPC	Cancer Risk		Non-Cancer Risk	
	VISL	J&E	VISL	J&E
Chloroform	$8.4x10^{-8}$	$1.6x10^{-8}$	0.0001	0.0001
CT	$5.5x10^{-7}$	$8.5x10^{-8}$	0.0026	0.0004
PCE	$1.7x10^{-8}$	$2.2x10^{-9}$	0.0045	0.0006
TCE	$4.1x10^{-8}$	$3.0x10^{-9}$	0.0140	0.0021
VC	**$4.1x10^{-5}$**	**$7.9x10^{-6}$**	0.2600	0.0500
Total	**$4.2x10^{-5}$**	**$8.1x10^{-6}$**	0.2812	0.0531

Table 5. Well PMW21-04 VI Risk Results

COPC	Cancer Risk		Non-Cancer Risk	
	VISL	J&E	VISL	J&E
Chloroform	$4.4x10^{-8}$	$8.3x10^{-9}$	0.0001	0.0001
CT	$5.5x10^{-7}$	$8.3x10^{-8}$	0.0026	0.0004
PCE	**$4.5x10^{-6}$**	$5.8x10^{-7}$	**1.2000**	0.1600
TCE	**$1.6x10^{-5}$**	**$1.2x10^{-6}$**	**5.6000**	0.8100
VC	$4.1x10^{-7}$	$7.7x10^{-8}$	0.0026	0.0005
Total	**$2.2x10^{-5}$**	**$2.6x10^{-6}$**	**6.8053**	0.971

The VISL calculator identified a cumulative cancer risk greater than $1x10^{-6}$ for one or more individual COPCs and the combined risk at all three wells; a non-cancer risk greater than 1.0 was identified for two individual COPCs at PMW21-04 and for the combined risk at PMW21-04 and DR2-1. The J&E model identified a cumulative cancer risk greater than $1x10^{-6}$ for one individual COPC and the combined risk at all three wells; a non-cancer risk greater than 1.0 was not identified at these wells.

The cancer and non-cancer risks calculated by VISL are five to ten times greater than the risks calculated with the J&E model. This difference is largely due to the incorporation of site-specific lithological data and depth to contamination in the J&E model to estimate an indoor air concentration rather than the VISL default attenuation factor of 0.001.

While the VISL and J&E models calculated different cancer and non-cancer risks, both methods identified risks greater than the target $1x10^{-6}$ for cancer (USEPA, 2015); therefore, VOCs are present in the subsurface that may present an unacceptable human health risk from VI. In addition to the VI risk identified at wells PMW21-04, DR2-1 and MW100B, COPCs detected in other wells on the MI may also present a VI risk (Figure 1).

CONCLUSIONS AND RECOMMENDATIONS

This assessment concludes:

- Chemicals present in groundwater are sufficiently volatile and toxic to pose a potential human health risk from VI to indoor air of current and future buildings;
- Recent analytical results for COPCs in groundwater exceed commercial SLs estimated using the VISL calculator beneath occupied buildings indicating a potential human health risk from VI (Figure 1); and
- October 2016 groundwater analytical results and lithological data for three representative wells (PMW21-04, DR2-1, and MW100B) used with the J&E model provided lower human health risk estimates than with the VISL calculator; the J&E results were an order of magnitude lower for cancer risk and about 50 percent lower for non-cancer risk.

The potential human health risk from COPCs in groundwater within occupied structures at DDMT is greater than $1x10^{-6}$ for cancer and greater than 1.0 for non-cancer. Soil gas samples will be collected in order to more precisely estimate human health risk. A work plan for soil gas sampling will be prepared in accordance with the statement of Work for Task Order 0002.

REFERENCES

CH2MHILL, 2004. *Land Use Control Implementation Plan,* February.

DOD, 2009. *DOD Vapor Intrusion Handbook,* January.

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USEPA, 2003, *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings.* February

USEPA, 2015. *OSWER 9200.2-154, Technical Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to indoor Air,* June.

USEPA, 2016. *Vapor Intrusion Screening level (VISL) Calculator Users Guide,* May. Available online at: http://www.epa.gov/oswer/vaporintrusion/guidance.html

USEPA, 2017. *Regional Screening Levels*, https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017. June.

Figure

Notes:
1. Groundwater contours from October 2016.
2. CVOC contours from October 2016.

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Legend

- PCE Commercial Vapor Intrusion Screening Level (65 ug/L)
- TCE Commercial Vapor Intrusion Screening Level (7.4 ug/L)
- CT Commercial Vapor Intrusion Screening Level (1.8 ug/L)
- CF Commercial Vapor Intrusion Screening Level (3.6 ug/L)
- VC Commercial Vapor Intrusion Screening Level (2.5 ug/L)
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Fluvial Aquifer Well
- Intermediate Aquifer Well
- Property Boundary
- Area Available for Unrestricted Use
- Roads
- Building with Number and Lessee(s)
- Clay Elevation Exceeds Groundwater Elevation

Figure 1

Comprehensive Vapor Intrusion Map

Main Installation VI Study

Defense Depot
Memphis, Tennessee

0 250 500
Feet

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

Date: 6/12/2017
Edition: Rev 0

HDR

A

Appendix A.

Vapor Intrusion Screening Level Calculator Results

Appendix A-1
Groundwater Screening Level Calculation

VI Groundwater Screening Levels (micrograms per liter)

EPA-OLEM VAPOR INTRUSION ASSESSMENT

Vapor Intrusion Screening Level (VISL) Calculator Version 3.5.1 (May 2016 RSLs)

The primary objective of risk-based screening is to identify sites or buildings unlikely to pose a health concern through the vapor intrusion pathway. Generally, at properties where subsurface concentrations of vapor-forming chemicals (e.g., groundwater or "near source" soil gas concentrations) fall below screening levels (i.e., VISLs), no further action or study is warranted, so long as the exposure assumptions match those taken into account by the calculations and the site fulfills the conditions and assumptions of the generic conceptual model underlying the screening levels. In a similar fashion, the results of risk-based screening can help the data review team identify areas, buildings, and/or chemicals that can be eliminated from further assessment. The generic conceptual model underlying these screening levels is described in OSWER Publication 9200.2-154 (OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway From Subsurface Vapor Sources to Indoor Air) (EPA 2015; Section 6.5)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS		Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does chemical have inhalation toxicity data? (IUR and/or RfC)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source? Cvp > Cia,target?	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source? Chc > Cia,target?	Target Indoor Air Conc. @ TCR = 1E-06 or THQ = 1 MIN(Cia,c;Cia,nc)	Toxicity Basis	Target Sub-Slab and Exterior Soil Gas Conc. @ TCR = 1E-06 or THQ = 1 Csg	Target Ground Water Conc. @ TCR = 1E-06 or THQ = 1 Cgw	Is Target Ground Water Conc. < MCL? Cgw<MCL?	Pure Phase Vapor Conc. @ 25°C Cvp	Maximum Groundwater Vapor Conc. Chc	Temperature for Max. Groundwater Vapor Conc. Tgw or 25	Lower Explosive Limit** LEL	LEL Source	Inhalation Unit Risk IUR	IUR Source[a]	Reference Concentration RfC	RFC Source[a]	Mutagenic Indicator i	Target Indoor Air Conc. for Carcinogens @ TCR = 1E-06 Cia,c	Target Indoor Air Conc. for Non-Carcinogens @ THQ = 1 Cia,nc
56-23-5	Carbon Tetrachloride	Yes	Yes	Yes	Yes	2.0E+00	C	6.8E+01	1.9E+00	Yes (5)	9.52E+08	8.95E+08	25			6.00E-06	I	1.00E-01	I		2.0E+00	4.4E+02
67-66-3	Chloroform	Yes	Yes	Yes	Yes	5.3E-01	C	1.8E+01	3.6E+00	Yes (8.0E+01(F))	1.27E+09	1.19E+09	25			2.30E-05	I	9.80E-02	A		5.3E-01	4.3E+02
127-18-4	Tetrachloroethylene	Yes	Yes	Yes	Yes	4.7E+01	C	1.6E+03	6.5E+01	No (5)	1.85E+08	1.49E+08	25			2.60E-07	I	4.00E-02	I		4.7E+01	1.8E+02
79-01-6	Trichloroethylene	Yes	Yes	Yes	Yes	3.0E+00	C	1.0E+02	7.4E+00	No (5)	4.88E+08	5.15E+08	25	8	N	see note	I	2.00E-03	I	TCE	3.0E+00	8.8E+00
75-01-4	Vinyl Chloride	Yes	Yes	Yes	Yes	2.8E+00	C	9.3E+01	2.5E+00	No (2)	1.00E+10	1.00E+10	25	3.6	N	4.40E-06	I	1.00E-01	I	VC	2.8E+00	4.4E+02

