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THE MEMPHIS DEPOT
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COVER SHEET

AR File Number 636

Memphis Depot

Dunn Field

Soil Vapor Extraction Treatability Study Workplan

Memphis Depot Caretaker

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CH2MHILL

U.S. Army Engineering and Support Center, Huntsville

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Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
BCT	Base Cleanup Team
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
cfm	cubic feet per minute
CGI/O_2	combustible gas indicator/oxygen
COC	Chain-of-Custody
CO_2	carbon dioxide
DNAPL	dense non-aqueous phase liquid
DQOs	Data Quality Objectives
EISOPQAM	Environmental Investigations Standard Operating Procedures and Quality Assurance Manual
EPA	U.S. Environmental Protection Agency
FID	flame ionization detector
FS	Feasibility Study
GAC	Granular-Activated Carbon
HASP	Hazardous and Toxic Waste Health and Safety Plan
Hg	mercury
ICE	internal combustion engine
IDW	investigation derived waste
Jacobs	Jacobs Engineering, Inc.
k	in-situ soil permeability
LEL	Lower Explosive Limit
mg/kg	milligram per kilogram
MP	monitoring point
O_2	oxygen
PCE	Tetrachloroethene
PVC	polyvinyl chloride

QA	quality assurance
QAPP	Final Generic Quality Assurance Project Plan
QC	quality control
RAB	Restoration Advisory Board
RI	Remedial Investigation
ROI	radius of influence
RPO	Remedial Process Optimization
SVE	Soil Vapor Extraction
SVOC	Semi-volatile Organic Compound
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TS	Treatability Study
USACE	U.S. Army Corps of Engineers
VW	venting well
V	volt
VOC	Volatile Organic Compound

1.0 Project Description

This Treatability Study (TS) workplan presents the objectives and activities for a Soil Vapor Extraction (SVE) pilot-scale TS to be conducted for the U.S Army Engineering and Support Center, Huntsville, at Dunn Field on the Memphis Depot (the Depot) in Memphis, Tennessee. The SVE TS is being conducted as a presumptive remedy screening prior to development of the Dunn Field Feasibility Study (FS). This study will determine if SVE is an applicable full-scale remedial technology for vadose zone soils impacted by Volatile Organic Compounds (VOCs) at Dunn Field. In addition, information concerning the cost for implementing SVE at full scale will be developed through this study and will be used in the evaluation of this technology during completion of the FS report.

This study will focus on the area known as the Disposal Area, where materials were buried in several pits throughout this portion of Dunn Field. Figure 1-1 shows the general location of the Disposal Area. Subsurface soil samples have been collected at various periods during the Remedial Investigation (RI) of Dunn Field and the Disposal Area, and sample analysis has revealed impacts from various contaminants, including VOCs, Semi-volatile Organic Compounds (SVOCs), metals, and pesticides. Because of the continuing potential threat to groundwater by VOCs in the vadose zone, the focus of the SVE will be toward remediation of the soil in this zone. Concentrations of VOCs in subsurface soil samples collected during RI sampling in 1999 have shown significant levels of the following chlorinated VOCs: 1,1,2,2-Tetrachloroethane; 1,2-Dichloroethane; carbon tetrachloride; chloroform; methylene chloride; Tetrachloroethene (PCE); Trichloroethene (TCE); and vinyl chloride. For example, the highest level of TCE detected was 460 milligrams per kilogram (mg/kg). Table 1-1 presents a summary of subsurface soil sample data collected during the RI within the Disposal Area.

Based on analysis of the data from the Draft Final RI Report and on detection of possible dense non-aqueous phase liquid (DNAPL) in groundwater immediately west of the central portion of the Disposal Area, CH2M HILL conducted further soil sampling efforts in October 2000 in an effort to further delineate potential source areas. Fifteen soil borings were installed in the central area particularly around the former location of soil boring SBLCA (see Figure 1-2). Analysis of soil samples collected from these borings has revealed VOC concentrations ranging from 0.7 to 22,600 mg/kg. Table 1-2 presents a summary of soil sample analytical data collected from these soil borings. Appendix A presents additional information concerning soil borings installed in October 2000.

Based on available soil analytical data and review of subsurface soil characteristics, the central portion of Dunn Field was selected as most representative of Dunn Field contaminant concentrations, geology, and as the best location for a presumptive remedy screening and SVE TS. As a result, two venting wells and 16 monitoring points (4 points per boring) were installed in this area during the final phases of the RI field effort (Figure 1-2). This workplan also describes the installation of four new monitoring points to enhance the data collection efforts of this SVE TS. Figure 1-3 displays the locations for existing and proposed monitoring points.

The installation of the venting and monitoring points is discussed further in Appendices A and B of this document.

This workplan and subsequent field activities is supplemented by a June 2001 *Final Remedial Process Optimization* (RPO) report developed by Parsons Engineering Science, which reviews the current and planned remedial activities at the site. Treatability study parameters developed in this workplan are based in part on information from this study. This workplan has been written by CH2M HILL and, subsequent to approval, will be forwarded to Jacobs Engineering, Inc. (Jacobs), who will be conducting the field activity and completing the TS technical memorandum.

1.1 Contents of the Workplan

The contents of the workplan are as follows:

- Section 2 presents information on SVE as a treatment technology;
- Section 3 contains the test objectives for the TS;
- Section 4 contains a description of the SVE study process including mobilization and set-up procedures, field methods for transient and steady-state pressure tests, vapor monitoring and flow measurements, and demobilization;
- Section 5 contains a listing of select vendors capable of supplying SVE equipment suitable for the purpose of the subject TS (contact names and phone numbers for each vendor are provided);
- Section 6 contains procedures for collection of samples and Data Quality Objectives (DQOs) for analytical data;
- Section 7 presents data management procedures for the field effort;
- Section 8 presents methods that will be used for data analysis and interpretation;
- Section 9 presents health and safety aspects of the study, which are supplemental to the existing plan for the site,
- Section 10 contains information concerning the management of investigation derived waste (IDW), both potentially hazardous waste and non-hazardous waste;
- Section 11 details how community relations will be handled during the field effort of the study;
- Section 12 presents a summary of the contents of the final report for the study;
- Section 13 presents a preliminary schedule of activities associated with this study;
- Section 14 contains a list of reference documents for this workplan;
- Appendix A presents information concerning venting and monitoring points that were installed as part of the Dunn Field RI;

- Appendix B presents construction completion diagrams for existing venting wells and monitoring points; and
- Appendix C presents standard operational procedures for transient and steady-state pressure tests.
- Appendix D presents standard operational procedures for soil sampling for VOCs during IDW sample collection.

2.0 Treatment Technology Description

SVE is a relatively simple process that physically separates contaminants from soil. As the name suggests, SVE *extracts* contaminants from the *soil* in *vapor* form. Therefore, SVE systems are designed to remove contaminants that have a tendency to volatilize or evaporate easily. SVE removes *volatile* organic compounds (VOCs) and—to a limited extent—some *semi-volatile* organic compounds (SVOCs) from soil beneath the ground surface in the unsaturated zone—that part of the subsurface located above the water table. By applying a vacuum through a system of underground wells, contaminants are pulled to the surface as vapor or gas. An added benefit of introducing air into the soil is that it can stimulate *bioremediation* of some contaminants (that are amenable to aerobic biodegradation).

In this technology, a vacuum is applied to the contaminated soil matrix through extraction wells, which creates a negative pressure gradient that causes movement of vapors toward these wells. Volatile constituents in the vapor phase are removed from the subsurface through the extraction wells. The extracted vapors are then treated, as necessary, and discharged to the atmosphere or possibly reinjected to the subsurface (if permitted by applicable state laws)

Some of the factors, other than the contaminant characteristics, that determine the effectiveness of SVE are as follows:

- Permeability of the soil;
- Soil structure and stratification;
- Soil moisture;
- Native organic material;
- Temperature; and
- Depth to groundwater.

The permeability of the soil affects the rate of air and vapor movement through the soil; the higher the permeability of the soil, the faster the movement and (ideally) the greater the amount of vapors that can be extracted. Soil structure and stratification are important to SVE effectiveness because they can affect how and where soil vapors will flow within the soil matrix under extraction conditions. Structural characteristics (e g., layering, fractures) can result in preferential flow behavior that can lead to ineffective or significantly extended remedial times if they are positioned so that the induced air flow occurs outside the area of contamination.

High moisture content in soils can reduce soil permeability and, consequently, the effectiveness of SVE by restricting the flow of air through soil pores. Fine-grained soils create a thicker capillary fringe than coarse-grained soils. SVE is generally not effective in treating soils below the top of the capillary fringe unless water table depression pumps are used to draw down the water table. In the vicinity of the extraction wells, the water table responds to the vacuum by rising, or "upwelling," which can cause the well screen to become submerged thereby reducing airflow.

The design of the SVE system must include certain parameters to be effective. Design radius of influence (ROI) is the most important parameter to be considered. The ROI is defined as the greatest distance from an extraction well at which a sufficient vacuum and vapor flow can be induced to adequately enhance volatilization and extraction of the contaminants in the soil. Extraction wells should be placed so that the overlap in their radii of influence completely cover the area of contamination.

Fluctuations in the groundwater table should also be considered when designing an SVE system. Significant seasonal or daily fluctuations may, at times, submerge some of the contaminated soil or a portion of the extraction well screen, making it unavailable for air flow. This is most important for horizontal extraction wells, where the screen is parallel to the water table surface.

Surface seals might be included in an SVE system design to prevent surface water infiltration that can reduce air flow rates, reduce emissions of fugitive vapors, prevent vertical short-circuiting of air flow, or increase the design ROI. These results are accomplished because surface seals force fresh air to be drawn from a greater distance from the extraction well. If a surface seal is used, the lower pressure gradients result in decreased flow velocities. This condition may require a higher vacuum to be applied to the extraction well.

Pilot–scale treatability studies are an extremely important part of the design phase. Data provided by treatability studies are necessary to properly design the full-scale SVE system. These studies also provide information on the concentration of VOCs that is likely to be extracted during the early stages of operation of the SVE system.

A pilot-scale test is recommended for evaluating SVE effectiveness and design parameters for any site, especially where SVE is expected to be only marginally to moderately effective. Pilot-scale studies typically include short-term (1 to 30 days) extraction of soil vapors from a single extraction well, which may be an existing monitoring well at the site. However, longer pilot-scale studies (up to 6 months) that utilize more than one extraction well may be appropriate for larger sites Different extraction rates and wellhead vacuums are applied to the extraction wells to determine the optimal operating conditions. Off-gas control is also a common component of SVE studies at sites for protection of human health and the surrounding environment.

Vapor concentrations are also measured at two or more depth and areal intervals during the study to estimate initial vapor concentrations of a full-scale system. The vapor concentration, vapor extraction rate, and vacuum data are also used in the design process to select extraction and treatment equipment.

3.0 Test Objectives

Analysis of soil and groundwater sample laboratory analytical data collected during the Dunn Field RI field effort indicates that contaminants exist in site soils at levels not protective of groundwater. The analysis also indicates that the soils may not be protective of human health and the environment. The removal of these contaminants, which act as a contaminant source, will be a priority for the impending Dunn Field remedial action. Therefore, the primary objective of this SVE TS is to act as a presumptive remedy screening tool prior to conclusion of the Dunn Field FS. SVE is considered a viable technology for removal of VOCs from soil at Dunn Field based upon review of available literature describing the results of remedial actions involving SVE and, also, review of projects where CH2M HILL has implemented the technology at sites with similar chemical and geologic characteristics. If, after completing the TS, the technology is deemed applicable for removal of VOCs from the Dunn Field soil and if the technology is presented to the public as the preferred remedial alternative in the Proposed Plan and selected as the remediation method in the Record of Decision for the site, the data generated from the study will be used as a design and cost basis for a full-scale SVE system. Other objectives of this TS include definition of the relationship between applied vacuum and flow from the well, air permeability of the soils, contaminant removal rates as a function of time, vacuum distribution in soils surrounding the extraction well, water table response to applied vacuum, and condensate/liquid production.

Since the RI and associated Baseline Human Health Risk Assessment (BHHRA) have not been finalized as of the date of this document, preliminary remediation goals for site soils have also not been finalized. As a result, the performance of the SVE system will be judged against certain parameters that define the effectiveness of removal of VOCs from the two formations underlying the site—the loess and underlying fluvial sands and gravels. These parameters include: vacuum influence zone (or ROI); soil permeability to air; organic vapor concentrations in each formation prior to testing, during the study, and post-study; soil gas chemistry for each formation; and relationship between applied vacuum and volumetric vapor flow rate.

4.0 Treatability Study Design and Procedures

Activities for the TS include preliminary activities followed by set-up and conductance of the test.

4.1 Preliminary Study Activities

The preliminary study activities will include locating utilities at the site and installation of three additional monitoring points (MPs) to refine the anticipated ROI. Appendices A and B described the existing monitoring points at the site. Figure 1-2 shows the location of these existing monitoring points.

4.1.1 Utility Location

The field engineer will mark locations of three additional MPs, MP-5 through MP-8 at least 2 weeks prior to installation. All locations will be approved by Depot representatives, and all utilities will be marked by a professional utilities locating service prior to the start of drilling. The proposed MPs will be located at varying distances (10, 20, 30, and 200 feet) and angles (e.g., 0°, 120°, and 240° from north) from the existing venting well (VW) cluster. Exact locations may change based on utility locations and conditions encountered in the field. The installation of the MPs is the only intrusive activity planned for this field effort.

4.1.2 SVE MP Installation

Four additional MPs (MP-5 through MP-8) will be installed to augment MP-1 through MP-4 and to refine the anticipated ROI, especially within the loess deposit. Loess is typically composed of clay and silt that form dense layers with secondary permeability. The vacuum flow through this material is expected to have a shorter ROI than that of the underlying sand and gravel fluvial aquifer. Three of the new MPs will be located between VW-1 and the nearest existing probe, MP-3, which is 40 feet from VW-1 (Figure 1-3). MP-5 will be located 10 feet from VW-1 at 0° north and will be constructed with screens centered at depths of approximately 10 and 20 feet below ground surface (bgs) within the loess deposits. MP-6 will be located 20 feet from VW-1 at an angle of 120° and will be constructed with screens centered at depths of approximately 10 and 20 feet bgs within the loess deposits, and at 50 and 70 feet bgs within the sand and gravel fluvial aquifer. However, if water is detected within the soil cuttings at the 70-foot depth, the remaining screen will be placed at a shallower depth. MP-7 will be located 30 feet from VW-1 at an angle of 240° and will be constructed with screens centered at depths of approximately 5 and 15 feet bgs within the loess deposits, and at 40 and 60 feet bgs within the sand and gravel fluvial aquifer. Construction of MP-5 through MP-7 will be similar to that of existing MP probes (in terms of materials, screen length, bentonite seal, sand pack, protective cover, etc.). Refer to Appendices A and B for construction records of existing VWs and MPs.

