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TENNESSEE

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SECOND FIVE-YEAR REVIEW

Defense Depot Memphis, Tennessee

Defense Logistics Agency

e2M
engineering-environmental Management, Inc.

AFCEE Contract FA8903-04-D-8722
Task Order No. 0019

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Defense Depot Memphis, Tennessee

Prepared for:

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
BCT	BRAC Cleanup Team
bgs	Below Ground Surface
BRA	Baseline Risk Assessment
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Constituent of Concern
CVOC	Chlorinated Volatile Organic Compound
CWM	Chemical Warfare Material
DCE	Dichloroethene
DDMT	Defense Depot Memphis, Tennessee
DLA	Defense Logistics Agency
DRI	Design-related Investigation
EISR	Early Implementation of Selected Remedy
e^2M	engineering-environmental Management, Inc.
ERH	Electrical Resistance Heating
FFA	Federal Facilities Agreement
FS	Feasibility Study
GAC	Granular Activated Carbon
HHRA	Human Health Risk Assessment
IRACR	Interim Remedial Action Completion Report
ISTD	In Situ Thermal Destruction
IRA	Interim Remedial Action
LTM	Long-term Monitoring
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
MI	Main Installation
MIP	Membrane Interface Probe
MLGW	Memphis Light, Gas and Water
MNA	Monitored Natural Attenuation

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

MW	Monitoring Well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operations and Maintenance
PCA	Tetrachloroethane
PCE	Tetrachloroethene
PRB	Permeable Reactive Barrier
ppb	Parts per Billion
RA	Remedial Action
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
SDWA	Safe Drinking Water Act
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
TCE	Trichloroethene
TDEC	Tennessee Department of Environmental Conservation
USEPA	U.S. Environmental Protection Agency
VMP	Vapor Monitoring Point
VOC	Volatile Organic Compound
ZVI	Zero-valent Iron

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for

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1.0 INTRODUCTION

The lead agency for the environmental restoration activities at Defense Depot Memphis Tennessee (DDMT) is the Defense Logistics Agency (DLA). The regulatory oversight agencies are U.S. Environmental Protection Agency (USEPA) Region 4 and the Tennessee Department of Environmental Conservation (TDEC). The site identification number for DDMT is TN4210020570.

The purpose of the five-year review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports, and if any issues are identified during the review, recommendations are provided to address them.

This Five-Year Review report is prepared pursuant to CERCLA §121 and the National Contingency Plan (NCP). CERCLA §121 states: *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

USEPA interpreted this requirement further in the NCP; 40 CFR §300.430(f)(4)(ii) states: *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

engineering-environmental Management, Inc (e^2M), the Remedial Action (RA) contractor at DDMT, performed the review and prepared this report under Contract FA8903-04-D-8722, Task Order 0019 to the Air Force Center for Environmental Excellence. This review was performed in accordance with *Comprehensive Five-Year Review Guidance* (USEPA, 2001).

This is the second five-year review for DDMT. The triggering action for this statutory review was the completion of the initial five-year review, *Memphis Depot, Dunn Field, Five Year Review* (CH2M HILL, 2003). The initial statutory review was triggered by initiation of the Interim Remedial Action groundwater recovery system at Dunn Field on DDMT in 1998. The five-year review is required because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure.

2.0 SITE CHRONOLOGY

Year	Activity
1944 - 1997	Supply Distribution activities
1980s	Initial Installation Assessment completed in 1981. Compliance programs established for DA and DOD regulations and local, state, and federal regulatory programs including the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act (SDWA), RCRA, and the Toxic Substances Control Act.
1990	On 28 September 1990, USEPA Region 4 and TDEC issued the Depot a RCRA Part B permit for the storage of hazardous waste (No. TN4 210-020-570). The 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 USC, USEPA prepared a final Hazard Ranking System (HRS) Scoring Package for the facility.
1992	On 14 October 1992, based on the final HRS score of 58.06, 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 an 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 RI/Feasibility Study (FS) Work Plan was prepared to indicate how the RI and FS would be accomplished. USEPA and TDEC approved RI/FS Field Sampling Plans (FSPs) for each 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 DRC were given the responsibility of planning and coordinating the reuse of the Depot.

1996	USEPA and TDEC approved a ROD for an Interim Remedial Action (IRA) for Groundwater at Dunn Field.
1997	Sampling of RI, screening, and BRAC sites was conducted on the MI.
1997 - 1998	During 1997 and 1998, the Depot requested and received closure of its air permits, underground storage tank (UST) permits, stormwater 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 PCB contaminated soil removal action at Bldg 274. Phase 1 of the IRA was completed with the installation of 7 recovery wells and the discharge piping system; the system was expanded in 2001, with 4 additional recovery wells.
1999	The Depot completed a lead contaminated soil removal project at the old paint shop and maintenance area (Parcels 35 and 28). Additional monitoring wells were installed west of Dunn Field to provide more information regarding the hydrogeology of the area. Additional recovery wells for the IRA system were approved by the BCT and installed by the end of 1999. The Depot completed RI fieldwork at the MI and started fieldwork for Dunn Field.
2000	The Depot began the removal action for CWM disposal locations at Dunn Field. The Depot completed and provided to the public the MI RI Report, FSs for Soil and Groundwater, and 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 ROD, DLA exercised its removal authority under CERCLA Section 104, as delegated in EO 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 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. Dunn Field Five Year Review. Dunn Field Proposed Plan. Dunn Field disposal site confirmation sampling .

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. Main Installation Final Remedial Design (RD). Dunn Field Disposal Sites Final RD. CVOC concentrations above 500 micrograms per liter (µg/L) in downgradient monitoring wells 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. Early Implementation of Selected Remedy Work Plan Main Installation Land Use Control Implementation Plan Post-ROD Community Involvement Plan
2005	MI Notice of Land Use Restrictions filed with Shelby County Registrar on 26 January 2005. Dunn Field Disposal Sites RA begun March 2005. Early Implementation of Selected Remedy (EISR) Interim Remedial Action Completion Report (IRACR) TDEC denied renewal of the Depot's Hazardous Waste Corrective Action Permit terminating DDC'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)
2006	The Depot completed the Disposal Sites RA in March 2006 and received USEPA approval of the Disposal Sites Remedial Action Completion Report on 25 August 2006. The Depot completed the Dunn Field Source Areas remedial design investigation in March 2006 Completed construction of the ZVI PRB implementation study in June 2006. Began construction of the enhanced bioremediation treatment system in May 2006 and completed construction and began MI RA operations in September 2006.
2007	Completed Dunn Field Source Areas RD Completed Source Areas Fluvial SVE RAWP Dunn Field Source Areas RA begun May 2007 Completed construction and began operation of the Fluvial SVE in July 2007 Completed Source Areas Loess/ Groundwater RAWP

3.0 BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

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 642 acres and includes two components: the Main Installation (MI) and Dunn Field (Figure 2). The MI contains approximately 578 acres with open storage areas, warehouses, former military family housing, and outdoor recreational areas. Dunn Field, which is located across Dunn Avenue from the north-northwest portion of the MI, contains approximately 64 acres and includes 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.

The Depot terrain is relatively level, with elevations ranging from 282 to 300 feet above mean sea level (msl). There are only two surface water bodies on the Depot, Lake Danielson and the golf course pond. No perennial streams, flood-prone areas, or wetlands occur within the Depot. The lake and pond are fed by stormwater runoff and are too shallow to intercept the fluvial aquifer.

The geologic units of interest at DDMT are (from youngest to oldest): loess, including surface soil; fluvial deposits; Jackson Formation/Upper Claiborne Group; and Memphis Sand. The loess consists of wind-blown and deposited, brown to reddish-brown, low-plasticity clayey silt to silty clay. The loess deposits are about 20 to 30 feet thick and are continuous throughout the site area.

The fluvial (terrace) deposits consist of two general layers. The upper layer is a silty, sandy clay that transitions to a clayey sand and ranges from about 10 to 36 feet thick. The lower layer is composed of interlayered sand, sandy gravel, and gravelly sand, and has an average thickness of approximately 40 feet. The uppermost aquifer is the unconfined fluvial aquifer, consisting of saturated sands and gravelly sands in the lower portion of the deposits. The saturated thickness of the fluvial aquifer ranges from 3 feet to 50 feet and is controlled by the configuration of the uppermost clay in the Jackson Formation/Upper Claiborne Group. This uppermost clay layer does not appear to be present at the base of the fluvial deposits in the northwestern part of the MI and the southwestern part of Dunn Field. Water level data indicate that there also may be gaps in the clay west and northwest of Dunn Field. Where present, these gaps create connections to the underlying intermediate aquifer from the fluvial deposits. Groundwater contour maps for the fluvial aquifer on the Main Installation and Dunn Field are shown on Figures 3 and

4, respectively. Water from the fluvial aquifer is not currently used as a source of drinking water by the City of Memphis.

The Jackson Formation/Upper Claiborne Group consists of clays, silts, and sands. The intermediate aquifer is locally developed in deposits of the Jackson Formation/Upper Claiborne Group. The Memphis Aquifer primarily consists of thick-bedded, white to brown or gray, very fine-grained to gravelly, partly argillaceous and micaceous sand. Lignitic clay beds constitute a small percentage of the total thickness. The Memphis Aquifer ranges from 500 to 890 feet in thickness and begins at a depth below ground surface (bgs) of approximately 120 to 300 feet. The Memphis Aquifer is confined by overlying clays and silts in the Cook Mountain Formation (part of the Jackson/Upper Claiborne Group) and contains groundwater under strong artesian (confined) conditions regionally. The City of Memphis obtains the majority of its drinking water from this unit. The Allen Well Field, which is operated by Memphis Light, Gas and Water (MLGW), is located approximately 2 miles west of Dunn Field.

3.2 LAND AND RESOURCE USE

The DDMT property was used for cotton farming prior to purchase by the U.S. Army in 1940. DDMT was officially activated on January 26, 1942 as the Memphis General Depot. Its initial mission was to provide stock control, storage, and maintenance services for the Army Engineer, Chemical and Quartermaster Corps. During World War II, DDMT served as an internment center for 800 prisoners of war and performed supply missions for the Signal and Ordnance Corps. From 1963 until closure, the facility was a principal distribution center for DLA (formerly the Defense Supply Agency) for shipping and receiving a variety of materials including hazardous substances; textile products; food products; electronic equipment; construction materials; and industrial, medical, and general supplies. In 1995, DDMT was placed on the list of the Department of Defense facilities to be closed under Base Realignment and Closure (BRAC). Storage and distribution of material continued until the facility closed in September 1997.

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 the Depot south to the Interstate 240 interchange. Memphis Light, Gas, and Water operates a large substation located northwest of Dunn Field along Person Avenue. The Frisco Railroad and Illinois Central Gulf Railroad rail lines are north of Dunn Field. A number of large

industrial and warehousing operations are located along the rail lines in this area. A triangular area located immediately north of the MI along Dunn Road also contains several industrial firms. Zoning controls and subdivision requirements are under the jurisdiction of the Memphis and Shelby County Office of Planning and Development. DDMT is currently zoned for Light Industrial (I-L) uses.

After DDMT was placed on the BRAC closure list, the City of Memphis and County of Shelby established the Memphis Depot Redevelopment Agency, now the Depot Redevelopment Corporation (DRC), to plan and coordinate the reuse of the Depot. The DRC conducted several public meetings to obtain community feedback on future land use plans. The DRC board of directors, the City of Memphis, and Shelby County approved the *Memphis Depot Redevelopment Plan* in 1997. The intended land use is industrial for the MI and the majority of Dunn Field; the northeast section of Dunn Field was identified for recreational use.

In September 1997, Department of the Army (DA) provided DRC a Master Interim Lease for the MI; parcels were made available for sublease by DRC through a series of Finding of Suitability to Lease (FOSL) documents prepared by DLA and approved by DA. As of August 1999, all property on the MI was approved for sublease. In March 2003, DA signed a supplemental agreement converting the Master Interim Lease to a Lease in Furtherance of Conveyance (LIFC) granting DRC immediate, exclusive, possessory interest in the leased properties and extending the term to 31 August 2052. Since October 1997, DRC has completed 27 subleases accounting for the reuse of more than 4 million square feet of covered and uncovered facilities (94% of the MI) and the production of approximately 982 jobs.

All of the DDMT property is to be transferred for re-use. Parcels are made available for transfer through a series of Finding of Suitability to Transfer (FOST) documents prepared by DLA and approved by DA. Three FOSTs have been completed for the MI with a total of 381 acres transferred to Alpha Omega Veterans (housing), City of Memphis (golf course and police precinct) and the DRC (Memphis Depot Business Park). One FOST for 41 acres has been completed for Dunn Field. The City of Memphis received 1.5 acres for Hayes Road widening and was to receive the remaining 39.5 acres for parkland. However, the City of Memphis declined the deed and the property was put up for public sale. The sale is scheduled to be completed in August 2007.

3.3 HISTORY OF CONTAMINATION

Starting in the 1940s, DDMT received, warehoused, and distributed supplies common to all U.S. military services and some civilian agencies. Activities at the MI included storing and shipping various materials

(e.g., food, clothing, medical supplies) and industrial supplies (e.g., hazardous materials).. Hazardous materials that were used or stored at the Depot during its operational period included flammables, solvents, petroleum/oil/lubricants (POL), paints, pesticides, herbicides, wood treating products, oxidizers, corrosives, and reactives. During the 1940s and 1950s, a pistol range was located in the present golf course area.

Types of past activities that could result 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 CVOCs in groundwater above background concentrations at the MI.

Historically, Dunn Field was used as a landfill; as a pistol range; for storage of mineral stockpiles; and for periodic testing of flamethrowers, smoke generators, and smoke pots using diesel fuel and fog oil. The pistol range building also was used for pesticide and herbicide storage. Mineral stockpiles were maintained for many years as part of the Defense National Stockpile. These stockpiles have been sold to private industry and removed.

Disposal activities at Dunn Field began in July 1946 when 29 mustard-filled German bomb casings and mustard-contaminated items (railcar wood, clothing, etc.) were decontaminated, destroyed (via burning) and buried. This activity included the use of Decontaminating Agent Non-Corrosive (DANC), an organic N-chloroamide compound in solution with 1,1,2,2-tetrachloroethane (PCA). A mixture similar to DANC formulations (S-210 suspension formulation) contained tetrachloroethene (PCE).

During the early to mid-1950s, Chemical Agent Identification Sets (CAIS) were allegedly disposed of and buried at Dunn Field (USATHAMA, 1982). A search of the archived records also indicated that the remains of destroyed (burned or detonated) explosive ordnance (OE) consisting of military souvenirs, such as a 3.2-inch mortar round, smoke pots, chloroacetophenone (CN [also known as tear gas agent]) canisters, and smoke grenades, were occasionally buried in pits in the Disposal and Stockpile Areas. Based on completion of early response actions, the USACE issued a Statement of Clearance for Chemical Warfare Materiel (CWM) and OE at Dunn Field in August 2003.

Other chemicals were reported buried in Dunn Field. Use and disposal of unknown quantities of chlorinated lime, super topical bleach (STB) and calcium hypochlorite (HTH) is documented. Food stocks, paints/thinners, petroleum/oil/lubricants (POL), acids, herbicides, mixed chemicals, and medical waste were also reportedly destroyed or buried in pits and trenches at Dunn Field (USACE, 1995a,b). These are the sources for the chlorinated volatile organic compounds (CVOCs) found in the soil and groundwater at Dunn Field.

The Depot was a RCRA generator of hazardous wastes in Tennessee under generator No. TN 4210020570. The majority of hazardous wastes generated by the Depot consisted of hazardous substances that reached shelf-life expiration dates and could no longer be used by the military services, and from vehicle maintenance. The Depot also generated hazardous wastes from the cleanup of small hazardous substance spills.

3.4 INITIAL RESPONSE

On 28 September 1990, USEPA Region 4 and TDEC issued the Depot a RCRA Part B permit for the storage of hazardous waste. The permit included requirements for the identification and, if necessary, corrective action of Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs). Subsequent to issuing the permit, and in accordance with Section 120(d)(2) of CERCLA, and Title 42, Section 9620(d)(2), of the USC, USEPA prepared a final Hazard Ranking System (HRS) Scoring Package for the facility. On 14 October 1992, based on the final HRS score of 58.06, USEPA added the Depot to the NPL (57 Federal Register 47180 No. 199).

In March 1995, a Federal Facilities Agreement (FFA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Section 120, and Resource Conservation and Recovery Act, Sections 3008(h) and 3004(u) and (v), was entered into by the agencies. The FFA outlined the process for site investigation and cleanup at DDMT under CERCLA.

The following response actions were taken at the MI prior to completion of the ROD. The locations are shown on Figure 5.

- Approximately 602 cubic yards (cy) of soil from the PCP dip vat area (Building 737) in Functional Unit 4 (FU4) was excavated, transported, and disposed offsite because of elevated levels of PCP (completed in 1985).
- Approximately 3,700 cy of soil in the Housing Area of FU6 was excavated, transported, and disposed offsite 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 was excavated, transported, and disposed offsite because of elevated levels of PCBs (completed in November 1998).
- Approximately 980 cy_3 of surface and subsurface soil from near Buildings 1084, 1085, 1087, 1088, 1089 and 1090 was excavated, transported, and disposed offsite 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. The locations are shown on Figure 6.

- Approximately 914 cy of soil contaminated with mustard degradation by-products, 19 cy of mustard-contaminated soil and 29 bomb casings were excavated, transported, and disposed offsite (completed in March 2001).
- Approximately 930 cy of lead-contaminated surface soil from the former pistol range was excavated, transported, and disposed offsite (completed in March 2003).

The original Part B RCRA permit issued by TDEC for a hazardous waste storage facility was terminated by TDEC on 22 October 1998 upon request from DLA because DDMT had been closed and the storage facility had not been constructed or operated. The HSWA portion of the RCRA permit issued by USEPA Region 4 for the purpose of RCRA corrective action for releases from SWMUs remained in effect. Based on requirements of TDEC and USEPA, the Depot submitted a corrective action permit renewal application on 29 March 2004. On 19 January 2005, TDEC issued DDC a Denial to Reissue the Hazardous Waste Corrective Action Permit, which terminated the Depot's requirement to continue corrective action under the hazardous waste management regulations and noted that all corrective action activities shall continue to be performed under CERCLA authority.

3.5 BASIS FOR TAKING ACTION

To assist investigations conducted at DDMT under the requirements of CERCLA and the NCP, the facility was divided into four Operable Units (OUs). Dunn Field, located north of the MI and identified as OU-1, is the only known and documented burial area on the Depot. The MI was divided into three OUs (2 through 4). OU-2 is located in the southwestern quadrant of the MI area of the Depot and is characterized as an industrial area where maintenance and repair activities took place. OU-3 is located in

the southeastern quadrant of the MI area and contains the entire southeastern watershed and golf course. OU-4 is located in the north-central section of the MI area where material storage took place. The MI was also divided into seven Functional Units (FUs) based on similar historical use for conducting baseline risk assessments (Figure 5).