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell G10) Symbol	Selected Value
Averaging time for carcinogens	(yrs)	ATc_R	70	ATc_C	70	ATc	70
Averaging time for non-carcinogens	(yrs)	ATnc_R	26	ATnc_C	25	ATnc	25
Exposure duration	(yrs)	ED_R	26	ED_C	25	ED	25
Exposure frequency	(days/yr)	EF_R	350	EF_C	250	EF	250
Exposure time	(hr/day)	ET_R	24	ET_C	8	ET	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell G10) Symbol	Selected Value
Groundwater	(-)	AFgw_R	0.001	AFgw_C	0.001	AFgw	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R	0.03	AFss_C	0.03	AFss	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)

Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)

Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene

	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell G10) Symbol	Selected Value
mIURTCE_R	1.00E-06	mIURTCE_C	0.00E+00	mIURTCE	0.00E+00
IURTCE_R	3.10E-06	IURTCE_C	4.10E-06	IURTCE	4.10E-06

Mutagenic Chemicals

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Age Cohort	Exposure Duration (years)	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 This factor is used in the equations for mutagenic chemicals.

See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:

NVT = Not sufficiently volatile and/or toxic to pose inhalation risk in selected exposure scenario for the indicated medium
C = Carcinogenic
NC = Non-carcinogenic
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
E = The Engineering ToolBox. Available online at http://www.engineeringtoolbox.com/explosive-concentration-limits-d_423.html
N = Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH). Pocket Guide to Chemical Hazards. Available online at: http://www.cdc.gov/niosh/npg/default.html http://www.cdc.gov/niosh/npg/default.html
M = Chemical-specific MSDS
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
**Lower explosive limit is the minimum concentration of the compound in air (% by volume) that is needed for the gas to ignite and explode.

Appendix A-2
Well DR2-1

DR2-1

EPA-OLEM VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5.1 (May 2016 RSLs)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ
56-23-5	Carbon Tetrachloride	3.2E+01	3.61E+01	**1.8E-05**	8.2E-02
67-66-3	Chloroform	5.0E+00	7.46E-01	**1.4E-06**	1.7E-03
127-18-4	Tetrachloroethylene	2.1E+02	1.51E+02	**3.2E-06**	8.6E-01
79-01-6	Trichloroethylene	5.9E+00	2.38E+00	8.0E-07	2.7E-01
75-01-4	Vinyl Chloride	1.0E+00	1.14E+00	4.1E-07	2.6E-03

Inhalation Unit Risk IUR $(ug/m^3)^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
6.00E-06	I	1.00E-01	I	
2.30E-05	I	9.80E-02	A	
2.60E-07	I	4.00E-02	I	
see note	I	2.00E-03	I	TCE
4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).

EPA-OLEM VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5.1 (May 2016 RSLs)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR ($(ug/m^3)^{-1}$)	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i

VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

Appendix A-3
Well MW-100B

MW-100B

EPA-OLEM VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5.1 (May 2016 RSLs)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
56-23-5	Carbon Tetrachloride	1.0E+00	1.13E+00	5.5E-07	2.6E-03	6.00E-06	I	1.00E-01	I	
67-66-3	Chloroform	3.0E-01	4.50E-02	8.4E-08	1.0E-04	2.30E-05	I	9.80E-02	A	
127-18-4	Tetrachloroethylene	1.1E+00	7.89E-01	1.7E-08	4.5E-03	2.60E-07	I	4.00E-02	I	
79-01-6	Trichloroethylene	3.1E-01	1.23E-01	4.1E-08	1.4E-02	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	1.0E+02	1.15E+02	**4.1E-05**	2.6E-01	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater (-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas (-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).

EPA-OLEM VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5.1 (May 2016 RSLs)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR ($(ug/m^3)^{-1}$)	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i

VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

Appendix A-4
Well PMW21-04

PMW21-04

EPA-OLEM VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5.1 (May 2016 RSLs)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR ($(ug/m^3)^{-1}$)	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
56-23-5	Carbon Tetrachloride	1.0E+00	1.13E+00	5.5E-07	2.6E-03	6.00E-06	I	1.00E-01	I	
67-66-3	Chloroform	1.6E-01	2.36E-02	4.4E-08	5.5E-05	2.30E-05	I	9.80E-02	A	
127-18-4	Tetrachloroethylene	2.9E+02	2.12E+02	**4.5E-06**	**1.2E+00**	2.60E-07	I	4.00E-02	I	
79-01-6	Trichloroethylene	1.2E+02	4.91E+01	**1.6E-05**	**5.6E+00**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	1.0E+00	1.14E+00	4.1E-07	2.6E-03	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).

EPA-OLEM VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.5.1 (May 2016 RSLs)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR ($(ug/m^3)^{-1}$)	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i

VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

B

Appendix B.

Johnson and Ettinger VI Calculator Results

Appendix B-1
Well DR2-1

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
67663	4.97E+00	Chloroform

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2590	915	1675		B	SI			1.00E-08

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	7.92E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.6E-07	3.2E-04

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
56235	3.20E+01	Carbon tetrachloride

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2590	915	1675		B	SI			1.00E-08

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	7.93E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.6E-06	1.2E-02

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
127184	2.08E+02	Tetrachloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2590	915	1675		B	SI			1.00E-08

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.00E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
4.1E-07	1.1E-01

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79016	5.92E+00	Trichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2590	915	1675		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.10E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
5.6E-08	3.9E-02

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
75014	1.00E+00	Vinyl chloride (chloroethene)

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2590	915	1675		B	SI			1.00E-08

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.76E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.3E-07	6.8E-04

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

Appendix B-2
Well MW-100B

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
67663	3.00E-01	Chloroform

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2526	548	1978		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	7.92E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.6E-08	2.0E-05

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
56235	1.00E+00	Carbon tetrachloride

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2526	548	1978		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	7.93E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
8.5E-08	3.9E-04

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
127184	1.09E+00	Tetrachloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2526	548	1978		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.00E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.2E-09	5.9E-04

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79016	3.06E-01	Trichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2526	548	1978		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.10E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
3.0E-09	2.1E-03

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
75014	1.01E+02	Vinyl chloride (chloroethene)

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2526	548	1978		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.76E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
7.9E-06	5.0E-02

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

Appendix B-3
Well PMW21-04

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
67663	1.57E-01	Chloroform

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2545	793	1752		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	7.92E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
8.3E-09	1.0E-05

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
56235	1.00E+00	Carbon tetrachloride

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2545	793	1752		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	7.93E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
8.3E-08	3.9E-04

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
127184	2.93E+02	Tetrachloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2545	793	1752		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.00E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
5.8E-07	1.6E-01

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79016	1.22E+02	Trichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2545	793	1752		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.10E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.2E-06	8.1E-01

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES X

Groundwater Vapor Emissions To Indoor Air
Commercial/Industrial Exposure Scenario
Moderate/Low Permeability Soil Scenario

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
75014	1.00E+00	Vinyl chloride (chloroethene)

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
22	15	2545	793	1752		B	SI	CL		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
CL	1.48	0.442	0.168	SI	1.35	0.489	0.167		1.5	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.76E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
7.7E-08	4.9E-04

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

E

Appendix E.
Community Notification

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT
600 ARMY PENTAGON
WASHINGTON, DC 20310-0600

10 March 2017

MEMORANDUM FOR Former Restoration Advisory Board Members, U.S. Environmental Protection Agency and Tennessee Department of Environment and Conservation Officials

SUBJECT: Notification of Five-Year Review, Defense Depot Memphis, Tennessee

1. This memorandum is provided to notify you that the Department of the Army is conducting a Five-Year Review under the Comprehensive Emergency Response, Compensation and Liability Act (CERCLA) for the selected remedies at:

Former Defense Depot Memphis, Tennessee (DDMT)
2163 Airways Boulevard
Memphis, Shelby County, Tennessee

2. The purpose of this Five-Year Review is to determine whether the remedies at the Former DDMT remain protective of human health and the environment. The methods, findings, and conclusions of the review will be documented in a Five-Year Review report, and if any issues are identified, recommendations will be provided to address them.

3. The selected remedies for DDMT were described in the Main Installation Record of Decision approved in 2001, the Dunn Field Record of Decision approved in 2004, and the Dunn Field Record of Decision Amendment approved in 2009. The contaminants of concern are metals, petroleum hydrocarbons and volatile organic compounds (VOCs) in soil and chlorinated volatile organic compounds (CVOCs) in groundwater. The selected remedy for the Main Installation was:

- Excavation, transportation, and off-site disposal of lead-contaminated surface soil near Building 949.
- Deed restrictions and site controls on residential land use, daycare facilities, drilling and groundwater use, and site access.
- Enhanced bioremediation of CVOCs in the most contaminated part of the groundwater plume.
- Long-term groundwater monitoring.

The selected remedy, as amended for Dunn Field included:

- Excavation, transportation, and disposal of soil and material within disposal sites.
- Soil vapor extraction (SVE) to reduce VOC concentrations in subsurface soils.
- Injection of zero-valent iron within Dunn Field to treat CVOCs in the most contaminated part of the groundwater plume and installation of an air sparging and SVE system to remediate CVOCs within the off site areas of the groundwater plume.

- Monitored natural attenuation and long-term groundwater monitoring.
- Implementation of land use controls consisting of deed and/or lease restrictions; Notice of Land Use Restrictions; zoning restrictions and groundwater well restrictions.

4. All selected remedies have been implemented. Construction, operation and performance monitoring for the remedies were documented in interim remedial action completion reports, which were reviewed and approved by the U.S. Environmental Protection Agency (USEPA) and Tennessee Department of Environment and Conservation (TDEC). Additional site information is available at the Information Repository at TDEC's office at 8383 Wolf Lake Drive, Bartlett, TN 38133, (901) 371-3000. Please call ahead for an appointment. TDEC staff will assist you in viewing documents. You may also find information online at: http://www.epa.gov/region4/superfund/sites/fedfacs/memdedpttn.html.

5. The implemented remedies have either met cleanup standards or are making progress toward the standards, except for groundwater contamination on the Main Installation. Enhanced bioremediation was implemented on the Main Installation in 2006 to 2009 and 2012 to 2014. While concentrations of groundwater contaminants were reduced, the reductions were not sufficient to meet the cleanup standards. A Supplemental Remedial Investigation is currently being performed, and a Focused Feasibility Study will be performed upon completion of the Investigation to develop a remedial strategy to achieve cleanup standards throughout the Main Installation. The supplemental investigation includes document review to examine the basis for the selected remedy and field investigation to improve the site hydrogeological model and delineation of contaminant plumes and to evaluate potential off-site impacts to groundwater. Further investigation is planned in 2017 and will include additional monitoring wells, groundwater modeling, risk assessment and vapor intrusion study. All activities are being performed with review and concurrence from USEPA and TDEC. Further remedial action will be conducted after the feasibility study is completed and the selected remedy has been confirmed or revised.

6. The National Contingency Plan requires that remedial actions that result in any hazardous substances, pollutants or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure the protection of human health and the environment. This is the fourth Five-Year Review for the Former DDMT and is to be signed by January 23, 2018. Notification of report completion and availability for public review will be provided at that time.

7. The Department of the Army invites community participation in the Five Year Review process. If you would like further information or to comment on the protectiveness of the selected remedy or the remedial actions at DDMT, please call the Community Involvement Line at (901) 774-3683 or send an email to denise.cooper@hdrinc.com. Comments will be accepted through May 15, 2017.

8. A public notice inviting comments from the community for the Five-Year Review will be published in the *Memphis Commercial Appeal* on March 15, 2017.

SUBJECT: Notification of Five-Year Review, Defense Depot Memphis, Tennessee

9. For additional information please contact: Mr. Tom Holmes, HDR Project Manager at (404) 295-3279, email: thomas.holmes@hdrinc.com; or Ms. Joan Hutton, BRAC Environmental Coordinator at (571) 403-3308, email: joan.hutton@calibresys.com.

James C. Foster
Program Manager,
Base Realignment and Closure Division

cc:

Elected Officials

The Honorable Jim Strickland, Mayor of the City of Memphis
The Honorable Mark H. Luttrell, Jr., Mayor of Shelby County
Councilman Joe Brown, Memphis City Council Super District 8 - Position 1
Councilwoman Janis Fullilove, Memphis City Council Super District 8 - Position 2
Councilman Martavius Jones, Memphis City Council Super District 8 - Position 3
Councilwoman Jamita Swearengen, Memphis City Council District 4
Commissioner Reginald Milton, Shelby County Board of Commissioners District 10

Civic Representatives

Dr. Tyler Zerwekh, Shelby County Health Department
Mr. Reid Dulberger, Economic Development Growth Engine
Mr. Tom Winford, Memphis Light, Gas and Water

Former Restoration Advisory Board Community Representatives

Mr. Dave Bond
Ms. Doris Bradshaw
Ms. Peggy Brooks
Reginald Eskridge, Esquire
Mr. Ulysses Truitt
Mr. Stanley Tyler
Mr. Mondell Williams
Ms. Elizabeth Young

Regulatory Agency Representatives

Ms. Diedre Lloyd, U.S. Environmental Protection Agency, Region 4
Mr. Jamie Woods, Tennessee Department of Environment and Conservation

White House: Trump paid $38M in taxes in 2005

TV host: Papers came in over the transom

GREGORY KORTE
USA TODAY


Trump


Maddow

WASHINGTON - President Trump paid $38 million in taxes in 2005 on an income of more than $150 million, a senior White House official confirmed Tuesday night.

That rare acknowledgment came in anticipation of a report by MSNBC host Rachel Maddow, who purported to have copies of Trump's tax returns from 11 years ago. The White House official spoke on condition of anonymity to discuss a sensitive financial matter.

Trump defied decades of tradition during the 2016 presidential campaign in refusing to voluntarily release his tax returns, which would shed light on the size and breadth of his sprawling real estate and entertainment empire.

Maddow said she had two pages of Trump's Form 1040 from 2005, which she obtained from financial journalist and Trump biographer David Cay Johnston.

"I got them in the mail. They came in over the transom," he told Maddow.

The White House pushed back Tuesday night, saying that publishing those returns would be illegal.

"You know you are desperate for ratings when you are willing to violate the law to push a story about two pages of tax returns from over a decade ago," the White House said in a statement.

The unauthorized release of federal tax returns is a criminal offense. But Maddow argued that MSNBC was exercising its First Amendment right to publish information in the public interest.

Trump long insisted the American public wasn't interested in his returns and said little could be learned from them. But Trump's full returns would contain key details about things like his charitable giving and how much he earned each year.

Previously, the only Trump tax returns publicly known were state tax returns from 1995 showing he lost more than $913 million — a figure that would allow him to potentially take a deduction for losses for years. Those returns were obtained by The New York Times in October.

Maddow said the 2005 return also included $103 million in deductions. But the few pages of tax returns leaked so far shows the bottom lines of his financials for two years a decade apart — and without the schedules that would detail the sources of that income. And while a legally required financial disclosure statement discloses Trump's holdings in more than 500 different ventures, that document gives only a broad outline of his financial interests.

More than 1 million people have signed a petition on the White House website that called on Trump to release his tax returns. But Trump has been dismissive of the issue, saying in early January that "the only ones who care about tax returns are reporters."

Contributing: Associated Press

White House distances itself from King comments

Iowa lawmaker stands by his rhetoric about immigration

ASSOCIATED PRESS

WASHINGTON - The White House on Tuesday distanced itself from Republican Rep. Steve King's inflammatory comments about immigrants, as Democrats pressed House GOP leaders to punish the Iowa lawmaker by stripping him of a chairmanship.

King said this weekend that America can't restore "our civilization with somebody else's babies" and warned of a liberal effort to destroy Western civilization through immigration. Questioned about the comments, White House spokesman Sean Spicer said President Donald Trump "believes that this is not a point of view that he shares."

"He believes he's the president for all Americans, and so I'll leave it at that," Spicer told reporters at his daily briefing.

King was a strong supporter of Trump in the 2016 campaign and backed the candidate's tough stand on immigration.

In a statement Tuesday, Minority Leader Nancy Pelosi said Speaker Paul Ryan and other GOP leaders should immediately take the chairmanship of a House Judiciary subcommittee from King.

"Where are Speaker Ryan and the GOP leadership?" asked Pelosi, D-Calif. "Does their silence mean Congressman Steve King's vile racism is acceptable? House Republicans think they can keep quiet, but their contempt for the great diversity of our nation is being heard loud and clear."

Several Republicans and Democrats criticized King for his comments, with Ryan saying he disagreed with the remarks.

"We're a melting pot. My family's here because the potatoes stopped growing in Ireland," he told Fox News Monday night. "The American idea is this beautiful idea which is there for everyone, which is that the condition of your birth doesn't determine your outcome in life."

Ryan said he hadn't spoken with King. "I'd like to think he misspoke and it wasn't really meant the way it sounds and hopefully he's clarified that," said the Wisconsin Republican.

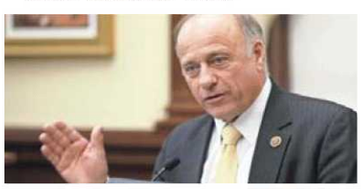
King stood by his comments in a Monday CNN interview in which he also said, "If you go down the road a few generations or maybe centuries with the intermarriage, I'd like to see an America that (is) so homogenous that we look a lot the same from that perspective."

King's initial comments on Twitter were part of a tribute to Geert Wilders, a Dutch politician who opposes immigration and has spoken against Islam. It came as the Dutch prepared for an election for prime minister.

King is known for making racially charged commentary. Last year, at the Republican National Convention, King questioned contributions to civilization by nonwhites. In 2013, he described children in the country illegally as having "calves the size of cantaloupes because they've been hauling 75 pounds of marijuana across the desert."

Later Monday, in an interview with Iowa radio host Jan Mickelson on 1040 WHO, King said blacks and Hispanics will be battling each other before whites become the minority in the United States.

King was responding to Univision's Jorge Ramos' comments about changes in the U.S. demographic in the next decades.


CHARLIE NEIBERGALL/AP

U.S. Rep. Steve King of Iowa, seen in 2014, has a history of making racially charged statements. Over the weekend he paid tribute to anti-immigration Dutch politician Geert Wilders.

Project

Continued from Page 1A

The developers filed preliminary plans with Germantown on Thursday, Mayor Mike Palazzolo said, and the project would have to go through months of review and approvals before workers break ground.

"Germantown doesn't have a town square like some cities do, so this would be an opportunity to create that village setting, that live, work, play, all in our central business district," the mayor said.

The dimensions throughout the project are large: 254,500 square feet of retail space, 56,400 square feet of office space, 302 apartment units and a 130-room hotel, according to a preliminary map.

Germantown Alderman John Barzizza said he'd met with Elkington and one of his partners to discuss the development. "Based on what I saw, it'll pretty much complement Saddle Creek South as far as retail and what have you. It's going to have some pretty nice retail."

Barzizza said he recommended the developers talk with the neighbors about their plans, and said he believed they'd done so.

The proposed development is separate from two other major mixed-use developments in Germantown: the TraVure mixed-use development under construction on Poplar near Kirby Parkway; and the Thornwood project on South Germantown Road.

Investment in TraVure was estimated last year at $90 million, while the price tag for Thornwood is $13.1 million. By comparison, the $200 million estimate for the new Germantown development would be comparable to the cost to renovate the 1.1 million-square-foot Crosstown Concourse building in Midtown Memphis.

The concept goes before the Germantown Planning Commission Smart Code Review Committee on March 22 and then the full Planning Commission meeting on April 4, said Cameron Ross, Economic and Community Development director. Then an outline plan would go to the Board of Mayor and Aldermen for review.

Business editor Ted Evanoff and Reporter David Royer contributed to this story.

F

Appendix F.
FYR Site Inspection Checklist

Five-Year Review Site Inspection Checklist (Template)

I. SITE INFORMATION	
Site name: Defense Depot Memphis, Tennessee (DDMT)	**Date of inspection:** 17 & 18 July 2017
Location and Region: Memphis, Tennessee/ Region 4	**EPA ID:** TN4210020570
Agency, office, or company leading the five-year review: HDR, Inc. under contract to USACE-Mobile for Army BRAC Office	**Weather/temperature:** 88 deg, partly cloudy

Remedy Includes: (Check all that apply)

- □ Landfill cover/containment
- X Access controls
- X Institutional controls
- □ Groundwater pump and treatment
- □ Surface water collection and treatment
- X Enhanced Bioremediation
- X Air Sparging with Soil Vapor Extraction (AS/SVE)
- □ Monitored natural attenuation
- X Groundwater monitoring
- □ Vertical barrier walls

Other: Other remedial actions completed prior to the last FYR.

Attachments: □ Inspection team roster attached X Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager:** Tom Holmes, Senior Project Manager, HDR

The Fourth FYR was conducted under direction of Mr. Holmes; he has been the project manager for remedial action activities at DDMT since 2004. Interviews with O&M staff were not necessary.

Interviewed □ at site □ at office □ by phone Phone no. _____
Problems, suggestions; □ Report attached

2. **O&M staff** _____ _____ _____
Name Title Date
Interviewed □ at site □ at office □ by phone Phone no. _____
Problems, suggestions; □ Report attached
NA

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency: Shelby County Health Department, Water Quality Branch
Contact Greg Parker, Supervisor, 6/26/17, (901) 222--9549
Name Title Date Phone no.
Problems; suggestions; **X** Report attached
Mr. Parker confirmed that no permits have been issued for construction of consumptive use/production groundwater wells at the Main Installation.

4. **Other interviews** (optional) X Reports attached.

Property owners contacted. No problems noted.

Ms. Anita Bunn of Colliers International – the property management firm for the Memphis Depot Industrial Park (26 June 2017); Mr. Greg Ward of Barnhart Crane (26 June 2017); Mr. Robert Keskey of Supply Chain Solutions LLC (6 July 2017); and Mr. Randy Richardson for the Economic Development Growth Engine of Memphis/Shelby County (26 June 2017).

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **O&M Documents**

X O&M manual	**X** Readily available	**X** Up to date	□ N/A
X As-built drawings	**X** Readily available	**X** Up to date	□ N/A
X Maintenance logs	**X** Readily available	**X** Up to date	□ N/A

Remarks: Only operating system at DDMT is the Off Depot AS/SVE System. O&M Plan includes as-built drawings. System inspections records with weekly readings and maintenance activities are maintained in electronic project files, as are records of equipment maintenance/repair by subcontractors.
HDR, 2011. *Dunn Field Off Depot Groundwater Air Sparge and Soil Vapor Extraction System Operations and Maintenance Manual, Defense Depot Memphis, Tennessee, Department of the Army, Revision 0.* Prepared for the Air Force Center for Engineering and the Environment. March 2011.

2. **Site-Specific Health and Safety Plan** **X** Readily available □ Up to date □ N/A
□ Contingency plan/emergency response plan □ Readily available □ Up to date **X** N/A
Remarks:
HDR, 2015. *Site Safety and Health Plan for Defense Depot Memphis, Tennessee, Environmental Restoration Support, Department of the Army, Revision 0.* Prepared for USACE-Mobile. March, 2015

3. **O&M and OSHA Training Records** □ Readily available □ Up to date **X** N/A
Remarks: No permanent personnel located at DDMT. OSHA training records for field personnel checked during periodic field events.

4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	**X** N/A
	□ Effluent discharge	□ Readily available	□ Up to date	**X** N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	**X** N/A
	□ Other permits_____	□ Readily available	□ Up to date	**X** N/A
	Remarks: DDMT operations ended upon closure in 1997. All of the Main Installation has been transferred for re-use. Dunn Field is undeveloped. No permits are required for remedial activities. SCHD canceled Permit #01030-01P for AS/SVE operations in May 2016 and exempted the AS/SVE system based on emissions consistently below the de minimus limit.			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	**X** N/A
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	**X** N/A
7.	**Groundwater Monitoring Records**	□ Readily available	□ Up to date	□ N/A
	Remarks: See discussion of groundwater monitoring in section IX. D.			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	**X** N/A
9.	**Discharge Compliance Records**			
	□ Air	**X** Readily available	**X** Up to date	□N/A
	□ Water (effluent)	**X** Readily available	**X** Up to date	□N/A
	Remarks			
10.	**Daily Access/Security Logs**	**X** Readily available	**X** Up to date	□ N/A
	Remarks: O&M Staff and site visitors are listed on weekly system inspection records which are maintained in electronic project files.			

IV. O&M COSTS		
1.	**O&M Organization**	
	□ State in-house	□ Contractor for State
	□ PRP in-house	□ Contractor for PRP
	□ Federal Facility in-house	**X** Contractor for Federal Facility
	□ Other _____	

2. **O&M Cost Records**
□ Readily available **X** Up to date □ Funding mechanism/agreement in place
Original O&M cost estimate $3,311,000 (w/o construction) **X** Breakdown attached

Estimated AS/SVE construction, O&M and monitoring costs provided in the Off Depot RD (CH2MHILL, 2008) and actual costs from project invoices are shown on attached Table 1.

Total annual cost by year for review period if available

	Date		Date		Total cost	
From	Jan 2012	To	Jan 2013	(Y3)	$268,325	**X** Breakdown attached
	Date		Date		Total cost	
From	Jan 2013	To	Jan 2014	(Y4)	$265,700	**X** Breakdown attached
	Date		Date		Total cost	
From	Jan 2014	To	May 2016	(Y5)	$341,600	**X** Breakdown attached
	Date		Date		Total cost	
From	May 2016	To	May 2017	(Y6)	$295,869	**X** Breakdown attached
	Date		Date		Total cost	

Note: Y5 extended due to system shutdown from lightning in February 2014; repairs completed and operation restarted in March 2015.

3. **Unanticipated or Unusually High O&M Costs During Review Period**
Describe costs and reasons: Total AS/SVE costs are consistent with the RD cost estimate. Repair costs are included in Y5 and Y6 due to damage from lightning (see Table 1). Total costs to date are slightly higher than estimated (see Table 1) due to system operations continuing past the estimate of 5 years.

V. ACCESS AND INSTITUTIONAL CONTROLS □ Applicable □ N/A

A. Fencing

1. **Fencing damaged** □ Location shown on site map **X** Gates secured **X** N/A
Remarks No damage observed during the annual LUC/FYR inspection in July 2017. Weekly drive-by inspections are performed. Damage to fences has been observed a few times since the last FYR and repairs were made within about a week

B. Other Access Restrictions

1. **Signs and other security measures** □ Location shown on site map **X** N/A
Remarks:

C. Institutional Controls (ICs)

1. **Implementation and enforcement**
Site conditions imply ICs not properly implemented □ Yes **X** No □ N/A
Site conditions imply ICs not being fully enforced □ Yes **X** No □ N/A

Type of monitoring (*e.g.*, self-reporting, drive by): Drive-by visual and contacts with Shelby County Health Department and with property owners for transferred property.

Frequency: Annual

Responsible party/agency: Army BRAC Office, BRAC Environmental Coordinator (BEC)

Contact Joan Hutton BEC NA 571-403-3308
Name Title Date Phone no.

Reporting is up-to-date **X** Yes □ No □ N/A
Reports are verified by the lead agency **X** Yes □ No □ N/A

Specific requirements in deed or decision documents have been met **X** Yes □ No □ N/A
Violations have been reported □ Yes □ No **X** N/A
Other problems or suggestions: **X** Report attached
2017Annual LUC Inspection Report attached. Report prepared for Army BRAC Office by HDR under direction of Tom Holmes, Project Manager.

2. **Adequacy** **X** ICs are adequate □ ICs are inadequate □ N/A
Remarks:

D. General

1. **Vandalism/trespassing** □ Location shown on site map **X** No vandalism evident
Remarks: No vandalism observed during the annual LUC/FYR inspection in July 2017. A few episodes including cutting fences and setting fires on top of concrete pads for monitoring wells. Only minor damage has been observed, with repairs made soon after observation.

2. **Land use changes on site** **X** N/A
Remarks

3. **Land use changes off site** **X** N/A
Remarks

VI. GENERAL SITE CONDITIONS
A. Roads X Applicable □ N/A
1. **Roads damaged** □ Location shown on site map X Roads adequate □ N/A Remarks: Roads surrounding DDMT are maintained by the City of Memphis. Roads on the Main Installation are maintained by Memphis Depot Industrial Park. The access road for the remaining federal property (24.5 acres) on Dunn Field is maintained by Army and is in good condition.
B. Other Site Conditions
Remarks: The Main Installation is maintained by the property owners, primarily the Memphis Depot Industrial Park, and is in good condition. The remaining federal property on Dunn Field is maintained by Army contractors; it is regularly mowed April to October and a drive-by inspection is made weekly.
VII. LANDFILL COVERS □ Applicable X N/A
VIII. VERTICAL BARRIER WALLS □ Applicable X N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES X Applicable □ N/A
Section A revised for the AS/SVE system
A. ~~Groundwater Extraction Wells, Pumps, and Pipelines~~ **Air Sparging with Soil Vapor Extraction** X Applicable □ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** X Good condition □ All required wells properly operating X Needs Maintenance □ N/A Remarks The AS/SVE system consists of 90 AS wells, 12 SVE wells, 10 vapor monitoring points (VMPs) and two equipment buildings with an AS air compressor, two SVE blowers and system controls. The AS and SVE wells are connected to the compressor or blower manifold via piping in trenches backfilled with soil. The system is in generally good condition but needs maintenance to remove water from SVE lines and to reconnect about 10% of the AS wells. The required maintenance has not significantly impacted system operations based on AS and SVE flow rates or groundwater concentrations reported in LTM. The compressor and blowers are maintained and repaired as needed by the original manufacturer (Kaeser) which has a shop in Memphis. The electrical system is maintained by a local contractor (TriState Armature & Electric) and is in good condition; surge protectors and additional grounding were installed following the system damage from lightning in 2014.
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** X Good condition X Needs Maintenance Remarks: Condensate generated by the AS compressor and the SVE blowers is transferred to an outside 500-gallon tank within a fenced enclosure. The transfer piping is functional but needs to be replaced and protected from freezing during winter; that is planned for 2018.

3. **Spare Parts and Equipment**
□ Readily available **X** Good condition □ Requires upgrade □ Needs to be provided
Remarks

B. Surface Water Collection Structures, Pumps, and Pipelines □ Applicable **X** N/A

C. Treatment System □ Applicable **X** N/A

1. **Treatment Train** (Check components that apply)
□ Metals removal □ Oil/water separation □ Bioremediation
□ Air stripping □ Carbon adsorbers
□ Filters _____
□ Additive (*e.g.*, chelation agent, flocculent)_____
□ Others_____
□ Good condition □ Needs Maintenance
X Sampling ports properly marked and functional
□ Sampling/maintenance log displayed and up to date
□ Equipment properly identified
□ Quantity of groundwater treated annually NA
□ Quantity of surface water treated annually NA
Remarks: Treatment of vapor removed by the SVE system is not required based on results of quarterly vapor samples.
Sampling and maintenance activities are recorded on forms from the O&M Plan and stored electronically.

2. **Electrical Enclosures and Panels** (properly rated and functional)
□ N/A **X** Good condition □ Needs Maintenance
Remark:

3. **Tanks, Vaults, Storage Vessels**
□ N/A **X** Good condition □ Proper secondary containment **X** Needs Maintenance
Remarks: Vessels are limited to pressure equalization tank for the AS compressor, an air/water separator for the SVE blower and storage tanks for condensate. The transfer pipe for condensate needs to be replaced in 2018.

4. **Discharge Structure and Appurtenances**
X N/A □ Good condition □ Needs Maintenance
Remarks:

5. **Equipment ~~Treatment~~ Building(s)**
X N/A **X** Good condition (esp. roof and doorways) □ Needs repair □ Chemicals and equipment properly stored
Remarks: AS and SVE buildings are in good condition.

6.	**Monitoring Wells** (LTM ~~pump and treatment remedy~~) **X** Properly secured/locked □ Functioning **X** Routinely sampled **X** Good condition **X** All required wells located **X** Needs Maintenance □ N/A Remarks: There are 147 monitoring wells for the Main Installation and 85 monitoring wells for Dunn Field. All wells are used for water level measurements during semiannual LTM events; the wells are assigned for semiannual, annual or biennial sampling based on past results or location. Well conditions are assessed during water level measurements. Wells that are damaged and not usable are scheduled for abandonment; other well maintenance (new locks, manholes or well pads) is made as needed.

D. Monitoring Data	
1.	Monitoring Data □ Is routinely submitted on time □ Is of acceptable quality
2.	Monitoring data suggests: □ Groundwater plume is effectively contained □ Contaminant concentrations are declining

D. Monitored Natural Attenuation

Monitored natural attenuation is listed as a component of the groundwater remedy for OU-1 (Dunn Field), but there is little evidence for natural biological degradation of contaminants which is consistent with aerobic conditions and low natural carbon content in the Fluvial aquifer.

Monitoring wells are maintained for long-term monitoring, also a component of the remedy, on the Main Installation and Dunn Field, as noted in C. 6. above.

1.	**Monitoring Wells** (natural attenuation remedy) □ Properly secured/locked □ Functioning □ Routinely sampled □ Good condition □ All required wells located □ Needs Maintenance **X** N/A Remarks

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). The AS/SVE system was installed to cross the core of the plume near the downgradient end in order to intercept the majority of the Off Depot CVOC plume and to reduce individual CVOC concentrations to 50 µg/L or less. The AS/SVE system is to continue operations until upgradient concentrations do not exceed 50 µg/L for individual CVOCs. Since April 2012, only TCE in one LTM well near the AS/SVE system, MW-159, has exceeded the 50 µg/L objective. Additional AS wells will be installed south of MW-159 to increase removal of CVOCs from groundwater. The new AS wells will be installed upon completion of an updated access agreement with MLGW and will be incorporated into system operations following installation. Based on sustained reduction in CVOC concentrations following start of AS/SVE operations, the remedy is effective and functioning as designed. There was limited increase in CVOC concentrations in groundwater within the AS/SVE treatment area following shutdown due to damage from lightning in 2014, but CVOC concentrations were reduced after the system was restarted in 2015.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. AS/SVE system operating time has exceeded 90 percent since operations began, except during the equipment failure and repair in 2014 and 2015. HDR has managed AS/SVE operations since startup in 2009 and qualified subcontractors are used to perform required maintenance and repairs. The implementation and scope of O&M has been sufficient to maintain protectiveness of the remedy.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. There have not been unexpected changes in cost or scope of O&M. Maintenance of major equipment (compressor and blowers) and inspection when problems are identified is performed by qualified technicians from the original equipment manufacturer. There is no indication of future compromise in protectiveness of the remedy.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Opportunities for optimization are considered during preparation of annual reports for AS/SVE system and LTM. AS/SVE system operations have been adjusted periodically to reduce potential for plume diversion around the treatment area due to reduced permeability from air sparging. The LTM well classification system for LTM wells was revised the 2016 LTM report based on the aquifer and well location and updated criteria were established for sample frequency.

Attachment A

Site Maps

Legend

LTM Well Classification

MW-16	Background
MW-219	Boundary
MW-21	EBT-Performance
MW-88	Performance
MW-34	Sentinel
MW-268	To Be Determined

- Property Boundary
- Buildings *490 - DDMT Assigned Number*
- Roads

Groundwater Use Restrictions:

- No productive/consumptive use of groundwater or drilling of groundwater wells.

Land Use Restrictions:

- Area Available for Unrestricted Use
- No Residential Development or Child Daycare Uses

Figure 14

Main Installation Land Use Controls

2017 Site Management Plan

Defense Depot
Memphis, Tennessee

0 250 500
Feet

Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet , mean sea level

Date: June 2016
Edition: Rev 0

Path: W:\SMP\2017\14_Figure_14.mxd

Legend

LTM Well Classification

MW-04	Background
MW-07	Background-NE
MW-03	Performance-FSVE
MW-15	Performance
MW-250	Sentinel

- Original Dunn Field Boundary
- Fence
- Roads
- Railroad

Land Use Restrictions:

No residential development or child daycare uses.

Groundwater Use Restrictions:

No productive or consumptive use or drilling of groundwater wells.

No placement of groundwater wells within plume.

No placement of groundwater wells within a half mile of plume boundaries.

Figure 24

Dunn Field Land Use Controls

2017 Site Management Plan

Defense Depot
Memphis, Tennessee

N W E S

0 100 200
Feet

Projection: NAD 1927 StatePlane Tennessee
Units: Feet, Elevation Units: Feet , mean sea level

Date: 11/9/2016
Edition: Rev 0

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Attachment B

Interview Records

Telephone Record

Date:	Monday, June 26, 2017		
Project:	DDMT Land Use Controls Annual Inspection	Project No:	
Call to:	Greg Parker, Shelby County Health Department	Phone No:	901-222-9549
Call from:	Denise Cooper, HDR	Phone No:	901-268-2478
Subject:	DDMT Annual LUC Inspection 2017		

Discussion, Agreement, and/or Action:
I contacted Mr. Greg Parker of the Shelby Health Department, Water Quality Control division on June 28. 2016, as part of Land Use Controls Annual Site Inspection as his office manages permitting for the construction of groundwater wells within Memphis and Shelby County. I explained the purpose of the annual site inspection and described the land use controls in place at the Main Installation and Dunn Field regarding installation of production/consumptive use of groundwater wells at the former Defense Depot Memphis, Tennessee, or within the groundwater contamination plume west of Dunn Field. I asked Mr. Parker if his office had issued any permits for the construction of production/consumptive use groundwater wells at the former Depot or within contaminated groundwater down gradient of Dunn Field. Mr. Parker stated his office had not issued any permits for well construction within the prescribed area. I thanked him for the information and ended the call.

Prepared by:
Denise K. Cooper
HDR
Senior Environmental Analyst

Telephone Record

Date:	Thursday, June 29, 2017		
Project:	DDMT Land Use Controls Annual Inspection	Project No:	10058697 AC 8
Call to:	Anita Bunn, Colliers International	Phone No:	901-942-4939
Call from:	Denise Cooper, HDR	Phone No:	901-268-2478
Subject:	DDMT Annual LUC Inspection 2017		

Discussion, Agreement, and/or Action:
I contacted Ms. Anita Bunn of Colliers International on June 26, 2017, as part of Land Use Controls Annual Site Inspection. Colliers International manages 250.63 acres of property containing 4.2 million square feet of buildings owned by Mayfield Properties LP as well as 35.59 acres owned by the Depot Owners Association containing the Memphis Depot Parkway and storm water retention ponds at the former Defense Depot Memphis, Tennessee. I explained the purpose of the annual site inspection and described the land use controls in place at the Main Installation.

I asked her if Colliers International, Mayfield Properties, Depot Owners Association or, to the best of her knowledge, any of their tenants were using property for residential purposes or child-occupied facilities, including day care operations, and if they had constructed any production/consumptive use groundwater wells on the property. She confirmed that neither Colliers International, Mayfield Properties, Depot Owners Association, nor any of their tenants have used the property for residential purposes or child-occupied facilities, including day care operations, and that they have not constructed any production/consumptive use groundwater wells. I also requested that she provide via email a tenant list, tenant map and Memphis Depot Industrial Park property ownership map. I thanked her for the information and ended the call. On June 29, 2017, via email Ms. Bunn provided a Memphis Depot Industrial Park property ownership map, a tenant list and tenant map to further support her information that none of their property was being used for residential purposes or as child-occupied facilities, including day care operations

Prepared by:
Denise K. Cooper
HDR
Senior Environmental Analyst

Note: Based on the acreage information obtained during preparation of the 2014 Annual Land Use Controls Inspection, Mayfield Properties LP, EDGE and Barnhart Crane owned 467 acres; this leaves a discrepancy of 42 acres from the 2014 Site Management Plan property transfer status table that indicated the total should be approximately 509 acres. Since the inspection in July 2014, the three major property owners (Mayfield Properties LP, EDGE and Barnhart Crane)

created the Depot Owners Association and agreed that 35.59 acres of the Memphis Depot Industrial Park that was considered reserve property for roadways and storm water retention ponds would fall under the auspices of the Depot Owners Association. In 2014 Mayfield Properties LP and Barnhart Crane identified discrepancies in property boundaries that were rectified by a property survey completed on August 25, 2014; that survey indicates the four organizations own 508.04 acres.

Telephone Record

Date:	Monday, June 26, 2017		
Project:	DDMT Land Use Controls Annual Inspection	Project No:	10058697 AC 8
Call to:	Greg Ward, Barnhart Crane	Phone No:	901-568-5202
Call from:	Denise Cooper, HDR	Phone No:	901-268-2478
Subject:	DDMT Annual LUC Inspection 2017		

Discussion, Agreement, and/or Action:
I contacted Greg Ward, Barnhart Crane Yard Manager, on June 26, 2017, as part of the Land Use Controls Annual Site Inspection. An error on the figure provided in 2016 by Collier's International that was used to calculate property ownership resulted in a change of 25.3 acres from DRC/EDGE ownership to Barnhart Crane ownership in 2017. Barnhart Crane and Barnhart Real Estate LLC, which is associated with Barnhart Crane, currently own 143.75 acres including the buildings and former open storage areas on the west side of the former Defense Depot Memphis, Tennessee (DDMT) as well as the former administration building on Airways Blvd. I explained the purpose of the annual site inspection and described the land use controls in place at the Main Installation. I asked Mr. Ward if Barnhart Crane or Barnhart Real Estate LLC were using any of their property for residential or child-occupied purposes, including daycare operations, and if they had constructed any production/consumptive use groundwater wells. Mr. Ward replied that neither Barnhart Crane nor Barnhart Real Estate LLC used any of its property for residential or child-occupied facility purposes nor had they constructed any groundwater wells. I thanked him for his time and ended the call.
I re-contacted Mr. Ward on July 12, 2017 to confirm the acreage and asked about the community garden project. He confirmed Barnhart owns 143.75 acres. The community garden project is located in a small (less than 1/4 acre) fenced area on the northeast corner of their property. They sowed wildflowers directly in the soil and planted vegetables in eight raised containers.

Prepared by:
Denise K. Cooper
HDR
Senior Environmental Analyst

Note: Based on the acreage information obtained during preparation of the 2014 Annual Land Use Controls Inspection, Mayfield Properties LP, EDGE and Barnhart Crane owned 467 acres leaving a discrepancy of 42 acres from the 2014 Site Management Plan property transfer status table that indicated the total should be approximately 509 acres. Since the previous inspection in July 2014, the three major property owners (Mayfield Properties LP, EDGE and Barnhart Crane) created the Depot Owners Association and agreed that 35.59 acres of the Memphis

Depot Industrial Park Barnhart that was considered reserve property for roadways and storm water retention ponds would fall under the auspices of the Depot Owners Association. In 2014 Mayfield Properties LP and Barnhart Crane had identified discrepancies in property boundaries that were rectified by a property survey completed on August 25, 2014 that indicate these four organizations own 508.04 acres.

Telephone Record

Date:	Monday, June 26, 2017		
Project:	DDMT Land Use Controls Annual Inspection	Project No:	10058697 AC 8
Call to:	Randy Richardson, Director of Port of Memphis and Vice President of Port and Industrial Property for Economic Development Growth Engine of Memphis/Shelby County representing the Depot Redevelopment Corporation	Phone No:	901-948-4422
Call from:	Denise Cooper, HDR EOC	Phone No:	901-268-2478
Subject:	DDMT Annual LUC Inspection 2017		

Discussion, Agreement, and/or Action:
I contacted Randy Richardson of EDGE, which represents the Depot Redevelopment Corporation (DRC), on June 26, 2017, as part of the Land Use Controls Annual Site Inspection. An error on the figure provided in 2016 by Collier's International that was used to calculate property ownership resulted in a change of 25.3 acres from DRC/EDGE ownership to Barnhart Crane ownership in 2017. EDGE sold 8.17 acres to Supply Chain Solutions Leasing LLC in 2017. EDGE currently owns 69.88 acres of undeveloped property at the former Defense Depot Memphis, Tennessee. I introduced myself, explained about the annual site inspection and described the land use controls in place at the Main Installation. I asked Mr. Richardson if EDGE was using any of their property for residential purposes or child-occupied facilities, including day care operations and if they had constructed any production/consumptive use groundwater wells on their property. He responded that EDGE was not using any of its property for residential or child care facilities and they had not constructed any production/consumptive use groundwater wells. I thanked him for his time and the information.
I re-contacted Mr. Richardson on July 12, 2017 to confirm the acreage owned by EDGE. He confirmed that EDGE owns 69.88 acres.

Prepared by:
Denise K. Cooper
HDR
Senior Environmental Analyst

Note: Based on the acreage information obtained during preparation of the 2014 Annual Land Use Controls Inspection, Mayfield Properties LP, EDGE and Barnhart Crane owned 467 acres leaving a discrepancy of 42 acres from the 2014 Site Management Plan property transfer status table that indicated the total should be approximately 509 acres. Since the previous inspection in July 2014, the three major property owners (Mayfield Properties LP, EDGE and Barnhart Crane) created the Depot Owners Association and agreed that 35.59 acres of the Memphis Depot Industrial Park Barnhart that was considered reserve property for roadways and storm

water retention ponds would fall under the auspices of the Depot Owners Association. In 2014 Mayfield Properties LP and Barnhart Crane had identified discrepancies in property boundaries that were rectified by a property survey completed on August 25, 2014, that indicate these four organizations own 508.04 acres.

Telephone Record

Date:	Thursday, July 06, 2017		
Project:	DDMT Land Use Controls Annual Inspection	Project No:	10058697 AC 8
Call to:	Robert Keskey, Owner, Supply Chain Solutions	Phone No:	901-774-6533
Call from:	Denise Cooper, HDR	Phone No:	901-268-2478
Subject:	DDMT Annual LUC Inspection 2017		

Discussion, Agreement, and/or Action:
I contacted Robert Keskey, Supply Chain Solutions LLC, Owner, on July 6, 2017 via email, as part of the Land Use Controls Annual Site Inspection. In 2017, Supply Chain Solutions purchased 8.17 acres including Building 770 and the surrounding area from the Economic Development Growth Engine. In the email I explained the purpose of the annual site inspection and described the land use controls in place at the Main Installation. I asked Mr. Keskey if Supply Chain Solutions was using any of their property for residential or child-occupied purposes, including daycare operations, and if they had constructed any production/consumptive use groundwater wells. Mr. Keskey responded to the email on July 6, 2017 and replied that Supply Chain Solutions had not used any of its property for residential or child-occupied facility purposes nor had they constructed any groundwater wells.

Prepared by:
Denise K. Cooper
HDR
Senior Environmental Analyst

Telephone Record

Date:	Monday, June 26, 2017		
Project:	DDMT Land Use Controls Annual Inspection	Project No:	10058697 AC 8
Call to:	Vince Alfonso, Memphis Athletic Ministries Golf Operations Director	Phone No:	901-606-7332
Call from:	Denise Cooper, HDR	Phone No:	901-268-2478
Subject:	DDMT Annual LUC Inspection 2017		

Discussion, Agreement, and/or Action:
I contacted Vince Alfonso, Memphis Athletic Ministries (MAM) Golf Operations Director, on June 26, 2017, as part of the Land Use Controls Annual Site Inspection. Memphis Athletic Ministries leases from the City of Memphis the golf course area at the former Defense Depot Memphis, Tennessee (DDMT). I explained the purpose of the annual site inspection and described the land use controls in place at the Main Installation specific to the golf course – maintaining the fence around the golf course. I asked if MAM was responsible for maintaining the fence around the course and if so had there been any repairs since July 2016. Mr. Alfonso responded that MAM maintained the course fence and that there had been a large repair during the previous year. When a breach is discovered, South Memphis Fence completes repairs usually within 24 hours. He asked about the bollards around the north golf course monitoring well; I told him the bollards would be removed during the next round of monitoring well installation to be completed in 2017. We thanked each other for the information and ended the call.

Prepared by:
Denise K. Cooper
HDR
Senior Environmental Analyst

Attachment C

O&M Cost Breakdown

TABLE 1
AS/SVE COST SUMMARY
SITE INSPECTION, FOURTH FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

		Remedial Design Estimated Costs						Actual Costs				
	Year	Type	Construction	Sampling	O&M	PM & Tech Support	Total	Cumulative Costs	Construction & Repairs	O&M	Groundwater Monitoring	Total	Cumulative Costs
2009	0	Capital Cost	$2,549,069	$0	$0	$0	$2,549,069	$2,549,069	$2,180,395	$0	$0	$2,180,395	$2,180,395
2010	1	Annual	$0	$181,820	$174,102	$88,981	$444,903	$2,993,972	$0	$325,202	$182,333	$507,535	$2,687,930
2011	2	Annual	$0	$141,604	$110,182	$62,947	$314,733	$3,308,705	$0	$287,447	$61,978	$349,425	$3,037,355
2012	3	Annual	$0	$92,505	$110,182	$50,672	$253,359	$3,562,064	$0	$207,377	$60,948	$268,325	$3,305,680
2013	4	Annual	$0	$92,505	$110,182	$50,672	$253,359	$3,815,423	$0	$203,420	$62,280	$265,700	$3,571,380
2014 and 2015	5	Annual	$0	$92,505	$110,182	$50,672	$253,359	$4,068,782	$71,400	$215,566	$54,634	$341,600	$3,912,980
1/2016 to 5/2017	6	Annual	$0	$92,505	$0	$23,126	$115,631	$4,184,413	$33,862	$200,838	$61,169	$295,869	$4,208,849
5/2017 to 5/2018	7	Annual	$0	$92,505	$0	$23,126	$115,631	$4,300,044					
	8	Annual	$0	$92,505	$0	$23,126	$115,631	$4,415,675					
	9	Annual	$0	$92,505	$0	$23,126	$115,631	$4,531,306					
	10	Annual	$0	$92,505	$0	$23,126	$115,631	$4,646,937					
	11	Annual	$0	$57,868	$0	$14,467	$72,335	$4,719,272					
	12	Annual	$0	$57,868	$0	$14,467	$72,335	$4,791,607					
	13	Annual	$0	$57,868	$0	$14,467	$72,335	$4,863,942					
	14	Annual	$0	$57,868	$0	$14,467	$72,335	$4,936,277					
	15	Annual	$0	$57,868	$0	$14,467	$72,335	$5,008,612					
	16	Annual	$0	$57,868	$0	$14,467	$72,335	$5,080,947					
	17	Annual	$0	$57,868	$0	$14,467	$72,335	$5,153,282					
	18	Annual	$0	$57,868	$0	$14,467	$72,335	$5,225,617					
	19	Annual	$0	$57,868	$0	$14,467	$72,335	$5,297,952					
	20	Annual	$0	$57,868	$0	$14,467	$72,335	$5,370,287					
	21	Annual	$0	$39,197	$0	$9,799	$48,996	$5,419,283					
	22	Annual	$0	$39,197	$0	$9,799	$48,996	$5,468,279					
	23	Annual	$0	$39,197	$0	$9,799	$48,996	$5,517,275					
	24	Annual	$0	$39,197	$0	$9,799	$48,996	$5,566,271					
	25	Annual	$0	$39,197	$0	$9,799	$48,996	$5,615,267					
	26	Annual	$0	$39,197	$0	$9,799	$48,996	$5,664,263					
	27	Annual	$0	$39,197	$0	$9,799	$48,996	$5,713,259					
	28	Annual	$0	$39,197	$0	$9,799	$48,996	$5,762,255					
	29	Annual	$0	$39,197	$0	$9,799	$48,996	$5,811,251					
	30	Annual	$0	$39,197	$0	$9,799	$48,996	$5,860,247					
		Total	$2,549,069	$2,034,114	$614,830	$662,234	$5,860,247						

Memphis Depot. Dunn Field Off-Depot Groundwater Final Remedial Design. Defense Logistics Agency (CH2MHILL, 2008)

Actual Costs from HDR invoice summaries.