A fourth MP, MP-8, will be located approximately 200 feet from VW-1 and will serve as a background monitoring point outside the anticipated ROI to measure barometric pressure effects during the study. The screens for this MP will be installed at 15 and 50 feet bgs (loess deposit and sand and gravel fluvial aquifer, respectively). Construction of this MP will be similar to that of existing MP probes.

MP installation activities will include the collection of soil core samples through the use of Shelby Tubes for analysis, as described in Section 4.1.3. In addition, all field activities will involve oversight of the drilling activities by a qualified field technician. A hollow stem auger equipped drill rig will be used to install the borings, collect the Shelby Tubes, and install MPs. Each boring for the MPs will be completed without split-spoon sampling. However, the field technician will record visual observations of the soil cuttings and maintain a log of all drilling activities as well as keep other notes as described in Section 4.1.2.1. Importantly, because split-spoon samples will not be collected during the drilling of borings for the additional monitoring points, the depth to water in nearby monitoring wells will be ascertained prior to initiation of drilling to extrapolate the top of the underlying water table.

The augers and drill rig will be decontaminated between locations according to procedures defined in Appendix B of the EPA Region 4 Science and Ecosystems Services Division, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual* (EISOPQAM), dated May 1996 (revised in 1997). Ambient air monitoring will also be conducted in accordance with the existing Hazardous and Toxic Waste Health and Safety Plan (HASP) (CH2M HILL, August 1995). See Sections 6.0, 7.0, and 9.0 for further details on ambient air sampling.

4.1.2.1 Monitoring Probe Drilling Documentation and Equipment Requirements

The information presented in this section will be included in all field notes taken during the installation of the additional monitoring probes. In addition, the equipment specified in this section will be strictly adhered to.

Documentation Requirements

During drilling of the borings for the MPs, the documentation record will include the following information for each boring:

- Boring or well identification;
- Purpose of the boring (e.g., monitoring probe);
- Location in relation to an easily identifiable landmark;
- Names of drilling subcontractor and logger;
- Start and finish dates and times;
- Drilling method;
- Diameters of casing, casing type, and methods of installation;
- If saturated conditions are encountered, depth at which saturated conditions were first encountered;
- Lithologic descriptions and depths of lithologic boundaries as distinguished by analysis of soil cuttings;

- Depths at which Shelby Tubes are collected;
- Zones of caving or heaving;
- Drilling rate; and
- Drilling rig reactions, if any, such as chatter, rod drops, and bouncing.

MP Casing Requirements
The following casing requirements will be followed:

- All casing will be new, unused, and decontaminated;
- Glue will not be used to join casing, and casings will be joined only with flush-joint thread that will not interfere with the planned use of the well;
- All polyvinyl chloride (PVC) will conform to the American Society for Testing and Materials (ASTM) Standard F-480-88A or the National Sanitation Foundation Standard 14 (Plastic Pipe System); and
- The casing will be straight and plumb within the tolerance stated for the borehole.

MP Screen Requirements
Probe screen requirements are as follows:

- All requirements that apply to casing will also apply to well screen, except for strength requirements;
- Screens will be factory slotted or wrapped;
- Screen slots will be sized to prevent 90 percent of the filter pack from entering the well; and
- The bottom of the screen is to be capped, and the cap will be joined to the screen by threads.

4.1.3 Soil Core Sampling Procedures

Soil core samples through the use of Shelby Tubes will be collected for geotechnical analysis of the soil. These cores will be collected during the drilling of the borings for all new MPs and will be collected from both the loess deposits and the vadose zone of the fluvial aquifer at depths of 5, 10, 15, and 20 feet bgs in the loess deposits and at 40, 50, 60, and 70 feet bgs in the sand and gravel fluvial aquifer for a total of eight samples. Each core will be analyzed by a geotechnical laboratory for the following parameters:

- Soil moisture;
- Porosity;
- Particle density;
- Fraction of organic carbon; and
- Vertical and horizontal permeability.

All samples will be collected according to ASTM standards for soil core sampling. As each core is returned to the surface, the ends will be sealed with wax and then capped after the wax has cooled slightly. The cap at each will also be taped to ensure that cap will not come loose. An arrow indicating the up direction will be placed on the outside of the core barrel, and each core will be denoted with the sample number, sample depths, and the date and time of collection.

4.2 Treatability Study Process Design

This section summarizes general requirements for TS vacuum extraction equipment. It is not intended to function as a detailed specification for the vacuum pump and ancillary items. CH2M HILL expects to provide these requirements as performance criteria to vendors for bidding purposes and to allow each vendor to supply the equipment that can meet or exceed each requirement.

4.2.1 SVE Equipment Design

The test will require use of equipment that is portable and easily set-up and demobilized, and, ideally, that can be operated using energy sources other than electrical power, in the event that power is not readily available. Two feasible options for equipment exist as follows:

1) A trailer or skid mounted vacuum pump system, which operates using electric power, generator, or gas engine; and
2) An internal combustion engine (ICE) system, which operates using natural gas or propane.

A process flow diagram of the SVE system is included as Figure 4-1. General design requirements for the TS system include the following:

- Minimum vacuum requirement is 12 inches mercury (Hg), to provide for operation in the low permeability "loess" formation. Deep vacuum capability (up to approximately 25 inches Hg) is ideal, based on past experience by CH2M HILL in similar geologic conditions. Deep vacuum capability is preferred to accommodate for possible high resistance to air flow of the loess deposit. In addition, in the preliminary stages of the study, the soil permeability to air flow is unknown and, therefore, conservative selection of the vacuum pump is advised for test use.
- Minimum volumetric flow rate requirement is 60 cubic feet per minute (cfm) at 12 inches Hg, based on past experience by CH2M HILL in similar geologic conditions. The vacuum pump should be able to accommodate flow rates of at least 100 to 120 cfm at lower vacuum levels. In the preliminary stages of the study, the soil permeability to air flow is unknown and, therefore, conservative selection of the vacuum pump is advised for test use. Equipment rated for flow rates exceeding 150 cfm should not be used for the test unless a manifold equipped with an ambient air intake valve is provided. Full-scale design flow rates will likely range from 20 to 100 cfm per well; therefore, initial testing must simulate these conditions to the extent possible. A moisture separator or "knockout" tank of at least 30 gallons in volume with a high level interlock must also be provided to remove entrained water from the influent stream. The separator must be

equipped with a sight glass and/or high level sensor. In addition, an air/particulate filter should be placed in line between the VWs and the blower.

- A vapor extraction manifold with a throttle (gate, globe, or butterfly) valve, sight tube (for monitoring of liquid entrainment in the vapor stream), and sample port should be constructed prior to the test, or provided by the vendor. This manifold should also include vacuum gauges at the wellhead connection and vacuum pump to determine friction losses through the manifold. Use of vacuum rated flexible hose and "quick connect" camlock fittings for wellhead/manifold connections is recommended. A direct reading vapor flow gauge, or pitot tube, and magnehelic pressure gauge, must also be provided as part of the manifold. Flow readings can also be collected at the outlet of the vacuum pump, unless dilution air is used. Metal discharge piping will be placed at the effluent end of the blower with heat shields to protect workers instead of PVC.
- Vapor samples should be collected from the extraction manifold using a portable, high vacuum oil-less vacuum pump (such as a rotary vane pump) with a vacuum capability exceeding that of the SVE blower. Vapor samples should not be collected at the discharge of the pump, because hydrocarbon vapors may be entrained in the exhaust. For discussion of frequency of sampling, refer to Section 6.
- Vapor treatment is required for the duration of the test, in accordance with Section 1200-3-9.04(4) Subpart(d) Part 24 of the Tennessee Department of Environment and Conservation (TDEC) Air Regulations. Granular-Activated Carbon (GAC) beds or a catalytic oxidizer, sized to accommodate the previously specified flow rate will be incorporated into the system. To provide the proper amount of carbon or proper size oxidizer unit, air samples will be collected from the two VWs at least 3 weeks prior to mobilization of the SVE equipment. These samples will be collected in SUMMA® canisters after purging five volumes of air from each VW and analyzed for VOC content. Installation of the carbon beds in series or catalytic oxidizer unit will facilitate "breakthrough" monitoring. The Memphis Public Health Department will also be contacted for a permit or waiver (National Priorities List exclusion) at least 3 weeks prior to the planned test start date.

4.3 SVE Treatability Study Procedures

This section contains procedures for conducting the SVE TS including:

- Set-up procedures;
- Start-up procedures;
- Shutdown procedures;
- Flow and pressure monitoring;
- Procedures for the steady state and transient pressure tests;
- On site data analysis procedures; and
- Vapor monitoring.

The entire TS will be conducted over an estimated period of 14 days at both VW locations. The first portion of the test will consist of transient pressure tests at each of the extraction wells (VW-1 and VW-2) followed by steady-state pressure testing at each extraction well. The removal of pore volumes of soil gas will be an additional parameter in the completion of each steady-state test. Testing will be conducted on VW-1 extraction well first followed by a test at VW-2.

4.3.1 Set-up Procedures

The SVE system will be mobilized and brought to the site. The system will be connected to the extraction well and monitoring points. Power/fuel supply will be delivered to the site in advance of the test or delivered on an as-needed basis.

Following the equipment setup, the SVE unit will be briefly tested on ambient air to ensure proper operation. The vapor discharge will be leak tested with a soap solution. All field monitoring equipment, including the portable flame ionization detector (FID) and the combustible gas indicator/oxygen (CGI/O_2) meter) will be calibrated in accordance with their operation manuals and the calibration will be noted in calibration logs.

4.3.2 Start-up Procedures

The normal startup procedure for the SVE system is specified below. It may be necessary to restart the system following planned changes in operating conditions, or unexpected shutdown conditions. The typical start-up procedure is as follows:

1. Check the position of all valves. Ambient air intake valve and throttle valve should be open, all sample ports and other valves closed.
2. Check the control panel for alarm conditions.
3. Visually inspect the unit for any signs of air leakage or mechanical problems.
4. Start the electric generator or other power supply (if applicable), checking fuel and voltage levels.
5. Start the SVE blower.
6. Gradually close the ambient air intake valve and open the throttling valve. Attempt to fully close the dilution valve, while monitoring flow rate. Do not operate the blower at less than 20 percent of the nominal flow capacity to avoid overloading the unit (refer to the manufacturer performance curve to obtain the nominal flow capacity). If flow from the well is very low (i.e., soil resistance to air flow is high), it will be necessary to keep the intake valve partially open for the duration of the test.
7. Visually inspect all gauges and level indicators to ensure normal operation.

4.3.3 Shutdown Procedures

Both normal and emergency shutdown procedures are provided below.

4.3.3.1 Normal Equipment Shutdown Procedures

The normal shutdown procedures listed below will be carried out to conduct maintenance activities or due to a planned shutdown.

1. Open the ambient air intake valve (if applicable) and close the valve to the extraction well. Purge clean air through the system for a minimum of 1 minute.

2. Turn off the blower.
3. Turn off power supply.
4. Visually inspect the system noting any alarm conditions.

4.3.3.2 Emergency Equipment Shutdown Procedures

Emergency shutdown may be required as a response to an accident in the test area, explosive conditions, fire, or imminent danger. The emergency shutdown procedure is as follows:

1. Turn off the power supply or electrical quick disconnect switch to eliminate power to the SVE system.
2. Shut the valve at the wellhead.
3. Once the emergency has been addressed, reset the valve and switch positions before restarting the system.

4.3.4 Transient Pressure Test Procedures

The objective of the transient pressure test will be to evaluate the relationship between flow and vacuum pressure at the wellhead. To accomplish this objective, the ambient air intake ("dilution") valve or flow control ("throttling") valve will be adjusted in three increments or "steps," based on a maximum achievable flow rate. The vacuum at the wellhead and surrounding monitoring probes, as well as flow rate, will be measured at pre-determined time intervals. These data will be used to predict the vacuum influence zone at various applied flow/vacuum levels, as well as vacuum pump sizing for full-scale design. In the event that approximate steady-state conditions are observed during the transient test, these data may also be used to estimate vacuum influence zone and the soil permeability to air.

During the test procedures, all data collected shall be reviewed and processed to ensure that the data indicate that that the test was performed properly and is adequate for design or to ensure that the technology is not best for the site. This effort will require review of the test objectives stated in Sections 3.0 and 8.0 prior to normal equipment shutdown of the system. Refer to Appendix C, Standard Operating Procedure for Transient and Steady State Pressure Tests, for further details on the test method, equipment, and data interpretation.

4.3.5 Steady-State Pressure Test Procedures

The purpose of the steady-state pressure test is to determine approximate steady-state vacuum distribution and soil gas chemistry data. As in the case of an aquifer pump test, the pressure distribution "cone of depression" surrounding a venting well can, in some instances, require an extended period of time to achieve pseudo steady-state conditions. This extended time frame to achieve steady state is especially common in low permeability formations and where sources of recharge or flow barriers may be encountered. Because of the low density of air relative to water, steady state can be established within a short time frame (i.e., minutes to hours). For this test, a steady-state condition is the desired operating condition.

During each steady-state test, the total amount of pore volumes of soil gas removed must be measured. The steady-state test will not be considered complete until at least 5 pore volumes have been removed. The time required to remove the soil gas from the loess deposits is estimated at 2 days, whereas for the fluvial aquifer the removal may take approximately 6 days. Table 4-1 presents the TS soil gas purge time estimates. Also during test procedures, all data collected shall be reviewed and processed to ensure that the data indicate that that the test was performed properly and is adequate for design or to ensure that the technology is not best for the site. This effort will require review of the test objectives stated in Sections 3.0 and 8.0 prior to normal equipment shutdown of the system. Refer to Appendix C, Standard Operating Procedure for Transient and Steady-State Pressure Tests, for further details on the test method, equipment, and data interpretation.

4.4 Treatability Study Demobilization

At the conclusion of the transient and steady-state tests, the SVE unit and power source will be dismantled, as necessary, decontaminated, and transported from the site. Vacuum probes will remain in place and sealed to atmosphere for potential future use. Used vapor phase carbon canisters will remain on-site for characterization sampling and transport and disposal by a licensed contractor. Soil cuttings and wastewater generated during site activities will be handled as described in Sections 6.0 and 10.0.