3.5.1 Main Installation

Field investigations as part of the RI were conducted from 1995 through 1999 to characterize the contamination in surface and subsurface soil, groundwater, surface water, and sediment at the MI and surrounding areas. A phased approach was used to implement observational methods of investigation. Soil, surface water, and sediment samples were collected from the first RI/FS sampling event for each site at locations and depths of most probable contamination based on available information. At least one sample from each FU was analyzed for the target compound list/target analyte list (TCL/TAL). Efforts were made to analyze for the TCL/TAL on samples from the area of known highest contamination from previous sampling events, or the areas of most probable contamination as discussed above, to increase the likelihood of detecting compounds not previously identified at the site.

If, at any point, analytical results indicated either that contamination was not present or that the nature and extent of contamination had been defined based on comparison to the higher of either the background or risk-based concentration (RBC) of target compounds, no subsequent sampling was performed. However, if these criteria were not met, additional samples were collected and analyzed to more fully assess the nature and extent of contamination.

The soil COCs identified for consideration in the FS for surface soil included two metals (lead and arsenic) and the chlorinated pesticide dieldrin. A baseline risk assessment (BRA) was conducted for each of the FUs at the MI. Overall results indicate that, under current (limited) land use conditions at the MI, no threat to human health or ecological receptors exists above acceptable limits. Health risks to industrial workers are 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 are present at levels that do not allow for unrestricted use and unlimited exposure.

The COCs identified for consideration in the groundwater FS were PCE and TCE. Although contaminated groundwater poses an unacceptable risk through the ingestion pathway, none of the available RI or subsequent groundwater data suggest that DNAPLs occur in the groundwater under the MI. Specific MI sources of the VOC plumes were not identified during the RI or previous studies.

Considering the nature of the operations at the MI, it is likely that the plumes resulted from multiple small volume, undocumented releases, both on- and off-site.

Results from the BRA presented in the RI 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. Additionally, it was concluded that the ecological risk at FU2 is negligible, and there is no need for remediation based on ecological risk.

3.5.2 Dunn Field

From 1998 through 2002, DDMT conducted a Remedial Investigation (RI) (CH2M HILL, 2002) and a Feasibility Study (FS) (CH2M HILL, 2003) for Dunn Field. The RI/FS identified the types, quantities, and locations of substances detected in the environment and studied the feasibility of potential cleanup solutions. Dunn Field was divided into three geographic areas to facilitate the investigation (Figure 7).

- Northeast Open Area – Approximately 20 acres of land located in the northeast quadrant of Dunn Field. This area is mostly grass covered with some lightly wooded areas.
- Disposal Area – Approximately 14 acres of open land located in the northwest quadrant of Dunn Field, where the majority of disposal sites are located.
- Stockpile Area - Approximately 30 acres of open land located in the southeastern and southwestern portions of Dunn Field. This area includes the former bauxite and fluorspar stockpiles (removed in 1999) and burial areas in the eastern and southwestern portions of Dunn Field.

As a result of the risk assessment, the ROD determined that the eastern portion of Dunn Field, including most of the Northeast Open Area and the Stockpile Area with approximately 41 of the total 64 acres, is suitable for unrestricted use and unlimited exposure (Figure 7). The property was transferred to a private owner on 17 October 2007. The owner has proposed a warehousing and distribution center for the site.

The selected remedy in the ROD addresses buried wastes and associated soil within disposal sites, volatile organic compounds (VOCs) in subsurface soils, and chlorinated volatile organic compounds (CVOCs) in groundwater.

Disposal Sites

The Disposal Sites were prioritized according to historical records indicating the estimated quantity of material within each site, potential hazards of the material, and form of the material (i.e., solid versus

liquid). Seventeen sites were designated as high or medium priority sites (Level A and Level B) and were identified for additional investigation during the RD. The remaining 25 low priority sites (Level C) were determined to not require remedial action. The sites are listed on Table 1.

Disposal Area – Subsurface Soils

The following CVOCs were detected at elevated concentrations in subsurface soils in the Disposal Area:

- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- 1,2 Dichloroethene (1,2-DCE)
- Vinyl Chloride
- 1,1,2,2 Tetrachloroethane (1,1,2,2-PCA)
- 1,1,2 Trichloroethane (1,1,2-TCA)
- Carbon Tetrachloride (CCl_4)
- Chloroform

VOCs detected by laboratory analysis of soil samples correlate well with the extent of VOCs detected during a passive soil gas survey. The apparent clustering of the higher VOC concentrations correlates with the historical information indicating that the disposal pits and trenches were relatively small and separate. VOCs have been transported from near the base of the disposal trenches (8 to 10 feet below ground surface [bgs]) to the fluvial aquifer (up to 83 feet bgs). There is a complete migration pathway from disposal area to subsurface soil and then to groundwater for CVOCs.

Groundwater

The nature and extent of contamination in the fluvial aquifer underlying Dunn Field and areas to the west were assessed during the RI based on groundwater samples collected during 16 sampling events from January 1996 through February 2001. Groundwater samples were collected and analyzed for the presence of explosives, herbicides, metals (total), pesticides, polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), and VOCs. Groundwater samples were also analyzed for chemical warfare material (CWM) breakdown products, including Thiodiglycol, 1,4-Oxathiane, and 1,4-Dithiane. Of these parameters, VOCs, SVOCs, and total metals were the most frequently detected analytical constituents in groundwater samples. Based upon further review, metals and SVOCs were not selected as constituents of concern (COCs) for groundwater and will not be addressed in the remedial action.

The investigation identified three major CVOC plumes in the shallow groundwater under Dunn Field: a northern plume, a central plume, and a southern plume. There is some mixing of the plumes, as expected from influence by the active groundwater extraction system, natural groundwater flow, and degradation processes. All of the plumes have on- and off-site components. Nine primary CVOCs have been detected in groundwater during sampling events, including

- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- (Cis & Trans)1,2 Dichloroethene (1,2-DCE)
- 1,1 Dichloroethene (1,1-DCE)
- 1,1,2,2 Tetrachloroethane (1,1,2,2-PCA)
- 1,1,2 Trichloroethane (1,1,2-TCA)
- Carbon Tetrachloride (CCl_4)
- Chloroform

The plume along the northern boundary of the site contains PCE, TCE, and 1,1-DCE. The plume is considered to have both on-site and off-site sources since TCE, and 1,1-DCE have been detected in off-site monitoring wells, which are upgradient to the northeast of Dunn Field. Additional sampling and analysis are being performed by USEPA and TDEC to identify the off-site source area.

The central plume is a mixture of PCE, TCE, 1,2-DCE, 1,1-DCE, 1,1,2,2-PCA, 1,1,2-TCA, CCl_4, and chloroform. Off-site portions of this plume flow to the west and northwest. The southern plume is principally composed of 1,1,2,2-PCA, CCl_4, 1,1,2-TCA, and chloroform, but contains TCE, PCE, and 1,2-DCE. The suspected sources of the central and southern plumes appear to be located within the Disposal Area of Dunn Field.

Subsurface soils, including the disposal sites, in the Disposal Area are considered to be principal threat wastes, which have significantly degraded groundwater quality in the shallow fluvial aquifer. Based on the highest observed concentration of the detected solvents TCE and 1,1,2,2-PCA in groundwater, free-phase solvents may be present in Dunn Field groundwater and would be considered principal threat wastes. However, free-phase solvents were not detected during the RI or subsequent remedial design-related investigations.

4.0 REMEDIAL ACTIONS

4.1 REMEDY SELECTION

DDMT is divided into four Operable Units (OUs): Dunn Field, OU 1; Southwest Quadrant MI, OU 2; Southeastern Watershed and Golf Course, OU 3; and North-Central Area MI, OU 4. The *Record of Decision for the Interim Remedial Action of the Groundwater at Dunn Field (OU-1)* (CH2M HILL, 1996) was the initial ROD. The *Dunn Field, Final Record of Decision* (CH2M HILL, 2004b) addresses all media at OU 1, the only known and documented waste burial area. Disposal records and interviews with facility personnel identified specific instances when some waste burials occurred, with the earliest record of burial in 1946. The *Main Installation, Final Record of Decision* (CH2M HILL, 2001) includes OUs 2, 3, and 4.

4.1.1 Interim Remedial Action

The Interim Remedial Action (IRA) ROD was completed in January 1996 and 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 contaminants of concern were the following volatile organic compounds and metals:

- Carbon Tetrachloride (CCl4)
- 1,2-Dichloroethene (1,2-DCE)
- 1,1,2,2–Tetrachloroethane (1,1,2,2-PCA)
- 1,1-Dichloroethene (1,1-DCE)
- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- Arsenic
- Barium
- Chromium

- Lead
- Nickel

The final cleanup levels for groundwater were stated to be beyond the scope of this action and would be addressed in the final Dunn Field ROD.

The major components of the selected IRA include the following:

- Evaluation of aquifer characteristics which may include installation of a pump test well
- Installation of additional monitoring wells to locate the western edge of the groundwater plume
- Installation of recovery wells along the leading edge of the plume
- Obtaining discharge permit for disposal of recovered groundwater to the municipal sewer system
- Operation of the system of recovery wells until the risk associated with the contaminants is reduced to acceptable levels or until the final remedy is in place
- Chemical analysis to monitor the quality of the discharge in accordance with the city discharge permit requirements; the permit will include parameters to be monitored and frequency.

4.1.2 Main Installation

The MI ROD received final approval on September 6, 2001. The selected remedy addresses the remediation of surface soil and groundwater contamination, which will allow the transfer or lease of the MI property for its intended land use. The selected surface soil remedy consists of land use controls for FUs 1 through 6, coupled with excavation, transport, and off-site disposal of an estimated 7,200-ft_2 area of surface soil in FU4. The selected groundwater remedy for FU7 is enhanced bioremediation, which includes land use controls and long-term monitoring.

The groundwater RAOs are:

- prevent ingestion of water contaminated with VOCs in excess of MCLs from potential future on-site wells;
- restore groundwater to levels at or less than MCLs; and
- prevent migration horizontally and vertically off-site of groundwater contaminants in excess of MCLs for TCE (5 µg/L) and PCE (5 µg/L).

The surface soil RAO for protection of industrial workers is to prevent direct contact/ingestion of surface soils contaminated with lead in excess of industrial worker risk-based criteria (1,536 mg/kg). The surface soil RAO for protection of future on-site residents is to prevent direct contact/ingestion of surface soils contaminated with dieldrin and arsenic in excess of Human Health Risk Assessment (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. The RAOs will reduce the excess cancer risk and HI associated with exposure to contaminated soil to acceptable levels to future workers and will prevent future residential development of the site. This will be achieved by reducing the exposure concentration of lead to the target clean-up level of 1,536 mg/kg (calculated using blood-lead uptake models) and by imposing land use restrictions. Because there are no federal or state clean-up standards for soil contamination, these clean-up standards were established on the basis of the HHRA.

The major components of the selected remedy are:

- Excavation, transportation, and off-site disposal at a permitted landfill of an estimated 7,200 ft2 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 the following:
    - 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.
    - Elimination of casual access by adjacent off-site residents through maintenance of a boundary fence surrounding FU2.
- Enhanced bioremediation of chlorinated volatile organic compounds (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.

The land use controls (deed restrictions and site controls) that are included as part of the selected remedy provide additional layers of protection above the existing land use and groundwater controls as established by the: (1) City of Memphis and Shelby County zoning regulations; (2) Federal Property Management Regulations; and (3) Ground Water Quality Control Board for the City of Memphis and Shelby County.

The MI ROD included explanation of two significant changes from the remedy presented in the Proposed Plan:

- The plan identified Land Use Controls as the preferred alternative for each FU and the plan called for deed restrictions in conjunction with land use controls. In FU2, the Proposed Plan called for no fishing or swimming in Lake Danielson and the Golf Course Pond for safety reasons. During the public comment period, review of the Administrative Record indicated that human health risks from Lake Danielson and the Golf Course Pond do not materially increase the total risk at FU2. Absent such risk, there is no basis under CERCLA for a specific response action to address the two water bodies. Therefore, deed restrictions were not required for the prevention of fishing and swimming in Lake Danielson and the Golf Course Pond.
- The area of lead soil contamination located in FU 4 adjacent to building 949 was located in a key area for BRAC re-use. In order to accommodate the economic redevelopment of this site, the DLA exercised its removal authority under CERCLA Section 104 and removed the lead contaminated soil subsequent to development of, but prior to final execution of this ROD. This action had no effect on the protectiveness of the selected remedy because it merely expedited the soil response action. EPA and TDEC participated in oversight of the action to the same degree that they otherwise would have done if it had been conducted as part of the final remedy. However, the early completion of this action effectively eliminated it as part of the selected remedy and resulted in the explanation in the ROD.

4.1.3 Dunn Field

The Dunn Field ROD received final approval on 12 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.

Disposal sites

- Prevent groundwater impacts from a release of buried containerized hazardous liquids and the leaching of contaminants from buried hazardous solids.
- 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.
- 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.
- Remediate fluvial aquifer groundwater to drinking water quality to be protective of the deeper Memphis aquifer.

Because there are no federal or state cleanup standards for soil contamination, target levels were established that would both reduce the risk associated with exposure to soil contaminants to an acceptable level, and ensure minimal migration of contaminants into the groundwater. The subsurface soils, primarily within the Disposal Area of Dunn Field, have residual CVOC levels that exceed the soil-to-groundwater migration-based screening levels, and that have potential for vapor intrusion to indoor air under possible future land use conditions. Site-specific target values were calculated for the loess and fluvial deposits and are summarized below (values are expressed in mg/kg or parts per million [ppm]):

Soil Remedial Goals

	Loess	Fluvial
PCE	0.180	0.092
TCE	0.182	0.093
cis 1,2-DCE	0.755	0.404
trans 1,2-DCE	1.520	0.790
Vinyl Chloride	0.024	0.015
1,1,2,2-PCA	0.011	0.006
1,1,2-TCA	0.062	0.035
CCl_4	0.215	0.108
Chloroform	0.917	0.486

A HHRA was completed as part of the Dunn Field RI (CH2M HILL, 2002). The findings for the CVOCs detected in the groundwater in the fluvial aquifer indicate that concentrations are high enough to make the water unfit for drinking either by industrial workers or residential receptors. Currently there is no exposure to the contaminated groundwater in the fluvial aquifer at Dunn Field. Thus, the focus of the remedial action is to protect human health from potential future exposures as well as to allow maximum beneficial uses of the fluvial aquifer.

Since multiple CVOCs were detected in groundwater at the site and in the immediate downgradient area, targeting to meet the maximum contaminant levels (MCLs) may not be 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). Following the USEPA guidance for Superfund sites, an upper-bound limit on target cumulative risk level of 1 in 10,000 ($1 X10^{-4}$) and an HI of 1.0 are selected as the **target remedial goals** for the plumes within and immediately downgradient of Dunn Field. Thus upon completion of the remedial actions the residual risks will not exceed these target levels at the receptor points. The individual concentration of each CVOC within these plumes will be different from contaminated area to area; however, they will be within MCL levels and combined concentration levels will not exceed a cumulative upper-bound target risk of 1 in 10,000 ($1 X10^{-4}$) and HI of 1.0 in any given plume.

CVOCs in groundwater and their respective target concentration levels are shown below (in microgram per liter [ug/L] or parts per billion [ppb]. These 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.

	Groundwater Remedial Goals
PCE	2.5
TCE	5
cis 1,2-DCE	35
trans 1,2-DCE	50
1,1-DCE	7/340
1,1,2,2-PCA	2.2
1,1,2-TCA	1.9
CCl_4	12
Chloroform	3

The major components of the selected remedy for Dunn Field are:

- Excavation, transportation, and disposal of soil and material contained within disposal sites based upon results from 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.
- Implementation of land use controls, which consist of the following institutional controls: deed and/or lease restrictions; Notice of Land Use Restrictions; City of Memphis/Shelby County zoning restrictions and the Memphis and Shelby County Health Department groundwater well restrictions.

Additional studies performed since completion of the ROD have led to five changes to components of the selected remedy for Dunn Field.

Two of the changes are considered fundamental:

- use of enhanced bioremediation treatment for the Off Depot groundwater plume instead of a permeable reactive barrier; and
- use of thermal-enhanced SVE in the shallow subsurface soils (loess) on Dunn Field instead of conventional SVE.

Two changes are considered significant:

- reduction in the areal extent of soil vapor extraction (SVE) in subsurface soils and zero valent iron (ZVI) injections in groundwater on Dunn Field; and
- use of excavation, transportation and off-site disposal for a small area of VOC-impacted subsurface soils instead of SVE.

The final change is considered minor:

- the sequencing of remedial action components will be revised so that ZVI injections in groundwater on Dunn Field will occur after implementation of the subsurface soil remedies.

The changes are described in a Revised Proposed Plan (RPP) and a ROD Amendment currently being prepared. The RPP was submitted to the BCT for review on 4 June 2007 and the ROD Amendment on 24 July 2007.

4.2 REMEDY IMPLEMENTATION

4.2.1 Interim Remedial Action

The interim groundwater extraction system was to be installed in three phases: (1) installation of the initial seven recovery wells on Dunn Field; (2) installation of remaining recovery wells on Dunn Field; and (3) installation of offsite wells west of Dunn Field. At the end of the first two phases, monitoring data would be reviewed and any required changes would be made to offsite well design. The phased approach was developed because of an interest in having the initial wells onsite and limited data on the offsite hydrogeology and plume extent.

The final design for Phase I was completed in August 1997 and included seven groundwater extraction wells (RW-3 through RW-9), an underground conveyance system, flow measurement and control systems, and associated civil, electrical, and instrumentation/controls work. Phase 1 construction was performed January 1998 through October 1998 and the system began operation in November 1998.

The Phase II design was completed in January 2000, and included the addition of four extraction wells and associated electrical, mechanical, and instrumentation/controls components. The new recovery wells were installed in late 1999 and early 2000. The expanded groundwater extraction system was constructed September 2000 through February 2001 and brought on-line in the first quarter of 2001.

Monitoring results from Phases I and II and the Dunn Field RI strongly suggested that aquifer restoration could be accomplished more effectively by means other than expanding the interim groundwater extraction system as a final remedy. Phase III (offsite recovery wells) was not constructed. DLA, EPA, and TDEC agreed that the offsite groundwater plume in the fluvial aquifer would be addressed in the final remedy for Dunn Field and the existing groundwater extraction system would continue to operate until the final remedy is implemented.

From system startup in 1998 through June 30, 2007, the system has pumped approximately 278,664,000 gallons of groundwater from the fluvial aquifer beneath Dunn Field and discharged to the POTW. An estimated total of 864 pounds of VOCs, including 348 pound of TCE have been removed from the fluvial aquifer on Dunn Field. No violations of the Industrial Wastewater Discharge Agreement with the City of Memphis have been recorded.

Semiannual groundwater monitoring is performed for the IRA, including the 11 recovery wells and selected monitoring wells. Monitoring results are presented in annual reports which include historical groundwater analytical results and time-trend plots. The latest report was the *Annual Operations Report – 2006, Dunn Field Groundwater Interim Remedial Action – Year Eight* (e^2M, 2007). Fifty groundwater monitoring wells were sampled. Total CVOC concentrations for the wells sampled in October and November 2006 are shown on Figure 8.

4.2.2 Main Installation

The *Main Installation Final Remedial Design* (RD) (CH2MHILL, 2004a) was approved by USEPA on August 10, 2004. The RD incorporated a treatability study of enhanced bioremediation treatment (EBT), which included use of two electron donors (vegetable oil emulsion and sodium lactate solution) injected into the fluvial aquifer at two separate study areas on the MI. Following injection activities, groundwater samples were collected from injection-zone monitoring wells for analyses of chlorinated VOCs and dissolved organic carbon (DOC), among other parameters. Sodium lactate was chosen for use in the RA. The RD determined that injection wells would be installed in target treatment areas 1 and 2 (TTA-1 and TTA-2) where PCE plus TCE exceed 100 µg/L, and in TTA-2 where CT exceeds 100 µg/L. Other design specification addresses well spacing, screen lengths, injection solution concentrations, injection volume and injection interval. The RD also included a long-term groundwater monitoring (LTM) plan and a Land Use Control Implementation Plan (LUCIP).

The Notice of Land Use Restrictions required by the LUCIP was recorded at the City of Memphis/Shelby County Register of Deeds Office on January 26, 2005. Annual inspections required the LUCIP have been performed since 2005 with no significant deficiencies observed.

The *Remedial Action Work Plan, Main Installation* (RAWP) (MACTEC, 2005a) was prepared to aid implementation of EBT, LTM, and land use controls (LUC). USEPA approved the RAWP on September 12, 2005. A design-related investigation (DRI) was performed to evaluate site hydrogeology and contaminant concentrations during final planning for the Main Installation RA. The DRI was conducted

from March through June 2004 and included the installation of 24 monitoring wells. In order to select EBT injection locations, isopleths for the combined concentrations of PCE and TCE were generated for TTA-1 and TTA-2, and isopleths for CT were generated for TTA-2. The DRI report was included as an appendix to the RAWP. The RAWP made only minor changes to the RD: shifts in injection and monitoring well locations; use of rotasonic drilling rather than mud-rotary; and slight change to the amount of sodium lactate in the injection solution to simplify the injection process and reduce the time for each injection event.

The Notice of Mobilization for the Main Installation RA was submitted to USEPA and TDEC on 2 May 2006. Construction of the injection and performance monitoring wells, the lactate storage and transfer facility, and the injection trailer were completed in August 2006. A baseline monitoring event was completed 6 September and the initial lactate injection event began 13 September 2006.

Two injection wells (IW85-05 and IW85-06) and two performance monitoring wells (PMW85-04 and PMW85-05) were installed in TTA-2 from 19 to 27 February 2007. The wells were installed as replacements for wells IW85-03, IW85-04, PMW85-02 and PMW85-03, which were installed in perched zones.

Injections have been performed biweekly since the initial event. EBT monitoring has included measurement of field parameters prior to each injection event and collection of quarterly groundwater samples from 49 injection wells and 39 performance monitoring wells. Quarterly reports are submitted to document injection and performance monitoring activities.

Based on the monitoring results and discussions with the BCT, two modifications have been made. The volume of lactate solution injected in the MW-21 area of TTA-1 was increased and sugar was added to the lactate solution. The injection volumes were increased due to the lack of response observed in the monitoring wells in the MW-21 area. The injection volume was increased from 166 gallons to 250 gallons per well in February 2007 and to 500 gallons per well in May 2007. Table sugar was added (1 pound in each 500 gallons of solution) to accelerate creation of anaerobic conditions in monitoring wells.

The quarterly reports also include an evaluation of the progress in meeting the Operating Properly and Successfully criteria stated in the MI RAWP. The second quarter report noted that the OPS criteria were generally being met:

- The injection and performance monitoring wells were installed as shown in the RAWP.

- Lactate and other metabolic fatty acids (MFAs) were present in the monitoring wells in the MW-101 area and in TTA-2, but not in monitoring wells in the MW-21 area.
- The planned volumes of injections have been met.
- Anaerobic conditions were being created. Microbial activity was responsible for a loss of oxygen, nitrate and sulfate, which resulted in a decrease in ORP, and production of end-products of microbial metabolism, carbon dioxide, methane and hydrogen.
- Maintenance of anaerobic conditions was demonstrated in most of TTA-1 and TTA-2.
- Average PCE, and to a lesser extent, TCE concentrations declined in the injection wells and monitoring wells in all three areas The reduction in PCE and TCE concentrations in all areas generally corresponded to an increase in cDCE concentrations. In the TTA-2 area, average concentrations of CT declined in both the injection and monitoring wells with a corresponding increase in CF, mainly in injection wells.

Additional monitoring wells have been installed at the MI since implementation of the RA to further delineate the plumes and to aid development of compliance well networks (CWNs) required in the MI RD. Nine new plume wells were installed in August 2006 in accordance with the recommendations in the *Annual Long-Term Monitoring Report, Main Installation, Rev. 1* (MACTEC, 2006). An additional 27 monitoring wells were installed in March-April 2007. Additional wells have delineated seven site plumes including the 3 plumes in the two current EBT areas (TTA-1 and TTA-2). Options for source investigation and groundwater treatment are being evaluated.

4.2.3 Dunn Field

To facilitate remedy design and implementation, the remedial action for Dunn Field were divided into three parts:

- Disposal Sites RA to address excavation, transportation, and disposal at selected disposal sites on Dunn Field;
- Source Areas RA to address SVE in subsurface soils, ZVI injections in groundwater, and implementation of land use controls on Dunn Field; and
- Off-Depot Groundwater RA to address installation of a PRB, MNA, and LTM in the groundwater plume downgradient from Dunn Field.

Disposal Sites

The *Disposal Sites Final Remedial Design* (RD) (CH2MHILL, 2004b) was approved by USEPA on August 10, 2004. A pre-RD investigation was conducted to supplement existing data on the 17 former disposal sites designated as medium and high priority. The investigation included a land survey to mark the targeted disposal areas and a geophysical survey to corroborate historical site information and previous geophysical data. Forty-eight trenches and seven test pits were excavated in October 2003 to investigate the disposal sites as delineated by the geophysical investigation and samples were collected from the excavated materials. Based on the results of the pre-design investigation, soil and debris from Disposal Sites 3, 4.1, 10, 13, and 31 was to be excavated and transported for offsite disposal. Observations from the excavations and analytical results indicated that benzene, copper, lead and polynuclear aromatic hydrocarbons were present above RGs and that possible principal threat wastes (glass bottles and 55-gallon drums) were present.

The *Remedial Action Work Plan, Dunn Field Disposal Sites, Rev. 1* (RAWP; MACTEC 2004c) provided additional details and descriptions of tasks necessary to implement the RA. USEPA approved the RAWP on 16 November 2004. The *Remedial Action Work Plan, Addendum 1, Rev. 1 (*RAWP Addendum 1, MACTEC 2006) outlined the procedures to excavate, characterize, transport, and properly dispose buried waste materials associated with liquid containers encountered during the excavation of Disposal Site 3. Approval of the RAWP Addendum was received from TDEC and USEPA on 17 February 2006 and 21 February 2006, respectively.

The Disposal Sites RA was performed during two separate mobilizations. During the first mobilization from 14 March 2005 through 7 May 2005, Disposal Sites 4.1, 13, 31, and the majority of Disposal Site 10 were completed. An area of burn pit material that extended to the west of Disposal Site 10 and the presence of intact, unlabeled glass bottles encountered in Disposal Site 3 required additional remedial measures beyond the initial scope of work. The glass bottles contained a clear liquid that required further analysis to determine proper handling and disposal procedures; the liquid was identified as ortho-toluidine. Disposal Site 3 and the remaining materials from Disposal Site 10 were completed during the second mobilization performed from 27 February 2006 through 8 March 2006. A total of 4,051 tons (approximately 2,700 yd^3) of non-hazardous materials from Disposal Sites 3, 4.1, 10, 13, and 31 were transported off-site and disposed of at the BFI South Shelby County Landfill. A total of 351 tons (approximately 234 yd^3) of hazardous materials from Disposal Site 3 was transported to the Clean Harbors Lambton Secure Landfill in Canada for disposal. The RAOs outlined in the ROD for these sites were achieved based on the confirmation sample results for each excavation.

The RA is described in the *Dunn Field Disposal Site Remedial Action Completion Report* (RACR) (MACTEC, 2006). The Disposal Sites RACR was approved by USEPA on August 26, 2006.

Source Areas

The *Source Areas Final Remedial Design Rev. 0* (CH2M HILL, 2007) was approved by USEPA on 20 March and by TDEC on 23 March 2007. Three studies were performed on Dunn Field as part of the Source Areas RD: a field treatability study was conducted to evaluate the effectiveness of zero-valent iron (ZVI) injection for subsurface remediation of chlorinated volatile organic compounds (CVOCs); a soil vapor extraction (SVE) pilot study was performed to collect site-specific data for both the loess and the unsaturated fluvial deposits; and a remedial design investigation (RDI) was performed to delineate CVOC concentrations in the loess and to collect additional groundwater samples. The reports for the RDI and the SVE study are included as appendices to the RD.

The SVE pilot study was conducted in four phases to collect site-specific data for design of a full-scale system. The study findings supported use of SVE in the fluvial deposits and indicated the RAOs could be met within 5 years in that unit. However, the study demonstrated limited vapor extraction rates and high applied vacuum requirements for the loess. The estimated times required to meet RAOs for the two primary CVOCs in the loess were up to 235 years for 1,1,2,2 PCA and up to 14 years for TCE.

The RDI included a membrane interface probe (MIP) investigation and soil sample analyses to characterize the magnitude and extent of elevated CVOCs in the loess on 40-foot by 40-foot grid throughout the treatment areas identified in the ROD. The study resulted in better delineation of the loess deposits exceeding the remedial goals (RGs) and requiring SVE treatment. The total area within the four treatment areas was reduced from 5.5 acres as shown in the ROD to 1.3 acres.

Soil sampling and MIP results indicated a CVOC, chloroform, was present slightly above the RG at depths of 8.5 to 13 feet in one RDI boring. None of the surrounding borings had CVOCs above the RGs. Based on the limited extent and depth; this area will be excavated.

The revised loess treatment areas and the excavation area are shown on Figure 9. The highest CVOC concentrations in the fluvial vadose zone are assumed to be directly below the highest CVOC concentrations in the loess; the fluvial SVE layout is also shown on Figure 9. The reduced area requiring SVE treatment allows cost-effective implementation of thermal enhancements to the SVE system for the loess. Two applicable thermal technologies, electrical resistance heating (ERH) and in situ thermal

desorption (ISTD), have been identified and the final selection process is in progress. Thermal-enhanced SVE is expected to meet the RAOs in the loess in less than one year of operation.

The BCT determined that the Fluvial SVE component of the Source Areas remedial action should be implemented on an expedited basis. Operation of the system will significantly reduce continuing migration of CVOCs to groundwater while planning for the other components (ET&D of VOC-impacted soil; thermal-enhanced SVE in the loess; injection of ZVI to remediate CVOCs in groundwater; and land and groundwater use controls) is completed.

The *Dunn Field Fluvial Soil Vapor Extraction Remedial Action Work Plan, Rev.1* was approved by USEPA on 3 July 2007. The RA mobilization occurred May 14, 2007. Fluvial SVE system construction was completed in July 2007 and system operations began 25 July 2007. As of 1 November 2007, approximately 1200 pounds of CVOCs have been removed by the fluvial SVE system.

The *Dunn Field Loess/Groundwater Remedial Action Work Plan, Rev. 1* was submitted on 27 August 2007. The RAWP received partial approval from USEPA on 2 October 2007. Final approval will be granted upon agreement on procedures to show attainment of clean-up levels for the loess. Mobilization of personnel and equipment for ET&D and site preparation of the thermal-enhanced SVE treatment of the loess took place on 22 October 2007.

Off Depot Groundwater

DLA determined that an Early Implementation of Selected Remedy (EISR) using the ZVI process should be taken at the leading edge of the high-concentration portion of the central plume in the fluvial aquifer. The EISR was a response to levels of contamination not observed at this distance from Dunn Field during the RI. The rationale and scope for this action were described in a technical memorandum, *Early Implementation of Selected Remedy Component to Address Groundwater Contamination West of Dunn Field* (CH2M HILL, 2004c), which was approved by the BCT on 21 October 2004. The overall objective of the EISR was to reduce contaminant mass downgradient of the planned PRB location in order to ensure that the portion of the plume slated for MNA in the ROD was not unduly extensive or high in concentration.

ZVI injections were made following procedures in the *EISR Work Plan* (MACTEC, 2004c) from 18 November 2004 through 8 January 2005. Injections were made in 14 borings at 2-foot intervals over the fluvial aquifer thickness, which averaged 21 feet; the injection locations were spaced approximately 60 to

80 feet apart. The depth of injection ranged from approximately 70 to 100 feet bgs. The total mass of ZVI injected was approximately 192,500 pounds.

The *Early Implementation of Selected Remedy Interim Remedial Action Completion Report, Rev. 1* (MACTEC, 2005) was submitted 19 September 2005. The injections did not achieve the goal of 90 percent or greater reduction of TCE and PCA. The report included recommendations for decreased spacing between injection locations to achieve increased reduction in CVOCs. Significant CVOC reduction appears to require ZVI injection at a suitable mass-to-soil ratio throughout the treatment area. The IRACR was approved by USEPA on 22 September 2005.

The *Off-Depot Groundwater Prefinal Remedial Design, Rev. 0* (CH2M HILL, 2007) was submitted to USEPA and TDEC for review on 20 July 2007. A *Request for Extension in Dunn Field Off-Depot Remedial Design* was submitted to USEPA and TDEC on 28 November 2006 in accordance with the FFA. The extension for the Pre-Final Remedial Design from 11 December 2006 to 20 July 2007 was requested because additional information on hydrogeology and contaminant extent obtained since completion of the Dunn Field ROD created a need to re-consider the selection of a "permeable reactive barrier to remediate CVOCs within the off site areas of the groundwater plume".

Changes to the PRB component for Off Depot groundwater are based on information from the EISR (MACTEC, 2005) and the *Field PRB Implementation Study* in Appendix B of the Off Depot Groundwater Prefinal RD.

Additional monitoring wells installed for the EISR provided new information on groundwater flow gradient, saturated thickness, and contaminant concentrations around the ROD-proposed location of the ZVI PRB. The relatively low groundwater gradient in that area would make it difficult to ensure consistent flow through a ZVI PRB, while the thicker saturated zone would increase the construction cost. In addition, concentrations of chlorinated volatile organic compounds (CVOCs) downgradient of the ROD-proposed location exceed 5,000 parts per billion (ppb), which is an order-of-magnitude higher than those presented in the ROD. These concentrations are higher than considered appropriate for MNA and would require active treatment downgradient of the ZVI PRB.

To comply with the ROD and account for the new hydrogeologic information, a new ZVI PRB alignment near the midpoint of the off-Depot plume was considered. This location was selected because of a thinner saturated zone and a narrowing of the CVOC plume. The Field PRB Implementation Study was performed in this area. The results of the PRB study indicate that formation of a uniform PRB was not

achieved and that several technical issues would need to be solved for installation of an effective full-scale PRB.

Therefore, based on the hydrogeologic and CVOC data collected since the ROD was signed and the challenges associated with the installation of a cost-effective, full-scale ZVI PRB, enhanced bioremediation is considered a more appropriate remedy for the Off-Depot CVOC plume. Enhanced bioremediation involves adding nutrients, microbes, and/or chemicals that accelerate in-situ anaerobic or aerobic biodegradation processes via injection boreholes or wells. The injection of microorganisms into the subsurface is considered an experimental technology, while the injection of nutrients has been shown to be effective. A microcosm study using soil and groundwater from the Off Depot plume was begun in January 2007 to evaluate the effectiveness of various nutrients and of microbes that have been reported effective in remediating the CVOCs present in the Off Depot Plume. The study report is included as Appendix D of the Off Depot Groundwater Prefinal RD.

Enhanced bioremediation is presently being implemented on the Main Installation and the facilities and equipment could readily be used for the Off-Depot RA. Enhanced bioremediation offers implementation flexibility in that the treatment area can be adjusted to address changes in plume geometry. Finally, the use of multiple rows or transects of injection wells along the CVOC plume and perpendicular to groundwater flow would be a more aggressive approach than a single ZVI PRB for meeting Dunn Field RAOs.

An additional groundwater study was conducted in 2007 for the Off Depot Groundwater RD. Plume characterization efforts to-date have shown that the CVOC plumes originating at Dunn Field extend to the west and northwest in the offsite areas (Figure 8). Based on the groundwater model output and the date of the release, the CVOC plumes should be longer than current data suggest. In addition, the plume extent depicted in current maps does not match the groundwater seepage rates, especially for a plume that may be 50 years old. The additional groundwater investigation will be conducted to evaluate whether CVOCs are present in the intermediate aquifer due to downward vertical migration of the plume and to assess the hydraulic connectivity of the shallow and intermediate aquifers. The new data will improve the CSM of Dunn Field with respect to groundwater flow and hydraulic interconnectivity of the fluvial, intermediate, and Memphis Sand aquifers and will provide new site-specific and regional hydrologic information to recalibrate and revise the groundwater model.

A second *Request for Extension in Dunn Field Off-Depot Remedial Design* was submitted to USEPA and TDEC on 7 November 2007 in accordance with the FFA. The extension for the Final Remedial Design from 17 December 2007 to 17 May 2008 was requested in order to incorporate the results of the

intermediate aquifer study into the groundwater model because this model is a critical component of the natural attenuation portion of the Off-Depot remedy. The Off- Depot Groundwater RD is scheduled to be approved on 14 September 2008 and the RAWP on 11 February 2009. Mobilization for the Off Depot RA is scheduled on 13 May 2009.

4.3 SYSTEM OPERATION AND MAINTENANCE

Operation and maintenance (O&M) activities are currently conducted for the IRA groundwater recovery system, the Main Installation RA and the Fluvial SVE system.

4.3.1 Interim Remedial Action

O&M activities for the IRA will continue until the Source Areas RA remedy is fully implemented. The final component will be ZVI injections in groundwater which are scheduled to be completed in September 2009. The goals for IRA O&M are to:

- Maintain system operations through regular field inspections, maintenance, and repairs
- Monitor system effectiveness through the measurement of water levels and the collection and analysis of system effluent samples and groundwater samples from monitoring wells and recovery wells

IRA O&M currently includes the following activities:

- Weekly system inspections with repair or replacement of components, as required.
- Annual system calibration.
- Monthly discharge reports to document O&M activities, system status, and performance.
- Water levels measured weekly in recovery wells and quarterly in monitoring wells.
- Semi-annual groundwater samples collected from monitoring wells using passive diffusion bag samplers (PDB) and from recovery well samples using wellhead sampling ports. Samples analyzed for VOCs.
- Quarterly effluent samples analyzed for pH and VOCs with semi-annual effluent samples analyzed for semi-volatile organic compounds (SVOCs) and metals in accordance with the wastewater discharge agreement.

4.3.2 Main Installation

O&M activities for the MI RA will continue as long as injections are performed, currently scheduled through August 2008 (2 years). Each injection event includes the following activities:

- Ensuring access to injection and performance monitoring well locations;
- Calibration of portable equipment to measure groundwater dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, and conductivity;
- Field measurements of groundwater DO, ORP, pH, temperature, and conductivity in injection and performance monitoring wells prior to sodium lactate injection;
- Filling of the trailer-mounted storage tank with sodium lactate injection fluid; and
- Injection of sodium lactate into IWs at TTA-1 and TTA-2.

At the completion of each injection event, the trailer-mounted injection system is returned to the storage and transfer facility and rinsed with potable water to minimize biological growth on sodium lactate injection fluid remaining in the components.

A 2.16-percent solution of sodium lactate will be injected into each IW on a bi-weekly schedule during the first year and monthly during the second year. Initial injection volumes were:

- TTA-1, MW-21 area. 10-foot screens: 167 gallons of injection fluid per well
- TTA-1, MW-101 area. 15-foot screens: 250 gallons of injection fluid per well
- TTA-2. 10-foot screens: 111 gallons of injection fluid per well.

Performance monitoring of EBT zone injection and performance monitoring wells will be used to evaluate the creation and maintenance of anaerobic conditions within the EBT zones. Secondary performance monitoring parameters (DO, ORP, pH, temperature and conductance) will be measured in each injection and performance monitoring well before each injection event. Results of performance monitoring will be used to ensure stability of anaerobic aquifer conditions and reduction of VOC concentrations within EBT zones.

4.3.3 Source Areas - Fluvial SVE

The Fluvial SVE system will be operated continuously, with periodic downtime as necessary for maintenance and monitoring. It is estimated that the system will be operated for up to 5 years to meet the RAOs.

System operational checks were made weekly during the first month of operation. The system will be checked at least monthly for the first year of operations. The checks include:

- Flow and pressure at each SVE well
- Screening level vapor concentrations and pressures at the VMPs
- Blower run-times and operating parameters
- Mass removal rates based on vapor phase GAC influent and effluent vapor concentrations

If the system is not performing as designed, adjustments will be considered to improve performance. These adjustments may include:

- Flow rates and pressures at individual well; and
- Installation of passive vent wells.

Monthly system operational assessments may be changed to quarterly following approximately 1 year of system operation or after the system has stabilized.

Maintenance for the SVE blowers will include the following routine tasks:

- Quarterly blower oil changes and belt tensioning (direct drive), if necessary, and
- Maintenance of miscellaneous pumps, valves, etc., quarterly or as necessary.

SVE monitoring will consist of flow and pressure measurements, field vapor concentration measurements, and vacuum measurements. Vapor samples from the SVE wells and the treatment system influent and effluent will be collected routinely to evaluate the effectiveness of the SVE system and assess the need for system modifications.

During start-up in the first two weeks of system operations, field vapor concentrations were measured daily with a photo-ionization detector (PID) at the seven SVE wells, the vapor treatment system inlet and outlet, and the VMPs. Field vapor concentration measurements continued on a weekly basis for the first month and then at least monthly for the first year of operation. Baseline air samples were collected for laboratory analysis during the first few days of start-up operations. The air samples were collected at the

SVE well manifolds and the vapor treatment system inlet and outlet. Air samples for laboratory analysis were collected monthly during the first quarter and will be collected at least quarterly for the first year of operations.

Ambient air screening measurements will be made weekly. Condensate samples will be collected monthly (or as necessary) and submitted for laboratory analysis in accordance with the discharge agreement with the City of Memphis. The SVE monitoring schedule will be reviewed after the first year of operations.

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

5.1 PREVIOUS FIVE-YEAR REVIEW

This is the second five-year review for DDMT. The initial review, *Memphis Depot Dunn Field Five-Year Review, Rev 2* (CH2M HILL, 2003), was completed in January 2003. The initial review was intended to confirm that the interim remedial action and associated performance standards were being achieved and the existing site conditions were protective of human health and the environment. The following protectiveness statement was made:

"While over 300 pounds of VOCs have been removed from groundwater by the IRA, the extraction system does not provide complete control over groundwater flow and the spread of contaminant constituents in the fluvial aquifer from the western perimeter of Dunn Field. As a result, contaminant levels have been increasing in a few monitoring wells downgradient and offsite of Dunn Field. Since the extraction system has not completely contained the spread of contaminants toward the Allen Well Field, the remedy does not fully satisfy the principal IRA goals and can only be considered protective in the short term. The only goal that is being met by the remedy is incremental removal of contaminants. However, because there is no current use of, nor plan to use, the shallow groundwater as a drinking water supply, and because local ordinances restrict installation of private wells, the IRA is considered protective in the short term."

The recommendations made in the initial five-year review report and the current conditions are

Recommendation	**Current Condition**
Complete repairs to protect integrity of wells and samples achieved from each well.	All necessary well repairs have been made.
Continue inspections of monitoring wells and piezometers at and off-site of Dunn Field as part of	Wells and piezometers at Dunn Field and the MI are inspected during water level monitoring and

routine groundwater level monitoring efforts.	sampling events. Repairs are made as necessary.
Continue inspections of recovery wells at Dunn Field as part of routine groundwater level monitoring efforts	Recovery wells are inspected weekly.
Continue inspections of extraction system at Dunn Field as part of routine groundwater level monitoring efforts	The extraction system is inspected weekly.
Extraction system groundwater sampling should be continued at current rate to ensure efficiency and protectiveness of system	IRA groundwater sampling is performed semiannually.
Extraction system effluent sampling should be continued at current rate to ensure compliance with discharge permits	Effluent sampling is performed quarterly for VOCs and semiannually for SVOCs and metals in accordance with the discharge permit.
Continue with installation of offsite monitoring wells to the northeast of Dunn Field to define offsite groundwater contaminant plume source and location	TDEC has completed an initial investigation that eliminated one suspected source area. Investigation at a second suspected area will be completed in 2007.

:

5.2 ACTIONS TAKEN

The actions taken since the initial review are summarized below. Additional information was provided in the Section 2.0, Site Chronology and Section 4.0 Remedial Actions.

Main Installation

MI RD completed, including EBT study; approved by USEPA and TDEC

MI RAWP completed, including Design Related Investigation; approved by USEPA and TDEC

RA construction completed

Three quarters of injections and performance monitoring in EBT areas completed as of June 2007

Progress toward Operating Properly and Successfully documented in quarterly reports

LTM initiated outside EBT areas with additional wells installed to delineate additional plumes

Dunn Field

Dunn Field ROD completed; approved by USEPA and TDEC

Revised Proposed Plan, Rev. 0 submitted

Dunn Field ROD Amendment, Rev. 0 submitted

IRA

System operations continued

Semiannual groundwater sampling programs revised to include new monitoring wells.

Annual operations reports submitted.

Disposal Sites

Disposal Site RD completed, including pre-design investigation; approved by USEPA and TDEC

Disposal Sites RAWP and Addendum completed; approved by USEPA and TDEC

Site excavations completed; final confirmation samples were below RGs

Disposal Sites RACR completed; approved by USEPA and TDEC

Source Areas

Source Areas RD completed, including SVE studies, ZVI injection field trial and RDI; approved by USEPA and TDEC

Fluvial SVE RAWP completed; approved by USEPA and TDEC

Fluvial SVE construction completed

Loess/Groundwater RAWP, completed; partially approved by USEPA.

Began Loess ET&D and site preparation for thermal-enhanced SVE.

Off Depot

Additional monitoring wells installed and downgradient extent of plume defined

EISR Work Plan completed; approved by USEPA and TDEC

ZVI injections made in off-depot plume; concentration reduction target not achieved but results were used in RDs for Source Areas and Off Depot Groundwater.

EISR IRACR completed; approved by USEPA and TDEC

Off Depot Groundwater Prefinal RD submitted, including PRB field trial, Microcosm study and Groundwater model

Off Depot Intermediate Aquifer Investigation and Testing Work Plan completed; approved by USEPA and TDEC.

6.0 FIVE-YEAR REVIEW PROCESS

6.1 ADMINISTRATIVE COMPONENTS

The DDMT Second Five-Year Review was led by Tom Holmes, Project Manager for e^2M, the remedial action contractor at DDMT. The BCT was informed of the five-year review during preparation of the master schedule for the BRAC Cleanup Plan, Ver. 10 (e^2M, 2007).

This review included the following components:

- Community Involvement;
- Document Review;
- Data Review;
- Site Inspection;
- Interviews;
- Report Development and Review.

The report is scheduled to be completed 11 January 2008.

6.2 COMMUNITY INVOLVEMENT

The community was informed of the five-year review through an announcement in the Summer 2007 Environews, the semiannual newsletter prepared for the community by DLA. Environews is mailed to approximately 4,000 residents, primarily in the area surrounding DDMT. A letter was also sent to DDMT Restoration Advisory Board (RAB) members and local elected officials notifying them of the review. The notice and letter invited recipients to call the Community Information Line (901-774-3683) to comment on the protectiveness of the selected remedy or the remedial actions at DDMT. The status of the review was discussed at the 20 September 2007 RAB meeting and information on submittal of public comments was provided. Comments received from the community will be included in an appendix to the final review report. The community will be notified when the report is final and copies will be placed in the information repositories,

The Memphis Depot has conducted public participation activities throughout the CERCLA site cleanup process. Activities include RAB meetings since 1994, Community Information Sessions and public

meetings, a regular newsletter, and the establishment of information repositories, including a Community Outreach Room.

6.3 DOCUMENT REVIEW

This five-year review consisted of a review of relevant documents including the MI and Dunn Field RODs; RDs for the Disposal Sites, MI, Source Areas and Off Depot Groundwater; RAWPs for the Disposal Sites, MI, Fluvial SVE and Loess/Groundwater; Disposal Sites RACR; EISR IRACR; EBT monitoring and LTM reports for the MI; and IRA annual reports. RAOs, ARARs, and remedial goals (RGs) for soil and groundwater were taken from the RODs. A complete list of references is provided in Section 12.

6.4 DATA REVIEW

Success of the remedial actions at DDMT will be determined through comparison of soil and groundwater analytical results with RGs established in the RODs. The RGs were established through risk assessments to be protective of human health and the environment.

Only the Disposal Sites RA has been completed. The final confirmation samples collected from the excavations were below the soil RGs.

The MI RA is underway. CVOC concentrations in groundwater are to be reduced to below MCLs through EBT in treatment areas and through MNA outside those areas. Lactate injections in the EBT treatment areas began in September 2006 and are to continue through August 2008. Performance monitoring in the treatment areas has demonstrated that anaerobic conditions are being created and concentrations of the primary CVOCs (PCE, TCE and CT) are being reduced through microbially mediated reductive dechlorination. The concentration isopleths in the treatment areas from the second quarter EBT samples (March 2007) are shown on Figures 10, 11 and 12.

MI LTM sampling has been initiated outside the EBT treatment areas. In August 2006 and March-April 2007, 35 additional monitoring wells were installed to further delineate the plumes and to aid development of compliance well networks (CWNs) for the MNA areas. There are currently 98 monitoring wells in the MI LTM program; depending on location and past results, the wells are sampled on a quarterly, semiannual, annual or biennial interval. The results of the latest comprehensive LTM sampling event (October 2006) are shown on Figures 13 and 14.

Upon completion of the first year of the MI RA in August 2007, the performance monitoring and LTM results will be reviewed to determine if the OPS criteria are being met in the EBT and MNA areas. If the criteria are being met, an IRACR will be prepared with supporting information for the OPS determination by USEPA.

Monitoring for the IRA includes quarterly effluent samples from the main discharge and semiannual groundwater samples from 50 monitoring wells and 11 recovery wells. The monitoring network has been revised as new monitoring wells have been installed in the Dunn Field area. The extent of the plume was established through the monitoring wells installed for the EISR in 2004 and has appeared to be stable in subsequent monitoring events. The plume extent based on total CVOC concentrations from the *Annual Operations Report – 2006, Dunn Field Groundwater Interim Remedial Action – Year Eight* (e2M, 2007) is shown on Figure 8. The time trend plot of total CVOCs and TCE in the effluent discharge is shown on Figure 15.

Review of the IRA groundwater monitoring results and groundwater data collected for the Source Areas and Off Depot RD have shown that the CVOC plumes originating at Dunn Field extend to the west and northwest in the offsite areas. Based on the groundwater model output and the date of the release, the CVOC plumes should be longer than current data suggest. Additional groundwater investigation will be conducted to evaluate whether CVOCs are present in the intermediate aquifer due to downward vertical migration of the plume and to assess the hydraulic connectivity of the shallow and intermediate aquifers.

Upon implementation of the Source Areas and Off Depot Groundwater RAs, the IRA monitoring program will be replaced by the LTM program described in the Off Depot Groundwater RD.

6.5 SITE INSPECTION

Inspections were not conducted specifically for this Five-Year Review.

Annual inspections have been conducted at the MI as required by the LUCIP since approval of the MI RD, including the LUCIP, in August 2004. The inspections are performed to:

- Verify that boundary fence surrounding golf course area in FU2 remains intact.
- Verify that no residential housing/development or child daycare activities are occurring at the site (except Parcels 1 and 2 of FU6).

- Verify that no groundwater wells have been installed at the site (except for monitoring and injection wells that were done as part of the remedy) and that no production/consumptive use of groundwater is occurring.

Inspections were made on 14 July 2005, 13 July 2006 and 12 July 2007. The only deficiency noted was damage to a fence post and section of fence in 2005; the fence was repaired prior to the next inspection.

The Dunn Field LUCIP is currently being developed by DA and USEPA. Weekly inspections have been made at Dunn Field since e^2M began O&M of the IRA groundwater recovery system in October 2006; weekly reports are submitted to DLA. Regular mowing of Dunn Field and maintenance of the perimeter fence are performed to maintain the site appearance and security. Minor repairs to the fence have been required. No deficiencies have been identified that would endanger human health or the environment.

6.6 INTERVIEWS

Interviews were not conducted for this Five-Year Review.

7.0 TECHNICAL ASSESSMENT

7.1 IS THE REMEDY FUNCTIONING AS INTENDED BY THE DECISION DOCUMENTS?

The review indicates that where the final remedy has been implemented, it is functioning as intended by the RODs.

Excavation, transportation and disposal of the targeted Disposal Sites has achieved the RAOs to prevent groundwater impacts from buried containerized liquids/solids and to prevent risk of direct contact with buried liquids or solids during intrusive activities.

Enhanced bioremediation treatment (EBT) at the MI is still in progress. Anaerobic conditions have been created in the treatment areas and biologically mediated reduction in CVOC concentrations has been observed. Additional monitoring wells have been installed outside the EBT treatment areas to delineate CVOC groundwater plumes; further review is required to determine whether EBT or MNA will be initiated in these plumes to meet the RAOs. Further evaluation of the MI remedy will be made after the initial year has been completed.

Implementation of institutional controls at the MI has met the RAOs of preventing residential land use (except in FU6) and daycare facilities, and ingestion of water contaminated with VOCs in excess of MCLs from potential future on-site wells. No activities were observed that violated the institutional controls.

There were no current opportunities for system optimization observed during this review. Procedures for optimizing the LTM network are provided in the LTM plans for the MI and Dunn Field.

Implementation of the Source Areas remedy (SVE in the fluvial deposits, thermal-enhanced SVE and limited excavation in the loess, ZVI injection in groundwater, and institutional controls) has recently begun. The Off Depot Groundwater RD has not been completed. These remedies cannot be evaluated at present.

Additional studies performed since completion of the Dunn Field ROD have led to changes to components of the selected remedy for Dunn Field. The changes are described in a Revised Proposed Plan and a ROD Amendment currently being prepared.

Two of the changes are considered fundamental:

- use of enhanced bioremediation treatment for the Off Depot groundwater plume instead of a permeable reactive barrier; and
- use of thermal-enhanced SVE in the shallow subsurface soils (loess) on Dunn Field instead of conventional SVE.

Two changes are considered significant:

- reduction in the areal extent of soil vapor extraction (SVE) in subsurface soils and zero valent iron (ZVI) injections in groundwater on Dunn Field; and
- use of excavation, transportation and off-site disposal for a small area of VOC-impacted subsurface soils instead of SVE.

The final change is considered minor:

- the sequencing of remedial action components will be revised so that ZVI injections in groundwater on Dunn Field will occur after implementation of the subsurface soil remedies.

7.2 ARE THE EXPOSURE ASSUMPTIONS, TOXICITY DATA, CLEANUP LEVELS, AND REMEDIAL ACTION OBJECTIVES (RAOS) USED AT THE TIME OF THE REMEDY SELECTION STILL VALID?

There have been no changes in the physical conditions of the site or the planned re-use that would affect the protectiveness of the remedy.

The ARARs identified in the MI and Dunn Field RODs are listed on Table 2. There have been no changes in these ARARs and no new standards or TBCs affecting the protectiveness of the remedy.

The exposure assumptions used to develop the Human Health Risk Assessment are considered appropriate since the planned re-use has not changed. There has been no change to the standardized risk assessment methodology that would affect the protectiveness of the remedy. The sources for toxicity factors of the contaminants of concern provided in the RODs were reviewed. The following changes were noted:

- 1,1-Dichloroethene - the oral reference dose (RfD) has changed from 9E-03 to 5E-02 milligram/kilogram-day (mg/kg-day) and the oral and inhalation carcinogenic slope factors (SFs) have been withdrawn. There are no values currently.
- Vinyl Chloride - the oral and inhalation carcinogenic SFs have been changed in IRIS; the oral SF from 1.9E00 to 7.2E-01 kilogram-day per milligram (kg-day/mg) and the inhalation SF from 3E-01 to 1.5E-02 kg-day/mg.
- Carbon Tetrachloride - the inhalation RfD changed to 5.71E-04 to 5E-02 mg/kg-day
- Trichloroethene - the oral RfD changed from 6E-03 to 3E-04 mg/kg-day and inhalation RfD of 1E-02 mg/kg-day was added.

The groundwater RGs at the Main Installation and Dunn Field are based on MCLs which have not changed, and the subsurface soil RGs were derived from the MCLs to prevent impacts to groundwater. Since the MCLs have not changed, the RGs provided in the RODs are still considered protective.

As noted in Section 6.4, the groundwater model output and the estimated date of release indicate the CVOC plumes originating at Dunn Field should be longer than current data suggest. Additional groundwater investigation is planned to collect groundwater samples from the intermediate aquifer and to assess the hydraulic connectivity of the shallow and intermediate aquifers. The new data will improve the CSM of Dunn Field with respect to groundwater flow and hydraulic interconnectivity of the fluvial, intermediate, and Memphis Sand aquifers. The results will be used to review the RAOs.

7.3 HAS ANY OTHER INFORMATION COME TO LIGHT THAT COULD CALL INTO QUESTION THE PROTECTIVENESS OF THE REMEDY?

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

7.4 TECHNICAL ASSESSMENT SUMMARY

According to the data reviewed and the site inspections, the remedy is functioning as intended by the ROD, where implemented. There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy. There have been no changes to the ARARs cited in the ROD that would call into question the protectiveness of the remedy. Only limited changes in toxicity factors for the contaminants of concern were identified, and there have been no change to the standardized risk assessment methodology that could affect the protectiveness of the remedy.

Changes to components of the selected remedy for Dunn Field are currently proposed based on additional studies conducted since completion of the ROD. The RAOs presented in the ROD have not changed. A Revised Proposed Plan and a ROD Amendment are being prepared.

Additional monitoring wells have been added to the LTM wells at the MI. Groundwater sample results are being evaluated to determine if EBT treatment will be required to meet RAOs outside the current treatment areas.

Additional groundwater investigation will be conducted as part of the Off Depot Groundwater RD to assess the hydraulic connectivity of the shallow and intermediate aquifers and to improve the CSM of Dunn Field.

TDEC has not completed the investigation to identify the source of the offsite groundwater contaminant plume northeast of Dunn Field. This was noted as an issue in the original Five-Year Review. The presence of this plume impacts the groundwater remedy for Dunn Field.

8.0 ISSUES

Issues	Affects Current Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
Changes to Dunn Field selected remedy	N	Y
Additional groundwater plume delineation at MI	N	Y
Hydraulic connectivity of Fluvial and Intermediate aquifers	N	Y
Source of offsite plume NE of Dunn Field	N	Y

The remaining remedial actions at DMMT address groundwater contamination in the fluvial aquifer and the potential for continuing releases to groundwater from subsurface soils at Dunn Field. Water from the fluvial aquifer is not used as a source of drinking water by the City of Memphis. The identified issues address implementation of the selected remedy at Dunn Field and groundwater contamination at the Main Installation and at Dunn Field. The issues do not affect current protectiveness because there is no current exposure to COCs in subsurface soil or groundwater.

Gaps in the uppermost clay at the base of the fluvial aquifer that create hydraulic connections between the fluvial aquifer and deeper aquifers (Intermediate and Memphis) have been identified in the Memphis region. One such connection has been identified in the north-central Main Installation and two areas west of Dunn Field are considered potential connections based on water level data.

The issues affect future protectiveness because of the potential for vertical migration of COCs from the fluvial aquifer. All of the identified issues are considered to increase protectiveness because they will result in improvements to the remedial actions or will provide additional information on areas possibly needing remedial action.

Several changes are planned to the selected remedy at Dunn Field. The two fundamental changes (use of enhanced bioremediation instead of a permeable reactive barrier and use thermal-enhanced SVE instead of conventional SVE) will allow the implementation of more effective remedies in order to achieve the

RAOs. The two significant changes (reduction in treatment areas and use of ET&D in an isolated area) increase the cost-effectiveness of the remedy by eliminating areas where the planned SVE treatment was not required. The reduction in area, based on additional soil sampling during the remedial design, allowed implementation of thermal-enhanced SVE, which is significantly more expensive than conventional SVE. The one minor change (sequencing of remedial action) is expected to improve the effectiveness of the ZVI injections in groundwater by removing contaminant flux from the vadose zone.

Additional monitoring wells on the Main Installation have delineated groundwater plumes outside of the treatment areas identified in the Main Installation ROD. Options for source investigation and groundwater treatment are being evaluated. The additional information on plume extent and COC concentrations will aid remedial action.

Hydraulic connectivity of the fluvial and intermediate aquifers were investigated in 2007 through additional deep monitoring wells, groundwater sampling and aquifer tests. The investigation will provide information on connectivity through vertical migration of COCs through the clay layer at the base of the fluvial aquifer, rather than COCs in groundwater flow at gaps in the clay. The study will be used to complete the Off-Depot remedy.

TDEC has preliminarily identified a source of the groundwater plume entering Dunn Field from the northeast. Source identification is a necessary step in identifying the responsible part and planning remedial action.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Issues	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Changes to Dunn Field selected remedy	1) Complete Public Comment period for Proposed Plan 2) Complete ROD Amendment	DLA	USEPA/ TDEC	10/29/08 4/27/09	N	Y
Additional groundwater plumes delineation at MI	Determine treatment requirements	DLA	USEPA/ TDEC	6/30/08	N	Y
Hydraulic connectivity of Fluvial and Intermediate aquifers	1) Intermediate Aquifer Study Report 2) Incorporate results in Final Off Depot Groundwater RD	DLA	USEPA/ TDEC	1/11/08 5/17/08	N	Y
Source of offsite plume NE of Dunn Field	Installation of offsite monitoring wells	TDEC	USEPA	6/30/08	N	Y

10.0 PROTECTIVENESS STATEMENT

The remedy is expected to be protective of human health and the environment upon completion of remedial actions for subsurface soil at Dunn Field and for groundwater at the MI and Dunn Field. Attainment of RGs in the subsurface soils at Dunn Field are expected to be met within 5 years. Attainment of cleanup goals in groundwater will be achieved through active treatment and natural attenuation; groundwater RGs are expected to be met 10 years after remedy implementation on the MI (2016) and at Dunn Field (2018).

In the interim, exposure pathways that could result in unacceptable risks are being controlled and institutional controls are preventing exposure to, or the ingestion of, contaminated groundwater.

Long-term protectiveness of the remedial action will be verified by subsurface soil sampling after remedial actions are completed on Dunn Field and by groundwater sampling performed during LTM and compliance monitoring at the MI and Dunn Field.

11.0 NEXT REVIEW

The next five-year review for DDMT is required by January 2013, five years from the date of this review.

12.0 REFERENCES

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TABLES

TABLE 1
DUNN FIELD SITES

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

INSTALLATION RESTORATION SITE NUMBER	DSERTS SITE NUMBER(a)	PRIORITY LEVEL(b)	SITE TYPE	SITE DESCRIPTION
Northeast Open Area				
19	19	C	SS	Former Tear Gas Canister Burn Site [c]
20	20	C	SS	Probable Asphalt Burial Site
21	21	C	SS	XXCC-3 Impregnite Burial Site (300,000 Pounds)
50	50	C	SS	Dunn Field Northeastern Quadrant Drainage Ditch
60	60	Remediated	SS	Pistol Range Impact Area/Bullet Stop
62	62	C	SS	Bauxite Storage
85	85	Remediated	RI	Old Pistol Range Building 1184/Temporary Pesticide Storage
Disposal Area				
1	1	Remediated	CWM	Mustard and Lewisite Training Sets Burial Site (1955)
2	2	C	RI	Ammonia Hydroxide (7 Pounds) and Acetic Acid (1-Gallon) Burial Site (1955)
3	3	B	RI	Mixed Chemical Burial Site (Orthotouidine Dihydrochloride) (1955)
4	4	A	RI	POL Burial Site (13, 55-Gallon Drums of Oil, Grease and Paint)
4 1	90	A	RI	POL Burial Site (32, 55-Gallon Drums of Oil, Grease and Thinner)
5	5	C	RI	Methyl Bromide Burial Site A (3 Cubic Feet) (1955)
6	6	C	RI	40,037 Units of Eye Ointment Burial Site (1955)
7	7	A	RI	Nitric Acid Burial Site (1,700 Quart Bottles) (1954)
8	8	A	RI	Methl Bromide Burial Site B (Burning Pit Refuse) (1954)
9	9	C	RI	Ashes and Metal Burial Site (Burning Pit Refuse) (1955)
10	10	B	RI	Solid Waste Burial Site (Near MW-10) (Metal, Glass, Trash, etc)
11	11	B	RI	Trichloroacetic Acid Burial Site (1,433, 1-ounce Bottles) (1965)
12 & 12.1	12	B	RI	Sulfuric Acid and Hydrochloric Acid Burial (1967)
13	13	A	RI	Mixed Chemical Burial (Acid, 900 Pounds; Unnamed Solids, 8,100 Pounds)
14	14	C	RI	Municipal Waste Burial Site B (Near MW-12) (Food, Paper Products)
15	15	B	RI	Sodium Burial Sites (1968)
15 1	91	B	RI	Sodium Phosphate Burial (1968)
15 2	92	B	RI	14 Burial Pits: Na2PO4, Sodium, Acid, Medical Supplies, and Chlorinated Lime
16	16	B	RI	Unknown Acid Burial Site (1969)
16 1	93	B	RI	Acid Burial Site
17	17	B	RI	Mixed Chemical Burial Site C (1969)
18	18		Proposed NFA	Plane Crash Residue
22	22		Proposed NFA	Hardware Burial Site (Nuts and Bolts)
23	23	C	Proposed NFA	Construction Debris and Food Burial Site
24-A	24	Remediated	CWM	Bomb Casing Burial Site (29 Bomb Casings used to Transport Mustard Agent)
61	61	C	SS	Buried Drain Pipe
63	63	C	Proposed NFA	Aboveground Fluorspar Storage
64	64	C	Proposed NFA	Aboveground Bauxite Storage (1942 to 1972)
86	86	C	RI	Food Supplies
Stockpile Area [d]				
24-A	24	Remediated	CWM	Neutralization Pit for the Contents of the 29 Bomb Casing used to Transport Mustard Agent
62	62	C	SS	Aboveground Bauxite Storage
63	63	C	Proposed NFA	Aboveground Fluorspar Storage
64	64	C	SS	Aboveground Bauxite Storage (1949 to 1972)
--	64[e]	B	--	CC-2 Impregnite Burial Site (86,100 Pounds in 1947)
--	64[e]	B	--	Installation Assessment Site 31 Burning and Disposal Site

Notes.

SS:	Screening Site
RI	Remedial Investigation
RA.	Remedial Action
NFA:	No Further Action
CWM:	Chemical Warefare Material
Na2PO4.	Sodium Phosphate
POL	Petroleum, Oil, and Lubricants
XXCC-3/CC-2	Stabilized/Unstabilized Impregnite for Inpregnating Clothing Used to Protected Personnel against the Action of Vesicant-Type Chemical Agents

[a] Defense Site Environmental Restoration Tracking System (DoD Database)

[b] Priority levels were established for Installation Restoration Sites Number/DSERT Site Number Areas where remedial action would be required with some investigatory effort to determine extent of area Levels are as follows A - Highest Priority; B - Medium Priority; C - Lowest Priority (no RA likely) Designation was based on described quantity of material, potential hazard to human health and the environment, and form of material (solid or liquid). A pre-design investigation was conducted at Priority Sites A and B Remedial Action was required at Sites 3, 4 1, 10, 13 and 64 (Installation Assessment Site 31)

[c] According to the available information, burning in this area dated back to the 1940s and included chloroacetophenone (CN) canisters, fuses, and smokes, in addition to sanitary wastes Operations were conducted in pits and incorporated the weekly cleanup of residue and garbage in addition to material The ash was then allegedly buried in the north end of Dunn Field

[d] According to available information, USATHAMA (1982) Installation Assessment Site 31 is located in the southwest portion of Dunn Field This site was reportedly used for burning/disposal of smoke pots, CN (tear gas) grenades and souvenir ordnance, which included a 3.2 mortar round This area was covered by the bauxite storage pile (Site 64). Installation Site 31 was not designated as an IRP site or given a DSERTS site number However, the site is now included in DSERTS Site 64

[e] According to an April 15, 2003 email from the Defense Logistics Agency - DDC (New Cumberland) to DDC (Memphis) and CEHNC, DSERTS Site 64 will include the CC-2 Impregnite Burial Site and Installation Assessment Site 31 as a result of the proximity of all three sites and because Site 64 encompasses both of the other two sites

TABLE 2
ARARS AND TBC GUIDANCE

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Action/medium	Requirements	Prerequisite	Citation(s)
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(2)(b) - **relevant and appropriate**	TDEC 1200-5-1-.06 40 CFR 141 *et seq.*
	Except for naturally occurring levels, shall not contain constituents in excess of the concentrations listed in Table 1. *Inorganic Critena for General Use Ground Water*		TDEC 1200-4-3-.08(2)(a)
	Except for naturally occurring levels, shall not contain constituents exceeding those in TDEX 1200-4-3-.03 except that the criteria for *Fish and Aquatic Life* and *Recreational Use* shall not apply		TDEC 1200-4-3- 08(2)(b)
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)
	• use, where possible, of water or chemicals for control of dust; and		TDEC 1200-3-8-.01(1)(a)
	• 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)
	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 onginates.		TDEC 1200-3-8- 01(2)

TABLE 2
ARARS AND TBC GUIDANCE

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Action/medium	Requirements	Prerequisite	Citation(s)
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, 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)
	• 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
	• does not contain distinctly visible floating scum, oil, or other matter;		*General Permit No. TNR10-0000* Part III D 2.a
	• does not cause an objectionable color contrast in the receiving stream; and		*General Permit No. TNR10-0000* Part III D.2 a
	• 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.a
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 water quality standards	Class V injection well for innovative or experimental technologies – **relevant and appropriate**	TDEC 1200-4-6- 14(1)(b) TDEC 1200-4-6-.14(7)(b) and (8)(a)
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.*
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.*
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 Pollution Control Act	Emissions of air pollutants from new air contaminant sources - **applicable**	TDEC 1200-3-9-.01(1)(d) Memphis Code 16-77

TABLE 2
ARARS AND TBC GUIDANCE

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Action/medium	Requirements	Prerequisite	Citation(s)
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(b); 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)
	Must determine if waste is listed under 40 CFR Part 261, or		40 CFR 262.11(b) TDEC 1200-1-11-.03(1)(b)(2)
	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)
	Must refer to Parts 261, 262, 264, 265, 266, 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)
Characterization of hazardous waste	Must obtain a detailed chemical and physical analysis on 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)
	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)(l)(1)
	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 TDEC 1200-1-11-.10(1)(g)(1)(i)
	Must determine each EPA Hazardous Waste Number (Waste Code) to determine the applicable treatment standards under 40 CFR 268.40 et. seq.		40 CFR 268 9(a) TDEC 1200-1-11-.10(1)(l)(1)

TABLE 2
ARARS AND TBC GUIDANCE

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Action/medium	Requirements	Prerequisite	Citation(s)
Temporary storage of hazardous waste in containers	A generator may accumulate hazardous waste at the facility 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)
	• waste is placed in containers that comply with 40 CFR 265.171-173, and		40 CFR 262 34(a)(1)(i); TDEC 1200-1-11-.03(4)(e)(2)(ii)(I)
	• the date upon which 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)
	• container is marked with the words "hazardous waste" or		40 CFR 264.34(a)(3) TDEC 1200-1-11-.03(4)(e)(2)(iv)
	• 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) TDEC 1200-1-11-03(4)(e)(5)(i)(II)
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)
	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)
	Keep containers closed during storage, except to add/remove waste.		40 CFR 265.173(a) TDEC 1200-1-11-.05(9)(d)(1)
	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)
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)
	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) TDEC 1200-1-11-.06(9)(f)(3)
	Containers must be elevated or otherwise protected from contact with accumulated liquid		

TABLE 2
ARARS AND TBC GUIDANCE

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Action/medium	Requirements	Prerequisite	Citation(s)
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)
	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)
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)(iv) TDEC 1200-1-11- .10(1)(a)(3)(iv)(IV)
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)
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)
	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)
	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		

TABLE 2
ARARS AND TBC GUIDANCE

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee

Action/medium	Requirements	Prerequisite	Citation(s)
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)
	• 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)
	• 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)
	• 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)
Transportation of hazardous waste on site	The generator manifesting requirements of 40 CFR 262.20–262.32(b) do not apply Generator or transporter must comply with the requirements set forth in 40 CFR 263.30 and 263.31 in the event of a discharge of hazardous waste on a private or public right-of-way.	Transportation of hazardous wastes on a public or private right-of-way within or along the border of contiguous property under the control of the same person, even if such contiguous property is divided by a public or private right-of-way – **applicable**	40 CFR 262.20(f) TDEC 1200-1-11-.03(3)(a)(6)

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
DOT = U S Department of Transportation
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

FIGURES

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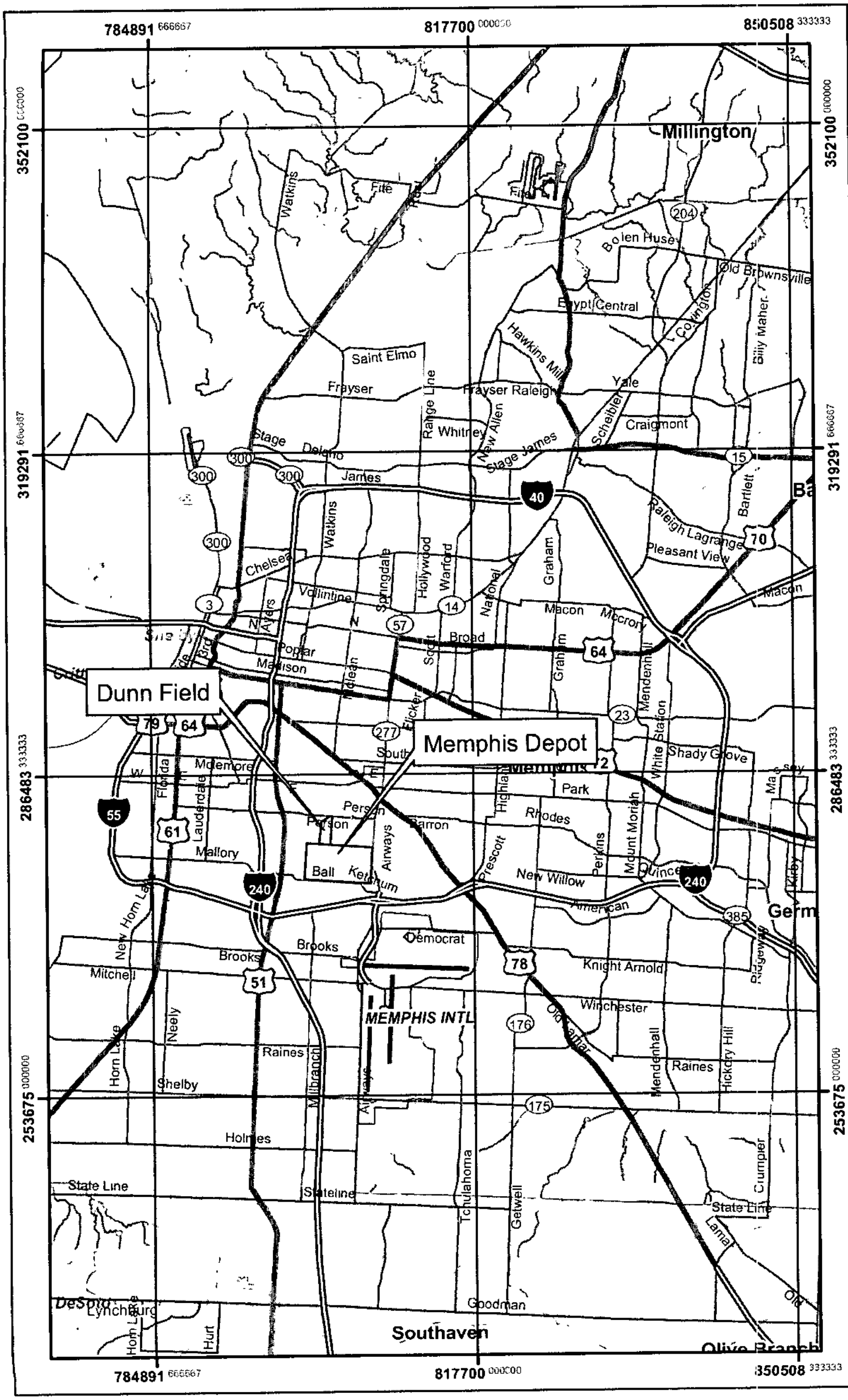

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Figure 1

SITE LOCATION MAP

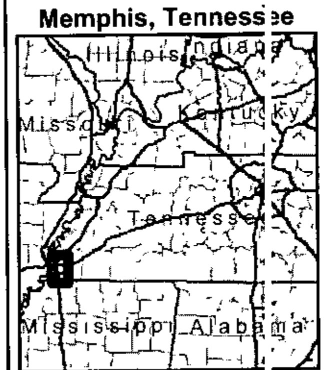
SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Projection: NAD 1927 StatePlane Tennessee
Datum : WGS 84
Units: Feet

0 0.6 1.2 1.8 2.4 3 Miles

Installation Location
Memphis, Tennessee



Date: December 2007
Edition: Rev 1

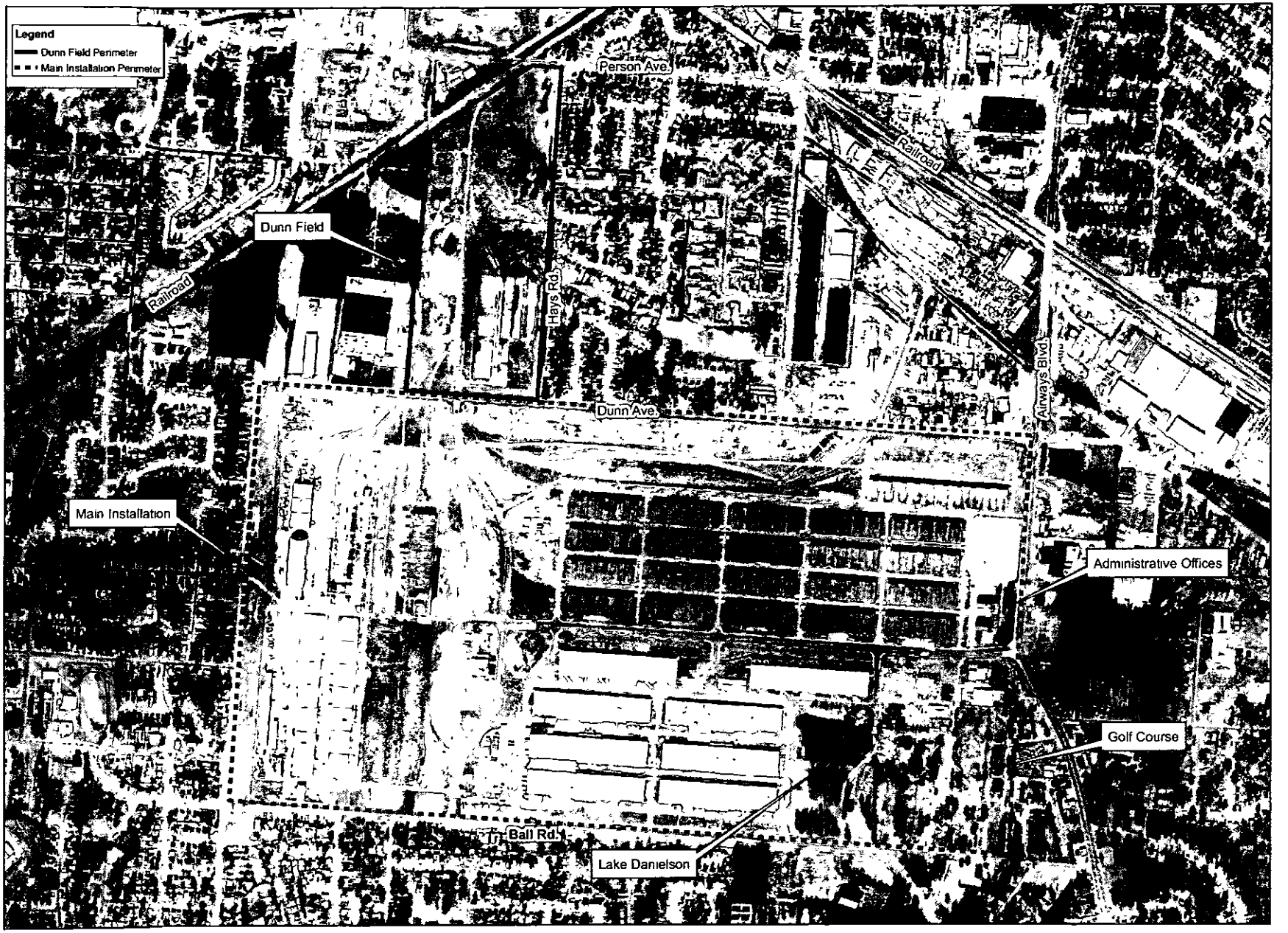


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Figure 2

MAJOR FEATURES OF THE DEPOT

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Projection: NAD 1927 StatePlane Tennessee
Datum WGS 84
Units: Feet

Aerial Photo Date: 2006

0 250 500 1,000 1,500
Feet

Installation Location
Memphis, Tennessee

Date: December 2007
Edition: Rev 1

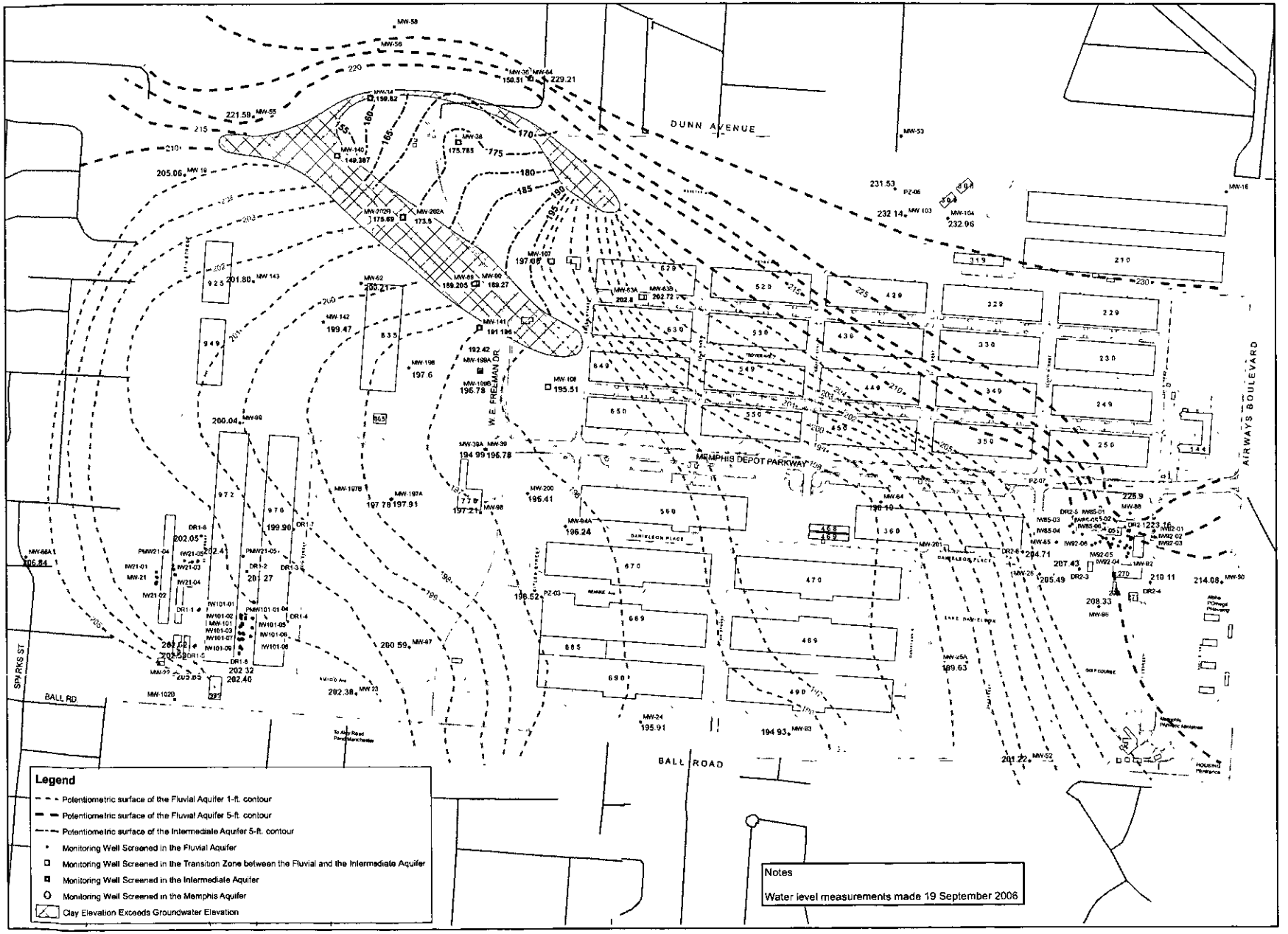

Figure 3
MAIN INSTALLATION GROUNDWATER ELEVATION, OCTOBER 2006

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT MEMPHIS, TENNESSEE

Projection NAD 1927 StatePlane Tennessee
Datum WGS 84
Units Feet

0 200 400 800 Feet

Installation Location
Memphis, Tennessee

Date December 2007
Edition Rev 1

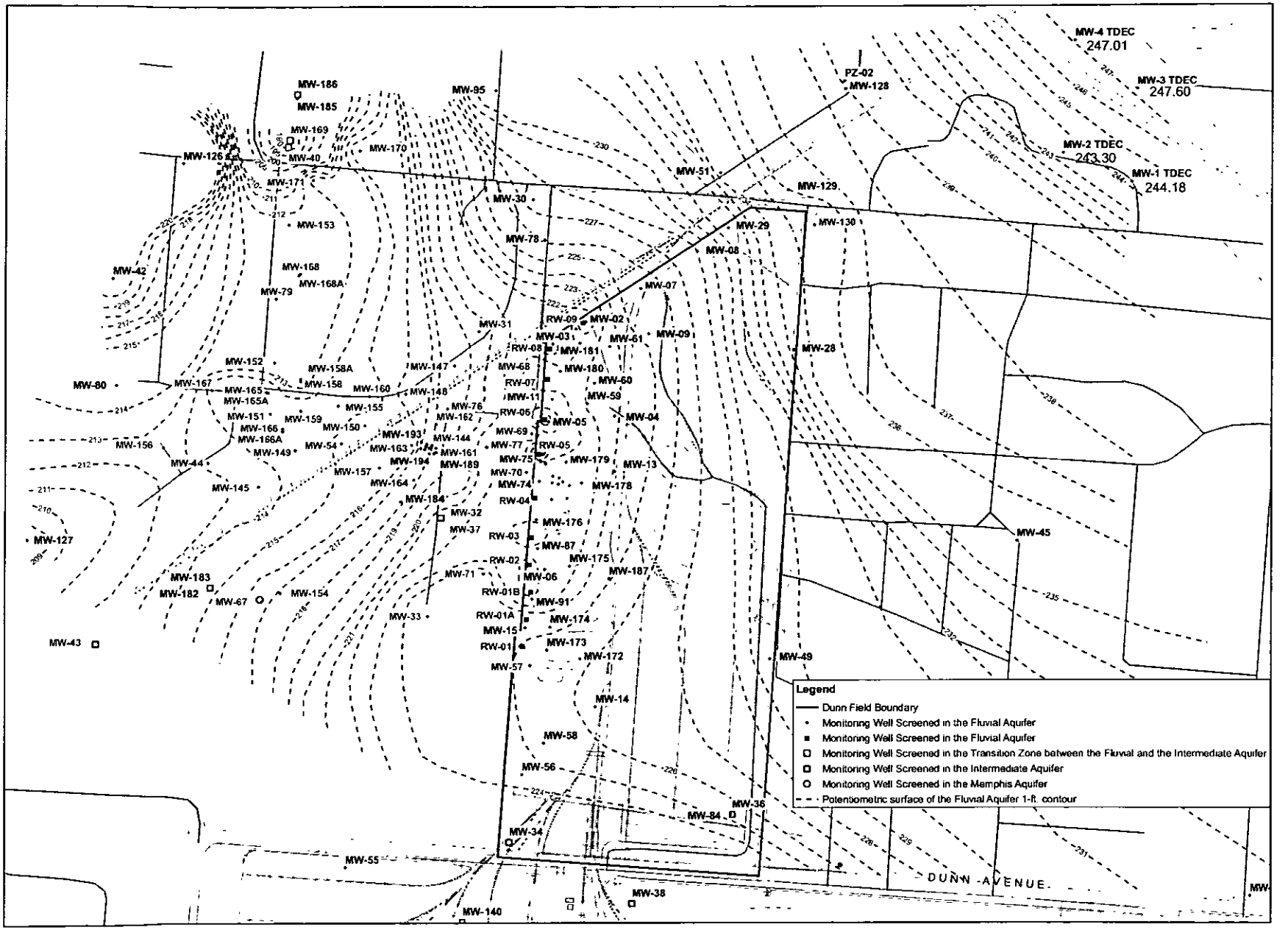

Figure 4

DUNN FIELD GROUNDWATER ELEVATIONS, OCTOBER 2006

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

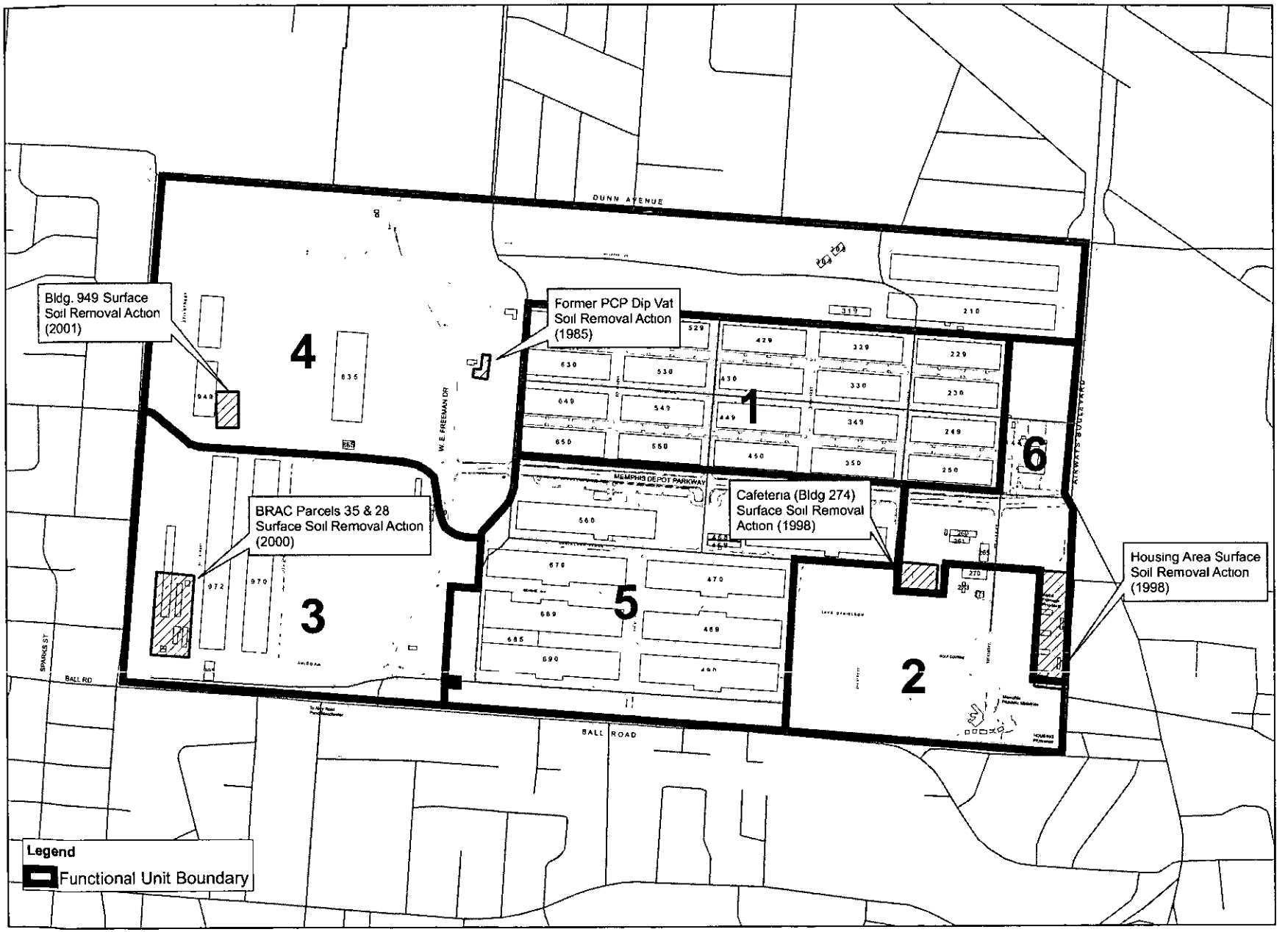

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Figure 5

MAIN INSTALLATION FUNCTIONAL UNITS AND PAST RESPONSE ACTIONS

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Projection NAD 1927 StatePlane Tennessee
Datum WGS 84
Units Feet

0 250 500 1,000
Feet

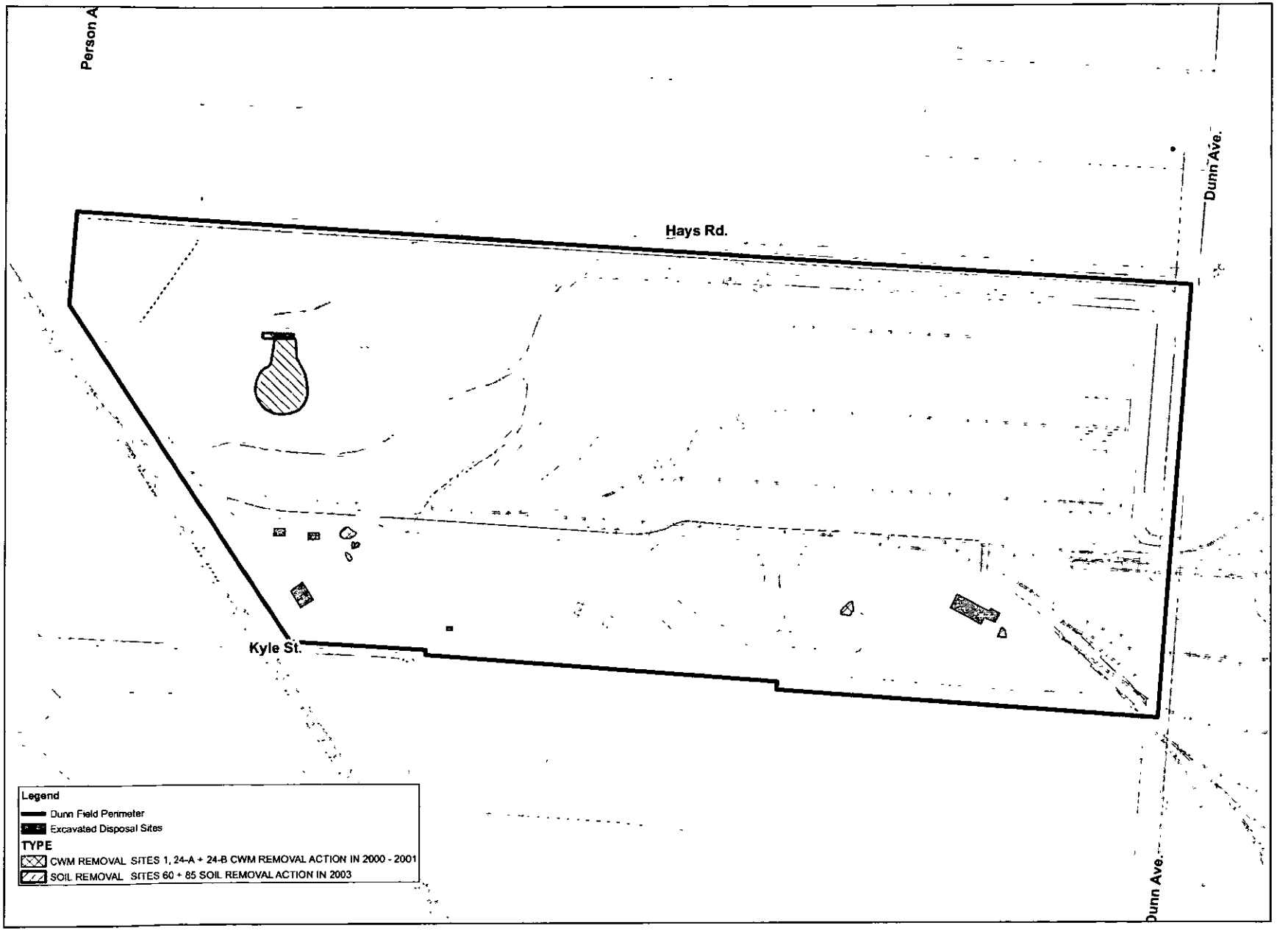

Figure 6

DUNN FIELD PAST RESPONSE ACTIONS AND DISPOSAL SITE EXCAVATIONS

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Projection: NAD 1927 StatePlane Tennessee
Datum: WGS 84
Units: Feet

Aerial Photo Date: 2006

0 100 200 400
Feet

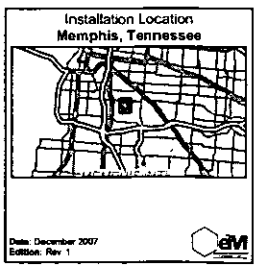

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Figure 7

AREA DESIGNATIONS AT DUNN FIELD

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Projection NAD 1927 StatePlane Tennessee
Datum WGS 84
Units Feet

Aerial Photo Date: 2006

0 100 200 400
Feet

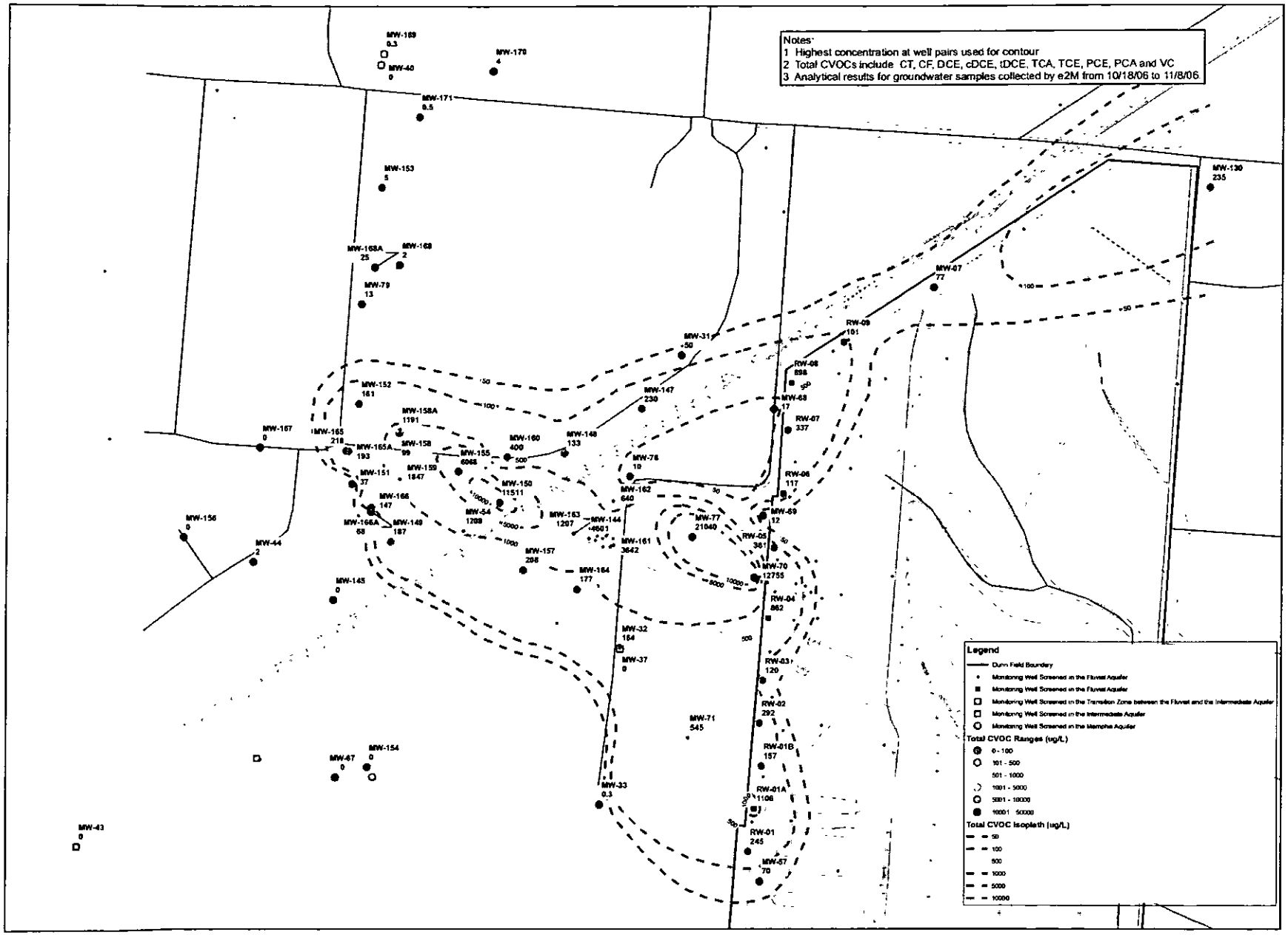

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Figure 8

DUNN FIELD IRA TOTAL CVOC CONCENTRATIONS, OCTOBER 2006

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT MEMPHIS, TENNESSEE

Projection: NAD 1927 StatePlane Tennessee
Datum WGS 84
Units Feet

0 100 200 400

Feet

Installation Location
Memphis, Tennessee

Date: December 2007
Edition: Rev 1

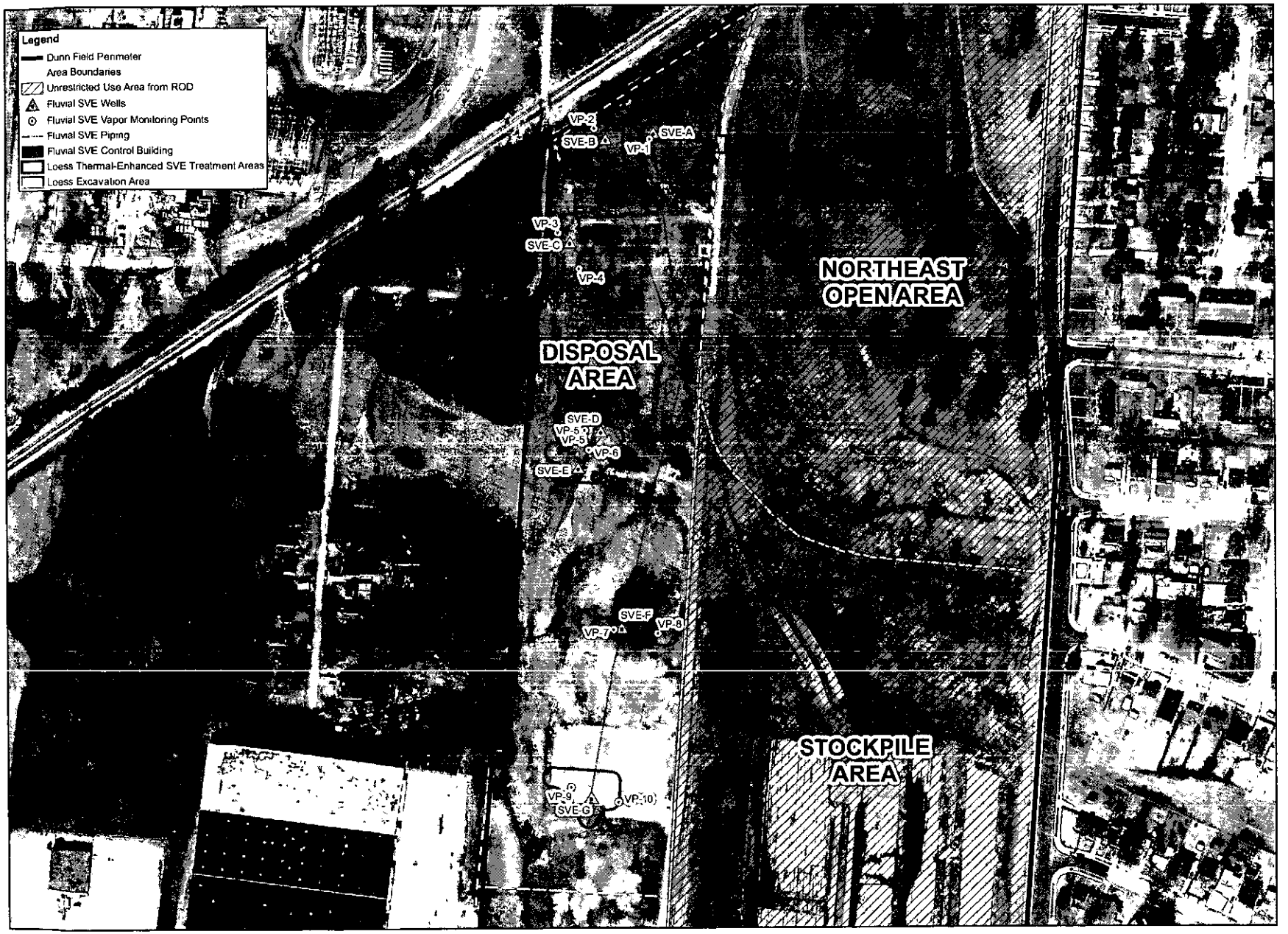


Figure 9

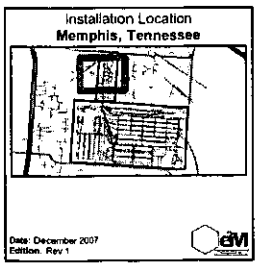
DUNN FIELD SUBSURFACE TREATMENT AREAS

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT MEMPHIS, TENNESSEE

Projection NAD 1927 StatePlane Tennessee
Datum: WGS 84
Units: Feet

0 50 100 200 300
Feet



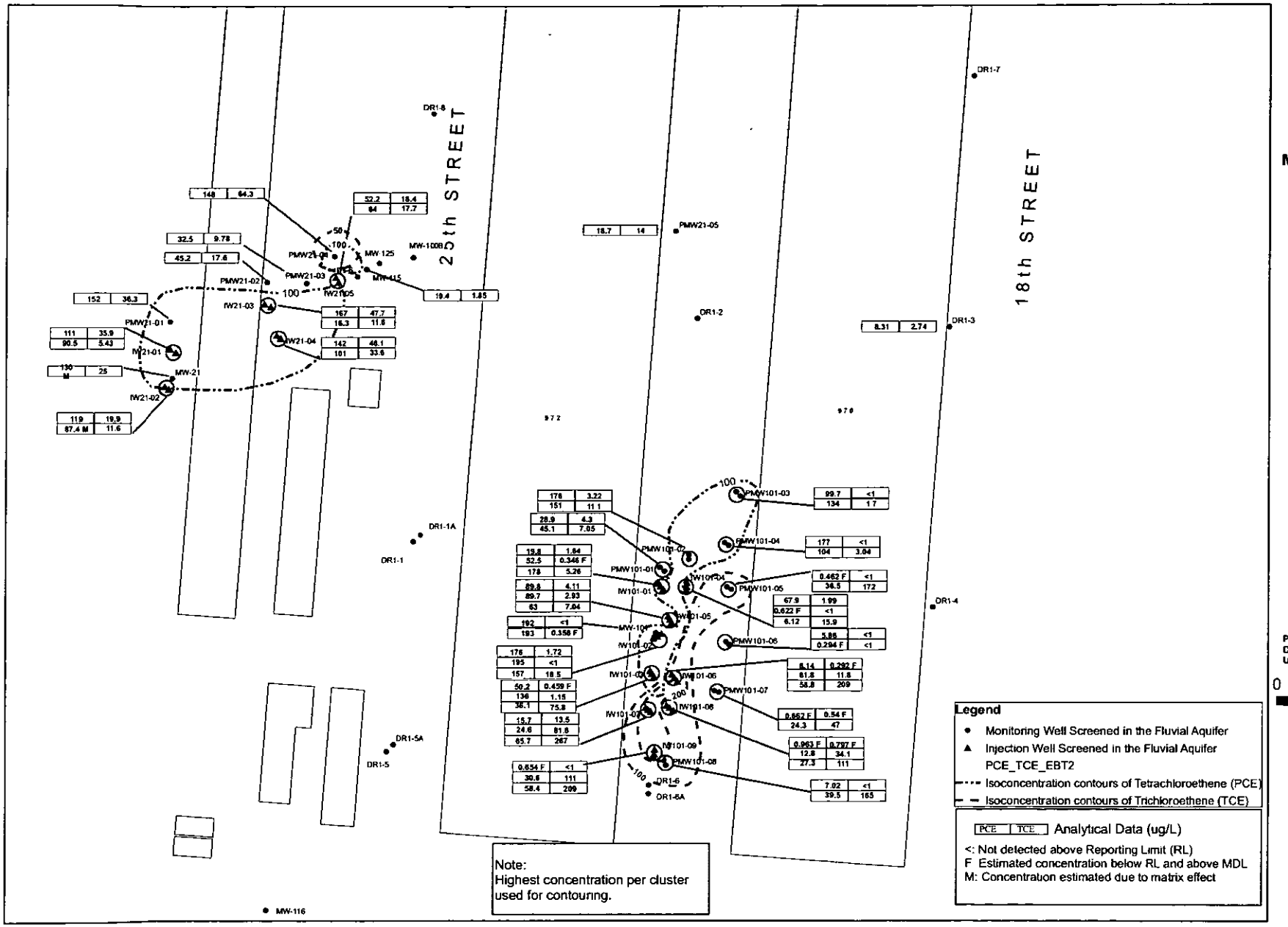


Figure 10

MAIN INSTALLATION EBT, TTA-1 PCE AND TCE CONCENTRATIONS

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

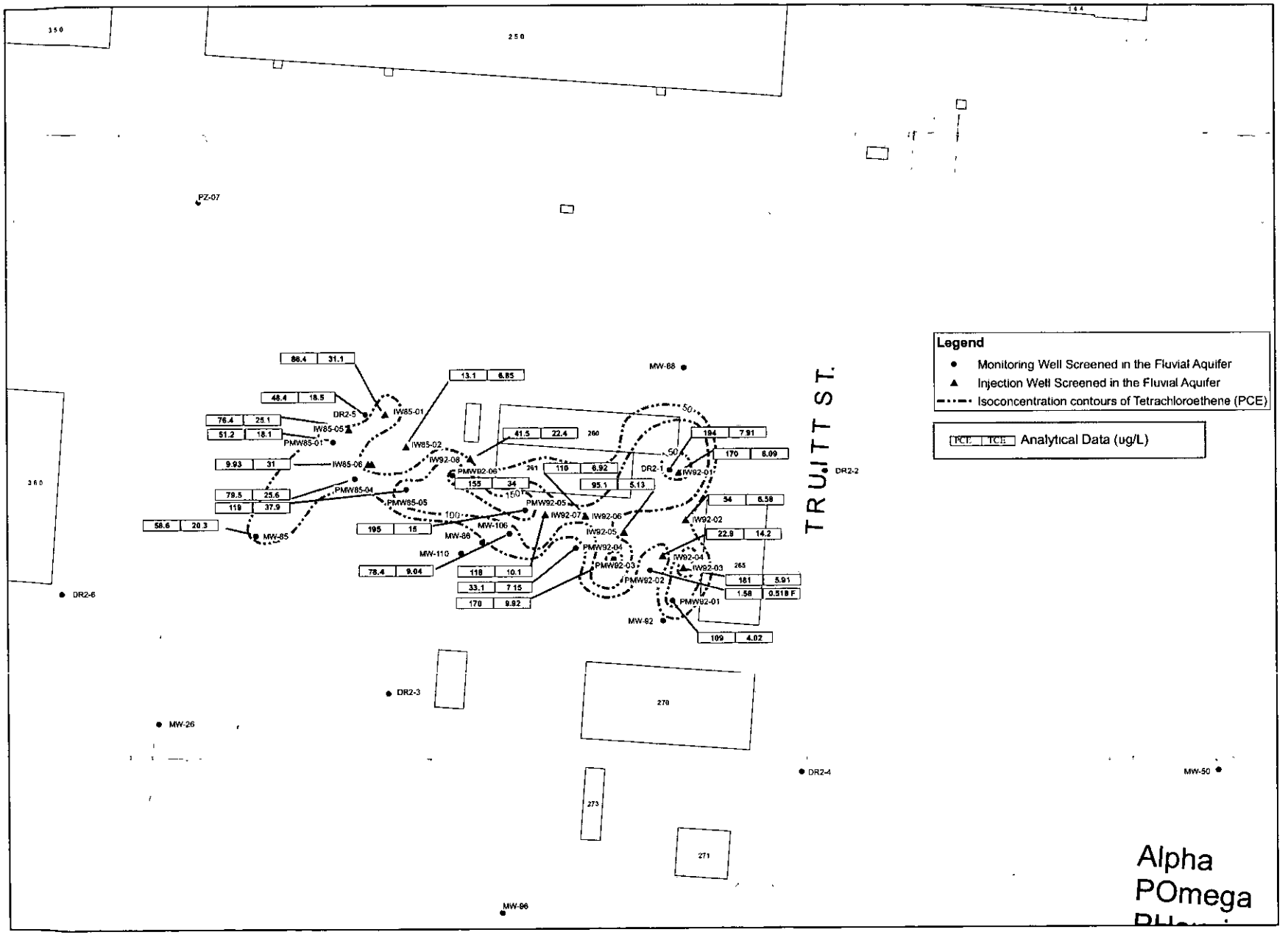


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Figure 11

MAIN INSTALLATION EBT, TTA-2 PCE AND TCE CONCENTRATIONS

SECOND FIVE-YEAR REVIEW

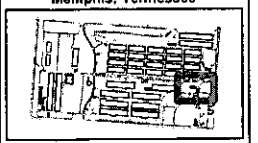
DEFENSE DEPOT
MEMPHIS, TENNESSEE

Projection NAD 1927 StatePlane Tennessee
Datum WGS 84
Units Feet

0 50 100 200

Feet

Installation Location
Memphis, Tennessee



Date December 2007
Edition Rev 1

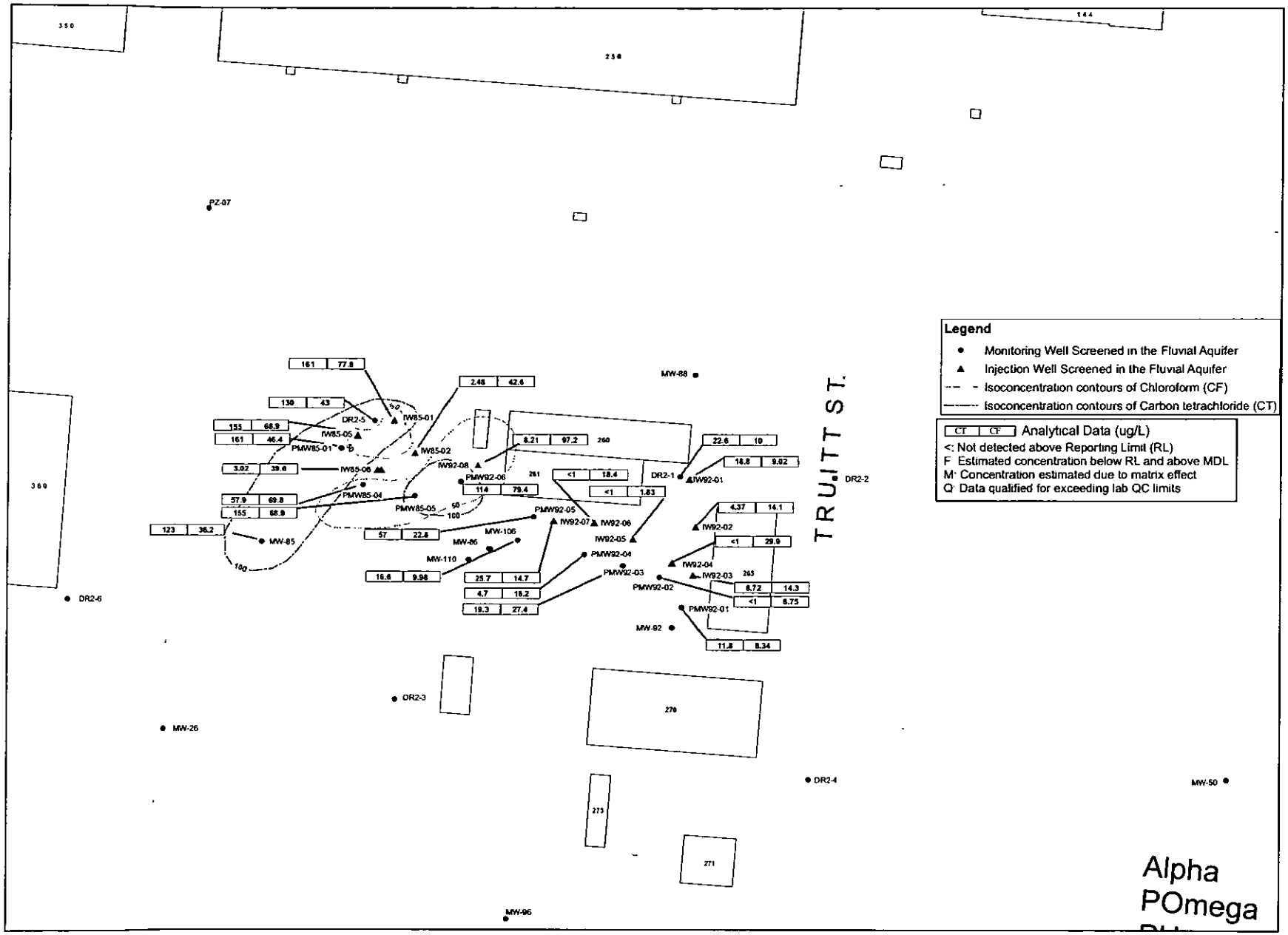


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Figure 12

MAIN INSTALLATION EBT, TTA-2 CT AND CF CONCENTRATIONS

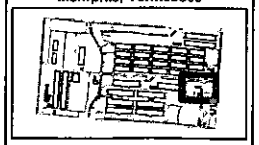
SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Projection: NAD 1927 StatePlane Tennessee
Datum: WGS 84
Units: Feet

0 50 100 200
Feet

Installation Location
Memphis, Tennessee



Date: December 2007
Edition: Rev 1

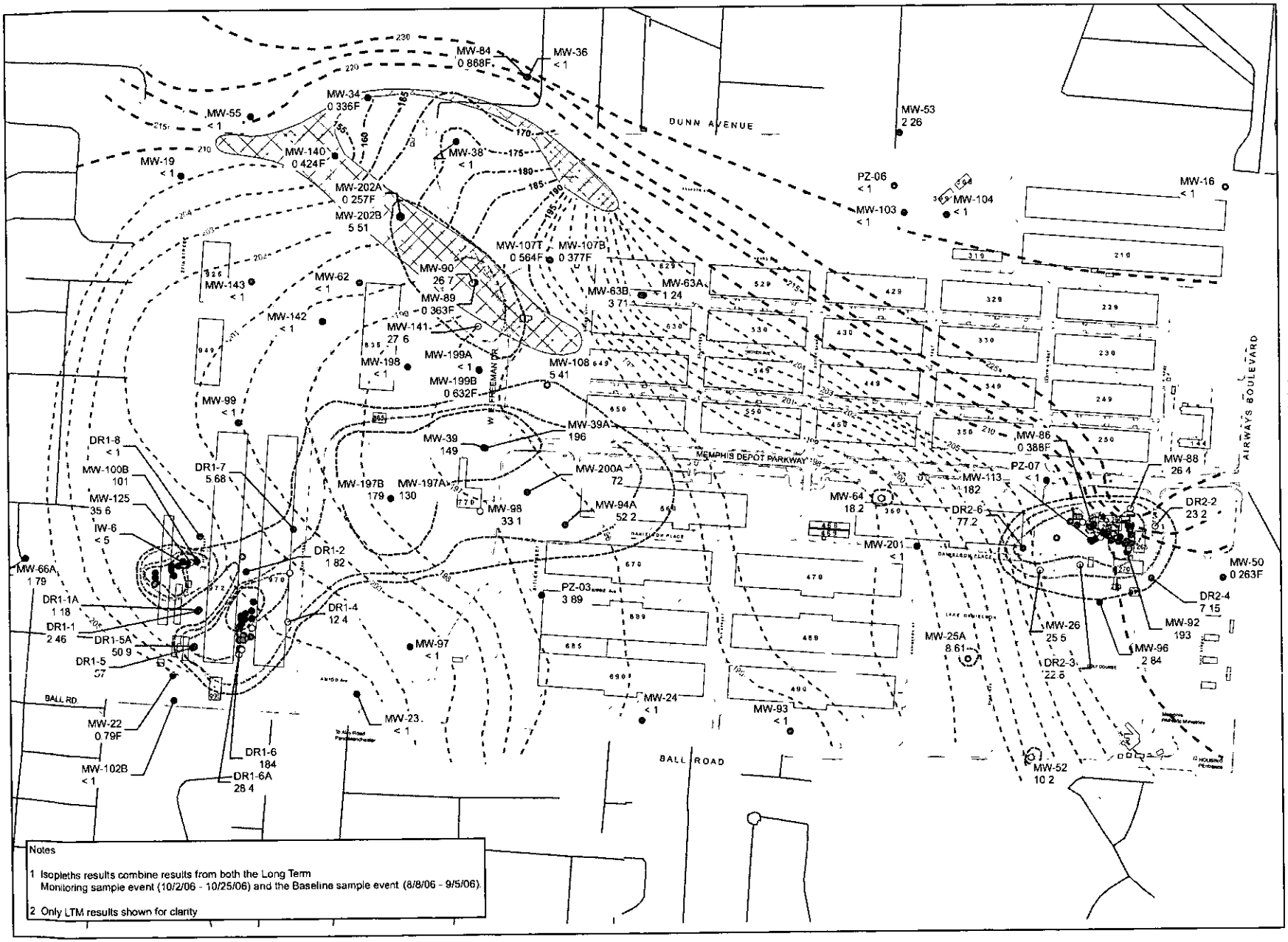


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Figure 13

MAIN INSTALLATION LTM, PCE CONCENTRATIONS

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT
MEMPHIS, TENNESSEE

Legend

PCE ISOPLETH
ug/L
- 5
- 10
- 50
- 100

PCE Ranges
ug/L
- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 300

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

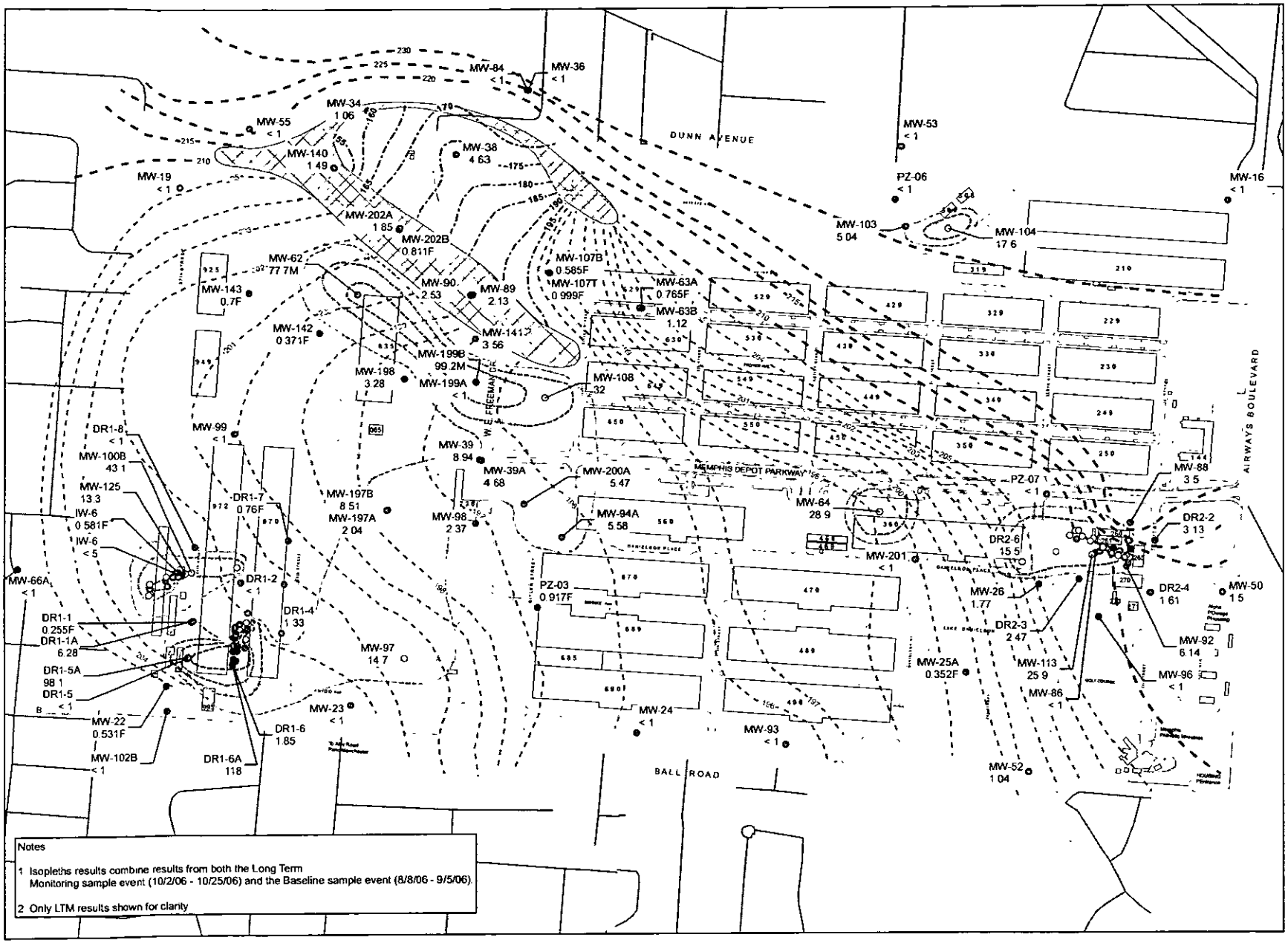
Projection NAD 1927 StatePlane Tennessee
Datum WGS 84
Units. Feet

0 200 400 600 800 Feet

Installation Location
Memphis, Tennessee

Date December 2007
Edition Rev 1

eM



Notes

1 Isopleths results combine results from both the Long Term Monitoring sample event (10/2/06 - 10/25/06) and the Baseline sample event (8/8/06 - 9/5/06)

2 Only LTM results shown for clarity

N

W E

S

Figure 14

MAIN INSTALLATION LTM, TCE CONCENTRATIONS

SECOND FIVE-YEAR REVIEW

DEFENSE DEPOT MEMPHIS, TENNESSEE

Legend

TCE ISOPLETH

ug/L

- 5
- 10
- 50
- 100

TCE RANGES

ug/L

- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 400
- Clay Elevation Exceeds Groundwater Elevation
- Potentiometric surface of the Fluvial Aquifer 1-ft. contour
- Potentiometric surface of the Fluvial Aquifer 5-ft. contour
- Potentiometric surface of the Intermediate Aquifer 5-ft. contour

Projection: NAD 1927 StatePlane Tennessee
Datum WGS 84
Units Feet

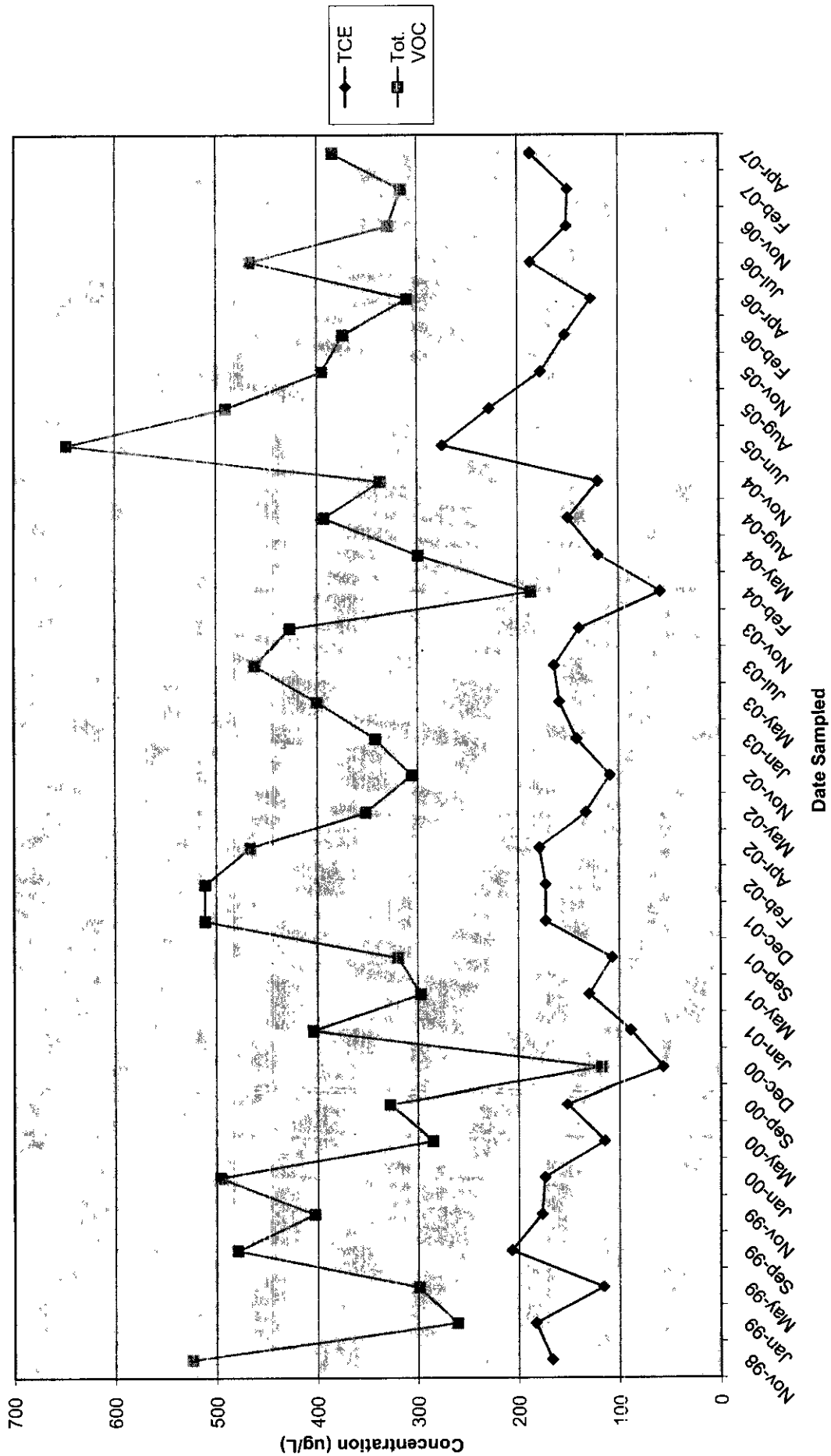
0 200 400 800 800 Feet

Installation Location
Memphis, Tennessee

Date: December 2007
Edition: Rev 1

FIGURE 15
IRA EFFLUENT DISCHARGE,
TCE AND TOTAL VOC CONCENTRATIONS

SECOND FIVE-YEAR REVIEW
Defense Depot Memphis, Tennessee



FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE