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## THE MEMPHIS DEPOT TENNESSEE

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# REMEDIAL ACTION SAMPLING AND ANALYSIS PLAN

## VOLUME I: FIELD SAMPLING PLAN

Defense Depot Memphis, Tennessee



Defense Logistics Agency

MACTEC

MACTEC Engineering and Consulting, Inc.



Air Force Center for Environmental Excellence  
Contract No. F41624-03-D-8606  
Task Order Nos. 0038 and 0080

November 2005  
Revision 1

**REMEDIAL ACTION SAMPLING AND ANALYSIS PLAN**  
**VOLUME I: FIELD SAMPLING PLAN**

**Defense Depot Memphis, Tennessee**

Prepared for:  
Air Force Center for Environmental Excellence  
Contract No. F41624-03-D-8606  
Task Order Nos. 0038 and 0080

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## PREFACE

The Remedial Action (RA) Sampling and Analysis Plan (SAP) prescribes those procedures necessary to perform the field activities, laboratory activities, and other contract requirements related to RA support for the Defense Depot Memphis, Tennessee, program. The RA SAP consists of two documents – the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP). This RA SAP was prepared in accordance with the requirements of the U.S. Environmental Protection Agency (USEPA) *Guidance for Quality Assurance Project Plans*, EPA 600/R-98/018 (USEPA, 1998); the USEPA *Requirements for Quality Assurance Project Plans*, EPA 240/B-01/003 (USEPA, 2001); and the Air Force Center for Environmental Excellence (AFCEE) *Guidance for Contract Deliverables – Appendix B: Field Sampling Plans, and Appendix C: Quality Assurance Project Plans* (AFCEE, 2001).

The FSP describes field activities to be performed and defines the procedures and methods required to collect field measurements and samples. The QAPP consists of information used to define and measure data quality objectives (DQOs). Definition of the DQOs assists in determining the appropriate procedures for fieldwork and laboratory analysis. The QAPP describes the quality assurance and quality control procedures necessary to meet project DQOs.

Key MACTEC Engineering and Consulting, Inc. (MACTEC) personnel participating in this project include Mr. Thomas Holmes, Project Principal; Mr. Paul Brafford, Senior Chemist; Mr. John Quinn, Senior Geologist; and Mr. David Price, Project Manager. The RA SAP was prepared by MACTEC under Contract No. F41624-03-D-8606, Task Order Nos. 0038 and 0080, for AFCEE and the Defense Logistics Agency.

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#### **LIST OF ACRONYMS**

AFCEE	Air Force Center for Environmental Excellence
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
C	Celsius
C-C	Chain of Custody
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DDMT	Defense Depot Memphis, Tennessee
DLA	Defense Logistics Agency
DO	Dissolved Oxygen
DQO	Data Quality Objective
DRC	Depot Redevelopment Corporation
DRI	Design-related Investigation
FFA	Federal Facility Agreement
FSP	Field Sampling Plan
ft/day	Feet per Day
HRS	Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments
ID	Inside Diameter
IDW	Investigation-derived Waste
MACTEC	MACTEC Engineering and Consulting, Inc.
MI	Main Installation
µm	Micrometer
mL	Milliliter
mL/min	Milliliters per Minute
MQO	Measurement Quality Objective
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level

**LIST OF ACRONYMS**  
**(Continued)**

NTU	Nephelometric Turbidity Units
O&M	Operation and Maintenance
ORP	Oxidation-reduction Potential
PDB	Passive Diffusion Bag
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
ROD	Record of Decision
SAP	Sampling and Analysis Plan
STL	Severn Trent Laboratories
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TOC	Total Organic Carbon
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
WTP	Work and Test Procedure

## 1.0 INTRODUCTION

MACTEC Engineering and Consulting, Inc., (MACTEC) has prepared this Field Sampling Plan (FSP) as part of the Remedial Action (RA) Sampling and Analysis Plan (SAP) under Contract No. F41624-03-D-8606 for the Air Force Center for Environmental Excellence (AFCEE). The FSP outlines the data collection and evaluation procedures to be performed during design-related investigations, RAs, and long-term monitoring at the Defense Depot Memphis, Tennessee (DDMT). The FSP includes summaries of the site conditions, project objectives for sampling and measurement activities, and procedures for monitoring data quality.

### 1.1 SITE LOCATION AND DESCRIPTION

The Memphis Depot (formerly known as the Defense Distribution Depot Memphis, Tennessee, and referred to in this report as “DDMT”) originated as a military facility in the early 1940s. Its initial mission and function was to provide stock control, materiel storage, and maintenance services to the U.S. Army (*BRAC Cleanup Plan Version 3* [Memphis Depot Caretaker Division, Environmental Office, 1998]). DDMT received, warehoused, and distributed supplies common to all U.S. military services and some civil agencies located mainly in the southeastern United States, Puerto Rico, and Panama. Stocked items included food; clothing; electronic equipment; petroleum products; construction materials; and industrial, medical, and general supplies. Approximately 4 million line items were received and shipped by DDMT annually; total shipments amounted to approximately 107,000 tons of goods per year. In 1995, DDMT was placed on the list of the U.S. Department of Defense facilities to be closed under Base Realignment and Closure (BRAC). Storage and distribution of materiel for all U.S. military services and some civil agencies continued until the facility closed in September 1997.

DDMT is in southeastern Memphis, Shelby County, Tennessee, approximately 5 miles east of the Mississippi River and just northeast of Interstate 240 (Figure 1-1). The latitude and longitude are 35°05'11"N and 89°59'18"W. The site address is 2163 Airways Boulevard, Memphis, Tennessee 38114.

The property consists of approximately 642 acres and includes two components: the Main Installation (MI), which comprises approximately 578 acres with open storage areas, warehouses, military family housing, and outdoor recreational areas, and Dunn Field, which comprises approximately 64 acres and includes former mineral storage and waste disposal areas.

Following closure, the U.S. Army Base Realignment and Closure Office in Fort Monroe, Virginia, is responsible for property dispositions (transfers) and is considered the owner. Four property transfers have been completed, covering a total of 422 acres. The local reuse authority, Depot Redevelopment Corporation (DRC), has a 50-year master lease on the MI. The entire DDMT property is zoned for Light Industrial Use. Land use controls have been established for all DDMT property with residual impacts above residential use criteria.

The lead agency for the site activities at DDMT is the Defense Logistics Agency (DLA). The regulatory oversight agencies are the U.S. Environmental Protection Agency (USEPA) Region 4 and the Tennessee Department of Environment and Conservation (TDEC). DDMT's USEPA Identification Number is TN4210020570.

Important dates for DDMT in regard to environmental regulatory activities include the following:

- In **January 1990**, USEPA Region 4 conducted a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) at the Memphis Depot through a contract with A.T. Kearney, Inc. (*RCRA Facility Assessment* [USEPA, 1990]). The RFA resulted in the identification of 49 solid waste management units (SWMUs) and 8 areas of concern (AOCs) at the facility.
- On **28 September 1990**, DDMT was issued a RCRA Part B permit for the storage of hazardous waste (No. TN4 210-020-570) by USEPA Region 4 and TDEC. The Hazardous and Solid Waste Amendments (HSWA) portion of the permit issued by USEPA included requirements for the identification and, if necessary, corrective action of SWMUs and AOCs. After issuing the permit, and in accordance with Section 120(d)(2) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Title 42, Section 9620(d)(2) of the U.S. Code, 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 DDMT to the National Priorities List (57 Federal Register 47180 No. 199).
- On **6 March 1995**, a Federal Facility Agreement (FFA) under CERCLA, Section 120, and RCRA, Sections 3008(h) and 3004(u) and (v), was entered into by USEPA, TDEC, and DLA. Appendix C of the FFA (*FY94 Site Management Plan*) identified a list of the original sites for investigation. A BRAC Cleanup Plan subsequently replaced the site management plan and included the list of sites for further investigation under CERCLA. The FFA outlined the process for investigation and cleanup of the sites at DDMT 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 TCA, Section 68-212-101 *et seq.*

- In **July 1995**, DDMT was identified for the closure under the BRAC process, which requires environmental restoration at DDMT to comply with the requirements for property transfer under Public Law 101-510 of Title XXIX, Defense Base Closure and Realignment. Since then, environmental restoration activities have been funded under BRAC. After DDMT was placed on the BRAC closure list, the City of Memphis and DRC were given the responsibility of planning and coordinating the reuse of DDMT. DRC conducted several public meetings during the preparation of its *Memphis Depot Redevelopment Plan* to obtain community feedback regarding future land use plans. The *Memphis Depot Redevelopment Plan* was approved in 1997 (The Pathfinders, 1997).
- On **22 October 1998**, the RCRA Part B permit was terminated by TDEC because the proposed storage unit was never constructed or operated.
- In **February 2001**, the Record of Decision (ROD) for the MI received final approval, and in **April 2004**, the ROD for Dunn Field was approved. Pursuant to the FFA, cleanup decisions have been made by the BRAC Cleanup Team (DLA, USEPA, and TDEC) for the MI and Dunn Field, and response actions have been and will be taken to address releases of hazardous substances that may present a risk to human health and the environment.

## 1.2 GEOLOGY AND HYDROGEOLOGY

### 1.2.1 Geology

A total of 224 wells have been installed in borings drilled at DDMT. A summary of well construction and hydrogeologic data is provided in Table 1-1. The well locations are shown in Figure 1-2. The geologic units of interest at DDMT are (from youngest to oldest) loess deposits, fluvial deposits, Jackson Formation/Upper Claiborne Group (Cockfield and Cook Mountain Formations), and Memphis Sand.

The Quaternary-age loess consists of brown to reddish brown low-plasticity clayey silt (ML) or low-plasticity silty clay (CL) and is continuous throughout the site. The loess deposits are generally 20 to 30 feet thick.

The Quaternary- and possibly Pliocene-age fluvial deposits consist of two general layers. The upper layer is a silty, sandy clay that transitions to a clayey sand and ranges from approximately 10 to 36 feet thick. The lower layer consists of interlayered sand, sandy gravel, and gravelly sand, and has an average thickness of approximately 40 feet. The fluvial deposits are commonly underlain by a thick clay unit of the Jackson Formation/Upper Claiborne Group.

The Late Eocene-age Jackson Formation/Upper Claiborne Group consists of clays, silts, and sands. The upper clay of the Jackson Formation/Upper Claiborne Group occurs at variable elevations (224 feet at MW-126 to 164 feet at DR1-2) and is highly variable in thickness.

This 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. Off-site gaps in the clay may be present to the west (at MW-43) and northwest (at MW-40) at Dunn Field. Where present, these gaps create connections to the underlying intermediate aquifer from the fluvial deposits.

The Early to Middle Eocene-age Memphis Sand consists mainly 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 total thickness. The Memphis Sand ranges from 500 to 890 feet in thickness and is at a depth of approximately 120 to 300 feet below ground surface (bgs). The City of Memphis obtains its drinking water from this unit; the Allen Well Field is located approximately 2 miles west of Dunn Field. The elevation of the Memphis Sand at the Allen Well Field is at approximately mean sea level (msl); *Hydrology of Aquifer Systems in the Memphis Area, Tennessee* [Criner et al., 1964]). Only one monitoring well installed at DDMT, MW-67, is screened in the Memphis Sand; the upper surface of the Memphis Sand was identified at 20.5 feet above msl.

### 1.2.2 Hydrogeology

There are only two surface water bodies at DDMT, Lake Danielson and the Golf Course pond. No perennial streams, flood-prone areas, or wetlands occur within DDMT. The lake and pond are fed by stormwater runoff and are too shallow to intercept the fluvial aquifer.

The Memphis area includes several aquifers of local and regional importance. In descending order, they are:

- Alluvial aquifer
- Fluvial (terrace) aquifer
- Intermediate aquifer
- Memphis aquifer

The alluvial aquifer's distribution is limited to the channels of primary streams; therefore, it does not occur at DDMT. The uppermost aquifer at DDMT is the unconfined fluvial aquifer, consisting of

saturated sands and gravelly sands in the lower portion of the fluvial deposits. Recharge to this unit is mainly from the infiltration of rainfall (*Potential for Leakage Among Principal Aquifers in the Memphis Area, Tennessee* [Graham and Parks, 1986]). Discharge from the fluvial aquifer is generally directed toward underlying units in hydraulic communication with the fluvial deposits, or laterally into adjacent stream channels. The fluvial aquifer provides water for domestic and farm wells in rural areas (*Hydrogeology of the Principal Aquifers and Relation of Faults to Interaquifer Leakage in the Memphis Area, Tennessee* [Kingsbury and Parks, 1993]), but is not used as a drinking water source within the area surrounding DDMT.

The low-permeability uppermost clay of the Jackson Formation/Upper Claiborne Group serves as the base of the fluvial aquifer at most locations. This clay has very low permeability, with an average hydraulic conductivity of  $6.4 \times 10^{-8}$  centimeters per second. Where present, the clay constitutes a hydraulic barrier to downward migration of groundwater. Groundwater also exists in the vadose zone of the fluvial aquifer deposits usually above small clay lenses. These perched water zones are isolated, are probably ephemeral, and are not considered part of the fluvial aquifer.

The saturated thickness of the fluvial aquifer is variable across DDMT and is controlled by the configuration of the uppermost clay in the Jackson Formation/Upper Claiborne Group. The saturated thickness averages 10 to 20 feet, but ranges from 0 feet (dry) to 57 feet (in the central portion of the MI). Groundwater elevations in the fluvial aquifer in June 2004 ranged from 257.71 feet (MW-65) to 193.95 feet (MW-39). In areas near gaps in the uppermost clay, groundwater appears to flow from the fluvial aquifer into the underlying intermediate aquifer, causing the fluvial aquifer to “pinch out”. Areas of unsaturated conditions in the fluvial aquifer are created in those areas, with groundwater flow in the fluvial aquifer toward the low point(s) in the uppermost clay at the window.

Slug tests performed in the fluvial aquifer at the MI indicate that hydraulic conductivity values for the fluvial aquifer range from approximately 1 to 60 feet per day (ft/day). Assuming an effective porosity of 30 percent, flow velocities throughout the MI average 0.6 ft/day. The hydraulic conductivities for the fluvial aquifer measured at Dunn Field average 8 to 17 ft/day based on slug tests. Results from a 1992 pumping test at Dunn Field (MW-3) indicate an average hydraulic conductivity of 100 ft/day. In the fluvial aquifer, groundwater flow is roughly toward the east-northeast in the southwestern portion of the MI, to the southwest in the eastern portion of the MI, and to the west at Dunn Field.

The intermediate aquifer underlying DDMT is locally developed in permeable deposits of the Jackson Formation/Upper Claiborne Group, which also contain laterally extensive, thick deposits of clay. The lithologic logs of MW-18, MW-40, MW-67, MW-82, and MW-83 show the intermediate aquifer to consist of interbedded sand, silt, and clay.

Aquifer tests conducted in August 1997 indicate the hydraulic conductivity for the intermediate aquifer is similar to that of the fluvial aquifer, with conductivities of 3.7 (MW-34) ft/day and 1.5 (MW-40) ft/day. Away from the influence of recharge from the fluvial aquifer, water level elevations in the intermediate aquifer are approximately 160 feet msl.

The Memphis aquifer contains groundwater under strong artesian (confined) conditions regionally and is the primary source of drinking water in the Memphis area. It receives most of its recharge from outcrop areas several miles east of Memphis. Some recharge is derived from overlying or hydraulically communicating units. The Memphis aquifer is confined by overlying clays and silts in the Cook Mountain Formation (part of the Jackson/Upper Claiborne Group). Clays and silts of the Cook Mountain Formation were observed above the Memphis Sand in MW-67, which encountered the upper surface of the Memphis Sand at approximately 255 feet bgs (20.5 feet above msl). The potentiometric surface of the Memphis Sand at MW-67 is approximately 160 feet above msl. Flow in the unit is generally westward, toward the Allen Well Field, a major local pumping zone (Parks and Carmichael, 1990).

### 1.3 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are developed for field and laboratory operations to clarify study objectives, define the appropriate type of data stipulated, and specify tolerable levels of potential decision errors that will be used to establish the quality and quantity of data needed to support decisions. DQOs determine the type, quantity, and quality of data needed to produce defensible data. DQOs will be presented in each project Work Plan.

The DQO process leads to the specification of sample handling procedures; preparatory (extraction/digestion), cleanup, and determinative methods; target analytes; method quantization or reporting limits; field and laboratory quality control (QC) samples; measurement quality objectives (MQOs) for data quality indicators; required corrective actions; and data assessment procedures necessary to meet the intended use of the data.

The U.S. Army Corps of Engineers (USACE) adopted USEPA's DQO process (*Data Quality Objectives Process for Hazardous Waste Site Investigations* [USEPA, 2000]) in theory, and transformed USEPA's seven-step process into four phases (I through IV), subsequently published as EM 200-1-2 (*USACE Technical Project Planning (TPP) Process* [USACE, 1998]).

The following DQO process for the RA SAP is presented as an example for the determination of potential future project DQOs:

- **Step 1 (USACE Phases I, II, III, and IV) – State the Problem.** Identify and update facility-wide sampling and analytical procedures used to produce data of sufficient quantity and quality to meet the overall program DQOs and activity-specific DQOs.
- **Step 2 (USACE Phases I and II) – Identify the Decision.** Produce an updated RA SAP to outline the sampling and analytical protocols to be utilized at DDMT to meet overall program DQOs.
- **Step 3 (USACE Phases II and III) – Identify Inputs into the Decision.** In order to produce an updated RA SAP for DDMT, the following information will be required:
  - USACE/AFCEE and USEPA sampling procedures
  - USACE/AFCEE and USEPA monitoring well installation and development guidance
  - USEPA and other approved methods for chemical and geotechnical analyses
  - USACE/AFCEE certified laboratories (where applicable)
  - Site description and history, and facility-wide geology and hydrogeology
  - USACE/AFCEE and USEPA analytical data quality criteria
  - Applicable or relevant and appropriate requirements (ARARs)
- **Step 4 (USACE Phases II and III) – Define the Boundaries of the Study.** The geographic boundary for the RA SAP is the DDMT site.
- **Step 5 (USACE Phases I, II, and III) – Develop a Decision Rule.** Produce an updated RA SAP to outline the sampling and analytical protocols to be utilized at DDMT to meet overall RA DQOs. DQOs are to be general in nature, with MQOs that can be obtained within USACE and project criteria.
- **Step 6 (USACE Phases II and III) – Specify the Limits on Decision Errors.** Following is a summary of the acceptable tolerances for error:
  - Measurement error (physical sampling process, analysis, and data reduction)

- Chemical data quality (within USACE Shell or AFCEE Quality Assurance Project Plan and laboratory limits)
- Tier-specific USEPA SW-846 and other specified methods (within acceptable limits)
- Detection limits (within method and laboratory limits as compared to ARARs)
- Statistical data evaluation requirements
- **Step 7 (USACE Phases III and IV) – Optimize the Sampling Design.** The RA SAP will identify comprehensive sampling and analysis procedures that may be utilized for any project at DDMT. The procedures will include quality assurance (QA)/QC criteria to produce data of sufficient quantity and quality to meet overall DQOs.

## 2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization and responsibilities for the overall DDMT program are presented in the following subsections. Figure 3-1 illustrates the program organization and responsibilities.

### 2.1 PROJECT ORGANIZATION

MACTEC has assembled the necessary technical and administrative staff to meet the objectives of the RA support activities at DDMT. MACTEC's technical staff will work under the direct supervision of the MACTEC project manager, Mr. David Price, and the project principal, Mr. Thomas Holmes. The MACTEC project manager will provide technical coordination with the AFCEE technical project manager.

Subcontractors will be utilized to perform various activities during the investigations as required. The subcontractors will report administratively to the MACTEC project manager and/or field team leader. Subsection 2.3 provides a list of the subcontractors that may be used during the field activities.

### 2.2 KEY PROJECT INDIVIDUALS

Key MACTEC participants in this project include the program manager, project principal, project manager, project geologist, project chemist, and field personnel. The following paragraphs provide a description of the proposed project assignments and responsibilities, a list of individuals expected to serve in each capacity, and a brief synopsis of the participants' related experience.

The program manager is responsible for the administrative requirements and overall contractual agreements. Mr. Steve Youngs is the program manager for DLA. Mr. Youngs is a principal geologist with MACTEC, specializing in RAs. He is a Professional Geologist with more than 28 years of experience in environmental consulting.

Mr. David Price is the project manager and is responsible for the overall management and quality of the project work. As project manager, he manages contractual and administrative requirements, schedules, and budgets for the program. The project manager also serves as the liaison between MACTEC and

AFCEE. Mr. Price is a Registered Geologist in Georgia with more than 20 years of environmental consulting experience.

Mr. Thomas Holmes is the project principal and is responsible for technical QA/QC oversight and direction for all aspects of the project. Mr. Holmes is a Registered Geologist in Georgia with more than 25 years of environmental consulting experience.

Mr. John Quinn is the MACTEC project geologist for DDMT. Mr. Quinn is a Registered Professional Geologist in Tennessee and Georgia with more than 19 years of experience in environmental consulting.

Mr. Paul Brafford is the project chemist and is responsible for preparing and implementing the field sampling, sample preservation, sample chain of custody (C-C), and sample shipping activities. He performs or supervises evaluation of analytical laboratory data and helps prepare technical reports. Mr. Brafford is a Certified Hazardous Materials Manager and a senior chemist at MACTEC with 25 years of experience in site investigation, site assessment, and laboratory analysis.

The field team leader is responsible for the oversight of the field and personnel activities. All field activities will be coordinated and executed through the field team leader. Based on the various activities to be performed under the RA SAP (Design-related Investigation [DRI], RA, long-term monitoring, and operation and maintenance [O&M]), a field team leader will be assigned for each activity. The members of the field team will come from within the MACTEC offices located in Kennesaw and Atlanta, Georgia; Birmingham, Alabama; and Jackson, Mississippi.

### 2.3 PROJECT SUBCONTRACTORS

Subcontractors for the activities conducted at DDMT may provide the following services: laboratory analysis, drilling and well installation, land surveying, and investigation-derived waste (IDW) disposal management. The subcontractors listed below are those currently under subcontract, but as new delivery orders are issued, these subcontractors may change:

- **Laboratory Analytical Services**  
Severn Trent Laboratories (STL)  
Contact: Roger Toth  
4101 Shuffel Drive NW  
North Canton, OH 44720  
(330) 497-9396

Environmental Testing & Consulting, Inc.  
Contact: Connie Bradbury  
2790 Whitten Road  
Memphis, TN 38133  
(901) 213-2400

- **Drilling Services**

Prosonic Corporation  
Contact: Blake Cabit  
825 South Main Street  
New Ellenton, SC 29809  
(803) 652-2705

- **Surveying Services**

Allen & Hoshall  
Contact: Jay Caughman  
1661 International Drive, Suite 100  
Memphis, TN 38120  
(901) 820-0820

- **IDW Management**

All Points Logistics, Inc.  
Contact: Andy Adams  
2567 Athens Highway  
Gainesville, GA 30507  
(770) 503-7474

### 2.3.1 Laboratory Analytical Services

Two laboratories are currently selected to perform the primary organic and inorganic parameter analytical services: STL-North Canton and Environmental Testing & Consulting. Future projects requiring analytical services may result in the selection of another vendor(s).

The selected laboratory will be responsible for providing sample shipping containers, C-C documents, chemical analysis and reporting, and laboratory (QA/QC). If required, a mobile laboratory will provide on-site analytical services for DDMT. All chemical testing laboratories used for the DDMT program must be USACE and National Environmental Laboratory Accreditation Program certified. Specialty laboratories and any other laboratory selected to perform work for DDMT will have to implement QA/QC specific to these activities in their laboratory operations and Standard Operating Procedures.

### **2.3.2 Drilling Services**

The drilling subcontractor will be contracted to install monitoring and injection wells at DDMT. The subcontractor will report directly to the MACTEC project geologist before and after fieldwork and to the MACTEC field team leader during field activities. Prosonic Corporation has been subcontracted to perform drilling services scoped for DRIs. Future projects requiring drilling services may result in the selection of another vendor.

### **2.3.3 Surveying Services**

A Tennessee-licensed survey firm will be subcontracted to survey sampling locations and elevations and provide the location data to MACTEC. The firm will report directly to the MACTEC field team leader during field activities and to the MACTEC project geologist or engineer before and after fieldwork. Allen & Hoshall personnel are currently designated to provide surveying services based on their previous experience at DDMT. Future activities requiring surveying services may result in the selection of another vendor.

### **2.3.4 Investigation-derived Waste Management**

All Points Logistics, Inc. was subcontracted to transport and dispose of IDW generated during the DRIs at DDMT. Future projects requiring IDW management will result in the selection of another vendor, as All Points Logistics is no longer performing IDW management services. The selected IDW management firm will report directly to the MACTEC field team leader during field activities and to the MACTEC project geologist before and after fieldwork.

### 3.0 FIELD ACTIVITIES

The following subsections describe the planned field activities at DDMT. The rationale and design for each field activity will be discussed in the appropriate Work Plan; typical field tasks and rationales are listed on Table 3-1. The Work and Test Procedures (WTPs) located in Appendix B outline the field activities in greater detail.

#### 3.1 SITE RECONNAISSANCE, PREPARATION, AND RESTORATION

Before the start of all field activities, a field team leader will be assigned. Working in conjunction with the task/project manager, the field team leader is responsible for preparation and organization of the field activities. The general responsibilities of the field team leader for site preparation and restoration are described in WTP 1.

Before any intrusive activities, underground and aboveground utilities will be identified. Drilling will proceed only in those areas where no utility obstructions are present. Existing underground power and communication lines, gas lines, stormwater and sanitary sewer lines, and water supply lines will be identified on site maps and will be referenced before field activities. Sufficient clearance for overhead utilities will be confirmed visually. DRC; the City of Memphis; Shelby County; Memphis Gas, Light, and Water; or private personnel may be requested to assist in the utility clearance process. Permits for installation of monitoring wells designated for the purposes of groundwater investigations off-site may be required.

#### 3.2 BOREHOLE CONSTRUCTION AND SOIL SAMPLING

Soil borings will be advanced by sonic drilling during investigation and remedial activities at DDMT. If hollow-stem or mud rotary drilling methods are required by site conditions, the method will be proposed for approval on a project-specific basis. Specifications for drilling operations are described in WTP 2.

The use of water during drilling will be avoided if possible. Should the use of water become necessary, it will come from a potable source and sampled as described in WTP 2. The quantity of any water used during drilling will be carefully monitored and recorded in the field logbook.

### **3.2.1 Sonic Drilling**

Sonic drilling is considered the most effective method for boring advancement and well installation under the geologic and hydrogeologic conditions at DDMT. The depth to water (approximately 100 feet bgs) and geologic characteristics of the fluvial aquifer (i.e., tight sands mixed with gravel up to cobble size) can present problems for other methods.

Sonic drilling uses a dual-case drilling system that employs high-frequency mechanical vibration to collect continuous core samples of overburden and most bedrock formations, and to advance casing into the ground. This drilling technique vibrates the entire drill string between 50 and 150 cycles per second. A sonic drill rig looks and operates very much like any conventional rotary or auger rig. The main difference is that a sonic drill rig has a specially designed hydraulically powered drill head or oscillator that generates adjustable high-frequency vibrational forces. In many overburden formations, a sonic drill rig can achieve rates of 1 foot per second.

### **3.2.2 Mud Rotary Drilling**

In some cases, site conditions may dictate the use of mud rotary drilling procedures. Direct mud rotary drilling uses a rotating drill pipe with a hard-tool drill bit attached at the bottom. Fluid is forced down through the drill pipe and then back up the borehole. It is then discharged at the surface through a pipe or ditch into a sedimentation tank, pond, or pit. As the cuttings settle, the fluid overflows into a suction pit, where a pump recirculates the fluid back through the drill rods. The drilling fluid cools and lubricates the bit; stabilizes the borehole wall; and prevents the inflow of formation fluids, thus minimizing cross-contamination of aquifers. Casing is not required during drilling.

### **3.2.3 Hollow-stem Auger Drilling**

Hollow-stem auger drilling has been used for boring advancement and well installation at DDMT, mainly before the development of sonic drilling. Hollow-stem auger drilling may be used again if required by site conditions. Hollow-stem auger drilling uses auger flights with a hollow drill stem to advance the borehole. As the borehole is advanced, the soil cuttings are conveyed to the surface by the auger flights. The hollow drill stem cases the borehole and provides an avenue for various sampling devices, including split-spoon and Shelby tube samplers.

### 3.2.4 Soil Sampling and Classification

Soil samples may be collected from surface soils, soil borings, soil piles, and the sidewalls and floor of excavations. Samples may be collected using split-spoon samplers, Shelby tubes, hand augers, or stainless steel spoons. Information and procedures for soil sampling activities are described in WTP 11.

## 3.3 WELL INSTALLATION

Monitoring wells and lactate injection wells will be installed, developed, and sampled as part of RAs at DDMT. Monitoring wells will be installed to monitor the concentration and migration of constituents, monitor the performance of an RA, and serve as compliance wells. Injection wells will be installed as required to implement RAs. Specifications for each well type, including details of well construction methods, materials, and acceptance criteria, are provided in WTPs 2 and 3. The general procedures are described below. All well installation activities will be conducted under the supervision of a Tennessee-registered Professional Geologist or Engineer.

The wells will be constructed within sonic drill casing as the casing is withdrawn from the boring. Borehole diameters will be at least 7 inches. The inside diameter (ID) of the sonic drill casing will be at least 4 inches larger than the outside diameter of the well casing and screen to facilitate proper installation of the well. Therefore, the sonic drill casing will require an inner annulus that is at least 6½ inch in diameter.

Monitoring wells will be constructed of 2-inch ID Schedule 40 polyvinyl chloride (PVC) casing and screens. Injection wells will be constructed of 4-inch ID Schedule 40 PVC casing and screens. Each well will have a filter pack around the screen, a bentonite seal above the filter pack, and cement grout to ground surface installed through the drill casing. The wells will be straight and plumb to allow passage of pumps or sampling devices.

## 3.4 WELL DEVELOPMENT

Well development will not begin until at least 24 hours has elapsed following well installation and grouting. Development will be conducted using a submersible pump (or similar) and continue until the parameters of temperature, pH, specific conductance, and turbidity have stabilized and at least four well volumes have been removed. If water was used during drilling or well installation, that volume will be

added to the four well volumes to be removed. The well will be considered stabilized when three or more readings of each parameter do not change within allowable limits following removal of the minimum required volume. At least 24 hours will be allowed to pass between development of the well and sample collection. The well construction and development procedures, including procedures for wells with little saturated thicknesses or slow recharge, are discussed in WTP 3.

### 3.5 GROUNDWATER SAMPLING PROCEDURES

Information and procedures related to groundwater sampling are provided in WTP 4. Before sampling, environmental conditions will be recorded in the field logbook.

Field sampling activities will include collection of the following samples:

- Groundwater
- Equipment rinsates
- Ambient blanks
- Field duplicates and extra aliquots for matrix spike (MS)/matrix spike duplicates (MSDs)

#### 3.5.1 Groundwater Sampling

Groundwater samples will typically be collected using a stainless steel, low-flow bladder pump equipped with Teflon™ bladders or a disposable Teflon™ bailer. Disposable Teflon™ bailers will be used only under low recharge conditions or in small-diameter piezometers, which do not permit use of low-flow/micro-purge techniques. Groundwater samples will be collected in accordance with *Low-flow (Minimal Drawdown) Ground-water Sampling Procedures* (USEPA, 1996; Appendix D). The groundwater samples will be collected after stabilization of field parameters within three successive readings as follows:

- $\pm 0.1$  for pH
- $\pm 10$  millivolts for oxidation-reduction potential (ORP)
- $\pm 3$  percent for specific conductivity
- $\pm 10$  percent for dissolved oxygen (DO)
- $<20$  nephelometric turbidity units (NTU) for turbidity

Wells should not be purged dry. If a well is purged to a point at which a sufficient quantity of water cannot be removed, a sample will be collected as soon as sufficient recharge occurs. Stabilization of turbidity, ORP, DO, temperature, specific conductance, and pH is not required under this scenario.

Groundwater samples will be collected in order of volatility. Site-specific parameters may vary. The general order for collection of primary parameters is presented below:

- Volatile organic compounds (VOCs)
- Dissolved gases
- Total organic carbon (TOC)
- Sulfide
- Miscellaneous organic parameters
- Total metals
- Dissolved metals
- Miscellaneous inorganic parameters

Groundwater samples to be analyzed for VOCs, dissolved gases, TOC, and sulfide will be collected to minimize headspace within the container and turbulence within the well while sampling. Samples will generally be collected at a flow rate of 100 milliliters per minute (mL/min). However, in the event of large sample volume or time constraints, only the sampling of VOCs will be performed at 100 mL/min (±20 milliliters [mL]). The remaining parameters will be collected at a flow rate of up to 300 mL/min.

In addition to samples collected for laboratory analysis, groundwater sample collection may also include screening analysis in the field for ferrous iron and carbon dioxide. These samples will be collected according to the manufacturers' instructions included in the test kits. Copies of these instructions are included in Appendix C.

### 3.5.2 Passive Diffusion Bag Sampling

Passive diffusion bag (PDB) sampling is utilized for semiannual sampling associated with O&M of the Dunn Field Interim Remedial Action. Procedures for PDB sampling are described in WTP 4.

A typical PDB sampler consists of a low-density polyethylene tube closed at both ends and filled with deionized water. It is positioned in the well at the desired target depth by attaching it to a weighted line or fixed object. The water within the bag is then allowed to equilibrate with the ambient groundwater for at least two weeks before being retrieved. The sampler water is then decanted into 40-mL volatile organic

analysis (VOA) vials and sent to the laboratory for analysis. Detailed procedures for using PDB samplers in wells can be found in *User's Guide for Polyethylene-based Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells, Part 1, Deployment, Recovery, Data Interpretation, and Quality Control and Assurance* (U.S. Geological Survey, 2001; Appendix D).

### **3.5.3 Filtration of Samples with Elevated Turbidity**

During attempts to sample a well using low-flow/micro-purge techniques, if the turbidity cannot be reduced to below 20 NTU after pumping for approximately 2 to 3 hours (and other field parameters are stable as indicated in Subsection 3.5.1), the field team leader will be contacted and informed of the situation. Upon approval from the field team leader (who may consult the task manager), the well may be sampled. If the turbidity is below 50 NTU, the well may be sampled without using filtration techniques. If the turbidity is 50 NTU or higher, dissolved and total metals and dissolved organic carbon and TOC samples will be obtained. Samples for organic compound analysis should not be filtered. The dissolved metals and organic carbon samples will be collected by filtration with a disposable 0.45-micrometer ( $\mu\text{m}$ ) in-line filter. The filter should be rinsed with approximately 500 mL of the groundwater to be sampled before collection of the sample.

The 0.45- $\mu\text{m}$  filter media size was selected for use at DDMT because this size is commonly accepted as the demarcation between dissolved and non-dissolved species (*Ground-water Sampling Guidelines for Superfund and RCRA Project Managers* [USEPA, 2002]). Additionally, 0.45- $\mu\text{m}$  filters are typically used for most regulatory programs (USEPA, 1996), and MACTEC operational experience has indicated clogging problems associated with use of smaller filters, including 0.1- $\mu\text{m}$  filters. Procedures for filtration of groundwater samples are described in WTP 4.

## **3.6 WELL ABANDONMENT**

The preferred method of well abandonment is to abandon the well in place by removing the surface completion (well pad and cover) and tremie grouting inside the well casing from the bottom upward using a cement/bentonite grout. In some circumstances, it may be necessary to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a bentonite grout. The exact well abandonment procedure is dictated by well or site conditions. Abandonment details are presented in WTP 3.

According to the *Long Term Groundwater Monitoring Plan* (CH2M Hill, 2004), wells are recommended for abandonment for the following reasons:

- The test objectives have been achieved, and the well is no longer needed.
- The well is improperly constructed; i.e.:
  - The well was installed with improper installation of the outer casing and position of the sand pack.
  - The well has an elevated pH reading (due to improper construction).
- The well has an improperly placed or long screen.
- The well has been vandalized or damaged.

### **3.7 HYDRAULIC CONDUCTIVITY TESTS**

*In situ* hydraulic conductivity testing (slug testing) may be performed in monitoring wells. The testing will be performed using the “slug in” and “slug out” tests as outlined in WTP 5. Calculations utilizing the collected data and standard formulas will be used to calculate the hydraulic conductivity. These data will assist in the development of each site’s conceptual hydrogeologic model and may be used for constituent transport evaluations.

### **3.8 SURVEYING**

The locations and elevations of newly installed monitoring wells will be surveyed by a Tennessee-registered Professional Land Surveyor using benchmarks consistent with previous DDMT surveys. The measurement point of the wells will be vertically and horizontally located to the nearest 0.01 foot using the Tennessee State Plane Coordinate System (NAD27). The locations will be referenced to existing horizontal control monuments and vertical benchmarks at DDMT. Additionally, the ground surface elevation at the well locations will be determined to the nearest 0.1 foot.

### **3.9 EQUIPMENT DECONTAMINATION**

Procedures for equipment decontamination are described in WTP 10. Sampling equipment such as split-spoon samplers, hand augers, stainless steel bowls, spoons, beakers, and bladder pumps will be cleaned after each use by scrubbing with a bristle brush in Alconox or equivalent phosphate-free detergent and water. Equipment will then be rinsed with potable water, spray rinsed with pesticide-grade methanol, rinsed twice with deionized water, and allowed to dry on a clean surface (aluminum foil or

clean plastic sheeting) for as long as practicable. Once dry, equipment will be wrapped in aluminum foil and stored until use. Dedicated equipment or equipment used once and disposed of, such as tubing or disposable bailers, will not require decontamination.

Downhole drilling tools will be cleaned by washing the external surface of equipment or materials with high-pressure hot water and Alconox or equivalent, and scrubbing with brushes if necessary until visible dirt, grime, grease, oil, loose paint, rust flakes, are rinsed from the equipment. The equipment will then be allowed to air dry for as long as practicable.

Drilling tools will be cleaned within a designated decontamination pad, and the waste water will be collected for disposal as IDW.

### **3.10 INVESTIGATION-DERIVED WASTE DISPOSAL**

Disposal of wastes generated from RAs, such as excavation of disposal sites, will be addressed in the RA Work Plan. Soil from drilling activities, groundwater from monitoring well installation and development, and soil and water from sampling activities will be placed in 55-gallon drums, roll-off boxes, or other appropriate containers. The IDW will be handled according to the procedures presented in WTP 6.

Waste water from well sampling, well development, and equipment decontamination will be transported from the well, using either drilling rig support trucks or sealed 5-gallon buckets, to a storage tank at Dunn Field. At the completion of activities, the waste water will be sampled. If the concentrations are below those listed in the City of Memphis Industrial Wastewater Discharge Requirements under Permit No. S-NN3-097, the water will be pumped directly from the tank into the City of Memphis sewer system via the Dunn Field treatment system. If the concentration limits are not met, a Water Treatment and Disposal Plan will be developed.

Soil from borings and material from well abandonment will be placed in roll-off boxes. The boxes will be sampled and analyzed for toxicity characteristic leaching procedure (TCLP) VOCs for final disposal purposes. If the results are less than the TCLP regulatory levels, the soil will be disposed of as nonhazardous IDW at a landfill approved to accept CERCLA off-site waste. If the results exceed TCLP regulatory levels, the material will be disposed in accordance with appropriate hazardous waste disposal requirements.

## 4.0 FIELD MEASUREMENTS

### 4.1 PARAMETERS

Field measurements made at DDMT will typically include surveying measurements, water level and total well depth measurements, physical dimensions, and sampling and development stabilization parameters. All sampling locations used during field investigations will be depicted on an accurate drawing or a topographic or other standard map, or be referenced in such a manner that the location(s) can be clearly established.

Each field measurement should be traceable to the person(s) making the measurement and to the field equipment used to make the measurement. Equipment maintenance and calibration records will be kept in logbooks and field records so that the procedures are traceable. Time records shall be kept in local time using the 24-hour format, with the time recorded to the nearest 5 minutes or less.

### 4.2 EQUIPMENT CALIBRATION AND QUALITY CONTROL

Equipment will be calibrated according to manufacturers' instructions or general accepted practices. Calibration of field instruments will be recorded in a calibration log. More detailed descriptions of calibration procedures and frequency are located in the referenced WTPs (Appendix B).

- The handheld portable atmospheric monitor used to screen for explosive conditions and hydrogen sulfide will be calibrated as described in the manufacturer's manual (WTP 13).
- The handheld portable organic vapor analyzer used to screen air vapors at the borehole and in the breathing zone will be calibrated daily with a 100-part-per-million isobutylene standard. The battery power supply will be recharged each evening before use (WTP 13).
- Where possible, an instrument that is designed to measure ORP, DO, pH, specific conductance, turbidity, and temperature of groundwater in-line at the wellhead will be used. This instrument will be calibrated per the manufacturer's instructions (WTP 4).
- Water level indicators and fiberglass measuring tapes will be visually checked to confirm that the measurement marks are readable and the equipment is in good working condition.

Field equipment will be stored overnight at a location to be determined by the field team leader in consultation with DRC. Equipment must be returned decontaminated and any malfunctions reported to the field team leader. The field team leader will take any actions necessary for the repair or replacement of the equipment. Equipment maintenance and calibration logs will be kept on file in the master project files. All sampling equipment should be maintained according to manufactured specifications before sampling or as otherwise specified.

#### **4.3 FIELD MONITORING MEASUREMENTS**

Monitoring for the presence of hazardous conditions will be performed during fieldwork, in accordance with the Health and Safety Plan, to prevent personnel exposure to chemical and physical hazards. Information gathered from air monitoring will be used to determine appropriate protective measures to be taken and to assess off-site migration of constituents released during construction activities or subsequent operation of remedial systems. This will ensure that appropriate contingency plans and/or control measures can be implemented.

Field screening may involve air monitoring using a photoionization detector, a flame ionization detector, or chemical-specific indicator tubes (Dräger tubes). Instruments used to monitor combustible gas levels may include a combination combustible gas/oxygen/hydrogen sulfide indicator (EXOTOX 40; WTP 13).

#### **4.4 FIELD PERFORMANCE AND SYSTEM AUDITS**

Field audits will consist of three elements: audits of field operations performed by AFCEE personnel or their designees, self audits of field operations performed by MACTEC, and desk audits performed by AFCEE or MACTEC personnel on the documentation generated during the field operations. The field audits will ensure the quality of work and attainment of the project DQOs presented in specific Work Plans. Appendix A contains the Field Audit Checklist.

## 5.0 SAMPLE HANDLING AND DOCUMENTATION

Sample handling involves the procedures used to label, identify, ship, and preserve samples collected in the field. Sample handling and documentation procedures for DDMT are presented in WTPs 7, 8, and 9.

Sample containers will be labeled before sample collection (in pre-preserved bottles as appropriate). Once samples are collected, the bottles will be placed into an iced cooler. While the coolers are packed for shipment, sample bottles will be checked to ensure that each container is filled with the prescribed amount of sample and contains the proper type and amount of preservative, and that all sample labels contain the required information (date, time, sampler's identification, and whether the sample is preserved). The samples will be sealed in bubble bags and/or plastic sealable bags and placed into the cooler.

Ice in plastic bags (double-bagged) will be placed in the coolers to keep the samples at 4° Celsius (C;  $\pm 2^{\circ}\text{C}$ ) throughout shipment. Each cooler will have a temperature blank. In addition, a trip blank will accompany any samples to be analyzed for volatiles. The C-C will be completed and taped to the underside of the cooler lid along with the sample Request for Analysis. A custody seal will be placed on the front and on the rear of each cooler. The seals will be initialed and dated.

During sampling events, sample numbers will be used to distinguish between categories of events; sampling locations; and, where appropriate, depth of sample collection. Extenders will consist of a two-digit matrix code (sample type, if other than groundwater), alphanumeric depth codes (if necessary), and QA/QC codes where applicable. Field split samples will be labeled in the same way as the parent sample, with a QA extender added to the end of the name. If groundwater samples are collected from PDBs, each sample number must reflect the top and bottom depth of the diffusion bag in the well.

Sample custody in the field begins with labeling each sample container, collecting and preserving the samples, and packaging samples for shipment to the designated laboratory. Proper documentation of field samples includes completing the logbook, the Field Sampling Report for each sample, and the C-C record for each sample shipment.

QC samples are collected and analyzed to assess the quality of the sampling effort and the analytical data. Field QC samples include duplicates and replicates of field samples, MS/MSDs, rinsate blanks, trip

blanks, and field (ambient condition) blanks. The type, description, preparation, collection, and frequency of field QC samples are as follows:

- Field Sample – The total sample collected at a specific site location. This sample may be soil, water, or vapor and may be divided to provide material for analysis for QA and/or QC samples.
- Duplicate Sample – A single sample divided into two equal parts for analysis, or two samples collected independently at a sampling location during a single act of sampling. Field duplicates will be collected at a frequency of approximately 10 percent of the samples collected.
- MS/MSD Samples – Samples analyzed by the laboratory to identify and diagnose problems related to sampling or analysis. One MS/MSD pair will be collected for approximately every 20 field samples.
- Rinsate Blank – Samples consisting of reagent water collected from a final rinse of sampling equipment after the decontamination procedure is performed. The rinsate blank determines whether the sampling equipment is causing cross-contamination of samples. Rinsates will be collected at a frequency of one per matrix, per sampling technique, per event. The exception is groundwater sampling with dedicated bladder pumps; rinsates will not be required for dedicated equipment or one-time-use disposable equipment.
- Trip Blank – Containers of organic-free reagent water that are kept with the field sample containers from the time they leave the laboratory until the time they are returned to the laboratory. The trip blank determines whether samples are being impacted during transit or storage. Trip blanks pertain only to VOAs; therefore, the containers must contain no headspace. A trip blank will accompany all coolers that contain samples for volatile analysis.
- Field (Ambient) Blank – Containers of organic-free reagent water that are collected at the sampling site. The field blank determines whether site activities are contributing to impacts on samples. Field blanks pertain only to VOAs; therefore, the container must contain no headspace. Field blanks are collected in the area where the samples are collected and are required only when samples are being collected downwind of possible VOC sources, such as road resurfacing.

## **6.0 NONCONFORMANCE/CORRECTIVE ACTIONS**

Corrective action will be taken anytime during the field effort when deemed necessary based on the field team leader's judgment or when QC data indicate a need for action. Table 6-1 presents a summary of field corrective actions procedures for potential QC problems. If the field team leader determines that corrective action is required, he or she will contact the project manager, who will review the selected corrective action. If the project manager concurs with the corrective action suggested by the field team leader, the corrective action will be implemented. In addition, documentation will be required for any deviation from the activities and/or procedures outlined in the associated Work Plan (e.g., change in number of samples to be collected, or sampling location changes).

## 7.0 REFERENCES

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## TABLES

TABLE I-1  
WELL DATA SUMMARY  
REMEDIATION ACTION SAMPLING AND ANALYSIS PLAN  
Defense Depot Memphis, Tennessee

Well ID	Date Completed	NORTHING	EASTING	Location	Ground Elevation (ft msl)	Top of Casing Elevation (ft msl)	Length of Screen (ft)	Elev. Of Top of Screen (ft toe)	Depth of Boring (ft bgs)	Elev. of Bottom of Boring (ft msl)	Depth to Clay (ft bgs)	Clay Elevation (ft msl)	Depth to Groundwater (ft msl)
MW-02	Jun-82	2811693.78	802244.75	DF	289.70	292.04	10	272.04	30	250.7	27.59	264.45	
MW-03	Jun-82	2811596.25	8021600.69	DF	290.40	292.35	10	236.85	75	215.4	na	67.82	224.53
MW-04	Jun-82	2811278.87	8021669.19	DF	300.00	301.61	20	241.61	80	220.0	na	74.10	227.51
MW-05	Jun-82	2811254.49	802084.68	DF	301.30	304.64	20	244.64	80	221.3	na	na	
MW-06	Jun-82	2801604.17	802069.13	DF	288.10	289.11	20	238.11	70	218.1	na	63.09	226.02
MW-07	Jun-82	2811839.88	8012481.70	DF	293.10	295.10	10	228.10	75	218.1	na	65.34	229.76
MW-08	Feb-89	2823901.04	802727.91	DF	292.74	292.59	10	236.09	75	217.7	na	60.50	232.09
MW-09	Feb-89	2811641.18	802516.42	DF	304.66	304.32	10	234.22	88	216.7	na	74.79	229.53
MW-10	Mar-89	2811662.55	802201.26	DF	289.20	288.79	10	230.19	75	214.2	na	62.53	226.26
MW-11	Mar-89	2811353.10	802099.00	DF	299.59	299.47	15	231.57	85	214.6	na	74.54	224.93
MW-12	Mar-89	2811067.19	802071.22	DF	301.70	301.30	15	231.90	90	211.7	na	76.02	225.28
MW-13	Mar-89	281033.56	802369.21	DF	310.10	300.01	15	234.01	85	215.1	na	72.41	227.60
MW-14	Mar-89	2808001.37	802288.95	DF	302.44	302.22	15	237.22	80	222.4	79.5	222.9	73.30
MW-15	Mar-89	2801985.36	801985.36	DF	295.23	295.12	15	231.72	80	215.2	na	68.68	226.44
MW-16	Mar-89	278837.83	807099.66	MI	300.19	299.86	15	242.26	85	215.2	75.0	56.10	243.76
MW-17	Abandoned June 2003	2779061.13	803801.63	MI	316.18	315.85	15	238.58	95	221.2	94.0	222.2	na
MW-18	Abandoned February 2005	279136.41	802448.08	MI	308.34	308.04	15	185.44	140	168.3	na	na	na
MW-19	Mar-89	278945.87	800782.26	MI	290.86	290.57	10	207.47	95	195.9	93.5	197.4	85.61
MW-20	Mar-89	2771677.96	800705.19	MI	285.71	285.21	15	202.11	100	185.7	na	na	
MW-21	Mar-89	276473.39	800602.39	MI	295.21	295.20	15	202.90	105	189.5	107.0	91.90	203.10
MW-22	Mar-89	275912.38	800702.16	MI	298.49	298.04	10	202.64	115	183.5	na	94.74	203.30
MW-23	Mar-89	275791.02	801817.13	MI	299.24	298.99	10	197.79	115	184.2	na	96.98	202.01
MW-24	Mar-89	275361.05	803538.81	MI	299.81	299.51	15	202.21	115	184.8	114.7	185.1	103.17
MW-25	Abandoned June 2003	275976.69	805529.10	MI	270.32	270.17	10	201.32	81.5	188.8	na	na	
MW-25A	Jul-03	275975.11	805521.27	MI	270.13	269.88	10	196.88	85	185.1	80.7	189.4	69.38
MW-26	Apr-89	276508.16	805962.09	MI	303.89	303.69	10	206.09	115	188.9	110.0	193.9	98.01
MW-27	Abandoned February 2005	2782385.47	802547.09	MI	304.28	303.98	15	227.78	100	204.3	96.0	208.3	na
MW-28	Nov-89	281568.58	803154.48	DF	294.89	294.79	15	240.49	81.5	213.4	80.0	214.4	57.02
MW-29	Nov-89	282104.02	80263.96	DF	273.35	273.22	20	239.02	56.5	216.9	na	36.63	236.59
MW-30	Nov-89	282229.19	802013.96	Offsite DF	274.10	275.14	20	236.14	66.5	207.6	66.0	208.1	45.69
MW-31	Dec-89	281651.53	801783.90	Offsite DF	282.50	290.37	15	226.27	76.5	211.0	76.3	211.2	68.98
MW-32	Nov-89	280834.37	801615.51	Offsite DF	285.30	285.38	15	232.68	71.5	214.1	66.5	219.1	62.38
MW-33	Dec-89	280398.10	801561.30	Offsite DF	277.70	280.71	15	236.11	61.5	216.2	60.0	217.7	55.35
MW-34	Nov-89	279111.21	801917.96	DF	300.80	299.97	20	163.37	158.5	142.3	158.3	142.5	132.14
MW-35	Nov-89	281072.31	802070.44	DF	301.70	300.46	20	230.86	92	209.7	90.5	211.2	76.46
MW-36	Dec-89	279531.02	802887.01	DF	311.15	310.24	15	117.94	21.2	99.2	90.0	221.2	149.01
MW-37	Dec-89	280831.22	801616.58	Offsite DF	285.50	284.91	15	119.21	183	102.5	66.5	219.0	124.52
MW-38	Nov-89	279141.38	802450.43	MI	308.45	307.45	15	167.55	158.5	102.5	150.0	153.5	128.47
MW-39	Jan-96	277280.67	802598.11	MI	296.58	296.28	20	200.78	116	180.6	na	101.17	195.11
MW-39A	May-04	277272.98	802607.72	MI	298.45	298.49	20	150.59	176	122.5	169.0	101.50	196.99
MW-40	Jan-96	282460.42	800948.23	Offsite DF	262.50	262.23	10	177.23	98.5	164.0	96.0	166.5	77.91
MW-41	Abandoned June 2003	279621.65	800457.21	Offsite DF	283.15	283.81	10	226.81	75	208.2	72.0	211.2	na

TABLE 1-1

**WELL DATA SUMMARY**  
**REMEDIATION ACTION SAMPLING AND ANALYSIS PLAN**  
 Defense Depot Memphis, Tennessee

Well ID	Date Completed	NORTHING	EASTING	Location	Ground Elevation (ft msl)	Top of Casing Elevation (ft msl)	Length of Screen (ft)	Elev. of Top of Screen (ft toe)	Depth of Boring (ft lbs)	Elev. of Bottom of Boring (ft msl)	Depth to Clay Elevation (ft msl)	Depth to Groundwater (ft toe)	Groundwater Elevation* (ft msl)
MW-42	Jan-96	281883.92	800182.40	Offsite DF	275.10	274.83	10	225.83	67.5	207.6	59.0	216.1	52.43
MW-43	Oct-98	280284.33	800111.73	Offsite DF	284.99	284.99	10	123.49	204.3	80.7	173.0	112.0	121.53
MW-44	Jan-96	281073.71	800601.09	Offsite DF	269.40	269.07	10	205.07	87.5	181.9	78.0	191.4	53.12
MW-45	Jan-96	280728.08	804125.99	Offsite DF	292.30	293.22	10	235.22	75	218.3	69.5	223.8	53.05
MW-46	Abandoned August 2004	281256.81	803115.96	Offsite DF	286.83	287.56	10	225.56	77.5	209.3	73.0	213.8	na
MW-47	Abandoned February 2005	275226.64	800780.89	Offsite MI	292.15	306.39	10	196.39	125	167.2	115.0	177.2	na
MW-48	Abandoned June 2003	276616.18	799193.92	Offsite MI	253.55	284.49	10	200.49	105	178.6	94.5	189.1	na
MW-49	Jan-96	280211.64	803051.31	DF	309.52	310.49	10	230.49	92.5	217.0	89.5	220.0	77.15
MW-50	Jan-96	276455.81	807065.28	MI	299.32	298.82	10	183.82	136	163.3	126.0	173.3	84.12
MW-51	Jan-96	282345.86	803828.62	Offsite DF	275.50	275.23	10	220.23	70	205.5	64.5	211.0	38.28
MW-52	Feb-96	275371.97	805897.36	MI	279.71	279.26	10	183.26	105	174.7	104.0	175.7	77.60
MW-53	Feb-96	279176.66	805136.05	Offsite MI	305.58	306.38	10	233.88	85	220.6	83.0	222.6	72.42
MW-54	Feb-96	281160.10	801183.32	Offsite DF	295.60	295.35	10	210.85	101	194.6	95.0	200.6	78.76
MW-55	Feb-96	279301.05	801204.62	MI	292.48	292.08	10	238.08	85.5	207.0	74.0	218.5	70.03
MW-56	Aug-98	279708.26	801971.55	DF	293.50	293.60	10	234.60	71.5	222.0	70.5	223.0	66.51
MW-57	Aug-98	280184.05	802006.19	DF	291.10	290.77	10	230.77	72.5	218.6	71.0	220.1	63.21
MW-58	Aug-98	279845.07	802066.44	DF	290.70	290.51	10	233.51	68.5	222.2	67.5	223.2	62.25
MW-59	Aug-98	281333.67	802252.00	DF	300.40	300.13	10	237.63	85.5	214.9	na	na	73.49
MW-60	Aug-98	281424.39	802282.05	DF	297.20	296.86	10	224.36	84	213.2	na	na	69.92
MW-61	Aug-98	281583.68	802347.35	DF	294.04	294.04	10	225.54	79	215.2	na	na	66.35
MW-62	Oct-98	278289.89	801858.16	MI	294.10	293.65	10	207.65	107	187.1	97.0	197.1	93.41
MW-63	Abandoned June 2003	278192.29	803585.63	MI	305.13	304.63	10	180.13	140	165.1	132.0	173.1	na
MW-63A	Jul-02	278200.31	803572.83	MI	306.33	305.96	10	165.96	145	161.3	140.0	166.3	101.81
MW-63B	Jul-02	278201.32	803553.77	MI	306.22	305.78	10	190.78	125	181.2	na	na	101.66
MW-64	Oct-98	276951.52	803005.97	MI	304.46	304.46	10	202.21	115	189.5	113.0	191.5	105.73
MW-65	Nov-98	283539.72	803887.68	Offsite DF	264.00	263.22	10	222.42	55	209.0	52.0	212.0	5.32
MW-66	Abandoned February 2005	276742.50	798517.42	Offsite MI	289.00	288.70	10	186.20	125	164.0	121.0	168.0	na
MW-66A	Jun-14	276626.02	799792.63	Offsite MI	284.34	284.22	20	205.59	106	178.3	96.0	188.3	77.78
MW-67	Jul-99	280474.00	800830.36	Offsite DF	275.53	278.21	15	18.21	275	0.5	69.0	206.5	117.3
MW-68	Feb-00	281500.76	802040.04	Offsite DF	291.60	291.69	10	219.19	83	208.6	82.5	209.1	68.03
MW-69	Nov-00	281702.55	803011.49	Offsite DF	304.90	307.02	10	224.94	92.2	212.7	92.0	212.9	82.68
MW-70	Nov-00	281029.60	801988.49	Offsite DF	302.80	304.99	10	224.18	93	209.8	90.0	212.8	80.7
MW-71	Nov-00	280584.68	801804.71	Offsite DF	291.90	294.40	10	228.90	77.7	214.2	75.5	216.4	69.11
MW-72	Abandoned February 2005	275626.27	798864.75	Offsite MI	295.41	295.11	10	184.41	128	167.4	125.0	170.4	na
MW-73	Nov-00	280989.42	802144.95	DF	301.10	300.65	20	228.65	93	208.1	91.5	209.6	74.55
MW-74	Nov-00	280991.20	802044.29	DF	304.00	303.68	20	233.68	93.5	210.5	89.5	214.5	78.39
MW-75	Nov-00	281080.10	802051.10	DF	304.30	303.61	20	232.61	93.5	210.8	90.4	213.9	78.65
MW-76	Nov-00	281311.98	801642.76	Offsite DF	303.30	302.71	20	229.71	94	209.3	90.8	212.5	83.42
MW-77	Nov-00	281142.96	801815.29	Offsite DF	304.42	304.42	20	236.42	88.5	216.2	87.0	217.7	81.83
MW-78	Dec-00	282051.71	802065.28	Offsite DF	275.40	275.00	20	230.50	68	207.4	63.5	211.9	46.76
MW-79	Dec-00	281794.22	800899.03	Offsite DF	285.40	285.03	20	202.53	104	181.4	101.0	184.4	69.75
MW-80	Dec-00	281417.56	800199.07	Offsite DF	274.00	273.81	20	220.81	78	196.0	72.0	202.0	58.68

TABLE I-1

**WELL DATA SUMMARY**  
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 Defense Depot Memphis, Tennessee

Well ID	Date Completed	NORTHING	EASTING	Location	Ground Elevation (ft msl)	Top of Casing Elevation (ft msl)	Length of Screen (ft)	Elev. Of Top of Screen (ft toe)	Depth of Boring (ft bgs)	Elev. of Bottom of Boring (ft msl)	Clay Elevation (ft msl)	Depth to Clay (ft toe)	Groundwater Elevation* (ft msl)
MW-81	Abandoned February 2005	275608 42	803525 67	MI	299.97	299.62	20	109.62	70.0	114.0	186.0	na	na
MW-82	Abandoned February 2005	276539 89	800862 13	MI	292.17	291.77	20	112.77	210	82.2	145.5	146.7	na
MW-83	Abandoned February 2005	276521 38	805969 16	MI	304.56	304.21	10	128.21	190	114.6	116.0	188.6	na
MW-84	May-01	279531 09	802878 65	DF	311.27	311.15	20	242.15	93	218.3	89.0	222.3	81.05
MW-85	Sep-01	276704 14	806606 45	MI	304.50	304.13	15	208.23	115	189.5	111.5	193.0	97.31
MW-86	Sep-01	276636 65	806301 24	MI	304.89	304.35	20	206.85	118	186.9	117.0	197.9	95.01
MW-87	Oct-00	280696 36	802038 25	DF	292.80	294.93	15	231.93	81	211.8	77.5	215.3	69.44
MW-88	Sep-01	276879 05	806512 88	MI	305.47	305.15	15	223.15	102.5	203.0	97.0	208.5	79.60
MW-89	Oct-00	278286 97	802555 25	MI	304.38	303.98	30	156.98	185	119.4	94.5	209.9	112.61
MW-90	Oct-00	278283 60	802539 51	MI	304.64	304.19	30	189.19	145	159.6	na	112.89	191.30
MW-91	Oct-00	280474 97	802014 43	DF	291.30	291.99	15	236.99	70	219.3	69.5	219.8	66.29
MW-92	Sep-01	276614 20	806489 66	MI	304.78	304.41	15	211.41	113	191.8	107.9	196.9	94.19
MW-93	Sep-01	275542 22	804440 10	MI	294.31	294.08	15	202.08	113.5	180.8	107.0	187.3	98.49
MW-94	Abandoned February 2005	276009 92	803375 23	MI	296.95	296.94	10	196.44	118	179.0	110.7	186.3	na
MW-94A	May-04	276805 80	803085 80	MI	303.23	303.00	10	193.63	136	167.2	117.5	185.7	106.46
MW-95	Dec-00	282707 50	801850 21	Offsite DF	259.70	259.43	20	219.43	65	194.7	59.0	200.7	24.87
MW-96	Sep-01	276310 14	806520 24	MI	289.67	289.02	20	213.52	103	186.7	98.0	194.2	80.42
MW-97	Oct-01	276074 23	802139 23	MI	297.70	297.44	20	199.94	123	174.7	117.5	180.2	97.10
MW-98	Oct-01	276891 57	802527 77	MI	294.93	294.43	10	157.43	148	146.9	147.0	147.9	97.10
MW-99	Oct-01	277443 37	801114 53	MI	285.69	285.33	20	193.83	118	167.7	111.5	174.2	85.78
MW-100	Oct-01	276590 49	800852 83	MI	291.54	291.16	20	183.66	132.5	159.0	127.0	164.5	88.47
MW-100B		276600 65	800854 43	MI	291.60	291.06	20	183.56	132.5	159.1	127.5	164.1	89.22
MW-101	Nov-01	276264 27	801110 38	MI	291.99	291.70	15	202.70	142	150.0	134.0	158.0	89.81
MW-101 (Three screened intervals in the same monitoring well)													
MW-102	Nov-03	275760 10	800716 10	MI	311.70	311.34	20	190.84	143	168.7	140.5	171.2	107.32
MW-102B		275760 59	800707 72	MI	312.07	311.40	20	190.90	143	169.1	140.5	171.6	107.42
MW-103	Oct-01	278691 92	801607 79	MI	301.90	301.35	20	231.55	93	208.9	90.1	211.9	103.98
MW-104	Oct-01	278677 45	805417 72	MI	296.13	295.76	20	225.26	93	203.1	90.5	205.6	61.87
MW-105	May-02	276698 44	806316 91	MI	304.42	304.25	10	215.25	105	199.4	100.0	204.4	94.54
MW-106	Apr-02	276708 07	806309 98	MI	304.65	304.44	10	207.44	110	194.7	107.0	197.7	94.81
MW-107	Oct-01	278419 07	803009 93	MI	305.18	304.92	15	176.92	167	138.2	158.0	147.2	106.26
MW-107 (Two screened intervals in the same monitoring well)													
MW-108	Oct-01	277658 02	802985 53	MI	303.25	303.07	10	143.07	187	116.3	170.0	133.3	106.71
MW-109	May-02	276707 71	806302 56	MI	304.75	304.57	10	211.57	105	199.8	103.0	201.8	95.06
MW-110	May-02	276707 51	806294 48	MI	304.82	304.64	10	212.64	105	199.8	102.0	202.8	95.04
MW-111	Apr-02	276690 51	806287 67	MI	304.87	304.66	10	215.66	105	199.9	99.0	205.9	95.39
MW-112	Apr-02	276690 57	806305 80	MI	304.77	304.57	10	214.57	105	199.8	100.0	204.8	95.05
MW-113	Apr-02	276679 10	806279 74	MI	304.92	304.81	10	208.81	115	189.9	110.0	202.9	95.60
MW-114	Apr-02	276695 47	806296 33	MI	304.84	304.66	10	212.66	105	199.8	102.0	202.8	95.20
MW-115	Apr-02	276588 14	800805 19	MI	291.92	291.67	10	202.17	101	190.9	108.5	183.4	89.48
MW-116	Apr-02	276593 32	800803 79	MI	291.93	291.67	10	193.17	115	176.9	108.5	182.6	89.68

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**WELL DATA SUMMARY**  
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 Defense Depot Memphis, Tennessee

Well ID	Date Completed	NORTHING	EASTING	Location	Ground Elevation (ft msl)	Top of Casing Elevation (ft msl)	Length of Screen (ft)	Elev. Of Top of Screen (ft toc)	Depth of Boring (ft tos)	Elev. of Bottom of Boring (ft msl)	Clay Elevation (ft tos)	Depth to Clay Elevation (ft tos)	Groundwater Elevation* (ft msl)	
MW-117	May-02	276382.76	800816.22	MI	291.57	291.38	10	192.38	115	176.6	109.0	182.6	89.40	
MW-118	May-02	276587.70	800815.05	MI	291.58	291.17	10	201.17	101	190.6	na	na	89.22	
MW-119	May-02	276399.18	800812.21	MI	291.74	291.50	10	201.50	101	190.7	na	na	89.51	
MW-120	Apr-02	276389.30	800809.53	MI	291.72	291.56	10	193.56	109	182.7	108.0	183.7	89.56	
MW-121	Apr-02	276394.70	800808.20	MI	291.83	291.63	10	199.63	103	188.8	na	na	89.60	
MW-122	May-02	276604.07	800810.23	MI	291.76	291.62	10	193.12	109.5	182.3	108.5	183.3	89.70	
MW-123	Apr-02	276586.10	800820.53	MI	291.36	291.09	15	201.09	106	185.4	na	na	89.15	
MW-124	May-02	276603.07	800816.13	MI	291.58	291.39	15	201.39	115	176.6	na	na	89.43	
MW-125	Apr-02	276594.62	800818.74	MI	291.47	291.35	15	197.35	110	181.5	109.0	182.5	89.40	
MW-126	Jul-02	283390.01	800491.67	Offsite DF	252.49	252.22	10	236.22	45	207.5	28.0	224.5	16.14	
MW-127	Jul-02	280738.40	799810.30	Offsite DF	268.86	268.71	10	208.71	85	183.9	71.0	197.9	57.57	
MW-128	Jun-03	282712.19	803376.38	Offsite DF	284.77	284.14	20	229.39	85	199.8	80.0	204.8	36.51	
MW-129	Jun-03	282327.08	803128.53	Offsite DF	293.33	293.01	15	228.01	85	208.3	80.0	213.3	53.04	
MW-130	Jun-03	282116.23	803242.02	Offsite DF	293.69	293.20	20	233.70	85	208.7	79.0	214.7	52.31	
MW-131	Oct-03	280972.56	802175.27	DF	300.83	300.64	15	224.64	92	208.8	92.0	208.8	74.16	
MW-132	Oct-03	281066.38	802129.1	DF	301.05	300.73	15	227.23	92	209.1	84.0	217.1	74.64	
MW-133	Oct-03	280978.12	802126.31	DF	301.08	300.89	15	225.89	95	206.1	90.0	211.1	74.60	
MW-134	Oct-03	281012.74	802102.58	DF	301.05	300.81	15	225.81	95	206.1	90.0	211.1	74.88	
MW-135	Oct-03	280981.62	802100.29	DF	300.76	300.53	15	233.53	95	205.8	86.0	214.8	52.31	
MW-140	May-04	279061.363	801715.86	MI	298.16	298.12	20	73.52	246	52.2	76.0	222.2	138.10	
MW-141	Jun-04	278129.185	802571.251	MI	303.70	303.71	20	153.01	181	122.7	110.0	193.7	110.71	
MW-142	May-04	278056.032	801629.121	MI	291.49	291.18	20	206.18	116	175.5	98.5	193.0	92.11	
MW-143	Apr-04	278301.64	801201.327	MI	290.74	290.56	15	212.06	106	184.7	92.5	196.2	89.85	
MW-144	Jun-04	281138.63	801538.843	Offsite DF	291.89	291.60	20	235.10	86	205.9	76.0	215.9	73.16	
MW-145	Jun-04	280967.632	800823.179	Offsite DF	284.86	284.72	20	204.72	106	178.9	97.0	187.9	68.52	
MW-147	Jun-04	281674.179	801674.179	Offsite DF	289.97	289.72	20	229.72	86	204.0	76.0	214.0	69.65	
MW-148	Jun-04	281377.941	801461.634	Offsite DF	294.87	294.71	20	224.71	96	198.9	87.0	207.9	76.77	
MW-149	Jun-04	281130.04	800983.764	Offsite DF	287.44	287.18	20	205.78	106	181.4	100.0	187.4	70.96	
MW-150	Jun-04	281132.662	801263.614	Offsite DF	297.15	296.81	20	225.61	106	191.1	90.0	207.1	79.91	
MW-151	Aug-04	281296.42	800874.385	Offsite DF	284.42	284.27	20	207.27	106	178.4	97.0	187.4	68.33	
MW-152	Aug-04	281515.56	800889.254	Offsite DF	289.82	289.59	20	198.59	116	173.8	109.0	180.8	73.92	
MW-153	Aug-04	282119.38	800953.24	Offsite DF	279.26	279.17	20	263.17	106	173.3	96.0	183.3	64.65	
MW-154	Aug-04	280501.53	800919.48	Offsite DF	274.07	273.81	15	220.81	76	198.1	67.0	207.1	55.33	
MW-155	Aug-04	281325.31	801168.93	Offsite DF	291.84	291.65	20	214.65	106	185.8	95.0	196.8	75.18	
MW-156	Aug-04	281143.439	801006.836	Offsite DF	269.21	269.15	20	213.71	76	193.2	69.0	200.2	54.9	
MW-157	Aug-04	281050.91	801348.32	Offsite DF	296.83	286.78	20	229.78	86	200.8	76.0	210.8	69.59	
MW-158	Oct-04	281434.42	801005.34	Offsite DF	294.38	294.07	15	15.00	203.06	116.0	178.4	106.0	188.4	78.21
MW-158A	Oct-04	281443.51	801005.67	Offsite DF	294.22	293.95	15.00	216.03	96.0	198.2	na	na	78.13	
MW-159	Oct-04	281364.29	801006.52	Offsite DF	286.58	286.33	20.00	205.89	106.0	180.6	99.0	187.6	70.35	
MW-160	Oct-04	281366.52	801304.26	Offsite DF	294.11	294.00	20.00	228.13	96.0	198.1	86.0	208.1	77.11	
MW-161	Oct-04	281120.29	801506.82	Offsite DF	296.67	296.40	20.00	234.60	86.0	210.7	80.5	216.2	77.21	
MW-162	Oct-04	281244.22	801596.06	Offsite DF	299.89	299.70	20.00	233.39	96.0	203.9	86.0	213.9	80.81	

TABLE 1-1  
WELL DATA SUMMARY  
REMEDIATION SAMPLING AND ANALYSIS PLAN  
Defense Depot Memphis, Tennessee

Well ID	Date Completed	WORTHING	EASTING	Location	Ground Elevation (ft msl)	Length of Screen (ft)	Elev. Of Top of Screen (ft toc)	Depth of Boring (ft bgs)	Elev. of Bottom of Boring (ft msl)	Clay Elevation (ft bgs)	Depth to Clay (ft toc)	Groundwater Elevation* (ft msl)
MW-163	Oct-04	281152.59	801487.27	Offsite DF	290.81	20.00	234.42	86.0	204.8	214.8	76.0	72.55
MW-164	Oct-04	280997.55	801497.47	Offsite DF	287.71	287.48	20.00	231.86	86.0	201.7	75.0	218.08
MW-165	Nov-04	281384.63	800855.489	Offsite DF	287.35	287.06	15	198.43	11.8	169.4	101.0	69.89
MW-165A	Nov-04	281383.55	800865.694	Offsite DF	287.53	287.26	15	215.96	88	199.5	na	71.55
MW-166	Nov-04	281224.99	800928.69	Offsite DF	280.96	283.44	15	199.59	113	168.0	101.0	67.5
MW-166A	Nov-04	281213.35	800927.36	Offsite DF	280.92	283.45	15	215.15	80	200.9	na	67.42
MW-167	Nov-04	281394.034	800618.542	Offsite DF	285.21	284.82	15	214.68	108	217.2	197.5	214.86
MW-168	Nov-04	281903.513	801003.578	Offsite DF	284.17	283.95	15	177.75	128	156.2	119.0	68.38
MW-168A	Nov-04	281896.495	800996.51	Offsite DF	283.56	283.20	15	209.42	88	195.6	na	67.5
MW-169	Dec-04	282491.23	800956.58	Offsite DF	262.17	261.90	20	194.12	11.8	144.2	95.5	186.85
MW-170	Dec-04	282443.17	801260.46	Offsite DF	273.98	273.75	20	214.14	106	168.0	79.5	194.5
MW-171	Dec-04	282315.35	801057.83	Offsite DF	271.02	270.69	15	217.72	96	175.0	75.0	166.55
DR1-1	May-04	2763100.454	800855.779	MI	293.26	293.09	20	171.26	146.0	147.3	141.5	151.8
DR1-1A	May-04	276307.374	800863.15	MI	293.29	293.13	20	203.79	120	181.3	na	91.06
DR1-2	May-04	276536.557	801152.64	MI	290.78	290.08	20	192.28	136.0	154.3	126.5	163.8
DR1-3	May-04	276527.266	801415.914	MI	291.11	290.93	20	181.26	136.5	126.5	164.6	186.85
DR1-4	May-04	276231.201	801399.528	MI	293.00	292.78	20	186.50	136.0	157.0	125.5	167.5
DR1-5	May-04	276079.577	800828.184	MI	294.88	294.50	20	169.28	156.0	138.9	144.0	150.9
DR1-5A	May-04	276086.881	800835.319	MI	294.88	294.61	20	204.88	120	182.9	na	91.06
DR1-6	Jun-04	276044.05309	801103.491	MI	293.44	292.98	20	177.14	146.0	147.4	136.0	157.4
DR1-6A	Jun-04	276035.125	801103.292	MI	293.52	293.14	20	202.32	116.0	177.5	na	90.99
DR1-7	Jun-04	276791.264	801441.157	MI	289.46	289.15	20	180.86	146.0	143.5	136.0	163.5
DR1-8	Jun-04	276752.436	800875.458	MI	290.37	289.02	20	197.37	121.0	169.4	116.0	179.4
DR2-1	Jun-04	276756.07	8016491.45	MI	305.08	304.90	20	231.00	106	199.1	96.5	211.1
DR2-2	May-04	276771.063	8006658.743	MI	304.49	304.37	15	225.37	106	198.5	103.0	212.5
DR2-3	May-04	276539.12	8016203.16	MI	303.66	303.44	15	210.44	116	187.7	106.0	197.7
DR2-4	May-04	276455.681	8006632.639	MI	303.80	303.47	20	215.47	116	187.8	106.5	197.3
DR2-5	Jun-04	276814.93	806184.58	MI	305.55	305.44	15	220.44	106	199.6	99.0	206.6
DR2-6	Jun-04	276643.99	8058660.91	MI	304.92	304.70	20	210.10	126	178.9	116.0	188.9
PZ-01	Abandoned February 2005	275150.00	801750.76	Offsite MI	303.00	307.76	10	204.06	115	193.0	na	na
PZ-02	Oct-98	282748.00	803373.00	Offsite DF	285.00	284.39	10	240.39	54.5	230.5	na	36.17
PZ-03	Oct-98	276379.35	802941.05	MI	298.98	298.51	10	189.61	120	179.0	na	101.70
PZ-04	Abandoned February 2005	275905.40	799780.49	Offsite MI	303.00	302.30	10	204.06	109	194.0	95.31	210.13
PZ-05	Abandoned February 2005	274934.56	806177.53	Offsite MI	257.00	256.04	10	187.94	79	178.0	na	204.87
PZ-06	Nov-98	278855.86	805100.13	MI	303.00	302.74	10	213.34	101.6	201.4	na	231.98
PZ-07	Nov-98	277053.25	8016006.75	MI	305.22	304.72	10	203.42	112	193.2	na	97.80
PZ-08	Abandoned February 2005	274652.33	800732.76	Offsite MI	290.00	289.35	10	191.15	111.2	178.8	na	196.81
PZ-09	Abandoned February 2005	276705.58	806329.97	MI	304.29	304.03	10	215.03	107	197.3	99.0	205.3
PZ-10	Abandoned February 2005	276705.58	806329.97	MI	304.29	304.03	10	215.03	107	197.3	99.0	205.3

TABLE 1-1

**WELL DATA SUMMARY**  
**REMEDIATION SAMPLING AND ANALYSIS PLAN**  
 Defense Depot Memphis, Tennessee

Well ID	Date Completed	NORTHING	EASTING	Location	Ground Elevation (ft msl)	Top of Casing Elevation (ft msl)	Length of Screen (ft)	Elev. of Top of Screen (ft toc)	Depth of Boring (ft bgs)	Elev. of Bottom of Boring (ft msl)	Depth to Clay (ft msl)	Clay Elevation (ft msl)	Depth to Groundwater (ft toc)	Groundwater Elevation* (ft msl)
IW-2	Apr-02	276714.75	806324.06	MI	304.49	304.21	15	214.21	106	198.5	105.0	199.5	94.13	210.08
IW-3	Apr-02	276706.78	806317.92	MI	304.47	304.21	15	216.21	105	199.5	103.0	201.5	94.10	210.11
IW-4	Apr-02	276705.54	806311.11	MI	304.66	304.53	15	214.53	115	189.7	105.0	199.7	94.66	209.87
IW-5	Apr-02	276585.57	800787.32	MI	292.43	292.12	10	189.12	130	162.4	113.0	179.4	91.94	200.18
IW-6	May-02	276580.44	800795.75	MI	292.27	291.94	10	192.94	115	177.3	109.0	183.3	89.75	200.19
IW-7	May-02	276593.69	800791.35	MI	292.26	292.00	10	192.50	115	177.3	109.5	182.8	91.82	200.18
RW-01	Oct-99	280267.14	801973.88	DF	294.10	295.71	5	229.57	77	217.1	72.3	221.9	69.15	226.56
RW-01A	Oct-99	280386.26	801990.08	DF	293.87	295.42	5	228.43	77	216.9	72.5	221.4	70.8	224.62
RW-01B	Oct-99	280504.87	802009.37	DF	287.85	289.17	5	227.48	72	215.9	68.0	219.9	67.4	221.77
RW-02	Oct-99	280624.56	802003.32	DF	288.49	289.92	5	225.93	75	213.5	70.0	218.5	67.90	222.02
RW-03	Feb-98	280743.76	802012.69	DF	297.73	299.34	10	231.40	80	217.7	78.5	219.2	75.1	224.24
RW-04	Feb-98	280918.07	802027.11	DF	301.69	305.11	10	230.48	90	213.7	86.0	217.7	80.55	224.56
RW-05	Mar-98	281113.38	802041.97	DF	305.75	307.13	10	226.09	95	210.8	92.0	213.8	86.12	221.01
RW-06	Jan-98	281264.22	802067.17	DF	303.15	304.56	10	227.94	90	213.2	88.0	215.2	83.15	221.41
RW-07	Jan-98	281442.21	802079.19	DF	296.07	297.44	10	228.33	80	216.1	79.5	216.6	74.15	223.29
RW-08	Jan-98	281574.72	802088.53	DF	291.56	292.99	10	223.84	83	208.6	81.0	210.6	75.18	217.81
RW-09	Jan-98	281688.06	802232.41	DF	289.26	290.67	10	225.98	76	213.3	75.5	213.8	69.15	221.52

Notes:

Bottom of clay layer at MW-140 was 115 ft. bgs

Bottom of clay layer at MW-141 was 110 ft. bgs

(\*) Water Level Measurements taken 21 May 2005

(1) Water Level Measurements taken 19 Feb 2005

Water Level Measurements taken 24-25 June 2004

bgs below ground surface

msl mean sea level

toc top of casing

na not applicable

-- PZ-61, 62, 63 and Pump Test Well installed for use in aquifer test conducted by Engineering-Science in 1992 further construction details are unavailable

TABLE 3-1

**FIELD TASK RATIONALE**  
**REMEDIAL ACTION SAMPLING AND ANALYSIS PLAN**  
**Defense Depot Memphis, Tennessee**

<b>Field Task</b>	<b>Rationale<sup>(a)</sup></b>
Advance soil borings. Collect and analyze subsurface soil samples.	To provide vertical profiles of contamination (if any) in soil to further evaluate the presence or absence of contamination, to support remedial design, to characterize lithology, and to assess effectiveness of remedial activity.
Install monitoring wells and collect and analyze groundwater samples from monitoring wells.	To provide groundwater characterization data, to determine groundwater flow direction, to support remedial design, and to assess effectiveness of remedial action.
Conduct in-situ hydraulic conductivity testing at monitoring wells.	To assist in determining aquifer hydraulic conductivity values for the estimation of contaminant migration rates and for evaluation of potential remedial actions.
Construct test pits.	To identify and determine depth of buried material
Collect and field screen surface and subsurface soil and/or sediment samples.	To evaluate the vertical and horizontal profiles of contamination that will be used to guide the extent of a remedial excavation/removal.
Collect and analyze composite soil samples from the walls and bottom of an excavation.	To confirm the effectiveness of a remedial excavation/removal.
Conduct quarterly groundwater sampling events	To aid in monitoring natural attenuation of contaminants and estimating degradation rates.
Conduct groundwater measurements	To estimate groundwater flow direction

**Notes:**

(a) These tasks are general and are subject to change for site-specific requirements.

TABLE 6-1  
**FIELD CORRECTIVE ACTION PROCEDURES**  
**REMEDIAL ACTION SAMPLING AND ANALYSIS PLAN**  
 Defense Depot Memphis, Tennessee

Situation	Calibration <sup>(a)</sup>	Frequency	Field Objective Affected	Corrective Action Procedure
pH	<ul style="list-style-type: none"> <li>- Calibrated with two buffer solutions that bracket expected sample pH</li> </ul>	- Twice daily	Equipment is calibrated and operating properly	<ul style="list-style-type: none"> <li>- Notification of site supervisory personnel</li> <li>- Repair or replace malfunctioning parts</li> <li>- Recalibrate and/or replace standards</li> <li>- Resample or repeat task if necessary</li> <li>- Document to Project Manager</li> <li>- Project Manager approval of corrective action</li> </ul>
SC	<ul style="list-style-type: none"> <li>- Calibrate with two standards in expected range of sample SC</li> </ul>	- Twice Daily		
Temperature	<ul style="list-style-type: none"> <li>- Calibrate within expected temperature range of samples</li> </ul>	- Prior to project by manufacturer		
Turbidity	<ul style="list-style-type: none"> <li>- Check calibration within expected range of sample turbidity</li> </ul>	- Twice Daily		
DO	<ul style="list-style-type: none"> <li>- Calibrate using air-calibration chamber in air method</li> </ul>	- Twice Daily		
ORP	<ul style="list-style-type: none"> <li>- Calibrate using Zobell ORP calibration solution</li> </ul>	- Twice Daily		
Incorrect sample collection procedures	NA	NA	Samples are taken according to standard operating procedures.	<ul style="list-style-type: none"> <li>- Notification of site supervisory personnel</li> <li>- Review of situation and correct procedures, recollect the sample</li> <li>- Document to Project Manager</li> <li>- Project Manager approval of corrective action</li> </ul>
Insufficient sample volume collection	NA	NA	Sufficient sample volume is provided to maintain sample integrity and so that all required analyses can be conducted.	<ul style="list-style-type: none"> <li>- Notification of site supervisory personnel by laboratory manager</li> <li>- Review site affected and impact of samples on site characterization correct procedures; recollect sample if necessary</li> <li>- Document to Project Manager and USACE</li> <li>- TPM</li> <li>- Project Manager approval of corrective action</li> </ul>

TABLE 6-1  
**FIELD CORRECTIVE ACTION PROCEDURES**  
**REMEDIAL ACTION SAMPLING AND ANALYSIS PLAN**  
 Defense Depot Memphis, Tennessee

Situation	Calibration <sup>(a)</sup>	Frequency	Field Objective Affected	Corrective Action Procedure
Incorrect measurement data collection	NA	NA	Measurements are conducted according to standard operating procedures	– Notification of site supervisory personnel – Review of situation and correct procedures – Document to Project Manager and Quality Assurance Officer (QAO) – Project Manager approval of corrective action
Measurement Outside of Expected Range				
pH	5 to 7.5	NA	Measurements are conducted according to standard operating procedures	– Notification of site supervisory personnel – Review of situation and correct procedures – Document to Project Manager and Quality Assurance Officer (QAO) – Project Manager approval of corrective action
Conductivity	.050 to 1.50 mS/cm (SM 1992)			
Temperature	15 to 27°C			
Dissolved Oxygen	0 to 10 mg/L (Driscoll, 1986)			
Redox Potential	–800 to 400 mV			

**Notes:**

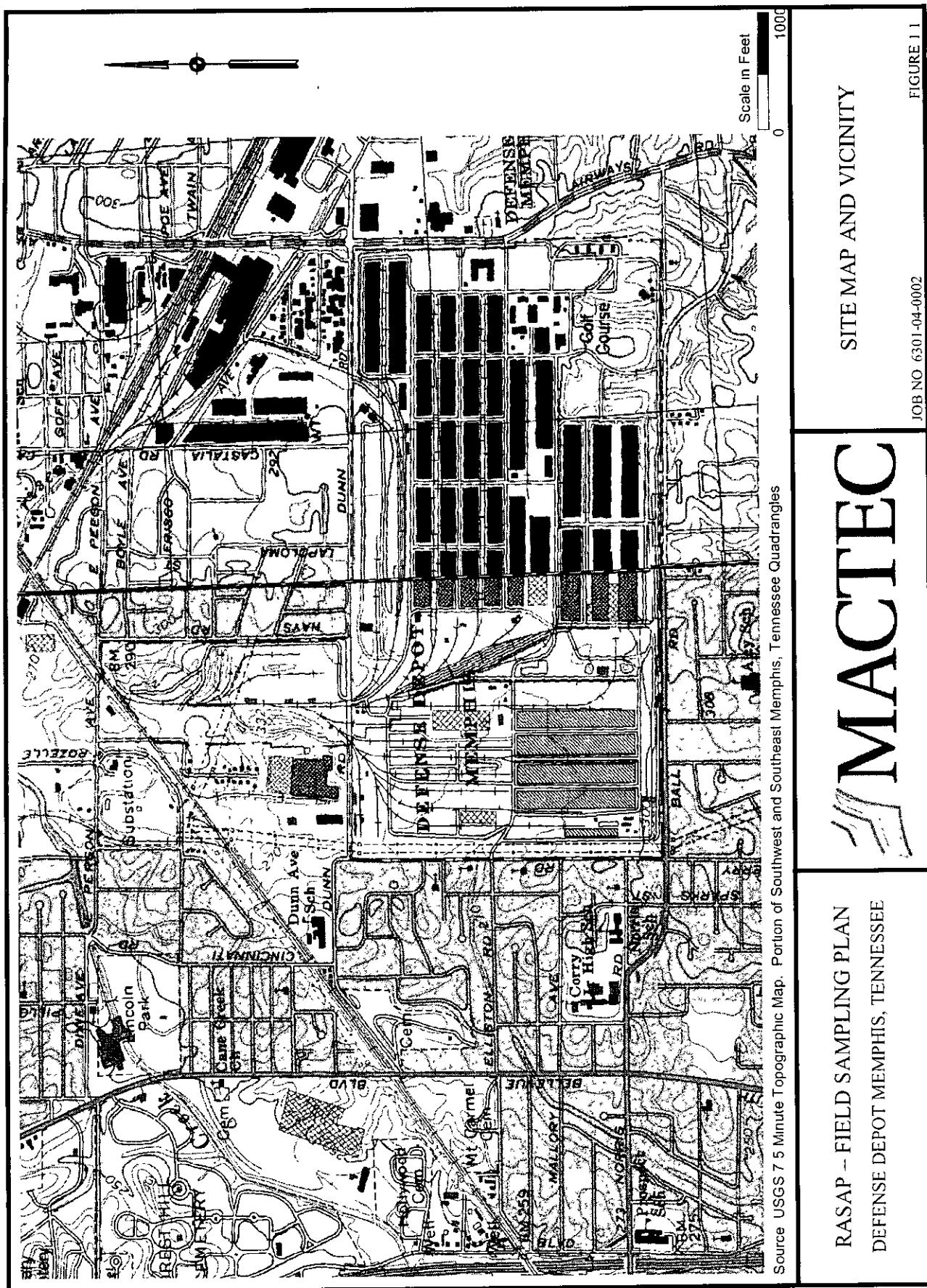
NA – Not Applicable

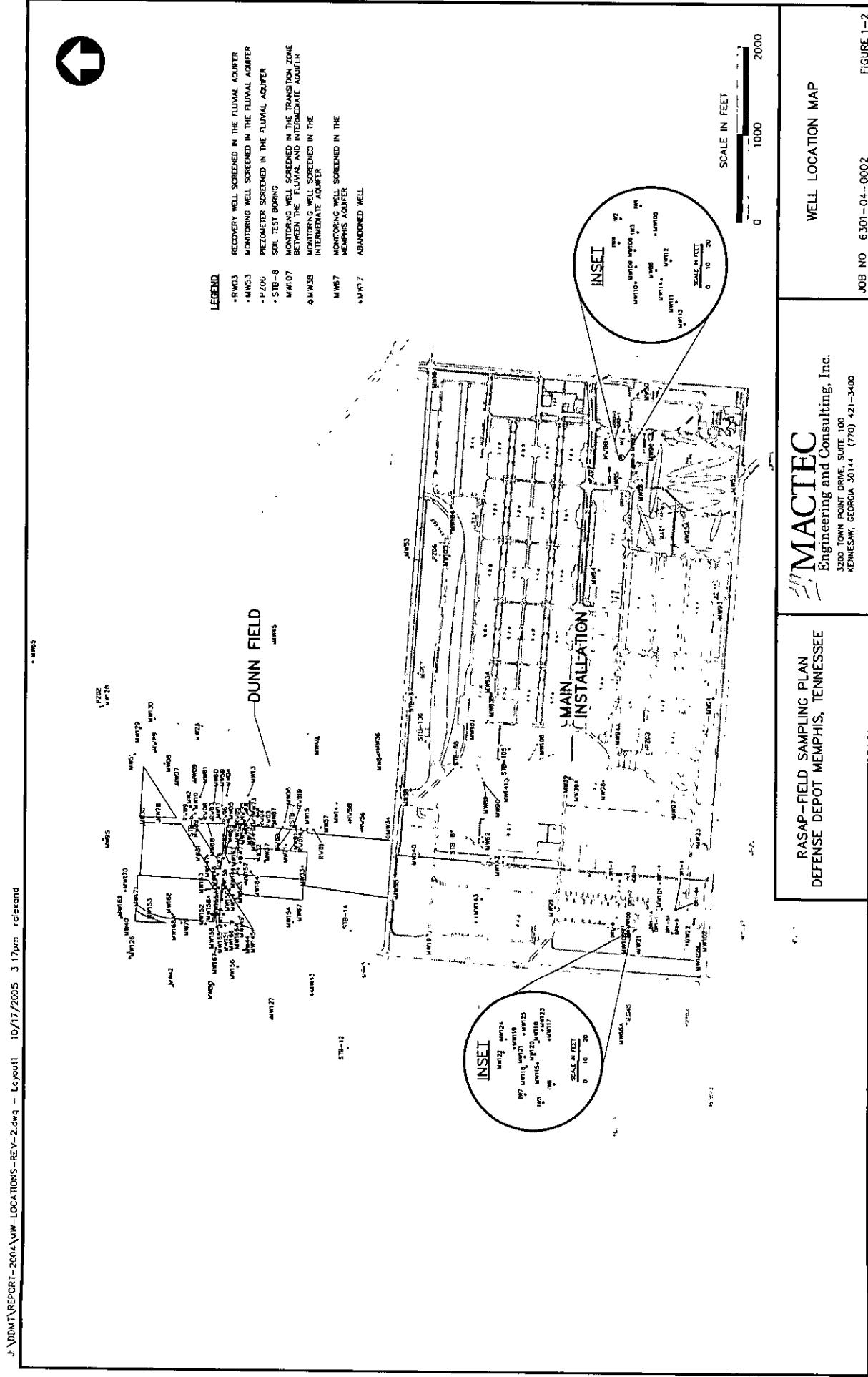
(a) For multiple test units, follow manufacturers instructions.

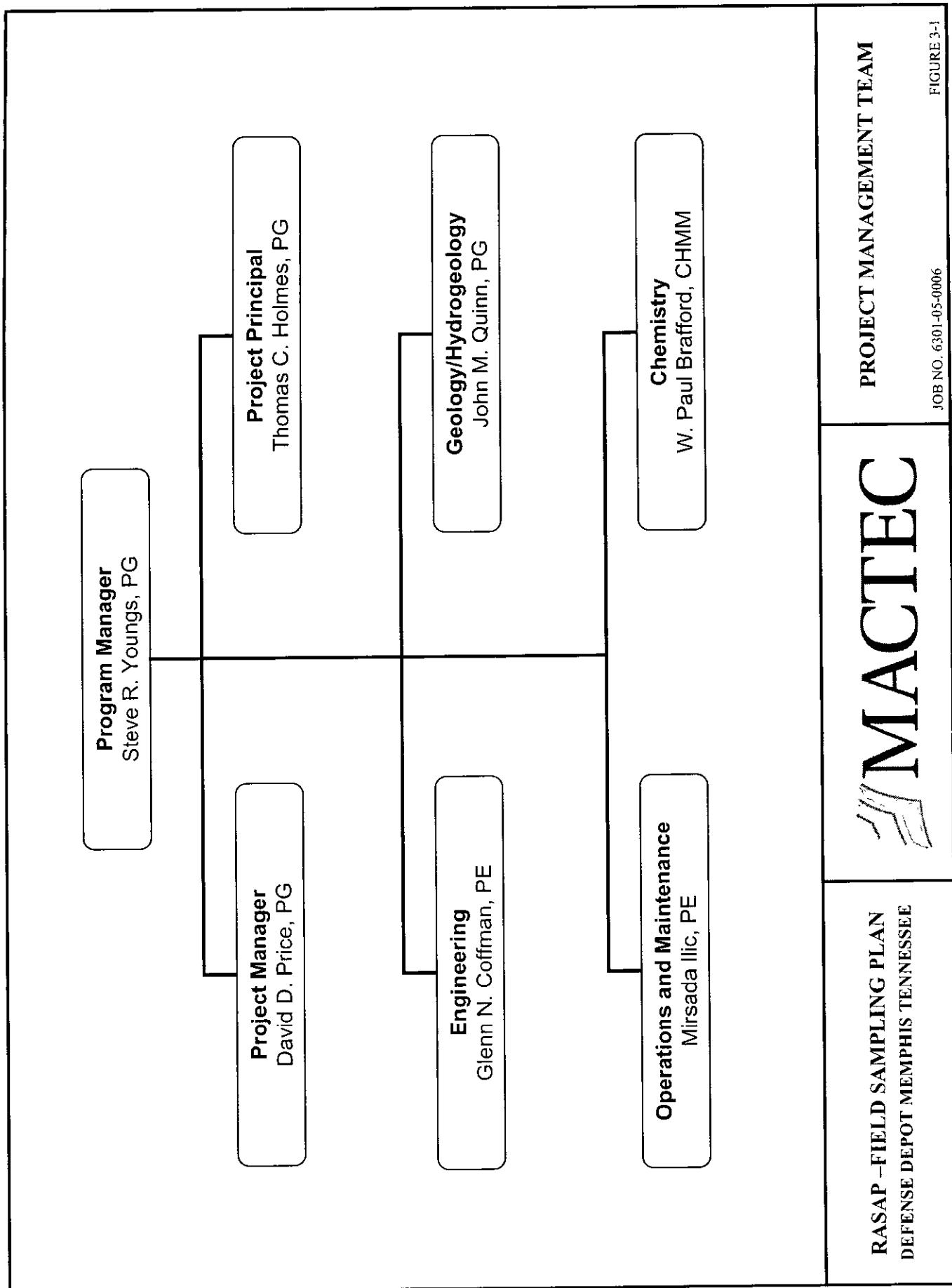
*RA SAP – Defense Depot Memphis, Tennessee  
Volume I – Field Sampling Plan  
MACTEC Project Nos. 6301-04-0002 & 6301-05-0006*

*November 2005  
Revision 1*

## **FIGURES**







*RA SAP – Defense Depot Memphis, Tennessee  
Volume 1 – Field Sampling Plan  
MACTEC Project Nos. 6301-04-0002 & 6301-05-0006*

*November 2005  
Revision 1*

**APPENDIX A**  
**FIELD AUDIT CHECKLIST**

### FIELD AUDIT CHECKLIST

#### SUPPLIES AND MATERIALS

The following supplies and materials will be necessary to perform the field audit:

- Site-Specific Work Plan
- Site-Specific Health and Safety Plan (HSP)
- Sampling and Analysis Plan (SAP)
- Standard Operating Procedures (SOPs)
- Any Field Adjustment Forms already in place
- List of site manager, field personnel and subcontractors
- Field Schedule
- Clipboard and pencils

#### GENERAL OFFICE

	<u>Yes</u>	<u>No</u>	<u>N/A</u>
1. Was site office in a neat and orderly appearance?	—	—	—
2. Was a Sign In/Sign Out Form available?	—	—	—
3. Was the Sign In/Sign Out Form current and being filled out daily?	—	—	—
4. Was a field briefing held each morning with each of the personnel?	—	—	—
5. Did the <i>initial</i> field briefing contain the following elements:			
• Site/project history and objectives	—	—	—
• Team assignments and responsibilities	—	—	—
• Sampling location assignments and directions	—	—	—
• Explanation of record keeping (i.e., fieldbook, FSRs, boring logs, etc.)	—	—	—
• Maps provided and directions to the hospital given	—	—	—
• Discussion of chemical and biological hazards and their action levels	—	—	—
• Calibration of field equipment and troubleshooting	—	—	—
• General office layout and procedures	—	—	—
• Team key and logbook assignments	—	—	—
6. Did the <i>follow-on</i> field briefings contain the following elements:			
• Sampling location assignments and directions	—	—	—
• Review and correction of field records	—	—	—
• Any additional information on chemical and biological hazards	—	—	—
• Any additional information on equipment calibration and troubleshooting	—	—	—
7. Was office equipment, storage and solvent rooms open and available to field personnel for use during working hours?	—	—	—
8. Were office rooms, facilities and gates locked prior to leaving the area?	—	—	—
9. Prior to the end of the field effort or shift, were the office, facilities and equipment cleaned and left in working order?	—	—	—
10. Was the following performed at the end of the field effort or shift:			
• rental equipment/cars returned, as appropriate	—	—	—
• equipment needing repair sent off-site or repaired on-site	—	—	—
• drums stored in drum storage area	—	—	—
• map of drum storage area drawn	—	—	—

- inventory of supplies \_\_\_\_\_
- round of water levels (if required) \_\_\_\_\_
- supplies ordered for next shift (if required) \_\_\_\_\_
- site office cleaned and left orderly for next field shirt? \_\_\_\_\_

#### HEALTH and SAFETY

1. Did each person read the HSP and sign the form? \_\_\_\_\_
2. Does each person have their 40hr/8hr OSHA card? \_\_\_\_\_
3. Does each person have the following PPE:
  - Safety glasses \_\_\_\_\_
  - Respirator with annual fit test record (if required) \_\_\_\_\_
  - Steel toed rubber boots or steel toed boots with boot covers \_\_\_\_\_
  - Gloves and protective clothing as specified in the SSHSP \_\_\_\_\_
4. Were maps to the hospital readily available in each team vehicle? \_\_\_\_\_
5. Did each team vehicle contain the following H&S equipment?
  - First aid kit \_\_\_\_\_
  - Eye Wash \_\_\_\_\_
  - Respirator cartridges (if required) \_\_\_\_\_
  - Draeger tubes \_\_\_\_\_
  - PID and LEL \_\_\_\_\_
  - Caution tape and stakes \_\_\_\_\_
  - Boot wash and equipment decontamination supplies \_\_\_\_\_
6. Was each team member aware of the action levels and what corrective steps were to be taken? \_\_\_\_\_
7. Was each team member aware of what number to call in case of emergency and who the H&S officer is on-site? \_\_\_\_\_
8. Were MSDS sheets available for decontamination solutions and preservatives? \_\_\_\_\_

#### INSTRUMENT CALIBRATION

1. Were instruments calibrated at the frequency specified in the FSP?
  - Purge Saver \_\_\_\_\_
  - Turbidimeter \_\_\_\_\_
  - OVA (PID or FID) \_\_\_\_\_
  - LEL \_\_\_\_\_
  - Other (write in) \_\_\_\_\_
2. Were the specified calibration solutions available and within expiration dates (see below)?
  - pH buffer 4.0 (expiration date \_\_\_\_\_)
  - pH buffer 7.0 (expiration date \_\_\_\_\_)
  - pH buffer 10.0 (expiration date \_\_\_\_\_)
  - specific conductance standard (expiration date \_\_\_\_\_)
  - turbidity standards (expiration dates \_\_\_\_\_)
  - PID isobutylene standard (expiration date \_\_\_\_\_)
  - Other (write in) \_\_\_\_\_ (expiration date \_\_\_\_\_)
3. Were the manufacturer's calibration and repair records available for each instrument? \_\_\_\_\_

### DECONTAMINATION PROCEDURES

1. Were the specified decontamination solutions available and within expiration dates (see below)?

- Pesticide grade hexane (expiration date \_\_\_\_\_) \_\_\_\_\_
- Pesticide grade methanol (expiration date \_\_\_\_\_) \_\_\_\_\_
- Liquinox/Alconox (expiration date \_\_\_\_\_) \_\_\_\_\_
- ASTM Type II Reagent grade water stored in glass containers \_\_\_\_\_

2. Were rinse/spray bottles made of Teflon? \_\_\_\_\_

3. Was a decontamination area available for large equipment (if required)? \_\_\_\_\_

- Did pad consist of sump lined with 6-mil polyethylene sheeting? \_\_\_\_\_
- Did pad consist of barriers to contain solutions? \_\_\_\_\_

4. Was sampling equipment decontaminated per the procedures specified in WTP 15? \_\_\_\_\_

5. Was a separate tub available for the solvent sprays/rinses? \_\_\_\_\_

6. Were decontamination fluids drummed for disposal? \_\_\_\_\_

7. Were drums labeled per the procedures specified in the FSP? \_\_\_\_\_

### SAMPLING PROCEDURES

Prior to sampling, were H&S zones, decontamination tubs and monitoring equipment assembled? \_\_\_\_\_

1. Soil Sampling:

- A. Was equipment decontaminated prior to use? \_\_\_\_\_
- B. Were working surfaces covered in poly sheeting or aluminum foil? \_\_\_\_\_
- C. Were working surfaces covered with new material between samples? \_\_\_\_\_
- D. Was a new pair of sampling gloves donned between each sample? \_\_\_\_\_
- E. Were sample labels, FSRs and fieldbooks completed in black ink? \_\_\_\_\_
- F. Were sample labels, FSRs and fieldbooks completed per WTP 7? \_\_\_\_\_
- G. Were soil samples collected per the procedures specified in WTP 11? \_\_\_\_\_
- H. If VOCs were to be collected, were sample vials prepared with preservative solutions and weighed? \_\_\_\_\_
- I. Were VOC sample syringes weighed and adjusted to 5.0 to 5.5 grams prior to insertion into the vial? \_\_\_\_\_
- J. Were labeled samples placed in an iced cooler? \_\_\_\_\_
- K. Were samples transported to the site office for packing and shipping immediately after sampling? \_\_\_\_\_
- L. If required, were samples logged? \_\_\_\_\_
- M. Were soil cuttings containerized (if required) in 55-gallon drums for disposal? \_\_\_\_\_
- N. Were drums labeled per the procedures specified in the FSP? \_\_\_\_\_
- O. Was the site restored to its original condition? \_\_\_\_\_

2. Groundwater Sampling:

- A. Was equipment decontaminated prior to use? \_\_\_\_\_
- B. Were water levels measured and recorded prior to sampling? \_\_\_\_\_
- C. Were working surfaces covered in poly sheeting or aluminum foil? \_\_\_\_\_
- D. Were working surfaces covered with new material between samples? \_\_\_\_\_
- E. Was a new pair of sampling gloves donned between each sample? \_\_\_\_\_
- F. Were sample labels, FSRs and fieldbooks completed in black ink? \_\_\_\_\_
- G. Were sample labels, FSRs and fieldbooks completed per WTP 7? \_\_\_\_\_

H. Was the purge flow rate adjusted to no more than 300 mls/min?	_____	_____	_____
I. Were stabilization parameters measured every 10 mins for a minimum of 3 measurements/30 mins?	_____	_____	_____
J. Was stabilization achieved prior to sampling?	_____	_____	_____
K. If VOCs were to be collected, was the flow rate adjusted to 100mls/min +/- 20 mls?	_____	_____	_____
L. Were groundwater samples collected per the procedures specified in WTP 4?	_____	_____	_____
M. Were labeled samples placed in an iced cooler?	_____	_____	_____
N. Were samples transported to the site office for packing and shipping immediately after sampling?	_____	_____	_____
O. Was purge water containerized (if required) in 55-gallon drums for disposal?	_____	_____	_____
P. Were drums labeled per the procedures specified in the FSP?	_____	_____	_____
Q. Was the monitoring well locked and the site restored to its original condition?	_____	_____	_____

### DRILLING PROCEDURES

Prior to drilling, were H&S zones, decontamination tubs and monitoring equipment assembled? \_\_\_\_\_

1. Were drill rigs, augers, and drilling tools decontaminated prior to use?	_____	_____	_____
2. Was the equipment decontaminated as specified in WTP 2?	_____	_____	_____
3. Were drilling locations cleared for utilities prior to drilling?	_____	_____	_____
4. Does drilling personnel have their 40hr/8hr OSHA training card?	_____	_____	_____
5. Does drilling subcontractor have the appropriate licenses?	_____	_____	_____
6. Were drilling procedures performed per the directions specified in WTP 2?	_____	_____	_____
7. Were drilling logs filled out per the procedures specified in WTP 2?	_____	_____	_____
8. Was the borehole abandoned per the procedures specified in WTP 3?	_____	_____	_____
9. Were drill cuttings and fluids containerized (if required) in 55-gallon drums for disposal?	_____	_____	_____
10. Were drums labeled per the procedures specified in the FSP?	_____	_____	_____
11. Was the site restored to its original condition?	_____	_____	_____

### MONITORING WELL INSTALLATION

Refer to drilling procedures above in addition to criteria listed below.

1. Were the following well screen criteria followed:	_____	_____	_____
• Were well screens and risers steam cleaned prior to use?	_____	_____	_____
• Were well screens 20 feet or less?	_____	_____	_____
• If well screens were greater than 10 feet, was approval obtained from TDEC and/or the BCT?	_____	_____	_____
• Were well screens PVC or stainless steel as specified by the work plan?	_____	_____	_____
• Was the depth of the well screen installed as specified in the Work Plan??	_____	_____	_____
2. Were the following filter pack criteria followed:	_____	_____	_____
• Did filter pack consist of contaminant free silica sand with <2% flat particles?	_____	_____	_____
• Was filter pack tremied from bottom of well to 2 feet above top of well screen?	_____	_____	_____
• Was well surging filter pack placement process used during well construction?	_____	_____	_____

3. Were the following bentonite and grout seal criteria followed:

- Was a minimum 2-foot thick bentonite seal installed above the filter pack? \_\_\_\_\_
- Was the bentonite seal composed of 100% sodium bentonite? \_\_\_\_\_
- Was the bentonite seal allowed to hydrate for 4 hours prior to placement of grout collar? \_\_\_\_\_
- Was a cement-bentonite grout seal placed in the annular space from top of bentonite seal to ground surface? \_\_\_\_\_
- Was cement-bentonite mixture composed of those elements listed in WTP 3? \_\_\_\_\_
- Was grout tested with mud balance to +/- 0.2 lbs/gal initial weight? \_\_\_\_\_

5. Was the well completed per WTP 3? \_\_\_\_\_

6. Was the well installed per WTP 3? \_\_\_\_\_

7. Were well installation diagrams completed per WTP 3? \_\_\_\_\_

#### **WELL DEVELOPMENT**

1. Was the well developed later than 24 hrs after installation? \_\_\_\_\_
2. Was equipment decontaminated prior to use? \_\_\_\_\_
3. Were 3 well volumes and fluids lost during installation removed from the well? \_\_\_\_\_
4. Were suspended sediment content of <0.75 ml/L achieved? \_\_\_\_\_
5. Was turbidity measured at or below 5 NTUs for at least 30 minutes? \_\_\_\_\_
6. Were pH, temperature and EC stabilized per WTP 3? \_\_\_\_\_
7. Were all sediments removed from bottom of well? \_\_\_\_\_
8. Were the procedures for deviations to the above criteria followed per the WTP? \_\_\_\_\_
9. Were the well development forms completed per WTP 3? \_\_\_\_\_
10. Were well development fluids containerized in 55-gallon drums or a storage tank? \_\_\_\_\_
11. Were drums labeled per the procedures specified in the FSP? \_\_\_\_\_
12. Was the monitoring well locked and the site restored to its original condition? \_\_\_\_\_

*RA SAP – Defense Depot Memphis, Tennessee  
Volume I – Field Sampling Plan  
MACTEC Project Nos. 6301-04-0002 & 6301-05-0006*

*November 2005  
Revision 1*

**APPENDIX B**  
**WORK AND TEST PROCEDURES**

## PREFACE

The following Work and Test Procedures (WTP's) have been compiled to provide procedures for the execution of field activities and the formulation of project-related documents, including project work plans, the Quality Assurance Project Plan, and the Health and Safety Plan for DDMT. The WTPs are general in nature and procedures may need to be modified depending on project-specific requirements. In many cases, sections have been taken directly from the following source documents.

MDNR, 1994. *Guidance Document Verification of Soil Remediation*. Environmental Response, Waste Management Division. Michigan Department of Natural Resources. July, 1994.

USACE, 2001. *Requirements for the Preparation of Sampling and Analysis Plans*, E200-1-3, 1 February 2001.

USEPA, 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD)*, OSWER-9950.1, September 1986

USEPA, 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, Environmental Compliance Branch, Athens, Georgia, November, 2001.

USEPA, 1992. *RCRA Groundwater Monitoring: Draft Technical Guidance*, Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C., EPA/530-R-93-071, November 1992.

USEPA, 2000. *Data Quality Objectives Process for Hazardous Waste Site Investigations*. U.S. Environmental Protection Agency, Office of Environmental Information, Washington D.C., EPA/600/R-00/007, January 2000.

NUMBER	NAME
1	General Procedures for Field Personnel
2	Drilling Operations
3	Well Installation, Development, and Abandonment
4	Groundwater Sampling
5	Hydraulic Conductivity Testing
6	Investigation Derived Waste Disposal
7	Sample Control and Documentation
8	Sample Containers and Preservation
9	Sample Packing and Shipping
10	Sampling Equipment Decontamination
11	Soil Sampling
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

These procedures will be adhered to and will form the basis for most project-related work. Personnel performing field activities will be familiar with these WTPs and with project-specific work plans prior to mobilization of the field team.

These procedures are designed to generate data that is consistently collected, accurate, legally defensible, and in compliance with Air Force Center for Environmental Excellence (AFCEE) requirements. Variances for sample collection, handling, and decontamination procedures may be allowed due to the following reasons:

1. Regulatory Comment
2. Data Quality Objectives (DQOs)

The quality of the data will be consistent with the purpose for which it is to be finally used. These are the DQOs. A discussion of the nomenclature and selection of criteria for DQOs are provided in the document entitled *Data Quality Objectives Process for Hazardous Waste Site Investigations* (USEPA, 2000). A summary of the DQO process as it relates to DDMT is provided in the FSP. There are two types of data quality, from the very high quality, legally defensible data often used in risk assessment and principle responsible party determination (Definitive) to the field monitoring data used during site characterization and implementation (Screening). Development of DQO's for project specific activities will be described in the relevant work plans.

The project-specific documents will incorporate most of the WTPs either directly or by reference and should be reviewed to identify any procedural variances from the procedures presented herein. In the event that these WTPs contradict specified procedures in a work plan, those specified in the work plan will take precedence.

## **WORK AND TEST PROCEDURE 1**

### **GENERAL PROCEDURES FOR FIELD PERSONNEL**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for the general field practices to be followed by MACTEC personnel while in the field at DDMT. A review of this WTP is mandatory prior to any field activities.

#### **2.0 DISCUSSION**

This WTP provides general guidance for field operations. The project-specific work plan will be referred to in order to determine the exact requirements for a specific project.

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

Minimum required personal protective equipment (PPE) for all employees involved in field work are steel-toed work boots. Additional PPE will be discussed in project specific work plans and in the site Health and Safety plan. A general checklist of personal supplies and equipment is presented as Attachment 1.1.

#### **3.0 PROCEDURES**

The following WTPs should be considered in conjunction with this WTP:

<b>NUMBER</b>	<b>NAME</b>
1	General Procedures for Field Personnel
2	Drilling Operations
3	Well Installation, Development, and Abandonment
4	Groundwater Sampling
5	Hydraulic Conductivity Testing
6	Investigation Derived Waste Disposal
7	Sample Control and Documentation

NUMBER	NAME
8	Sample Containers and Preservation
9	Sample Packing and Shipping
10	Sampling Equipment Decontamination
11	Soil Sampling
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

### **3.1 PREPARATION**

This section discusses the procedures to be used prior to beginning the field activities at each site.

#### **3.1.1 Office**

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

1. The Project/Task Manager will assign a Field Team Leader to direct field activities and coordinate with project/task managers, and personnel. Task specific responsibilities of the Field Team Leader will be addressed in the appropriate WTP; general responsibilities include;
  - Reviewing project-specific work plan, Health and Safety Plan (HSP), and Quality Assurance Project Plan (QAPP).
  - Notifying site personnel to arrange site access and coordinate schedules; contacts include DRC, affected tenants, and/or offsite property owners.
  - Coordinating field efforts with the project chemist and analytical laboratory
  - Generating appropriate paperwork for each event. Shipping appropriate paperwork and field books to the site.
  - Ordering appropriate supplies and equipment for delivery prior to the start of each event.
  - If any work is to be subcontracted, a review of the subcontractor contract, work plan, and Health and Safety plan
  - Ensure that all employees traveling to the site have Driver's License (or other picture identification) and an OSHA Certification Card in their possession prior to leaving the office.

### **3.1.2 Field**

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

- Verify that all required paperwork and equipment for field activities is on site. Inventory all rental equipment.
- Conduct site set up activities to include posting of signage (if applicable), delineation of work zones as specified by the SHSO or the Field Team Leader.
- Calibrate monitoring equipment (as needed).
- Conduct team safety meetings as required by the HASP.
- Conduct team review of the WTP and procedures to be followed.

## **3.2 FIELD OPERATIONS**

Prior to commencement of operations at each of the sites, a site reconnaissance will be performed to determine requirements for site preparation and clearance, such as clearing of brush and other identifying obstructions. Proposed drilling and sampling locations will be clearly marked. Clearance for utilities at drilling locations will then be conducted by utility operators or locating services such as Tennessee One-Call. No intrusive activities will be conducted until utility clearance has been completed. The MACTEC Field Team Leader will also select appropriate locations for the decontamination area, emergency equipment, and a drum staging area through consultation with DRC and site tenants as necessary.

The responsibilities incumbent on field personnel at DDMT are project and task specific. At a minimum, the field personnel are required to

1. Maintaining a logbook that describes field activities, and other information. In the logbook or on various forms that may be required, the following information must be recorded for each activity:
  - Location
  - Date and time
  - Identity of persons performing the activity
  - Weather conditions

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

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

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

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

2. Completing any required data collection/sample control forms (e.g., Chain-of-Custody, Field Sampling Report, etc.).
3. Communication with the MACTEC project/task manager regarding site conditions and out of scope work to be performed.
4. Before leaving the site daily, the following procedures will be performed by on-site personnel:
  - Decontaminate field equipment.
  - Field Team Leader is responsible for checking that all personnel have completed logbooks and field forms daily
  - Properly dispose of soiled PPE.
  - Ensure that any drums containing investigation-derived waste or PPE are sealed nightly and clearly labeled with the contents, date, and site/location name.
  - Make arrangements for shipment of samples (if applicable). Check daily with the analytical laboratory to ensure samples arrived in good condition.

### **3.3 POST-OPERATION**

This section discusses the procedures to be followed after field activities have been completed.

#### **3.3.1 Field**

Upon the completion of field activities, the MACTEC Field Team Leader will visit each site to verify that the area has been cleared and restored as closely as possible to its prior condition. Trash will be removed

from the site, and surface damage, such as wheel ruts caused by the drilling and support equipment, will be repaired.

- Ensure that equipment and associated supplies have been shipped back to the office.

### **3.3.2 Office**

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

- Submit logbook and original forms to Project/Task Manager for review.
- Check equipment and supplies shipped back to the office.
- Arrange for proper disposal of investigation-derived waste.
- Contact the analytical laboratory to ensure that the samples arrived in good condition (e.g., temperature is within acceptable ranges).

## **4.0 REFERENCES**

USACE, 2001. Engineering and Design Requirements for the Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001.

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

## **5.0 ATTACHMENTS**

Attachment 1.1 - Personal Field Equipment and Supplies Checklist

**ATTACHMENT 1.1****PERSONAL FIELD EQUIPMENT AND SUPPLIES GENERAL CHECKLIST**

Steel Toe Workboots	_____
Full Face Respirator (with appropriate cartridges)	_____
Safety glasses	_____
Logbook	_____
Pens	_____
Data Collection Forms	_____
Respirator Cartridges	_____
OSHA Certification Card	_____
Tape Measure	_____
Hard Hat	_____
Hammer	_____
First Aid Kit and Emergency Eyewash Station	_____
Overshoes	_____
Sun Screen	_____
Work Gloves	_____
Disposable Gloves	_____

## **WORK AND TEST PROCEDURE 2**

### **DRILLING OPERATIONS**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for drilling operations used in support of investigative activities at DDMT. Intrusive drilling activities will enable collection of subsurface soil samples and allow the installation of monitoring and injection wells.

#### **2.0 DISCUSSION**

There are several methods by which drilling operations may be conducted including, manual (hand) augering, power augering with hollow-stem augers, sonic drilling, and cable tool or mud rotary drilling with installation of surface casing. Generally, hand augering is useful only for surficial soil sampling while the other methods are used for deeper, subsurface investigations and for the installation of monitoring wells. Sonic drilling is the recommended method of drilling at DDMT because it has proven to be the most effective method for boring advancement and well installation under the site geologic and hydrogeologic conditions. The depth to water (i.e. 75-105 ft bgs on average) and geologic characteristics of the fluvial aquifer (i.e. tight sands mixed with gravel up to cobble size) present more problems for well installation using other drilling methods.

Drilling activities that require the use of a truck-mounted drill rig will be subcontracted. Specific requirements for drilling subcontractors include:

- Provision of a Health and Safety Plan in compliance with that of the project
- Subcontractor employees must have completed the OSHA 40-Hour course with the OSHA 8-Hour refresher, as necessary
- Subcontractor employees must be in a medical surveillance program
- Equipment sufficient to carry out the work as specified in the time allotted
- All required licenses to drill and install wells in the state of Tennessee
- Appropriate experience on similar projects.

MACTEC Engineering and Consulting (MACTEC) personnel will provide on-site support for drilling activities. This support will consist of the following:

- Oversight of the drilling operation
- Preparation of the soil boring log (see Attachment 2.1) with lithologic interpretations and observations relevant to investigative activities
- Physical collection of the soil samples for field or laboratory analysis (if any).
- Site monitoring in accordance with the HSP.

MACTEC personnel on site will include, at a minimum, a qualified geologist/engineer. Drill rig equipment and other field supplies and equipment will be decontaminated as described under Section 3.2.3 of this WTP.

### **3.0 PROCEDURES**

The following WTPs should be considered for review in conjunction with this WTP:

NUMBER	NAME
1	General Instructions for Field Personnel
3	Well Installation and Development
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

#### **3.1 PREPARATION**

The following subsections list the procedures to be followed prior to beginning of drilling operations.

##### **3.1.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:

- Coordinating with the analytical laboratory to ensure that the sample containers, and preservatives based on the expected number of samples and days on site are shipped to the site and arrive prior to the start of drilling.

- Generating appropriate paperwork for each event including HTW drilling logs. Shipping appropriate paperwork and field books to the site prior to the start of sampling.
- Ordering appropriate supplies and equipment for delivery prior to the start of sampling. A generalized list of sampling equipment and supplies is provided as Attachment 2.2.
- Provide drilling subcontractor with number and depth of boring to be drilled and ensure that sufficient material quantities will be available. Confirm drilling schedule.
- Arrange for surveyor to locate drilling locations, as necessary
- Notify utility locating services at least three business days prior to drilling activities.

### **3.1.2 Field**

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

- Meet with site contacts, as necessary to confirm drilling locations and IDW storage (roll-off boxes)
- Verify that required equipment for drilling operations is on-site and functional
- Conduct site set up activities to include; posting of signage, provision of drums to contain drill cuttings and other IDW (PPE, decon water), delineation of the drilling area with hazard/caution tape, and marking/staking of the locations to be drilled
- Tour the site and check the decontamination area
- Calibrate monitoring equipment (as needed)
- Conduct team review of the WTP and procedures to be followed (subcontractor and MACTEC personnel)

## **3.2 FIELD OPERATIONS**

A qualified geologist or engineer will oversee the drilling activities. Modifications to boring locations will be approved by the Project/Task Manager prior to implementation.

### **3.2.1 Drilling Procedures**

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

The following requirements will apply to drilling activities:

1. Drilling will conform to Shelby County rules and regulations, and Rules of TDEC, Division of Water Supply, Chapter 12-4-10, Well Construction and Abandonment Standard. Activities will also conform to EPA Region 4, Science and Ecosystems Services Division EISOPQAM (2001).
2. All necessary precautions will be taken to prevent leakage of hydraulic oil or other contaminants from the drilling rig into the borehole or onto equipment that is placed in the hole.
3. The only acceptable drilling fluid is water. However, water will be used only when necessary as approval by the project/task manager, and will be from an approved source. Any bentonite that may be added to the water will be 100 percent sodium bentonite.
4. If water is used as a drilling fluid, a water sample from the drilling water supply tank will be collected and analyzed for the contaminants of concern.

#### **3.2.1.1 Drilling Procedures**

The following procedures will be followed for completing each soil boring/well:

1. Advance boring to the target depth. Water sources used during drilling will be sampled as outlined in 3.2.1.2.
2. Monitor the breathing zone for organic vapors in accordance with the procedures contained in the HSP. The tops of the boreholes will be monitored for percent oxygen and combustible gases (LEL) using a combination explosimeter/oxygen meter.
3. Collect soil samples at specified intervals in borings for soil classification and/or chemical analysis or field screening as specified in the project-specific work plan.
4. Determine and record the depth to groundwater observed during drilling.

### **3.2.1.2 Drilling Water Source**

Water used during the drilling program will be clean, non-chlorinated water, where possible. Clean, potable water will be used if a non-chlorinated source is not readily available. MACTEC's drilling supervisor will record the amount of water used. One sample of the water used will be collected from the water source. Each water transportation vehicle will also be sampled once during the drilling program. These samples will be analyzed for the same parameters specified for the groundwater samples. Information regarding the source of water used and any impact on analytical results will be included in the field notes.

### **3.2.1.3 Drilling Logs**

The geologist/engineer will log the subsurface conditions encountered in the boring, and record the information on a Hazardous and Toxic Waste (HTW) Drilling Log (Attachment 2.1) and the logbook. Additional pertinent information will also be recorded on the logbook, including, but not limited to, the following:

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

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

### **3.2.2 The Borehole**

For a nominal 2-inch outside diameter well casing, borehole diameter will be a minimum of 6 inches. The borehole shall provide a minimum of two inches of annular space between the outside diameter of the well casing and the borehole wall. Therefore, the sonic drill casing will require an inner annulus that is 6 inch diameter or larger. In cases where a hollow-stem auger is used, the inside diameter will be at least four inches larger than the outside diameter of the casing and well screen.

### **3.2.3 Drill Rig Decontamination**

#### **3.2.3.1 Decontamination Area**

The location of the decontamination area will be cleared with DRC personnel. The decontamination pad will consist of a wooden frame lined with minimum 6-mil plastic sheeting. The pad will slope so that water can be temporary containerized in DOT-approved, 55-gallon, closed-top steel drums or other approved containers. A schematic of the proposed equipment/vehicle decontamination layout is presented in Attachment 2.3.

#### **3.2.3.2 Decontamination Water Source**

Potable water from the municipal water system will be used as a rinse in the decontamination procedure. The Field Team Leader will be responsible for coordinating with DRC personnel to secure an adequate supply of tap water for decontamination procedures.

### **3.2.3.3 Drill Rig and Support Equipment**

The following procedure will be used to decontaminate drill rigs and support equipment.

1. Wash the external surface of equipment or materials with high-pressure hot water and scrub with brushes and Liquinox or equivalent, if necessary, until all visible dirt, grime, grease, oil, loose paint, rust flakes, etc., have been rinsed from the equipment.
2. Rinse with potable water.
3. This decontamination procedure will be performed prior to each use and between each well and sampling location. Decontamination solutions will be placed in DOT-approved, 55-gallon, closed-top steel drums or other approved containers, maintained at the site, and labeled.
4. Decontamination water is considered investigation-derived wastes (IDW). Therefore, the containers will be permanently labeled in a waterproof manner and inventoried as to their contents and source. The containers will be stored in the temporary staging area until proper disposal is arranged.

### **3.2.4 Borehole Abandonment**

Boreholes will be abandoned in accordance with both project-specific requirements and the applicable TDEC, Shelby County and USEPA guidance and requirements referenced in section 3.2.1.

Soil borings that encounter groundwater will be abandoned by filling the boring with grout (cement/bentonite) until undiluted grout is visible at the surface. The grout will be tremied into the boring, keeping the tremie pipe below the grout surface. The tremie pipe should have side discharge holes, not end discharge. The side discharge will help to maintain the integrity of the underlying material. The grout will serve to seal off the aquifer from contamination from surface influences. The remaining annular space created by the settlement of the grout will be finished to the ground surface with the surface cap material present prior to drilling (i.e., soil, concrete, asphalt, etc.).

### **3.2.5 Investigative-Derived Waste**

Any investigative-derived waste (i.e., drill cuttings, drilling fluid) that is contaminated will be disposed of in an approved fashion as specified in the FSP.

### **3.3 POST-OPERATION**

The following subsections list the procedures to be followed after drilling operations have been completed.

#### **3.3.1 Field**

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

- Decontaminate all field equipment that has come in contact with soil or groundwater.
- Ensure that each drilling location is clearly marked for surveying.
- Complete logbook, making notations as to site conditions, anomalous readings, etc.
- Complete HTW Drilling Log (Attachment 2.1).
- Ensure that equipment and associated supplies are shipped back to the office.
- Ensure that IDW containers (e.g. drill cuttings, decontamination water) or PPE are sealed and have been labeled clearly with the date, name, contents and source.
- Ensure that the site is returned to its condition prior to drilling operations to the extent feasible (i.e., trash related to drilling operations must be disposed of prior to departure from the site).

#### **3.3.2 Office**

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

- Submit logbook and any original forms to Project/Task Manager for review.
- Inventory equipment and supplies shipped back to the office.
- Make arrangements for the proper disposal of IDW.

#### **4.0 REFERENCES**

USACE, 1998, Monitoring Well Design, Installation, and Documentation at Hazardous Toxic and Radioactive Waste Sites. November 1998.

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

USEPA, 1991. Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies. Final, OSWER Directive 9835.1 Document 070191-1, July 1991.

USEPA, 1992. RCRA Groundwater Monitoring: Draft Technical Guidance. EPA530-R-93-001. United States Environmental Protection Agency, November 1992.

USEPA, 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document. OSWER-9950.1. United States Environmental Protection Agency, September 1986.

#### **5.0 ATTACHMENTS**

Attachment 2.1 - HTW Drilling Log

Attachment 2.2 – General Field Supply Checklist-Drilling Activities

Attachment 2.3 - Vehicle/Equipment Decontamination Layout

## ATTACHMENT 2.1

HTW DRILLING LOG				HOLE NO			
1. COMPANY NAME		2. DRILLING SUBCONTRACTOR		SHEET OF SHEETS			
3. PROJECT		4. LOCATION (CITY, STATE)					
5. NAME OF DRILLER		6. MANUFACTURER'S DESIGNATION OF DRILL					
7. SIZE AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		9. HOLE LOCATION (SITE)					
		10. SURFACE ELEVATION					
8. WEATHER		11. DATE STARTED		12. DATE COMPLETED			
13. OVERBURDEN THICKNESS		16. DEPTH GROUNDWATER ENCOUNTERED					
14. DEPTH DRILLED INTO ROCK		17. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED					
15. TOTAL DEPTH OF HOLE		18. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)					
19. GEOTECHNICAL SAMPLES #)		DISTURBED	UNDISTURBED	20. TOTAL NUMBER OF CORE BOXES			
21. SAMPLES FOR CHEMICAL ANALYSIS		VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	22. TOTAL CORE RECOVERY %
23. DISPOSITION OF HOLE		BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	24. SIGNATURE OF INSPECTOR		
25. CHECKED BY. 26. NAME OF INSPECTOR							
ELEV.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREENING RESULTS (ppm)	GEOTECH SAMPLE OR CORE BOX No.	ANALYTICAL SAMPLE No.	BLOW COUNTS	REMARKS
0	1.0						
	2.0						
	3.0						
	4.0						
MRK FORM JUN 99		55-1	PROJECT NAME & NO.			HOLE NO.	

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**ATTACHMENT**  
**2.1 (continued)**

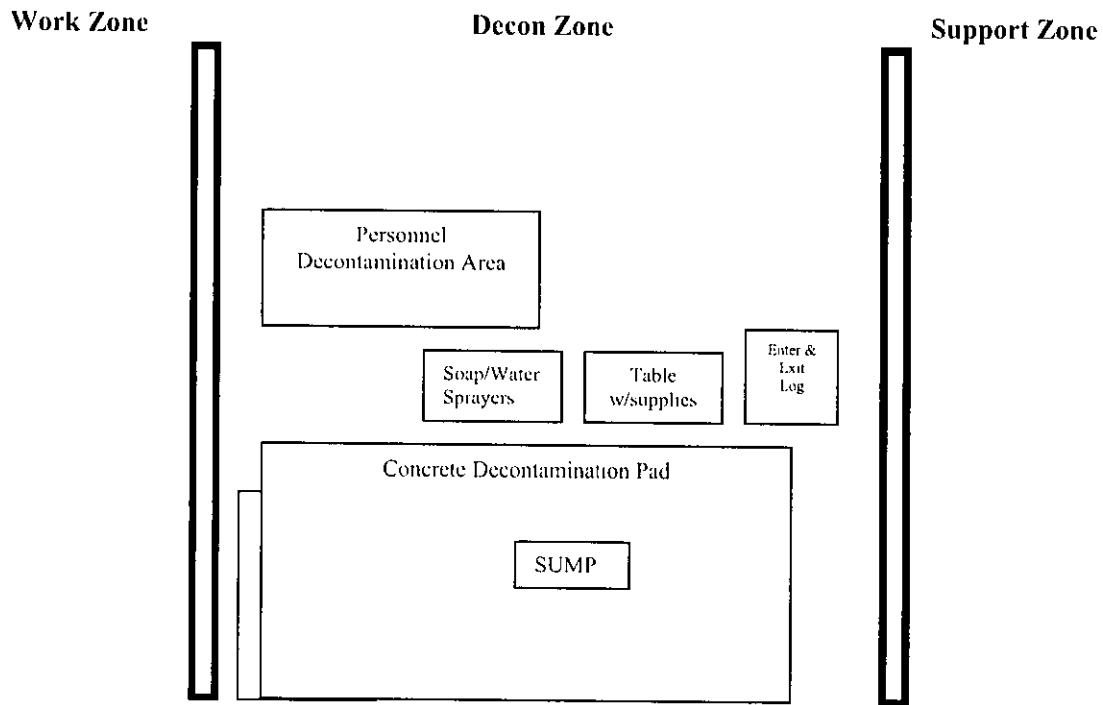
HTW DRILLING LOG						HOLE NO.	
PROJECT			INSPECTOR			SHEET OF	SHEETS
ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS (ppm) d	GEOTECH SAMPLE OR CORE BOX No. e	ANALYTICAL SAMPLE No. f	BLOW COUNTS g	REMARKS h
	6.0						
	7.0						
	8.0						
	9.0						
	0.0						
	1.0						
	2.0						
	3.0						
	4.0						
	5.0						
	6.0						
MRK	FORM JUN 89	55-2	PROJECT NAME & NO.				HOLE No.

**ATTACHMENT 2.2****General Field Supply Checklist-Drilling Activities**

Steel Toe Workboots	_____
Full Face Respirator (with appropriate cartridges)	_____
Safety Glasses	_____
Logbook	_____
Pens	_____
Data Collection Forms	_____
OSHA Certification Card	_____
Tape Measure	_____
Hard Hat	_____
Hammer	_____
First Aid Kit and Emergency Eyewash Station	_____
Overshoes	_____
Sun Screen	_____
Work Gloves	_____
Disposable Gloves	_____
FID	_____
LEL	_____
Water Level Indicator	_____

### ATTACHMENT 2.3

#### VEHICLE/EQUIPMENT DECONTAMINATION LAYOUT Defense Depot, Memphis, Tennessee



**WORK AND TEST PROCEDURE 3**  
**WELL INSTALLATION, DEVELOPMENT, AND ABANDONMENT**

**1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for the installation and development of monitoring wells suitable to generate data for determination of the extent of groundwater contamination and of site hydrogeological conditions. Procedures for well abandonment are also included.

**2.0 DISCUSSION**

This WTP specifies details and procedures for the design, construction, installation, and development of monitoring and injection wells at DDMT.

Monitoring wells allow for direct measurement of both groundwater contamination and flow parameters beneath the site. Monitoring wells will be designed and installation supervised by qualified environmental professionals according to project specifications, and in accordance with USEPA guidelines.

Well installation will be performed by the drilling subcontractor under the direction of a MACTEC geologist/engineer. General requirements for the drilling subcontractor and oversight are provided in WTP 2, Drilling Operations.

**3.0 PROCEDURES**

**3.1 ASSOCIATED PROCEDURES**

The following WTPs should be considered for review in conjunction with this WTP;

NUMBER	NAME
1	General Instructions for Field Personnel
2	Drilling Operations
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

### **3.2 PREPARATION**

Well installation will occur immediately after drilling. Therefore preparation for well installation should be made prior to beginning drilling operations, these preparations are given in WTP 1 and 2.

### **3.3 WELL CONSTRUCTION**

Included in this section is the rationale for selection of well construction materials. A qualified geologist/engineer will oversee well installation activities.

#### **3.3.1 Well Construction Materials**

Well risers will consist of material durable enough to retain their long-term stability and structural integrity and be relatively inert to minimize alteration of groundwater samples. Selection of PVC or stainless steel for the monitoring wells is based on the primary purpose of the well, which is the detection of potential contaminants. PVC has demonstrated very good chemical resistance except to high concentrations of low molecular-weight ketones, aldehydes, and chlorinated solvents. Stainless steel has demonstrated very good chemical resistance, including resistance to high concentrations of low molecular-weight ketones, aldehydes, and chlorinated solvents. Low concentrations of these same chemicals with long term exposure to PVC have not had documented effects (Barcelona et al., 1983; NWWA, 1989).

Stainless steel resistance to corrosion, in most corrosive environments, particularly under oxidizing conditions, has been shown to be very effective. Stainless steel requires exposure to oxygen in order to attain its highest corrosion resistance. Oxygen combines with part of the stainless steel alloy to form an invisible protective film on the surface of the metal. As long as the film remains intact, the corrosion resistance of the stainless steel remains high. According to Barcelona et al. (1983), in cases where long-term exposures in very corrosive conditions are eminent, corrosion may occur with the subsequent release of chromium or nickel as contaminants in ground water samples.

Well materials will consist of new, threaded, flush joint polyvinyl chloride (PVC) or stainless steel pipe, with a minimum inside diameter of 2 inches. If PVC is used, the riser pipe will conform to ASTM D 1785, Standards for Schedule 40 Pipe. Materials will be new and unused and will be decontaminated prior

to installation. Casing will only be joined with compatible welds or couplings that do not interfere with the primary purpose of the well. Use of solvent or glue will not be permitted.

Well screens will consist of new, commercially fabricated, threaded, flush joint, minimum 2-inch inside (ID) diameter, factory slotted or continuous wrap PVC, or, in the case where known or expected chlorinated solvents are present in the groundwater, stainless steel screen. Screen slot size will be based on previous available soil information, but will be generally sized to prevent 90 percent of the filter pack from entering the well. The screen slot size will be adjusted if site geologic conditions significantly differ from the expected conditions. Previous well installation at DDMT have generally used factory-slotted or wire-wrapped screens with 0.010-inch openings, no less than 10-feet in length, and no greater than 20-feet in length.

Silt traps will not be used in monitoring wells. Silt traps usage fosters a stagnant, turbid environment, which could influence analytical results for trace concentrations. A notch will be cut in the top of the casing to be used as a measuring point for water levels.

### **3.3.2 Well Design**

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

This section describes well installation and construction procedures including the placement of the screen, installation of the filter pack, bentonite seal, and grout seal. The Field Team Leader and the Project/Task Manager will collectively make decisions on well depths, locations, screened intervals, etc. Boring at DDMT are generally drilled 10-feet into the clay unit at the base of aquifers to confirm the local presence of the lower confining unit. Well screens are generally set above the clay at the base of the aquifer; the deeper portion of the boring is filled with bentonite.

#### **3.3.2.1 Screen Location**

The screened intervals will be selected for each proposed well based on specific DQOS. There are several water bearing units of interest present at DDMT (fluvial, intermediate, and Memphis aquifer). Both the fluvial and intermediate aquifers can be found in unconfined conditions, with significant saturated

thickness (>50 feet). In most areas, the saturated thickness of the fluvial aquifer is 20 feet or less. For most wells at DDMT the screen will start from the top of clay upward, for a maximum of 20 feet of screen per well. If the saturated thickness is substantially greater than 20 feet, a cluster well may be installed so that the entire saturated interval is screened.

### 3.3.2.2 Filter Pack

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

A filter pack size of (20-40) will be used based on wells previously installed at DDMT. This sand size was determined from grain-size analysis of the screened intervals by previous consultants at the site. If the site conditions show significant change (i.e. more gravelly, or much more clayey) from those previously encountered a grain-size analysis will be completed and filter pack design based on those results.

The filter pack will be placed from the bottom of the hole to a minimum of 4 feet above the top of the well screen. The filter pack will not extend across more than one water-bearing unit. When sonic drilling methods are used, the filter pack will be emplaced through the nominal 6-inch diameter steel casing using the gravity method. The procedure for gravity installation of the filter pack will be as follows:

Prior to installation of the well casing, the inside of the 6-inch steel casing will be thoroughly cleared of sediment and cuttings by reaming with the 4-inch sampling barrel and flushing with potable water. The sand filter pack will be gravity-placed through the 6-inch steel casing in lifts of no more than approximately 1 foot. Care will be taken to prevent bridging by frequently measuring the thickness of the filter pack as it is placed. As the steel casing is slowly withdrawn between lifts, it will be vibrated with the sonic drilling head to compact the sand filter pack.

### 3.3.2.3 Bentonite Seal

A minimum 5-foot thick bentonite seal will be installed above the filter pack in the annular space of the well. Only 100 percent sodium bentonite (pellets or chips) will be used and care will be taken to prevent

bridging by frequently measuring the thickness of the bentonite as it is gravity placed. When the seal is installed above the water table, the bentonite will be hydrated with water from an approved water source as described in WTP 2 - Drilling Operations. At least 5 gallons of water will be added after each 24 to 30 inches of bentonite is placed. The bentonite seal will be allowed to hydrate for a minimum of 4 hours prior to placement of the grout collar around the wells (USACE, 1998).

### **3.3.2.4 Annular Space**

As described above, the annular space between the well riser and the borehole wall will be filled with a filter pack, a bentonite seal, and a grout seal. In the case of deeper, Type III wells, the upper section of the borehole will be cased with solid PVC or iron pipe and grouted in place.

### **3.3.2.5 Plumbness and Alignment**

The well pipe assembly will be hung in the borehole, prior to placement of the filter pack, and not allowed to rest on the bottom of the hole to keep the well assembly straight and plumb. Centralizers will be installed at 50-foot intervals in wells greater than 20 feet in depth. The centralizers will not be attached in the length containing the well screen or bentonite seal. In addition the centralizers should not restrict the passage of the tremie pipe used for filter pack and grout placement (USACE, 1998).

### **3.3.2.6 Grout Seal**

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

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

### 3.3.2.7 Well Completion Details

Type II and Type III Monitoring Wells will be completed as shown in the project Well Installation Diagrams (Attachment 3.1 and 3.2 respectively).

Based on well location and future area use, the Project/Task Manager will determine surface completion (flush or projected above ground surface) requirements for all permanent monitoring well installations. Temporary monitoring well installations will be clearly marked by the use of wooden stakes placed around the well and cordoned off with silt fencing and/or barrier tape. For permanent monitoring well installations, if a well stick up is not appropriate, surface completions will be flush with the land surface. The casing will be cut approximately 3 inches below land surface and will be secured with a water tight casing cap to prevent surface water from entering the well. A water-proof valve box with locking cover will be placed over the well casing. The valve box lid will be centered in a 3-foot by 3-foot by 4-inch thick concrete pad that slopes away from the box.

If an aboveground surface completion is used, the well casing will be extended 2 or 3 feet above land surface. A casing cap will be provided for each well. A vent hole will be placed in the protecting casing and a ventilated well cap will be used. A steel sleeve will be placed over the casing to shield the extended casing and cap. The steel sleeve will be seated in a minimum 3-foot by 3-foot by 4-inch concrete surface pad. The diameter of the sleeve will be a minimum of 4 inches greater than the diameter of the casing. A weep hole will be drilled in the steel sleeve about 1 inch above the top of the well pad. The pad will be sloped away from the well sleeve and a lockable cap or lid will also be installed. Three 3-inch diameter concrete-filled steel guard posts will be installed around each well unless the well is located in an area receiving vehicular traffic. These guard posts will be 5 feet in total length and installed radially from the well head. The guard posts will be installed approximately 2 feet into the ground and set in concrete; these posts will not be installed in the concrete pad placed at the well base. The protective sleeve and guard posts will be painted orange using a brush (USACE, 1998). Installation of the well will be completed prior sampling the well.

Wells will be secured immediately after well completion. Corrosion-resistant locks will be provided for both flush and aboveground surface completions. A brass survey marker will be installed in the concrete pad. The information required by the TDEC (i.e., well identification number, registration number, etc.) should be inscribed, stamped or otherwise permanently marked on monitoring well identification tags.

### **3.3.3 Well Installation**

Well installation will be supervised by a qualified geologist. When installing wells through more than one water bearing zone or aquifer, measures will be taken to prevent cross-connection or cross-contamination of the zones during the drilling and well installation.

#### **3.3.3.1 Procedures**

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

1. Remove the PVC or stainless steel screen and riser from packaging and steam clean to remove manufacturing residues.
2. Fill deepest part of boring that has intersected the clay layer with bentonite.
3. Install a 10 to 20-foot section of minimum 2-inch (I.D.), threaded, flush jointed, pre-manufactured PVC or stainless steel screen inside the steel drill casing.
4. Install solid riser to ground surface, plus 24-to 36-inch stick-up (if required).
5. Install the filter pack using the gravity method through the annular opening between drill casing and well screen, as the drill casing is removed, to distribute the filter pack around the screen in a uniform height and density. Take care to prevent bridging by measuring the thickness of the filter pack as it is placed.
6. Continue removing drill casing and installing filter pack until at least 4 feet above the top of the well screen. Use the sonic drilling head to vibrate the steel casing as it is slowly withdrawn in order to compact the filter pack and prevent bridging.
7. Install a minimum 5-foot bentonite seal. The bentonite seal will be hydrated with potable water. Allow the bentonite seal a minimum of 4 hours of hydration time before grouting the annulus. Deeper wells below the water table can utilize bentonite slurry for the bentonite seal if the potential exist for the bentonite to bridge during installation through water or drilling mud; bentonite slurry, if used, will be placed with a side-discharge tremie pipe.
8. Remove remaining drill casing and grout boring annulus to ground surface with grout/bentonite mixture.
9. Develop well (after waiting no less than 24 hours after installation).

### **3.3.3.2 Well Installation Diagrams**

The field supervisor will maintain suitable logs detailing drilling and well construction practices. Well dimensions, amount, type and manufacture of materials used to construct each well will be recorded on the Monitoring Well Installation Diagrams (Attachment 3.1 and 3.2). Only Type II wells are currently planned for installation at DDMT. Additional information to be recorded on the monitoring well installation diagram will include:

- Well identification
- Drilling method
- Installation date(s)
- Elevations of ground surface and the measuring point notch
- Total boring depth
- Lengths and descriptions of the screen and rising
- Thickness and descriptions of filter pack, bentonite seal, casing grout, and any backfilled material
- Record quantities of all materials
- Summary of material penetrated by the boring

Each installation diagram will be completed in the field, reviewed in the office and submitted in an appendix of the Technical Report.

### **3.3.4 Well Development**

The purpose of well development is to create good hydraulic contact between the well and the aquifer and to remove accumulated sediments from the well. Each newly installed monitoring well will be developed. Drilling fluids used during well construction will be removed during development. The following sections describe the procedures for well development.

#### **3.3.4.1 Well Development Procedures**

Each monitoring well will be developed no sooner than 24 hours after installation to allow for adequate grout curing time. Wells will be developed using pumps equipped with surge rings or bailers. Any other

techniques must be approved by the Project/Task Manager. The monitoring well development protocol is as follows:

1. Measure the static water level and the depth to the top of sediment in the well.
2. Record the total depth of the well (from the Well Installation Diagram).
3. Calculate the volume of water in the well and saturated annulus.
4. Begin developing the well using a combination of surging and pumping. Continue pumping and periodically surging until each the following criteria have been met:
  - a. Fluids lost to the formation during well installation have been removed (this is a minimum requirement where conditions permit).
  - b. The well water is clear to the unaided eye and the turbidity of the water removed.
  - c. pH, temperature, turbidity, and specific conductance have stabilized. In general, field parameters are stable when nephelometric turbidity units (NTUs) are less than 10, pH is within 0.1 on consecutive readings, and temperature and specific conductance are within 10 percent of previous readings. It should be noted that natural turbidity levels in ground water may exceed 10 NTU.
  - d. If feasible, monitor the static water level (SWL) during purging. Adjust the purge rate to keep the SWL from dropping more than 0.3 meter from the initial SWL.
  - e. No sediment remains in the bottom of the well. However, it can be accepted if the sediment thickness remaining within the well is less than 1 percent of the screen length or less than 0.1 ft for screen equal or less than 10 feet long.
5. In the event that the above criteria have not been met after six hours of pumping, surging, and bailing (including recharge time for poorly recharging wells), development activities will be temporarily discontinued at that well. The MACTEC field staff will advise the MACTEC Project/Task Manager who will decide whether or not to continue development of the well.
6. In the event of slowly recharging wells that will not sustain pumping or bailing, the MACTEC field staff will advise the Project/Task Manager as soon as a determination of estimated recharge time has been made.
7. Physical characteristics of the water (suspended sediment, turbidity, temperature, pH, EC, purge rate, odor, etc.) will be recorded throughout the development operation. At a minimum, they will be recorded initially and after each well volume has been removed, or every 30 minutes, whichever comes first.
8. The total quantity of water removed and final depth to the top of sediment (total depth of well) will be recorded.
9. The static water level in the well (after at least 24 hours) will also be recorded once the water level in the well has completely recovered.

No detergents, soaps, acids, bleaches, or other additives will be used to develop a well. Well development equipment will be decontaminated as specified in WTP 11 -Sampling Equipment Decontamination.

### **3.3.4.2 Well Development Records**

Well development data will be recorded on Well Development Data Sheets. An example of this sheet is shown as Attachment 3.3.

### **3.3.4.3 Well Development Water**

Development water will be drummed or stored in bulk containers. The containers will be clearly labeled with site name, well name, date, and contents. The development water will be properly disposed in accordance with IDW procedures set forth in the FSP

### **3.3.5 Well Abandonment**

After it has been determined that a monitoring well is no longer needed it will be abandoned. According to the LTM Plan (CH2M Hill, 2004), wells are recommended for abandonment for the following reasons:

- The test objectives have been achieved and the well is no longer needed.
- The well is improperly constructed, i.e.:
  - Well installed with improper installation of the outer casing and position of the sand pack
  - Wells with elevated pH readings (due to improper construction)
- The wells that have improperly placed screens or long screens.
- The monitoring wells where dense non-aqueous phase liquid has been potentially indicated.
- The well has been vandalized or damaged.

To properly abandon a well, the surface completion (concrete pad and protective casing) should be removed and the well filled with a cement/bentonite grout from the bottom. An alternative method is to completely remove the well casing and screen from the borehole. This may be accomplished by over-drilling the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig.

The borehole can then be backfilled with the appropriate grout material. The grout should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method). The top 2 feet of the borehole should be poured with concrete to insure a secure surface seal (plug). The concrete surface plug can also be recessed below ground surface if the potential for construction activities exists.

### **3.3.6 Survey of Well Locations**

Upon completion of the wells, a Tennessee licensed professional surveyor will locate each new monitoring well by standard surveying methods. A vertical survey will be conducted to establish the elevation of each monitoring well casing and brass disk. Vertical control will be to the National Geodetic Vertical Datum. The horizontal grid coordinates within 0.1 foot, the ground elevation to within 0.01 foot, and the elevation of the top of casing (notch) within 0.01 foot will be recorded. The survey will be referenced to the State Plane coordinate system.

## **3.4 POST-OPERATION**

### **3.4.1 Field**

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

- Decontaminate all field equipment.
- Ensure that installed/developed wells are secured.
- Complete logbook, making notations as to site conditions, anomalous readings, etc.
- Complete monitoring well development records and well installation diagram.
- Ensure that related equipment and associated supplies have been shipped back to the office.
- Ensure that all IDW containers are sealed and labeled clearly with the date, name, and contents.
- Ensure that the site is returned to its condition prior to well installation to the extent feasible (i.e., all trash related to well installation and development must be disposed of prior to departure from the site).

### **3.4.2 Office**

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

- Submit logbook and any original forms to Project/Task Manager for review.
- Inventory equipment and supplies shipped back to the office.
- Make provisions for the proper disposal of IDW.

## **4.0 REFERENCES**

USACE, 1998. Monitoring Well Design, Installation, and Documentation at Hazardous Toxic, and Radioactive Waste Sites. November 1998.

USEPA, 1991. Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies. Final, OSWER Directive 9835.1 Document 070191-1, July 1991.

Barcelona, et. al., 1983. A Guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling. Urbana, IL: Illinois State Water Survey, ISWS Contract Report 327.

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

NWWA, 1989. Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells. Dublin, OH: National Water Well Association.

USEPA, 1992. RCRA Groundwater Monitoring: Draft Technical Guidance. EPA530-R-93-001. United States Environmental Protection Agency. November 1992.

USEPA, 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document. OSWER-9950-1. United States Environmental Protection Agency, September 1986.

## **5.0 ATTACHMENTS**

Attachment 3.1- Type II Monitoring Well Stickup Installation Diagram  
Attachment 3.2- Type II Monitoring Well Flush Mount Installation Diagram  
Attachment 3.3 - Well Development Record

## ATTACHMENT 3.1

TYPE II MONITORING WELL INSTALLATION DIAGRAM (STICK-UP COMPLETION)		
PROJECT NAME _____	WELL NO _____	PROJECT NO. _____
DATE _____	WELL LOCATION _____	TIME _____
GROUND SURFACE ELEVATION _____	BENTONITE TYPE _____	
TOP OF SCREEN ELEVATION _____	MANUFACTURER _____	
REFERENCE POINT ELEVATION _____	CEMENT TYPE _____	
TYPE FILTER PACK _____ GRADATION _____	MANUFACTURER _____	
FILTER PACK MANUFACTURER _____	BOREHOLE DIAMETER _____	
SCREEN MATERIAL _____	MACTEC FIELD REPRESENTATIVE _____	
MANUFACTURER _____	DRILLING CONTRACTOR _____	
SCREEN DIAMETER _____ SLOT SIZE _____	AMOUNT BENTONITE USED (SEAL) _____	
RISER MATERIAL _____	AMOUNT BENTONITE USED (GROUT) _____	
MANUFACTURER _____	AMOUNT CEMENT USED (GROUT) _____	
RISER DIAMETER _____	AMOUNT SAND USED _____	
DRILLING TECHNIQUE _____	STATIC WATER LEVEL (>24 hrs after dev) MEASURED ON (Date/Time) _____	
REMARKS _____		
<p>(NOT TO SCALE; ALL MEASUREMENTS IN FEET)</p>		
QA / QC	DRILLER: _____ DISCREPANCIES: _____	INSPECTOR: _____ CHECKED BY: _____ DATE: _____

ATTACHMENT 3.2

TYPE III MONITORING WELL INSTALLATION DIAGRAM (FLUSH MOUNT COMPLETION)	
PROJECT NAME _____	PROJECT NO. _____
WELL NO. _____	WELL LOCATION _____
DATE _____	TIME _____
GROUND SURFACE ELEVATION _____	BENTONITE TYPE _____ MANUFACTURER _____
TOP OF SCREEN ELEVATION _____	CEMENT TYPE _____
REFERENCE POINT ELEVATION _____	MANUFACTURER _____
TYPE FILTER PACK _____ GRADATION _____ FILTER PACK MANUFACTURER _____	BOREHOLE DIAMETER _____
SCREEN MATERIAL _____ MANUFACTURER _____	MACTEC FIELD REPRESENTATIVE _____
SCREEN DIAMETER _____ SLOT SIZE _____	DRILLING CONTRACTOR _____
RISER MATERIAL _____ MANUFACTURER _____	AMOUNT BENTONITE USED (SEAL) _____ AMOUNT BENTONITE USED (GROUT) _____
RISER DIAMETER _____	AMOUNT CEMENT USED (GROUT) _____
DRILLING TECHNIQUE _____ AUGER/BIT SIZE AND TYPE _____	AMOUNT SAND USED _____
REMARKS _____	STATIC WATER LEVEL (>24 hrs after dev) MEASURED ON (Date/Time).
(NOT TO SCALE: ALL MEASUREMENTS IN FEET)	
QA / QC	DRILLER: _____ DISCREPANCIES: _____
	INSPECTOR: _____ CHECKED BY: _____ DATE: _____

### ATTACHMENT 3.3

#### WELL DEVELOPMENT DATA

PROJECT NAME \_\_\_\_\_ PROJECT No. \_\_\_\_\_

DEVELOPED BY \_\_\_\_\_ CHECKED BY \_\_\_\_\_ SHEET 1 OF \_\_\_\_\_

1. Well No.: \_\_\_\_\_ Site Location: \_\_\_\_\_
2. Date of Installation: \_\_\_\_\_
3. Date of Development: \_\_\_\_\_
4. Static Water Level: Before Development \_\_\_\_\_ ft.; 24 hrs. After \_\_\_\_\_ ft.; Date/Time \_\_\_\_\_
5. Organic Vapor: Before Development \_\_\_\_\_ ppm; After Development \_\_\_\_\_ ppm
6. Quantity of Water Loss During Drilling, If Used: \_\_\_\_\_ gal.
7. Quantity of Standing Water in Well and Annulus Before Development: \_\_\_\_\_ gal.
8. Depth From Top of Well Casing to Bottom of Well: \_\_\_\_\_ ft. (from Well Installation Diagram)
9. Well Diameter: \_\_\_\_\_ in.
10. Screen Length: \_\_\_\_\_ ft.
11. Minimum Quantity of Water to be Removed: \_\_\_\_\_ gal.
12. Depth to Top of Sediment: Before Development \_\_\_\_\_ ft.; After Development \_\_\_\_\_ ft.
13. Physical Character of Water (Before/After Development):  
 \_\_\_\_\_  
 \_\_\_\_\_
14. Type and Size of Well Development Equipment: \_\_\_\_\_  
 \_\_\_\_\_
15. Description of Surge Technique, If Used:  
 \_\_\_\_\_  
 \_\_\_\_\_
16. Height of Well Casing Above Ground Surface: \_\_\_\_\_ ft. (from Well Installation Diagram)
17. Quantity of Water Removed: \_\_\_\_\_ gal. Time for Removal: \_\_\_\_\_ hr. / min.
18. 1-Liter Water Sample Collected: \_\_\_\_\_ (Time) Photographed? Y / N
19. Final Turbidity in Nephelometric Units: \_\_\_\_\_ NTUs
20. Final Imhoff Cone Measurements < 0.75 mL/L, If Applicable: \_\_\_\_\_

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**ATTACHMENT 3.3**  
**(continued)**

**WELL DEVELOPMENT DATA**  
(Continued)

PROJECT NAME \_\_\_\_\_ PROJECT No. \_\_\_\_\_

DEVELOPED BY \_\_\_\_\_ CHECKED BY \_\_\_\_\_ SHEET \_\_\_\_\_ OF \_\_\_\_\_

Well No.: \_\_\_\_\_ Site Location: \_\_\_\_\_

## **WORK AND TEST PROCEDURE 4**

### **GROUNDWATER SAMPLING**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for collection of groundwater samples for field or laboratory analysis.

#### **2.0 DISCUSSION**

This WTP specifies details and procedures for collecting groundwater samples for chemical analysis. Groundwater samples will be collected from monitoring wells using either a disposable Teflon bailer or a stainless steel bladder pump. The groundwater samples will be analyzed to identify chemical constituents and their concentrations.

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be considered for review in conjunction with this WTP:

<b>NUMBER</b>	<b>NAME</b>
1	General Instructions for Field Personnel
3	Well Installation and Development
7	Sample Control and Documentation
8	Sample Containers and Preservation
9	Sample Packing and Shipping
10	Sampling Equipment Decontamination
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

##### **3.2 PREPARATION**

###### **3.2.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:

- Working with the project chemist to generate a sampling plan detail listing the wells and constituents to be sampled
- Coordinating with the analytical laboratory to ensure that the sample containers, and preservatives are shipped to the site and arrive prior to the start of sampling event
- Generating appropriate paperwork for each event including; sample labels, request for analysis forms, field sampling reports, purge forms. Shipping appropriate paperwork and field books to the site prior to the start of sampling.
- Ordering appropriate supplies and equipment for delivery prior to the start of sampling. A generalized list of sampling equipment and supplies is provided as Attachment 4.2
- Confirm the shipping receipts and schedule with lab and equipment suppliers

### **3.2.2 Field**

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

- Check that required sampling equipment has arrived on site.
- Conduct site set up activities; posting of signage and establishment of a decontamination area, and organization and inventory of supplies in the field storage area.
- Check that monitoring equipment is functioning properly, and calibrated as needed.
- Ensure that sufficient drums are on site to containerize any excess sample material collected.
- Assign task to field teams according to the project work plans

### **3.3 FIELD OPERATIONS**

Prior to sampling, a field station will be established. The station will contain equipment, supplies, safety gear, and instrumentation necessary for the collection of samples. Field instruments will be calibrated, files containing sample information will be processed, and sample bottles will be sorted for each sample location according to analyses.

Environmental conditions will also be noted. Each sampling site will be characterized by the following factors:

- Location of work
- Weather conditions
- Rainfall amounts
- Temperature – minimum and maximum
- Wind direction
- Ongoing activities that may influence or disrupt sampling efforts
- Accessibility to the sampling locations (e.g., rough terrain, fallen trees, flooding, etc.)

These conditions will be recorded in the field sampling books and used to assess sampling procedures in relation to the sample data. A Site Manager – Daily Quick Reminder List for use in guiding field activities is included as Attachment 4.6.

### **3.3.1 Sampling Equipment Calibration**

Field measurements of groundwater physical parameters are used for groundwater sampling and for independent measurements during remedial actions. Before, during, and after use, the water-quality measurement equipment will be properly calibrated per manufacturer's instructions and following EPA Guidance (EISOPQAM 2001). After sampling, before leaving the site, a calibration check will be made as described in the following sections.

Field measurements will be made with a YSI 6920 or similar multi-probe device with flow-through cell. The flow cell allows a water sample to be pumped from a source, such as a groundwater monitoring well, to a sonde. Flow cells add efficiency to low flow purging and field sampling applications, when it is impossible or undesirable to place a sonde down-hole in situ in a well. Calibration procedures for the YSI 6920 are given as Attachment 4.1.

### **3.3.2 Sample Collection Procedures**

Groundwater samples may be collected from monitoring and injection wells, or piezometers. In most cases, non-dedicated bladder pumps or disposable bailers will be used to sample the wells. Passive Diffusion Bags may also be used for groundwater sampling. Decontamination of pumps at water level indicators are required prior to and after each sampling event. A general supply list for groundwater sampling is given as Attachment 4.2.

Sampling will be performed no less than 24 hours after well development is completed. Observations made during sample collection will be recorded in a field notebook and on a monitoring well purge and

sampling form. The following intitial steps will be followed before collecting groundwater samples in the field.

1. Locate the well to be sampled and record the condition of the well including any damage or evidence of tampering.
2. Lay out plastic sheeting around the wellhead and place the monitoring, purging, and sampling equipment on the sheeting to prevent contamination of the surface soils and the equipment.
3. Determine concentration of organic vapors every time a casing cap is removed to measure a water level or to collect a sample.
4. Water levels will be measured before purging, during purging, and after sampling. For wells with dedicated pumps, water levels will be measured ONLY if the water is above the top of the pump. DO NOT pull the pump to measure the water level. The water level probe should be carefully lowered down the well to minimize disturbance.

Caution shall be used when opening each well to avoid fumes which may have accumulated and to prevent foreign materials from entering the well. All ground-water levels shall be measured to the nearest 0.01 foot (from the well datum reference point) using an electronic water level indicator. Each well will be marked with an easily identifiable permanent reference point that will be located on the top of the well casing. The depth to ground water will be measured from this reference point to the ground-water surface in the well. The depth to ground water data will be recorded in either a project field notebook or on a ground-water level measurement sheet. The depth to the ground water is subtracted from the surveyed elevation of the reference point to determine the ground-water elevation.

The water-level indicator and tape will be decontaminated prior to each use. The decontamination procedure for the water level indicator is.

- A. Hand wash the calibrated tape and probe with a solution of Alconox (or equivalent).
- B. Rinse with deionized (Reagent Grade II) water.
5. Measure the water level from the measuring point to the nearest 0.01 foot, as specified in ASTM D4750.
6. DO NOT measure the total depth of the well prior to sampling. Well depth should be obtained from well logs. Measuring to the bottom of the well casing may cause re-suspension of settled solids.
7. If the turbidity cannot be reduced to below 20 NTUs after purging for approximately two hours (and other field parameters are stable as indicated in the following sections), then the field team leader shall be contacted for approval to sample the well. If the turbidity is below 50 NTU, then the well may be sampled without using

filtration techniques. If the turbidity is 50 NTU or higher, then both dissolved and total metals and dissolved and total organic carbon samples should be collected (samples for organic compound analysis should not be filtered). The dissolved metals and organic carbon samples should be collected by filtration with a disposable 0.45  $\mu\text{m}$  in-line filter. Approximately 500 mL of the groundwater should be pumped through the filter and disposed prior to sample collection.

### **3.3.2.1 Sampling using a Disposable Bailer**

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

1. Well sampling equipment will be decontaminated as specified in WTP 11 – Sampling Equipment Decontamination, and protected from recontamination until use. Purging and sampling will be conducted in a manner that minimizes the agitation of sediments in the well and formation. Equipment will not be allowed to free fall into a well.
2. Measure the static water level prior to purging using a decontaminated electronic water level indicator. The probe of the water level indicator will be lowered into the well bore and the water level will be recorded.
3. Attach the Teflon coated stainless steel leader rope to the bailer and polypropylene (or nylon) rope to the Teflon coated rope. Lower the bailer into the well, until it contacts the water surface. Allow the bailer to sink and fill with a minimum of water surface disturbance. Slowly withdraw the bailer from the well, preventing the bailer and bailing line from touching the ground.
4. The well should be purged until a minimum of three well volumes is removed from the well, and the water quality indicators of pH, specific conductivity, and turbidity stabilize. Readings will be taken every 5 to 10 minutes and recorded on the well purge form (Attachment 4.4). Stabilization is achieved after three successive readings are within  $\pm 0.1$  for pH,  $\pm 3\%$  for specific conductance, and <20 NTU for turbidity. Temperature will also be measured and recorded, but will not be used as a stabilization parameter. Sampling may begin once the well has stabilized. If stabilization does not occur or turbidity cannot be reduced below 20 NTU, the field team leader should be contacted for further guidance. If the well is purged dry, a sample will be collected as soon as sufficient recharge has occurred within 24 hours. Temperature, specific conductance, turbidity and pH will also be measured and recorded; however, stabilization of these parameters is not required.
5. After purging the well and allowing for sufficient recharge, collect samples by pouring the water from the bailer into the appropriate sample containers. This process will be repeated as necessary to fill each container.
6. Collect the samples to be analyzed for volatile organics first, filling the bottle, leaving zero headspace. Proceed with the collection of samples for the remaining

analyses, collecting the more volatile parameters first. (Refer to sampling order presented in the low-flow section).

7. Wells should be sampled in order of increasing contamination (i.e. - samples that are expected to be least contaminated will be collected before those that are more highly contaminated) and as specified in the project specific work plan and WTP-8 - Sample Control and Documentation, and WTP-9 - Sample Containers and Preservation.
8. Add preservatives if necessary to samples as indicated in the QAPP and WTP-9 - Sample Containers and Preservation, label the sample containers as specified in the QAPP and WTP-8 - Sample Control and Documentation, and WTP-9-Sample Containers and Preservation. Required sample containers and holding times are presented in the project work plan, QAPP, and WTP-9 - Sample Containers and Preservation.
9. After samples have been collected, replace the well cap and lock the security casing.
10. Place samples into the cooler with ice and fill out required Chain-of-Custody documents in accordance with the procedures specified in the QAPP.
11. Record field conditions, any problems encountered during sampling, and sample appearance in the field logbook and transfer the information to the Field Sampling Report (Attachment 4.2). In addition to the information required in any field sampling investigation (WTP 1 - General Instructions for Field Personnel), the following information will also be recorded in the logbook each time a well is purged and sampled.
  - Depth to water before and after purging
  - Total depth of the well (measure after sample collected)
  - Condition of each well, including visual (mirror) survey
  - The thickness of any floating hydrocarbon layer
  - Field parameters such as pH, conductance, temperature, and turbidity

### **3.3.2.2 Sampling Using a Bladder Pump**

The sampling protocol will be as follows for the collection of groundwater samples using a stainless steel/Teflon bladder pump:

1. Slowly and carefully lower the pump inlet to, or slightly above, the screened interval where representative groundwater flow is expected. In cases where the entire screen is not saturated, place the pump inlet at or slightly above the middle of the saturated zone, keeping in mind the limitations stated below.
2. DO NOT place pump inlet less than 2 feet above the bottom of the well, as this may cause the mobilization of bottom sediments. If saturated screen length is 2 feet or less, place pump inlet to, or slightly above, the middle of the screened interval.

3. Allow at least 1 foot of water above the inlet so there is little risk of entrainment or air in the sample.
4. After the water level in the well has equilibrated, begin purging at a rate of 200 to 500 mL/minute. All purge water will be containerized as IDW. The appropriate and final purge rate will be determined by monitoring groundwater drawdown. Drawdown should not exceed 4 inches.
5. The discharge during purging and sampling must flow with minimal turbulence or agitation.
6. The water level should stabilize and the pump rate should allow water to recharge the well so that little or no water level drawdown is observed.
7. Record groundwater level frequently until stabilization occurs. Adjust discharge rate appropriately to make sure that excessive drawdown does not occur. After stabilization, measure water levels at regular intervals.
8. If drawdown is greater than 4 inches, decrease the discharge rate of the pump and repeat discharge and water level measurements. Repeat until the water level stabilizes to closely match the recharge rate. Record pumping rate and any adjustments and depths to water on the purging and sampling log sheet.
9. An in-line multi-probe flow-through cell will be used to monitor the indicator parameters so as not to expose the sample to the atmosphere prior to measurement of the parameters. During purging, water quality indicator parameters [pH, redox potential (ORP), turbidity, specific conductivity, and dissolved oxygen (DO)] will be measured every 5-10 minutes until the parameters have stabilized. Measurement should be recorded on the well purge form (Attachment 4.4) A minimum of 5 sets of water quality indicator parameters should be recorded.
10. Stabilization is achieved after three successive readings are within  $\pm 0.1$  for pH,  $\pm 10$  mV for ORP,  $\pm 3\%$  for specific conductance,  $\pm 10\%$  for DO, and  $<20$  NTU for turbidity. Temperature will also be measured and recorded, but will not be used as a stabilization parameter. Sampling may begin once the well has stabilized.
11. Specific conductance and DO usually take the longest to stabilize. Fifteen minutes to 1.5 hours of purging at the recommended purge rate may be required to reach stabilization. Stabilized purge indicator trends are generally obvious and follow either an exponential or asymptotic change to stable parameter values during purging. The above stabilization guidelines are provided as estimates and will not be appropriate for use in all circumstances.
12. The pump will not be turned off between the purging and sampling processes.
13. If stabilization does not occur or turbidity is  $>20$  NTU after two hours of purging, the field team leader should be contacted for further guidance.

Wells installed in very low permeability formations ( $<0.1$  L/minute recharge rate) will require alternative purging and sampling methods. Use of the usual low-flow techniques is impractical in this type of

environment, because devices to pump at such low flow rates are not readily available. Under these conditions, the wells will be pumped at the lowest practical rate, and an attempt will be made to stabilize all parameters except drawdown. Sampling will commence early enough to ensure that the screened interval is not exposed to atmospheric conditions by the time the last sample is taken. In the event the added limitation of an insufficient volume of water in the well is encountered, the well will be sampled using a disposable Teflon bailer. The well will be bailed to dryness and sampled when it has recharged to the static water level.

Groundwater samples will be collected by gently filling the sample bottles with minimum turbulence once equilibrium is established. Lower the flow rate to 100 mL/minute and collect the parameters in the following order:

- VOCs (no headspace)
- Methane, Ethane, Ethene (no headspace)
- Carbon Dioxide (no headspace)
- TOC (no headspace)
- Sulfide (no headspace)
- Anions
- Alkalinity
- Metals (total and dissolved)
- Field Parameters (ferrous iron and carbon dioxide)

### **3.3.2.3 Sampling Using a Passive Diffusion Bag Sampler**

Select groundwater samples will be collected for VOC analyses using passive diffusion bag (PDB) sampling. A typical PDB sampler consists of a low-density polyethylene tube closed at both ends and filled with deionized water. It is positioned in the well at the desired target depth by attaching it to weighted line, or a fixed object. The water within the bag is then allowed to equilibrate with the ambient groundwater (at least two weeks) before being retrieved. The sampler water is then decanted into 40 mL volatile organic analysis (VOA) vials and sent to the lab for analysis. Detailed procedures for using PDB samplers in wells can be found in “User’s Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells” (USGS, 2001). The following is a generalized summary of PDB sampling:

1. The top and bottom of the PDB sampler will be attached to 3/16” polyester or similar non-buoyant rope strong enough to support the weight of the sampler and subject to minimal stretch. The PDB will be suspended within the well screen at various depths

based on the measured total depth and knowledge of the location of the screen in the well. Weights will be attached to the bottom of the sampler to keep it in place in the hole. The sampler can also be configured to rest on the bottom of the well. The sampler will be allowed to equilibrate before being carefully retrieved with the attached line and the contents analyzed.

2. For wells with dedicated in-well pumps, the PDB sampler will be tied to the pump just below the inlet using plastic cable ties or stainless rings. Total well depth will be measured after pump removal and compared to current records to ensure that the PDB will not rest in sediment settled in the bottom of the well. A stainless steel weight will be attached to the bottom of the PDB to counterbalance the buoyancy of the sampler and keep it in position. The pump/PDB apparatus will then be very carefully lowered back down the hole and secured in position.
3. After the equilibration period, the bags will carefully be withdrawn from the hole and the bag removed from the pump and inspected. Any evidence of algae or other coatings on the bag or tears in the membrane will be noted in the field book. If there are tears, the sample will be rejected.
4. The contents of the intact bag will then be transferred to pre-preserved VOA vials causing as little agitation of the sample as possible. The samples will then be shipped to the laboratory for analysis.

### **3.4 POST-OPERATION**

#### **3.4.1 Field**

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

- Decontaminate equipment.
- Complete logbook, making notations as to site conditions, anomalous readings, etc.
- Ensure that equipment and associated supplies have been shipped back to the office.
- Ensure that the site has been cleaned to its pre-sampling state (i.e., ensure that all trash generated as a result of sampling activities is disposed of).
- Ensure that all drums containing any IDW are properly labeled with the date and drum contents. If IDW samples are to be taken, follow the procedures outlined in WTP 7 – Waste Sampling.

#### **3.4.2 Office**

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

- Submit logbook and any original forms to Project Manager for review.

- Inventory equipment and supplies shipped back to the office.
- Make provisions for proper disposal of IDW upon receipt and review of the laboratory data concerning the contents.

#### 4.0 REFERENCES

ASTM, 1984. Annual Book of ASTM Standards, American Society of Testing and Materials, 1986.

Barcelona, et. al., 1983. A Guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling. Urbana, IL: Illinois State Water Survey, ISWS Contract Report 327.

USACE, 2001. Requirements for the Preparation of Sampling and Analysis Plans, United States Army Corps of Engineers, EM 200-1-3, February, 2001.

USEPA, 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document. OSWER-9950.1. United States Environmental Protection Agency, September 1986.

USEPA, 1991. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, February 1, 1991.

USEPA, 1992. RCRA Groundwater Monitoring: Draft Technical Guidance, Office of Solid Waste, Washington, D.C., November 1992.

USEPA, 1996. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, Office of Solid Waste, Washington, D.C., April 1996.

#### 5.0 ATTACHMENTS

Attachment 4.1 – Sample Equipment Calibration  
Attachment 4.1a - YSI Calibration Sheet  
Attachment 4.2 - General Field Supply Checklist-Sampling Activities  
Attachment 4.3 - Field Sampling Report Form  
Attachment 4.4 – Purge Form  
Attachment 4.5 - Daily Quality Control Report Form  
Attachment 4.6 – Site Manager - Daily Quick Reminder List

## ATTACHMENT 4.1

### YSI 6920 Calibration Procedures

The YSI 6920 will be calibrated for the following parameters; pH, temperature, specific conductivity meter, turbidimeter, dissolved oxygen, and redox potential. The following sections describe the procedures for calibrating each of these parameters. Date, time, and any problems encountered during calibration and check should be noted in the site field book, and complete records of each calibration recorded on YSI calibration sheet (Attachment 5.1a)

#### Conductivity

The following steps will be followed to calibrate the conductivity probe on the YSI 6290.

1. Prior to calibration, put the sonde into the **Run** mode and let the sensors make readings in air. The conductivity reading should be less than 3 uS/cm. If the readings are much higher (>10 uS/cm), follow the probe cleaning procedures before calibrating the sonde
2. Pour enough standard into the calibration/transport cup to fully immerse the conductivity cell and thermistor. The calibration standard used should be within the same range as the water to be sampled. However, standards with less than 1 mS/cm (1000 uS/cm) are NOT recommended.

Recommended Calibration Standards.

Freshwater:	1 mS/cm standard
Brackish water:	10 mS/cm standard
Seawater:	50 mS/cm standard

3. Place the probe into the standard and make sure that the probe is completely immersed past the vent hole. Gently tap the side of the calibration cup to dislodge any air bubbles trapped inside the cell
4. Allow at least 1 minute for temperature equilibrium to occur before proceeding.
5. From the **Calibrate** menu, select Conductivity and then **SpCond** to calibrate for Specific Conductance (or temperature-compensated conductivity). Enter the value of the standard in mS/cm at 25°C and press Enter  
NOTE: The value entered MUST be in mS/cm. Multiply the value in uS/cm by 1000 to convert to mS/cm
6. Observe the conductivity readings until they stabilize and do not significantly change for approximately 30 seconds and then press Enter. The screen will indicate that calibration

has been accepted and will prompt you to press Enter again to return to the **Calibrate** menu.

7. Escape out of the **Calibrate** menu back to the **Main** menu. Select **Advanced** and then **Cal Constant**. Record the **Cond** cell constant which should range between 4.55 and 5.45
8. Rinse the sensors and calibration cup in DI water and then proceed to calibrate pH.

#### Conductivity Calibration Tips:

- Calibrate conductivity first to avoid carry-over from other standards. NOTE: pH buffers are highly conductive!
- Never calibrate with standards that are less than 1.0 mS/cm. These standards are easily interfered with by outside electrical noise (RF, etc.)
- Pre-rinse the sensor with a small amount of standard to eliminate contamination.
- Ensure that the conductivity probe is completely immersed in standard. The hole in the side of the probe MUST be under the surface of the solution and NOT have any trapped bubbles in the openings.
- If the meter reports “**Out Of Range**,” investigate the cause. NEVER override a calibration error without fully understanding the cause. The most typical cause is an incorrect entry of the standard value such as 1000 (uS/cm) rather than 1.0 (mS/cm). Other common errors are (1) not using enough standard to fill the cell and vent hole and (2) air bubbles trapped in the cell.
- When the calibration has been accepted, check the conductivity cell constant found in the **Advanced** menu under **Cal Constants**. The **Cond** cell constant should be 4.55 to 5.45. Values out of this range usually indicate a problem with the calibration process or calibration standard.

#### pH

The following procedure describes a 3 point to calibration of the pH probe on the YSI 6290.

1. Place enough pH 7 buffer into the calibration cup to immerse the pH probe, reference junction, and thermistor. Allow at least 1 minute for temperature equilibration before reading.
2. From the **Calibrate** menu, select **ISE1 pH** and then choose **2-Point** or **3-Point** depending on the calibration procedure required. For example, if the water to be monitored has a pH of 7.5, then there is no need to calibrate the probe with a pH 4 buffer – a 2 point calibration will be sufficient.
3. Enter **7.0** when prompted for the first pH value. **ALWAYS** begin with pH 7. Observe the pH reading and record the pH mV reading. The pH mV should range between -50 to +50.

When the values show no significant change for approximately 30 seconds, press Enter. The display will indicate that the calibration has been accepted and will prompt you to enter a second pH value.

**NOTE:** While calibrating pH, it is recommended that the pH mV readings are recorded. To enable pH mV, select **Report** from the **Main** menu. Highlight pH mV and press Enter to enable this value.

4. After the pH 7 calibration is accepted, press Enter again to continue. Rinse the sensors DI before rinsing them in the second buffer.
5. Place enough buffer (pH 4 or 10) into the calibration cup to immerse the pH probe, reference junction, and thermistor. Allow at least 1 minute for temperature equilibration before reading. Observe the pH reading and record the pH mV reading. The pH mV should range between 130 to 230 in pH 4 buffer and -130 to -230 in pH 10. Press enter when the pH reading shows no significant change for approximately 30 seconds. Press enter again to return to the **Calibrate** menu or to proceed to the third pH calibration buffer.

**NOTE:** Subtract the pH 7 mV from the pH 4 or 10 mV. This difference must be greater than 165 mV. While the pH probe may continue to calibrate with less than 165 mV, this indicates that the pH probe will soon need replacement.

6. If a 3-Point calibration is being performed, follow the directions above.
7. Rinse the sensors and calibration cup in DI water

### Dissolved Oxygen

The following steps will be followed to calibrate the dissolved oxygen (DO) probe on the YSI 6290,

1. Place approximately 1/8 inch of water in the bottom of the calibration cup. Engage only 1 thread of the calibration cup onto the sonde to ensure that the DO probe is readily vented to the atmosphere. Ensure that the DO probe and the thermistor are NOT in contact with the water. Wait at least 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.
2. Observe the **DO charge** reading (DO ch) and ensure that the reading ranges between 25 and 75.
3. Observe the temperature and DO readings and when they show no significant change for approximately 30 seconds, the press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to return to the **Calibrate** menu.  
**NOTE:** If you are using YSI model 600XLM, 6920, 6000, or 6600, you will need to make sure the auto-sleep functions are disabled. To disable the auto-sleep functions, go to the **Advanced** menu and select **Setup**. Choose **Auto-sleep RS232** and press Enter to disable. Then select **Auto-sleep SDI12** and press Enter.
4. Escape out of the **Calibrate** menu back to the **Main** menu. Select **Advanced** and then **Cal Constant**. Record the **DO Gain** which should range between -0.7 and 1.5.

5. Rinse the sensors and calibration cup in DI water

**DO Calibration Tips:**

- Inspect the DO probe anodes (silver rectangles), recondition using the 6035 reconditioning kit if they are darkened or gray in color.
- The KCl solution and membrane should be changed prior to each long-term deployment and at least once every 90 days. In addition, the KCl and membrane should be replaced if (1) bubbles are visible under the membrane; (2) deposits of dried KCl appear on the membrane or o-ring; (3) the readings are unstable; (4) the DO charge reading is out of range (<25 or >75).
- If needed install a new membrane, making sure that it is tightly stretched and wrinkle free. **CAUTION:** If you remove the DO probe from the sonde, be sure to inspect the probe port for moisture. Remove any moisture from the connector area. Also verify that the probe is clean and dry and apply a small amount of silicone grease to the o-ring before re-installing the probe. **NOTE:** DO membranes will be slightly unstable during the first 3 to 6 hours after they are installed. It is suggested that a calibration check be made after this time period.

**DO Calibration Check:**

1. From the **Report** menu, enable the **DO Charge**. Then go to the **Run** menu and start the sonde in the **Discrete Run** mode at a 4 second rate and allow the sonde to run (burn-in) for at least 10 minutes. Record the **DO Charge** (DO ch) after 5 minutes which should be 25 to 75.
2. After the burn-in is complete, go to the **Advanced** menu, then **Setup** and confirm that the **Auto-sleep RS232** and **Auto-sleep SDI12** functions are enabled. **NOTE:** Wait at least 60 seconds before proceeding to the next step.
3. Start the sonde in the **Discrete Run** mode at a 4 second rate and record the first 10 DO% numbers in your log book. These numbers must start high and gradually decrease. For example: 110, 105, 102, 101.5, 101.1, etc. It does not matter if the numbers do not reach 100%, it is only important that they have the same high to low trend. If you have a probe that starts with a low number and steadily climbs upward, then the sensor has a problem and the calibration must be rejected. **NOTE:** The initial power up can corrupt the first 2 DO% samples; disregard any low numbers that appear in this position.
4. The probe is now ready to be calibrated.

Oxidation Reduction Potential (ORP)

The following steps will be followed to calibrate the oxidation reduction potential (ORP) probe on the YSI 6290;

1. Place enough ORP (gold) calibration solution into the calibration cup to immerse the ORP probe, reference junction, and thermistor. Allow at least 1 minute for temperature equilibration before reading.
2. From the **Calibrate** menu, select **ISE2 ORP**
3. Enter 240.0 when prompted for it. When the values show no significant change for approximately 30 seconds, press Enter. The display will indicate that the calibration has been accepted.
4. Rinse the sensors and calibration cup in DI water

### Turbidity

The following steps will be followed for a two point calibration of the turbidity probe on the YSI 6290;

1. Place enough 0 NTU solution into the calibration cup to immerse the turbidity probe, reference junction, and thermistor. Allow at least 1 minute for temperature equilibration before reading.
2. From the **Calibrate** menu, select **Optic T-Turbidity-6026** (or Turbidity 6136) and then choose **2-Point**.
3. Enter 0.0 at the prompt, and press Enter
4. When the values show no significant change for approximately 30 seconds, press Enter. The display will indicate that the calibration has been accepted and will prompt you to enter a second turbidity value. If needed activate the wiper 1-2 times by pressing 3-Clean Optics as shown on the screen, to remove any bubbles.
5. Rinse the sensors and calibration cup in DI water
6. Place enough 100 or 200 NTU solution into the calibration cup to immerse the turbidity probe, reference junction, and thermistor. Allow at least 1 minute for temperature equilibration before reading.
7. Enter 100.0 or 200.0 depending on the solution you are using. When the values show no significant change for approximately 30 seconds, press Enter. The display will indicate that the calibration has been accepted and will prompt you to enter.

### Calibration Check

At the completion of sampling activities, and before leaving the site each night a calibration check of the YSI will be made including; DO, conductivity, pH, turbidity, and ORP. Calibration will be checked by placing the probe in the solution for each parameter, allowing at least one minute for temperature equilibration before reading the value and recording on the YSI calibration sheet (Attachment 5 1a). The

sensors and calibration cup should be rinsed with DI water between each solution. If a significant difference ( $\pm 5\%$ ) between the initial calibration and calibration check is observed, the Field Team Leader should be notified, the change should be noted in the field book, and on all purge forms, and field sampling reports used during that period.

### **References**

Water Monitoring Solution, Inc. YSI Calibration Procedures Profiling and Logging, available online;  
<http://www.water-monitor.com>. July 2004.

YSI Incorporated. Environmental Monitoring Systems, Operations Manual. Available online; July 2004.

**ATTACHMENT 4.1a**  
YSI CALIBRATION PRIOR TO SAMPLING

DATE \_\_\_\_ / \_\_\_\_ / \_\_\_\_ TIME \_\_\_\_ : \_\_\_\_ : \_\_\_\_  
 SONDE ID \_\_\_\_\_ HANDSET ID \_\_\_\_\_  
 BATTERY VOLTAGE \_\_\_\_\_

**DISSOLVED OXYGEN**

CHANGED DO MEMBRANE? YES NO If yes, when? \_\_\_\_ / \_\_\_\_ / \_\_\_\_ : \_\_\_\_

**Note:** If membrane is changed, wait 6 to 8 hours before completing DO test and final calibration

DO % VALUE BEFORE CALIBRATION \_\_\_\_\_ %; AFTER CALIBRATION \_\_\_\_\_ %

DO CHARGE \_\_\_\_\_ (range 25 to 75) DO GAIN \_\_\_\_\_ (range -0.7 to 1.5)

**CONDUCTIVITY**

**Note:** Calibrate first to avoid carry-over from other standards (i.e. pH buffers are highly conductive)

CALIBRATION STANDARD USED \_\_\_\_\_  $\mu$ S/cm, TEMP \_\_\_\_\_ °C

READING BEFORE CALIBRATION \_\_\_\_\_  $\mu$ S/cm, AFTER CALIBRATION \_\_\_\_\_  $\mu$ S/cm

CONDUCTIVITY CELL CONSTANT \_\_\_\_\_  $\mu$ S/cm (Range 5.0 ± 0.5)

**pH**

pH 7 VALUES BEFORE CALIBRATION: \_\_\_\_\_ (pH) AFTER CALIBRATION: \_\_\_\_\_ (pH)

pH 7 MILLI-VOLT READINGS: \_\_\_\_\_ mV Range -50 to +50 mV

pH 10 VALUES BEFORE CALIBRATION: \_\_\_\_\_ (pH) AFTER CALIBRATION: \_\_\_\_\_ (pH)

pH 10 MILLI-VOLT READINGS: \_\_\_\_\_ mV Range -130 to -230 mV

pH 4 VALUES BEFORE CALIBRATION: \_\_\_\_\_ (pH) AFTER CALIBRATION: \_\_\_\_\_ (pH)

pH 4 MILLI-VOLT READINGS: \_\_\_\_\_ mV Range 130 to 230 mV

**Note:** Span between pH 4 and 7, 7 and 10 mV numbers should be ~165-180 mV

**REDOX POTENTIAL (ORP)**

CALIBRATION STANDARD USED \_\_\_\_\_ mV, CAL TEMP \_\_\_\_\_ °C

READING BEFORE CALIBRATION \_\_\_\_\_ mV, AFTER CALIBRATION \_\_\_\_\_ mV

**TURBIDITY**

Wiper Parked ~180° from optics? Y N Note: Change wiper if probe is not parked correctly

TURBIDITY STANDARD \_\_\_\_\_ (NTUs)

VALUES BEFORE CALIBRATION: \_\_\_\_\_ (NTUs) AFTER CALIBRATION: \_\_\_\_\_ (NTUs)

TURBIDITY STANDARD \_\_\_\_\_ (NTUs)

VALUES BEFORE CALIBRATION: \_\_\_\_\_ (NTUs) AFTER CALIBRATION: \_\_\_\_\_ (NTUs)

CALIBRATION SUCCESSFUL? YES NO INITIAL \_\_\_\_\_

DESCRIBE ANY PROBLEMS ENCOUNTERED \_\_\_\_\_

\_\_\_\_\_

**ATTACHMENT 4.1a-continued**  
YSI CALIBRATION CHECK AFTER SAMPLING

DATE \_\_\_\_ / \_\_\_\_ / \_\_\_\_      TIME \_\_\_\_ : \_\_\_\_ : \_\_\_\_  
 SONDE ID \_\_\_\_\_      HANDSET ID \_\_\_\_\_  
 BATTERY VOLTAGE \_\_\_\_\_

NOTE: CALIBRATION IS SUCCESSFUL WHEN THERE IS NO SIGNIFICANT DIFFERENCES ( $\pm 5\%$ ) BETWEEN INITIAL CALIBRATION AND CALIBRATION CHECK

DISSOLVED OXYGEN

CHANGED DO MEMBRANE? YES    NO    If yes, when? \_\_\_\_ / \_\_\_\_ / \_\_\_\_ : \_\_\_\_  
**Note:** If membrane is changed, wait 6 to 8 hours before completing DO test and final calibration  
 DO % VALUE BEFORE CALIBRATION \_\_\_\_\_ %, AFTER CALIBRATION \_\_\_\_\_ %  
 DO CHARGE \_\_\_\_\_      DO GAIN \_\_\_\_\_  
 CALIBRATION SUCCESSFUL? YES    NO    INITIAL \_\_\_\_\_

CONDUCTIVITY

**Note:** Calibrate first to avoid carry-over from other standards (i.e. pH buffers are highly conductive)  
 CALIBRATION STANDARD USED \_\_\_\_\_  $\mu\text{S}/\text{cm}$ , CAL TEMP \_\_\_\_\_  $^{\circ}\text{C}$   
 VALUE \_\_\_\_\_  $\mu\text{S}/\text{cm}$   
 CONDUCTIVITY CELL CONSTANT \_\_\_\_\_  $\mu\text{S}/\text{cm}$  (Range  $5.0 \pm 0.5$ )  
 CALIBRATION SUCCESSFUL? YES    NO    INITIAL \_\_\_\_\_

pH

pH 7 VALUE \_\_\_\_\_ (pH)  
 pH 7 MILLI-VOLT READINGS: \_\_\_\_\_ mV Range -50 to +50 mV  
 pH 10 VALUE \_\_\_\_\_ (pH)  
 pH 10 MILLI-VOLT READINGS: \_\_\_\_\_ mV Range -130 to -230 mV  
 pH 4 VALUE \_\_\_\_\_ (pH)  
 pH 4 MILLI-VOLT READINGS: \_\_\_\_\_ mV Range 130 to 230 mV  
**Note:** Span between pH 4 and 7, 7 and 10 mV numbers should be ~165-180 mV  
 CALIBRATION SUCCESSFUL? YES    NO    INITIAL \_\_\_\_\_

REDOX POTENTIAL (ORP)

CALIBRATION STANDARD USED \_\_\_\_\_ mV, CAL TEMP \_\_\_\_\_  $^{\circ}\text{C}$   
 VALUE \_\_\_\_\_ mV  
 CALIBRATION SUCCESSFUL? YES    NO    INITIAL \_\_\_\_\_

TURBIDITY

Wiper Parked  $\sim 180^{\circ}$  from optics? Y    N    Note: Change wiper if probe is not parked correctly  
 TURBIDITY STANDARD 1 \_\_\_\_\_ (NTUs)  
 VALUE \_\_\_\_\_ (NTUs)  
 TURBIDITY STANDARD 2 \_\_\_\_\_ (NTUs)  
 VALUE \_\_\_\_\_ (NTUs)  
 CALIBRATION SUCCESSFUL? YES    NO    INITIAL \_\_\_\_\_

**ATTACHMENT 4.2****General Field Supply Checklist-Sampling Activities**

Steel Toe Workboots	_____
Full Face Respirator (with appropriate cartridges)	_____
Safety Glasses	_____
Logbook	_____
Pens	_____
Data Collection Forms	_____
OSHA Certification Card	_____
Tape Measure	_____
Hard Hat	_____
Hammer	_____
First Aid Kit and Emergency Eyewash Station	_____
Overshoes	_____
Sun Screen	_____
Work Gloves	_____
Disposable Gloves	_____
Stainless Steel Bladder Pump (with extra bladders and grab plates)	_____
Disposable Teflon Bailers	_____
Air Compressor and Controller	_____
Water Level Indicator	_____
YSI (or similar meter with flow through cell) with calibration solution	_____
Plastic Sheeting	_____
Teflon Lined Plastic Tubing	_____
Safety Line	_____
DI Water, Methanol, and Liquinox for Decon	_____

## ATTACHMENT 4.3

<b>FIELD SAMPLING REPORT</b>		JOB No. <u>6301-04-0002</u>																												
		JOB NAME <u>DDMT</u>																												
		DATE <u>  </u> TIME <u>  </u>																												
		SAMPLING POINT: _____																												
		DEPTH _____																												
<b>SAMPLE INFORMATION</b>		SAMPLE I.D. NO.: <u>EB-1</u>																												
MATERIAL:		<input type="checkbox"/> WATER <input type="checkbox"/> SOIL <input type="checkbox"/> SLUDGE <input type="checkbox"/> OTHER (LIST) _____																												
TYPE:		<input type="checkbox"/> GRAB <input type="checkbox"/> COMPOSITE <input type="checkbox"/> OTHER (LIST) _____																												
HAZARDOUS		<input type="checkbox"/> YES <input type="checkbox"/> NO <input type="checkbox"/> UNKNOWN																												
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">CONTAINER</th> <th rowspan="2" style="text-align: center;">NUMBER</th> <th rowspan="2" style="text-align: center;">PRESERVATIVE/ PREPARATION</th> <th rowspan="2" style="text-align: center;">COMMENTS</th> </tr> <tr> <th style="text-align: center;">TYPE</th> <th style="text-align: center;">VOLUME</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>				CONTAINER		NUMBER	PRESERVATIVE/ PREPARATION	COMMENTS	TYPE	VOLUME																				
CONTAINER		NUMBER	PRESERVATIVE/ PREPARATION	COMMENTS																										
TYPE	VOLUME																													
COMMENTS: (WELL PURGING VOLUME: SAMPLE APPEARANCE; ODOR; COLOR, ETC.)  _____																														
<b>GENERAL INFORMATION</b>		WEATHER _____	AIR TEMPERATURE _____																											
SAMPLES SHIPPED TO: _____																														
SPECIAL HANDLING: _____																														
MODE OF SHIPMENT:		<input type="checkbox"/> CAR/TRUCK <input type="checkbox"/> BUS <input type="checkbox"/> PLANE <input type="checkbox"/> COMMERCIAL VEHICLE																												
<b>QA/QC</b>		SAMPLE COLLECTED BY: _____ SAMPLING OBSERVED BY: _____																												
		DISCREPANCIES: _____																												

#### Attachment 4.4

#### WELL PURGING - FIELD WATER QUALITY MEASUREMENTS FORM

Location: DDMT - \_\_\_\_\_ Site Name \_\_\_\_\_  
 Well ID \_\_\_\_\_  
 Field Sampling Personnel \_\_\_\_\_

page \_\_\_\_ of \_\_\_\_

876 114

Identify Measuring Point (MP)  
 (e.g. Top of Casing)  
 Depth to Screen below MP  
 (ft below MP)

Purge Device (Pump Type)  
 Pump Intake at (ft below MP)

of screen

Top

Bottom

of screen

Comments

(e.g. Dedicated pump, peristaltic pump, bailer, bladder pump, etc.)

Redox

Potential

mV

Flow cell

DO

mg/L

(low)

Cum Volume

gallons

Purged

gallons

Comments

Hach

Ferrous

Iron

mg/L

Notes:  
 Note when "Stabilization" has occurred. Stabilization Criteria (achieved after a minimum of three successive readings)   
 +0.1 for pH  
 +10 mV for redox  
 ±3% for specific cond.  
 +10% for DO  
 <20 NTUs for turbidity  
 NA for temperature

**ATTACHMENT 4.5****DAILY QUALITY CONTROL REPORT**

**Report No.** \_\_\_\_\_ **Contract No.** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Location of Work:** Defense Depot, Memphis, Tennessee

**Description of Work:** \_\_\_\_\_

**Weather:** \_\_\_\_\_ **Rainfall (inches) Avg.** \_\_\_\_\_ **Temp:** \_\_\_\_\_

**Activities Performed:**

**Field Team Leader:**

**Team # 1:**

**Team # 2:**

**Team # 3:**

**Team # 4:**

**Collected samples are listed below:**

**Samples Collected:**

Team 1	Team 2	Team 3	Team 4

**Personnel On-Site:**

**Difficulties:**

**Visitors:**

**Field Team Leader:** \_\_\_\_\_

#### ATTACHMENT 4.6

#### SITE MANAGER – DAILY QUICK REMINDER LIST

##### **Arrival at Site**

- Pick up sampling supplies – compare inventory packing list with shipment
- Call lab daily to check status of samples. No sample bottle breakage, COC matches what is in cooler and samples received at correct temperature.

##### **Instrument Calibration**

- Supervise calibration of instruments and review calibration forms
- Call in for barometric pressure, used to calibrate DO for YSI meter
- Make sure each team conducts the mid-day calibration check on the YSI and fills out daily form

##### **Health and Safety**

- Make sure each team has appropriate PPE, first aid kit and fire extinguisher in each vehicle, map to nearest hospital, and knowledge of emergency phone nos.
- Make sure members are aware of any team member with medical emergency issues (i.e. allergic reactions to bees, etc.) and has necessary equipment to handle the incidence
- Make sure each team is aware of “Stop work” PID action levels

##### **Vehicle Load Out**

- Prepare coolers for samplers and assign locations to field teams. Emphasize QC locations.
- Make sure each team has field test kit supplies for ferrous iron and carbon dioxide.
- Distribute sample folders to team members each day

##### **Purging and Sampling**

- Remind team members to call in field measurements and verify reasonableness. Review field measurements for reasonableness (real time) and trouble shoot if required. Sign off on purge forms at end of day.
- Make team member aware of IDW disposal/storage procedures. Methanol must be containerized separately from wash water and rinse water.
- Oversee sample packing and shipping procedures. Verify that metals and sulfide pH has been checked and adjusted if necessary. Make sure coolers with VOCs have a trip blank. Verify that each cooler has a COC, RFAs, temperature blank, double bagged ice, trip blank (if required), and custody seals. Complete shipping checklist.
- Remind teams to leave no equipment or valuables in vehicles parked at the hotel (due to recent theft)

##### **End of Day Activities**

- Check field books, FSRs, and Purge forms for completeness daily
- Remind teams to leave no equipment or valuables in vehicles parked at the hotel (due to recent theft)
- Remind teams to charge equipment overnight
- Fax daily reports and purge forms to Paul Brafford/John Quinn daily – COCs to Judy Hartness
- Check schedule daily and update as needed

**End of Shift Activities**

- Call in work hours on Friday by 10:00AM EST for field team.
- Conduct supply inventory
- Pack and return all rental supplies to vendors
- Make sure all equipment has been decontaminated and wrapped in aluminum foil and stored neatly
- Make sure IDW has been sampled and labeled properly

Site Manager: \_\_\_\_\_ Date: \_\_\_\_\_

## **WORK AND TEST PROCEDURE 5**

### **HYDRAULIC CONDUCTIVITY TESTING**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for conducting various hydraulic conductivity tests at DDMT. Hydraulic conductivity tests provide information concerning the transmission characteristic of an aquifer.

#### **2.0 DISCUSSION**

This WTP specifies details and procedures for conducting hydraulic conductivity tests. The project-specific work plan will be referred to in order to determine the requirements for a specific project.

Although there are several types of hydraulic conductivity tests that can be performed, this WTP addresses only In-Situ Hydraulic Conductivity Testing (Slug Testing). The in-situ hydraulic conductivity test (slug test) is used to estimate the rate of groundwater flow at a single well point. If an aquifer pump test is considered necessary for measurement of hydrogeologic characteristics, a separate work plan will be provided. Hydraulic conductivity testing will be performed and interpreted by a qualified geologist/engineer.

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be considered for review in conjunction with this WTP:

<b>NUMBER</b>	<b>NAME</b>
1	General Instructions for Field Personnel
2	Drilling Operations
3	Well Installation, Development, and Abandonment
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

### **3.2 PREPARATION**

#### **3.2.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1 as well as the following actions:

- Ordering appropriate supplies and equipment for delivery prior to the start of activities. A generalized list of equipment and supplies is provided as Attachment 5.1.

#### **3.2.2 Field**

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

- Check that required equipment has arrived on site, and is functioning properly.

### **3.3 FIELD OPERATIONS**

#### **3.3.1 In-Situ Hydraulic Conductivity Testing**

Hydraulic conductivity tests will be performed on selected monitoring wells. The test will begin with water level at static conditions using a "slug"; no fluid will be put into the well.

The tests to be performed are termed "slug in" and "slug out" tests. The "slug in" test involves inserting a slug (solid PVC rod) into the water column in the well to raise the water level. The water level recovery to the static level is recorded over time using an electronic pressure transducer and hydrologic recorder. Readings will be taken continuously at a 1-second interval for the first minute, every 30-seconds for the next five minutes, and every minute thereafter until the static level is reached. The slug is removed for the "slug out" test and recovery of the water level to the original static level is recorded over time. Where the screened interval is not fully saturated, only a slug-out test will be performed. This is due to the effect of the unsaturated filter pack in a slug-in test, which biases the test results.

The data results of the hydraulic conductivity test are then calculated. The Bouwer and Rice formula (Bouwer, 1989) can be utilized to calculate hydraulic conductivity (K) in open or screened wells that are fully or partially penetrating:

$$K = \frac{r_c^2 \ln(R_e / r_w)}{2 L_c} * (1/t) * \ln(Y_0 / Y_t)$$

Where:

$r_c$	=	well radius
$R_e$	=	effective radial distance over which the head difference is dissipated
$r_w$	=	radial distance between the well center and the undisturbed aquifer
$L_c$	=	height of saturated screen
$Y_0$	=	water level Y at time zero
$Y_t$	=	water level Y at time t
t	=	time since $Y_0$

The Bouwer and Rice method was originally developed for unconfined aquifers, but it can be used under confined conditions if the top of the well screen is some distance below the bottom of the confining layer. In cases where wells do not fully penetrate an aquifer, the Hvorslev Method (Hvorslev, 1951) should be used to calculate hydraulic conductivity:

$$K = \frac{r^2 \ln\left(\frac{L}{R}\right)}{2LT_0}$$

Where:

K	=	hydraulic conductivity
r	=	radius of the well casing
R	=	radius of the well screen
L	=	length of the well screen
$T_0$	=	time it takes for water level to rise or fall to 37% of the initial change

Once the data is collected it will be inputted to analytical software and the parameters discussed above calculated. The test results will be reviewed by a qualified geologist/engineer for completeness and accuracy. Test results which are considered anomalous will be identified and reported as such.

### **3.4 POST-OPERATION**

#### **3.4.1 Field**

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

- Decontaminate all field equipment that has come in contact with groundwater
- Complete logbook, making notations as to site conditions, anomalous readings, etc.
- Ensure that equipment and associated supplies are shipped back to the office.

#### **3.4.2 Office**

- Upon return to the office, field personnel will perform the following:
- Submit logbook and any original forms to Project/Task Manager for review.
- Inventory equipment and supplies shipped back to the office.

### **4.0 REFERENCES**

Bouwer and Rice, 1989. The Bouwer and Rice Slug in Test - An Update. *Groundwater*. Volume 27, No. 3.

Hvorslev, M.J. 1951. Time Lag and Soil Permeability in Groundwater Observations. U.S. Army Corps of Engineers Waterway Experimentation Station, Bulletin 36.

USACE, 2001. Engineering and Design Requirements for the Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001.

USEPA, 1992. RCRA Groundwater Monitoring: Draft Technical Guidance. EPA 530-R-93-001. United States Environmental Protection Agency. November 1992.

USEPA, 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document. OSWER-9950-1. United States Environmental Protection Agency. September 1986.

### **5.0 ATTACHMENTS**

Attachment 5.1 General Field Supply Checklist-Hydraulic Conductivity Testing

## ATTACHMENT 5.1

**General Field Supply Checklist-Hydraulic Conductivity Testing**

Steel Toe Workboots	_____
Full Face Respirator (with appropriate cartridges)	_____
Safety Glasses	_____
Logbook	_____
Pens	_____
Data Collection Forms	_____
OSHA Certification Card	_____
Tape Measure	_____
Hard Hat	_____
Hammer	_____
First Aid Kit and Emergency Eyewash Station	_____
Overshoes	_____
Sun Screen	_____
Work Gloves	_____
Disposable Gloves	_____
Hydrologic Datalogger	_____
Electronic Pressure Transducer	_____
Water Level Indicator	_____
Slug (solid PVC rod, or similar device)	_____
Plastic Sheeting	_____
Safety Line	_____
DI Water, Methanol, and Liquinox for Decon	_____

## **WORK AND TEST PROCEDURE 6**

### **INVESTIGATION DERIVED WASTE SAMPLING AND DISPOSAL**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for collection of samples of investigation derived waste (IDW) to be analyzed for use in the proper disposal of IDW material.

#### **2.0 DISCUSSION**

This WTP specifies details and procedures for collecting IDW samples. The project-specific workplan will be referred to in order to determine the exact requirements. The sampling objectives will be to allow for efficient and proper disposal of the IDW.

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be considered in conjunction with this WTP:

<b>NUMBER</b>	<b>NAME</b>
1	General Instructions for Field Personnel
7	Sample Control and Documentation
8	Sample Containers and Preservation
9	Sample Packing and Shipment
10	Sample Equipment Decontamination
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

#### **3.2 PREPARATION**

##### **3.2.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:

- Determine appropriate sampling methods and ensure that sufficient supplies are shipped to the site;

- Ensure that sufficient preprinted sample and container storage labels are shipped to the site;
- Review the existing data to determine the probable identity of various compounds that may be present in the waste.

### **3.2.2 Field**

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

- Check that required sampling equipment has arrived on site in operating order;
- Check that monitoring equipment is functioning properly, calibrated as needed and that respective manuals are present.

## **3.3 FIELD OPERATIONS**

Four categories of IDW are anticipated to be generated during the RA field activities:

- Soil cuttings from borings drilled for monitoring well installation
- Development and purge water from monitoring well development and groundwater sampling activities
- Decontamination fluids resulting from cleaning of heavy equipment and from decontamination of sampling equipment
- Miscellaneous waste, consisting of disposable supply containers and used personal protective equipment (PPE) (i.e., Tyvek coveralls, boot covers, gloves and respirator cartridges)

Disposal options for the DDMT IDW are based primarily on contaminant concentrations of the waste. Non-hazardous wastes may be disposed of at the investigation site or off-site at a RCRA Subtitle D facility. Hazardous wastes must be containerized and disposed off-site in accordance with RCRA Subtitle C requirements. Attachment 6.1 illustrates the factors that will be considered in deciding how the IDW will be managed.

IDW will be containerized at each site in 55-gallon drums or alternative storage containers which meet the requirements of 40 Code of Federal Regulation (CFR) Subpart I – Use and Management of Containers, including:

- Keeping the container in good condition
- Using containers made of material that is compatible with the waste
- Keeping the container closed during storage

A label will be placed on each drum identifying the site where the waste was generated, the matrix of the waste in the drum, and the date that accumulation of the waste began. Drum labels will be kept simple and easy to read. Attachment 6.2 provides an example of a typical label. Further, drums containing hazardous waste will be labeled in accordance with applicable DOT regulations, including 49 CFR Parts 172, 173, 178 and 179.

At DDMT, purge water from purging wells prior to sampling, developing wells, and equipment decontamination will be transported from the well in drill rig support trucks or sealed 5-gallon buckets to a Baker tank at Dunn Field or 55-gallon drums in the decontamination area. At the completion of activities, the waste water will be sampled from the midpoint of the Baker tank or the drums using disposable Teflon bailers. If the concentrations are below those listed in the City of Memphis Industrial Wastewater Discharge Requirements under Permit No. S-NN3-097, the water is pumped directly from the tank into the City of Memphis Sewer system via the Dunn Field treatment system. Waste methanol generated during decontamination procedures will be stored separately and treated as a hazardous waste.

Soil from borings and material from well abandonment will be placed into 20-cubic-yard roll-off boxes. Material in the boxes will be sampled at approximately four locations in each box using a pre-cleaned stainless steel spoon or hand auger. The material to be analyzed for TCLP VOCs for final disposal purposes will be deposited directly into the appropriate labeled laboratory supplied containers. If TCLP analyses other than VOCs are required, the material collected from the different locations in the box will be composited into one sample in a pre-cleaned stainless steel bowl. It will then be placed in the appropriate labeled laboratory supplied containers and analyzed for the additional analyses as needed. Upon receipt of the results of the laboratory analyses, the material will be disposed of in accordance with the analytical results. If the results are less than the TCLP regulatory levels, the soil will be disposed of as non-hazardous Investigation Derived Waste at a landfill approved to accept CERCLA off-site waste. If the results exceed TCLP regulatory levels, the material will be disposed of in accordance with hazardous waste requirements.

### **3.4 POST-OPERATION**

#### **3.4.1 Field**

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

- Decontaminate or dispose of sampling equipment;
- Complete logbook, making notations as to site conditions, anomalous readings, etc.;
- Ensure that drums or containers containing investigative-derived waste are properly labeled with the date and drum contents.

#### **3.4.2 Office**

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

- Submit logbook and any original forms to Task/Project Manager for review;
- Inventory all equipment and supplies shipped back to the office;
- Make provisions for proper disposal of investigative derived waste.

### **4.0 REFERENCES**

ASTM, 1984. Annual Book of ASTM Standards, American Society of Testing and Materials, 1986.

CH2M Hill, 2004. Main Installation Pre-Final Remedial Design. Prepared for the U.S. Army Engineering and Support Center, Huntsville. February 2004.

USACE, 2001. Engineering and Design Requirements for Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001.

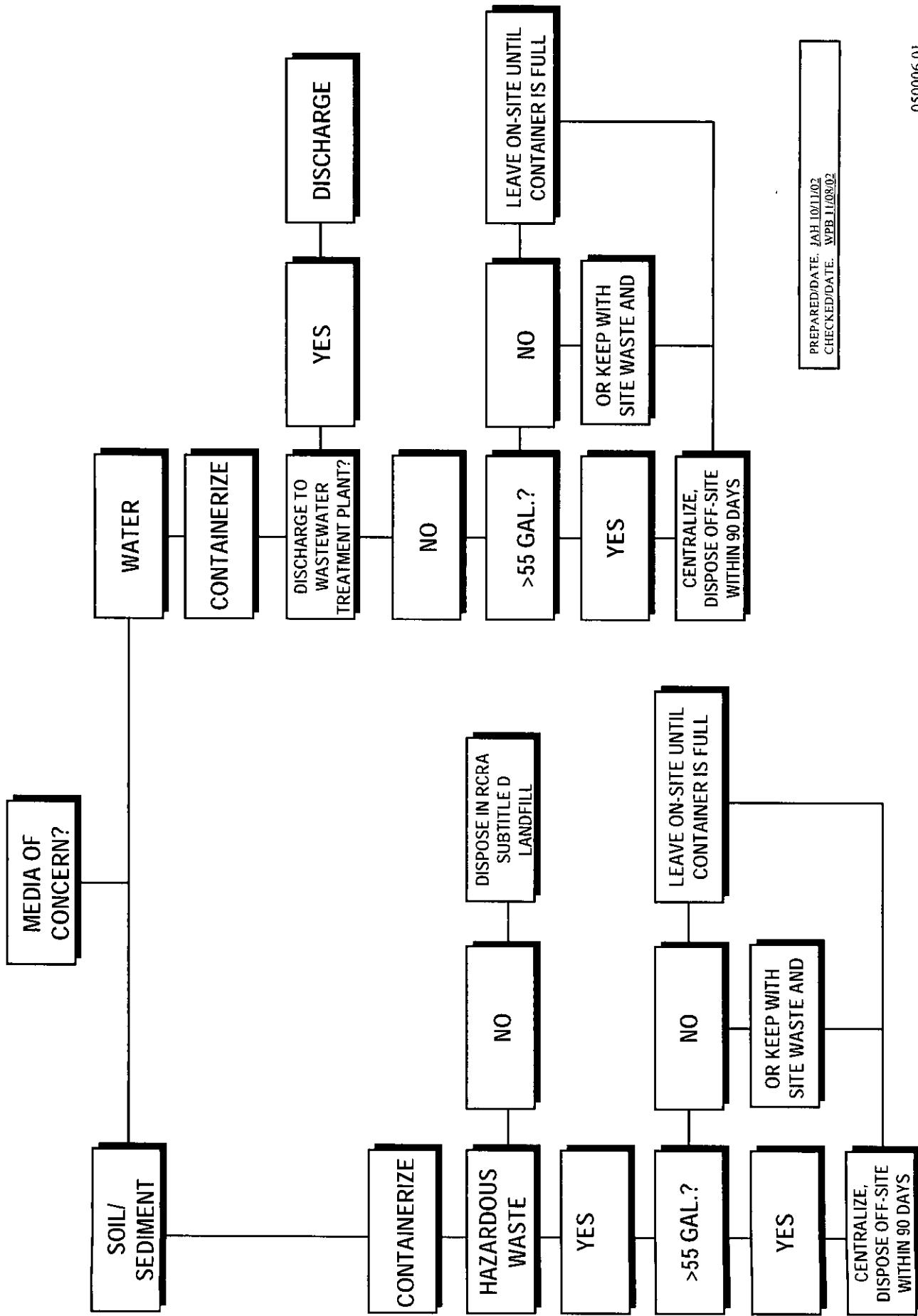
USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

### **5.0 ATTACHMENTS**

Attachment 6.1 - IDW Decision Tree  
Attachment 6.1 - Example Drum Label

# IDW DECISION TREE

## Attachment 6-1



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## Attachment 6.2

# INVESTIGATION DERIVED WASTE LABEL

## Drilling and Sampling Waste

These materials may be hazardous or special waste, pending laboratory analysis, and / or other evaluation.

The contents should not be disposed or removed without consent of the generator listed below.

CONTENTS: Drill Cuttings  
Purge and/or Development Water  
Other \_\_\_\_\_

Date Placed \_\_\_\_\_  
in Container: \_\_\_\_\_ Drum No. \_\_\_\_\_  
Source I.D. \_\_\_\_\_  
(Boring #, Well #, etc.)

Generator Name: \_\_\_\_\_

Contact: \_\_\_\_\_

Phone: \_\_\_\_\_

## **WORK AND TEST PROCEDURE 7**

### **SAMPLE CONTROL AND DOCUMENTATION**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for sample control and identification, data recording, and the proper completion of Chain-of-Custody (C-C) forms.

#### **2.0 DISCUSSION**

This WTP specifies details and procedures for sample control and documentation. The project-specific work plan will be referred to in order to determine exact requirements for the sampling activities. Sample control and documentation are required to support the legal defensibility of data generated from sampling activities. Required documents include the sampling logbooks, sample labels and seals, analytical reports, C-C forms, and daily field sampling reports.

Relevant information will be recorded in the project logbook. This information will include weather conditions, sample description, and whether any unusual odors were noticed upon sample collection.

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be considered for review in conjunction with this WTP:

NUMBER	NAME
1	General Instructions for Field Personnel
4	Groundwater Sampling
8	Sample Containers and Preservation
9	Sample Packing and Shipping
10	Sample Equipment Decontamination

### **3.2 PREPARATION**

#### **3.2.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:

- Work in conjunction with the project chemist to create a sampling plan detail
- Create a sample tracking sheet (Attachment 7.1)
- Coordinating with the analytical laboratory to ensure that proper documentation including chain of custody forms and custody seals are shipped to the site.

#### **3.2.2 Field**

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

- Check that required supplies are on-site;
- Record relevant data in the logbook (including ambient air temperatures, weather conditions, sample appearance, odor, etc.).

### **3.3 FIELD OPERATIONS**

#### **3.3.1 Sample Location and Identification**

This section details sample nomenclature procedures to be used in general field investigations.

##### **3.3.1.1 Sample Identification**

Individual samples will be identified by a unique alphanumeric code (also referred to as a sample ID number or field number) which will be written on the sample label and recorded on the C-C form. Additional information to be written on the label includes location ID, time and date of sample, sampler's initials, and the analytical methods to be performed (Attachment 7.2).

During sampling events during the field effort, nomenclature will be used to distinguish between categories of sampling events, sample locations, and, where appropriate, depth of sample collection.

The extenders will consist of a two-digit matrix code (sample type, if other than ground water), alphanumeric depth codes (if necessary), and quality QA/QC codes where applicable. Field split samples will be labeled the same as the parent sample, with a QA extender added to the end of the name.

TB	Trip Blank
FB	Field Blank
EB	Equipment Blank
MS	Matrix spike
MSD	Matrix spike duplicate
MW	Monitoring well (groundwater)
SW	Surface water
SB	Soil boring (0-2', 2-4', 4-6', etc.)
SS	Surface Soil (0-6")

The identity of the trip blanks, field blanks, and equipment blanks will consist of the prefix TB, FB, or EB, respectively, followed by the date without punctuation. When two or more trip, field, or equipment blanks are collected in a day, the date will be followed by a sequential number. QA/QC split sample trip blanks and equipment blanks will be identified by adding the suffix "QA" to the end of the sample ID. If groundwater samples are collected from PDBs, each sample number must reflect the top and bottom depth of the diffusion bag in the well.

The identity of field duplicate samples will be concealed from the laboratory by using a consecutively numbered generic name indicating the area from which the duplicate was collected. For example, the first duplicate sample collected from target treatment area 1 will be named TTA1DUP-1. The true identity of duplicates/replicates will be recorded on the sampling plan detail (SPD) and field notebook. The SPDs will be maintained in the project file and copies will be kept at the on-site field office. Copies of these forms will be provided to the QA Coordinator and the data validation team as needed for their reviews. An example SPD is presented in Attachment 7.3.

### **3.3.2 Completing the Log Book**

The logbook is a written record of sampling activities that is completed in the field during sampling. The purpose of the log book is to record and document field conditions or procedural exceptions that may aid in the analysis of data generated from sampling activities.

Information pertaining to environmental conditions at the site during the field investigation will be noted in the field log book each day. Information will be recorded in indelible ink in a log book with

sequentially numbered pages. The recorder will sign and date each page. The following information will be recorded for each activity:

1. Location
2. Date and time
3. Identity of people performing the activity
4. Weather conditions

For field measurements, the following information will be recorded:

1. The numerical value and units of each measurement
2. The identity of and calibration results for each field measurement

For field sampling activities, the following information will be recorded:

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

These criteria will be recorded in the field sampling book and used to assess sampling procedures in relation to the sample data. Information that is contained elsewhere (such as in the Field Sampling Report or the Purge Log) should be repeated in the logbook.

### **3.3.3 Daily Quality Control Reports (DQCRs)**

Each day the Field Team Leader will prepare a DQCR (Attachment 7.7). The DQCR will include weather information at the time of sampling, ID of samples collected, data from field instruments and calibrations, and will reflect any problems that occurred in the field. In addition, the DQCR documents personnel and visitors at the site during field activities. Modifications to field procedures will be requested by a Field Adjustment Form (Attachment 7.8).

### **3.3.4 Photographs**

Photographs taken for the purpose of project documentation must be recorded in the field logbook. When movies, slides, or photographs are taken of a site location, they are numbered to correspond to logbook

entries. The name of the photographer, date, time, site location, site description, sequential number of the photograph and the roll number, orientation of photograph and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image enhancement techniques will be avoided, since they can adversely affect the admissibility of evidence. Adequate logbook notations and receipts will be used to account for routine file processing. Once processed, the slides or photographic prints will be serially numbered and labeled according to the logbook descriptions. For instant photographs, the required information will be entered on the back of each photograph as soon as it is taken.

### **3.3.5 Completing Sample Labels/Tags**

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

- Name or initials of collector
- Date, place, and time of collection
- Job name and number
- Sample number and/or boring number and depth
- Preservative (if required)
- Analysis requested

### **3.3.6 Collecting Samples**

Proper sampling procedures are vital to the data acquisition process. Once collected, it is also important to maintain the integrity of the samples. Detailed sampling and decontamination protocols are described in WTP 4 - Groundwater Sampling, WTP 7 - Waste Sampling, and WTP 11 - Sampling Equipment Decontamination. A summary of the planned sample containers, sample volumes, preservation and maximum allowable holding times from the time of collection to analysis are presented in WTP 9 - Sample Containers and Preservation.

### **3.3.7 Sample Custody**

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

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

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

### **3.3.7.1 C-C Record**

C-C records will be provided in each sample cooler. The custody record will be fully completed, in triplicate, by the field technician designated by the Field Team Leader as responsible for sample shipment to the laboratory. The information specified on the C-C record will contain the same level of detail found in the site log book, with the exception that on-site measurement data will not be recorded. The custody record will include, among other things, the following information:

- Name of person collecting the samples
- Date samples were collected
- Type of sampling conducted (composite/grab)
- Location of sampling station (including the site location)
- Number and type of containers used
- Signature of the MACTEC person relinquishing samples to a non-MACTEC person (such as a Federal Express agent), with the date and time of transfer noted, and the cooler designation.
- Airbill Number

In addition, if samples are known to require rapid turnaround in the laboratory because of project time constraints or analytical concerns such as extraction time or sample retention period limitations, the person completing the C-C record (Attachment 7.4) should note these constraints in the remarks section of the custody record and the Request for Analysis Form (Attachment 7.5). The same C-C form will be adapted for each subcontract laboratory unless a form is provided by the subcontract laboratory.

If it is not practicable to seal the sample shippers at a Federal Express office, they will be sealed beforehand. The duplicate custody record will, therefore, have the signature of the relinquishing field technician and a statement of intent (for example, to Federal Express P.M. June 30, 2001).

The duplicate custody record will then be placed in a plastic bag, taped to the underside of the cooler lid, and the cooler closed. The container will be tightly bound with filament tape. Finally, seals (see section 3.3.6.2 below) will be signed by the individual relinquishing custody and affixed in such a way that the cooler cannot be opened without breaking the seals.

The original and duplicate custody records and the airway bill or delivery note together constitute a complete record, and it is the responsibility of the Project Manager to ensure that all records are consistent and that they are made part of the permanent job file.

At the laboratory, the Sample Control Coordinator will open the package, retrieve the original record, and complete the “Received at Laboratory by box” by affixing his/her signature. The Sample Control Coordinator will record the condition of samples received on the Cooler Receipt Form (Attachment 7.6).

Custody Seals: Custody seals will be preprinted, adhesive-backed seals designed to break if disturbed. Sample shipping containers (coolers, cardboard boxes, etc., as appropriate) will be sealed in as many places as necessary to ensure security. Seals will be signed and dated before use. Upon receipt by the laboratory, the custodian will check and certify, by completing logbook entries, that the seals on boxes and bottles are intact.

Sample Handling: The sample custodian will receive the samples for the laboratory. He/she will perform the following actions upon sample receipt:

- Document whether the individual samples, boxes, or ice chests were sealed upon receipt and document any damaged condition of custody seals in the appropriate section of the cooler receipt form (Attachment 7.6).
- Check cooler temperature and record on the cooler receipt form.
- Sign C-C records, and identify the date and time of sample receipt.
- Check the pH of all samples except VOC samples. Notify project chemist of discrepancies.
- Log samples into the Receipt Logbook and computer file.
- Place sample numbers (from Receipt Logbook) on sample containers and secure the samples in appropriate refrigeration unit.
- Complete the cooler receipt form.

- The laboratories will submit sample receipt confirmation electronically daily to MACTEC to check for discrepancies.

Sample Log-In: Incoming samples will be accompanied by a MACTEC Request for Analysis Form (Attachment 7.5). In the event that this form does not accompany the incoming samples, it will be completed by the Sample Custodian who logs in the samples, or faxed by MACTEC upon immediate notification of the MACTEC Project Chemist. The custodians will enter the laboratory and test setup information into the computer. The laboratory custodian will have the Request for Analysis Form checked and initialed by a supervisor, and will issue copies to the applicable labs, normally on the day samples are received.

The Internal C-C for the Laboratory: Once a sample is within the custody of the laboratory, the transfer of the sample, its aliquot or extract will be documented in the internal C-C record. Every time a sample is transferred from one person to another, whether it is for distribution, storage, sample preparation, analysis or disposal, it will be relinquished by the person who has custody to the person who will then take new custody of the sample. Date and time of the exchange will be recorded. The sample will be shown and this person is tasked with ensuring secure and appropriate handling of the sample. There will be no lapses in sample accountability. The internal C-C form will be fully signed by each person who had contact with the sample.

### 3.4 POST-OPERATION

#### 3.4.1 Field

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

- Check that sampling bottles assigned to the specific sampling location have been filled with the prescribed amount of sample and that sample labels contain required and relevant information (date, time, sampler's identification).
- Maintain custody of samples, maintaining them as specified for the analyses to be performed.
- Prepare samples for shipment to the laboratory.
- Complete the C-C forms.

- Contact the laboratory to inform them that samples will be shipped and also remind them of any unusual analytical requirements for the samples to be analyzed (i.e., holding times for hexavalent chromium).
- Verify completion of logbook, ensuring that required information has been recorded.

Upon completion of the field effort, ensure that associated supplies have been shipped back to the office, rental company, or laboratory as needed.

### **3.4.2 Office**

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

- Submit logbook and any original forms to Project Manager for review.
- Inventory equipment and supplies shipped back to the office.
- Contact the laboratory to verify that samples were received in good condition and that requested analyses are understood.

## **4.0 REFERENCES**

CH2M Hill, 2004. Long-Term Groundwater Monitoring Plan. Prepared for the U.S. Army Engineering and Support Center, Huntsville. July 2002.

EIM, 1991a. Installation Restoration Program Information Management Systems Data Loading Handbook. EIM, Brooks Air Force Base, Texas.

EIM, 1991b. Installation Restoration Program Information Management Systems Contractor Data Loading Tool Users Manual. EIM, Brooks Air Force Base, Texas.

USACE, 2001. Engineering and Design Requirements for the Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001.

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

**5.0 ATTACHMENTS**

Attachment 7.1 – Sample Tracking Sheet  
Attachment 7.2 - Example Sample Label  
Attachment 7.3 – Sampling Plan Detail  
Attachment 7.4 –C-C Form  
Attachment 7.5 - Request for Analysis Form  
Attachment 7.6 - Cooler Receipt Form  
Attachment 7.7 – Daily Quality Control Report  
Attachment 7.8 – Field Adjustment Form

Retszky 1

ATTACHMENT 7-1  
SAMPLE TRACKING SHEET

RAATIP - Dynamic Digital Memphis Framework  
Version 1 - 1st Edition Sample Page

876 140

Sample ID	Comment	Date Sample Collected	Time Collected	Matrix	Number of Containers	Requested Analysis	Type of Pump	Date Sample Shipped	Shipment Tracking Number
MW-31					3	VOCS (SW 8260 B)			
MW-32					3	VOCS (SW 8260 B)			
MW-44					3	VOCS (SW 8260 B)			
MW-54					3	VOCS (SW 8260 B)			
MW-70					3	VOCS (SW 8260 B)			
MW-76					3	VOCS (SW 8260 B)			
MW-77					3	VOCS (SW 8260 B)			
MW-79					3	VOCS (SW 8260 B)			
MW-80	Collect MS/MSD				9	VOCS (SW 8260 B)			
MW-144	Collect DUP				3	VOCS (SW 8260 B)			
MW-145					3	VOCS (SW 8260 B)			
MW-147					3	VOCS (SW 8260 B)			
MW-148					3	VOCS (SW 8260 B)			
MW-149					3	VOCS (SW 8260 B)			
MW-150					3	VOCS (SW 8260 B)			
DUNNDUP-1	Dup of MW-144				3	VOCS (SW 8260 B)			
MW-151					3	VOCS (SW 8260 B)			
MW-152					3	VOCS (SW 8260 B)			
MW-153					3	VOCS (SW 8260 B)			
MW-154					3	VOCS (SW 8260 B)			
MW-155					3	VOCS (SW 8260 B)			
MW-156					3	VOCS (SW 8260 B)			
MW-157	Collect DUP				3	VOCS (SW 8260 B)			
DUNNDUP-2	Dup of MW-157				3	VOCS (SW 8260 B)			
TTA-2-EQB-1	Rinsate				3	VOCS (SW 8260 B)			
TTA-2-EQB-2	Rinsate				3	VOCS (SW 8260 B)			
TTA-2-EQB-3	Rinsate				3	VOCS (SW 8260 B)			
TB-	Trip Blank				2	VOCS (SW 8260 B)			
TB-	Trip Blank				2	VOCS (SW 8260 B)			
TB-	Trip Blank				2	VOCS (SW 8260 B)			
TB-	Trip Blank				2	VOCS (SW 8260 B)			

---

**ATTACHMENT 7.2**  
**EXAMPLE LABEL**

SampleID#: \_\_\_\_\_  
Matrix: \_\_\_\_\_  
Analysis: \_\_\_\_\_  
Container: \_\_\_\_\_  
Preservative: \_\_\_\_\_  
Project#: \_\_\_\_\_  
Location: \_\_\_\_\_  
Date: \_\_\_\_\_ Time: \_\_\_\_\_  
Initials: \_\_\_\_\_  
MACTEC , Inc.

Parameter	VOCs		Anions (Nitrate & Sulfate)	
	Method	SW8260B	E 300.0	
	Container	40 mL VOA vial	250 mL Plastic	
Preservative	HCl to pH<2, Cool to 4°C		No Preservative Cool to 4°C	
Sample ID	Comment	Date	Time	STL CEMRD
1 PX-1D	Deep Well			3 0
2 PX-2				3 0
3 PX-4				3 0
4 PX-6				3 0
5 PX-8				3 0
6 PX-9*				3 1
7 PX-10*				3 1
8 PX-11*				3 1
9 PX-12*				3 1
10 PX-14*				3 1
11 PX-15*	Collect Dup/Split			3 1
12 PX-16*				3 1
13 PX-17*				3 1
14 PX-18*	Collect MS/MSD			9 3
15 PX-19*	Collect Dup/Split			3 1
16 PX-20				3 0
17 PX-21				3 0
18 PX-24*				3 1
19 PX-25*				3 1
20 PX-26*				3 1
21 PX-35*				3 1
22 PXDup1*	Dup of PX-19			3 1
23 PXDup2*	Dup of PX-15			3 1
24 PX-19QA*	Split of PX-19			3 1
25 PX-15QA*	Splt of PX-15			3 1
			TOTAL	75 6 18 2
26 PXEQB-1	***			3 1
			TOTAL	3 1
27 TB-	Trip Blank (a)			2
28 TB-	Trip Blank (a)			2
29 TB-	Trip Blank (a)			2
30 TB-	Trip Blank (a)			2
31 TB-	Trip Blank (a)			2
32 TB-	QA Trip Blank (a)			2
33 TB-	QA Trip Blank (a)			2
34 TB-	QA Trip Blank (a)			2
			TOTAL	10 6

\* Wells to be additionally sampled for nitrate, sulfate, methane, and alkalinity

\*\* The laboratory does not perform MS/MSD on Methane

- Do not collect extra vials for MS/MSD

\*\*\* Equipment blanks will not be collected on dedicated equipment

However, if for any reason the dedicated equipment cannot be used, an equipment blank will be collected for each analytical method

(a) Actual number of trip blanks based on number of shuttles to be shipped

**Chain of  
Custody Record**

ATTACHMENT 7.4

**SEVERN  
TRENT** **STL**  
Severn Trent Laboratories, Inc.

DISTRIBUTION: WHITE. Returned to Client with Biscuit CANARY. Sings with the Sultans. BIRDS FIELD CO.

50006.01

## Attachment 7.5

Mactec  
 3200 Town Point Dr, Suite 100  
 Kennesaw, GA 30144

### REQUEST FOR ANALYSIS

Project Manager Tom Holmes  
 Project Chemist: Jessica Vickers  
 Project: DDMT

Matrix: Groundwater  
 Sample ID. MW-47

Container	No.	Preservation	Parameter	Method	Prep
40 mL VOA w/septum	3	HCL to pH<2 Cool to 4 C	VOCs	SW8260B	SW5030B
500 mL Plastic	1	No Preservative Cool to 4 C	Anions/Sulfate/Bromide/Alk	E310 1/E300.0	
40 mL VOA w/septum	2	HCL to pH<2 Cool to 4 C	Total Organic Carbon	SW9060	
40 mL VOA w/septum	2	HNO3 to pH <2/Cool to 4C Field Filter	Dissolved Organic Carbon	E415 1	
500 mL Plastic	1	ZnAc & NaOH to pH>9 Cool to 4 C	Sulfide	E376 1	
1 L Poly	1	HNO3 to pH <2 Cool to 4 C	Total Metals (As, Mn, Se)	SW6010B	
40 mL VOA w/septum	2	HCL to pH<2 Cool to 4 C	Methane/Ethane/Ethene	RSK 175	
40 mL Amber VOA w/septum	3	No Preservative Cool to 4 C	Metabolic Fatty Acids		

Comments: \_\_\_\_\_  
 Prepared By: \_\_\_\_\_ Checked By: \_\_\_\_\_

**ATTACHMENT 7.6**

**COOLER RECEIPT FORM**

Contractor Cooler \_\_\_\_\_

LIMS# \_\_\_\_\_

QA Lab Cooler # \_\_\_\_\_

Number of Coolers \_\_\_\_\_

PROJECT: \_\_\_\_\_ Date received: \_\_\_\_\_

USE BOTTOM OF PAGE 2 OF THIS FORM TO NOTE DETAILS CONCERNING CHECK-IN PROBLEMS.

A. PRELIMINARY EXAMINATION PHASE: Date cooler was opened: \_\_\_\_\_  
 by (print) \_\_\_\_\_ (sign) \_\_\_\_\_

1. Did cooler come with a shipping slip (air bill, etc.)? ..... YES NO  
 If YES, enter carrier name & air bill number here: \_\_\_\_\_
2. Were custody seals on outside of cooler? ..... YES NO  
 How many & where \_\_\_\_\_ seal date: \_\_\_\_\_ seal name: \_\_\_\_\_
3. Were custody seals unbroken and intact at the date and time of arrival? ..... YES NO
4. Did you screen samples for radioactivity using the Geiger counter? ..... YES NO
5. Were custody papers in a plastic bag & taped inside to the lid? ..... YES NO
6. Were custody papers filled out properly (ink, signed, etc.)? ..... YES NO
7. Did you sign custody papers in the appropriate place? ..... YES NO
8. Was the project identifiable from custody papers? If YES, enter project name at the top of this form ..... YES NO
9. Were temperature blanks used? ..... YES NO  
 Cooler Temperature \_\_\_\_\_ (°C) Thermometer ID No. \_\_\_\_\_
10. Have designated person initial here to acknowledge receipt of cooler: \_\_\_\_\_ (date) \_\_\_\_\_

B. LOG-IN PHASE: Date samples were logged in: \_\_\_\_\_  
 by (print) \_\_\_\_\_ (sign) \_\_\_\_\_

11. Describe type of packing in cooler: \_\_\_\_\_
12. Were all bottles sealed in separate plastic bags? ..... YES NO
13. Did all bottles arrive unbroken with labels in good condition? ..... YES NO
14. Were all bottle labels complete (ID, date, time, signature, preservative, etc.)? ..... YES NO
15. Did all bottle labels agree with custody papers? ..... YES NO
16. Were correct containers used for the tests indicated? ..... YES NO
17. Were samples preserved to correct pH, if applicable? ..... YES NO
18. Was a sufficient amount of sample sent for tests indicated? ..... YES NO
19. Were bubbles absent in volatile organic analysis (VOA) samples? If NO, list VOA samples below ..... YES NO
20. Was the project manager called and status discussed? If YES, give details on the bottom of this form ..... YES NO
20. Who was called? \_\_\_\_\_ By whom? \_\_\_\_\_ (date) \_\_\_\_\_

**ATTACHMENT 7.7**

**DAILY QUALITY CONTROL REPORT**

**Report No.** \_\_\_\_\_ **Contract No.** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Location of Work:** Defense Depot, Memphis, Tennessee

**Description of Work:** \_\_\_\_\_

**Weather:** \_\_\_\_\_ **Rainfall (inches) Avg.** \_\_\_\_\_ **Temp:** \_\_\_\_\_

**Activities Performed:**

**Field Team Leader:**

**Team # 1:**

**Team # 2:**

**Team # 3:**

**Team # 4:**

**Collected samples are listed below:**

**Samples Collected:**

<b>Team 1</b>	<b>Team 2</b>	<b>Team 3</b>	<b>Team 4</b>

**Personnel On-Site:**

**Difficulties:**

**Visitors:**

**Field Team Leader:** \_\_\_\_\_

## ATTACHMENT 7.8

 MACTEC  
FIELD ADJUSTMENT FORM

Date: \_\_\_\_\_

Project: Defense Depot Memphis Tennessee

Project Number: \_\_\_\_\_

Field Effort: \_\_\_\_\_

#### Description of field adjustment and rationale:

Prepared by/Title: \_\_\_\_\_

I have read the above description and rationale and concur with the adjustment

---

**Signature**

Date

## **WORK AND TEST PROCEDURE 8**

### **SAMPLE CONTAINERS AND PRESERVATION**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for the selection of sample containers, required cleaning for the specified containers, required sample volumes for various analyses, preservation requirements, and required holding times.

#### **2.0 DISCUSSION**

This WTP specifies details and procedures for selection and preparation of sample containers and for preservation of the samples once they have been collected. The project-specific work plan will be used to determine the exact sampling requirements.

The selection of suitable containers will prevent contamination of sample from container materials. Adequate preservation of the samples by prescribed methods will ensure that no biological or chemically mediated changes in sample integrity/concentration occurred while the sample was in transit. Both the selection of suitable containers and the proper preservation will support the legal defensibility of data generated as a component of investigative activities. Container type and preservation methods are analytical method-specific.

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be considered for review in conjunction with this WTP:

<b>NUMBER</b>	<b>NAME</b>
1	General Instructions for Field Personnel
4	Groundwater Sampling
7	Sample Control and Documentation
9	Sample Packing and Shipping
10	Sample Equipment Decontamination

### **3.2 PREPARATION**

#### **3.2.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:

- Work with the project chemist to generate a sampling plan detail listing the wells and constituents to be sampled
- Coordinate with the analytical laboratory to ensure that the sample containers, and preservatives are shipped to the site and arrive prior to the start of sampling event

#### **3.2.2 Field**

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

- Check that sufficient sample containers, preservatives and coolers are present on site for storage and shipment.

### **3.3 FIELD OPERATIONS**

#### **3.3.1 Sample Container Selection/Preparation**

The sample container to be selected is matrix and method specific. Sample containers are specified and selected to ensure that little, if any chemicals are transferred from the sample containers to the sample itself, thereby skewing the results. The sample containers will be pre-cleaned and provided to MACTEC by the laboratory. Cleaning procedures will be performed according to USEPA guidelines. A summary of recommended sample containers is provided by method in Attachment 8.1.

#### **3.3.2 Sample Preservation**

Samples are generally collected into containers containing preservative in the field prior to shipping to the laboratory to minimize any chemical or physical changes to the sample contents during shipment. Sample preservation and temperature will be checked immediately upon receipt of samples at the laboratory. The results of these checks will be recorded on the cooler receipt form. A summary of recommended preservation techniques by matrix by method is summarized in Attachment 8.1.

It should be noted that the USEPA (1992) do not recommend filtration of samples. However, where required by the scope of work, samples for dissolved metals will be collected and filtered with an in-line 0.45 micron filter at each well location, then preserved with appropriate preservatives.

### **3.3.3 Holding Times**

Project samples will be preserved and analyzed within the time intervals specified for each method and matrix listed in Attachment 8.1. For samples analyzed by gas chromatography, first column analysis and second column confirmations will be completed within the maximum holding times specified in Attachment 8.1.

With regard to holding time requirements and definitions presented in Attachment 8.1, extraction is defined as completion of the sample preparation process as described in the applicable method. Analysis completion is defined as completion of analytical runs, including dilutions, second column confirmations, and any required reanalyses.

## **3.4 POST OPERATION**

### **3.4.1 Field**

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

- Check that sampling bottles assigned to the specific sampling location have been filled with the prescribed amount of sample, contain the proper type and amount of preservative and that all sample labels contain relevant information (date, time, sampler's identification, and whether the sample has been preserved).
- Maintain custody of samples, maintaining them as specified for the analyses to be performed.
- Prepare samples for shipment to the laboratory.
- Complete the C-C forms and other relevant information.
- Contact the laboratory to verify that samples are received in good condition and that request for analyses are understood.

Upon completion of the field effort ensure that associated supplies have been properly stored, disposed of or shipped back to the office as appropriate.

### **3.4.2 Office**

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

- Submit logbook and any original forms to Task/Project Manager for review.
- Inventory equipment and supplies shipped back to the office.
- Contact the laboratory to verify that samples were received in good condition and that requested analyses are understood.

## **4.0 REFERENCES**

USACE, 2001. Engineering and Design Requirements for the Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001.

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

## **5.0 ATTACHMENTS**

Attachment 8.1 - Requirements for Containers, Preservation Techniques, and Holding Times for Groundwater Samples

Attachment 8.2 - Requirements for Containers, Preservation Techniques, and Holding Times for Soil Samples

ATTACHMENT 8.1

CONTAINERS, PRESERVATIVES, AND HOLDING TIMES  
 MATRIX: GROUNDWATER SAMPLES

Parameter	Units	Method	Container	Minimum Recommended Quantity (mL)	Preservative	Holding Time
Groundwater						
Volatile Organics	µg/L	SW 5030B/8260B	VOA w/ Teflon®-lined septum	3 X 40 (no headspace)	4°C; HCl to pH<2	14 days/7 days if unpreserved
Dissolved Gases: Methane, Ethane, Ethene	µg/L	STL SOP COI-GC-005 (EPA RSK SOP-175M)	VOA w/ Teflon®-lined septum	3 X 40 (no headspace)	4°C; HCl to pH<2	14 days
Carbon Dioxide	mg/L	STL SOP COI-GC-005 (EPA RSK SOP-175M)	VOA w/ Teflon®-lined septum	2 X 40 (no headspace)	4°C	7 days
Semi-Volatile Organics	µg/L	SW 3520C/8270C	G-TLC (amber)	1000	4°C	7 d Extraction/ 40 d Analysis
Pesticides	µg/L	SW 3520C/8081A	G-TLC (amber)	1000	4°C	7 d Extraction/ 40 d Analysis
PCBs	µg/L	SW 3520C/8082	G-TLC (amber)	1000	4°C	7 d Extraction/ 40 d Analysis
Herbicides	µg/L	SW 3520C/8151A	G-TLC (amber)	1000	4°C	7 d Extraction/ 40 d Analysis
Metals ICP	mg/L	SW 3005A/6010B Trace	P	1000	HNO <sub>3</sub> to pH<2 (dissolved – filter on site)	6 months
Mercury	mg/L	SW 7470A	P	500	HNO <sub>3</sub> to pH<2 (dissolved – filter on site)	28 days
Anions: Bromide, Chloride, Nitrate, Nitrite, and Sulfate	mg/L	EPA 300.0/SW 9056	P, G	250	4°C	28 days (Br, Cl, SO <sub>4</sub> ) 48 hours (NO <sub>2</sub> , NO <sub>3</sub> )

ATTACHMENT 8.1

CONTAINERS, PRESERVATIVES, AND HOLDING TIMES  
 MATRIX: GROUNDWATER SAMPLES

Parameter	Units	Method	Container	Minimum Recommended Quantity (mL)	Preservative	Holding Time
Alkalinity	mg/L	EPA 310.1	P	250 (no headspace)	4°C	48 hours
Sulfide	mg/L	EPA 376.1	P	500 (no headspace)	4°C; Zinc Acetate & NaOH to pH>10	7 days
TOC	mg/L	SW 9060/EPA 415.1	P, G	2 X 40 (no headspace)	4°C, H <sub>2</sub> SO <sub>4</sub> to pH<2	28 days
Dissolved Organic Carbon	mg/L	EPA 415.1	P, G	2 X 40 (no headspace) (dissolved – filter on site)	4°C, H <sub>2</sub> SO <sub>4</sub> to pH<2	28 days
Volatile Fatty Acids	mg/L	ASTM D 1552	VOA w/ Teflon® lined septum	1 X 40 (no headspace)	4°C;	28 days
CONTAINER AND SAMPLE HANDLING GUIDE						
MATRIX: FIELD TESTS FOR GROUNDWATER						
pH	units	EPA 150.1	P, G	50	N/A	ASAP
Specific Conductance	mS/cm	EPA 120.1	P, G	250	4°C	24 hours
Temperature	°C	EPA 170.1	P, G	50	N/A	ASAP
Turbidity	NTUs	EPA 180.1	P, G	250	N/A	ASAP

ATTACHMENT 8.1

CONTAINERS, PRESERVATIVES, AND HOLDING TIMES  
 MATRIX: GROUNDWATER SAMPLES

Parameter	Units	Method	Container	Minimum Recommended Quantity (mL.)	Preservative	Holding Time
Redox Potential	mV	SM 2580	P, G	50	N/A	ASAP
Dissolved Oxygen	mg/L	MCAWW 360.1	P, G	50	N/A	ASAP
Ferrous Iron	mg/L	HANNA Kits 38039/38041	P, G	50	N/A	ASAP
Carbon Dioxide	mg/L	HANNA Kit 3818	P	50	N/A	ASAP

Acronym Definitions:

P = Polyethylene  
 G = Glass  
 G-TLS = Glass with Teflon®-lined septum  
 G-TLC = Glass with Teflon®-lined cap

PTFE = Fluoropolymer Resin/Teflon®

PREPARED BY:	
CHECKED BY:	

ATTACHMENT 8.2  
 CONTAINER AND SAMPLE HANDLING GUIDE  
 MATRIX: SOIL

Parameter	Units	Method	Container	Minimum Recommended Quantity	Preservative	Holding Time
Volatile Organics Compounds – Encores*	µg/kg	SW 5035/8260B	G-TLC/ Encores™	4 X 5 gram Encores™	4°C	48 hrs for preservation/ 14 days Analysis
Semi-Volatile Organics	µg/kg	SW 3550B/8270C	G-TLS	8 oz.	4°C	14 day Extraction/ 40 day Analysis
Pesticides	µg/kg	SW 3550B/8081A	G-TLS	8 oz.	4°C	14 day Extraction/ 40 day Analysis
PCBs	µg/kg	SW3540/8082	G-TLS	8 oz.	4°C	14 day Extraction/ 40 day Analysis
Herbicides	µg/kg	SW 8151A	G-TLC	8 oz.	4°C	14 day Extraction/ 40 day Analysis
Metals ICP	mg/kg	SW 3050A/SW 6010B	P, G	8 oz.	4°C	6 months
Mercury	mg/kg	SW 7471A	P, G	8 oz.	4°C	28 days
TOC	mg/kg	Walkley Black	G	8 oz.	4°C	28 days
TCLP	mg/L	SW 1311	G-TLS/ Encore™	Extractables, metals-16 oz. VOCs-25g Encore™ or 4 oz.	4°C	VOCs-14 days Ext/NA/14 days Analysis, Extractables-14 days Ext/7 days

\* If collecting for volatile organic compounds only, an additional aliquot of soil must be obtained in a one 4-oz wide mouth jar for moisture content determination.

Acronym Definitions:

P = Polyethylene      G-TLS = Glass with Teflon®-lined septum  
 G = Glass      G-TLC = Glass with Teflon®-lined cap

PTFE = Fluoropolymer Resin/Teflon®

PREPARED BY:	
CHEKED BY:	

**WORK AND TEST PROCEDURE 9**  
**SAMPLE PACKING AND SHIPPING**

**1.0 PURPOSE**

The purpose of this WTP is to provide guidance for packing and shipping environmental samples to the laboratory for analysis. A Sample Handling, Packing and Shipping Instructions Checklist is included as Attachment 9.1.

**2.0 DISCUSSION**

This WTP specifies details and procedures for packing and shipment of samples to the laboratory for analysis. The project-specific work plan will be used to identify the exact shipping requirements for a specific project.

The goals for sample packing and shipping are that: 1) the integrity of the sample is maintained, and 2) no personnel exposure to the sample container contents occurs during transit. These goals should be met regardless of the method by which the samples were shipped.

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

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

### 3.0 PROCEDURES

#### 3.1 ASSOCIATED PROCEDURES

The following WTPs will be reviewed in conjunction with this field effort:

NUMBER	NAME
1	General Instructions for Field Personnel
4	Groundwater Sampling
6	Investigation Derived Waste Disposal
7	Sample Control and Documentation
8	Sample Containers and Preservation
10	Sample Equipment Decontamination
11	Soil Sampling

#### 3.2 PREPARATION

##### 3.2.1 Office

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:

- Work with the project chemist to ensure that a sufficient amount of sample containers, sample transportation containers, and sample packing material have been shipped to the site based on the total number of samples and average number of samples to be collected per day.
- Develop guidelines on the number/type of samples per shipper based on type of samples being collected and analytical results from past sampling events at the site(i.e. VOCs in one cooler to limit the number of trip blanks needed, samples from high concentration wells packed in separate cooler to prevent cross contamination)

##### 3.2.2 Field

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

- Check that required sample containers, sample transport containers, and packing material are on-site.

### **3.3 FIELD OPERATIONS**

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

- The samples will be shipped to the laboratory by an overnight courier service.
- Samples will not remain on site for more than 24 hours after collection, unless samples were collected on a weekend. These samples will be stored on ice at 4°C until the first possible courier shipment.
- Glass sample containers will be placed inside sealed plastic bubble wrap bags or wrapped in bubble wrap and placed in sealable plastic bags as a precaution against cross-contamination due to leakage or breakage.
- All sample bottles will be placed in coolers supplied by the laboratory in such a manner as to eliminate the chance of breakage and/or leakage during shipment.
- Sufficient ice in plastic bags (double-bagged) will be placed in the coolers to keep the samples at 4°C throughout shipment.
- Special arrangements will be made with the laboratory's point-of-contact for samples that are to be delivered to a laboratory on a Saturday so that hold times and/or sample preservations are not compromised.

In order to demonstrate that the samples and coolers have not been tampered with during shipment, custody seals will be used. Custody seals are adhesive labels that are placed across the cooler lids in such a manner that they will be visibly disturbed upon opening of the sample container or cooler. The seals will be initialed and dated upon placement. Upon receipt at the laboratory, the sample custodian will note the condition of custody seals and will also check the sample temperature, recording these items on the laboratory cooler receipt form.

In no instance will a highly contaminated sample (such as waste or pure product) be shipped in the same container as a low level contaminated sample (such as environmental soil and groundwater samples). This procedure is to minimize the possibility of cross-contamination.

### **3.4 POST-OPERATION**

#### **3.4.1 Field**

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

- Ensure that the sample transport containers are properly packed and are in compliance with DOT and IATA regulations.
- Confirm receipt of samples at laboratory.
- Fill out sample tracking form noting sample shipment

### **3.4.2 Office**

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

- Submit logbook and any original forms to Project Manager for review.
- Inventory all equipment and supplies shipped back to the office.

## **4.0 REFERENCES**

Code of Federal Regulations, Part 49, Sections 100-199.

USACE, 2001. Engineering and Design Requirements for the Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001.

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

## **5.0 ATTACHMENTS**

Attachment 9.1 – Sampling Handling, Packing & Shipping Instructions Checklist

## ATTACHMENT 9.1

### **SAMPLE HANDLING, PACKING & SHIPPING INSTRUCTIONS** **CHECKLIST**

When packing samples for shipment to the laboratory, review this list to ensure that all project samples, documents, and materials are included in the sample shipper.

#### PROJECT SAMPLES

- All samples, duplicates, MS/MSDs, equipment blanks, ambient blanks, and trip blanks should be included in the cooler that are listed on the COC.
- Verify that the proper number of bottles with appropriate preservative(s) were collected for each sample
- Verify that samples were checked for pH (except volatile samples)

#### DOCUMENTS

- Chain-of-Custody (COC)** generated for *each* cooler
- Review the COC for completeness, including appropriate signature(s) and date(s), and include the **courier tracking/shipping number** on the COC
- Request for Analysis (RFA)** form for every sample included in the cooler
- The COC and RFAs should be placed in a Ziploc bag and taped to the underside of the cooler lid
- Custody seals should be placed on the front and back of each cooler

#### PACKING MATERIALS

- Verify that ice is "double-bagged" and is sufficient to maintain a temperature of 4°C
- Glass bottles should be placed in a bubble bag to prevent breakage and leakage
- Place highly contaminated samples (if known) together
- Place a **trip blank** in each cooler that contains samples for VOC analyses at beginning of day
- To minimize the number of trip blanks, place all VOC samples in the same cooler
- Each cooler contain a **temperature blank**
- All sample coolers insured by shipper (\$1000.00)

Comments: \_\_\_\_\_

Checklist Completed By: \_\_\_\_\_ Date: \_\_\_\_\_

Note: This Checklist should be included in the project file with the field documents.

## **WORK AND TEST PROCEDURE 10**

### **FIELD EQUIPMENT DECONTAMINATION**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for the proper decontamination of field equipment. This WTP also provides guidance for collection of equipment rinsates that will measure the quality of the decontamination procedure.

#### **2.0 DISCUSSION**

This WTP specifies details and procedures for decontamination of field equipment that may become contaminated as a result of field sampling activities. The decontamination of sampling equipment will help prevent cross-contamination of samples collected at one location with residual contamination from samples collected at another location; will help prevent exposure of individuals to residual contamination present on the equipment; and will help prevent the spread of contamination via sampling equipment. Proper decontamination procedures will also support the legal defensibility of data generated as a component of investigative activities.

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

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be reviewed in conjunction with this WTP:

<b>NUMBER</b>	<b>NAME</b>
1	General Instructions for Field Personnel
2	Drilling
3	Well Installation, Development, and Abandonment
4	Groundwater Sampling
5	Hydraulic Conductivity Testing

NUMBER	NAME
6	Investigative Derived Waste Disposal
7	Sample Control and Documentation
8	Sample Containers and Preservation
9	Sample Packing and Shipping
11	Soil Sampling

### **3.2 PREPARATION**

#### **3.2.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:

- Ensure that sufficient quantities of decontamination supplies and materials have been shipped to the site based on expected number of samples and days at site.

#### **3.2.2 Field**

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

- Verify that decontamination supplies and equipment have arrived on site.
- Set up decontamination area(s).

### **3.3 FIELD OPERATIONS**

#### **3.3.1 Decontamination Area**

The location of the decontamination area, used primarily for larger pieces of equipment, will be determined in consultation with DRC personnel. The decontamination pad will consist of a sump lined with 6-mil polyethylene sheeting. The sump will be constructed by either excavating a small area to create a depression to collect the decontaminated water or by elevating the edges of the sheeting to create a pool-like structure to collect the decontaminated water.

#### **3.3.2 Decontamination Water Source**

Tap water from the municipal water treatment system will be used as a rinse in the decontamination procedure. The Field Team Leader will be responsible for coordinating with DRC personnel to secure an

adequate supply of tap water for decontamination procedures. One sample of each water source used will be analyzed for the full range of parameters as the field samples to be collected. If water supply is a portable water tank, a sample must be collected from each tank used.

### **3.3.3 Decontamination Procedures**

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

1. Wash the external surface of equipment or materials with high pressure hot water and Alconox or equivalent, and scrub with brushes if necessary until all visible dirt, grime, grease, oil, loose paint, rust flakes, etc., have been rinsed from the equipment into a collection structure.
2. Air dry.
3. Decontamination solutions will be stored in tanks or drums and maintained at the site until analyses have been completed.

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

1. Wash and scrub with Alconox or equivalent detergent.
2. Double tap water rinse.
3. Rinse with American Society for Testing and Materials (ASTM) Type II Reagent - Grade Water
4. A pesticide grade methanol spray rinse (all solvents must be pesticide grade or better) in a stainless steel bowl. The methanol waste will be containerized separate from purge water and disposed of as a hazardous waste.
5. Rinse with ASTM Type II Reagent - grade water.
6. Wrap in oil free aluminum foil for transport.

The decontamination procedure for the water level indicator and the oil/water interface probe is:

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

### 3.3.4 Equipment Rinsate Collection

When field cleaning equipment is required during a sampling investigation, a piece of the field-cleaned equipment is selected for collection of a equipment rinsate. At least one equipment rinsate will be collected for each sampling protocol (i.e. soil sampling, pumps used for groundwater sampling) during each week of sampling operations. Equipment rinsates will be conducted in a manner which allows proper representation of field decontamination procedures.

Sampling Equipment: Equipment rinsates will be obtained from decontaminated bladder pumps, bailers, HydroPunch sampler, stainless steel split-spoons, hand augers, sludge samplers, Ponar dredges, stainless steel bowls, and beakers with ASTM Type II water or better.

The equipment rinsate protocol will be as follows:

- a. Label Sample Container - Label the sample container as outlined in WTP 7
- b. Collect Sample - Equipment rinsates will be collected on all equipment types used to collect samples. The collection procedure is described below:

After sample collection equipment has been decontaminated as described above, an equipment rinsate will be collected. ASTM Type II water (or better) will be poured over and through sampling equipment (i.e., split-spoon, bailer, stainless steel beaker) into a cleaned stainless steel bowl (preferably the equipment and bowl to be used on a specifically identifiable sample location). Water collected will then be poured into the appropriate sample container. Repeat the process as necessary to fill each container to the required volume. Vials for volatile analysis and bottles for total organic carbon (TOC) analysis will be completely filled, leaving no air space above the liquid portion (to minimize volatilization). Check that the Teflon on the Teflon- lined silicone septum is toward the sample in the caps and secure the cap tightly. If semi-volatile compounds are to be sampled for, collect these samples next. Proceed to the collection of samples for the remaining analyses. Be careful of all pre-preserved bottles. If acids are present, open the bottle downwind and away from the body.

- c. Custody, Handling and Shipping - Complete the procedures as outlined in WTPs 8 - Sample Control and Documentation and 10 - Sample Packing and Shipping.

## 3.4 POST OPERATION

### 3.4.1 Field

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

- Decontaminate all equipment.
- Properly store decontamination derived waste (i.e., decontamination water).
- Ensure that sampling equipment and associated decontamination supplies have been shipped back to the office.

### **3.4.2 Office**

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

- Submit logbook and any original forms to Task/Project Manager for review.
- Inventory equipment and supplies shipped back to the office
- Arrange for proper disposal of the decontamination derived waste after determination of its contents.

## **4.0 REFERENCES**

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

USACE, 2001. Engineering and Design Requirements for the Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001.

## **5.0 ATTACHMENTS**

None

## **WORK AND TEST PROCEDURE 11**

### **SOIL SAMPLING**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for collection of soil samples for analytical analysis.

#### **2.0 DISCUSSION**

This WTP specifies details and procedures for collecting soil samples for chemical analysis at DDMT. Soil samples will be collected from surface soils, soil borings, soil piles, and from the sidewalls and floor of excavations. Samples may be collected using split-spoons, Shelby tubes, hand augers, Encore or Terracore Samplers, or stainless steel spoons. Sampling will be conducted at locations and depths specified in the project specific work plan. The soil samples will be analyzed to identify chemical constituents and their concentrations.

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be reviewed in conjunction with this WTP:

<b>NUMBER</b>	<b>NAME</b>
1	General Instructions for Field Personnel
2	Drilling Operations
7	Sample Control and Documentation
8	Sample Containers and Preservation
9	Sample Packing and Shipping
10	Sampling Equipment Decontamination
12	Personnel Protective Equipment Decontamination
13	Health and Safety Monitoring

### **3.2 PREPARATION**

#### **3.2.1 Office**

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1. A general list of supplies needed for soil sampling is given as Attachment 11.1.

#### **3.2.2 Field**

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

- Ensure that required sampling equipment has arrived on site.
- Ensure that sufficient drums or other containers are on site to containerize any excess sample material collected.

### **3.3 FIELD OPERATIONS**

Soil excavation and sampling procedures will be supervised by a qualified geologist or engineer. The sample locations will be specified in the project specific work plan. Soil sampling and Quality Assurance/Quality Control procedures will be supervised by the senior/project chemist.

#### **3.3.1 Soil Sampling**

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

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

The plasticity of fines description will include:

- Color using Munsell Color System
- Moisture (dry, wet, or moist)

- Consistency of fine grained soils
- Structure of consolidated materials
- Cementation (weak, moderate, or strong)

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

During advancement of the soil borings, the following sampling devices may be used:

- Chemical Sample Collection: 2 or 3-inch diameter carbon steel split-barrel sampler lined with California brass rings (CBRs)
- Geotechnical Sample (disturbed) Collection: 2-inch diameter carbon steel split-barrel sampler

Geotechnical Sample (undisturbed) Collection: 3-inch diameter “Shelby Tube” or thin-walled tube sampler

### **3.3.1.1 Sample Collection during Sonic Drilling**

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

At five-foot intervals within the soil cores, the headspace will be screened with an FID or PID. The headspace samples will be brought (if necessary) to a temperature of between 20°C (68°F) and 32°C (90°F), and the reading will be obtained 5 minutes thereafter. The soil sample will be split into two jars and readings will be made with the PID/FID (unfiltered) on one jar. If the reading is greater than 10 parts per million (ppm), a reading will be made on the second jar with an activated charcoal filter on the FID. A total corrected hydrocarbon measurement of the sample will be calculated by subtracting the filtered reading from the unfiltered reading.

The headspace samples will be collected and analyzed using the following procedure:

1. From the sampling location within the soil core, remove the top 1 to 2 inches of soil using a decontaminated stainless steel spoon.
2. Fill  $\frac{1}{2}$  of two decontaminated 16-ounce containers with soil from the resulting hole using the stainless steel spoon.
3. Cover the jars immediately with aluminum foil and fasten the jar lids.
4. Allow the sample vapors to equilibrate in the jars (approximately 5 minutes).
5. Punch a hole in the aluminum foil with the tip of a calibrated PID/FID.
6. Record the highest reading.
7. If the reading is  $> 10$  ppm, repeat Steps 5 and 6 with the activated charcoal filter on the calibrated FID for the second jar.

Selected soil samples may be collected for laboratory analysis based upon the results of the headspace screening. At these selected locations, samples for VOC analysis will be collected using an Encore or Terracore sampler, or acceptable equivalent.

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

1. Remove sampler and cap from package and attach T-handle to the 5-gram sampler body.
2. Quickly push the sampler into a freshly exposed surface of soil until the sampler is full.
3. Carefully wipe the exterior of the sampler head with a clean disposable paper towel so that the cap can be tightly attached.
4. Push cap on with a twisting motion to attach and seal the sampler.
5. Attach the label onto the sampler body, place the sampler into a plastic Ziploc<sup>TM</sup> bag and place into a cooler with ice.
6. Repeat steps 1 through 5 for the remaining 5-gram and 25-gram sampler.
7. Collect a bulk soil sample for screening and moisture determination in a 2 or 4-ounce wide mouth glass jar. Fill the jar completely allowing no headspace. Place the sample in a cooler containing ice.
8. Thoroughly mix remaining soil and place into specified labeled containers for remaining parameters.
9. Place sample bottles into Ziploc or bubble bag and in an iced cooler.

10. When soil sampling is completed at that location or when time permits, transfer samples to site office for final packaging. Complete C-C documentation and shipping procedures in accordance with WTPs-7 and -9.
11. Record field conditions, any problems encountered during sampling and sample appearance in the field logbook and the Field Sampling Report Form and Daily Quality Control Report Form.

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

1. Label appropriate laboratory containers
2. Quickly push the sampler (Terracore or equivalent) into a freshly exposed surface of soil to collect 5 grams ( $\pm 0.5g$ ) of sample. Also collect a bulk aliquot container for moisture content analysis in the laboratory supplied 4 ounce container.
3. Carefully wipe the exterior of the sampler head with a clean disposable paper towel.
4. Empty sampler into appropriate laboratory container. The cored samples must be extruded from the selected coring tool to a VOA vial in accordance with collection and preservation methods described in EPA method 5035A. The extruded core is transferred into a laboratory pre-weighed (tared) VOA vial with septum cap. Unpreserved VOA vials must be analyzed within 48 hours of collection, VOA vials preserved with sodium bisulfate or methanol must be analyzed within 14 days of collection.
5. Place the sample into a plastic Ziploc™ bag and place into a cooler with ice.
6. Complete C-C documentation and shipping procedures in accordance with WTPs 7 and 9.

Additionally, for borings where a monitoring well will be installed, a sample for total organic carbon (TOC) analysis may be collected from the interval to be screened. The TOC samples will be collected from the soil core using a pre-cleaned stainless steel spoon and placed in the appropriate laboratory supplied container.

All measurements will be recorded on the logging form at the corresponding depths. The samples will be handled in such a way as to minimize the loss of volatile compounds. Soil cuttings will be examined for their hazardous characteristics. If suspect samples are encountered, they will be noted on the boring log form for reference during investigation derived waste (IDW) sampling. Soil samples for laboratory analysis will also be collected from the boring for each new monitoring well.

### **3.3.1.2 Hand Auger/ Spade and Scoop Soil Sample Collection**

Surface soil samples collected using a hand auger or spade and scoop will be collected from the floor or sidewalls of the test pits, surface soils from 0 to 6 inches and subsurface soil samples at pre-specified intervals from soil borings.

A boring will be advanced by using a trowel, hand-augering, or using a power-driven hand held auger to the predetermined sample depths at each site. The sample collection procedures are described below.

1. Prior to sampling, don the appropriate PPE and set up safety zones as required.
2. Decontaminate sampling equipment in accordance with the procedures specified in WTP 10 and the project-specific work plan prior to the start of sampling. When not in use, place tools on clean polypropylene sheeting
3. Label sample bottles as described in WTP-7.
4. Excavate using a shovel or garden trowel as necessary to remove gravel, sod or vegetation overlying the soil stratum to expose the sample location. A pry-bar may be required to excavate paving materials present at a site.
5. For surface soils, advance the hand auger to 6 inches and retrieve from boring location.
  - a. Place soil in a stainless steel bowl and immediately sample for volatile organic analysis as described in the following procedure:
6. Follow the procedure outlined in 3.3.2.1, Encore™ Sampler.

### **3.3.1.3 Soil Sampling Using a Split-Spoon and Shelby Tube Samplers**

Subsurface soil samples may be collected using a drill rig and split-spoon and Shelby Tube samplers. Sampling will be completed using drill rig or direct push rig capable of driving the samplers. The drive shoe on the rig will be properly equipped with a basket-retainer/ring assembly, and the drive weight assembly will consist of a 140-pound weight, a driving head, and a guide permitting a free fall of 30-inches.

Procedures for soil sampling using the split-spoon sampler are described below. A standard penetration test, following the guidance of American Society of Testing Methods D1586, will be performed every time a split-spoon sample is taken.

1. A 3-inch or 2-inch split-spoon sampler will be used for borings in which chemical samples will be collected. The split-spoon sampler will be driven at sequential depth intervals and samples will be collected at each interval. At each target depth interval, the split-spoon sampler will be brought to the surface and opened. After the soil is brought to the surface it will immediately put into plastic bags and checked for organic vapors by monitoring with an instrument equipped with a PID/FID. The PID/FID reading will be recorded on the hazardous and toxic waste (HTW) log. The Site Geologist will describe the materials encountered at each depth interval on the HTW drilling log.
2. The soil samples for chemical laboratory analysis, including samples for compositing, will be collected from the split-spoon before any other samples are collected (i.e., geotechnical analyses). If VOC analysis is required the following EnCore™ Sampler Procedures are to be performed:
  - a. Follow the procedure outlined in 3.3 1, Encore™ Sampler.
  - b. Collect samples for VOC analysis as soon as possible after splitting the spoon, taking care to cause as little disturbance to the sample as possible. If split samples are to be collected, use a decontaminated stainless steel spoon to split the tube contents in half longitudinally.
3. Collect a bulk soil sample for screening and moisture determination into a 2 or 4-ounce wide mouth glass jar. Fill the jar completely allowing no headspace. Place the sample in a cooler containing ice.
4. Thoroughly mix remaining soil and place into specified labeled containers for remaining parameters.
5. Place samples for geotechnical analysis into a clear 8-ounce jar. Label the sample containers as specified in the WTP-7. The jars containing the geotechnical samples will be labeled as to the collection date, location, site name, and blow counts.
6. When soil sampling is completed at that location, place the samples on ice and transfer samples to the site office for final packaging. Complete C-C documentation and shipping in accordance with WTPs-7 and -9.

Record field conditions, any problems encountered during sampling and sample appearance in the field logbook and the Field Sampling Report Form.

### **3.3.2 Soil Excavation**

Excavation or test pits are typically advanced with a small backhoe and provide opportunity for visual inspection and to obtain bulk samples if required. Excavation activities will be conducted under the direct supervision of a qualified geologist, or engineer. Excavation equipment will at a minimum be capable of

excavating a horizontal surface 8 feet below ground surface. The backhoe should utilize a straight-edge bucket.

Test pits will be excavated to the depth specified in the work plan. If underground utilities are expected, the exact location(s) of the utilities will be determined prior to beginning excavation operations. Underground installations will be protected, supported, or removed while the excavation is open. A barrier or tape should be placed around the pit area to warn personnel of its presence.

Equipment will be placed at least 2 feet from the edge of an excavations, and excavations will be sloped at an angle not steeper than one and one-half horizontal to one vertical [29 CFR Ch. XVII (7-1-92 Edition)]. A ladder, ramp, or other safe means of egress will be located in excavations that are 4 feet or more in depth. If the test pit is to be dug adjacent to a building or other structure, support systems such as shoring, bracing, or underpinning will be provided by the subcontractor. Soil will be removed in lifts. Hand excavation may be necessary to identify buried objects near the surface (approximately upper four feet). Test pits will not extend below the water table.

The approximate extent of excavation will be specified in the work plan. If on-site MACTEC personnel are satisfied that the contents of the anomalous area have been identified, the test pit may be closed prior to reaching the excavation limits set in the work plan. Excavation will not continue beyond the limits estimated in the work plan without approval from the Project/Task Manager.

Air quality tests will be performed before a worker enters an excavation more than 4 feet deep when the potential for a hazardous atmosphere exists. Tests will be conducted as often as necessary to ensure the quality and quantity of the atmosphere. This includes checks for flammable gases and oxygen deficiency.

### **3.4 POST-OPERATION**

#### **3.4.1 Field**

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

- Decontaminate all equipment.
- Complete logbook, making notations as to site conditions, anomalous readings, etc.

- Ensure that the site has been cleaned to its pre-sampling state (i.e., ensure that all trash generated as a result of sampling activities is disposed of).
- Ensure that all containers containing any investigative-derived waste are properly sealed and labeled with the date and drum contents. Drums will be sealed.

### **3.4.2 Office**

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

- Submit logbook and any original forms to Task/Project Manager for review.
- Inventory all equipment and supplies shipped back to the office.
- Make provisions for proper disposal of investigative derived waste.

## **4.0 REFERENCES**

ASTM, 1986 Annual Book of ASTM Standards, American Society of Testing and Materials, 1986.

ASTM, 1998. "Draft Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds", D4547, Annual Book of ASTM Standards, American Society of Testing and Materials, February, 1998.

MDNR, 1994. Guidance Document Verification of Soil Remediation. Environmental Response, Waste Management Division. Michigan Department of Natural Resources. July, 1994

USACE, 2001. Engineering and Design Requirements for the Preparation of Sampling and Analysis Plans, Department of the Army, Washington D.C. February 1, 2001

USEPA, 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Compliance Branch, Athens, Georgia, November, 2001.

USEPA, 1996. "Closed System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples" Method 5035, Test Methods for Evaluating Solid Wastes, EPA SW846, 3rd ed., Volume II, Update III, December, 1996

## **5.0 ATTACHMENTS**

Attachment 11.1 - General Field Supply Checklist-Soil Sampling Activities

**ATTACHMENT 11.1****General Field Supply Checklist-Soil Sampling Activities**

Steel Toe Workboots	_____
Full Face Respirator (with appropriate cartridges)	_____
Safety Glasses	_____
Logbook	_____
Pens	_____
Data Collection Forms	_____
OSHA Certification Card	_____
Tape Measure	_____
Hard Hat	_____
Hammer	_____
First Aid Kit and Emergency Eyewash Station	_____
Overshoes	_____
Sun Screen	_____
Work Gloves	_____
Disposable Gloves	_____
Three-inch or five-inch diameter stainless steel bucket hand auger (with extendible handles)	_____
Hand-held power driven auger; to advance boring in deeper or difficult boreholes	_____
Pry bars/digging bars	_____
Shovel	_____
Garden trowel (stainless steel) and stainless steel spoon	_____
Stainless steel bowl(s)	_____
Aluminum foil	_____
Polypropylene sheeting	_____
Decontamination supplies	_____
Sample collection bottles appropriate for the analyses to be performed	_____
EnCore™ samplers, 5-gram and 25-gram core sizes	_____
2-inch outer diameter (OD), 2-foot long carbon steel split-barrel sampler	_____
3-inch or 2-inch OD, 2-foot long carbon steel split-barrel sampler	_____

## **WORK AND TEST PROCEDURE 12**

### **PERSONNEL PROTECTIVE EQUIPMENT DECONTAMINATION**

#### **1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for the decontamination of personal protective equipment. Proper decontamination of personal protective equipment minimizes the spread of contamination as well as minimizes the possibility of worker exposure to contaminants.

#### **2.0 DISCUSSION**

The project-specific Health and Safety Plan should be used to determine the exact requirements of personal protective equipment for a specific project. The purpose of decontamination is to remove or neutralize contaminants that have accumulated on personnel and equipment. Decontamination protects workers from hazardous substances that may contaminate and eventually permeate protective clothing and other equipment used on site. It also minimizes the transfer of contaminants to clean areas and protects the community by preventing uncontrolled transportation of contaminants off-site. All personnel will complete appropriate decontamination prior to leaving the site in a manner that is responsive to actual site conditions. A personnel decontamination area will be set up at an appropriate location specified by the SHSO. The decontamination process will consist of a series of procedures performed in a specific sequence. Each procedure is performed at a separate station in order to prevent cross-contamination.

#### **3.0 PROCEDURES**

##### **3.1 ASSOCIATED PROCEDURES**

The following WTPs should be reviewed in conjunction with this field effort:

<b>NUMBER</b>	<b>NAME</b>
1	General Instructions for Field Personnel

### 3.2 PREPARATION

#### 3.2.1 Office

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1 as well as the following actions:

- Ensure that sufficient decontamination supplies (including detergent, sufficient water, towels, decontamination solutions, etc.) are shipped to the site.

#### 3.2.2 Field

After arrival on site, but prior to commencement of operations, the following procedures should be employed:

- Verify that all required equipment and supplies for decontamination have arrived on site.
- Identify the location of and set up the decontamination area.

### 3.3 FIELD OPERATIONS

#### 3.3.1 Decontamination Facilities

A detergent solution will be adequate to remove the chemical constituents identified at DDMT. Wash tubs containing dilute detergent decontamination solution and soft-bristle brushes will be used to clean reusable personal protective clothing and boots. Following the detergent wash, equipment will be rinsed at least once using clean, potable water. Decontamination solutions and rinse waters will be drummed and disposed of in a manner consistent with the handling of hazardous wastes.

Trash receptacles will be provided for all disposable items. The receptacles will be conventional trash cans lined with heavy duty polyethylene trash bags.

Personal hygiene primarily entails washing and is not strictly considered decontamination. Each individual should conduct proper personal hygiene, which includes washing of hands, face and any exposed skin for 3 to 5 minutes prior to eating, drinking, smoking and leaving the site. It is recommended that each person shower at the end of each work day. Routine showering facilities will not be provided in

the Support Zone. OSHA (29 CFR 1910.120) requires that shower facilities be provided only when remediation exceeding six months in duration is performed on site.

### **3.3.2 Decontamination Equipment and Supplies**

Supplies that will be available for personnel decontamination procedures include:

- Tubes for washing and rinsing equipment
- Detergent (i.e., Alconox)
- Scrub brushes (soft bristle)
- Potable water source
- Drying rack for equipment drying
- Aluminum foil for wrapping clean equipment
- Respirator wipes and bags for clean respirator storage
- Paper towels
- Trash receptacles and polyethylene bags
- Hand soap
- Receptacle(s) for storage of decontamination liquid wastes pending disposal
- Drop cloths (polyethylene sheeting)

### **3.3.3 Decontamination Procedures**

#### **3.3.3.1 Level D Protection**

A minimum decontamination for Level D site work consists of cleaning and removal of boots and gloves, changing into street shoes before leaving the site, and washing hands and face. Because there is limited access to hand/face washing stations at DDMT, antibacterial wipes should be available to all personnel and all personnel are required to wash hands and face when a wash source becomes available.

#### **3.3.3.2 Level C-Protection**

The decontamination layout depicted in Attachment 13.1 will be adjusted to accommodate actual site conditions. Decontamination procedures for Level C include the following:

##### First Drop Site

1. Field equipment is placed at the first drop site for later decontamination.
2. Boot covers and gloves are washed with detergent solution and rinsed in clean, potable water.

3. Boot covers and outer gloves are removed. Inner boots and/or safety suit (non-disposable) are washed with a detergent solution and rinsed with clean, potable water.
4. Disposable clothing is removed and discarded into the trash receptacle.

#### Second Drop Site

1. Non-disposable inner gloves, hard hats, and boots are removed and deposited at a second drop site.
2. For respirator cartridge or canister change-over, the cartridge/canister can be replaced following decontamination of outer garments and removal of contaminated boot covers and outer gloves. Redress, including clean boot covers and outer gloves, is performed following the cartridge canister change. Return to work site.

#### Third Drop Site

1. Respirators are removed, washed, swabbed down with respirator wipes and bagged for storage. Used respirator cartridges are removed and disposed. Respirators are left at the third drop site for cleaning. A disinfectant solution (i.e., CIDEX) will be used on a regular basis to disinfect the respirators. (Note: Personnel with respiratory tract infections, however minor they may seem, should disinfect their respirators at least weekly).
2. Street shoes can be put on. All personnel will thoroughly wash face and hands before exiting the site.

#### **3.3.3.3 Level B Protection**

The decontamination layout depicted in Attachment 12.1 will be adjusted to accommodate actual site conditions. Decontamination procedures for Level B include the following:

#### First Drop Site

1. Field equipment is placed at the first drop site for later decontamination.
2. Non-disposable boots/boot covers, gloves and outer garments are washed with detergent solution and rinsed in clean water.

#### Second Drop Site

1. Boot covers and outer gloves are removed and disposed at second drop location. Inner boots and/or safety suit (non-disposable) are washed.

### Third Drop Site

1. For site exit, clothing, boots, inner gloves and hard hats are removed and deposited at a third drop site. SCBA equipment is removed and segregated for decontamination. Street shoes can be put on. All personnel are to thoroughly wash face and hands before exiting the site.
2. For SCBA tank change-out, SCBA tank can be replaced following decontamination of outer garments and removal of contaminated boot covers and outer gloves. Redress, including clean boot covers and outer gloves is performed following tank change. Return to work site.

**Note:** An occasional CIDEX or Clorox wash of inside of boots is recommended to alleviate odor problems. A thorough rinse is required after such use.

## **3.4 POST-OPERATION**

### **3.4.1 Field**

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

- Properly dispose of all soiled, disposable PPE.
- Properly dispose of any decontamination water.
- Complete logbook entries relevant to decontamination.
- Ensure that all decontamination equipment and associated supplies are properly stored
- Restore the decontamination area to its pre-arrival state (i.e., any trash generated as a result of decontamination operations should be properly disposed of).

### **3.4.2 Office**

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

- Submit logbook and any original forms to Task/Project Manager for review.
- Inventory all equipment and supplies shipped back to the office.

#### **4.0 REFERENCES**

LAW, 1996. Health and Safety Training for Hazardous Waste Operations: A 40-hr. Course. EnviroSource, Inc., Law Engineering and Environmental Services, Inc., Training Center. August 1996.

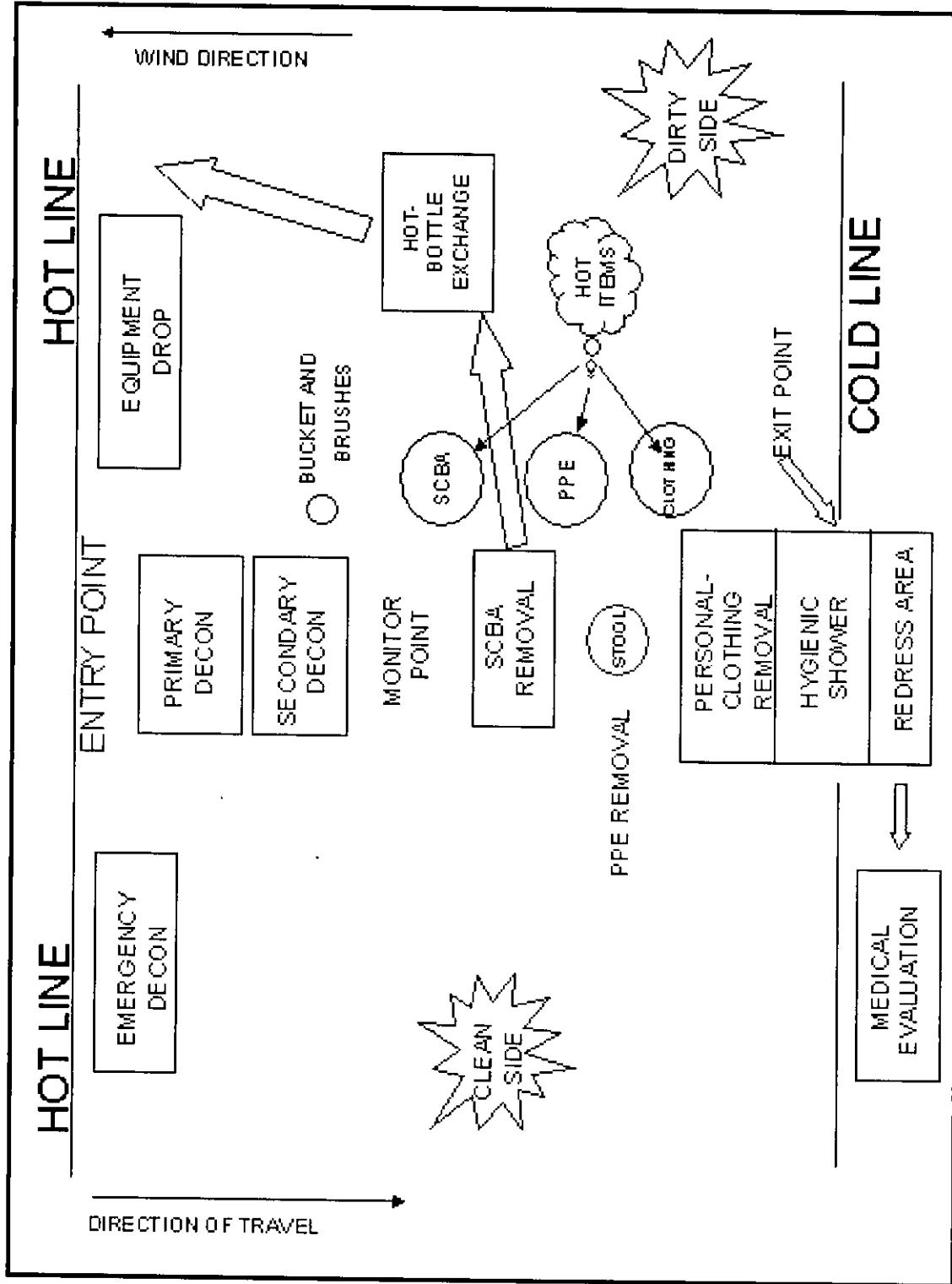
NIOSH/OSHA/USCG/EPA, 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. USDHHS.

#### **5.0 ATTACHMENTS**

Attachment 12.1 – Decontamination Layout

ATTACHMENT 12.1

DECONTAMINATION LAYOUT



**WORK AND TEST PROCEDURE 13**  
**HEALTH AND SAFETY MONITORING**

**1.0 PURPOSE**

The purpose of this Work and Test Procedure (WTP) is to provide guidance for monitoring levels of combustible gas and organic vapors. This monitoring is performed to minimize the risks to field personnel associated with combustible gases and to minimize on-site worker exposure to organic vapors through a preliminary identification of the concentration of organic compounds detectable with a photoionization detector (PID) or Flame Ionization Detector (FID).

**2.0 DISCUSSION**

Specific monitoring requirements will be provided in the work plan or HSP. Information gathered from air monitoring will be used to determine appropriate protective measures to be taken and assess off-site migration of contaminants released during construction activities or subsequent operation of remedial systems so that appropriate contingency plans and/or control measures can be implemented.

**2.1 COMBUSTIBLE GAS**

A combination combustible gas/oxygen/hydrogen sulfide indicator (EXOTOX 40) will be used to monitor combustible gas levels. The EXOTOX 40 has the capability to monitor for oxygen, explosive gases, and a “toxic” gas (carbon monoxide or hydrogen sulfide) simultaneously. Only one toxic gas can be fitted to the EXOTOX and is chosen at the time of order. The monitor does not have the capability to detect specific explosive gases, but quantitatively detects % lower explosive limit (LEL) by comparison with a known calibration gas (usually methane). The oxygen sensor calibration is affected by humidity, so calibration of this sensor should take place in conditions similar to the working environment.

The LEL refers to the lowest concentration of a combustible gas in air that will explode or support combustion. The upper explosive limit (UEL) is the highest concentration of a combustible gas in air that will support combustion or detonation. Generally, the combustibility of an atmosphere is defined in terms of a proportion of the LEL or UEL. Most combustible gas meters are calibrated to provide this information.

## 2.2 PHOTOIONIZATION DETECTOR

A commonly used air monitoring instrument is the PID. The instrument operates under the principle of photoionization, i.e., the absorption of light by a gas molecule resulting in the molecule's ionization. The sensor of the instrument consists of a sealed ultraviolet light source that emits photons at an energy level high enough to ionize most organic compounds, but not high enough to ionize the major components of air (i.e., O<sub>2</sub>, N<sub>2</sub>, CO, CO<sub>2</sub>, or H<sub>2</sub>O).

Most PIDs are designed for use with interchangeable probes with lamps of different energies (9.5 eV, 10.2 eV, and 11.7 eV). Lamps are selected based on the ionization potential (IP) of suspected contaminants on-site; the lamp energy must be equal to or greater than the IP of a compound for the compound to be detected. IPs for contaminants expected on-site can be found in the Health and Safety Plan. The PID is sensitive to many organic and inorganic vapors/gases and therefore, cannot be used as a qualitative instrument in unknown situations. It is strictly qualitative except when the nature of the contamination is known, and the instrument has been calibrated to that specific contaminant. High humidity decreases the sensitivity of the PID. Atmospheres with concentrations of gases above the detection limits of the instrument will cause inconsistent behavior.

## 2.3 FLAME IONIZATION DETECTOR

Another commonly used air monitoring instrument is the flame ionization detector (FID). The instrument operates by drawing in an aliquot of the gas or vapor under consideration into the instrument ionization chamber. The extracted gas is then ionized in a flame. A current is produced that is proportional to the number of carbon atoms present and this information is relayed to a meter or strip chart recorder. In many FID monitoring instruments, the instrument can be operated under two modes: survey mode and gas chromatography (GC) mode. In the survey mode, all organic compounds are detected at the same time; in the GC mode, volatile species are separated, thus enabling tentative identification and measurement of various compounds.

A limitation to the use of this instrument is that it does not detect any inorganic gases or vapors nor some synthetic gases. The instrument should not be used at temperatures less than 40° Fahrenheit. High concentrations of contaminants or oxygen-depleted environments will affect results and will require system modification. In the survey mode, readings reported are relative to the calibration standard used. Specific analyte identification requires calibration with the analyte of interest.

## 2.4 CHEMICAL-SPECIFIC DRAEGER TUBES

Chemical-specific detector tubes will be used in conjunction with the FID and PID to detect and quantify specific organic vapor levels at the sites. Detector tubes indicate the presence of a specific chemical by a color change in the tubes' packing material. A prespecified sample volume is drawn through the detector tube at a constant flow rate. If the sample contains the vapor or gas in question, it will react with the chemical on the packing material, resulting in a color change. The concentration of the vapor is directly proportional to the length of the stain. Detector tubes are pre-calibrated prior to being shipped from the manufacturer. The pump used in sampling must be checked regularly to verify flow rate and sample volume per pump stroke.

Problems contributing to poor accuracy of the detector tubes include the following: leaking pump, insufficient contact (analysis) time, high humidity and/or temperature, difficulty in reading the scale, interferences from other compounds, improperly stored tubes, outdated tubes, and operator error.

## 3.0 PROCEDURES

### 3.1 ASSOCIATED PROCEDURES

The following WTPs should be reviewed in conjunction with this WTP:

NUMBER	NAME
1	General Instructions for Field Personnel

### 3.2 PREPARATION

#### 3.2.1 Office

Prior to leaving the office for field work, the field team leader is responsible for activities listed in WTP 1, as well as the following actions:.

- Determine monitoring requirements by review of HSP
- Identify site contaminants to target or monitor
- Ship necessary equipment and calibration supplies

### 3.2.2 Field

After arrival on site, but prior to commencement of operations, the following procedures should be employed:

- Confirm all necessary equipment has arrived at the site
- Calibrate equipment as specified by the manufacturer

## 3.3 FIELD OPERATIONS

### 3.3.1 Field Operations

#### 3.3.1.1 Combustible Gases

Combustible gas monitoring will be performed at selected locations during intrusive site activities where vapor accumulation is considered likely, using a calibrated EXOTOX 40 portable multi-gas monitor. Action levels based on Lower Explosive Limit (LEL) readings monitored at the source are as follows:

<u>LEL Level</u>	<u>Action</u>
<10% LEL	None; proceed with work and continue monitoring
10 - 25% LEL	Potential explosion hazard; proceed with caution and monitor LEL levels closely, notify SSO
>25% LEL	Explosion hazard exists; stop work; evacuate site and ventilate area until levels of combustible gases fall below 25% LEL

#### 3.3.1.2 FID/PID

Monitoring for organic vapors will be performed in the breathing zone and/or at the source (as appropriate) to determine appropriate levels of PPE to be used during work. A PID or FID will be used in conjunction with chemical-specific detector tubes to detect and quantify organic vapor levels.

Ambient air in the breathing zone will be monitored for organic vapors at least once every 15 minutes during site operations and with every change in task or work location. Continuous monitoring will be conducted at locations where vapor buildup is a potential hazard. Since the PID/FID only provides non-specific quantitative readings, chemical-specific detector tubes (Draeger tubes) will also be used, as dictated by action levels, during field investigations to monitor for the presence of specific organic

vapors. Action levels for organic vapors and chemical detector tubes are project specific and are presented in the site-specific Health and Safety Plan.

Atmospheric monitoring measurements obtained are compared with 50% of the OSHA Permissible Exposure Limits (PELs) and/or 50% of the ACGIH Threshold Limit Values, whichever standard is lower. Site-specific action criteria based on the results of vapor monitoring are specified in the site-specific Health and Safety Plan.

### **3.3.1.3 Calibration**

All atmospheric monitoring equipment will be calibrated a minimum of two times daily in accordance with the manufacturer's instructions: before work begins; and in the afternoon of the work shift. Calibration procedures for each instrument can be found in the manufacturer's instruction manuals. An example of the calibration record form that will be used to record daily calibration is shown in Attachment 13.1.

The EXOTOX is factory-calibrated, but may be recalibrated by following manufacturer's instructions. H<sub>2</sub>S gas (or carbon monoxide), ambient fresh air, and methane gas are used in the calibration procedure.

The PID is factory-calibrated to a benzene gas standard. Calibration will be checked prior to and after each usage following procedures described in manufacturer's instruction manual. Isobutylene is used as a check gas for the on-site instrument calibration.

The FID is factory-calibrated to a Methane gas standard. Calibration will be checked prior to and after each usage following procedures described in manufacturer's instruction manual. Methane is used as a check gas for the on-site instrument calibration.

## **3.4 POST-OPERATION**

### **3.4.1 Field**

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

- Decontaminate any contaminated monitoring equipment.

- Complete logbook and required monitoring forms, making notations as to site conditions, anomalous readings, etc.
- Ensure that the site is cleaned to the condition that it was in prior to monitoring operations (i.e., all trash related to monitoring operations must be disposed of prior to departure from the site).

### **3.4.2 Office**

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

- Submit logbook and any original forms to Task/Project Manager for review.
- Inventory all equipment and supplies shipped back to the office.

## **4.0 REFERENCES**

NIOSH/OSHA/USCG/EPA, 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. USDHHS.

## **5.0 ATTACHMENTS**

Attachment 13.1 - Daily Instrument Calibration Form

876 190

*RASAP - Defense Depot Memphis Tennessee  
Volume I - Field Sampling Plan  
MACTEC Project No. 6301-05-0006*

November 2005  
Revision 1

**ATTACHMENT 13.1**  
**DAILY INSTRUMENT CALIBRATION FORM**

SITE LOCATION: \_\_\_\_\_ DATE: \_\_\_\_\_

CALIBRATION PERFORMED BY: \_\_\_\_\_

CALIBRATION STANDARD: \_\_\_\_\_ CONCENTRATION: \_\_\_\_\_

876 191

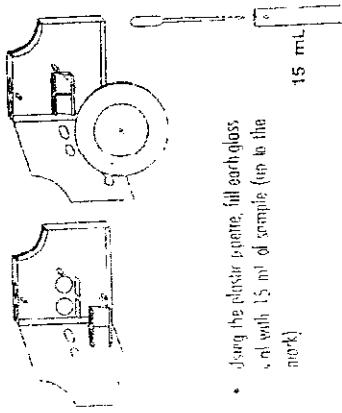
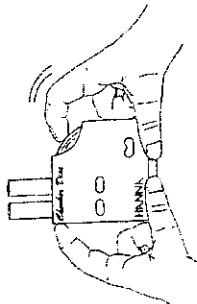
*RA SAP – Defense Depot Memphis, Tennessee*  
*Volume I – Field Sampling Plan*  
*MACTEC Project Nos. 6301-04-0002 & 6301-05-0006*

*November 2005*  
*Revision 1*

#### **APPENDIX C**

#### **FERROUS IRON AND CARBON DIOXIDE FIELD TEST KIT INSTRUCTIONS**

- Keep the checker disc at a distance of 30-40 cm (12-16") from the eye to match the color while having a uniform background (e.g. a white sheet). Rotate the disc while looking at the color test windows and stop when you find the color match. Read the value in the result window directly in mg/l (or ppm) of iron.



- Using the electric pipette, fill each glass vial with 15 mL of sample (up to the 15 mL mark).

## SIGNIFICANCE AND USE

Generally, ground and surface water contains no more than 1 mg/L (ppm) iron, but due to mining and industrial discharge, higher levels of iron have been observed. Iron in water appears to be more of a nuisance than a hazard. The presence of iron can stain laundry and give water a bitter-sweet taste.

The Hanna Test Kit determines the iron concentration in water by conversion of the ferrous ( $Fe^{2+}$ ) state. The test is fast and easy. The checker disc makes it simple to obtain the iron level in water.

Note: mg/L is equivalent to  $ppm$  (parts per million).

## CHEMICAL REACTION

Iron can exist as ferrous ( $Fe^{2+}$ ) or ferric ( $Fe^{3+}$ ) ions. The Hanna Test Kit determines both iron levels in water via a colorimetric method. First, all ferric ions are reduced by sodium sulfite to ferrous ions. Phenanthroline complexes with ferrous ion to form an orange colored solution. The color intensity of the solution determines the iron concentration.

Dear customer,  
Thank you for choosing a Hanna Product. Please read the instruction sheet carefully before using the test kit. It will provide you with the necessary information for correct use of the kit. If you need additional information, do not hesitate to e-mail us at [tech@hannainst.com](mailto:tech@hannainst.com). Remove the chemical test kit from the packing material and examine it carefully to make sure that no damage has occurred during shipping. If there is any noticeable damage, notify your Dealer or the nearest Hanna office immediately.

- Each kit is supplied with:
  - H1 3834-0 Reagent, powder (100 g).
  - 1 checker disc (containing a mirror, a mirror holder and the 38039 disc).
  - 2 glass vials with caps.
  - 1 plastic pipette (3 mL).

Note: Any damaged or defective item must be returned in its original packing materials.

## Instruction Manual

### SPECIFICATIONS

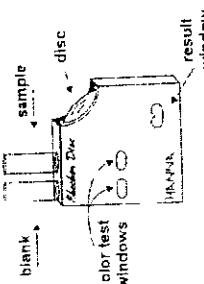
Range	0 to 15 mg/L (ppm) Fe
Smallest Increment	0.02 mg/L (ppm) Fe
Analysis Method	Colorimetric
Sample Size	15 mL
Number of Tests	100
Case Dimensions	235x175x15 mm (9 2/8" x 6 7/8" x 5 7/8")
Shipping Weight	476 g (1.54 lb.)

## HI 38039 Iron Low Range Test Kit with Checker Disc

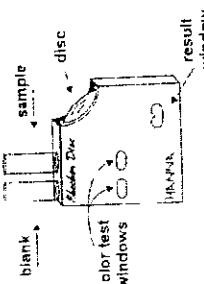


[www.hannainst.com](http://www.hannainst.com)

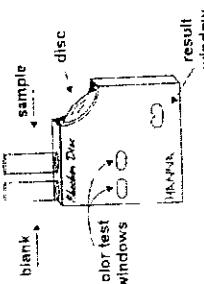
- Insert one of the vials into the left hand opening of the checker disc. This is the blank.



- Insert one of the vials into the left hand opening of the checker disc. This is the blank.



- Insert one of the vials into the right hand opening of the checker disc. This is the sample.



For best results, perform the reading three times and take the average value (divide by 3). The sum of the three numbers (intensely colored samples will make the color matching difficult and they should be adequately treated before performing the test. Suspended matter in large amounts should be removed by prior filtration).

Caution: Ultraviolet radiation may cause fading of color. When not in use, keep the disc protected from light in a cool and dry place.

Interferences: Molybdate and Molybdenum above 50 ppm calcium above 10000 ppm (as  $CaCO_3$ ), magnesium above 10000 ppm, chloride above 18500 ppm

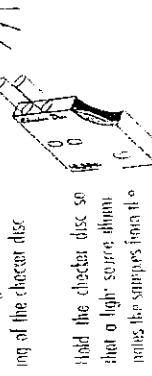
## REFERENCES

- 1987 Annual Book of ASTM Standard, Volume 11.0 Water (1), pages 531-535
- Standard Methods for the Examination of Water or Wastewater, 16th Edition, pages 215-219

## INSTRUCTIONS

### READ THE ENTIRE INSTRUCTIONS BEFORE USING THE KIT

- Verify that the mirror is broken and the disc are properly handled. Read the relevant Health and Safety Data Sheet before performing this test.



- Hold the checker disc so that a light source illuminates the sample from the top.

## Instruction Manual

### SPECIFICATIONS

Range	0 to 110 mg/l (ppm) Fe
Smallest Increment	0.7 mg/l (ppm) Fe
Analysis Method	Colorimetric
Sample Size	5 mL
Number of Tests	10
Case Dimensions	233 x 75 x 15 mm (9.14 x 2.95 x 0.59 in.)
Shipping Weight	980 g (34.7 oz.)

### SIGNIFICANCE AND USE

Generally, ground and surface water contains no more than 1 mg/l (ppm) iron, but due to mining and industrial discharge, higher levels of iron have been observed. Iron in water appears to be more of a concern than a hazard. The presence of iron can cause an object to give a poor billiard cue test. The Hanna Test Kit determines the iron concentration in water by conversion of the ferrous ( $Fe^{2+}$ ) state. The test is fast and easy. The checker disc makes it simple to obtain the iron level in water.

Note: mg/l is equivalent to ppm (parts per million).

### CHEMICAL REACTION

Iron exists as ferrous ( $Fe^{2+}$ ) or ferric ( $Fe^{3+}$ ) ions. The Hanna Test Kit determines total iron levels. If only one colorimetric method is used, iron is reduced to sodium sulfite to form iron phenanthroline complexes with ferrous ion to form an orange colored solution. The color intensity of the solution depends on the iron concentration.

## HI 38041 Iron High Range Test Kit with Checker Disc

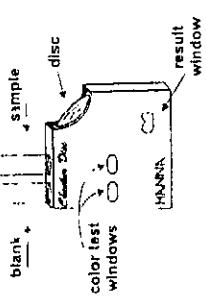
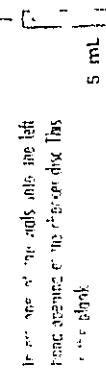


www.hannainst.com

### INSTRUCTIONS

#### FOR THE ENTIRE INSTRUCTIONS REFER USING THE KIT

- Bring the plastic vials full each glass vial with 5 mL of sample up to the mark.



Keep the checker disc at a distance of 30-40 cm (12-16") from the eyes to match the color, while having a uniform background (e.g. a white sheet). Place the disc while looking at the color test windows, and stop when you find the color match. Read the value in the result window and multiply it by 2 to obtain mg/l (ppm) of iron.

For best results, Perform the reading three times and take the average value (divide by 3 the sum of the three numbers). Intensely colored samples will make the color matching difficult and they should be adequately heated before performing the test. Suspended matter in large amounts should be removed by prior filtration.

Caution: Ultraviolet radiation may cause fading of colors. When not in use, keep the disc protected from light, in a cool and dry place.

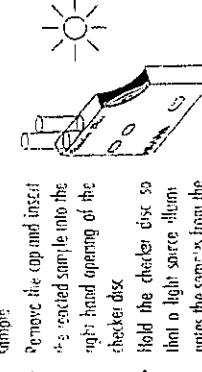
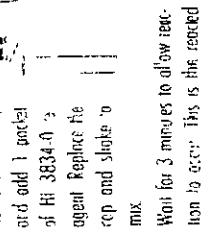
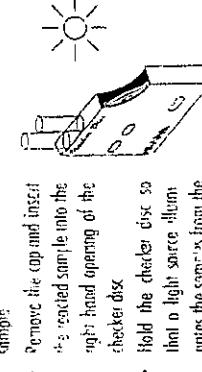
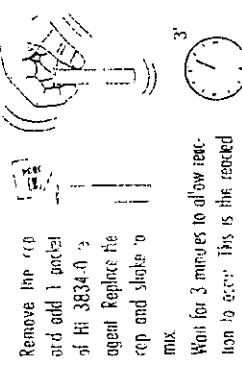
Interferences: Molybdate and Molybdenum above 30 ppm, chlorine above 10000 ppm (as  $Ca(ClO)_2$ ), magnesium above 100000 ppm, chloride above 185000 ppm

### REFERENCES

- 1987 Annual Book of ASTM Standard, Volume 11.01 Water (1), pages 53-535
- Standard Methods for the Examination of Water and Wastewater, 18<sup>th</sup> Edition, pages 215-219

### HEALTH AND SAFETY

The chemicals contained in this kit may be hazardous if improperly handled. Read the Material Health and Safety



- Remove top (top and insert and add 1 packet of HI 3834-0.)
- Replace the cap and shake to mix.
- Wait for 3 minutes to allow reaction to occur. This is the tested sample.
- Remove the top and insert right hand opening of the checker disc.
- Hold the checker disc so that a light source illuminates the sample from the back of the vial.

Dear Customer,  
Thank you for choosing a Hanna<sup>®</sup> product.  
Please read the instruction sheet carefully before using the test kit. It will provide you with the necessary information for correct use of the kit. If you need additional information, feel free to e-mail us at [tech@hannainst.com](mailto:tech@hannainst.com). Remove the chemical test kit from the packing material and examine it carefully to make sure that no damage has occurred during shipping. If there is any noticeable damage, notify your Dealer or the nearest Hanna office immediately.

- Each kit is supplied with:
  - HI 3834-0 Reagent, packets (100 pieces)
  - Distilled Water, 1 bottle (500 mL)
  - 1 checker disc (containing the 38040 disc),
  - 2 glass vials with caps
  - 1 plastic pipette (3 mL)
  - 1 long plastic pipette
- Note: Any damaged or defective item must be returned in original condition.

## Instruction Manual

## SIGNIFICANCE AND USE

Certain carbon dioxide levels are required in nature and in man's environment. Seawater makes old newsprint less than 10 mg/l. • carbon dioxide however, strengthens it. Infused water can generate large amounts due to evaporation or mineral decomposition. These results can make the water corrosive and toxic to aquatic life-forms like fish. The monitoring of carbon dioxide levels is also critical in the man-made environment. A certain amount of carbon dioxide is introduced into potable water during the initial stages of the water-treatment process. In water systems, a delicate balance of carbon dioxide must be maintained to prevent either corrosion or encrustation of pipes and storage tanks. Carbon dioxide levels can be measured quickly and safely with the Hanna Carbon Dioxide Test Kit. This compact, portable kit allows the user the choice of either dry or wet use. The design makes the kit easy to handle and accurate for HI 3818-0, practically prevents accidental injury or damage due to spills.

Note: right is equivalent to ppm (parts per million).

Remove the chemical test kit from the packing material and examine it carefully to make sure that no damage has occurred during shipping. If there is any noticeable damage, notify your dealer or the nearest Hanna office immediately.

Remove the chemical test kit from the packing material and examine it carefully to make sure that no damage has occurred during shipping. If there is any noticeable damage, notify your dealer or the nearest Hanna office immediately.

- Phenolphthalein indicator, 1 bottle (10 ml) with dropper.
- HI 3818-0 bottle (120 ml).
- 2 calibrated vessels (10 and 50 ml).
- 1 calibrated syringe.

Note: Any damaged or defective item must be returned in its original packing materials.

## SPECIFICATIONS

Range	0 to 10 mg/l (ppm) $\text{CO}_2$ 0 to 50 mg/l (ppm) $\text{CO}_2$ 0 to 100 mg/l (ppm) $\text{CO}_2$
Smallest Increment	0.1 mg/l [in the 0-10 mg/l range] 0.5 mg/l [in the 0-50 mg/l range] 1 mg/l [in the 0-100 mg/l range]
Analysis Method	Base titration using phenolphthalein indicator
Sample Size	5 ml, 10 ml and 50 ml
Number of Tests	110 (average)
Case Dimensions	200x120x60 mm (7.9x4.7x2.4")
Shipping Weight	460 g (1 lb)

## INSTRUCTIONS

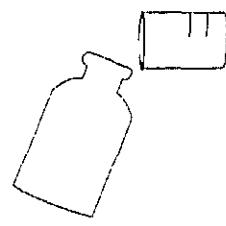
### READ ALL THE INSTRUCTIONS BEFORE USING THE TEST KIT LOOK AT THE BACK PAGE FOR THE ILLUSTRATED PROCEDURE

### Determination in the 0 to 100 mg/l Carbon Dioxide

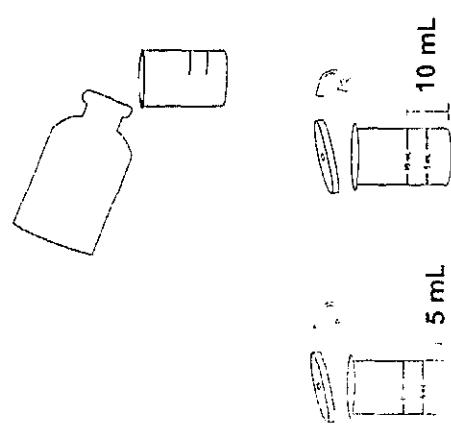
- Remove the cap from the small plastic vessel. Rinse the plastic vessel with water sample, fill to the 5 ml mark and replace the cap.
- Add 1 drop of Phenolphthalein indicator through the cap port, and mix thoroughly swirling the vessel in eight circles. If the solution is pink or red, then record as 0 mg/l  $\text{CO}_2$ . If the solution remains colorless, then proceed to next step.

<img alt="Diagram of a graduated cylinder with a stopper. A 5 ml mark is indicated. A 10 ml mark is indicated. A 15 ml mark is indicated. A 20 ml mark is indicated. A 25 ml mark is indicated. A 30 ml mark is indicated. A 35 ml mark is indicated. A 40 ml mark is indicated. A 45 ml mark is indicated. A 50 ml mark is indicated. A 55 ml mark is indicated. A 60 ml mark is indicated. A 65 ml mark is indicated. A 70 ml mark is indicated. A 75 ml mark is indicated. A 80 ml mark is indicated. A 85 ml mark is indicated. A 90 ml mark is indicated. A 95

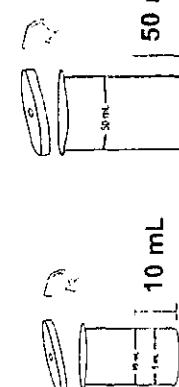
H1 3818 CARBON DIOXIDE TEST KIT



HANNA  
instruments

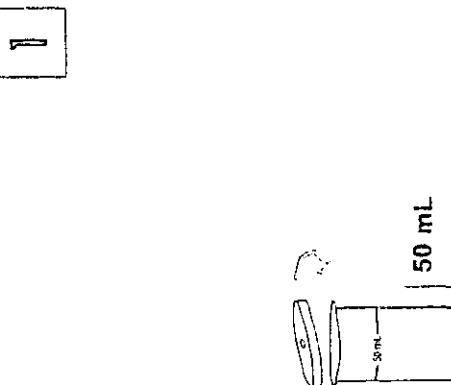


0-100 mg/L      0-50 mg/L      0-10 mg/L



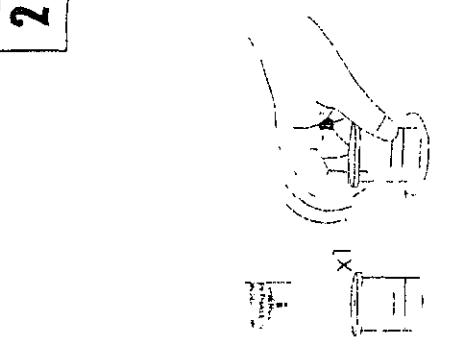
50 | 10 mL

0-100 mg/L	5 mL	0-50 mg/L	10 mL	0-10 mg/L
				50



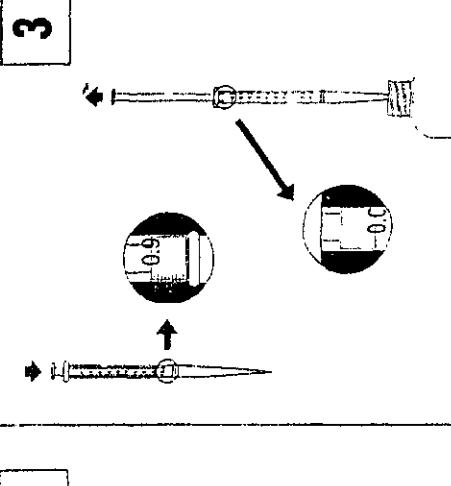
50 mL

50 mL



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十一



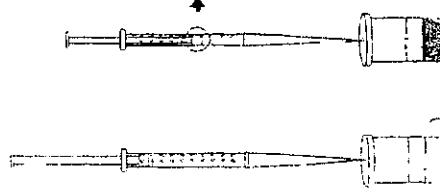
110

100-1000

5 mL sample

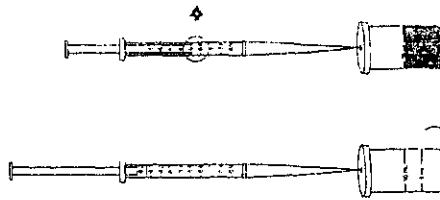
10 mL sample

50 mL samp

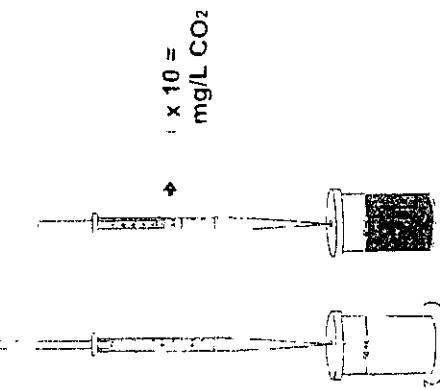


$$\times 100 =$$

$$\times 50 =$$



mg/L CO<sub>2</sub>



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1

#### APPENDIX D

#### GROUNDWATER SAMPLING REFERENCES

USEPA, 1996. *Low-flow (Minimal Drawdown) Ground-water Sampling Procedures*,  
EPA/540/S-95/504, USEPA Office of Solid Waste and Emergency Response, April 1996.

USGS, 2001. *User's Guide for Polyethylene-based Diffusion Bag Samplers to Obtain Volatile  
Organic Compound Concentrations in Wells, Part 1, Deployment, Recovery, Data Interpretation,  
and Quality Control and Assurance*, USGS, Columbia, SC, 2001.

United States  
Environmental Protection  
Agency

Office of  
Research and  
Development

Office of Solid Waste  
and Emergency  
Response

EPA/540/S-95/504  
April 1996



# Ground Water Issue

## LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls<sup>1</sup> and Michael J. Barcelona<sup>2</sup>

### Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

For further information contact: Robert Puls, 405-436-8543, Subsurface Remediation and Protection Division, NRMRL, Ada, Oklahoma.

### I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing

units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic units. With time it became apparent that conventional water supply generalizations of homogeneity did not adequately represent field data regarding pollution of these subsurface resources. The important role of heterogeneity became increasingly clear not only in geologic terms, but also in terms of complex physical,

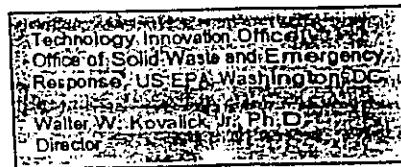
<sup>1</sup>National Risk Management Research Laboratory, U.S. EPA

<sup>2</sup>University of Michigan



Superfund Technology Support Center for  
Ground Water

National Risk Management Research Laboratory  
Subsurface Protection and Remediation Division  
Robert S. Kerr Environmental Research Center  
Ada, Oklahoma



objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new *in situ* remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry, analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

## II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

### A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with hybrid variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

- 1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;
- 2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and
- 3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

### B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

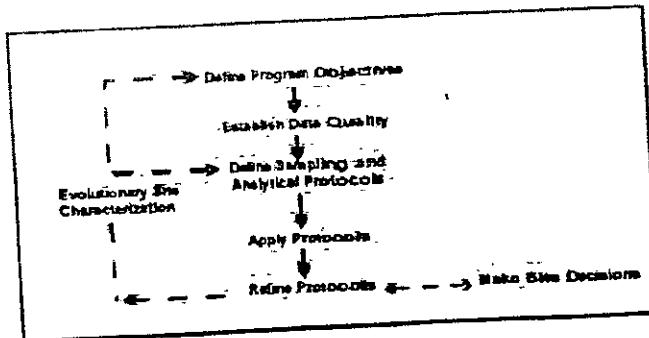


Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

#### A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

#### B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxida-

tion-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volume. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

#### C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the mobile load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

### 1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of low flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause significant drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

### 2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other grab type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of stagnant water in the casing and the dynamic water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

### E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over any other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

### F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a fix for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally dissolved [i.e., samples filtered with 0.45  $\mu$ m filters]) concentrations of major ions and trace metals, 0.1  $\mu$ m filters are recommended although 0.45  $\mu$ m filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO<sub>2</sub> composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g., oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0  $\mu$ m). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

### G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality

the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

#### A. Low-Permeability Formations (<0.1 L/min recharge)

##### 1. Low-Flow Purging and Sampling with Pumps

- a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.
- b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

##### 2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

#### B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

#### VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum, information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop - A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

#### VII. Notice

The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described herein as part of its in-house research program and under Contract No. 68-C4-0031 to Dynamac Corporation. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

#### VIII. References

- Backhus, D.A., J.N. Ryan, D.M. Groher, J.K. McFarlane, and P.M. Gschwend. 1993. Sampling Colloids and Colloid-Associated Contaminants in Ground Water. *Ground Water*, 31(3):466-479.
- Barcelona, M.J., J.A. Helfrich, E.E. Garske, and J.P. Gibb. 1984. A laboratory evaluation of groundwater sampling mechanisms. *Ground Water Monitoring Review*, 4(2):32-41.

# Questions about the MicroPurge concept

1. Is MicroPurge unique to QED?
2. Why should I go to MicroPurge sampling? What are the advantages?
3. Is the screen zone of a well really "flushed" by the aquifer?
4. Are there wells or sites that are not candidates for low-flow sampling?
5. What about low yield wells that draw down even at very low pumping rates?
6. Does a MicroPurge sample represent the entire screen zone, or just the area near the pump intake?
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10. What is a sufficient purge volume when MicroPurge sampling is used?
11. What are indicator parameters and why are they measured during purging?
12. What exactly is stabilization? How do I know when my readings are stable?
13. Isn't turbidity an indicator parameter? What role does it play in MicroPurge sampling?
14. What if my parameters don't stabilize?

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5. How often do you calibrate the Flow Cell?
6. Is there a chance of cross-contamination when using the Flow Cell?

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## FREQUENTLY ASKED QUESTIONS ABOUT MICROPURGE SAMPLING

**Questions about the MicroPurge concept****1. Is MicroPurge unique to QED?**

The term "MicroPurge" refers to the process of purging and sampling wells at low flow rates from within the well screen zone to minimize purging and improve sample quality. QED coined the term as a means of promoting the practice of low-impact sampling. While QED did not invent the process, we have been instrumental in bringing information on the MicroPurge concept to the marketplace and providing Well Wizard sampling equipment designed specifically for MicroPurge applications.

**2. Why should I go to MicroPurge sampling? What are the advantages?**

There are several advantages to the MicroPurge process, the most obvious being the reduction in purge volume (typically 90-95%) and the potential for time savings, especially in higher-yield wells. There are also additional cost saving and method control advantages to MicroPurge sampling. Sample quality and accuracy are improved through reduced turbidity in samples and minimized degassing and volatilization. In most cases, filtration of samples before analysis can be eliminated. Sample precision can also improve, since low-rate, low-volume pumping reduces mixing and dilution effects on the concentration of contaminants, improving consistency with each sampling event. Sampling systems are simpler and less expensive, as the need for high-flow purging pumps is eliminated. MicroPurge sampling can extend the useful life of a monitoring well and preserve the integrity of the filter pack by reducing the movement of fine sediments into the well that result from high-rate pumping. Health and safety advantages include reduced exposure of field personnel to potentially-contaminated purge water, and reduced liability from the off-site disposal of this water.

**3. Is the screen zone of a well really "flushed" by the aquifer?**

If there is any ground water movement in the well screen zone, and the well is properly constructed and in good condition, then water should pass continuously through the screen, since it is "hydraulically invisible" by design (the filter pack has greater hydraulic conductivity than the surrounding geologic material, and the screen is more conductive than the filter pack). In most cases, even minimal ground water flow is sufficient to maintain an exchange of water in the well screen to provide representative samples with minimal purging. Sampling this water without mixing or disturbing the water column is the basis for MicroPurge sampling.

**4. Are there wells or sites that are not candidates for low-flow sampling?**

MicroPurge sampling methods can be used in a wide range of hydrogeologic settings and at all types of facilities. The decision to use low-flow sampling methods is based on several factors, including purge water handling/disposal requirements, sample quality and precision concerns (especially turbidity control), monitoring program duration, and time and labor costs. While MicroPurge sampling could be applied almost anywhere, an analysis of the cost and quality benefits will typically be the basis for converting to

**Micropurge FAQ****MicroPurge sampling.****5. What about low yield wells that draw down even at very low pumping rates?**

If the yield of a well is too low to maintain minimal drawdown in the well at a very low pumping rate (100 ml/minute or less), the well could be sampled using a dedicated pump by purging only the volume of the sampling device and tubing. This method, termed "passive sampling", is considered to be at least as good as the traditional method of "evacuating" the well and sampling upon recovery, and would be considerably better than bailing a well that contains very little water. This concept is supported in the published literature, and supported by QED with specific system configurations for passive sampling.

**6. Does a MicroPurge sample represent the entire screen zone, or just the area near the pump intake?**

Since low-flow pumping does not induce sufficient flow to mix the water column, MicroPurge samples typically represent only the area of the well and surrounding formation immediately adjacent to the intake of the pump. Though this doesn't provide a fully mixed "composite" sample of the entire screen zone, as would a bailed sample, it will tend to be more accurate than a bailed sample and may allow identification of specific water-quality zones within a well screen. Pump placement becomes an issue for some users, and is dictated by factors such as knowledge of the geology in the screen zone of the borehole (from drilling logs, soil sampling logs or geophysical logs) and the type of contaminants anticipated (lighter than water, dissolved, or heavier than water). It is important to remember that well design and other hydrogeologic factors such as vertical gradients can play a role in the composition of the water in the screen zone, therefore, homogeneity of the water within the screen may occur regardless of purging or sampling methods used.

**7. What flow rate should be used for low-flow sampling?**

The flow rate used is dependent on the hydraulic performance of each well and the desire to minimize the mobilization of suspended colloidal material (turbidity). The proper flow rate for MicroPurge sampling in any given well should be based on the ability to establish a low flow rate at an acceptable level of drawdown (0.2 - 0.3 feet), and with minimal fluctuation of that dynamic water level during pumping. I suggest that a user start out at the minimum flow capability of the pump, then gradually increase the flow rate until some initial drawdown is observed. The flow rate can then be reduced slightly to achieve a stabilized pumping water level, and this rate should be established as the maximum purge rate for that well. In any case, the flow rate should not exceed 10 liter/minute, as higher rates will tend to increase turbidity.

**8. Why do I need to monitor the water level when MicroPurge sampling?**

Since the goal of low-flow MicroPurge sampling is to obtain a sample from the well screen zone, excessive drawdown of the water column in the well would cause mixing of

water from above the sampling point with the zone of interest. Most guidance suggests that drawdown should be kept to a maximum of 0.3 feet, with long water columns; this could vary, depending on the screen length, the location of the sampling pump intake in relation to the screen, and whether the top of the screen extends above the water table or is submerged.

**9. How do I get a water level reading without disturbing the water column in the well?**

Inserting a water level probe into the well shouldn't significantly disturb the water column. If this is a major concern, a dedicated water level measurement system could be a solution. Dedicated water level measurement devices, such as down-hole transducers or QED's pneumatic probes can also provide continuous readout of the water level during pumping, which simplifies the MicroPurge sampling process. Water column disturbance is also a consideration if the user must sound the well bottom. QED's dedicated bottom sounders that are used after sampling can solve this problem.

**10. What is a sufficient purge volume when MicroPurge sampling is used?**

This will depend on the choice of low-flow sampling methods, low-rate pumping or passive sampling. For low-rate pumping, the purge volume is dependent on the pumping rate used, the lower the rate, the smaller the volume required to achieve stabilization of indicator parameters. Typical volumes are as little as 2 liters or as much as 10 liters, with 4-8 liters being the average reported in published studies. If the passive sampling approach is used, the purge volume is dictated by the volume of the sampling device and tubing and is usually some multiple of this volume. For example, if the pump and tubing volume is 300 milliliters 450-600 milliliters may be the volume discarded prior to sampling.

**11. What are indicator parameters, and why are they measured during purging?**

Indicator parameters are water quality measurements, such as pH, conductivity, dissolved oxygen, and oxidation-reduction potential (ORP, or "redox") that can be used to identify relative changes in water chemistry. Measuring these parameters continuously during purging can identify when purging is completed. An initial change in the measurements typically indicates that water is being drawn from a different source ("active" versus "stagnant" water), and stabilization of these parameters would indicate that the water is coming from a steady-state source, the formation immediately surrounding the well screen near the pump intake.

**12. What exactly is stabilization? How do I know when my readings are stable?**

Stabilization can be defined as a designated range of measurement values determined over a period of time, a selected number of readings, or a selected volume of water. Stabilization criteria are typically user-defined or determined by regulatory guidance. Most users will define stabilization as three consecutive readings that are within a defined range, such as +/- 5% or 10%. Others may define stabilization in units of measurement,

**Micropurge FAQ**

such as three consecutive readings within +/- 0.1 pH unit, 0.1 C0, 0.1 PPM DO, and 5.0 conductivity units. The time interval between readings is usually dictated by the pumping rate, and may be as little as 1 minute apart, or as much as 3-5 minutes apart.

**13. Isn't turbidity an indicator parameter? What role does it play in MicroPurge sampling?**

Turbidity is not an indicator of water chemistry, and therefore is not an indicator of a change in ground water chemistry, such as might occur when purging a monitoring well prior to sampling. Turbidity is a general indicator of water quality (suspended solids), and the level of turbidity in a ground water sample could affect the ability to determine accurately the dissolved concentration of organic or inorganic analytes in a sample. The actual turbidity value that might affect analyte concentration can vary based on the nature of the solids present and the characteristics of the analytes of interest. Many regulatory guidelines recommend 5 NTU or less, which is a secondary drinking water standard for water supply wells. Natural turbidity in ground water can exceed 5 NTU, and may be considerably higher. The only way to scientifically determine the level of turbidity that will artificially affect sample analysis is to compare a true "dissolved" sample (filtered at 0.1 micron) with a "total metals" sample to identify any significant difference in analyte concentrations. In summary, turbidity values don't directly indicate when purging is completed, but turbidity measurements are valuable in interpreting analytical data from unfiltered samples for dissolved metals.

**14. What if my parameters don't stabilize?**

If stabilization does not occur, it may be the result of excessive pumping rates that caused drawdown and mixing within the water column. Research has shown that dependable parameters such as DO and conductivity will stabilize readily at low pumping rates within a very small purge volume, usually less than 10 liters. If a MicroPurge user can't achieve stabilization, it may be due to problems with flow rate control or the precision of the instruments used for measurement.

**Questions about regulatory acceptance of MicroPurge sampling****1. Has MicroPurge been approved by my state/EPA region/EPA Headquarters?**

This is the most frequently asked MicroPurge question! The answer is **three-part**:

1. Many regulatory agencies accept the MicroPurge concept, with some having specific guidance or SOPs for its use. Approval is typically given on a sit-by-site basis.

2. MicroPurge sampling has been accepted by a majority of states and EPA regions. Contact QED if you aren't certain about a specific agency.

## Micropurge FAQ

3. MicroPurge has been written into some recent EPA documents, most notably the recent Ground Water Issue publication "Low-Flow (Minimal Drawdown) Sampling Procedures" EPA Publication # EPA/540/S-95/504. It is also included in other general guidance documents such as Region VIII's SOP #4.1 on Well Purging, Region I's draft SOP for Low Flow Purging and Sampling, and Region IX's Quick Reference Advisory on low-flow sampling. Call QED if you need a copy of these documents.

### 2. Who is using MicroPurge sampling in my state or EPA Region?

MicroPurge users now exist in most of the states, and nearly all EPA regions. QED can provide you with names of selected references in your area, and contact names for many regulatory agencies

### 3. How do I propose MicroPurge sampling to my regulators? Do I have to change my sampling and analysis plan (SAP)?

The most common way to get MicroPurge acceptance from a regulator is to propose its use by submitting a modification to an existing SAP, or submitting an SAP for a new site incorporating MicroPurge methods. Many regulators like to see some supporting literature if they're not familiar with MicroPurge yet. QED can provide you with copies of a number of published papers that support MicroPurge methods. Occasionally, some regulators want to see a pilot demonstration of the process for some sites, or a comparison of the MicroPurge method with the current purging and sampling methods used. Some published papers have data comparisons that may satisfy the method comparison requirements. With the wide and gaining acceptance of MicroPurge, SAP changes to accommodate low-flow revisions are becoming simpler, and the cost of the time and paperwork required are small, especially when compared to the cost savings to be gained

### 4. Is QED working with the regulators to gain wider acceptance for MicroPurge?

QED has made presentations on MicroPurge to many state agencies, eight EPA regions, and numerous industry conferences and seminars. We will continue to make these presentations to additional agencies and groups as needed. Additionally, we are occasionally asked to comment on state and EPA documents on sampling and MicroPurge methods. If you need regulatory support in your territory, contact QED for information

## Questions about sampling equipment and MicroPurge sampling

### 1. What type of sampling devices are acceptable for MicroPurge sampling?

Low-flow sampling is not restricted to a particular type or brand of pump; any device that can reliably operate continuously at very low flow rates from the sampling depth required can be used. Of course, consideration should be given to ease of flow rate adjustability.

**Micropurge FAQ**

accuracy and precision of sample quality, and long-term operation and maintenance costs. Generally, it is best to use a device that is specifically designed for ground-water sampling at low flow rates. Of these devices, bladder pumps typically provide the best combination of accuracy, ease of use and reliability, and are widely accepted by regulators for all ground-water sampling applications.

**2. Why can't bailers and inertial-lift pumps be used for MicroPurge sampling?**

As stated in the U.S. EPA's Ground Water Issue paper on low-flow sampling, "Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water, which causes mixing of these stagnant waters and the dynamic waters within the screened interval." Bailers and inertial-lift pumps cause this mixing, dramatically increase turbidity, and can introduce uncontrolled operator variability. Due to the disturbance these devices create in the sampling zone, they are considered inappropriate for MicroPurge sampling.

**3. Can I use a portable pump for MicroPurge sampling, or is dedicated equipment required?**

While portable pumps can be used for low-flow sampling, the choice between dedicated and portable pumps will have the greatest impact on the time required to achieve parameter stabilization and the resulting purge volume generated. Portable pumps will cause some mixing of the stagnant and dynamic water zones and resuspension of solids that have settled in the well, directly affecting the time required for purging, by as much as 50-100% or more. Besides reducing the purging time and volume, dedicated pumps further reduce sampling time and control costs by reducing equipment set-up, eliminating decontamination and equipment blank samples, and improving sample consistency and method control. Dedicated equipment is strongly recommended for wells that will undergo routine sampling over time.

**4. Is a flow cell required for MicroPurge, or can separate instruments be used?**

To successfully accomplish taking readings when low-rate purging, a flow cell is the only practical way to measure multiple parameters in short time intervals. If passive sampling is used, stabilization is not an issue and separate instruments could be used, especially where the purge volume is insufficient to fill the cell. Systems such as QED's MP20 Flow Cell can measure up to six parameters simultaneously, and 100 frames of data can be automatically saved for review and recording, saving time in field data management.

**5. How often do you calibrate the Flow Cell?**

It's important to distinguish between checking calibration and calibrating. Calibration of the pH, conductivity and dissolved oxygen should be checked each time the MP20 Flow Cell is used, usually at the beginning of each day. The MP20 will hold its calibration for a long time compared to some instruments, but should be recalibrated when checking indicates inaccurate readings.

**6. Is there a chance of cross-contamination when using the Flow Cell?**

Samples are usually taken upstream of the MP20 Flow Cell, so cross-contamination of samples shouldn't occur. This can be done by either by disconnecting the tubing before sampling or using an optional in-line T fitting and valve assembly. Using the T fitting will decrease the flow through the cell, and may affect reading values during sampling.



# USER'S GUIDE FOR POLYETHYLENE-BASED PASSIVE DIFFUSION BAG SAMPLERS TO OBTAIN VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN WELLS

## PART 1: DEPLOYMENT, RECOVERY, DATA INTERPRETATION, AND QUALITY CONTROL AND ASSURANCE

Water-Resources Investigations Report 01-4060

Prepared in cooperation with the

**U.S. AIR FORCE**

**U.S. NAVAL FACILITIES ENGINEERING COMMAND**

**U.S. ENVIRONMENTAL PROTECTION AGENCY**

**FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE**

**DEFENSE LOGISTICS AGENCY**

**U.S. ARMY CORPS OF ENGINEERS and**

**INTERSTATE TECHNOLOGY REGULATORY COOPERATION WORK GROUP**

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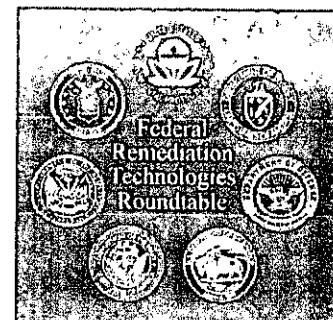


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# User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells

*Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance*

*By* Don A. Vroblesky

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## Conversion Factors, Vertical Datum, Acronyms, and Abbreviations

Multiply	By	To obtain
<i>Length</i>		
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1,609	kilometer
<i>Area</i>		
square mile (mi <sup>2</sup> )	2,590	square kilometer
<i>Flow</i>		
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft <sup>2</sup> /d)	0.09294	meter squared per day
gallon per minute (gal/min)	0.06308	liter per second
gallon per day (gal/d)	0.003785	cubic meter per day
inch per year (in/yr)	25.4	millimeter per year
<i>Volume</i>		
gallon (gal)	3,785	liter

*Temperature* is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation, °F = 9/5 (°C) + 32.

*Sea level* refers to the National Geodetic Vertical Datum of 1929 (NGVD) of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

*Chemical concentration* in water is expressed in metric units as milligrams per liter (mg/L) or micrograms per liter (µg/L).

## Additional Abbreviations

EDB	1,2-Dibromomethane
AFCEE	Air Force Center for Environmental Excellence
cDCE	cis-1,2-Dibromoethene
ft <sup>3</sup> /d	cubic feet per day
ft <sup>3</sup> /mg	cubic feet per milligram
°C	degrees Celsius
g	gram
ITRC	Interstate Technology Regulatory Cooperation
LDPE	low-density polyethylene
L	liter
µg	microgram
µm	micrometer
µL	microliter
mg	milligram
mL	milliliter
mL/min	milliliter per minute
MTBE	Methyl- <i>tert</i> -butyl ether
NAVFAC	Naval Facilities Engineering Command
NAPL	non-aqueous phase liquid
PDB	passive diffusion bag
PCE	Tetrachloroethene
TCE	Trichloroethene
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOA	Volatile organic analysis
VOC	Volatile organic compound

# User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells

## Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance

By Don A. Vroblesky

### EXECUTIVE SUMMARY

Water-filled passive diffusion bag (PDB) samplers described in this report are suitable for obtaining concentrations of a variety of volatile organic compounds (VOCs) in ground water at monitoring wells. The suggested application of the method is for long-term monitoring of VOCs in ground-water wells at well-characterized sites.

The effectiveness of the use of a single PDB sampler in a well is dependent on the assumption that there is horizontal flow through the well screen and that the quality of the water is representative of the ground water in the aquifer directly adjacent to the screen. If there are vertical components of intra-bore-hole flow, multiple intervals of the formation contributing to flow, or varying concentrations of VOCs vertically within the screened or open interval, then a multiple deployment of PDB samplers within a well may be more appropriate for sampling the well.

A typical PDB sampler consists of a low-density polyethylene (LDPE) lay-flat tube closed at both ends and containing deionized water. The sampler is positioned at the target horizon of the well by attachment to a weighted line or fixed pipe.

The amount of time that the sampler should be left in the well prior to recovery depends on the time required by the PDB sampler to equilibrate with ambient water and the time required for the environmental disturbance caused by sampler deployment to return to ambient conditions. The rate that the water within the PDB sampler equilibrates with ambient water depends on multiple factors, including the type of compound being sampled and the water temperature. The concentrations of benzene, *cis*-1,2-dichloroethene,

tetrachloroethene, trichloroethene, toluene, naphthalene, 1,2-dibromoethane, and total xylenes within the PDB samplers equilibrated with the concentrations in an aqueous mixture of those compounds surrounding the samplers under laboratory conditions within approximately 48 hours at 21 degrees Celsius (°C). A subsequent laboratory study of mixed VOCs at 10 °C showed that tetrachloroethene and trichloroethene were equilibrated by about 52 hours, but other compounds required longer equilibration times. Chloroethane, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and 1,1-dichloroethene were not equilibrated at 52 hours, but appeared to be equilibrated by the next sampling point at 93 hours. Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane were not equilibrated at 93 hours, but were equilibrated by the next sampling point at 166 hours. Different equilibration times may exist for other compounds. Differences in equilibration times, if any, between single-solute or mixed VOC solutions have not yet been thoroughly examined.

The samplers should be left in place long enough for the well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment. Laboratory and field data suggest that 2 weeks of equilibration probably is adequate for many applications; therefore, a minimum equilibration time of 2 weeks is suggested. In less permeable formations, longer equilibration times may be required. When applying PDB samplers in waters colder than previously tested (10 °C) or for compounds without sufficient corroborating data, a side-by-side comparison with conventional methodology is advisable to justify the field equilibration time.

Following the initial equilibration period, the samplers maintain equilibrium concentrations with the ambient water until recovery. Thus, there is no specified time for sampler recovery after initial equilibration. PDB samplers routinely have been left in ground waters having concentrations of greater than 500 parts per million (ppm) of trichloroethylene for 3 months at a time with no loss of bag integrity, and at one site, the PDB samplers have been left in place in VOC-contaminated ground water for 1 year with no reported loss of sampler integrity. The effects of long-term (greater than 1 month) PDB-sampler deployment on sampler and sample integrity have not yet been thoroughly tested for a broad range of compounds and concentrations, however. Moreover, in some environments, development of a biofilm on the polyethylene may be a consequence of long-term deployment. Investigations of semipermeable membrane devices (SPMDs) have shown that the transfer of some compounds across a heavily biotouched polyethylene membrane may be reduced, but not stopped. If a heavy organic coating is observed on a PDB sampler, it is advisable to determine the integrity of the sample by comparison to a conventional sampling method before continuing to use PDB samplers for long term deployment in that well.

Recovery consists of removing the samplers from the well and immediately transferring the enclosed water to 40-milliliter sampling vials for analysis. The resulting concentrations represent an integration of chemical changes over the most recent portion of the equilibration period (approximately 48 to 166 hours, depending on the water temperature and the type of compound).

The method has both advantages and limitations when compared to other sampling methods. Advantages include the potential for PDB samplers to eliminate or substantially reduce the amount of purge water associated with sampling. The samplers are relatively inexpensive and easy to deploy and recover. Because PDB samplers are disposable, there is no downhole equipment to be decontaminated between wells, and there is a minimum amount of field equipment required. The samplers also have the potential to delineate contaminant stratification in the formation across the open or screened intervals of monitoring wells where vertical hydraulic gradients are not present. In addition, the samplers integrate concentrations over time, which may range between about 48 to 166 hours depending on the compound of interest. Because the pore size of LDPE is only about

10 angstroms or less, sediment does not pass through the membrane into the bag. Thus, PDB samplers are not subject to interferences from turbidity. In addition, none of the data collected suggest that VOCs leach from the LDPE material, or that there is a detrimental effect on the VOC sample from the PDB material.

Water-filled polyethylene PDB samplers are not appropriate for all compounds. The samplers are not suitable for inorganic ions and have a limited applicability for non-VOCs and for some VOCs. For example, although methyl-*tert*-butyl ether and acetone and most semivolatile compounds are transmitted through the polyethylene bag, laboratory tests have shown that the resulting concentrations were lower than in ambient water. A variety of factors influence the ability of compounds to diffuse through the polyethylene. These factors include the molecular size and shape and the hydrophobic nature of the compound. Unpublished laboratory test data of semivolatile compounds in contact with PDB samplers showed a higher concentration of phthalates inside the PDB sampler than outside the PDB sampler, suggesting that the polyethylene may contribute phthalates to the enclosed water. Thus, the samplers should not be used to sample for phthalates.

VOC concentrations in PDB samplers represent concentrations in the vicinity of the sampler within the well screen or open interval. This may be a limitation for PDB samplers and some other types of sampling, such as low-flow sampling, if the ground-water contamination is above or below the screen or not in the sample intervals providing water movement to the PDB samplers. If there is a vertical hydraulic gradient in the well, then the concentrations in the sampler may represent the concentrations in the water flowing vertically past the sampler rather than in the formation directly adjacent to the sampler. Vertically spaced multiple PDB samplers may be needed in chemically stratified wells or where flow patterns through the screen change as a result of ground-water pumping or seasonal water-level fluctuations.

The purposes of this document are to present methods for PDB sampler deployment, and recovery; to discuss approaches to determine the applicability of passive diffusion samplers; and to discuss various factors influencing interpretation of the data. The intended audience for the methodology sections of this report is managers and field personnel involved in using PDB samplers. The discussion of passive diffusion sampler applicability and interpretation of the data is

suites for project managers, technical personnel, and the regulatory community. Part 2 of this report presents case studies of PDB sampler field applications.

## INTRODUCTION

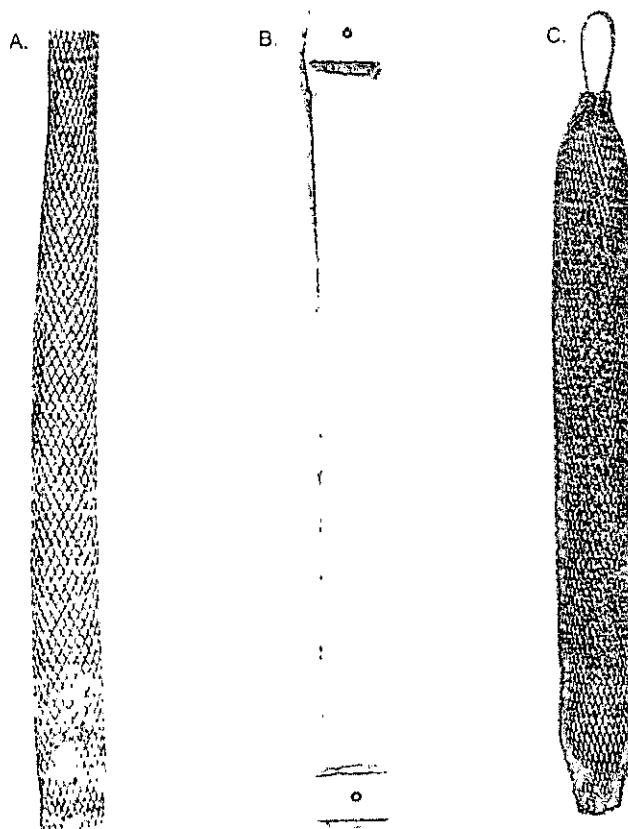
The use of PDB samplers for collecting ground-water samples from wells offers a cost-effective approach to long-term monitoring of VOCs at well-characterized sites (Vroblesky and Hyde, 1997; Gefell and others, 1999). The effectiveness of the use of a single PDB sampler in a well is dependent on the assumption that there is horizontal flow through the well screen and that the quality of the water is representative of the ground water in the aquifer directly adjacent to the screen. If there are vertical components of intra-borehole flow, multiple intervals of the formation contributing to flow, or varying concentrations of VOCs vertically within the screened or open interval, then deployment of multiple PDB samplers within a well may be more appropriate for sampling the well.

The samplers consist of deionized water enclosed in a LDPE sleeve (fig. 1) and are deployed adjacent to a target horizon within a screened or open interval of a well. The suggested application is for long-term monitoring of VOCs in ground-water wells. Where the screened interval is greater than 10 feet (ft), the potential for contaminant stratification and/or intra-borehole flow within the screened interval is greater than in screened intervals shorter than 10 ft. It is important that the vertical distribution of contaminants be determined in wells having 10-ft-long well screens, and that both the vertical distribution of contaminants and the potential for intra-borehole flow be determined in wells having screens longer than 10 ft. For many VOCs of environmental interest (table 1), the VOC concentration in water within the sampler approaches the VOC concentration in water outside of the PDB sampler over an equilibration period. The resulting concentrations represent an integration of chemical changes over the most recent part of the equilibration period (approximately 48 to 166 hours, depending on the water temperature and the type of compound being sampled). The approach is inexpensive and has the potential to eliminate or substantially reduce the amount of purge water removed from the well.

A variety of PDB samplers have been utilized in well applications (fig. 1). Although the samplers vary in specific construction details, a typical PDB sampler consists of a 1- to 2-ft-long LDPE tube closed at both ends and containing laboratory-grade deionized water (fig. 1). The typical diameter for PDB samplers used in a 2-inch-diameter well is approximately 1.2 inches; however, other dimensions may be used to match the well diameter. Equilibration times may be longer for larger diameter PDB samplers. On the outside of the PDB sampler, a low-density polyethylene-mesh sometimes is used for protection against abrasion in open boreholes and as a means of attachment at the prescribed depth. The PDB sampler can be positioned at the target horizon by attachment to a weighted line or by attachment to a fixed pipe.

PDB samplers for use in wells are available commercially. Authorized distributors as of March 2001 are Columbia Analytical Services (800-695-7222; [www.caslab.com](http://www.caslab.com)) and Eon Products (800-474-2490, [www.eonpro.com](http://www.eonpro.com)). A current list of vendors and PDB-sampler construction details can be obtained from the U.S. Geological Survey Technology Transfer Enterprise Office, Mail Stop 211, National Center, 12201 Sunrise Valley Drive, Reston, Virginia 20192 (telephone 703-648-4344, fax 703-648-4408). PDB samplers employ patented technology (U.S. patent number 5,804,743), and therefore, require that the user purchase commercially produced samplers from a licensed manufacturer or purchase a nonexclusive license for sampler construction from the U.S. Geological Survey Technology Enterprise Office at the above address.

The purposes of this document are to present methods for PDB sampler deployment, and recovery; to discuss approaches for determining the applicability of passive diffusion samplers; and to discuss various factors influencing interpretation of the data. The intended audience for the methodology sections of this report is managers and field personnel involved in using PDB samplers. The discussion of PDB sampler applicability and interpretation of the data is suited for project managers, technical personnel, and the regulatory community. Part 2 of this report presents case studies of PDB-sampler field applications.



**Figure 1.** Typical water-filled passive diffusion bag samplers used in wells, including (A) diffusion bag with polyethylene mesh, (B) diffusion bag without mesh, and (C) bag and mesh attached to baffle bottom.

**Table 1** Compounds tested under laboratory conditions for use with passive diffusion bag samplers  
[From Vroblesky and Campbell, 2001]

Tested compounds showing good correlation (average differences in concentration of 11 percent or less between diffusion-sampler water and test-vessel water) in laboratory tests

Benzene	2-Chlorovinyl ether	<i>cis</i> -1,2-Dichloroethene	1,1,1-Trichloroethane
Bromodichloromethane	Dibromochloromethane	<i>trans</i> -1,2-Dichloroethene	1,1,2-Trichloroethane
Bromotorm	Dibromomethane	1,2-Dichloropropane	Trichloroethene
Chlorobenzene	1,2-Dichlorobenzene	<i>cis</i> -Dichloropropene	Trichlorofluoromethane
Carbon tetrachloride	1,3-Dichlorobenzene	1,2-Dibromoethane	1,2,3-Trichloropropane
Chloroethane	1,4-Dichlorobenzene	<i>trans</i> -1,3-Dichloropropene	1,1,2,2-Tetrachloroethane
Chloroform	Dichlorodifluoromethane	Ethyl benzene	Tetrachloroethene
Chloromethane	1,2-Dichloroethane	Naphthalene	Vinyl chloride
	1,1-Dichloroethene	Toluene	Total xylenes

Tested compounds showing poor correlation (average differences in concentration greater than 20 percent between diffusion-sampler water and test-vessel water) in laboratory tests

Acetone*	Methyl- <i>tert</i> -butyl ether	Styrene
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\*T.M. Sivavec and S.S. Baghel, General Electric Company, written commun., 2000.

## Summary of Passive Diffusion Bag Sampler Advantages and Limitations

### Advantages

1. PDB samplers have the potential to eliminate or substantially reduce the amount of purge water associated with sampling.
2. PDB samplers are inexpensive.
3. The samplers are easy to deploy and recover.
4. Because PDB samplers are disposable, there is no downhole equipment to be decontaminated between wells.
5. A minimal amount of field equipment is required.
6. Sampler recovery is rapid. Because of the small amount of time and equipment required for the sampling event, the method is practical for use where access is a problem or where discretion is desirable (that is, residential communities, business districts, or busy streets where vehicle traffic control is a concern).
7. Multiple PDB samplers, distributed vertically along the screened or open interval, may be used in conjunction with borehole flow meter testing to gain insight on the movement of contaminants into and out of the well screen or open interval or to locate the zone of highest concentration in the well. Analytical costs when using multiple PDB samplers sometimes can be reduced by selecting a limited number of the samplers for laboratory analysis based on screening by using field gas chromatography at the time of sample collection.
8. Because the pore size of LDPE is only about 10 angstroms or less, sediment does not pass through the membrane into the bag. Thus, PDB samplers are not subject to interferences from turbidity. In addition, none of the data collected suggest that VOCs leach from the LDPE material or that there is a detrimental effect from the PDB material on the VOC sample.

### Limitations

1. PDB samplers integrate concentrations over time. This may be a limitation if the goal of sampling is to collect a representative sample at a point in time in an aquifer where VOC-concentrations substantially change more rapidly than the samplers equilibrate. Laboratory results obtained indicate that a variety of compounds equilibrated within 48 hours at 21 °C (Vroblesky and Campbell, 2001). Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane may require between 93 and 166 hours to equilibrate at 10 °C (T.M. Sivavec and S.S. Baghel, General Electric Company, written commun., 2000). The initial equilibration under field conditions may be longer to allow

well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment.

2. Water-filled polyethylene PDB samplers are not appropriate for all compounds. For example, although methyl-*tert*-butyl ether and acetone (Vroblesky, 2000; Paul Hare, General Electric Company, oral commun., 2000) and most semivolatile compounds are transmitted through the polyethylene bag, laboratory tests have shown that the resulting concentrations were lower than in ambient water. A variety of factors influence the ability of compounds to diffuse through the polyethylene membrane. These factors include the molecular size and shape and the hydrophobic nature of the compound. Compounds having a cross-sectional diameter of about 10 angstroms or larger (such as humic acids) do not pass through the polyethylene because the largest (transient) pores in polyethylene do not exceed about 10 angstroms in diameter (Flynn and Yalkowsky, 1972; Hwang and Kammermeyer, 1975; Cornyn, 1985). The samplers are not appropriate for hydrophilic polar molecules, such as inorganic ions. A detailed discussion of the relation between hydrophobicity and compound transport through polyethylene can be found in Gale (1998). Unpublished laboratory test data (D.A. Vroblesky, U.S. Geological Survey, written commun., 1998) of semi-volatile compounds in contact with PDB samplers showed a higher concentration of phthalates inside the PDB sampler than outside the PDB sampler, suggesting that the polyethylene may contribute phthalates to the enclosed water. Thus, the samplers should not be used to sample for phthalates.

3. PDB samplers rely on the free movement of water through the well screen. In situations where ground water flows horizontally through the well screen, the VOC concentrations in the open interval of the well probably are representative of the aquifer water in the adjacent formation (Gillham and others, 1985; Robin and Gillham, 1987; Kearn and others, 1992; Powell and Puls, 1993; Vroblesky and Hyde, 1997). In these situations, the VOC concentration of the water in contact with the PDB samplers, and therefore, the water within the diffusion samplers, probably represents local conditions in the adjacent aquifer. However, if the well screen is less permeable than the aquifer or the sandpack, then under ambient conditions, flowlines may be diverted around the screen. Such a situation may arise from inadequate well development or from iron bacterial fouling of the well screen. In this case, the VOC concentrations in the PDB samplers may not represent concentrations in

the formation water because of inadequate exchange across the well screen. PDB samplers have not yet been adequately tested to determine their response under such conditions.

4. VOC concentrations in PDB samplers represent ground-water concentrations in the vicinity of the screened or open well interval that move to the sampler under ambient flow conditions. This is a limitation if the ground-water contamination lies above or below the well screen or open interval, and requires the operation of a pump to conduct contaminants into the well for sampling.

5. In cases where the well screen or open interval transects zones of differing hydraulic head and variable contaminant concentrations, VOC concentrations obtained using a PDB sampler may not reflect the concentrations in the aquifer directly adjacent to the sampler because of vertical transport in the well. However, a vertical array of PDB samplers, used in conjunction with borehole flow meter testing, can provide insight on the movement of contaminants into or out of the well. This information then can be used to help determine if the use of PDB samplers is appropriate for the well, and to select the optimal vertical location(s) for the sampler deployment.

6. In wells with screens or open intervals with stratified chemical concentrations, the use of a single PDB sampler set at an arbitrary (by convention) depth may not provide accurate concentration values for the most contaminated zone. However, multiple PDB samplers distributed vertically along the screened or open interval, in conjunction with pump sampling (as appropriate), can be used to locate zone(s) of highest concentration in the well. Multiple PDB samplers also may be needed to track the zone of maximum concentration in wells where flow patterns through the screened interval change as a result of ground-water pumping or seasonal water-table fluctuations.

#### PASSIVE DIFFUSION BAG SAMPLER DEPLOYMENT

A variety of approaches can be used to deploy the PDB samplers in wells. A typical deployment approach, described in this section, is to attach the PDB samplers to a weighted line. It also is acceptable to attach the weights directly to the PDB sampler if the attachment point is of sufficient strength to support the weight. The weights attached to the bottom of the

line are stainless steel and can be reused, but must be thoroughly decontaminated with a detergent before the first use or before using in a different well. Rope, such as 90 pound, 3/16 inch braided polyester, can be used as the line for single-use applications if it is of sufficient strength to support the weight and sampler, is nonbuoyant, and is subject to minimal stretch; however, the rope should not be reused because of the high potential for cross contamination. Stainless-steel or Teflon-coated stainless-steel wire is preferable. The weighted lines should not be reused in different wells to prevent carryover of contaminants. A possible exception is coated stainless-steel wire, which can be reused after sufficient decontamination. An alternative deployment approach, not discussed in this section, is to attach the PDB samplers to a fixed pipe in the well (Vroblesky and Peters, 2000, p. 3; also included in Part 2 of this publication). The PDB samplers should not contact non-aqueous phase liquid (NAPL) during deployment or retrieval to prevent cross contamination. An approach that can be utilized to deploy diffusion samplers through a layer of floating NAPL is described in the field test at Naval Station North Island, California (Vroblesky and Peters, 2000, p. 3-4, also included in Part 2 of this publication).

If the PDB sampler is to be compared with a conventional pumping approach to sampling, then it is suggested that both the pump and the PDB sampler be deployed at the same time, with the sampler attached near (such as directly below) the pump inlet. This approach eliminates potential concentration differences between the two methods that may result from well disturbance during equipment removal and deployment at the time of sampling. An alternative method is to deploy the PDB samplers independently of the pumps and recover the samplers immediately prior to placing the pump down the well.

PDB samplers are available either prefilled (field ready) with laboratory-grade deionized water or unfilled. The unfilled samplers are equipped with a plug and funnel to allow for field filling and sample recovery. To fill these samplers, remove the plug from the sampler bottom, insert the short funnel into the sampler, and pour laboratory-grade deionized water into the sampler. The sampler should be filled until water rises and stands at least half way into the funnel. Remove excess bubbles from the sampler. Remove the funnel and reattach the plug. A small air bubble from the plug is of no concern.

The following steps should be used for deploying PDB samplers in wells:

1. Measure the well depth and compare the measured depth with the reported depth to the bottom of the well screen from well-construction records. This is to check on whether sediment has accumulated in the bottom of the well, whether there is a nonscreened section of pipe (sediment sump) below the well screen, and on the accuracy of well-construction records. If there is an uncertainty regarding length or placement of the well screen, then an independent method, such as video imaging of the well bore, is strongly suggested.
2. Attach a stainless-steel weight to the end of the line. Sufficient weight should be added to counterbalance the buoyancy of the PDB samplers. This is particularly important when multiple PDB samplers are deployed. One approach, discussed in the following paragraphs, is to have the weight resting on the bottom of the well, with the line taut above the weight. Alternatively, the PDB sampler and weight may be suspended above the bottom, but caution should be exercised to ensure that the sampler does not shift location. Such shifting can result from stretching or slipping of the line or, if multiple samplers are attached end-to-end rather than to a weighted line, stretching of the samplers.
3. Calculate the distance from the bottom of the well, or top of the sediment in the well, up to the point where the PDB sampler is to be placed. A variety of approaches can be used to attach the PDB sampler to the weight or weighted line at the target horizon. The field-fillable type of PDB sampler is equipped with a hanger assembly and weight that can be slid over the sampler body until it rests securely near the bottom of the sampler. When this approach is used with multiple PDB samplers down the same borehole, the weight should only be attached to the lowermost sampler. An additional option is to use coated stainless-steel wire as a weighted line, making loops at appropriate points to attach the upper and lower ends of PDB samplers. Where the PDB sampler position varies between sampling events, movable clamps with rings can be used. When using rope as a weighted line, a simple approach is to tie knots or attach clasps at the appropriate depths. Nylon cable ties or stainless-steel clips inserted through the knots can be used to attach the PDB samplers. An approach using rope as a weighted line with knots tied at the appropriate sampler-attachment points is discussed below.

(a) For 5-ft-long or shorter well screens, the center point of the PDB sampler should be the vertical midpoint of the saturated well-screen length. For example, if the well screen is at a depth of 55 to 60 ft below the top of casing, and the measured depth of the well is 59 ft, then the bottom of the well probably has filled with sediment. In this case, the midpoint of the sampler between the attachment points on the line will be midway between 55 and 59 ft, or at 57 ft. Thus, for a 1.5-ft-long sampler, the attachment points on a weighted line should be tied at distances of 1.25 ft (2 ft - 0.75 ft) and 2.75 ft (2 ft + 0.75 ft) from the top of the sediment in the well, or the bottom of the well, making adjustments for the length of the attached weight. When the PDB sampler is attached to the line and installed in the well, the center of the sampler will be at 57-ft depth. If, however, independent evidence is available showing that the highest concentration of contaminants enters the well from a specific zone within the screened interval, then the PDB sampler should be positioned at that interval.

(b) For 5- to 10-ft-long well screens, it is advisable to utilize multiple PDB samplers vertically along the length of the well screen for at least the initial sampling (fig. 2). The purposes of the multiple PDB samplers are to determine whether contaminant stratification is present and to locate the zone of highest concentration. The midpoint of each sampler should be positioned at the midpoint of the interval to be sampled. For 1.5-ft-long samplers, at each sampling depth in the screened interval, make two attachment points on the weighted line at a distance of about 1.5 ft apart. The attachment points should be positioned along the weighted line at a distance from the bottom end of the weight such that the midpoint between the knots will be at the desired sampling depth along the well screen. Sampler intervals are variable, but a simple approach is to use the top knot/loop of one sampler interval as the bottom knot/loop for the overlying sampler interval.



**Figure 2.** Example of multiple PDB samplers prepared for deployment.

(c) PDB samplers should not be used in wells having screened or open intervals longer than 10 ft unless used in conjunction with borehole flow meters or other techniques to characterize vertical variability in hydraulic conductivity and contaminant distribution or used strictly for qualitative reconnaissance purposes. This is because of the increased potential for cross contamination of water-bearing zones and hydraulically driven mixing effects that may cause the contaminant stratification in the well to differ from the contaminant stratification in the adjacent aquifer material. If it is necessary to sample such wells, then multiple PDB samplers should be installed vertically across the screened or open interval to determine the zone of highest concentration and whether contaminant stratification is present.

4. The samplers should be attached to the weights or weighted line at the time of deployment. For samplers utilizing the hanger and weight assembly,

the line can be attached directly to the top of the sampler. PDB samplers utilizing an outer protective mesh can be attached to a weighted line by using the following procedure.

(a) Insert cable ties through the attachment points in the weighted line.

(b) At each end of the PDB sampler, weave the ends of the cable ties or clamp through the LDPE mesh surrounding the sampler and tighten the cable ties. Thus, each end of the PDB sampler will be attached to a knot/loop in the weighted line by means of a cable tie or clamp. The cable ties or clamps should be positioned through the polyethylene mesh in a way that prevents the PDB sampler from sliding out of the mesh.

(c) Trim the excess from the cable tie before placing the sampler down the well. Caution should be exercised to prevent sharp edges on the trimmed cable ties that may puncture the LDPE.

5. When using PDB samplers without the protective outer mesh, the holes punched at the ends of the bag, outside the sealed portion, can be used to attach the samplers to the weighted line. Stainless-steel spring clips have been found to be more reliable than cable ties in this instance, but cable ties also work well.

6. Lower the weight and weighted line down the well until the weight rests on the bottom of the well and the line above the weight is taut. The PDB samplers should now be positioned at the expected depth. A check on the depth can be done by placing a knot or mark on the line at the correct distance from the top knot/loop of the PDB sampler to the top of the well casing and checking to make sure that the mark aligns with the lip of the casing after deployment.

7. Secure the assembly in this position. A suggested method is to attach the weighted line to a hook on the inside of the well cap. Reattach the well cap. The well should be sealed in such a way as to prevent surface-water invasion. This is particularly important in flush-mounted well vaults that are prone to flooding.

8. Allow the system to remain undisturbed as the PDB samplers equilibrate.

#### PASSIVE DIFFUSION BAG SAMPLER AND SAMPLE RECOVERY

The amount of time that the samplers should be left in the well prior to recovery depends on the time required by the PDB sampler to equilibrate with ambient water and the time required for environmental disturbances caused by sampler deployment to return to ambient conditions. The rate that the water within the PDB sampler equilibrates with ambient water depends on multiple factors, including the type of compound being sampled and the water temperature. The concentrations of benzene, *cis*-1,2-dichloroethene (*c*DCE), tetrachlorethene (PCE), trichloroethene (TCE), toluene, naphthalene, 1,2-dibromoethane (EDB), and total xylenes within the PDB samplers equilibrated with the concentrations in an aqueous mixture of those compounds surrounding the samplers under laboratory conditions within approximately 48 hours at 21 °C (Vroblesky and Campbell, 2001). A subsequent laboratory study of mixed VOCs at 10 °C showed that PCE and TCE were equilibrated by about 52 hours, but other compounds required longer equilibration times (T. M. Sivavec and S. S. Baghel, General Electric Company, written commun., 2000). Chloroethane, *c*DCE, *trans*-1,2-dichloroethene, and 1,1-dichloroethene were not

equilibrated at 52 hours, but appeared to be equilibrated by the next sampling point at 93 hours. Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane were not equilibrated at 93 hours, but were equilibrated by the next sampling point at 166 hours. Different equilibration times may exist for other compounds. Differences in equilibration times, if any, between single-solute or mixed-VOC solutions have not yet been thoroughly examined.

Under field conditions, the samplers should be left in place long enough for the well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment. The results of borehole dilution studies show that wells can recover to 90 percent of the predisturbance conditions within minutes to several hours for permeable to highly permeable geologic formations, but may require 100 to 1,000 hours (4 to 40 days) in muds, very fine-grained loamy sands, and fractured rock, and may take even longer in fractured shales, recent loams, clays, and slightly fractured solid igneous rocks (Halevy and others, 1967).

In general, where the rate of ground-water movement past a diffusion sampler is high, equilibration times through various membranes commonly range from a few hours to a few days (Mayer, 1976; Harrington and others, 2000). One field investigation showed adequate equilibration of PDB samplers to aquifer trichloroethene (TCE) and carbon tetrachloride (CT) concentrations within 2 days in a highly permeable aquifer (Vroblesky and others, 1999). In other investigations, PDB samplers recovered after 14 days were found to be adequately equilibrated to chlorinated VOCs (Obrien & Geie Engineers, Inc., 1997a, 1997b; Hare, 2000); therefore, the equilibration period was less than or equal to 14 days for those field conditions. Because it appears that 2 weeks of equilibration probably is adequate for many applications, a minimum equilibration time of 2 weeks is suggested. When applying PDB samplers in waters colder than previously tested (10 °C) or for compounds without sufficient corroborating field data, a side-by-side comparison with conventional sampling methodology is advisable to justify the field equilibration time.

In less permeable formations, longer equilibration times may be required. It is probable that water in the well bore eventually will equilibrate with the pore-water chemistry; however, if the rate of chemical change or volatilization loss in the well bore exceeds the rate of exchange between the pore water and the well-bore water, then the PDB samplers may under-

estimate pore-water concentrations. Guidelines for equilibration times and applicability of PDB samplers in low-permeability formations have not yet been established. Therefore, in such situations, a side-by-side comparison of PDB samplers and conventional sampling methodology is advisable to ensure that the PDB samplers do not underestimate concentrations obtained by the conventional method. A detailed discussion of diffusion rates relevant to diffusion sampler equilibrium in slow-moving ground-water systems can be found in Harrington and others (2000).

Following the initial equilibration period, the samplers maintain equilibrium concentrations with the ambient water until recovery. Thus, there is no specified maximum time for sampler recovery. PDB samplers have routinely been left in ground waters having concentrations of greater than 500 ppm of TCE for 3 months at a time with no loss of bag integrity, and at one site, the PDB samplers have been left in place in VOC-contaminated ground water for 1 year with no reported loss of sampler integrity (Paul Hare, General Electric Company, oral commun., 2000). The effects of long-term (greater than 1 month) PDB-sampler deployment on sampler and sample integrity have not yet been thoroughly tested for a broad range of compounds and concentrations. Moreover, in some environments, development of a biofilm on the polyethylene may be a consequence of long-term deployment. Investigations of semipermeable membrane devices (SPMDs) have shown that the transfer of some compounds may be reduced, but not stopped, across a heavily biofouled polyethylene membrane (Ellis and others, 1995; Huckins and others, 1996; Huckins and others, in press). If a heavy organic coating is observed on a PDB sampler, it is advisable to determine the integrity of the sample by comparing contaminant concentrations from the PDB sampler to concentrations from a conventional sampling method before continuing to use PDB samplers for long-term deployment in that well.

Recovery of PDB samplers is accomplished by using the following approach:

1. Remove the PDB samplers from the well by using the attached line. The PDB samplers should not be exposed to heat or agitated.
2. Examine the surface of the PDB sampler for evidence of algae, iron or other coatings, and for tears in the membrane. Note the observations in a sampling field book. If there are tears in the membrane, the

sample should be rejected. If there is evidence that the PDB sampler exhibits a coating, then this should be noted in the validated concentration data.

3. Detach and remove the PDB sampler from the weighted line. Remove the excess liquid from the exterior of the bag to minimize the potential for cross contamination.

4. A variety of approaches may be used to transfer the water from the PDB samplers to 40-mL volatile organic analysis (VOA) vials. One type of commercially available PDB sampler provides a discharge device that can be inserted into the sampler. If discharge devices are used, the diameter of the opening should be kept to less than about 0.15 inches to reduce volatilization loss. Two options are presently available to recover water from the sample using discharge devices. One option involves removing the hanger and weight assembly from the sampler, inverting the sampler so that the fill plug is pointed upward, and removing the plug. The water can be recovered by directly pouring in a manner that minimizes agitation or by pouring through a VOC-discharge accessory inserted in place of the plug. The second approach involves piercing the sampler near the bottom with a small-diameter discharge tube and allowing water to flow through the tube into the VOA vials. In each case, flow rates can be controlled by tilting or manipulating the sampler. Alternatively, the PDB sampler can be cut open at one end using scissors or other cutting devices which have been decontaminated between use for different wells. Water can then be transferred to 40-mL VOA vials by gently pouring in a manner that minimizes water agitation. Acceptable duplication has been obtained using each method. Preserve the samples according to the analytical method. The sampling vials should be stored at approximately 4 °C in accordance with standard sampling protocol. Laboratory testing suggests that there is no substantial change in the VOC concentrations in PDB samplers over the first several minutes after recovery; however, the water should be transferred from the water-filled samplers to the sample bottles immediately upon recovery.

5. A cost-effective alternative when using multiple PDB samplers in a single well is to field screen water from each sampler using gas chromatography. These results can be used to decide which of the multiple PDB samplers should be sent to an EPA-approved laboratory for standard analysis. Typically, at least the sample containing the highest concentration should be analyzed by a laboratory.

6. If a comparison is being made between concentrations obtained using PDB samplers and concentrations obtained using a conventional sampling approach, then the well should be sampled by the conventional approach soon after (preferably on the same day) recovery of the PDB sampler. The water samples obtained using PDB samplers should be sent in the same shipment, as the samples collected by the conventional approach for the respective wells. Utilizing the same laboratory may reduce analytical variability.

7. Any unused water from the PDB sampler and water used to decontaminate cutting devices should be disposed in accordance with local, state, and Federal regulations.

#### DETERMINING APPLICABILITY OF PASSIVE DIFFUSION BAG SAMPLERS AND INTERPRETATION OF DATA

When attempting to determine whether the use of PDB samplers is appropriate at a particular well, a common approach is to do a side-by-side comparison with a conventional sampling method during the same sampling event. This approach is strongly suggested in wells having temporal concentration variability. In a well having relatively low temporal concentration variability, comparison of the PDB-sampler results to historical concentrations may provide enough information to determine whether the PDB samplers are appropriate for the well. In general, if both PDB and conventional sampling produce concentrations that agree within a range deemed acceptable by local, state, and Federal regulatory agencies and meet the site-specific data-quality objectives, then a PDB sampler may be approved for use in that well to monitor ambient VOC concentrations. If concentrations from the PDB sampler are higher than concentrations from the conventional method, it is probable that concentrations from the PDB sampler adequately represent ambient conditions because there usually is a greater potential for dilution from mixing during sampling using conventional methods than during sampling using PDB samplers.

If, however, the conventional method produces concentrations that are significantly higher than those obtained using the PDB sampler, then it is uncertain whether the PDB-sampler concentrations represent local ambient conditions. In this case, further testing can be done to determine whether contaminant stratification and/or intra-borehole flow is present. Multiple sampling devices can be used to determine the presence

of contaminant stratification, and borehole flow-meters can be used to determine whether intra-borehole flow is present. When using flowmeters to measure vertical flow in screened boreholes, however, the data should be considered qualitative because of the potential for water movement through the sand pack. Borehole dilution tests (Halevy and others, 1967; Drost and others, 1968; Grisak and others, 1977; Palmer, 1993) can be used to determine whether water is freely exchanged between the aquifer and the well screen.

Once the source of the difference between the two methods is determined, a decision can be made regarding the well-specific utility of the PDB samplers. Tests may show that VOC concentrations from the PDB samplers adequately represent local ambient conditions within the screened interval despite the higher VOC concentration obtained from the conventional method. This may be because the pumped samples incorporated water containing higher concentrations either from other water-bearing zones induced along inadequate well seals or through fractured clay (Vroblesky and others, 2000), from other water-bearing zones not directly adjacent to the well screen as a result of well purging prior to sampling (Vroblesky and Petkewich, 2000), or from mixing of chemically stratified zones in the vicinity of the screened interval (Vroblesky and Peters, 2000).

The mixing of waters from chemically stratified zones adjacent to the screened interval during pumping probably is one of the more important sources of apparent differences between the results obtained from PDB sampling and conventional sampling because such stratification probably is common. Vertical stratification of VOCs over distances of a few feet has been observed in aquifer sediments by using multilevel sampling devices (Dean and others, 1999; Pitkin and others, 1999), and considerable variation in hydraulic conductivity and water chemistry has been observed in an aquifer in Cape Cod, Massachusetts, on the scale of centimeters (Wolf and others, 1991; Smith and others 1991, Hess and others, 1992). Multiple PDB samplers have been used to show a change in TCE concentration of 1,130  $\mu\text{g/L}$  over a 6-ft vertical screened interval in Minnesota (Vroblesky and Petkewich, 2000). Tests using PDB samplers in screened intervals containing VOC stratification showed that the PDB-sampler data appeared to be point-specific, whereas the pumped sample integrated water over a larger interval (Vroblesky and Peters, 2000).

The decision on whether to use PDB samplers in such situations depends on the data-quality objectives for the particular site. If the goal is to determine and monitor higher concentrations or to examine contaminant stratification within the screened interval, then the PDB samplers may meet this objective. If the goal is to determine the average concentrations for the entire screened interval, then a pumped sample or an average from multiple diffusion samplers may be appropriate.

As an aid in the decision-making process, the following section examines the influences that hydraulic and chemical heterogeneity of an aquifer can have on sample quality in long-screened wells. Because VOC concentrations from PDB samplers commonly are compared to VOC concentrations from other sampling methodologies, the second section examines the differences in sample quality between these methodologies in situations of hydraulic and chemical heterogeneity.

#### **Influences of Hydraulic and Chemical Heterogeneity on Sample Quality in Long-Screened Wells**

Sampling biases and chemical variability in long-screened wells, which can be loosely defined as wells having significant physical and chemical heterogeneity within the screened interval and in the adjacent aquifer (Reilly and LeBlanc, 1998), have been the subject of numerous investigations. Sources of chemical variability in such wells include non-uniform flow into wells (Robbins and Martin-Hayden, 1991; Reilly and Gibbs, 1993; Chiang and others, 1995; Church and Granato, 1996; Reilly and LeBlanc, 1998), lithologic heterogeneity (Reilly and others, 1989; Robbins, 1989; Martin-Hayden and others, 1991; Gibbs and others, 1993; Reilly and Gibbs, 1993), and in-well mixing. In a well open across a chemically or hydraulically heterogeneous section of the aquifer, differences in the sampling methodology can produce significant differences in the sampling results.

Long-screened wells have the potential to redistribute chemical constituents in the aquifer where there are vertical hydraulic gradients within the screened interval. Water can move into the well from one horizon and exit the well at a different horizon (Church and Granato, 1996; Reilly and LeBlanc 1998). If there is vertical flow in the screened or open interval, and the zone of low hydraulic head (outflow from

the well) is within the contaminated horizon, then the PDB samplers (or any standard sampling methodology) can underestimate or not detect the contamination. The reason is that, in this case, the contaminated horizon does not contribute water to the well under static conditions. Instead, water from other horizons with higher hydraulic head will invade the contaminated horizon by way of the well screen. Under pumped conditions, the majority of the extracted water will be from the most permeable interval, which may not be the contaminated zone. Even when pumping induces inflow from the contaminated interval, much of that inflow will be a reflection of the residual invaded water from other horizons. In this situation, a substantial amount of purging would be required before water representative of the aquifer could be obtained (Jones and Lerner, 1995). Such sampling is not likely to reflect a significant contribution from the contaminated zone, and concentrations in the contaminated zone probably will be underestimated.

Similarly, if VOC-contaminated water is flowing into the well and is exiting the well at a different horizon, then VOCs will be present along the screened interval between the two horizons. In this case, VOC concentrations in the screened interval may be representative of aquifer concentrations at the inflow horizon, but may not be representative of aquifer concentrations near the outflow horizon.

In areas where vertical stratification of VOC concentrations is anticipated, using multiple PDB samplers may more fully characterize the contaminated horizon than using a single PDB sampler. This is particularly true in wells having screens 10 ft or longer, however, significant VOC stratification has been observed over intervals of less than 5 ft (Vroblesky and Peters, 2000). Because of the increased probability of vertical concentration or hydraulic gradients within the open interval of long-screened (greater than 10 ft) wells, it is advisable to determine the zones of inflow and outflow within the screened or open interval of these wells using borehole flowmeter analysis (Hess, 1982; 1984; 1986; 1990; Young and others, 1998).

#### **Comparison of Passive Diffusion Bag Sampling Methodology to Conventional Methodologies**

Traditional sampling methodologies, such as the purge-and-sample (or conventional purging method), low-flow or low-volume sampling, and using straddle packers and multilevel samplers, produce VOC

concentrations that may differ from VOC concentrations obtained from PDB samplers because the methodologies sometimes are influenced in different ways by aquifer hydraulic and chemical heterogeneity. This section examines potential sources of concentration differences between traditional methodologies and the PDB methodology.

The purge-and-sample approach to ground-water monitoring differs from the diffusion-sampler approach primarily because the area of the screened or open interval that contributes water to the purged sample typically is greater than for the PDB sampler, and the potential for mixing of stratified layers is higher. When pumping three or more casing volumes of water prior to collecting a sample, chemical concentrations in the discharging water typically change as the well is pumped (Keely and Boateng, 1987; Cohen and Kabold, 1988; Martin-Hayden and others, 1991; Robbins and Martin-Hayden, 1991; Reilly and Gibbs, 1993; Barcelona and others, 1994; Martin-Hayden, 2000), due to mixing during pumping and other factors, such as the removal of stagnant water in the casing and changing patterns of inflow and outflow under ambient and pumping conditions (Church and Granato, 1996). The induction of lateral chemical heterogeneity during pumping also may produce variations in the sampled concentrations. The amount of mixing during purging can be highly variable (Barber and Davis, 1987; Church and Granato, 1996; Reilly and LeBlanc, 1998; Martin-Hayden, 2000), and may result in concentrations that are not locally representative (Reilly and Gibbs, 1993). Substantial vertical hydraulic gradients, even in shallow homogeneous aquifers, have been observed to bias sampling using conventional purging because the majority of the pumped water may come from a particular horizon not related to the contaminated zone and because the intra-well flow that intruded the aquifer may not be adequately removed during purging (Hutchins and Acree, 2000). Thus, differences may be observed between concentrations obtained from a pumped sample and from a PDB sample in a chemically stratified interval if the pumped sample represents an integration of water collected from multiple horizons and the PDB sampler represents water collected from a single horizon.

Low-flow purging and sampling (Barcelona and others, 1994; Shanklin and others, 1995) disturbs the local ground water less than conventional purge-and-

sample methods. Thus, samples obtained by PDB samplers are likely to be more similar to samples obtained by using low-flow purging than to those obtained by using conventional purge-and-sample methods. Even under low-flow conditions, however, purging still can integrate water within the radius of pumping influence, potentially resulting in a deviation from VOC concentrations obtained by PDB sampling. One investigation found that in low hydraulic conductivity formations, low-flow sampling methodology caused excessive drawdown, which dewatered the screened interval, increased local ground-water velocities, and caused unwanted colloid and soil transport into the ground-water samples (Sevee and others, 2000). The authors suggest that in such cases, a more appropriate sampling methodology may be to collect a slug or passive sample from the well screen under the assumption that the water in the well screen is in equilibrium with the surrounding aquifer.

Isolating a particular contributing fracture zone with straddle packers in an uncased borehole allows depth-discrete samples to be collected from the target horizon (Hsieh and others, 1993; Kaminsky and Wylie, 1995). Strategically placed straddle packers often can minimize or eliminate the impact of vertical gradients in the sampled interval. However, even within a packed interval isolating inflowing fracture zones, deviations between VOC concentrations in water from PDB samplers and water sampled by conventional methods still may occur if the conventional method mixes chemically stratified water outside the borehole or if the packed interval straddles chemically heterogeneous zones.

The use of multilevel PDB samplers and other types of multilevel samplers (Ronen and others, 1987; Kaplan and others, 1991; Schirmer and others, 1995; Gefell and others, 1999; Jones and others, 1999) potentially can delineate some of the chemical stratification. Diffusion sampling and other sampling methodologies, however, can be influenced by vertical hydraulic gradients within the well screen or the sand pack. When vertical hydraulic gradients are present within the well, water contacting the PDB sampler may not be from a horizon adjacent to the PDB sampler. Rather, the water may represent a mixing of water from other contributing intervals within the borehole. In a screened well, even multilevel samplers with baffles to limit vertical flow in the well cannot prevent influences from

vertical flow in the gravel pack outside the well screen. Such vertical flow can result from small vertical differences in head with depth. A field test conducted by Church and Granato (1996) found that vertical head differences ranging from undetectable to 0.49 ft were sufficient to cause substantial flows (as much as 0.5 liters/minute) in the well bore.

## QUALITY CONTROL AND ASSURANCE

The sources of variability and bias introduced during sample collection can affect the interpretation of the results. To reduce data variability caused during sampling, a series of quality-control samples should be utilized.

Replicate samples are important for the quality control of diffusion-sampler data. Sample replicates provide information needed to estimate the precision of concentration values determined from the combined sample-processing and analytical method and to evaluate the consistency of quantifying target VOCs. A replicate sample for water-filled diffusion samplers consists of two separate sets of VOC vials filled from the same diffusion sampler. Each set of VOC vials should be analyzed for comparison. Approximately 10 percent of the samplers should be replicated.

The length of the PDB sampler can be adjusted to accommodate the data-quality objectives for the sampling event. The length can be increased if additional volume is required for collection of replicate and matrix spike/matrix spike duplicate samples.

Trip blanks are used to determine whether external VOCs are contaminating the sample due to bottle handling and/or analytical processes not associated with field processing. Trip blanks are water-filled VOA vials prepared offsite, stored and transported with the other bottles used for collecting the environmental sample, and then submitted for analysis with the environmental sample. Consideration also should be given to the collection of a predeployment PDB trip blank to determine if the PDB samplers are exposed to extraneous VOCs prior to deployment. The predeployment trip blank should be a PDB sampler that is stored and transported with the field PDB samplers from the time of sampler construction to the time of deployment in the wells. An aliquot of the predeployment blank water should be collected from the PDB sampler in a VOA vial and submitted for analysis at the time of sampler deployment.

Water used to construct the diffusion samplers should be analyzed to determine the presence of background VOCs. Although many VOCs accidentally introduced into the diffusion-sampler water probably will reequilibrate with surrounding water once the diffusion samplers are deployed, some VOCs may become trapped within the diffusion-sampler water. For example, acetone, which is a common laboratory contaminant, does not easily move through the polyethylene diffusion samplers (Paul Hare, General Electric Company, oral commun., 1999). Thus, acetone inadvertently introduced into the diffusion-sample water during sampler construction may persist in the samplers, resulting in a false positive for acetone after sampler recovery and analysis.

## SUMMARY

Water-filled passive diffusion bag (PDB) samplers described in this report are suitable for obtaining a variety of VOCs in ground water at monitoring wells. The suggested application for PDB samplers is for long-term monitoring of VOCs in ground-water wells at well-characterized sites. Where the screened interval is greater than 10 ft, the potential for contaminant stratification and/or intra-borehole flow within the screened interval is greater than in screened intervals shorter than 10 ft. It is suggested that the vertical distribution of contaminants be determined in wells having 10-ft-long well screens, and that both the vertical distribution of contaminants and the potential for intra-borehole flow be determined in wells having screens longer than 10 ft. A typical PDB sampler consists of a 1- to 2-ft-long low-density polyethylene lay-flat tube closed at both ends and containing deionized water. The sampler is positioned at the target horizon by attachment to a weighted line or fixed pipe.

The amount of time that the samplers should be left in the well prior to recovery depends on the time required by the PDB sampler to equilibrate with ambient water and the time required for environmental disturbances caused by sampler deployment to return to ambient conditions. The rate that water within the PDB sampler equilibrates with ambient water depends on multiple factors, including the type of compound being sampled and the water temperature. Concentrations of benzene, *cis*-1,2-dichloroethene, tetrachlorethene, trichloroethene, toluene, naphthalene, 1,2-dibromoethane, and total xylenes within the PDB samplers equilibrated with the concentrations in an

aqueous mixture of those compounds surrounding the samplers under laboratory conditions within approximately 48 hours at 21 °C. A subsequent laboratory study of mixed VOCs at 10 °C showed that tetrachloroethene and trichloroethene were equilibrated by about 52 hours, but other compounds required longer equilibration times. Chloroethane, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and 1,1-dichloroethane were not equilibrated at 52 hours, but appeared to be equilibrated by the next sampling point at 93 hours. Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane were not equilibrated at 93 hours but were equilibrated by the next sampling point at 166 hours. Different equilibration times may exist for other compounds. Differences in equilibration times, if any, between single-solute or mixed-VOC solutions have not yet been thoroughly examined.

The samplers should be left in place long enough for the well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment. Laboratory and field data suggest that 2 weeks of equilibration probably is adequate for many applications. Therefore, a minimum equilibration time of 2 weeks is suggested. In less permeable formations, longer equilibration times may be required. When deploying PDB samplers in waters colder than previously tested (10 °C) or for compounds without sufficient corroborating data, a side-by-side comparison with conventional methodology is advisable to justify the field equilibration time.

Following the initial equilibration period, the samplers maintain equilibrium concentrations with the ambient water until recovery. Thus, there is no specified maximum time for sampler recovery after initial equilibration. PDB samplers have routinely been left in ground waters having concentrations of greater than 500 ppm of TCE for 3 months at a time with no loss of bag integrity, and at one site, the PDB samplers were left in place in VOC-contaminated ground water for 1 year with no reported loss of sampler integrity. The effects of long-term (greater than 1 month) PDB-sampler deployment on sampler and sample integrity have not yet been thoroughly tested for a broad range of compounds and concentrations. In some environments, development of a biofilm on the polyethylene may be a consequence of long-term deployment. Investigations of semipermeable membrane devices

(SPMDs) have shown that the transfer of some compounds across a heavily biofouled polyethylene membrane may be reduced, but not stopped. If a heavy organic coating is observed on a PDB sampler, it is advisable to determine the integrity of the sample by comparing sampler results to a conventional sampling method concentrations before continuing to use PDB samplers for long-term deployment in that well.

PDB methodology is suitable for a broad variety of VOCs, including chlorinated aliphatic compounds and petroleum hydrocarbons. The samplers, however, are not suitable for inorganic ions and have a limited applicability for non-VOCs and for some VOCs. For example, although methyl-*tert*-butyl ether and acetone and most semivolatile compounds are transmitted through the polyethylene bag, laboratory tests have shown that the resulting concentrations were lower than in ambient water. The samplers should not be used to sample for phthalates because of the potential for the LDPE to contribute phthalates to the water sample.

When attempting to determine whether the use of PDB samplers is appropriate at a particular well, a common approach is to do a side-by-side comparison with a conventional sampling method. This approach is strongly suggested in wells having temporal concentration variability. In a well having relatively low temporal concentration variability, comparison of the PDB-sampler results to historical concentrations may provide enough information to determine whether the PDB samplers are appropriate for the well. In general, if the two approaches produce concentrations that agree within a range deemed acceptable by the local, state, and Federal regulatory agencies, then use of a PDB sampler in that well will provide VOC concentrations consistent with the historical record. If concentrations from the PDB sampler are higher than concentrations from the conventional method, then it is probable that the concentrations from the PDB sampler are an adequate representation of ambient conditions. If, however, the conventional method produces concentrations that are substantially higher than the concentrations found by using the PDB sampler, then the PDB sampler may or may not adequately represent local ambient conditions. In this case, the difference may be due to a variety of factors, including mixing or translocation due to hydraulic and chemical heterogeneity of the aquifer within the screened or open interval of the well and the relative permeability of the well screen.

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