5.0 Equipment and Materials

Potential vendors for mobilization of equipment (vacuum pump, power source, vapor treatment, manifold, gauges, carbon units, catalytic oxidizers, etc.) to the site are summarized in the table below. Vendor contact names, phone numbers, and type of equipment available for rental are also provided. Please note that this list is not comprehensive and other sources for this equipment may be available.

SVE Treatability Study Equipment Vendors

Vendor Name	Contact Name and Phone Number	Type of Equipment Available for Rental
Pro-Act Services Ludington, MI	Bob Hawkins/Frank Smiddy (231) 843-2711 or (231) 920-0606	Skid/Trailer Mounted Vacuum Pump Systems ICE Systems
Engineered Environmental Equipment Tipp City, OH	Fred Swensen (937) 667-8183	Skid/Trailer Mounted Vacuum Pump Systems
ECOVAC Services Atlanta, GA	Nick Athens (888) 432-6822 (888) 817-1491 (pager)	ICE Systems Vacuum Trucks
Seneca Remediation Systems	Jim Ramm or Dan Nolan (800) 369-3500	Pilot test units
Carbtrol	Peter Schurr - 770 396 8625 Kelly Kreigh - 800 242.1150 (Corp)	Carbon Units
Thermtech	Brian Smith (800) 659-8271	Catalytic Oxidizers

The trailer/skid mount systems requiring electrical power will need 230 volt (V) or 460 V, three-phase service, which must be arranged at least 2 weeks prior to the test. If an ICE system is used, natural gas/propane should be provided to the site in the form of a 300- to 500-gallon bulk tank, unless a service line with a separate meter is available locally. Piping between wellheads and general manifold piping should consist of Schedule 40 PVC. The PVC will be secured to prevent movement as the PVC "heats up" with temperature increases from friction with air movement. Piping located immediately after the blower will be metal and will have heat shields to protect workers from burns. Piping between and connecting the carbon beds should be flexible, gas-resistant hose suitable for vacuum/pressure applications with camlock quick-connect fittings.

6.0 Sampling and Analysis

A *Final Generic Remedial Investigation/Feasibility Study Work Plan* and a *Final Generic Quality Assurance Project Plan* (QAPP) was prepared by CH2M HILL in 1995 as part of the RI/FS field effort at Dunn Field. These documents have been supplemented or amended with case-specific material as required for additional field efforts as part of the RI. This section presents material that is to be considered as an addendum to these documents, as necessary, and will be instituted prior to commencement of the TS.

6.1 Scope of Activities

During the SVE TS at Dunn Field, equipment will be utilized that will extract VOCs from the surrounding soils. The concentration of the VOCs being extracted from the soil and the volume of air removed compared to the rate at which air is being removed from the soil are critical factors in determining the success of the treatability system. The required sampling and analysis procedures to be conducted during the TS are as follows:

- Field screening of ambient conditions prior to, during, and after the transient and steady-state tests are conducted;
- Collection of samples for VOC analysis from VWs and MPs prior to, during, and subsequent to the testing effort;
- Collection and analysis of air samples from the SVE system during operation of the system for the transient and steady-state tests;
- Collection of ambient conditions around testing equipment; and
- Measurement of flow/velocity of air through the system during the transient and steady-state tests.

6.2 Sampling Methods

All ambient air and air quality samples for field screening and laboratory analysis will be collected in accordance with the:

1. RI/FS Work Plan (1995);
2. QAPP (1995); and
3. EISOPQAM (1996, revised in 1997).

6.2.1 Ambient Air Screening with a FID

In accordance with the existing RI/FS Workplan and for Health and Safety protection of all field staff, field monitoring (or ambient air monitoring) with a calibrated FID at regular intervals is required for the entire testing period during both the steady-state and transient tests. In addition, ambient air and ambient temperature measurements will be collected prior to the test to establish ambient and background conditions and at the end of the test to determine if any residual vapors exist near the testing area. FID monitoring will be conducted at the influent and effluent of the carbon canister vapor collection system. Monitoring will be conducted at intermediate locations as well, if dual carbon beds in series are utilized. Analytical instruments will be calibrated in accordance with the manufacturer's instructions. All measurements will be recorded in field notebooks with the date, time, and location of the recording clearly noted and noted in a daily calibration log.

6.2.2 Screening with a FID for VOCs

As described on Table 6-1, field screening with a calibrated FID for VOC levels will be conducted at regular intervals for the entire testing period during both the steady-state and transient tests. In addition, measurements will be collected prior to the test to establish ambient and background conditions. This sampling is necessary to establish a qualitative level of VOCs in background, VW, and MP locations and to define how VOC vapor levels are effected during the testing period. Prior to analysis with the FID, each sample will be collected in a Tedlar® bag. Except for ambient air samples, all screening samples will be collected from VW and MP wellhead sampling points only. Use of a rotary vane pump, such as that used in the asbestos air monitoring industry, or equivalent, will be necessary to collect wellhead vapor samples under a strong vacuum. Analytical instruments will be calibrated in accordance with the manufacturer's instructions. All measurements will be recorded in field notebooks with the date, time, and location of the recording clearly noted and noted in a daily calibration log.

6.2.3 Air Sampling for VOCs

Samples using SUMMA® canisters will be collected according to the vapor monitoring schedule summarized in Table 6-1 and according to methods described in Section 14 of the EISOPQAM. Samples will be collected prior to, during, and at the conclusion of each steady state and transient test. These samples are necessary to establish a quantitative level of VOCs in background, VW, and MP locations and to define how VOC vapor levels are effected during the testing period. SUMMA® canister samples will be analyzed in a laboratory for VOCs per EPA Method TO-15 for VOCs. These samples will be collected at each VW wellhead through connection to the extraction manifold at a point prior to any dilution effects. One sample will also be collected during each test at the terminus of the exhaust manifold system (after the carbon canister vapor collection system). All measurements will be recorded in field notebooks with the date, time, and location of the recording clearly noted. SUMMA® canisters will be packed properly in coolers to prevent any potential puncture of the canister or exposure to excess heat that may cause the canister to rupture.

6.2.4 Air Monitoring for Hazardous Ambient Conditions

During the test, screening for hazardous ambient conditions will be conducted through the use of a CGI/O_2 meter according to the schedule presented in Table 6-1. This sampling effort is necessary to alert personnel to potential buildup of explosive levels of gases in the piping of the test system. The screening will take place at the VW wellhead prior to any dilution from ambient air intake valves. If necessary, the influent air stream will be diluted to maintain the air stream below 20 percent of the Lower Explosive Limit (LEL) (unlikely for this site). The measurements will be recorded in field notebooks with the date and time of the recording and location of the measurement clearly noted. Analytical instruments will be calibrated in accordance with the manufacturer's instructions and noted in a daily calibration log.

6.2.5 Air Sampling for Oxygen and Carbon Dioxide

Oxygen (O_2) and carbon dioxide (CO_2) will be measured periodically throughout the test to evaluate biological activity and future viability of bioremediation. The sample schedule for these two parameters can be found in Table 6-1. Each sample will be collected in a Tedlar® bag. Samples will be collected from VWs and MPs wellhead sampling points only. Use of a rotary vane pump, such as that used in the asbestos air monitoring industry, or equivalent, will be necessary to collect wellhead vapor samples under a strong vacuum. The sample should be analyzed using appropriate analysis equipment, such as a CGI/O_2 or GasTech meter and other equipment. The measurements will be recorded in field notebooks with the date and time of the recording and location of the measurement clearly noted. Analytical instruments will be calibrated in accordance with the manufacturer's instructions and noted in a daily calibration log.

6.2.6 Velocity/Flow and Pressure Measurements

Velocity/flow and pressure measurements will be conducted through monitoring of gauges to establish the mass removal rate, and should be monitored in conjunction with FID readings. The gauges should be connected directly to the manifold in locations shown on Figure 4-1. All measurements will be recorded in field notebooks with the date, time, and location of the recording clearly noted.

6.2.7 IDW Sampling

IDW from this project will include soil cuttings, water derived from decontamination activities and the knockout tank, and solid waste. Soil cuttings generated from the MP installation procedures will be placed in drums or other appropriate equipment and stored at the site prior to sampling for characterization purposes and disposal. Samples will be collected through the use of a hand auger or other appropriate device and placed into a decontaminated stainless steel bowl for compositing. Soil samples for analysis of VOC content will be collected according to EPA Method 5035 and procedures described in Appendix D. Wastewater generated from site activities will also be stored at the site prior to removal from Dunn Field The water will be sampled for final disposal purposes.

6.3 DQOs for Analytical Data

The DQOs for each sampling task described above are listed in Table 6-2. The sampling and analytical requirements, field quality control (QC) requirements, and the required level of quality and data packages are listed in Table 6-3. The project-specific QC objectives for those data are included in the QAPP. These include the quantitation, accuracy, precision, completeness, representativeness, and comparability limits by which the data will be evaluated.

Validation of laboratory data will be performed initially by the laboratory. After the data have been released, CH2M HILL will review and perform a data quality evaluation. As a final review step, the data will be reviewed by personnel from the US Army Corps of Engineers Center of expertise. Data validation results will be provided in the SVE treatability study technical memorandum that discusses the SVE study results.

6.3.1 Analytical Methods

Analytical requirements for this sampling and analysis amendment are listed in Table 6-3. All samples will be analyzed according to EPA SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, where necessary. Each air sample for VOCs will be analyzed according to Method TO-15. IDW soil cuttings will be analyzed in compliance with 40 *Code of Federal Regulations* 261(c), including full Toxicity Characteristic Leaching Procedure (TCLP) and other parameters specified by the treatment, storage, and disposal facility. If necessary, IDW water samples should be analyzed for Dunn Field groundwater contaminants according to EPA SW-846 Test Methods as well as any other parameters identified by disposal permits from the City of Memphis.

7.0 Data Management

Data management for the SVE TS will match the requirements of the DQOs presented in Section 6 and Table 6-3. Most of the field data will be obtained through the efforts of field screening, which includes use of direct-reading instruments. Other data to be obtained will come from analysis of samples that have been sent to an analytical laboratory. The information in this section is considered supplemental to the *Final Generic QAPP* for the Memphis Depot activities.

7.1 Sample Numbering System

During the SVE TS, four tests will be conducted—two transient tests and two steady-state tests at both venting wells. During collection of field notes and measurements, the current test will have to be correctly noted in the field notebooks. All sample numbers will also have to reflect the current test effort and which type of testing (i.e., transient or steady-state) is active. For transient tests, the active phase or "step" of the test will also have to be noted. Therefore, the following sample numbering protocol will be used for the tests:

Sample Numbering System Reference Table

Sample Task	Venting Well (VW) or Monitoring (MP) Point Number	Test Type	Test Phase (only applicable to Transient test)	Proposed Sample Numbering System
Ambient Air Screening	Applicable to site area	Transient	1, 2, 3, or 4	VW1-T-1-AA-* or VW2-T-AA-*
		Steady-state		VW1-S-AA-* or VW2-S-AA-*
Screening with an FID for VOCs	VW-1 or VW-2 and MP-[and no]	Transient	1, 2, 3, or 4	VW1-T-1-FID-* or VW2-T-1-FID-* or MP[Insert location no. here]-T-FID-*
		Steady-state		VW1-S-FID-* or VW2-S-FID-* or MP[Insert location no. here]-S-FID-*
Air Sampling for VOCs	VW-1 or VW-2	Transient	1, 2, 3, or 4	VW1-T-1-SMA-** or VW2-T-1-SMA-**
		Steady-state		VW1-S-1-SMA-** or VW2-S-1-SMA-**
Air Monitoring for VOCs	VW-1 or VW-2	Transient	1, 2, 3, or 4	VW1-T-1-CGI-* or VW2-T-1-CGI-* or MP[Insert location no. here]-T-CGI-*
		Steady-state		VW1-S-CGI-* or VW2-S-CGI-* or MP[Insert location no. here]-S-CGI-*
Air Sampling for O_2 and CO_2		Transient	1, 2, 3, or 4	MP[Insert location no. here]-T-1-O2-* or MP[Insert location no. here]-T-1-CO2-*
		Steady-state		MP[Insert location no. here]-S-1-O2-* or MP[Insert location no. here]-S-1-CO2-*

Sample Numbering System Reference Table

Sample Task	Venting Well (VW) or Monitoring (MP) Point Number	Test Type	Test Phase (only applicable to Transient test)	Proposed Sample Numbering System
Pressure, Velocity/Flow	VW-1 or VW-2 and MP-[and no.]	Transient	1, 2, 3, or 4	Direct read from gauge. Note time, location, venting well, test type, and phase when collecting reading.
		Steady-state		Direct read from gauge. Note time, location, venting well, test type, when collecting reading.

*Sample numbers will be followed by a sequential number, beginning with 1 and ending with the last sample collected For example, the first sample collected for ambient air screening during the first step of the transient test on VW-1 would be numbered VW1-T-1-AA-1.
**Sample number will reflect the time expired since test began Samples are to be taken at 4, 12, 36, and 72 hours after the test has begun; therefore, for example, the sample taken during the steady-state test of VW-1 after 4 hours of testing will be numbered VW1-S-SMA-4.
FID = Flame Ionization Detector; SMA = SUMMA® Canister, CGI = Combustible Gas Indicator; O2 = Oxygen; CO2 = Carbon dioxide.

Importantly, for background or baseline samples, the acronym BCKG for background and BSLN for baseline samples should be inserted as a prefix to the sample numbers presented in the table above. For example, the background sample collected for ambient air screening prior to the first step of the transient test on VW-1 would be numbered BCKG-VW1-T-1-AA-1.

For some of the sampling tasks, the location of the sampling point will be noted on a map of the site. This is especially important for demarcating background locations or points not immediately adjacent to MPs or VWs.

7.2 Field Screening Data Management

As presented in Section 6.2 and Table 6-2, field screening efforts will include ambient air screening with a FID, screening with a FID for VOCs, air monitoring for hazardous ambient conditions using a CGI/O_2 meter, pressure and velocity/flow measurements, and air sampling for O_2 and CO_2. The data collected will be derived from direct-reading instruments that will require the full attention of the operator to ensure that reported values are not misinterpreted or misunderstood. Data that will be recorded with each measurement include the following:

1. Date and time;
2. Elapsed time since test beginning, as necessary;
3. Location of measurement/location where the sample was collected; and
4. Instrument measurement.

Each measurement will be handwritten into a bound field notebook and, after the entire test has been completed, the data will be transferred into an electronic file for use within the TS report.

Other field notes to be collected during performance of the TS and written in the field notebook(s) include: weather information; personnel on-site during the test; subcontractor names and activities; sketches of the SVE system used during the study; notes on the proximity of the system to established facilities on Dunn Field: type of test being conducted (transient versus steady-state); and any other pertinent information that may affect the study results. This information will be included in the TS report, as necessary.

7.3 Analytical Laboratory Data Management

Only SUMMA® canisters collected from the VW wellheads will be submitted to an analytical laboratory for VOC analysis and reporting. During collection of the SUMMA® canister samples, the date, time, location of sample collection, test type, and sample number will be recorded in the field notebook. This information will be transferred, as required, to the Chain-of-Custody (COC) documents for the SUMMA® canisters. Copies of the COC documents will be kept at the site until the test is over and will be transferred to the site files for record keeping.

After the analytical data have been received from the laboratory, the data will be stored electronically, summarized, and reproduced for the technical memorandum. Prior to this, however, the data will be reviewed by a project chemist for quality assurance (QA). If there are any differences between the chemist's and the laboratory's review of the data, a letter report will be issued describing the differences and any potential results for the study.

8.0 Data Analysis and Interpretation

The data from the test will be reviewed following methods described in Section 4-5 of the *Soil Vapor Extraction and Bioventing*, Engineer Manual No. 1110-1-4001, U.S. Army Corps of Engineers (USACE), November 1995. All test data will be presented in tabular and graphical format. Graphical data regression and analysis will also be part of the data analysis procedures. The SVE treatability study technical memorandum will present a description of the test and the process, a field and laboratory data summary, laboratory results, and recommended parameters for the final design.

The objectives of this TS technical memorandum include definition of the relationship between applied vacuum and flow from the well, air permeability of the soils, contaminant removal rates as a function of time, vacuum distribution in soils surrounding the extraction well, water table response to applied vacuum, and condensate/liquid production.

Treatability study data analysis will be completed in one of two ways:

1. The in-situ soil permeability (k) of the vadose zone and vacuum ROI can be estimated using analytical models that describe pressure and velocity distribution and volumetric vapor flow rate in homogeneous porous media under equilibrium (steady state) conditions. These models are based on Darcy's Law for compressible flow and the continuity of mass equation and were developed by Johnson et al., (1990). While somewhat antiquated, this approach is straightforward and permits rapid calculation of vacuum ROI.
2. The results of this test can be analyzed quantitatively to: (1) obtain permeability and leakance values, (2) establish the subsurface pressure distribution, and (3) predict the subsurface velocity field. The data are analyzed using the aquifer pump test solution model, such as the AQTESOLV computer model, which contains analytic solutions for fluid flow under various conditions. The solution typically used for SVE treatability studies is the Hantush solution for unsteady flow to a well in a semi-confined aquifer The major assumption is that a confining layer (a concrete floor or pavement) is infinite in areal extent and that all air leaks through the confining layer. The model uses non-linear regression analysis, by the Gauss-Newton method of parameter estimate, to obtain a best-fit of curve data.

Either analysis method has inherent limitations. The second method is more rigorous; it is also more useful and accurate for predicting vacuum/flow field response for a full-scale, multiple extraction well design. The method chosen to analyze the data will be based upon preliminary review of all field and laboratory data as well as review of requirements for development of a full-scale SVE system.

In addition to either method of data analysis described above, the data will be used to construct a subsurface vacuum/flow response curve, to define biological activities in the subsurface soils, and to construct mass removal versus time graphs for projection of mass loading in a full-scale design.

9.0 Health and Safety

The existing site-specific HASP for the site was prepared by CH2M HILL in August 1995 and revised for additional RI activities in August 2000. The plan will be revised for the conductance of the SVE TS. Although a majority of the plan will remain the same, issues particular to an SVE test will be discussed within the revised HASP. These issues include the following:

- **Electrical Hazards (as applicable)** – The electrical generator, power panel, and portions of the control panel operate at high voltages. All high-voltage wiring will be performed by a licensed electrician. Field technicians will do work inside the electrical panels (e.g., changing a fuse) only with the electrical power turned off.
- **Noise** – The vacuum pump may create a noise hazard for personnel working in the close vicinity during operation (5 to 10 feet). Hearing protection will be used in all areas with greater than 80 decibel of noise.
- **Oxygen Depletion from GAC** – GAC can create oxygen depletion inside the vessel. Each GAC vessel must be treated as a confined space. At no time is an operator to put any portion of their body inside a filled GAC vessel
- **Carbon Bed Fires** – High concentrations of certain VOCs (i.e., ketones) can cause carbon bed fires. Typically, these fires occur when the system is shut down and heat does not dissipate. As part of normal shutdown procedures, operate the SVE system on ambient air for several minutes to dissipate heat.
- **Explosive Environments** – Explosive levels of vapors may form in portions of the SVE system, which will be monitored for explosivity at start-up. An ambient air intake valve will be used to control vapor concentration at a level below 10 percent of the LEL. The SVE system will be located at least 30 feet away from any sources of ignition including the electrical generator.
- **Rotating Mechanical Equipment** – Rotating mechanical equipment, such as the SVE blower, will not be operated with the safety protection removed.
- **Ambient Air Monitoring Action Levels** – The existing HASP provides action levels for upgrading levels of personnel protection from level D to level C. However, employing engineering controls to prevent VOC emissions is preferable to using personnel protective equipment. If the action levels for Level D are exceeded during the operation of this test, the test will be stopped and corrective action taken. Corrective action may include changing carbon vessels or repairing pipe leaks.

10.0 Residuals Management

Waste handling will be dealt with during the conductance of the TS. Waste may be classified as noninvestigative waste or investigative/field-generated waste.

Noninvestigative waste, such as litter and household garbage, will be collected on an as-needed basis to maintain the site in a clean and orderly manner. This waste will be containerized and transported to the designated sanitary landfill or collection bin. Acceptable containers will be sealed containers or plastic garbage bags.

Investigative/field-generated waste will be properly containerized and temporarily stored at each site, prior to transportation. Depending on the constituents of concern, fencing or other special marking may be required. The number of containers will be estimated on an as-needed basis. Acceptable containers will be sealed, U.S. Department of Transportation-approved steel 55-gallon drums or roll-off box-type containers. The containers will be transported in a manner to prevent spillage or particulate loss to the atmosphere. To facilitate handling, the containers will be no more than half full when moved.

The investigative/field-generated waste will be segregated at the site according to matrix (solid or liquid) and means of derivation (drill cuttings and decontamination fluids). Each container will be properly labeled with site identification, sampling point, depth, matrix, constituents of concern, and other pertinent information for handling.

Soil cuttings generated from the monitoring point installation procedures will be placed in drums or other appropriate storage devices and stored at the site. The soil will be sampled for final disposal purposes according to methods described in Section 6.2.7 . Once the soil analytical data have been obtained, the soil will be removed from Dunn Field within 60 days. Previous IDW soil samples were analyzed by TCLP methods and were found to be non-hazardous. The soil did not require special procedures for transportation and disposal.

Wastewater generated from decontamination activities and the SVE system knockout tank must also be stored at the site prior to removal from Dunn Field. Once analytical data have been obtained, the water will be removed from Dunn Field within 60 days. During past investigation activities at Dunn Field, IDW water was disposed of in the City of Memphis sewer system after a temporary permit had been obtained from the City of Memphis Public Works Department. The permit provided an explanation that the water contained concentrations of contaminants similar to the effluent from the operating Dunn Field groundwater extraction system, which discharges into the City's sewer system.

11.0 Community Relations

The Memphis Depot has an active community involvement that monitors the events that occur at the Memphis Depot site as well as Dunn Field. The SVE treatability study will occur with the knowledge of members of the community, many of which live just beyond the eastern and western perimeter of Dunn Field. It is imperative that this study be conducted according to the specifications presented herein and that if any changes are necessary proper notification is followed along with discussions with all stakeholders.

It is anticipated that the plans for the TS will be presented to the Memphis Depot Restoration Advisory Board (RAB) prior to field activities. In addition, prior to initiation of field activities, fact sheets describing the treatability test and duration of the fieldwork will be distributed to the local community members that live in the area surrounding Dunn Field. The findings from the TS will also be presented to the RAB members once they are finalized.

12.0 Reports

An SVE TS technical memorandum will provide the necessary documentation of the completed TS process. Jacobs will complete the technical memorandum according to the schedule presented in Section 13.0. The technical memorandum should report findings according to methods described in Sections 4-6 through 4-8 of the *Soil Vapor Extraction and Bioventing*, Engineer Manual No. 1110-1-4001, USACE, November 1995. The technical memorandum will include, but not be limited to the following:

- A description of the SVE system construction and additional monitoring point installation;
- Description of the test methods enacted during the study and SVE system performance;
- Field measurement methods;
- Summary of field and laboratory analytical data as presented in graphs and tables;
- Results of analysis of the analytical data via computer models, including contaminant concentrations, soil gas chemistry, change in vapor concentration versus pore volumes;
- Description of the ROI, subsurface pressure distribution, and subsurface velocity field; and
- Recommended parameters for the final design.

The technical memorandum will also contain a separate section that covers the data quality and validity. At a minimum, the following information will be included in this section:

- Assessment of measurement data precision, accuracy, and completeness;
- System and performance audit results;
- Potential QA problems and corrective actions implemented; and
- Copies of documentation, such as memos and reports.

13.0 Schedule

13.1 Schedule

The following preliminary schedule is presented for the SVE TS fieldwork and preparation of the final technical memorandum.

Task	Date Completed
Submit Draft Treatability Study (TS) Workplan to the U.S. Corps of Engineers for Internal Review	July 12, 2001
Present the Rev. 0 TS Workplan to the BCT	August 20, 2001
Receive Comments on Rev. 0 TS Workplan from Agencies	September 21, 2001
Submit Rev 1 TS Workplan	October 5, 2001
Contact Utility Locators (Tenn. Utilities Hotline at 800-351-1111)	October 5, 2001
Install Additional SVE Monitoring Probes and Mobilize SVE System to Site	October 19, 2001
Mobilize for Field	October 29, 2001
Perform SVE Treatability Study	November 12, 2001
Conduct Laboratory Analyses of Air Samples	November 26, 2001
Conduct Laboratory Data Evaluation	December 3, 2001
Prepare Technical Memorandum for submittal with Dunn Field FS report	December 21, 2001
Submit Weekly Field Status Report to USACE & BCT and Conduct Monthly Teleconferences to Discuss Field/Lab Results	October, November, December 2001

14.0 References

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TABLE 1-1
Frequency of Detection for All Media (except Groundwater) in the Disposal Area
Rev 1 Dunn Field SVE Treatability Study WP

Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration
Metals							
Surface Soils (0-1 ft bgs)							
MG/KG	SILVER	50	14	0 65	8 4	1 4	2
MG/KG	ALUMINUM	50	50	6070	31100	13937 8	23810
MG/KG	ARSENIC	50	50	1 9	43 7	11 0	20
MG/KG	BARIUM	8	8	112	423	178 6	234
MG/KG	BERYLLIUM	50	34	0 21	1 3	0 6	1 1
MG/KG	CALCIUM	8	8	986	61200	18979 5	5840
MG/KG	CADMIUM	50	5	0 64	1 2	0 9	1 4
MG/KG	COBALT	10	10	3.2	10 8	7 8	18 3
MG/KG	CHROMIUM, TOTAL	49	49	9 5	212	30 0	24 8
MG/KG	COPPER	50	44	6 8	796	54 4	33 5
MG/KG	IRON	8	8	13200	51000	25075 0	37040
MG/KG	MERCURY	50	18	0 03	1 3	0 2	0 4
MG/KG	POTASSIUM	8	8	1320	3000	2053 8	1820
MG/KG	MAGNESIUM	8	8	2240	3920	2836 3	4600
MG/KG	MANGANESE	8	8	211	866	580	1304
MG/KG	SODIUM	8	4	58 2	400	243 8	
MG/KG	NICKEL	50	49	3	37 1	17 9	30
MG/KG	LEAD	50	50	7 4	1020	104 4	30
MG/KG	ANTIMONY	50	22	1 5	356	22 2	7
MG/KG	SELENIUM	50	9	0 24	1 3	0 5	0 8
MG/KG	THALLIUM	50	20	0.22	0 68	0 5	
MG/KG	VANADIUM	8	8	30 9	53 8	40 5	48 4
MG/KG	ZINC	50	44	41 1	935	127 5	126
Subsurface Soils							
MG/KG	ALUMINUM	69	69	721	32200	12410	21829
MG/KG	ANTIMONY	69	30	1 1	5 9	2 13	
MG/KG	ARSENIC	69	64	1 4	35 6	8 8	17
MG/KG	BARIUM	66	65	2 6	312	111 0	300
MG/KG	BERYLLIUM	69	23	0 43	0 89	0 6	1 2
MG/KG	CALCIUM	66	60	572	6680	2130	2432
MG/KG	CHROMIUM TOTAL	69	69	1 6	74 6	18 7	28 4
MG/KG	COBALT	66	61	2 2	13	7 3	20 4
MG/KG	COPPER	69	25	6 6	69 9	20 0	32 7
MG/KG	IRON	66	66	2090	32400	19405	38480
MG/KG	LEAD	69	69	0 65	180	23 6	23 9
MG/KG	MAGNESIUM	66	61	116	3950	2599	4900
MG/KG	MANGANESE	66	66	2 5	1090	503	1540
MG/KG	MERCURY	68	21	0 03	0 15	0 1	0 2
MG/KG	NICKEL	69	67	1 4	29 4	17 8	36 6
MG/KG	POTASSIUM	66	50	119	3190	1298	1800
MG/KG	SELENIUM	69	5	0 59	1 4	1 0	0 6
MG/KG	SILVER	69	4	0 57	1 2	0 9	1
MG/KG	SODIUM	66	42	37 5	627	159	
MG/KG	THALLIUM	69	8	0 31	0 64	0 4	
MG/KG	VANADIUM	66	66	2	64 6	29 6	51 3
MG/KG	ZINC	69	25	2 2	2650	155	114
OC Pesticides							
Surface Soils (0-1 ft bgs)							
MG/KG	ALPHA-CHLORDANE	28	6	0 0003	0 006	0 002	0 029
MG/KG	GAMMA-CHLORDANE	28	7	0 0003	0 004	0 002	0 028
MG/KG	DDD (1 1-bis(CHLOROPHENYL) 2 2 DICHLOROETHANE)	28	21	0 0002	0 126	0 023	0 0067
MG/KG	DDE (1 1 bis(CHLOROPHENYL)-2 2 DICHLOROETHENE)	28	23	0 0006	0 6	0 091	0 16
MG/KG	DDT (1 1-bis(CHLOROPHENYL) 2 2 2-TRICHLOROETHANE)	28	24	0 0003	1 46	0 195	0 074
MG/KG	DIELDRIN	28	20	0 0005	0 964	0 104	0 086
MG/KG	ENDOSULFAN SULFATE	28	6	0 0043	0 091	0 036	
MG/KG	ENDRIN	28	1	0 0036	0 004	0 004	
MG/KG	ENDRIN KETONE	28	1	0 003	0 003	0 003	
MG/KG	HEPTACHLOR EPOXIDE	28	2	0 0034	0 029	0 016	0 0045
MG/KG	METHOXYCHLOR	28	2	0 0042	0 054	0 029	
Subsurface Soils							
MG/KG	DDD (1 1 bis(CHLOROPHENYL)-2,2 DICHLOROETHANE)	21	6	0 00078	0 0786	0 021	
MG/KG	DDE (1,1-bis(CHLOROPHENYL)-2 2 DICHLOROETHENE)	21	9	0 00021	0 0221	0 005	0 0015
MG/KG	DDT (1 1-bis(CHLOROPHENYL) 2 2 2 TRICHLOROETHANE)	21	8	0 00056	0 0164	0 004	0 0072
MG/KG	DIELDRIN	21	6	0 0005	0 016	0 005	0 37
MG/KG	HEPTACHLOR	21	1	0 0001	0 0001	0 0001	
MG/KG	HEPTACHLOR EPOXIDE	21	1	0 0326	0 0326	0 0326	0 0021
MG/KG	METHOXYCHLOR	21	1	0 05	0 05	0 05	
MG/KG	TOXAPHENE	21	1	0 167	0 167	0 167	
Organics							
Surface Soils (0-1 ft bgs)							
MG/KG	Total Polynuclear Aromatic Hydrocarbons	29	22	0 03	74 83	9 80	
Subsurface Soils							
MG/KG	Total Polynuclear Aromatic Hydrocarbons	26	12	0 005	9 98	1 77	
Polynuclear aromatic Hydrocarbons							
Surface Soils (0-1 ft bgs)							
MG/KG	ACENAPHTHENE	29	6	0 014	1.3	0 29	
MG/KG	ANTHRACENE	29	9	0 008	1 8	0 43	0 096
MG/KG	BENZO(a)ANTHRACENE	29	19	0 009	5 8	0 82	0 71
MG/KG	BENZO(a)PYRENE	29	19	0 057	6 7	0 89	0 96
MG/KG	BENZO(b)FLUORANTHENE	29	17	0 074	8 2	1 17	0 9
MG/KG	BENZO(g h i)PERYLENE	29	20	0 035	3 8	0 58	0 82
MG/KG	BENZO(k)FLUORANTHENE	29	18	0 069	6 3	0 87	0 78
MG/KG	CHRYSENE	29	19	0 068	6 3	0 90	0 94
MG/KG	DIBENZ(a h)ANTHRACENE	29	15	0 02	1 6	0.27	0 28
MG/KG	FLUORENE	29	7	0 01	0 86	0.24	
MG/KG	FLUORANTHENE	29	20	0 098	17	1 88	1 6
MG/KG	INDENO(1 2 3-c d)PYRENE	29	19	0 038	4 6	0 66	0 7
MG/KG	2 METHYLNAPHTHALENE	29	2	0 11	0 34	0 23	
MG/KG	NAPHTHALENE	29	3	0 041	0 26	0 16	
MG/KG	PHENANTHRENE	29	18	0 011	13	1 38	0 61
MG/KG	PYRENE	29	20	0 072	12	1 55	1 5
Subsurface Soils							
MG/KG	2 METHYLNAPHTHALENE	28	1	0 12	0 12	0 12	
MG/KG	ACENAPHTHENE	28	1	0 055	0 055	0 06	

MG/KG = milligrams per kilogram MG/L = milligrams per liter

Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration
MG/KG	ACENAPHTHYLENE	28	1	0 079	0 079	0 08	
MG/KG	ANTHRACENE	28	4	0 005	0 11	0 06	
MG/KG	BENZO(a)ANTHRACENE	28	10	0 004	0 74	0 16	
MG/KG	BENZO(a)PYRENE	28	9	0 003	0 97	0 21	
MG/KG	BENZO(b)FLUORANTHENE	28	7	0 02	1.2	0 31	
MG/KG	BENZO(g h i)PERYLENE	28	7	0 017	0 57	0 19	
MG/KG	BENZO(k)FLUORANTHENE	28	7	0 02	0 95	0 27	
MG/KG	CHRYSENE	28	7	0 024	0 91	0 26	
MG/KG	DIBENZ(a h)ANTHRACENE	28	5	0 041	0.2	0 09	
MG/KG	FLUORANTHENE	28	8	0 052	1.2	0 40	0 045
MG/KG	FLUORENE	28	1	0 042	0 042	0 04	
MG/KG	INDENO(1,2 3-c d)PYRENE	28	7	0 014	0 69	0 21	
MG/KG	NAPHTHALENE	69	2	0 069	0 082	0 08	
MG/KG	PHENANTHRENE	28	7	0 041	0 56	0 23	
MG/KG	PYRENE	28	8	0 038	1 6	0 39	0 042
Polychlorinated biphenyls							
Surface Soils (0-1 ft bgs)							
MG/KG	PCB-1254 (AROCHLOR 1254)	28	1	0 012	0 012	0 01	
MG/KG	PCB-1260 (AROCHLOR 1260)	28	5	0 005	0 120	0 04	0 11
Subsurface Soils							
MG/KG	PCB-1260 (AROCHLOR 1260)	21	2	0 006	0 020	0 01	
Semivolatile Organic Compounds							
Surface Soils (0-1 ft bgs)							
MG/KG	BENZYL BUTYL PHTHALATE	29	1	0 0034	0 0034	0 0034	0 645
MG/KG	bis(2 ETHYLHEXYL) PHTHALATE	29	6	0 016	0 17	0 11	
MG/KG	CARBAZOLE	29	8	0 049	2	0 51	0 067
MG/KG	DIBENZOFURAN	29	3	0 077	0 52	0 299	0 647
MG/KG	DIETHYL PHTHALATE	29	2	0 0044	0 15	0 077	
MG/KG	DI-n BUTYL PHTHALATE	29	2	0 01	0 018	0 014	
Subsurface Soils							
MG/KG	1,2 4-TRICHLOROBENZENE	69	1	0 09	0 09	0 09	
MG/KG	2 4 6-TRICHLOROPHENOL	28	1	0 27	0 27	0 27	
MG/KG	bis(2-ETHYLHEXYL) PHTHALATE	28	5	0 021	0 16	0 05	
MG/KG	CARBAZOLE	28	2	0 096	0 097	0 10	
MG/KG	DI-n BUTYL PHTHALATE	28	2	0 012	0 035	0 02	
MG/KG	DIBENZOFURAN	28	1	0 023	0 023	0 02	0 72
MG/KG	DIETHYL PHTHALATE	28	2	0 0087	0 16	0 08	
MG/KG	HEXACHLOROBUTADIENE	69	1	0 003	0 003	0 003	
MG/KG	PENTACHLOROPHENOL	28	1	0.22	0.22	0 22	
MG/KG	PHENOL	28	1	0 022	0 022	0 022	19
Volatile Organics							
Surface Soils (0-1 ft bgs)							
MG/KG	ACETONE	45	2	0 2	0 44	0 32	
MG/KG	BENZENE	45	4	0 002	0 028	0 009	
MG/KG	TOLUENE	45	4	0 0008	0 026	0 008	0 002
MG/KG	CARBON DISULFIDE	45	1	0 015	0 015	0 015	0 002
MG/KG	CARBON TETRACHLORIDE	45	2	0 001	0 039	0 02	
MG/KG	1,1 DICHLOROETHENE	45	1	0 002	0 002	0 002	
MG/KG	TOTAL 1,2 DICHLOROETHENE	45	7	0 0009	0 87	0 16	
MG/KG	1 2 DICHLOROPROPANE	45	1	0 002	0 002	0 002	
MG/KG	ETHYLBENZENE	45	1	0 006	0 006	0 006	
MG/KG	METHYL ETHYL KETONE (2-BUTANONE)	45	27	0 002	0 039	0 01	0 002
MG/KG	METHYLENE CHLORIDE	45	1	0 0007	0 0007	0 0007	
MG/KG	1 1,2 2 TETRACHLOROETHANE	45	2	0 007	0 083	0 045	
MG/KG	TETRACHLOROETHYLENE(PCE)	45	9	0 0003	0 049	0 01	
MG/KG	STYRENE	45	4	0 0002	0 0008	0 0005	
MG/KG	1,1,2 TRICHLOROETHANE	45	1	0 002	0 002	0 002	
MG/KG	TRICHLOROETHYLENE (TCE)	45	11	0 0009	0 65	0 16	
MG/KG	CHLOROFORM	45	7	0 001	0 089	0 018	
MG/KG	VINYL CHLORIDE	45	1	0 11	0 11	0 11	
MG/KG	XYLENES, TOTAL	45	1	0 011	0 011	0 011	
Subsurface Soils							
MG/KG	1,1 2 2-TETRACHLOROETHANE	155	56	0 003	160	6 16	
MG/KG	1,1,2 TRICHLOROETHANE	155	25	0 0003	2 2	0 18	
MG/KG	1 1-DICHLOROETHENE	155	8	0 0004	0 06	0 01	
MG/KG	1,2 DICHLOROETHANE	155	5	0 001	0 048	0 02	
MG/KG	1,2 DICHLOROPROPANE	155	3	0 0003	0 005	0 002	
MG/KG	2-HEXANONE	155	1	0 035	0 035	0 035	
MG/KG	ACETONE	154	4	0 0651	0 933	0 36	
MG/KG	BENZENE	155	4	0 0003	0 003	0 0013	
MG/KG	BROMODICHLOROMETHANE	155	4	0 001	0 011	0 005	
MG/KG	CARBON DISULFIDE	155	7	0 001	0 004	0 003	0 002
MG/KG	CARBON TETRACHLORIDE	155	16	0 0005	6 8	0 52	
MG/KG	CHLOROBENZENE	155	5	0 0004	0 007	0 003	
MG/KG	CHLOROETHANE	155	1	0 003	0 003	0 003	
MG/KG	CHLOROFORM	154	37	0 0008	14	0 94	
MG/KG	ETHYLBENZENE	155	2	0 0005	0 004	0 002	
MG/KG	METHYL ETHYL KETONE (2 BUTANONE)	155	20	0 002	0 13	0 011	
MG/KG	METHYL ISOBUTYL KETONE (4 METHYL 2 PENTANONE)	155	3	0 001	0 004	0 002	
MG/KG	METHYLENE CHLORIDE	155	20	0 0005	0 039	0 007	
MG/KG	STYRENE	155	10	0 0002	0 0007	0 0004	
MG/KG	TETRACHLOROETHYLENE(PCE)	155	56	0 0004	4 4	0 16	
MG/KG	TOLUENE	155	9	0 0004	0 008	0 003	
MG/KG	TOTAL 1 2 DICHLOROETHENE	105	42	0 0006	190	7 93	
MG/KG	trans-1,2-DICHLOROETHENE	49	22	0 0007	0 044	0 005	
MG/KG	TRICHLOROETHYLENE (TCE)	155	92	0 0005	460	7 69	
MG/KG	VINYL CHLORIDE	155	15	0 002	7	0 64	
MG/KG	XYLENES, TOTAL	106	4	0 0006	0 02	0 007	0 002

MG/KG = milligrams per kilogram MG/L = milligrams per liter

Table 1-2
Soil Boring/Soil Sample Data
Supplemental (DNAPL) RI Investigation
October/November 2000
Rev 1 Dunn Field SVE Treatability Study Workplan

Compound	Range of Detection (ug/kg)
Volatile Organic Compounds	
1,1,2,2-TETRACHLOROETHANE	3J - 22,600
1,1,2-TRICHLOROETHANE	10.2*
1,2-DICHLOROETHANE	1J*
ACETONE	65.1 - 933
CHLOROFORM	0.8J - 5.31
cis-1,2-DICHLOROETHYLENE	0.7J - 132
HEXACHLOROBUTADIENE	3.09*
METHYLENE CHLORIDE	1J*
TETRACHLOROETHENE (PCE)	0.96J - 65.7
TOTAL 1,2-DICHLOROETHENE	56*
trans-1,2-DICHLOROETHENE	0.9J - 44.4
TRICHLOROETHENE (TCE)	2J - 3,610
VINYL CHLORIDE	55.2 - 74

*Out of 64 samples for VOCs, these compounds were only detected once

TABLE 4-1
Treatability Study Purge Time Estimates*
Rev 1 Dunn Field SVE Treatability Study Workplan

PARAMETER	VW-1	VW-2
Top of contaminated layer (ft bgs)	8	28
Bottom of contaminated layer (ft bgs)	28	78
Estimated radius of influence (ft)	40	80
Estimated air-filled void fraction[1]	0.35	0 35
Flow rate (cfm)[2]	75	200
Thickness of treatment zone (ft)	20	50
Volume of soil to be treated (ft^3)	100,531	1,005,310
Volume of air-filled void (ft^3)	35,186	351,858
Five times air-filled void (ft^3)	175,929	1,759,292
Extraction time (days)	1.6	6.1

*** Source: *Draft Remedial Process Optimization Report*, Parsons Engineering Science, March 2001**

[1]Air-filled void fraction does not include pore space filled with normal soil moisture.

[2]These are recommended rates that are necessarily to be used during the Treatability Study Extraction times for 5 pore volume removal will require recalculation if different extraction or flow rates are used

TABLE 6-1
Vapor Monitoring Summary
Rev 1 Dunn Field SVE Treatability Study Workplan

Parameter	Location	Test Method/ Sampling Equipment	Frequency[1]
Volatile Organic Compounds	VW and MP wellhead (extraction manifold, before dilution) and GAC exhaust	EPA Method TO-15 with DCPD for all SUMMA® Canisters. FID with Tedlar® Bags for field monitoring.	Baseline: One sample from each VW and one from terminus of the carbon canister collection system (SUMMA® canister). One sample from each MP using FID. During test: Collect samples in Tedlar® bags at VW and each MP every 30 minutes for first 4 hours followed by sampling once every 4 hours. Analyze with FID. Collect samples in SUMMA® canisters at VW at 4, 12, 36, and 72 hours into each test. Collect one sample from terminus of carbon canister collection system during each test. Completion: Collect sample from VW in SUMMA® canister.
Explosivity-%LEL	Wellhead (before dilution) at VWs	CGI/O_2 meter	Every 30 minutes for first 4 four hours and then once every 4 to 8 hours for the remainder of the test.
Oxygen (O_2), and Carbon Dioxide (CO_2)	Wellhead (before dilution) at all MPs	Tedlar bags, FID, other appropriate equipment	Baseline: One sample from each MP using field instruments. During test: Collect samples in Tedlar® bags at each MP every 30 minutes for first 4 hours followed by sampling once every 4 hours. Analyze with appropriate equipment.
Pressure, Flow/Velocity	Wellhead (before dilution) at VW and MPs	Wellhead or system inlet (before dilution)	Every 15 secs for 2 mins, every 1 min for 10 mins, every 5 mins for a ½ hr, and every 15 mins thereafter.

[1]Quality assurance samples will include two duplicate vapor samples, one ambient air blank, and one equipment blank collected in SUMMA® canisters and analyzed for VOCs at an analytical laboratory.

TABLE 6-2
Data Quality Objectives
Rev 1 Dunn Field SVE Treatability Study Workplan

Sampling Activity	Data Quality Objective Category	Sampling Purpose
Ambient Air Screening with a Flame Ionization Detector	Screening	Health and safety of field personnel Establish background conditions prior to testing
Screening with a FID for VOCs	Screening	Establish and develop qualitative levels of VOC vapor in soil and define reaction to testing effort
Air Sampling for VOCs	Definitive	Establish and develop quantitative levels of VOC vapor in soil and define reaction to testing effort.
Air Monitoring for Hazardous Ambient Conditions	Screening	Define potential hazardous levels of explosive gases within system. Health and safety of field personnel
Air Sampling for Oxygen (O_2) and Carbon Dioxide (CO_2)	Screening	Parameters to determine biological activity in vadose zones
Velocity/Flow and Pressure Measurements	Definitive	Effectiveness and mass removal rates of system. Response of vadose zones (loess deposits and fluvial aquifer).

TABLE 6-3
Sampling and Analytical Summary
Rev 1 Dunn Field SVE Treatability Study Workplan

Sample Task	Sample Point	Matrix	Sampling Frequency	Approx Sample Number	Sampling Method	Sampling Equip.	TAT	DQO Level/Data Package Reqmnt	Required Analysis	Analytical Method	Holding Time	Containers
Ambient Air Screening	Breathing Zones	Air	Prior to test, every 4 hours during test, and at end of test	Depends on length of test	Direct read on instrument	FID	Instant	Screening	Ambient air	Screening	NA	None
Screening with an FID for VOCs	VW and MP wellhead	Air	Prior to test, every 30 min for first 4 hrs and once every 4 hrs	Depends on length of test	Fill Tedlar® bag w/ rotary vane pump and analyze w/ FID	Tedlar® bag and FID	Instant	Screening	Total VOCs	Screening	NA	Tedlar® bag
Air Sampling for VOCs	At VW wellhead and carbon canister vapor collection system	Air	Baseline, at 4, 12, 36, & 72 hrs, and end of test, vapor collection once during test	No less than 3	SUMMA® canister and rotary vane pump	SUMMA® canister	14 days	Definitive	VOCs	TO-15	14 days	SUMMA® canister(s)
Air Monitoring for Hazards	At VW and MP wellhead	Air	Every 30 mins for first 4 hrs and once every 4 to 8 hrs for remainder of test	Depends on length of test	Direct read on instrument	CGI/O_2	Instant	Screening	Ambient Air	Screening	NA	None
Air Sampling for O_2 and CO_2	At MP wellhead only	Air	Prior to test, every 30 min for first 4 hrs and once every 4 hrs	Depends on length of test	Direct read on instrument	Tedlar® bag with appro equip	Instant	Screening	O_2 and CO_2	Screening	NA	None
Pressure, Velocity, Flow	At VW and MP wellhead	Air	Every 15 secs for 2 mins, every min for 10 mins, every 5 mins for a ½ hr, and every 15 mins thereafter	Depends on length of test	Direct read on gauge	NA	Instant	Screening	NA	Measurement	NA	NA
Quality Assurance Samples	Dup, Equipment, and Ambient Blanks	Air	Once	2 Dups, 1 Equip, & 1 Ambient	SUMMA® canister and rotary vane pump	SUMMA® canister	14 days	Definitive	VOCs	TO-15	14 days	SUMMA® canister

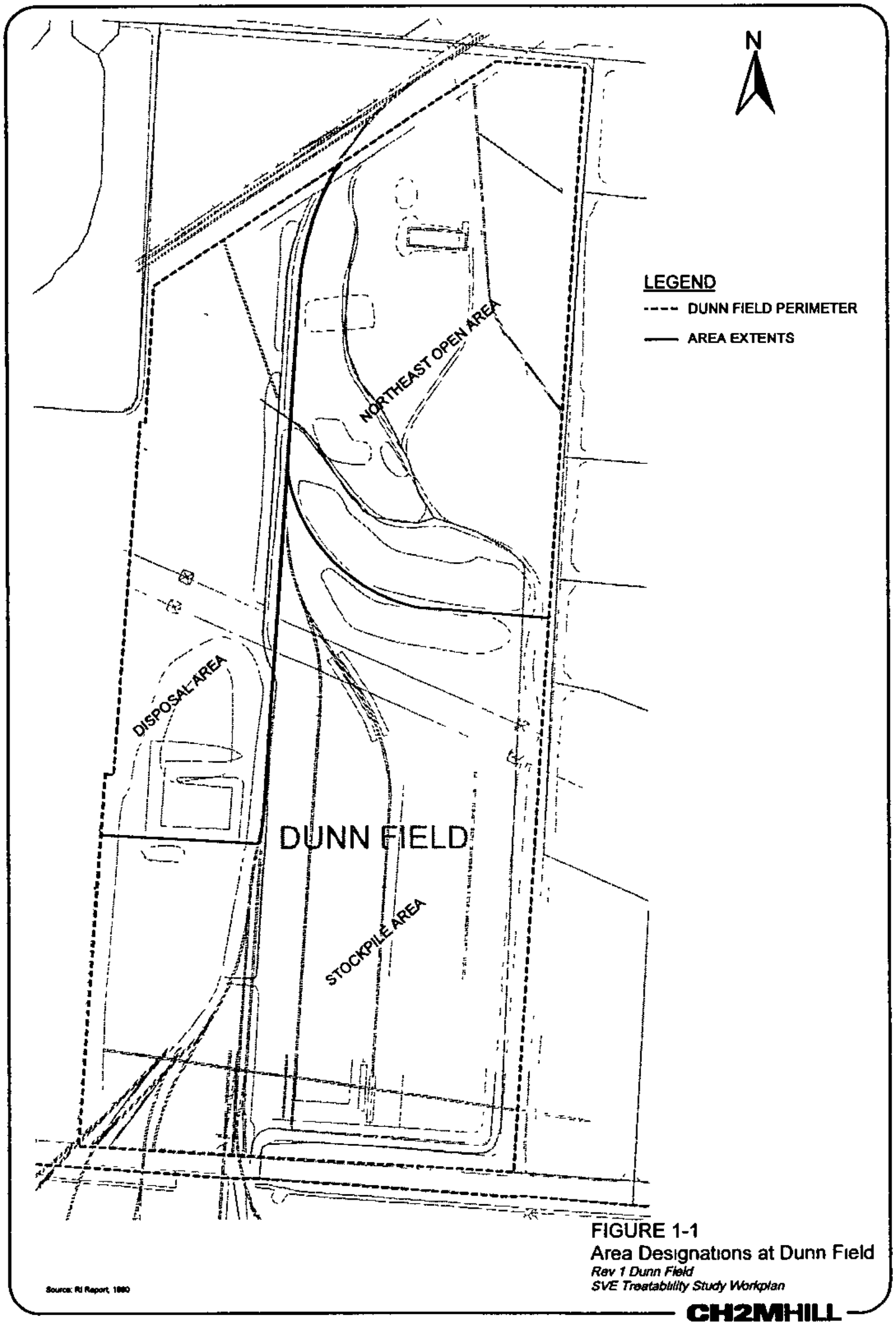


FIGURE 1-1
Area Designations at Dunn Field
Rev 1 Dunn Field
SVE Treatability Study Workplan

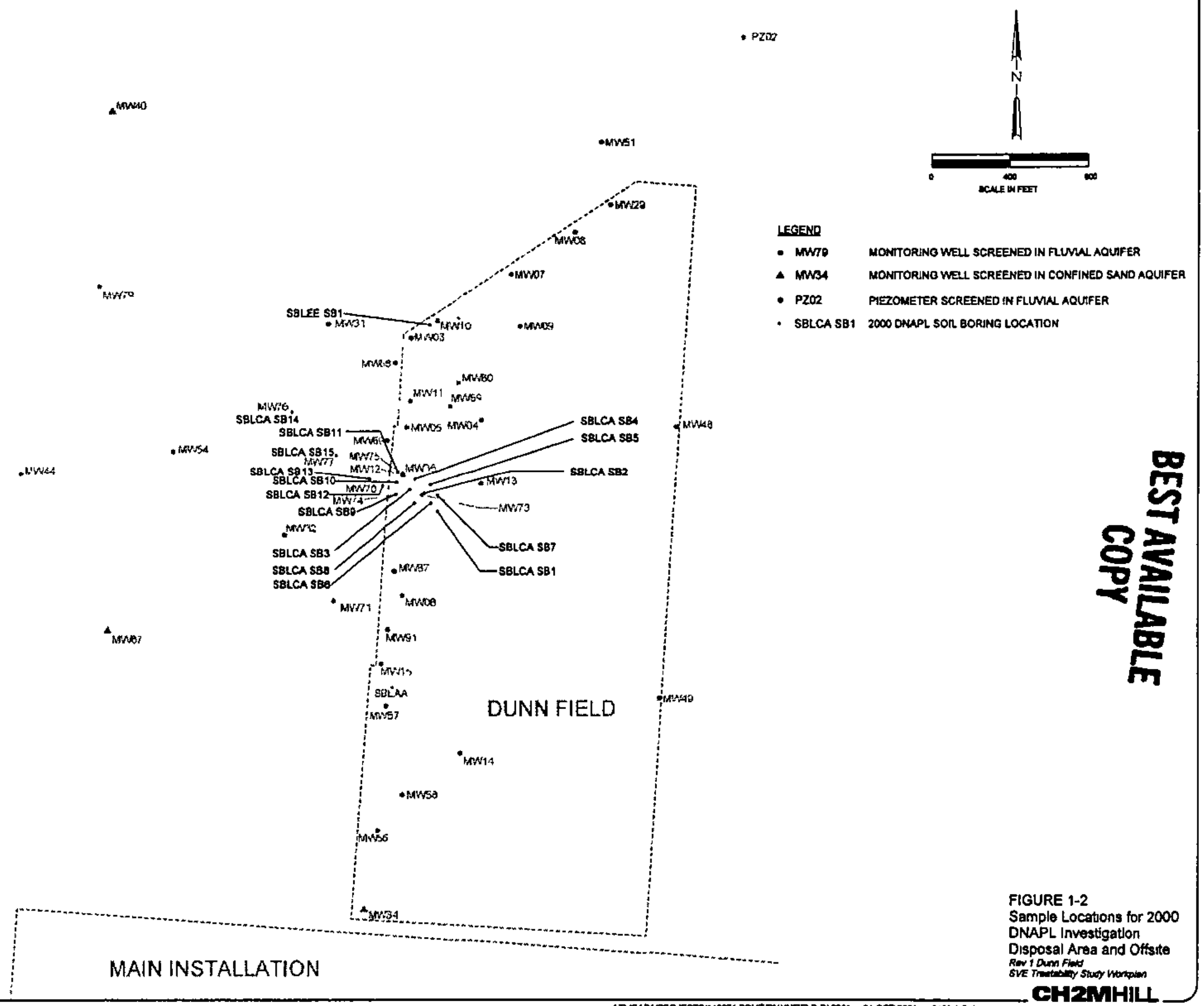


FIGURE 1-2
Sample Locations for 2000
DNAPL Investigation
Disposal Area and Offsite
Rev 1 Dunn Field
SVE Treatability Study Workplan

CH2MHILL

ATL/CAD1/PROJECTS/148071 DDMT/DUNNFIELD RI 2001 04-OCT-2001 0492-1-2.dgn

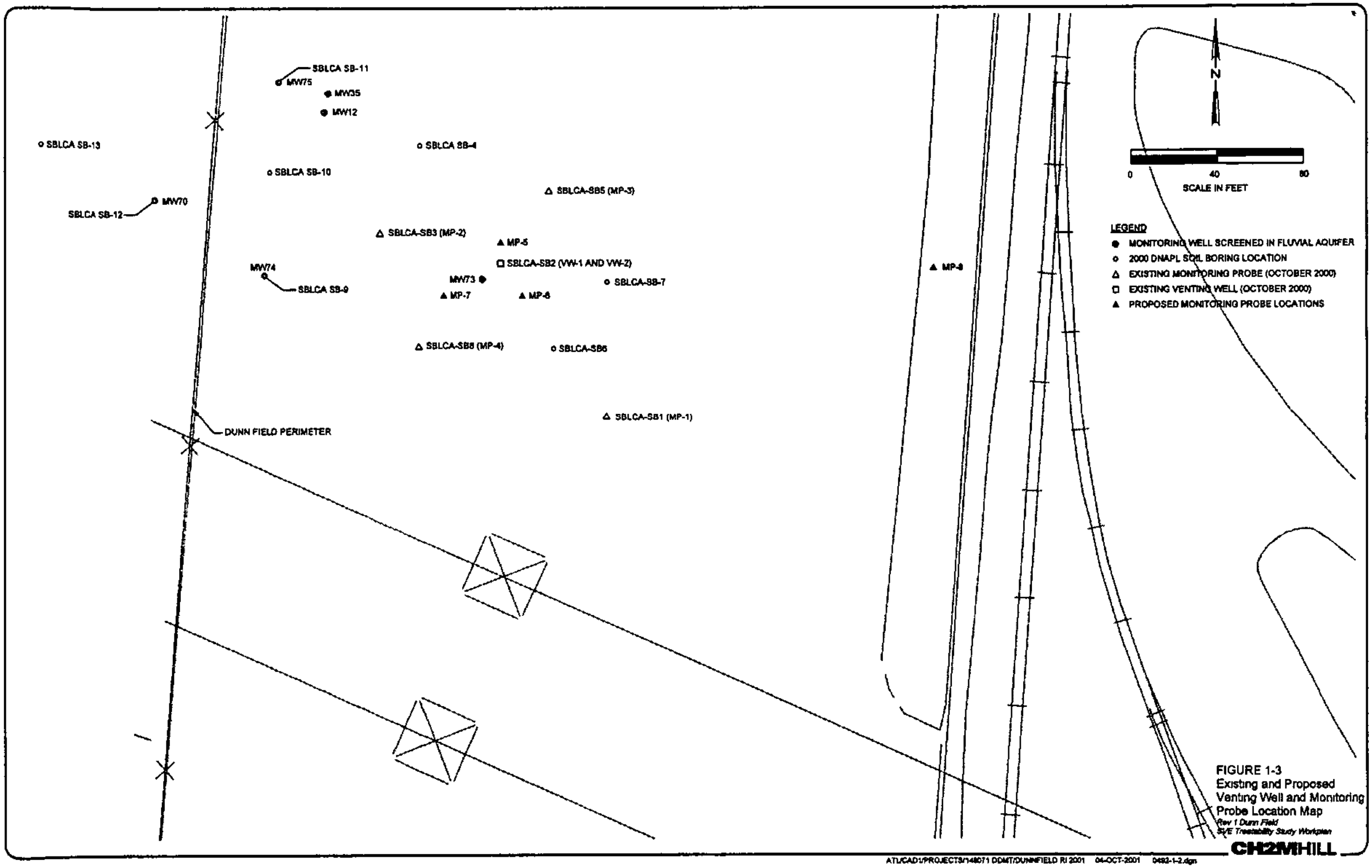
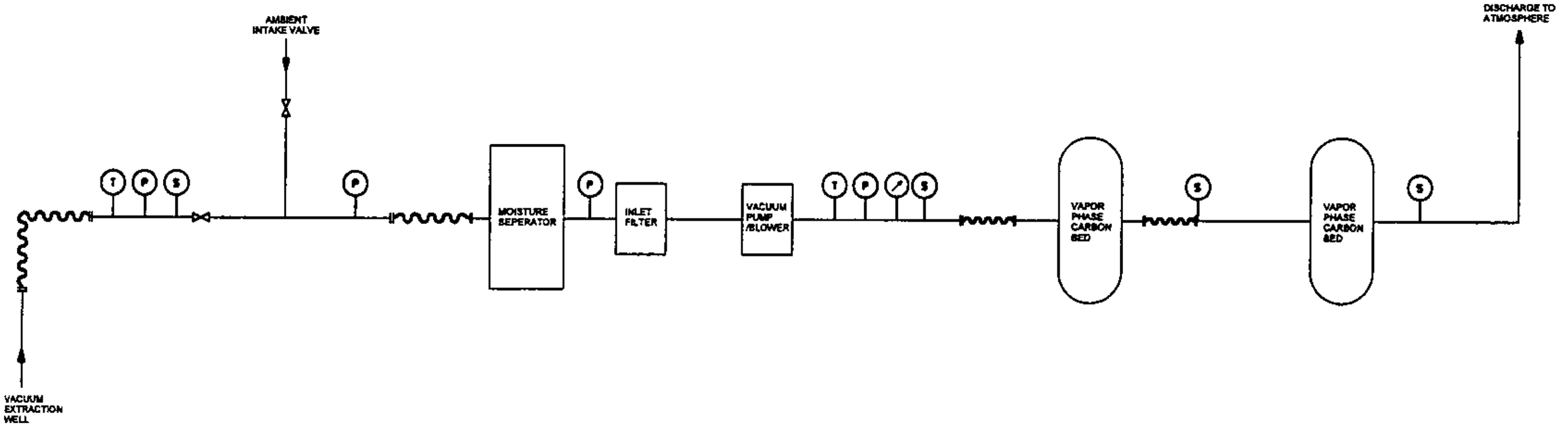


FIGURE 1-3
Existing and Proposed Venting Well and Monitoring Probe Location Map
Rev 1 Dunn Field SVE Treatability Study Workplan

CH2MHILL

ATL/CAD1/PROJECTS/148071 DDMT/DUNNFIELD RI 2001 04-OCT-2001 0492-1-2.dgn



NOTES

1. PIPING TO BLOWER SCHEDULE 40 PVC
2. PIPING FROM BLOWER - METAL WITH HEATSHIELDS FOR WORKER PROTECTION

LEGEND

- — 2 INCH COUPLING
- (P) —
- — FLOW INDICATOR
- — TEMPERATURE GAUGE
- SAMPLE PORTS
- — GATE VALVE (OR GLOBE/BUTTERFLY VALVE)
- — CAMLOCK HOSE COUPLER
- — FLEXIBLE HOSE

PRELIMINARY
NOT FOR CONSTRUCTION

DSGN	S SMITH
DR	M HALES
CHK	
APVD	

NO	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

CH2MHILL

EXAMPLE
SVE SYSTEM
DUNN FIELD
DEFENSE DEPOT-MEMPHIS TENNESSEE

FIGURE 4-1
SVE PILOT TEST PROCESS FLOW DIAGRAM
REV 1 DUNN FIELD
TREATABILITY STUDY WORK PLAN

SHEET	
DWG	
DATE	OCT 2001
PROJ	160492 TS 02

03-JUL-2001 figure4-1 dgn

TAB

Appendix A

Appendix A

Previously Installed Venting and Monitoring Points in the Disposal Area

Appendix A

Previously Installed Venting and Monitoring Points in the Disposal Area

Two venting or extraction wells and 16 MPs were previously installed at the site as part of the RI. In October 2000, CH2M HILL completed 15 soil borings in the Disposal Area in locations suspected of being impacted by disposal activities that may have led to contamination of the soil profile. The intent of the borings was to define the vertical extent of contamination that had been detected in soil samples collected from previous RI activities. Soil and soil vapor samples were collected from the soil borings. The data from the analysis of these samples revealed an overall trend of increasing VOC concentrations with depth in the vadose zone

Subsequent to completion of the borings, two nested VWs were installed in boring SBLCA-SB-2, which is adjacent to a "hot spot" identified during previous RI field efforts. The shallow well, VW-1, is screened from 9 to 24 feet bgs, entirely within the loess deposits. The deep well, VW-2, is screened from 32 to 72 feet bgs, within sand and gravel that comprises the unsaturated portion of the fluvial aquifer. The VWs are made of 2-inch PVC pipe. Figure 1-3 presents the location of the VWs. Construction details for the VWs and associated MPs can be found in Table A-1. Construction completion diagrams can be found in Appendix B.

Four MPs were installed within four of the soil borings, SLBCA-SB-1, SLBCA-SB-3, SLBCA-SB-5, and SLBCA-SB-8. The MPs, referred to as MP-1 through MP-4 (Figure 1-3), consist of four screened intervals within the same borehole separated by bentonite seals. Each of the MPs is constructed of ½ inch PVC pipe with ½-foot-long screens (Table A-1; Appendix B).

Table A-1
Venting Well and Monitoring Point Constrution Details
Rev 0 SVE Treatability Study Memphis Depot, Dunn Field

Identification	ID	Related to Main Installation (MI) or Dunn Field (DF)	Onsite or Offsite	Northing	Easting	Boring Type	Ground Elevation	Length of Screen	Depth to Top of Screen	Depth to Bottom of Screen	Elevation of Top of Screen	Elevation of Bottom of Screen	Depth of Boring (ft bgs)	Elevation of Bottom of Boring (ft)
VW-1	SBLCA SB2 (VW-1)	DF	On	280996 43	802153 34	SB/VW	301 20	15 00	9 00	24 00	292 20	277 20	93 0	208 2
VW-2	SBLCA SB2 (VW-2)	DF	On	280996 43	802153 34	SB/VW	301 20	40 00	32 00	72 00	269 20	229 20		
MP-1	SBLCA SB1 (MP-1)	DF	On	280925 92	802202 04	SB/MP	299 80	0 50	21 50	22 00	278 30	278 80	90 0	209 8
									34 50	35 00	265 30	265 80		
									57 50	58 00	242 30	242 80		
									70 00	70 50	229 80	230 30		
MP-2	SBLCA SB3 (MP-2)	DF	On	281010 26	802098 19	SB/MP	301 00	0 50	21 50	22 00	279 50	280 00	88 0	213 0
									34 50	35 00	266 50	267 00		
									57 50	58 00	243 50	244 00		
									70 00	70 50	231 00	231 50		
MP-3	SBLCA SB5 (MP-3)	DF	On	281029 52	802175 45	SB/MP	301 20	0 50	10 50	11 00	290 70	291 20	90 0	211 2
									26 50	27 00	274 70	275 20		
									48 50	49 00	252 70	253 20		
									67 00	67 50	234 20	234 70		
MP-4	SBLCA SB8 (MP-4)	DF	On	280957 77	802115 90	SB/MP	300 80	0 50	18 50	19 00	312 30	312 80	87 0	213 8
									47 5	48 0	253 3	253 8		
									57 5	58	243 3	243 8		
									69 5	70	231 3	231 8		

VW= Venting Well
MP= Monitoring Point
SB= Soil Boring
ft bgs =feet below ground surface

TAB

Appendix B

Appendix B

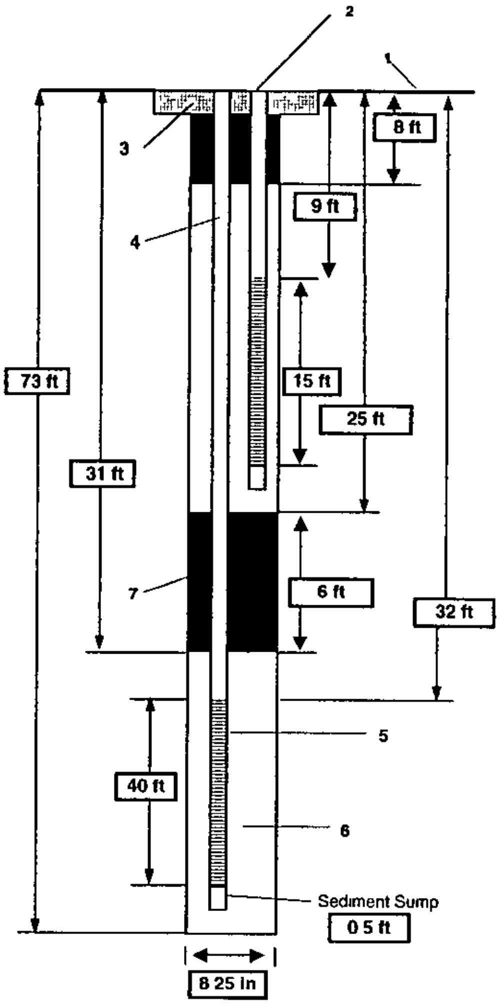
Construction Completion Diagrams for Existing Vapor Extraction Wells and Monitoring Points

PROJECT NUMBER	WELL NUMBER
148071.FI.LB	VW-1/VW-2(SBLCA-2B-2) SHEET 1 OF 1

CH2MHILL

SVE VENTING WELL COMPLETION DIAGRAM

PROJECT Memphis Depot LOCATION Memphis, Tennessee
DRILLING CONTRACTOR Boart Longyear
DRILLING METHOD AND EQUIPMENT USED Hollow Stem Auger 4 25 inch ID
WATER LEVELS None START 10/23/00 END 10/23/00 LOGGER Bryan Burkingstock



1- Ground elevation at well 301 2 feet MSL

2- Top of casing elevation None feet MSL

3- a) concrete pad dimensions 3ft x 3 ft

4- Diameter/type of well casing 2-inch Schedule 40 PVC

5- Type/slot size of screen 0 040 slot PVC

6- Type screen filter #3 filter sand
 a) Quantity used bags

7- Type of seal Bentonite Chips
 a) Quantity used bags

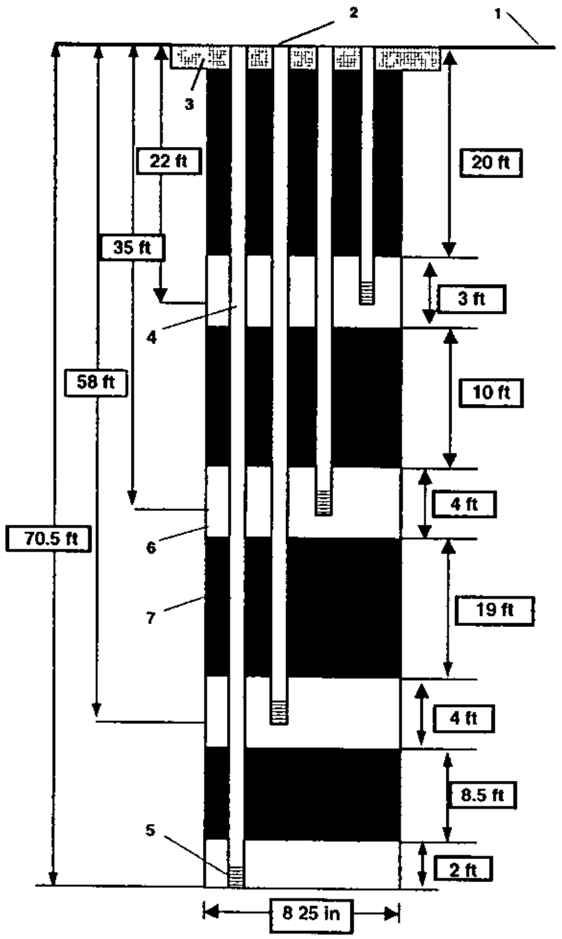
NOTE: Diagram is not to scale

PROJECT NUMBER	WELL NUMBER
148071.FI.LB	MP-1 (SBLCA-SB-1) SHEET 1 OF 1

CH2MHILL

SVE VENTING WELL COMPLETION DIAGRAM

PROJECT Memphis Depot LOCATION Memphis, Tennessee
DRILLING CONTRACTOR Boart Longyear
DRILLING METHOD AND EQUIPMENT USED Hollow Stem Auger 4 25 inch ID
WATER LEVELS None START 10/23/00 END 10/23/00 LOGGER Bryan Burkingstock



1- Ground elevation at well	299 8	feet MSL
2- Top of casing elevation	None	feet MSL
3- a) concrete pad dimensions	3 ft x 3 ft	
4- Diameter/type of well casing	1-inch PVC	
5- Type/slot size of screen	0 010 slot PVC	
6- Type screen filter	#2 filter sand	
a) Quantity used	bags	
7- Type of seal	Bentonite Chips	
a) Quantity used	bags	

NOTE: Diagram is not to scale

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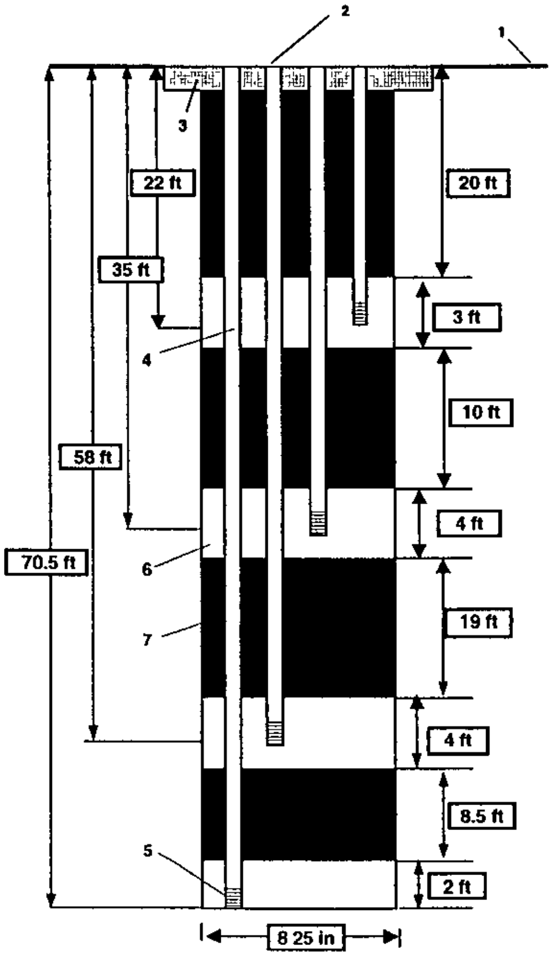
PROJECT NUMBER	WELL NUMBER
148071.FI.LB	MP-2 (SBLCA-SB-3) SHEET 1 OF 1

MONITORING POINT COMPLETION DIAGRAM

PROJECT Memphis Depot LOCATION Memphis, Tennessee
DRILLING CONTRACTOR Boart Longyear
DRILLING METHOD AND EQUIPMENT USED Hollow Stem Auger 4 25 inch ID
WATER LEVELS None START 10/23/00 END 10/23/00 LOGGER Bryan Burkingstock



1- Ground elevation at well	301 feet MSL
2- Top of casing elevation	None feet MSL
3- a) concrete pad dimensions	3 ft x 3 ft
4- Diameter/type of well casing	1-inch PVC
5- Type/slot size of screen	0 010 slot PVC
6- Type screen filter	#2 filter sand
a) Quantity used	10 bags
7- Type of seal	Bentonite Chips
a) Quantity used	30 bags

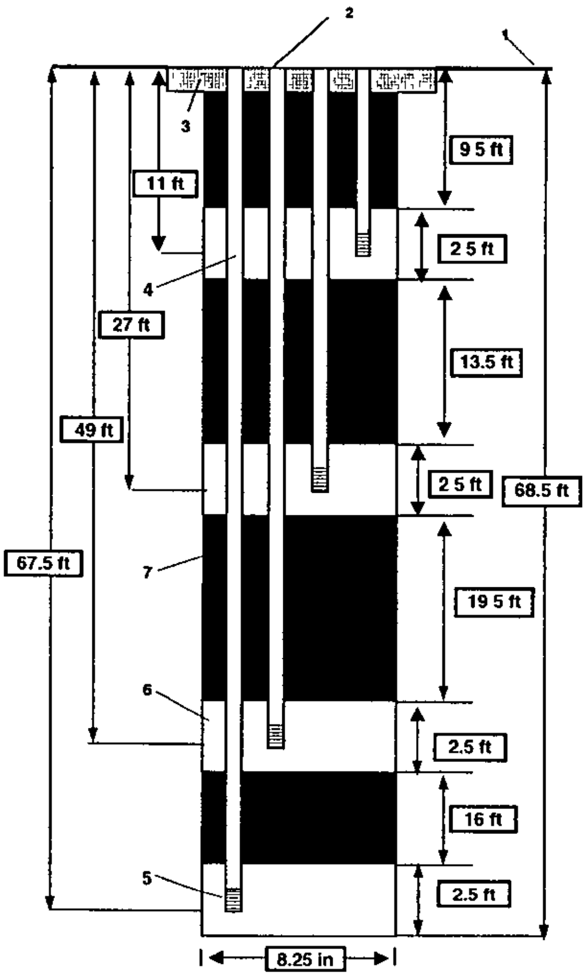
NOTE· Diagram is not to scale

CH2MHILL

PROJECT NUMBER	WELL NUMBER
148071.FI.LB	MP-3 (SBLCA-SB-5) SHEET 1 OF 1

MONITORING POINT COMPLETION DIAGRAM

PROJECT Memphis Depot LOCATION Memphis, Tennessee
DRILLING CONTRACTOR Boart Longyear
DRILLING METHOD AND EQUIPMENT USED Hollow Stem Auger 4 25 inch ID
WATER LEVELS None START 10/27/00 END 10/27/00 LOGGER Bryan Burkingstock



1- Ground elevation at well: 301 2 feet MSL

2- Top of casing elevation: None feet MSL

3- a) concrete pad dimensions: 3 ft x 3 ft

4- Diameter/type of well casing: 1-inch PVC

5- Type/slot size of screen: 0 010 slot PVC

6- Type screen filter: #2 filter sand
a) Quantity used: 10 bags

7- Type of seal: Bentonite Chips
a) Quantity used: 29 bags

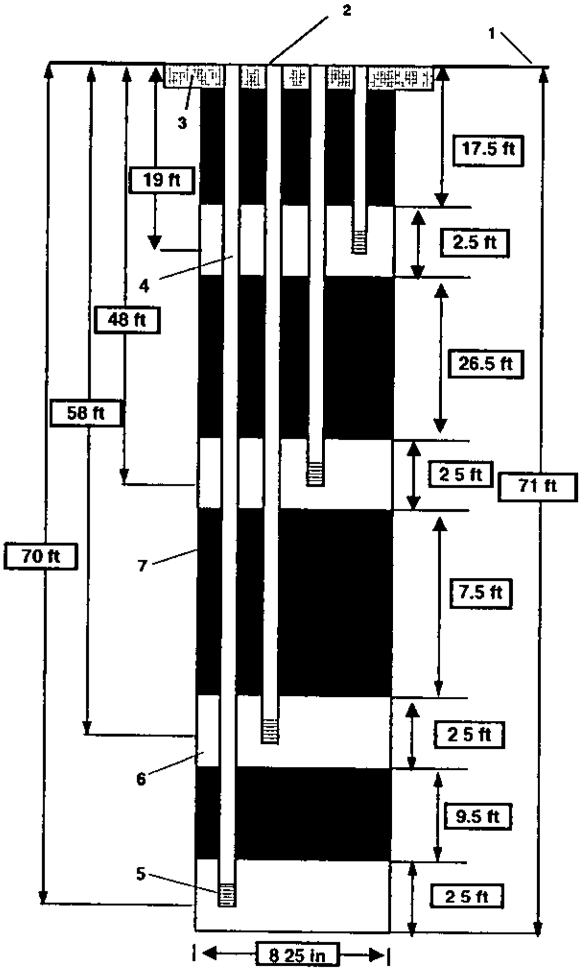
NOTE: Diagram is not to scale

CH2MHILL

PROJECT NUMBER	WELL NUMBER
148071.FI.LB	MP-4 (SBLCA-SB-8) SHEET 1 OF 1

MONITORING POINT COMPLETION DIAGRAM

PROJECT Memphis Depot LOCATION Memphis, Tennessee
DRILLING CONTRACTOR Boart Longyear
DRILLING METHOD AND EQUIPMENT USED Hollow Stem Auger 4 25 inch ID
WATER LEVELS None START 10/27/00 END 10/27/00 LOGGER Bryan Burkingstock



1- Ground elevation at well	300 8	feet MSL
2- Top of casing elevation	None	feet MSL
3- Concrete pad dimensions	3 ft x 3 ft	
4- Diameter/type of well casing	1-inch PVC	
5- Type/slot size of screen	0 010 slot PVC	
6- Type screen filter	#2 filter sand	
a) Quantity used	10 bags	
7- Type of seal	Bentonite Chips	
a) Quantity used	30 bags	

NOTE Diagram is not to scale

TAB

Appendix C

Appendix C

Standard Operational Procedure for Transient and Steady-State Pressure Tests

Appendix C

Standard Operating Procedure for Transient and Steady-State Pressure Tests

Objectives of this TS include definition of the relationship between applied vacuum and flow from the well, air permeability of the soils, contaminant removal rates as a function of time, vacuum distribution in soils surrounding the extraction well, water table response to applied vacuum, and condensate/liquid production. During the design process, these objectives will be used to model the velocity and pressure field from each of the proposed wells at alternative flow rates and well pressures.

Field Equipment and Supplies (in addition to that supplied by the vendor)

- Couplings to attach to the tops of the vacuum probes that will provide a seal to atmosphere;
- "Barbed" fittings suitable for attaching rubber or PVC tubing, one for each coupling, preferably equipped with a needle valve;
- Magnehelic vacuum gauges of multiple ranges (zero to 0.1, zero to 1, 1 to 10, and 1 to 100 inches of water) and/or data logger and pressure transducers;
- Stopwatches;
- Non hydrocarbon-based grease, such as lithium grease;
- Basic hand tools;
- Datalogger and pressure transducers. Use of a datalogger will allow for more efficient and accurate vacuum data collection, although additional set-up time and expertise are required;
- FID, LEL/oxygen, and CO_2 meters; and
- Tape measure or water level indicator

Transient Test

Two transient tests will be performed, one for each VW. Both transient tests will be conducted using various "steps" or flow rates. The tests will be performed following the steps listed below:

1. Collect baseline soil gas concentrations at each venting well and monitoring point for approximate equilibrium conditions (i.e., ensure all "stagnant" air in equilibrium to atmosphere is purged from the VW and MP). Monitor and sample according to Sections 6.0 and 7.0.

2. Calibrate all instruments, zero all gauges, and record all data calibration in logs. Set up pressure transducers in each monitoring probe and the datalogger (as applicable).
3. Verify depth of VW-1 (shallow) and VW-2 (deep) using an interface probe or tape measure. VW-1 is approximately 24 feet deep and VW-2 is approximately 72 feet deep.
4. Perform a brief system pre-test (1 to 2 minutes):

   - Start the vacuum pump with the manifold assembly connected to VW-1;
   - Determine the initial flow reading with the throttle valve fully opened. Throttle (valve down) the vacuum pump to a flow rate approximately one-third of the "full open" value;
   - Check that the system components are operating properly;
   - Check that the vacuum gauges are operating properly; and
   - Check the seal at the extraction well using a soap solution. Use a non-oil-based grease (such as white lithium grease) to seal temporary PVC piping, as necessary, or seal with glue.

5. Connect a magnehelic gauge to each MP using flexible tygon (or equivalent) tubing, equipped with a small isolation (ball) valve. If pressure transducers are used, a magnehelic gauge can be used for verification purposes. The gauge should be attached to the probe/transducer using a three-way joint with isolation valves, so that pressure transducer readings are not disturbed during gauge changes or during collection of gas samples. Use a non-oil-based grease to improve the vacuum seal. The latter step is especially critical for low-permeability soils where limited vacuum response is expected.
6. Wait until all monitoring units have returned to zero before starting the test.
7. Start the test. Immediately activate the stopwatch and/or datalogger.
8. For each VW and MP, record vacuum vs. time at exponential increments (i.e., according to schedule to Table 6-3). It may be necessary to switch gauges if one or more is "pegged out." The most sensitive (accurate) gauge available should be always be used to record vacuum levels. Flow, vacuum, O_2, and CO_2 monitoring should be collected at intervals described in Tables 6-1 or 6-3. Periodic FID checks of the vapor phase carbon treatment system intermediate and effluent is recommended for breakthrough monitoring. Refer to Table 6-3.
9. After a period of 1 hour, open the vacuum pump throttle valve gradually while monitoring the flow meter. Increase flow to approximately double the flow from the first hour, concluding "Step 1" of the transient test. Begin recording vacuum levels again at exponential increments as described in item 8 above. Run "Step 2" of the test for 1 hour before increasing the flow to "full open" and repeating the same procedure for Step 3.
10. Vapor samples should be collected at the conclusion of each "step" (1-hour test). Vapor samples can be collected using Tedlar® bags, SUMMA canister, or *MICROSEEPS* procedure. The samples will be submitted for laboratory analysis of VOCs via EPA method TO-15 (or equivalent). All other sampling should be performed according to Table 6-1.

11. After Step 3 is completed, the transient test at VW-1 is completed and the blower can be deactivated using the procedure described in Section 4.3. Allow all vacuum gauges to fully equilibrate to atmospheric conditions before transferring the vacuum manifold to VW-2 and repeating Steps 1 through 10.

Steady-State Test

Several days of "steady-state" testing is planned for each VW. The purpose of the steady-state tests is to determine approximate steady-state vacuum distribution and soil gas chemistry data. The steady-state test will follow essentially the same procedure outlined above for the transient test, although a nominal ("medium") flow rate will be selected and used for the duration of the test (8 to 10 hours). The "exponential" data collection schedule will be retained for the first hour of the test, followed by flow, vacuum, O_2, and CO_2 monitoring according to the summary in Tables 6-1 and 6-3. Vapor samples should be collected as described in Tables 6-1 and 6-3.

The steady-state test is likely to be necessary for the loess deposit (VW-1), because of the relatively slow expansion of the vacuum pressure "cone of depression" in low-permeability soil. A steady-state test may not be necessary for the fluvial sand formation (i.e., approximate steady-state conditions may be observed during the transient test at VW-2).

TAB

Appendix D

Appendix D

Standard Operating Procedure for Collecting Soil Samples for Volatile Organic Compounds

Appendix D

Standard Operating Procedure for Collecting Soil Samples for Volatile Organic Compounds

TO.	U S. Army Engineering and Support Center, Huntsville
COPIES:	Memphis Depot Caretaker (MDC)
	U.S. Environmental Protection Agency (EPA), Region 4
	Tennessee Department of Environment and Conservation (TDEC)
FROM·	CH2M HILL
DATE:	August 16, 2001

Standard Operating Procedure

This memorandum describes the use of pre-weighed VOC vials for collection of discrete sample aliquot to be analyzed for VOCs using EPA SW-846 Method 5035. Importantly, using this method, two vials need to be prepared for each sample submitted.

Collecting Soil Samples

1. Place latex gloves on hands for protection and to prevent cross-contamination.
3. Open the package containing the pre-cut syringe sample-collection device.
4. Open the vial that will be receiving the soil.
5. Retract the plunger of the cut-of syringe to between 5 or 6; mark on the syringe tube.
6. Insert the syringe into the soil.
7. Remove the syringe and the "slug" of soil into a pre-weighed vial. Replace the cap on the vial.
8. Label the vial with the sample ID and date sampled.
9. Repeat the steps above for the second sample vial.
10. Make sure that the preservative in the vial mixes with the slug of soil by shaking, if necessary.
11. Place vials into cooler with wet ice for shipment

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE