Phase I Field Test Results of an Innovative DNAPL Remediation Technology: The Hydrophobic Lance

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Prepared by the Savannah River Technology Center - Environmental Science & Technology Section

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1.0 EXECUTIVE SUMMARY

An innovative technology for recovery of pure phase DNAPL, the Hydrophobic Lance, was deployed in the subsurface near the M-Area Settling Basin. This project is part of the on-going Savannah River Site (SRS) effort to characterize and remediate DNAPLs in the A/M area per the M-Area Part B Permit requirements. This technology operates by placing a neutral/hydrophobic surface (Teflon) in contact with the DNAPL. The presence of the hydrophobic surface changes the in situ conditions experienced by the DNAPL, allowing it to selectively drain into a sump from which it can be recovered by pumping. The Hydrophobic Lance is thus a low-cost, passive technology to collect DNAPL from strategically selected sites expected or confirmed to have DNAPL.

The design and operation of the Lance require DNAPL continuity for flow to occur. It therefore represents a good preliminary option to reduce DNAPL saturation prior to implementing more aggressive and high-cost technologies. Collection of even small amounts of DNAPL can save years of pump-and-treat operation because of the generally low solubility of DNAPL components. In addition, draining DNAPL until it becomes discontinuous will make the DNAPL more accessible for destruction using aggressive technologies such as Fenton's chemistry.

There were advantages and limitations to testing this technology at the SRS M-Area. The advantage is that it is a very well characterized site requiring no further testing to determine appropriate drilling locations. The limitations are the relatively great depth at which the DNAPL lies, and the fact that there are multiple "hard" zones in the vicinity of the target zone which can cause refusal during cone penetrometer (CP) pushes. We planned to overcome these limitations by auguring through refusal zones to the water table prior to installing the Lance through the augers using direct push technology. The issue of hard zones and CP refusal still came into play, however, during this first field deployment of the technology.

Field activities commenced on July 6, 1998. On Friday, July 10, 1998, we encountered a layer of high DNAPL saturation, sufficiently high that DNAPL would drain relatively quickly from a soil sample. Three attempts were required to successfully install a Hydrophobic Lance. Evaluation of the first attempt results indicated a revision of the Lance design was necessary to better withstand the tensile forces imposed on the Teflon during installation. The second installation attempt was thwarted by the presence of the hard zones; we could not get the Lance down to the required depth without using hammering with a 300 pound down-hole hammer. The overall Lance construction was not designed to handle the resulting forces. The problems were overcome by overdrilling down to the desired depth, and setting the Lance in place. The successful deployment was completed on July 21, 1998.

Two rounds of development and sampling of the Lance have been completed. Sand and mud were removed which had accumulated in the Lance sump. DNAPL was not found in the lance during either sampling event. Water recovered during the development and sampling, however, had the characteristic strong odor of tetrachloroethylene (PCE), which is typical of the high dissolved concentrations in the ground water in this area.

Additional deployments are planned for FY99. We are currently planning to try roto-sonic drilling to overcome the hard-zone issue. The drill rods will be designed to couple directly with the Lance tip in order to get the maximum transfer of the roto-sonic energy to the tip during installation.

2.0 INTRODUCTION

An innovative technology for recovery of pure phase DNAPL was deployed in the subsurface near the M-Area Settling Basin, continuing the support of the A/M Area Ground Water Corrective Action Program (per Part B requirements). This technology, the Hydrophobic Lance, operates by placing a neutral/hydrophobic surface (Teflon) in contact with the DNAPL. This changes the in situ conditions experienced by the DNAPL, allowing it to selectively drain into a sump from which it can be pumped. Collection of even small amounts of DNAPL can save years of pump-and-treat operation because of the generally low solubility of DNAPL components.

3.0 BACKGROUND

The M-Area of Savannah River Site was a fuel and target fabrication facility. The mission of this area was processing uranium, lithium and other materials into fuel elements and targets for use in the nuclear production reactors. The processes were primarily metallurgical and mechanical, such as casting, extrusion, plating, hot-die-sizing, welding and magneforming. Solvent cleaning and acid/caustic etching were used to prepare the materials.

The M-Area Settling Basin and associated areas (the overflow ditch, Lost Lake, the seepage area, and the inlet process sewer line) have been designated as the M-Area Hazardous Waste Management Facility. This facility received process effluent from 1958 until 1985. VOC contamination of soils and ground water occurred in M-Area as a result of breaks in the old process-sewer line and disposal to the basin. Other sources in the A/M Area include the A-014 Outfall, the solvent storage tank, and surface discharges from the Savannah River Technology Center.

The M-Area Settling Basin was been capped and closed under RCRA as a certified landfill closure. The purpose of the work reported here was to support the A/M Area Ground Water Corrective Action Program.

3.1 DNAPL CHARACTERIZATION

Several technologies were used during the Phase I DNAPL characterization (Looney, et al. 1992). These included: (1) physical and chemical measurements in existing monitoring wells (e.g., interface probe and bailer samples, and visual examination), (2) cone penetrometer to provide detailed data on the geology (clay layers and lithologic controls), and (3) geophysical logging of existing monitoring wells to examine the well casing and formation outside the well casing for indications of DNAPL. Historical data were used to focus the study on the most promising wells and techniques.

A separate phase was identified in the sumps of two monitoring wells (Looney, et al. 1992), MSB-3D (screened zone at a depth interval of 128.0 to 147.5 ft.) and MSB-22 (screened zone at a depth interval of 115.0 to 135.0 ft.). Both identifications were made based on direct observation of a bottom filling bailer. The dense phases collected from these two wells were sampled and analyzed at different times to allow testing of various hypotheses for DNAPL occurrence. The observed changes in the volume and composition of the dense phase collected from the two sumps at separate times were specifically related to possible DNAPL behavior scenarios. The data suggest that DNAPL has reached the water table only at the largest volume release areas, the M-Area Settling Basin (Settling

Basin) and the A-014 Outfall. The relatively thick vadose zone beneath A/M-Area tends to limit the downward flux of DNAPL, capturing much of the DNAPL in layered clays. As expected, DNAPL below the water table has been observed where solvent release exceeded the capacity of the vadose zone to moderate the flux of the pure phase to the ground water. The clearest evidence of DNAPL below the water table was found at the Settling Basin, where a separate phase was identified in the sumps of two wells, as noted above. The data collected at separate times suggest that the DNAPL below the water table occurs as relatively diffuse ganglia and/or a thin layer on top of clay layers and that DNAPL collects in well sumps as a result of dynamic processes. One such process is the accumulation of dense ganglia in the well sump as the well is actively purged and sampled (similar to the accumulation of sediments in the sump). More recent investigations (Jackson, et al. 1996, Jerome, et al. 1996) provide evidence that the majority of DNAPL exists as relatively thin layers (less than one foot) on top of silt or clay strata. Therefore accurate delineation of these strata are important for selection of and targeting remediation technologies.

Cone penetrometer testing was used to refine delineation of an important clay zone (the "green clay") beneath the water table (Looney, et al. 1992). Undulations and other structural variations on top of this layer would serve to control the movement of a dense phase below the water table. Based on the cone penetrometer results, structure controlled pathways for density-dominated transport below the water table were discerned. Two potential pathways were identified. The primary potential pathway of contaminant migration begins near the Settling Basin, where DNAPL was found in monitoring wells MSB-3D and MSB-22, Figure 3.1. The contour grades toward the west and then north toward MSB-76, where high dissolved constituent concentrations ($> 1000 \mu\text{g/L}$) are reported. An area along the low points of the path described in this interpretation was selected for this demonstration. The geophysical logging data indicate the physical integrity of the PVC monitoring well casings in A/M-Area have not been substantially impacted by exposure to chlorinated solvents. The wells, even immediately adjacent to the highest volume release areas, do not show signs of mechanical instability, leakage, or other types of large scale failure. Data from a few monitoring wells, however, provide subtle indications of potential exposure to DNAPL. The most consistent DNAPL indications are provided in monitoring wells MSB-9A and MSB-22, with less probable indications from monitoring wells MSB-10A and MSB-11A.

3.2 DNAPL REMEDIATION STRATEGY

Phase I of the DNAPL characterization (Looney, et al. 1992) provided significant insight into the nature and location of DNAPL in the SRS subsurface. In particular, the data indicate a substantial amount of DNAPL has been trapped in clays and silts in the vadose zone above the water table. The DNAPL present is composed of approximately 95% PCE and 5% TCE (Looney, et al. 1992). Remediation of this material by soil vapor extraction (SVE) before it reaches the water table represents the first major DNAPL-targeted remediation technology. SVE demonstrations have been performed in the A/M-Area using both horizontal and vertical wells. A full scale SVE design, installed as a component of the A/M-Area ground water corrective action program is underway, and additional remediation technology demonstrations are planned. Phase I characterization data also suggest that DNAPL below the water table in A/M-Area is present as disconnected ganglia, rather than as a large, solvent-saturated layer. The objectives of the Phase 2 DNAPL remediation focus on: (1) pure phase DNAPL recovery, (2) recycle of DNAPL, and (3) on site destruction of DNAPL.

The Hydrophobic Lance (lance) is an inexpensive technology for recovering pure phase DNAPL. Demonstration of this technology therefore supports the Phase 2 DNAPL remediation efforts in the A/M-Area. The target site for implementation of the lance technology was selected based on known historical DNAPL locations and the results of current drilling efforts to characterize the DNAPL distribution in the A/M-Area subsurface.

Figure 3.1 M-Area Seepage Basin Map and the Hydrophobic Lance Field Test Location.

3.3 ADVANTAGES AND LIMITATIONS OF TESTING AT THE SRS A/M-AREA

One advantage of testing the lance in the A/M-Area is the existence of a significant, local barrier to vertical DNAPL migration which is present above the important A/M-Area "green clay." This barrier layer has the potential to support DNAPL in sufficient quantity that it could drain to a Hydrophobic Lance. The test could therefore be designed in a way that avoids penetration of the "green clay" confining zone. Another advantage of testing in the A/M Area is the high degree of characterization that has previously been done. This reduces the up-front characterization costs.

While there are significant advantages, it is important to emphasize that application of the Hydrophobic Lance at the SRS A/M Area represents an extreme test of its cost-effectiveness as a remediation technology. There are two primary reasons for this: 1) installation depth and 2) DNAPL continuity. Lance installation costs are likely to be much higher than most DNAPL sites for two reasons. First, the target zone lies at a relatively great depth, on the order of 120 to 150 feet below ground level. Further, at these depths in the A/M-Area, direct push technology (the primary installation method) has frequently reached its penetration limit ("refusal") due to "hard" zones in the vicinity of the water table. To circumvent this, we used a combination of standard drilling followed by direct push followed by driving with a hammer into hard zones to install the lance. This combination of multiple installation techniques significantly increases installation costs. However, even relatively minor amounts of DNAPL recovered can save significant amounts of pump-and-treat time. In addition, draining DNAPL to the point where it becomes discontinuous will make the remaining DNAPL more accessible to other, more aggressive technologies, such as Fenton's chemistry.

The second limitation of testing the lance technology in the A/M-Area is related to the requirement that the DNAPL be present as a continuous phase. The Hydrophobic Lance technology works by providing an attractive vertical surface along which DNAPL will flow to a collection point. In order for DNAPL collection to be sustained it must be laterally continuous. The significant age of the SRS DNAPL (on the order of 20 to 40+ years) makes it likely that the DNAPL is reaching, if it has not already reached the point where it becomes stabilized by capillary forces. The thin layer character of its presence in the A/M-Area subsurface (Jackson, et al. 1996, Jerome, et al. 1996) means that it could become discontinuous as it begins to flow toward the Lance. DNAPL recovery will halt once all pathways to the Lance become discontinuous. In addition, the A/M Area pump-and-treat system has been operating for approximately 15 years. This also may have reduced the continuity of the DNAPL.

4.0 SUMMARY DESCRIPTION OF TEST

The Hydrophobic Lance is primarily a passive remediation technology that relies on the hydrophobic nature of DNAPLs. Two criteria must be satisfied for successful DNAPL recovery through the Lance: 1) that the DNAPL be continuous so that it can flow, and 2) that the hydrophobic surface of the Lance be in contact with the DNAPL. The first criterion cannot be determined with any certainty, but the chances of its occurrence can be optimized by appropriate choice of installation technique. The second criterion depends on the nature of the DNAPL distribution (does it exist as continuous sheets or as randomly located, continuous channels), on whether the specific installation location passes through continuous DNAPL, and on the installation procedure. The installation procedure is the only factor over which we have effective control. Contact of any continuous DNAPL with the hydrophobic surface will be more likely if the Lance is installed using direct push

technology or other installation technology resulting in minimal disturbance of the sediments.

The installation procedure for the Lance was designed to minimize chances for refusal during the push and maximize the likelihood that good contact would be made between the hydrophobic surface and any DNAPL. Chances for refusal will be minimized by first drilling down to the water table using a conventional hollow-stem auger rig. The auger drill string was left in the ground during the Lance installation. Installation of the Lance occurred through the auger flights. Two techniques were used to optimize contact between DNAPL and the hydrophobic surface. First, we used a series of cone penetrometer pushes to collect split-spoon samples and to determine the detailed local stratigraphy at the installation site. This information was used to determine the precise placement of the hydrophobic surface with respect to fine-grained layers on which DNAPL has accumulated. Second, the Lance was designed with a sharp point which promotes good contact between the hydrophobic surface and the sediments (Baligh and Scott 1976). The hydrophobic surface is the exterior wall of two-inch diameter, Teflon well-casing.

Collection of DNAPL was further optimized by machining the Teflon casing in a fashion to direct DNAPL flow to the interior of the Lance as quickly as possible. DNAPL will accumulate in a sump at the Lance tip. The DNAPL will be brought to the surface for disposal using a gas-lift pump. Pump operation will be cyclic with the cycle timed to match the rate of DNAPL accumulation in the sump. A continuous record will be maintained of the volume of DNAPL collected. Success of the technology at the SRS will be measured by comparing the cost of DNAPL recovered by the lance with the estimated cost for recovering the same amount via the currently operating pump-and-treat system.

5.0 TECHNICAL BASIS

The Hydrophobic Lance technology requires that the DNAPL be continuous so that it can flow to the Lance. The DNAPL "layer" must also be of sufficient thickness that the rate of DNAPL drainage down the hydrophobic surface does not exceed the transmissive capacity of the DNAPL-saturated sediments to convey DNAPL to the Lance. This is necessary in order to prevent DNAPL from becoming discontinuous as it approaches the Lance.

5.1 MAXIMUM DNAPL RECOVERY RATE

The maximum rate of DNAPL recovery from a relatively thick DNAPL layer on top of a capillary barrier was estimated using two different methods. One model is based on annular flow, and the other is based on capillary flow. The first method, the "annular model," was to calculate flow in an annular space between the hydrophobic surface of the Lance and the exterior formation. The geometry of this model is illustrated in Figure 5.1. The second model assumes flow in uniform, vertical capillary tubes with the capillary tube diameter determined assuming uniform diameter, spherical grains packed in cubic fashion around the Lance. The diameter of the capillaries is taken to be the diameter of a circle inscribed into the somewhat triangular space defined by adjacent grain boundaries and the Teflon surface of the Lance. The geometry of this model is illustrated in Figure 5.2. That these models provide upper and lower limits on the maximum DNAPL recovery rate is also illustrated in this figure.

5.1.1 Annular Flow Model

The annular model gives an upper bound for maximum DNAPL flow rate into the Lance. The following assumptions are made for this calculation: 1) the separation between the hydrophobic surface and the formation is uniform everywhere; 2) a cross-section of the annular space is given by a circle within a circle; 3) the exterior wall of the annular space of the capillary barrier (the formation wall cut by the cone) is reasonably approximated as a smooth, impermeable surface, i.e., there are no roughness effects due to the particulate nature of the formation and no flow goes into the capillary barrier; 4) the width of the annulus is equal to one-quarter of the mean grain diameter of the porous medium, and 5) the annulus is completely filled by the DNAPL. The flow rate through a vertical annular space can be calculated using the following equation (Streeter and Wylie 1979).

$$Q = -\frac{\pi \rho g}{8\mu} \left(a^4 - b^4 - \frac{(a^2 - b^2)^2}{\ln(a/b)} \right) \quad (5.1)$$

where Q is the discharge (L^3T^{-1} , m^3/sec), ρ is the fluid density (ML^{-3} , kg/m^3), g is the acceleration of gravity (LT^{-2} , m/sec^2), μ is the fluid viscosity ($ML^{-1}T^{-1}$, $kg/m\cdot sec$), and a and b are the radii of the circles bounding the annular space (see Figure 5.1). The outside diameter (OD) of the Lance hydrophobic surface (b) is 2.375" (6.032 cm). We will assume the DNAPL has the properties and composition of the M-Area DNAPL sample collected in April 1991 from well MSB-3D (Looney et al. 1992). The density is 1.59 g/cm^3 (Looney et al. 1992). The estimated viscosity (Reid, et al. 1977) for the SRS DNAPL is 0.88 centipoise (cp), assuming it to be composed of only two components, TCE and PCE, in the same proportions found by Looney et al. (1992). See Appendix A for the viscosity estimate calculation. Table 5.1 contains the estimated potential DNAPL flow rates (i.e., potential DNAPL recovery rates) assuming various annular gaps (i.e., values for the parameter a).

5.1.2 Bundle of Capillary Tubes Flow Model

The second method used to estimate the maximum rate of DNAPL recovery treats the DNAPL flow along the Teflon wall as the sum of flow through uniform vertical capillary tubes. An individual capillary for DNAPL flow is assumed to be the circle inscribed between adjacent, uniform diameter, spherical porous medium grains and the wall of the Teflon casing. This geometrical arrangement is illustrated schematically in Figure 5.2. Flow in an individual vertical capillary tube of diameter D is given by the Hagen-Poiseuille equation (Streeter and Wylie 1979).

$$Q_i = -\frac{\pi \rho g D^4}{8\mu} \quad (5.2)$$

Q_i is the flow that occurs in a single capillary of diameter D . The diameter of the representative capillary is assumed to be that of the largest circle which can be inscribed between two uniform spheres and a plane as illustrated in Figure 5.2. The plane in Figure 5.2 is perpendicular to the plane of the paper. The spheres represent grains of sand/soil, and the plane represents the Teflon surface. Equation (5.2) gives the rate of flow in a single capillary. The total flow is then the sum of the flows in all capillaries. The number of capillaries, N , is given by the quotient of the outer circumference of the Teflon casing

Table 5.1. DNAPL collection rate estimates based on the annular flow and bundle of capillary tubes models.

Porous Medium Description	Grain Diameter (mm)	Flow Rates (cm ³ /day)	
		Annular Flow Model	Capillary Tube Model
medium sand	0.42	28,000	2100
medium sand	0.3	10,000	750
fine sand	0.21	3,500	260
fine sand	0.149	1,200	92
very fine sand	0.105	440	32
very fine sand	0.088	260	19
coarse silt	0.044	32	2.4
medium silt	0.0156	1.4	0.11
fine silt	0.0078	0.18	0.013
very fine silt	0.0039	0.022	0.0016

divided by the assumed uniform grain diameter, assuming all such model capillaries are filled with DNAPL. Table 5.1 contains estimated maximum DNAPL recovery rates assuming the bundle of capillaries model.

5.1.3 Comparison of Model Results

The annular flow model clearly provides an absolute upper bound to DNAPL drainage down the Hydrophobic Lance surface. The calculated flow in the annular model is a little more than an order of magnitude greater than the bundle of capillary tubes model. It is also clear that as the grain size of the porous medium decreases, the maximum DNAPL flow decreases sharply. This follows from both equations (5.1) and (5.2), since the flow rate goes as the fourth power of the spatial dimension defining the flow. Below the coarse to medium silt grain size range, the DNAPL flow rates become so low as to make the technology of questionable use.

The bundle of capillary tubes model likely provides a lower bound estimate for the maximum DNAPL recovery rate. This may be seen by comparing Figures 5.2a and 5.2c. Figure 5.2a is a representation of the model used to calculate the flow. Figure 5.2c is a representation of the more likely geometry since the DNAPL is expected to wet the Teflon surface. The later configuration clearly has more cross-sectional area available for DNAPL flow. The bundle of capillary tubes model is still an estimate of maximum DNAPL recovery since it is unlikely that all of the "capillaries" will be saturated with DNAPL. It is possible that these two factors, DNAPL wetting and incomplete DNAPL saturation, might balance each other out.

Figure 5.1. Geometry of annular flow model for maximum DNAPL recovery rate.

Figure 5.2. Bundle of capillary tubes model for estimating maximum DNAPL recovery rate. a. Model geometry; b. Calculation of capillary diameter. c. Likely geometry due to DNAPL wetting of the Teflon surface.

5.2 HYDROPHOBIC LANCE DESIGN

Figure 5.3 is a schematic illustration of a Lance and the mechanism by which it works. One feature of the Lance is the shunts designed to direct downward DNAPL flow along the hydrophobic surface into the interior of the Lance where it can be collected and pumped to the surface. The shunts are illustrated in the detailed drawings provided in the Appendix B. The sump provides sufficient volume to collect approximately 2.5 liters when the volume of the pump and tubing are subtracted. The frequency at which each lance must be pumped will depend on the DNAPL accumulation rate. The sump volume was determined such that the lance could collect DNAPL at a reasonable maximum rate for approximately one day. The maximum recovery rate calculation was based on the annular flow model for the lower fine sand medium for this purpose. This rate estimate was chosen because it is conservatively high. Thus if the Lance had to be down for any reason, to service a pump, for instance, at least one full day would be available before DNAPL collection would exceed the volume of the sump. Figure 5.4 illustrates the assembled Hydrophobic Lance, ready for installation. Detailed drawings of Hydrophobic Lance design are contained in Appendix B.

5.3 HYDROPHOBIC LANCE INSTALLATION

The Hydrophobic Lance would normally be installed in shallow, unconsolidated sediments using direct push technology via a cone penetrometer truck. Experience in the A/M-Area has indicated that refusal occurs during cone pushes approximately half of the time (Rossabi, personal communication). The following installation method was designed to minimize the chance of refusal and to permit precise placement of the Lance with respect to the elevation of expected confining units/DNAPL target zones.

The first step of the installation was to drill down just into the water table using a conventional hollow stem auger rig and small diameter augers. The augers were left in place, and all cone pushes were completed through the auger flights. Split spoon samples with a diameter of 1.75 inches were collected continuously down through the middle clay to a depth of 150 feet using DOE SCAPS cone penetrometer rig and Fugro's split-spoon sampler. The split spoon samples were analyzed for PCE and TCE to determine whether or not a DNAPL source was encountered. They were also used to determine the detailed local stratigraphy at the installation site. The stratigraphic information and soil-sample screening results were used to determine the depth for placement of the Lance. The depth was selected to optimize the location of the hydrophobic surface for directing DNAPL flow into the interior of the Lance. The Lance was then lowered into the hole, and we attempted to push it to the target depth. We still experienced refusal problems, however, beginning at a depth of approximately 150 feet. Had installation by this method been successful, the hole would then have been completed by grouting to the surface during removal of the augers.

Initial fluid recovery in a Hydrophobic Lance will likely contain significant amounts of sediment. This sediment must be removed by developing the Lance through a combination of hand bailing and gentle pumping. This must be completed prior to emplacement of the permanent pump for the DNAPL recovery system. The DNAPL recovery system is described in the next section.

Figure 5.3. Hydrophobic Lance geometry and mechanism of operation.

Figure 5.4. Hydrophobic Lance design dimensions.

5.4 DNAPL RECOVERY PLAN FOR THE HYDROPHOBIC LANCE

5.4.1 DNAPL Recovery System Design

A DNAPL recovery system will be installed once development of the Lance and initial sampling are complete. The DNAPL recovery system for a lance is illustrated in Figure 5.5. In general terms, the system consists of the lance itself, a gas-lift pump, pressurizing and sampling lines, a pump control unit, a gas pressure source, a vessel in which visual assessments and volumetric measurements can be made of the recovered DNAPL (a glass carboy), and a waste storage drum. The pump is a Solinst model 408 Double Valve pump. The intake has been modified to allow it to settle as low as possible into the sump. This will minimize the volume of DNAPL remaining in the sump following a round of pumping. The pressurizing and sampling lines consist of 1/4" x 1/8" Teflon tubing. The pump control unit is a Solinst model 465 controller. The pump control unit regulates the pressurizing and relaxing cycle for the gas-lift pump. A compressed gas cylinder (nitrogen) and associated regulators will be used as the gas pressure source. The vessel for visual measurements is an eight gallon glass carboy with a valve tap at the base. The waste storage drum is a 55 gallon drum.

5.4.2 DNAPL Recovery Procedure

There will be a minimum initial volume of water that will be recovered with each round of pumping. This volume will consist of the water inside the pump body and in the sample line from the pump to the water table.

5.4.3 Recovery Frequency

The frequency at which each lance must be pumped will depend on the DNAPL accumulation rate. The lance cannot accumulate more DNAPL than the volume of the sump. Table 5.3 contains estimated pumping frequency ranges for several of the estimated DNAPL recovery rates. The frequency range was calculated assuming the annular model provides an upper limit and the bundle of capillary tubes model a lower limit of DNAPL collection rates. The collection rates are given by dividing the assumed DNAPL collection rate by the volume of the sump (approximately 2.5 L). It is clear from this table that the Lance needs to be in material no finer than coarse silt. The collection rates become too low, and hence the pumping frequencies also become too low.

Table 5.3 DNAPL collection frequency from a Hydrophobic Lance.

Porous Medium Description	Range of Pumping Frequency
medium sand	1 to 11 times per day
medium sand	twice a week to 4 times per day
fine sand	3 times per month to twice per day
fine sand	1 per month to 1 every other day
very fine sand	4 times per year to 1 time per week
very fine sand	3 times per year to 3 times per month
coarse silt	1 time every other year to 4 times per month
medium silt	1 time every 62 years to 1 time every 5 years
fine silt	1 time every 520 years to 1 time every 38 years
very fine silt	1 time every 4,300 years to 1 time every 310 years

Figure 5.5. Schematic illustration of the Hydrophobic Lance DNAPL recovery system.

6.0 EVALUATION METHODS

The baseline unit cost for the pump-and-treat system in the A/M Area is \$87 per pound of DNAPL (see Appendix C). The cost estimate for the Hydrophobic Lance will be compared with the baseline cost. The unit cost for collection and handing of the A/M Area DNAPL will be computed using the following equation.

$$\text{Unit Cost} = (\text{Mobilization/Setup[Drill Rig + Cone Truck]} + \text{Pre-Installation Sampling/Fraction of Successful Hits} + \text{Demobilization} + \text{Development Costs} + \text{System Operation} + \text{DNAPL Disposal Cost} + \text{Project Management}) / \text{Pound of DNAPL} \quad (6.1)$$

At this stage it is not possible to calculate an accurate or reasonable unit cost for collection and disposal of the A/M Area DNAPL using the Hydrophobic Lance. There are several reasons for this. The first and most important is that no DNAPL has been collected yet, i.e., the denominator in the cost equation is zero. Hence, the cost cannot be defined. Second, several of the subcosts in the cost equation cannot be accurately estimated, since the installation technique is still being re-evaluated and redesigned based on the results obtained to date. Accurate assessment of the cost savings of employing the Hydrophobic Lance will be performed upon completion of Phase II in FY 1999.

7.0 FIELD INSTALLATION RESULTS

Field work began on July 6, 1998. This was the first effort to install a Hydrophobic Lance. Three installation attempts were made before a successful installation was accomplished. The installation attempts are summarized in this section. The detailed daily activities are available in the Daily Field Record which is reproduced in Appendix D.

7.1 DNAPL CHARACTERIZATION RESULTS

EMTC drilled with their auger rig down to a depth of approximately 130 feet, which was just into the water table. EMTC collected one split-spoon soil sample from 130 to 132 feet. It was apparent, however, that the hole had collapsed in on itself below the augers when they went in to collect the next sample. Fugro brought their cone penetrometer (CP) truck over the hole, and continuous split-spoon sample collection was resumed on Friday July 10 from 132 feet. Their split-spoon sampler has the capability to remain closed until the desired depth is reached, and can therefore overcome any problems with hole-collapse. The soils were scanned with a photoionization detector (PID) as an initial screening technique to identify DNAPL zones. The PID reading was recorded along with sediment descriptions and percent recovery. These data are presented in Table 7.1.

Two cubic centimeter (cm³) soil plugs were taken out of the split-spoon samples for laboratory analysis of PCE and TCE. These were analyzed using the headspace analytical technique (see Appendix E for the analytical results). The resulting data were recalculated into DNAPL saturation. Five different values of porosity were used which cover the expected range for these sandy materials (see Appendix F). The results are presented in Figure 7.1. Five samples came out with non-zero DNAPL saturation. The highest saturation calculated was from one of the 145' to 147' samples. The calculated DNAPL saturation (0.009 to 0.012) is too low, however, given the fact that free-phase DNAPL was observed to drain into the impression left by the soil sample collection procedure. The

headspace technique is apparently not recovering all of the free-phase DNAPL. Accurate saturation calculations will require either a new analytical technique, capable of recovering free-phase product or a more thorough calibration curve for the headspace technique that will allow correction for unrecovered PCE and TCE existing in a free-phase state.

7.2 FIRST INSTALLATION ATTEMPT

The PID results from the split-spoon sample screening were used to select a target depth to install a Hydrophobic Lance. The target depth was determined to be 155' to 156' for the tip of the Lance sump. This would place the connection between the Teflon casing and the sump at a depth of approximately 150'. The Teflon collection surface would stretch from 140' down to 150'. The first attempt to install the Hydrophobic Lance failed. The machined Teflon at the connection with the sump could not withstand the shear stress imposed by the soil as the Lance was pushed into the ground; it pulled apart at that point. The stress experienced by the Teflon needed to be minimized, if not eliminated.

7.3 RE-DESIGN OF LANCE

A "quick fix" for the Lance design was quickly conceived. Bracing the Teflon section with four 1/4" diameter stainless steel rods set in a square (when viewed in cross-section) would take the tensile stress load during the installation. These four rods possess nearly half the cross-sectional area, and hence tensile strength, of schedule 80 stainless steel casing. The Teflon should experience little or no tensile stress. A short section of stainless steel casing was added above the Teflon section to provide a surface to which the upper end of the support rods could be welded. The lower ends were welded to the sump. The revised design is illustrated in Figure 7.2. The SRTC ESS Machine and Fabrication Shop completed the revisions in a day, assembling two complete, modified Hydrophobic Lances.

7.4 SECOND INSTALLATION ATTEMPT

The Lance was dropped down the borehole twice during the operation to lower it into the ground. The first time it fell approximately 65 to 70 feet. The second time it fell approximately 30 feet. This Lance assembly was set aside, as the integrity of its shunt holes and the holes into the sump at the sump connection were suspect. Visual inspection suggested they were fine, but there was evidence that the Teflon had experienced noticeable compression as a result of the falls. Hence, the undamaged Lance was selected for installation.

The remaining, undamaged Lance was lowered into the hole, and the 30 ton ARA cone penetrometer truck was aligned over the top of it. The Lance needed to be pushed approximately 25 feet below the end of the augers in order to place the hydrophobic surface adjacent to the DNAPL layer and provide enough shunts that it could reasonably be expected to get collected. This would have set the Teflon surface over a depth range of 140 feet to 150 feet. The ARA rig was able to push the Lance in a distance of 19.5 feet before running into very strong resistance. They attempted to repeat numerous cycles of loading the rod followed by unloading it. Through this they were only able to push the rod another half foot, making the depth 20.1 feet, still nearly five feet short of the required target.

Table 7.1. Split-spoon sample data summary.

Depth (feet)	Sediment Description	Recovery (%)	PID Reading
130 - 132	yellow to brown, fine to medium sand	29	
132 - 134	brown, medium sand	33	
134 - 136	thin kaolin interbeds (135.5' to 136.0')	54	
138 - 140	medium or coarse sand (138' to 138.3') clayey sand (138.3' to 140')		
140 - 142	clayey sand (140' to 140.03') yellow-brown to reddish-brown, very coarse, well sorted quartz sand (140.03' to 140.29') very fine to fine, orangish-brown clayey sand (140.29' to 140.54')	54%	
142 - 144	fine to medium, silty sand, tan to yellow with manganese mottling	100	400 to 960
144 - 146	brown to mottled maroon, poorly sorted, fine to coarse clayey sand (144' to 144.9') very fine sand to silt w/ kaolinite stringers, brown to red sandy clay (144.9' to 145')	50	
145 - 147	very coarse, well-sorted sand, white to yellowish brown (145' to 146.8') thin, clayey sand layers in coarse to medium sand (146.8' to 147') Free-Phase DNAPL observed	100	> 2000
148 - 150		20	26.7

EMTC brought their auger rig back over the hole, and began hammering the Lance into place using a 140 pound, down-hole hammer. They were only able to advance the Lance an additional two feet in approximately 60 minutes of hammering. The decision was made to switch to a 300 pound, down-hole hammer. The 300 pound hammer was able to advance the Lance down to its target depth. When the depth of the well was measured, however, it appeared to bottom out at a depth of approximately 142 feet, thirteen (13) feet shy of the target depth. An initial interpretation of this result was that the upper section of stainless steel casing had pulled out of the PVC casing. The top schedule 80 stainless steel section of the Lance assembly (see Figure 7.2) was retrieved during overdrilling and "fishing" for the Lance. It came up with its connection to both the Teflon section below and some pieces of PVC casing from above. These results suggest that the heavy impact of the 300 pound hammer may have bowed the drill rod quickly and sharply enough to shatter

the PVC casing. The shallow depth of the well might therefore have been due to in-filling by sediment and/or pieces of PVC casing becoming wedged in the Lance.

7.5 COMPLETED INSTALLATION AND SPECIFICATIONS

A Hydrophobic Lance, an innovative remediation technology for DNAPLs, was successfully deployed on July 20-21, 1998. The installation was completed in the over-drilled hole from which part of the second Lance was recovered. The volume of the annulus between the Lance and the augers was calculated from the bottom of the hole to the top of the sump. Bentonite pellets were poured down the annulus in sufficient quantity to form a bentonite plug around the sump at the bottom of the Lance. The augers were slowly backed out of the hole up to the water table at 130 feet below grade. The formation collapsed back around the Teflon casing, forming a natural sand pack. The completed Hydrophobic Lance installation is illustrated schematically in Figure 7.3.

7.6 DEVELOPMENT AND SAMPLING OF THE LANCE

The Hydrophobic Lance was sampled twice since its installation to see whether any significant quantity of DNAPL had collected. The first time was August 18, 1998. There was no obvious indication of DNAPL in the first bailer sample that was pulled up. There was, however, plenty of sand. The bailer was used to surge the Lance, and thus stir up the sediment so that it might be more easily caught by the bailer. Approximately four liters (4 L) of water, mud, and sand were bailed from the Lance.

The second round of development was on August 27, 1998. The first bailer was lowered slowly and carefully. It still came up with a lot of fine to very fine sand and muddy water. The usual strong PCE aroma was noticed, but there was still no clear sign of DNAPL having entered the Lance. The bailer was used to surge and bail the Lance again. The mud content in the bailers quickly began to diminish, with the water becoming a pale yellow. Approximately 1.5 L of water and mud were bailed before the bailer began to come up empty; apparently the check-valve ball or seat had been exposed too much sand and grit.

Further development of the installed Hydrophobic Lance will be completed in FY 1999. Additional hand bailing will be tried first using a new Teflon bailer. Additional and final development will be completed using a gas lift pump. The filter for the pump will be removed in order to allow sediment to enter it. Development will continue until negligible sediment is recovered with the water. The presence of DNAPL in the Lance will be tested with the first quantity of water recovered during each round of development. An organic dye such as Sudan IV will be used for this testing.

Figure 7.1 Calculated DNAPL saturation as a function of depth.

Revised Hydrophobic Lance Design

Figure 7.2 Revised Hydrophobic Lance design with support rods.

Figure 7.3 As-built construction detail of the installed Hydrophobic Lance.

8.0 LESSONS LEARNED AND FUTURE PLANS

The first lesson was that the Teflon casing, which is being used as the hydrophobic surface, must be braced such that it experiences little or no tensile stress during installation. The revised design appears to accomplish this very well. A revised method of assembling the 1/4" round support rods has been developed which will increase their effectiveness.

Installation of Hydrophobic Lances near the M-Area Seepage Basin may not be possible using direct push technology because of the depth and the presence of "hard", dense sands in and just below the target zone. Three things might be tried to address this limitation. The first is to change the installation technique. This is currently being considered the first choice. The installation technique being considered now is to use Roto-Sonic technology to vibrate the Lance into place. Methods two and three are complimentary, and could easily be implemented together. The basic premise is to reduce the depth the Lance must be pushed to reach its target zone. There are two ways of doing this. The first is to drill deeper with the auger rig prior to beginning the push. The second is to reduce the length of the sump.

The current interpretation of the second attempt failure is that the PVC casing was the problem. This may have come from popping out of the stainless steel casing or it may have resulted from shattering due to the impact of drill rods as they deflected sharply because of the impact of the 300 pound hammer. Either way this is easily solved by using stainless steel casing from the top of the Lance to a point above the water table.

There may have been a chance to salvage the second installation if we had confirmed the failure mechanism: PVC casing pulling off the stainless steel casing or shattering due to the impact of the drill rods being flexed by the 300 pound hammer impact. More thorough evaluation and longer deliberation might be warranted prior to abandoning an installation.

9.0 REFERENCES

- Baligh, M. M. and R. F. Scott. 1976. "Analysis of wedge penetration in clay." *Géotechnique*. 26:185-208.
- Jackson, D. G., T. H. Payne, B. B. Looney and J. Rossabi. 1996. *Estimating the extent and thickness of DNAPL within the A/M Area of the Savannah River Site (U)*. WSRC-RP-96-0574. Westinghouse Savannah River Company.
- Jerome, K. M., B. B. Looney, M. L. Rhoden, B. Riha and S. Burdick. 1996. *Field test of single well DNAPL characterization using alcohol injection/extraction*. Technical Report WSRC-TR-96-348. Westinghouse Savannah River Company.
- Looney, B. B., J. Rossabi, D. M. Tuck, J. E. Jordan, C. L. Bergren, R. Van Pelt, W. E. Jones, A. E. Stevenson and B. S. Kristiansen. 1992. *Assessing DNAPL Contamination, A/M-Area, Savannah River Site: Phase I Results*. WSRC-RP-92-1302. Westinghouse Savannah River Company, Aiken, SC.
- Reid, R. C., J. M. Prausnitz and T. K. Sherwood. 1977. *The Properties of Gases and Liquids*. 3rd. McGraw-Hill Book Company, New York. 688 pp.
- Streeter, V. L. and E. B. Wylie. 1979. *Fluid Mechanics*. 7th. McGraw-Hill Book Company, New York. 562 pp.

APPENDIX A
ESTIMATION OF SRS A/M AREA DNAPL VISCOSITY

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Reid et al. (1977) provide several methods for estimating viscosity of liquid mixtures. They recommend the following method for situations where no data are available on the viscosity of a known mixture of the components. The following is a generalized form of equations which have been used to correlate viscosity Reid et al. (1977).

$$f(\eta_m)_L = \sum_i x_i f(\eta_i)_L \quad (A.1)$$

where $f(\eta_i)_L$ is some function of the liquid viscosity of the mixture components, $(\eta_i)_L$. In this relation $f(\eta_i)_L$ may be η_L , $\ln \eta_L$, $1/\eta_L$, and x_i may be the liquid volume, weight, or mole fraction. They recommend that the natural log function be used.

The following data were used in the viscosity estimate. Mole fraction data are from Looney et al. (1992).

Component	Mole Fraction	η (centipoise)	$\ln \eta$
PCE	0.93	0.904	-0.100926
TCE	0.07	0.575	-0.553385

Equation A.1 yields the following result when the natural log is used as the correlation function.

$$\ln (\eta_m)_L = -0.132598$$

$$(\eta_m)_L = 0.876$$

REFERENCES

Reid, R. C., J. M. Prausnitz and T. K. Sherwood. 1977. *The Properties of Gases and Liquids*. 3rd. McGraw-Hill Book Company, New York. 688 pp.

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APPENDIX B
HYDROPHOBIC LANCE DESIGN

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Overview of Hydrophobic Lance: Parts and Assembly

filename: "Parts & Assembly*90%"
prepared by David M. Tuck
June 3, 1998
revised September 10, 1998

filename: "Lance Tip & Dims*90%"
prepared by David M. Tuck
June 1, 1998

filename: "CPT Adapter & Tip*90%"
prepared by David M. Tuck
June 1, 1998

filename: "CPT Adapter & Dimensions"
prepared by David M. Tuck
June 1, 1998

Overview of Machining for the Teflon Casing of the Hydrophobic Lance

Machining Detail for "Channel Drains"

6 channels x 18 holes/channel = 108 holes

Sump Connection Machining

filename: "Sump connection*90%"
prepared by David M. Tuck
June 5, 1998

B-8

EXTERNAL THREAD DETAIL (SCALE = 2:1)

INTERNAL THREAD DETAIL (SCALE = 2:1)

NOTE: SPECIAL THREAD FORM -- 8 THREADS PER INCH

filename: "Sump connection-upper"
prepared by David M. Tuck
June 8, 1998

filename: "Sump-Hydrophobe connection"
prepared by David M. Tuck
June 8, 1998

APPENDIX C

BASELINE COST FOR A/M AREA PUMP-AND-TREAT SYSTEM

from

Jerome, K. M., B. Riha and B. B. Looney. 1997. *Final Report for Demonstration of In Situ Oxidation of DNAPL Using the Geo-Cleanse® Technology*. Technical Report WSRC-TR-97-00283. Westinhouse Savannah River Company.

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Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802

WSRC-TR-97-00283
September 19, 1997
Rev. 0
Page C-2

SEP 03 1996

Mr. John L. Steele, Manager
Manager, Focus Area Programs Department
Westinghouse Savannah River Company
P. O. Box 616
Aiken, SC 29802

Dear Mr. Steele:

SUBJECT: Cost Savings Analyses for Soil Vapor Extraction (SVE) (U)

A second independent analysis of projected and actual costs for the subject activity was performed by this office as a result of the meeting held on August 21 between your staff and Terry Brennan of this office.

This analysis supports your claim for comparing the new technology, SVE, to the cost of removing the same amount of solvent with the baseline pump and treat technology, the M-1 Air Stripper. The resulting savings for the solvent extracted by the SVE during the first twelve months of operation is \$4,380,000.

Questions from you or your staff may be directed to Terry Brennan at 725-4716.

Sincerely,

Karen L. Hooker, Director
Program Management and
Coordination Division

PM&CD-TJB:ap

OB-96-018

cc:

G. Hooker, WSRC, 773-41A

J. Iwert, WSRC, 773-41A

Westinghouse Savannah River Company
INTER-OFFICE MEMORANDUM

WSRC-TR-97-00283

September 19, 1997

Rev. 0

Page C-3

July 30, 1996

SRT-FAP-96-0173

To: J. L. Steele

From: G. J. Hooker *GJH*
J. W. Iwert

**ESTIMATED COST SAVINGS
SOIL VAPOR EXTRACTION COMPARED TO PUMP AND TREAT AND
IN WELL VAPOR STRIPPING COMPARED TO PUMP AND TREAT**

SUMMARY

This document details FY1996 cost savings attributable to Soil Vapor Extraction (\$4,380,000) and to In Well Vapor Stripping (\$2,462,000). These savings are derived by comparing the new technology to the cost of removing the same amount of solvent with the baseline pump and treat technology, the M-1 air stripper. Soil Vapor Extraction (SVE) removes the solvent from the vadose zone before it has migrated to the groundwater and avoids the greater cost of removal by pump and treat. In Well Vapor Stripping (IWVS) is being applied in the Southern Sector of the A/M contaminant plume to remove solvent from groundwater at low solvent concentrations where the economic advantage of IWVS over Pump and Treat is most significant.

The capital and O & M cost estimates were provided by the WSRC Site Project Cost Estimating Department. Technical input and review was provided by Roger White of SRTC and by Chris Bergren and Michael Hartz of WSRC-ER.

DISCUSSION

Soil Vapor Extraction

Four Soil Vapor Extraction units with catalytic oxidation were started up in A/M Area in May 1995. Although this innovative technology was anticipated in the 1993 Baseline its first full year of operation was completed in April 1996. We are therefore submitting the cost savings attributable to SVE for the FY1996 Award Fee Item.

It is estimated that over 1 million pounds of the solvent contaminant in the A/M Area plume remains in the vadose zone where it will continue to recharge the groundwater. Removal of the contaminant from the soil is less expensive than removal from the groundwater.

Exhibit I summarizes the full operating cost for removing 64,800 lbs of solvent (\$18.90 per lb) with the SVE units during the most recent 12 months, the full operating cost for removing 13,209 lbs of solvent (\$86.49 per lb) extracted by the M-1 air stripper for a similar period, and calculates the resulting savings for the solvent extracted by the SVE in this period, \$4,380,000.

In Well Vapor Stripping

The scope for this project is detailed in "Southern Sector Vertical Recirculation Wells-Phases 2 and 3", G-TC-A-0006. As a substitute for pump and treat remediation, a line of 12 Vertical Recirculation wells is being installed at the southernmost extent of the A/M Area plume to terminate its further migration and to remove the contaminant from the plume as it moves past the line of wells. Exhibit II summarizes the full cost per pound of solvent removal by IWVS (\$74.94 per lb), the adjusted cost per pound of solvent removal for the M-1 stripper operating in the low solvent concentration of the southern sector (\$1210.86 per lb), and the cost savings per pound of solvent removed by the IWVS (\$1135.92 per lb). The resulting FY1996 savings estimate is \$2,462,000.

Exhibit III is the June ER solvent removal summary report from which solvent removal rates were taken.

Exhibit IV is the Estimate Detail Sheet for Capital and O&M costs for the M-1 Stripper, the Soil Vapor Extraction, and the In Well Vapor Stripping. These calculations are further supported in the following Exhibits.

Capital costs for the pump and treat operation were estimated from the following document by Stone and Webster (and approved by DOE), "Pump and Treat of Contaminated Groundwater at USDOE Savannah River Site, Aiken, SC, June 1994. Exhibit V is the information used. Note that because the M-1 stripper is being modified to treat the offgas at a cost of \$449,000 this amount has been added to the final estimate for the M-1 stripper capital cost.

Exhibit VI is the final capitalized amount for the SVE operation.

Exhibit VII is the capital cost and other data provided for the IWVS cost estimate.

Exhibit VIII contains other miscellaneous notes and data sheets used in this estimate.

EXHIBIT I
ESTIMATED COST SAVINGS
SOIL VAPOR EXTRACTION COMPARED WITH PUMP AND TREAT

ANNUAL OPERATING COST FOR FOUR M AREA SVE UNITS:

Capital.....	\$260,000
O & M.....	\$964,000
Total.....	\$1,224,600

SOLVENT REMOVED BY THESE SVE UNITS, 6/95 THRU 5/96.....64,800 lbs

SVE COST PER POUND EXTRACTED:

$\$1,224,600 / 64,800 \text{ lbs} = \18.90

ANNUAL OPERATING COST FOR M-1 AIR STRIPPER:

Capital.....	\$172,500
O & M.....	\$970,000
Total.....	\$1,142,500

SOLVENT REMOVED BY M-1 AIR STRIPPER, 5/95 THRU 4/96.....13,209 lbs

M-1 COST PER POUND EXTRACTED:

$\$1,142,500 / 13,209 \text{ lbs} = \86.49

COST SAVINGS BY SVE:

$(\$86.49 - \$18.90) \times 64,800 \text{ lbs} = \$67.59 \times 64,800 \text{ lbs} = \$4,379,832$
Rounding..... 168
\$4,380,000

EXHIBIT II
ESTIMATED COST SAVINGS
INWELL VAPOR STRIPPING COMPARED WITH PUMP AND TREAT

ANNUAL OPERATING COST FOR INWELL VAPOR STRIPPING (IWVS):

Capital.....	\$62,400
O & M.....	\$100,000
Total.....	\$162,400

ESTIMATED ANNUAL SOLVENT REMOVAL FOR IWVS:

$$0.0217 \text{ lbs/hr} \times 12 \text{ wells} \times 24 \text{ hrs/day} \times 365 \text{ days/year} \times 0.95 \text{ availability} = 2167 \text{ lbs/year}$$
COST PER POUND OF SOLVENT REMOVED BY IWVS:

$$\$162,400 / 2167 \text{ lbs} = \$74.94 \text{ per lb}$$
COST OF REMOVING SOLVENT FROM THE IWVS FEEDSTREAM WITH M-1 STRIPPER:

From Exhibit I the operating cost of M-1 Stripper.....\$86.49 per lb
 Concentration of Solvent in M-1 Feedstream is.....7 ppm
 Concentration of Solvent in IWVS Feedstream is.....0.5 ppm

Cost of Operating M-1 in the IWVS Feedstream:

$$(7 \text{ ppm} / 0.5 \text{ ppm}) \times \$86.49 = 14 \times \$86.49 = \$1210.86 \text{ per lb}$$
ESTIMATED COST SAVINGS FOR THE IWVS:

$$(\$1210.86 - \$74.94) \times 2167 \text{ lbs} = \$1135.92 \times 2167 = \$2,461,534$$

Rounding.....	466
	<u>\$2,462,000</u>

Total pounds VOCs Removed per Month in A/M Area
 FY 1995 and FY 1996

FY '96	Oct. '94	Nov. '94	Dec. '94	Jan. '95	Feb. '95	Mar. '95	Apr. '95	May '95	June '95	July '95	Aug. '95	Sept. '95	Total
M-1 Stripper	1719	1444	823	785	588	1544	1174	1174	608	783	0	1893	12543
A-1 Stripper	55	47	43	47	15	48	35	33	48	36	5	47	480
IDU	445	0	0	345	0	0	0	22	286	1176	3355	508	6145
SVEU 3M	0	0	0	0	0	0	0	1000	1800	700	3000	3200	9500
SVEU 4M	0	0	0	0	0	0	0	1800	1800	600	700	600	8300
SVEU 5M	0	0	0	0	0	0	0	1800	1300	1400	2200	1500	8300
SVEU 6M	0	0	0	0	0	0	0	1400	200	0	800	1800	4000
									FY '95	Total pounds VOCs removed			74% target 80472
FY '96	Oct. '95	Nov. '95	Dec. '95	Jan. '96	Feb. '96	Mar. '96	Apr. '96	May '96	June '96	July '96	Aug. '96	Sept. '96	Total
M-1 Stripper	1200	1540	1307	1426	1158	702	1420						8761
A-1 Stripper	43	43	40	28	7	6	48						215
IDU	885	742	706	600	600	600	600						4833
SVEU 3M	2200	1800	300	300	1000	2000	3100	1400					12100
SVEU 4M	600	1200	1000	1500	700	1800	1500	600					8800
SVEU 5M	1100	1200	1800	1600	700	1800	700	1200					10000
SVEU 6M	800	1400	2000	1200	2800	2200	1600	1100					11200
A-2 Stripper	0	0	0	0	0	0	0	0					0
Other:	170	165	170	170	160	170	165	170					1340
Sum	7098	8060	7423	8624	8923	9078	9133	4370					68639
% of monthly goal	105.8	120.8	110.7	101.8	103.2	135.4	136.2	65.2					73
													current % of annual goal
													110

200

ERP and PC

06/19/96 WED 08:21 FAX 8036446922

WESTINGHOUSE SAVANNAH RIVER COMPANY

INTER-OFFICE MEMORANDUM

ENGINEERING & CONSTRUCTION SERVICES
SITE PROJECT ESTIMATING DEPARTMENT

ECS-SPE-96-0327

DATE: July 25, 1996

TO: G. I. HOOKER, 773-41A / 253

FROM: R. M. SIMPSON, 730-1B / 114

BY: C.B. JORDAN, 730-1B / 1066

COMPARATIVE COST FOR THE M-1 AIR STRIPPER, VALDOSE ZONE SOIL VAPOR EXTRACTION AND IN-WELL VAPOR STRIPPING (U)

Estimate Log No: 96-06-07A and 96-07-11 Estimate Type: Comparative Cost

Attached is the capital costs and operation and maintenance cost for the above listed treatment technologies.

COST BASIS:

The cost are based on previous life cycle costs and other information supplied by the ER Group.

ASSUMPTIONS:

The costs are in FY'96 Dollars. SRS Site mark-ups for subcontract work, construction management and projectsupport are not included.

MANAGEMENT RESERVE / CONTINGENCY:

No Management reserve or Contingency is included in the costs for this study.

ESTIMATE CLOSURE:

No response is required for this study.

DDH

cc: R. M. Simpson, 730-1B / 114
J. W. Iwert, 773-41A / 251
Estimate File

PROJECT NO: N/A
 PROJ. NAME: Comparative Technology Cost
 LOG NO: 11-47-11

SITE PROJECT ESTIMATING
 ESTIMATE DETAIL SHEET

ESTD BY: C. Jordan, D. Hansen
 PHONE: 2-8840
 LOC: 730-18/1986

ITEM	WBS	CSI	TYC	DESCRIPTION	QTY	UNIT	UNIT COST	MHRS	CR	MHRS	LABOR RATE	LABOR	ENGR'D EQUIP.	BULK MAT'L	SC	TOTAL DOLLARS
1.0				M-1 Air Stripper (ADS-816/1701)												
1.1				Capital Cost												
				Total Capital Cost (FY90 \$)			\$4,552,000									
				(Assume 30 Yr. Life)												
				Cost Per Year												\$151,700
				Escalation 1990 to 1995 @			13.70%									\$20,800
				Total Yearly Capital Cost												\$172,500
1.2				Operations & Maintenance												\$822,800
				M-1 Stripper - RMET Avg. Yr.												\$307,700
				ER Labor - Exempt												\$12,300
				ER Labor - Non-Exempt												\$27,800
				Power & Misc. O & M Costs												\$970,000
				Total Yearly O & M Costs												
2.0				Vadose Zone (ADS-816/1704)												
2.1				Capital Cost												
				Total Capital Cost (FY95 \$)			\$3,810,000									
				(Assume 15 Yr. Life)												
				Cost Per Year												\$254,000
				Escalation 1995 to 1998 @			2.60%									\$8,800
				Total Yearly Capital Cost												\$260,600
2.2				Operations & Maintenance												\$501,000
				Vadose Zone - RMET - F												\$391,000
				ER Labor - Exempt												\$48,000
				ER Labor - Non-Exempt												\$28,000
				Power & Misc. O & M Costs												\$961,000
				Total Yearly O & M Costs												

C-8

PROJECT NO: WA
PROJ. NAME: Comparative Technology Cost
LOG NO: 91-07-11
ESTD BY: G. Jordan, D. Hansen
PHONE: 8-5560
LOG: 730-187088

SITE PROJECT ESTIMATING
ESTIMATE DETAIL SHEET

ITEM	WBS	CSI	TWC	DESCRIPTION	QTY	UNIT	COST	UNIT	LABOR	LABOR	LABOR	EQUIP.	BULK	MATL	SG	TOTAL
									RATE							DOLLARS
2.0				Southern Sector In-Well Vapor Stripping												
3.1				Capital Cost			\$1,873,000									
				Total Capital Cost (FY98 \$)												
				(Assume 30 Yr. Life)												
				Cost Per Year												\$62,400
																\$62,400
3.2				Operations & Maintenance												
				ER Labor												\$41,000
				Inspection & Maintenance												\$47,000
				Power & Misc. O & M Costs												\$12,000
				Total Yearly O & M Costs												\$100,000

07/23/98 TUE 12:46 FAX 8037254129

ID Program Office

EXHIBIT V
(2 pages)

Q002

M-1 AIR STRIPPER - CAPITAL COST

Savannah River - Page 8 of 12

COST

- The production air stripper was designed and constructed in 1984-1985. The major capital cost elements associated are provided below. Annual operating costs based upon data from 1985 through 1990 are also listed. All information is based on an analysis performed in 1990 and all costs are in 1990 dollars.
- During 1985 to 1990, the average volume of water treated by the air stripper was 198 million gallons per year. Using the operating costs detailed below (in 1990 dollars), the total cost of operation and maintenance is \$0.75 per 1000 gallons treated.
- An assessment of total cost and duration of operation for the pump and treat system to complete the cleanup is not possible due to the multi-phased approach to environmental restoration of the A/M Area. As detailed on page 6, the overall treatment plan for the site includes future identification and implementation of technologies to achieve cleanup goals. The extent to which the pump and treat system will be part of that effort has not yet been determined therefore projected costs to cleanup can not be estimated.

Capital Costs

Design	\$420,000
Contracts (permitting, modeling, etc.)	368,000
Site Development	28,000
QA Engineering	18,000
Control Building	211,000
Electrical	877,000
Instrumentation	466,000
Piping/Construction	925,000
Tower Installation	132,000
Control System	230,000
Erect/Test Tower	428,000
Total	\$4,103,000

Operating Costs

Electrical Power (@ \$0.052/kwh)	\$26,000
Maintenance	
Labor (@ \$35/hr)	13,500
Equipment repair & replacement	13,000
Operation	
Operation & daily inspections	45,700
Well sampling & lab analysis	15,000
Engineering support	36,000
Total Annual Operating Cost	\$149,200

ESCAPATE to 96

U.S. Department of Energy

Savannah River - Page 11 of 12 -

ANALYSIS PREPARATION

This analysis was prepared by:

Stone & Webster Environmental
Technology & Services
245 Summer Street
Boston, MA 02210
Contact: Bruno Brodfield (617) 589-2767

Assistance was provided by the
WESTINGHOUSE SAVANNAH RIVER COMPANY
which supplied key information and reviewed report drafts.

for:

HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs
Oak Ridge, Tennessee 37831-7606

managed by
MARTIN MARETTA ENERGY SYSTEMS
for the

U.S. Department of Energy
under Contract DE-AC05-84OR-21400

This analysis was funded by:

U.S. Air Force
Headquarters USAFCEVR

CERTIFICATION

This analysis accurately reflects the performance and costs of the remediation:

x
C.L. Bergren

Westinghouse Savannah River Company
Environmental Restoration Department
Manager Northern Ground Water Facilities

x
G.E. Turner

Department of Energy
Savannah River Operations Office
Environmental Restoration Division
Environmental Specialist

U.S. Department of Energy

07/24/86 WED 09:51 FAX 8036444816

SWER DIVISION

1/24/86 WED 08:14 FAX 8036441519

CENTRE SOUTH

002
002

52-21-263-W
DT

EXHIBIT VI

**Westinghouse Savannah River Company
Closing Statement
January 31, 1996**

Project Number	SR Number	Accrual Reserve Account	B & R Code	Supplementry Data	WBS Number	Fixed Asset Voucher Number
CS9-4817	4817	YES	EW2010202	EQU99ZZ	011201	952374

Project Title **A/M AREA VADOSE ZONE REMEDIATION
COST FUNDED**

Building Number
730-2B .

Original Appropriation	\$4,637,000.00	Appropriation Changes	-\$826,766.04	Expended Amount	\$3,810,233.96
------------------------	----------------	-----------------------	---------------	-----------------	----------------

Additional Information	CENTS ELIMINATION	Amount	\$0.96	Reference Number	COST FUNDED

FIS Code	FIS Description	Amount
755	SHOP EQUIPMENT	\$3,768,465.00
720	LABORATORY EQUIPMENT	\$41,768.00
	Total	\$3,810,233

This is to advise that final costs for the work included in the above authorization have been recorded and the project has been financially closed.

C-12

EXHIBIT VII
DATA FOR ESTIMATING COST SAVINGS OF VERTICAL RECIRCULATION WELLS
 (Provided by Roger White, 7/16/96)

1.	Install 12(8" dia) wells: 12x170' = 2040 linear feet estimate \$17,000 per well	\$204,000
2.	Air Compressor, 30hp 12x\$25,000 ea	\$300,000
3.	Equipment enclosures: 12x\$10,000	\$120,000
4.	Vacuum System, 10hp 12x\$10,000	\$120,000
5.	Electrical Utilities: Run 13.8 etc.	\$300,000
6.	Finishing Materials for Wells 12x\$4000	\$48,000
7.	Well Packers 12x\$8000	\$96,000
8.	PVC Casing & Screens 12x\$5000	\$60,000
9.	Monitoring Wells, 8: 8x\$1200	\$96,000
10.	Characterization 12x\$4000	\$48,000
11.	Installation for above ground components:	\$50,000
12.	O&M Cost: Energy...assume 20hp continuous Inspection: 2 hrs per day Maintenance: \$10,000 per year ER Exempt Labor: 1/4 FTE	
13.	Productivity of wells: 0.0217 lbs solvent per hour per well [This to be documented in formal calculation by SRTC] Estimated solvent concentration in Southern Sector groundwater is 500 parts per billion.	
14.	License fees to EG&G for use of patents	\$128,000
15.	M-1 Stripper Feedstream: (per Michael Hartz) Solvent concentration (1995 annual average): TCE 4.1ppm PCE 2.9ppm Total 7.0ppm	

EXHIBIT VIII
(Misc. Notes)

M-1 AIR STRAPPER (1706)

Capital Cost

Total Cr. Cost	4,103,000
----------------	-----------

OFF GAS 545	449 000
-------------	---------

S/T	A 4552.000
-----	------------

PER YR COST	\$151,733
-------------	-----------

Expend '90-'96

FY XX-(Ar6.96-99) 622,506 RMEI

50% ER LABOR EXEMPT 307655 EXEMPT

50%	11	11	NEW EXHIB	12295	NEW EXHIB
-----	----	----	-----------	-------	-----------

SUBTOTAL 942,456

ELECT, EQ & MTL	26,000
-----------------	--------

*154K Process Mods 9.65,456

2952 M-1 OFFGAS TREAT. SYS.

449

VADOSE ZONE (1704) - ESCALATE CAPTION 95 to 96	
CAPITAL COST - ?	\$3810,000 +
PER YR COST DISBURSE	\$254,000 / YR
OPERATIONS -	
VADOSE ZONE - R/MET-F	501,000
ER LABOR - EXEMPT	391,000
ER LABOR - NON EXEMPT	46,000
SUBTOTAL OPERATIONS	938,000
ELECT, MAINT, ETC	26,000
	964,000

SOUTHERN SECTOR (1703) - IN WELL VADOSE STRIPPING
 12 WELLS

DESIGN	100,000
WELL INSTALL/FEQUIP/PER	1,453,000
SITE WORK PDS	150,000
MISC - PERMITS, CONCA SURVEY	170,000
	1,873,000 ÷ 3.0 YR = \$624,000

O & M

PWR	12,500
IBSP \$/MAINT	47,000
ER LABOR 500 MHR	41,000
	100,500

Fri 26 Jan 1996

U.S. Department of Energy
PROJECT 1670671 A-1/N-1 AIR STRIPPER GW - ADS 516, REVISION FY96.02
A-1/N-1 AIR STRIPPER GROUNDWATER
** PROJECT DIRECT SUMMARY - LEVEL 3 **

TIME 15:14:06

SUMMARY PAGE 7

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
A GROUNDWATER ASSESSMENT							
A.08 ADDITIONAL STUDIES						3,377	80.25
A.08.02 A-1 STS. CYCLING DEMO S/C FY97	67.00 HR	3,377	0	0	0	12,038	80.25
A.08.04 A-1 STS. CYCLING DEMO S/C FY97	150.00 HR	12,038	0	0	0	5,377	80.25
A.08.06 DEVELOP PROCEDURE - S/C FY97	67.00 HR	3,377	0	0	0	22,791	
		22,791	0	0	0		
A.09 REGULATORY REQUIREMENTS							
A.09.02 INTGRD AIR PERM MCD SC FY99		0	0	0	21,400	21,400	
A.09.03 INTGRD AIR PERM MCD SC FY00-22		0	0	0	470,800	470,800	
A.09.04 A-1A CUTFLL NPOES RENWL SC FY99		0	0	0	32,100	32,100	
A.09.05 A-1A CUTFLL NPOES RENWL SC FY00-22		0	0	0	706,200	706,200	
A.09.06 A-1 AIR PERMIT RENWL SC FY99		0	0	0	21,400	21,400	
A.09.07 A-1 AIR PERMIT RENWL SC FY00-22		0	0	0	470,800	470,800	
A.09.08 M-1 AIR PERMIT RENWL SC FY97		0	0	0	32,100	32,100	
A.09.09 M-1 AIR PERMIT RENWL SC FY00-22		0	0	0	21,400	21,400	
A.09.10 M-1 AIR PERMIT RENWL SC FY99		0	0	0	470,800	470,800	
A.09.11 M-1 AIR PERMIT RENWL SC FY00-22		0	0	0	64,200	64,200	
A.09.12 VADOSE ZONE RENWL SC FY99		0	0	0	256,800	256,800	
A.09.13 VADOSE ZONE RENWL SC FY00-22		0	0	0	2,568,000	2,568,000	
		0	0	0			
A.95 AOP - FISCAL YEAR 1995							
A.95.01 AOP - FISCAL YEAR 1995		435,668	0	0	1,439,150	2,074,838	
		435,668	0	0	1,439,150	2,074,838	
AOP - FISCAL YEAR 1995		658,479	0	0	4,007,150	4,645,629	
GROUNDWATER ASSESSMENT							
O GROUNDWATER OPERATIONS							
O.14 OPERATIONS						649,731	
O.14.02 M-1 STRIPPER - RMET FY96		47,000	0	42,800	559,931	565,281	
O.14.04 M-1 STRIPPER - RMET FY97		0	0	0	565,281	629,481	
O.14.06 M-1 STRIPPER - RMET FY98		0	0	0	629,481	645,531	
O.14.08 M-1 STRIPPER - RMET FY99		0	0	0	645,531	15,413,243	
O.14.10 M-1 STRIPPER - RMET FY00 - 22	23.00 YA	23,000	0	21,400	15,413,243	161,770	
O.14.12 A-1 STRIPPER - RMET FY96		0	0	0	161,770	365,405	
O.14.14 A-1 STRIPPER - RMET FY97		0	0	0	365,405	409,275	
O.14.16 A-1 STRIPPER - RMET FY98		0	0	0	409,275	419,975	
O.14.18 A-1 STRIPPER - RMET FY99		0	0	0	419,975		
O.14.20 A-1 STRIPPER - RMET FY99		0	0	0			

649,731

565,281

629,481

645,531

15,413,243

161,770

365,405

409,275

419,975

670,161.00

AVG 1,622,506

TIME 15:14:05
SUMMARY PAGE 8

U.S. Department of Energy
PROJECT 167051: A-1/N-1 AIR STRIPPER GV - ADS 516, REVISION FY96.02
A-1/N-1 AIR STRIPPER GROUNDWATER
** PROJECT DIRECT SUMMARY - LEVEL 3 **

Fri 26 Jan 1996

	QUANTITY	UNIT	LABOR	EQUIPMENT	MAT/SUPP	UNIT COST	TOTAL COST	UNIT COST
0.14.22 A-1 STRIPPER -RMET FT00-22	23.00	YR	0	0	0	10,028,573	230,000,000.00	436025.00
0.14.24 LABOR FY96	800	HR	615,309	0	0	615,309	615,309	82.47
0.14.26 ER LABOR EXEMPT FY97	7461	00 HR	615,309	0	0	615,309	615,309	82.47
0.14.28 ER LABOR EXEMPT FY98	7461	00 HR	615,309	0	0	615,309	615,309	82.47
0.14.30 ER LABOR EXEMPT FY99	17,603	00 HR	14,152,079	0	0	14,152,079	14,152,079	82.47
0.14.32 ER LABOR EXEMPT FT00 - 22	487	00 HR	24,589	0	0	24,589	24,589	50.19
0.14.34 ER LABOR NONEXEMPT FY96	487	00 HR	24,589	0	0	24,589	24,589	50.19
0.14.36 ER LABOR NONEXEMPT FY98	487	00 HR	24,589	0	0	24,589	24,589	50.19
0.14.38 ER LABOR NONEXEMPT FY99	11201	00 HR	153,849	0	0	153,849	153,849	50.19
0.14.40 ER LABOR NONEXEMPT FT00-22	153	849	5,330	0	0	5,330	5,330	50.19
0.14.51 PROCESS MODIFICATIONS	14,907		153,849	0	0	153,849	153,849	50.19
0.14.55 R-1 OFF-GAS TREATMENT SYSTEM	14,907		153,849	0	0	153,849	153,849	50.19
OPERATIONS								
GROUNDWATER OPERATIONS								
A-1/N-1 AIR STRIPPER GV								
	17,086	219	17,086,219	5,330	139,869	29,526,403	47,555,841	
	17,086	219	17,086,219	5,330	139,869	29,526,403	47,555,841	
	18,544	698	18,544,698	5,330	139,869	32,221,470	52,221,470	

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APPENDIX D
DAILY FIELD RECORDS

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Daily Activities Report

Project Hydrophobic Lance Installation		
Driller J. Hall - EMTC		Drilling Subcontractor EMTC
Well Number MHL-3	Technical Oversight Rossabi	Oversight Firm SRTC
Location M Area Basin - west of MJB-22		Date 7/6/98 + 7/8/98 Page 1 of 1

Start	Stop	Description of Activities/Remarks
8:35 am		Drillers arrive, begin setup, waiting on sandcaters, split spoons, waiting on Jim Jordan for waste handling training.
10:00 am		Dean Thomas arrived (ER H+S). Created trouble
10:30	J. Jordan gave training	Created a problem with the drillers by telling them they needed hard hat + safety glasses working on rig when the mast was down. It seems there was a technical issue because safety ropes and sign was up. Dean didn't like this. J. Jordan's Pager 14734
11:15		Leaking hydr. fluid. Went to get safety belt + hose.
12:10		Back. Bad seal on right hydraulic piston on mast. MUST bring rig back to shop. Maybe ready tomorrow morning. EMTC - 652-2718
7/8/98		Had to order part and get it shipped. Arrived 7/8/98 @ 10:31 am - Rig back on site @ 11:45 am Attached to auger Drilling at 12:15 pm 7/8/98
12:17 pm		1 stick in ground; #2 mounted; 10 in rack Mobile Drill B-57 vs DOT 375910 Auger flights are 5' long
12:25		2 sticks in ground; #3 mounted; 9 in rack
12:30		3 sticks in ground; #4 mounted; 8 in rack
12:35		4 sticks in ground; #5 mounted; 7 in rack
Technical Oversight Signature J. Jordan		Date 7/8/98

Daily Activities Report

Project <u>Hydrophobic Larvae Installation</u>		
Driller		Drilling Subcontractor
Well Number <u>MHL-3</u>	Technical Oversight	Oversight Firm
Location	Date	Page <u>2</u> of <u> </u>

Start	Stop	Description of Activities/Remarks
<u>12:41 pm</u>		<u>5 sticks in ground; #6 mounted, 6 in rack.</u> <u>Water break for driller ~ 5 min.</u>
<u>12:58</u>		<u>6 sticks in ground; #7 mounted, 5 in rack</u>
<u>1:02</u>		<u>7 sticks in ground; #8 mounted 4 in rack</u> <u>6" diameter auger 8 1/2 ft. o.d.</u> <u>~ 4" i.d.</u>
<u>1:05</u>		<u>8 sticks in ground; #9 mounted 3 in rack</u>
<u>1:08</u>		<u>9 sticks in ground; #10 mounted 2 in rack</u>
<u>1:15</u>		<u>10 sticks in ground; #11 mounted 1 in rack #1.</u>
<u>1:21</u>		<u>11 sticks in ground; #12 mounted 0 in rack #1 (right side)</u> <u>13 sticks in rack #2 (left side)</u> <u>of truck)</u>
<u>1:30</u>		<u>12 sticks in ground; #13 mounted 12 in</u> <u>rack #2</u>
<u>1:33</u>		<u>13 sticks in ground; #14 mounted; 11 in rack</u>
<u>2:00</u>		<u>Break for lunch till 1:58 pm.</u>
<u>2:00</u>		<u>14 sticks in ground; #15 mounted; 10 in rack</u>
<u>2:04</u>		<u>15 sticks in ground; #16 mounted; 9 in rack</u>
<u>2:08</u>		<u>16 sticks in ground; #17 mounted; 8 in rack.</u> <u>A little chatter on the rig.</u>
<u>2:11</u>		<u>17 sticks in ground; #18 mounted; 7 in rack</u>
<u>2:15</u>		<u>18 sticks in ground; #19 mounted; 6 in rack</u>

Technical Oversight Signature <u>J. Paulis</u>	Date <u>7/8/98</u>
---	-----------------------

Daily Activities Report

Project		
Driller		Drilling Subcontractor
Well Number MHL-3	Technical Oversight	Oversight Firm
Location		Date 7/8/98 Page 3 of 3
Start	Stop	Description of Activities/Remarks
2:17		19 sticks in ground #20 mounted. 5 in rack. Rig having a little trouble drilling at ~93'.
		When I say a stick is in the ground it means that 1/2 of it is (2.5') and 1/2 is sticking up.
2:27		AT 95' depth - get split spoon ready. sampled 2' split spoon from 95-105'
3:54		24 sticks in ground #25 mounted. 0 in rack #2
4:30		Dr. Hoss. left site after waiting on decision about tomorrow's work.
Technical Oversight Signature <i>J. Roubal</i>		Date 7/8/98

Title of Project

Hydr. LANCE

Project No.

Subject

MHL-3

Works

Computer

Date

7/8/98

Sheet No.

1

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30																																							
SOIL SAMPLES IN 22 H / Handpan vials 2cc to 5ml																																							
										Depth (ft-bls)																													
MHL3-1										95										} spoon 1																			
MHL3-2										95.5																													
MHL3-3										96																													
MHL3-4										97										} spoon 2																			
MHL3-5										97.5																													
MHL3-6										98																													
MHL3-7										98.5																													
MHL3-8										99										} spoon 3																			
MHL3-9										99.5																													
MHL3-10										100																													
MHL3-11										100.5										} spoon 4																			
MHL3-12										101																													
MHL3-13										101.5																													
MHL3-14										103										} spoon 5																			
MHL3-15										103.5																													
MHL3-16										104																													

D-4

Daily Activities Report

Project Hydrophobic Lanic Installation		
Driller J. Hall - EMTL		Drilling Subcontractor EMTL
Well Number MHL-3	Technical Oversight	Oversight Firm SRTC
Location M Area Basin - West of MSB-22	Date 7/9/98	Page 4 of

Start	Stop	Description of Activities/Remarks
6:15 am		Drillers arrive. No tag line. - CPT guys have something.
6:20 am		Rig started. Tagged bottom of hole - 120', hole open Mix of N + NW rod on rig - release line for sampler won't fit down one of the types (either N or NW) because diameter is too small. Have 140' of good stuff. Will get someone to drive out here.
7:02 am		Ready to go again. No slip ring for drillers
7:40 am		Put NW rods on next to 120' depth but couldn't get release tool down rods - will switch to cone rods
8:00 am	am	BAR pipe 4 rods strung together = 4 meters = 13.12 feet + $\approx 18''$ for sampler $9 \times 4 \text{ rods} = 118.08'$ Adder 9 rods, $\approx 18''$ stick up. Drill rig doesn't have enough weight to push rod. Pushed about 6" up.
8:30 am		Move CPT over the rods. cycled for ≈ 20 minutes didn't get anywhere -
9:50 am		Moved CPT off hole - will get drill rig to remove CPT rod. Now will get down to 152', then hammer 2" split-speed sampler to 147'.
Technical Oversight Signature J. Lomels		Date 7/9/98

Daily Activities Report

Project		
Driller		Drilling Subcontractor
Well Number MHL-3	Technical Oversight	Oversight Firm
Location		Date 7/9/98 Page 5 of

Start	Stop	Description of Activities/Remarks
		Then will move CPT over hole and push in hydrophobic lance.
	10:15	EMTC finished pulling up the CPT rod
10:15 AM		Start next round; # augering down to 132'
		+ 1 rod yellowish brown fine ser clayey sand
		+ 1 rod 130' We are into the water table.
		Willie Simmons earlier measured a depth to water at MSB-22 of approximately 129'
	10:33	Finished clearing sand & cuttings from the hole. Bottom of auger is at 130'
10:33	10:49	Break for the drillers
10:50		Start split spoon sampling
		130 131.5 yellow-brown silted fine-medium sand 2 samples MHL-3 131-132 sample length 1.7'
	11:25	Went down to take the second split spoon sample, but the hole had closed back up. The auger rig will not be able to take the split spoon samples. We'll try to get them with the CP rig
11:25	12:00	Pulled samples out, lowered CP rods down the hole, and brought the CP rig over the hole.
		Lunch Break

Technical Oversight Signature	Date
<i>David M. Duck</i>	7/9/98

Daily Activities Report

Project		
Driller		Drilling Subcontractor
Well Number <i>MHL-3</i>	Technical Oversight	Oversight Firm
Location	Date <i>7/9/98</i>	Page <i>6</i> of <i> </i>

Start	Stop	Description of Activities/Remarks
<i>12:50 PM</i>		<i>Pushed cone split-spoon samples to 132 ft. Will begin sampling again at that depth. CP rig had no difficulty pushing the split-spoon sampler to 134'</i>
		<i>sampler lost much of the sample. retrieved ~ 8" of brown, medium sand</i>
		<i>2 samples MHL-3 132-134'</i>
		<i>Pushed the cone to 136' (split-spoon) recovery ~ 1' 1"</i>
		<i>2 samples MHL-3 136' thin kaolin interbeds</i>
		<i>2 samples MHL-3 135' sandy layer immediately above ~ 6" above clay interbeds</i>
		<i>3:30 EMTC crew headed out</i>
	<i>3:30 pm</i>	<i>CP split-spoon pushed to 138' 3:30 pm</i>
<i>3:30</i>		<i>driller break</i>
		<i>from 4:05 split spoon sample reached the surface</i>
		<i>We only recovered about 7" to 8" of light brown fine to medium sand</i>
		<i>The end plug fell & seems to have pushed some of the soil/sand back out of the spoon</i>
		<i>2 samples MS MHL-3 137'</i>
Technical Oversight Signature		Date <i>7/9/98</i>

David M. Duck

Daily Activities Report

Project		
Driller		Drilling Subcontractor
Well Number MHL-3	Technical Oversight	Oversight Firm
Location		Date 7/10/98 Page 7 of
Start	Stop	Description of Activities/Remarks
6:30		Setting started. Warming up rigs and cleaning split-spoon samplers in preparation for this morning's work.
7:05		7:49 split-spoon is up
		138' to 139' 4" medium to coarse orange sand
		139' 4" to 140' 0" & very fine clayey sand yellow tan
		2 samples 139' 6" (MHL-3 139.5') clayey sand
		→ 2 samples 139' 4" (MHL-3 139.3') 8:02 am.
		initial rod stack 2 rods + sampler 8 racks of 6 + 3
		8:06 going back down for the next sample
		9 rods remaining when he started to push (probably 2 to Ground level)
		My <u>crude</u> calculation estimates a depth of 141'.
		8:55 140' to 140.05' clayey sand 140' 3/8"
		140.05' to 140' 7" very coarse, well sorted quartz sand yellow-brown to reddish-brown
		140' 7" to 141' 1" very fine to fine orangish-brown sand clayey sand
		10:24 142' to 144' split-spoon sample
		142' to 144' mottled (maroon?) (manganese?) 100% recovery we are getting high Hk readings (640) (400 to 961) fine to medium silty sand, w/ manganese mottling tan to yellow
Technical Oversight Signature		Date
David M. Duck		7/9/98

Daily Activities Report

Project Hydrophobic Lance Project		
Driller EMTC		Drilling Subcontractor
Well Number MHL 1-2-3	Technical Oversight Dave Tuck	Oversight Firm
Location M-Area Seepage Basin		Date 7-15-98
		Page 12 of
Start	Stop	Description of Activities/Remarks
0600		Drillers arrive - Started grouting hole MHL-2. Instructed to anchor MHL-1 to 130 when grouting is completed.
0655		Finished grouting of MHL-2. Setting up for anchor.
0713	0722	#1 anchor
0722	0725	#2 anchor
0725	0728	#3 anchor
0728	0732	#4
0732	0735	#5
0735	0738	#6
0738	0746	#7 105 ft Out of anchors - called in for more. Asked Drillers to bring 3"-4" Shaves to help stabilize lance for insertion
0815		Drillers returned with anchors + support for lance
0817	0820	#8
0820	0823	#9
0823	0828	#10
0828	0832	#11
0832	0842	#12
0843	0850	Asked Drillers to take 1 spoon sample to make sure hole is clean. Took 2 samples for testing VCLs.
0855		ARA truck arrives
11:45		STARTED MIXING GROUT
		Grouting of MHL-2 and one of the Rost (LIF) cone holes was completed by EMTC.
	3:00 PM	Problems with Fugro's LIF probe have shut the day. A break in their optical fiber cable put off testing that system until early evening at best.
		EMTC was sent home. ARA was sent home.
		ARA was on standby all day.
		Heat was
	6:00 PM	Repair of the optical fiber cable failed. Using heat to speed curing an epoxy used to attach the optical fibers to some metal cone electrical connectors. The heat melted the optical fibers. Fugro has set up another repair, but will allow it to cure on its own overnight.
Technical Oversight Signature Dave M. Tuck		Date 7/15/98

Daily Activities Report

Project Hydrophobic Lance		
Driller SCAPS truck (Fugro) & EMTC		Drilling Subcontractor
Well Number HML-3	Technical Oversight David M. Tuck	Oversight Firm
Location M-Area Basin	Date 7/16/98	Page 13 of _____

Start	Stop	Description of Activities/Remarks
6:30		EMTC drillers arrive. We are currently on hold until the SCAPS truck can complete their test of Fugro's Laser Induced Fluorescence (LIF) probe. Dennis of Fugro is completing the reconnection of the LIF probe. Testing revealed that the probe is working.
6:00		
	7:30	
7:30		Fugro is running the probe down the hole now. They made it down to approximately 170' when they realized that they hadn't strung cable through enough rods.
	8:15	
8:15	8:35	Fugro pushed the LIF probe down. A signal that was clearly greater than the background noise showed up at a depth of ~ 146', which is where we expected to see DNAPL. The spectrum is different from the MSB-3D DNAPL sample, but this is not unreasonable.
8:35		Fugro is pulling their rod & probe out of the ground. EMTC moved over the hole. They turned the augers, lowered the lance into the hole, and lowered ARA's rod.
		9:45 AM During the process of lowering the lance into the hole, EMTC's connector for holding the casing gave way. Four pieces of PVC casing had already been attached to the lance, and the next two pieces had been attached and raised to the top of the boom. The PVC threads on EMTC's "hook" pulled out, and the lance fell down the hole. With four sections of casing plus the length of the lance, the lance tip was at a depth of 60' to 65'. This means the lance fell approximately 65' to 70' before hitting the saturated sand at the bottom of the hole.
		The Teflon ST had 60' of PVC casing attached to the top plus the 5' of S.S. casing.
		EMTC was able to connect to the dropped lance string. In the process of pulling it up for me to examine, however, the connector snapped again when the cable became twisted. The fell again, this time only about 30'. EMTC needs to make another "bell" for their boom. We gave them a 5' piece of PVC casing to use to make a new bell connector. They left with Willie Simmons to drill some holes.

Technical Oversight Signature David M. Tuck	Date 7/16/98
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*bell

Daily Activities Report

Project Hydrophobic Lance		
Driller Fugro (SCAPstruck) + E MTC + ARA		Drilling Subcontractor
Well Number MHL-3	Technical Oversight David M. Tuck	Oversight Firm
Location M-Area Basin	Date 7/16/98	Page 14 of

Start	Stop	Description of Activities/Remarks
		The Teflon - S.S. casing connection pulled apart a little when the lance was pulled up. The S.S. tensile support rods looked like they had been bent and twisted when they absorbed the impact. The ground shunts machined into the Teflon all look fine. It looks like they withstood the impacts well. I can't see the connection between the Teflon & S.S. sump, so I don't know how well it fared.
		The LIF probe response in MHL-1 indicates that DNAPL is present just below the water augers at a depth of somewhere between 130' and 135'. I decided we will use the unburned/unaltered lance in this hole.
	12:00 noon	EMTC & ARA lowered the new lance into the hole and the cone rods for ARA.
12:20 PM		ARA began leveling their truck in preparation for pushing the lance. The target depth is 150' below ground to the top of the lance sump. The bottom of the augers is at 130'. The sump is 5' long, so the lance needs to be pushed 25' below the augers.
		The lance met strong resistance at a depth of 19.5' below the casing. This places the Teflon-Sump connection at a depth of approximately 144.5', which is still at least 0.5' above the DNAPL layer. With repeated cycling of pressure on + off the cone rods, ARA was only able to advance the lance to a depth of 20.1' below the augers, which places the Teflon-Sump connection at a depth of approximately 145.1'. This is just barely into the DNAPL layer. They cannot push any farther. We need to get the lance down another 5' to 6'.
		ARA is experiencing a minor hydraulic leak; they cannot get one of their pads to move. They were able to get the hydraulics to work sufficiently to raise their pads and pull off the hole.
15 * 2:30		We brought EMTC back over the hole and asked them to use their hammer to pound the lance down the remaining 5 feet. In 45 to 60 minutes they were only able to advance the lance 2 feet. They were using a 140 lb. hammer today. They will bring a 300 lb. hammer tomorrow tomorrow.
	3:15	

Technical Oversight Signature David M. Tuck	Date 7/16/98
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Daily Activities Report

Project Hydrophobic Lance		
Driller EMTC		Drilling Subcontractor
Well Number HML MHL-3	Technical Oversight David M. Tuck	Oversight Firm
Location M-Area Basin	Date 7/17/98	Page 15 of

Start	Stop	Description of Activities/Remarks
6:00 AM		Drillers arrive, and begin mounting their hammers and checking the rig
6:40 AM		Drillers begin hammering with the 300 lb. hammers.
	7:40 AM	The lance tip has reached the target depth of approximately 155'. The drillers begin to pull the CPT rods out of the hole.
7:50 AM		Well We begin to measure the depth of the lance tip. The top of the casing stands 5' above ground level after adding casing to what was in the ground. This makes approx 73 (30) feet of casing were added, making the total
		We tagged the bottom of the "well" at approximately 147', which means the ab below TOC, which means the tape was hitting bottom at ~142'. This is approximately 13' above where we expected to see it. We think the S.S. top casing pulled out of the PVC casing
		The driller recalled that the cone rods had been somewhat hard to pull at first. We are also easily able to turn the casing. Therefore the casing has clearly pulled out of the the S.S. casing section.
		8:20 AM The drillers pulled up what casing they could. There was 7' recovered 170' of on the PVC casing. This means that approximately 115' were in the ground, and 30' of casing is still in the ground. The drillers are going to try fishing it out now.
		They split the PVC casing and pulled up a small section of it. They are trying to fish out more.
8:40	9:10 AM	The cable on their rig locked up on the reel. Working to free it.
9:10	9:15 AM	Fishing again. They couldn't retrieve anything. They are probably just breaking up the PVC.
9:35		EMTC is going back to the ship to get more augers to overdrill the lance, hoping that we might be able to retrieve it. They will also bring materials to set a "normal" well.

Technical Oversight Signature David M. Tuck	Date 7/17
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Daily Activities Report

Project Hydrophobic Lance			
Driller EMTC		Drilling Subcontractor	
Well Number MHL-3	Technical Oversight David M. Tuck		Oversight Firm
Location M-Area Basin		Date 7/17/98	Page 16 of

Start	Stop	Description of Activities/Remarks
10:57		Driller return with auger.
		Discussions between drillers (Cowboy, Jim Haller, & Lewis), Brian Rich, Janelle Jansson, and Dave Tuck regarding how best to set a well in this hole. Janelle finally came up with an idea to drill down with a plug, pour some bentonite pellets in, then lower the well to the plug through the augers. Well use the well to knock the plug out of the augers. They will place more bentonite as they raise the augers until they reach the top of the sump. They will sand pack around the PVC screen, place bentonite on top of that. The hole will be finished with grout to the surface. Ideally, the construction will be like the illustration below.

Technical Oversight Signature	Date
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Daily Activities Report

Project Hydrophobic Lance		
Driller EMTC		Drilling Subcontractor
Well Number HML MHL-3	Technical Oversight David M. Tuck	Oversight Firm
Location M- Area Basin	Date 7/17/98	Page 17 of ____

Start	Stop	Description of Activities/Remarks
12:15		The drillers started overdrilling around the lance. The goal is to sand-lock the lance in the auger and pull it up with the drill string.
1:00 PM		Drillers begin to pull the drill string.
1:45 PM		The drill string came to the surface with part of the lance. Two sections of PVC casing were recovered along with the top S.S. casing above the Teflon, portions of the Teflon, and pieces of the 1/4" S.S. tensile support rods.
	2:40	EMTC is pulling off MHL-3. They are going to pull their augers from MHL-1. On Monday we will come back to finish MHL-3. Rather than complete it with a standard well, we are will complete it as illustrated on p. 16, but with the remaining hydrophobic lance rather than a standard well. The procedure will be as follows: <ol style="list-style-type: none"> 1) Drill with the augers back to 155' with a wood plug at the bottom of the augers. 2) Tap the wood plug loose (not out!) with drill rod. 3) Pour an amount of bentonite pellets in to come up to in to just below the top of the pump. 4) Lower the lance down the augers to into the bentonite until its points rests on the wood plug. 5) Slowly pull the augers allowing the formation to collapse back around the lance. 6) Grout to the surface.
	3:00 PM	Done for the day

Technical Oversight Signature

David M. Tuck

Date

7/20/98

Daily Activities Report

Project Hydrophobic Lance		
Driller EMTC		Drilling Subcontractor
Well Number HML-3	Technical Oversight David M. Tuck	Oversight Firm
Location M-Area Basin	Date 7/20/98	Page 18 of

Start	Stop	Description of Activities/Remarks
6:00 AM		Drillers arrive. They did not bring cement.
6:45	7:40 AM	Drillers head back to their office to get cement.
7:40		Drillers begin mixing the cement grout to fill the last hole (MHL-2).
7:55	8:25	Drillers begin to grout the last hole. Finish initial pour of grout into the last hole and cleaned out their pump.
8:27	9:10	Drillers took the rig to fill it with water.
9:19	10:05 AM	Drillers have the wrong size plug for their augers. They have to go back to their shop to get a replacement.
10:10	11:30 PM	Drillers begin redrilling the hole.
12:00 noon	12:30 PM	Drillers on standby waiting for Willie Simmons
12:30 PM		Lowered the lance into the hole. EMTC had problems getting the plug to drop out. They had pulled the augers up approximately 2.5 to 3'. I indicated that they needed to get the augers and lance tip back down to 155'. When they were drilling back down, the plug came out and the lance and drill rod fell. EMTC does not have enough drill rod on site to recover what they dropped.
2:40 PM	3:18 PM	Drillers left to get more rod pipe.
3:19		Fishing the drill rod out and pulling up the casing to add another section.
3:27 PM	3:36 PM	Drillers begin to put bentonite pellets into the augers to make the plug around the lance stump.
3:36	4:20 PM	We let the pellets swell prior to raising the augers further.
4:20	4:45 PM	Pulled the augers up to ~130' to let the formation collapse naturally around the lance forming a "natural" filter pack. We will let the hole sit overnight allowing it to collapse around the lance.

Technical Oversight Signature David M. Tuck	Date 7/20/98
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Daily Activities Report

Project Hydrophobic Lance		
Driller Em TC		Drilling Subcontractor
Well Number MHL-3	Technical Oversight David M. Tuck	Oversight Firm
Location M-Area Basin		Date 7/21/98
		Page 19 of
Start	Stop	Description of Activities/Remarks
6:10 AM		Drillers arrive.
6:40 AM		Start up rig. Check how much the formation has collapsed overnight. The formation collapsed back around the lance to a depth of 135' below grade. We will install the upper bentonite seal beginning at that level and extend it to above the water table.
6:58 AM		Began pulling the augers out of the hole. The augers began to stick when there was still approximately 85' remaining in the hole. EMTC had to turn the augers to pull them out any further. The casing began pulling up with the augers when there was approximately 75' remaining in the hole.
0830		Brought Brown Honey to site. D-scused plans with drillers.
0855		Secured driller returns - had to get gas. Plan to pull augers to locate break.
0925		Removed 100 ft of casing. Casing did not break. The threaded joint at 95 ft just gave way.
0930		Placed coupling on 10 ft section - fixed with a screw. Coupling at 95 feet.
0940		Started placing casing thru auger. After about 20 ft is placed drillers realize bentonite in the auger is preventing casing from going down further.
0945	1000	Start to remove augers. Noticed VOC smell from auger debris from 35-55 ft level.
1010		Reinstalling casing with augers removed.
1040	10:58	Drillers removing center rod (driller's rod)
1	11:45 AM	Lunch break
11:49 AM		Complete pulling the drill rod.
		Tagged the lance: 156.3' below grade
	12:14 pm	Tagged the annulus: ~100' below grade
		Drillers need to get 90' of tremmie (sp?) pipe for the great cowboy brought another driller crew member out to help while Lewis goes to get the tremmie. Break 12:15 to 12:33 p.m.
Technical Oversight Signature David M. Tuck		Date 7/21/98

Daily Activities Report

Project Hydro phobic Lance		Drilling Subcontractor	
Driller EMTC		Oversight Firm	
Well Number MHL-3	Technical Oversight David Tuck & Gary Exner		Oversight Firm
Location M-Area Basin		Date 7/21/98	Page 20 of
Start	Stop	Description of Activities/Remarks	
12:33		Poured two bags of sand down the annulus. Foster-Dixiana FX-50	
13:20	13:40	Started Steam cleaning annulus. Break	
13:40		Driller comes back with trimming pipe.	
13:50	14:08	Started installing trim pipe.	
14:08		Drillers went to get water for the grout.	
14:38		Drillers return with water.	
14:50		Place 2 1/2-3 bags cement into lance hole.	
14:55	15:06	Started to add cement to about 3rd hole. Added about 7 bags to this hole.	
	15:	Drillers pull out.	
 EMTC Drillers James Hall, Jr. Lewis Jackson James Cockran			
Technical Oversight Signature		Date 7/21/98	

Daily Activities Report

Project			
Driller		Drilling Subcontractor	
Well Number MHL-2	Technical Oversight	Oversight Firm	
Location		Date 7/10/98	Page 1 of

Start	Stop	Description of Activities/Remarks	sticks	sticks
1:28 P.M.		Started augering hole	1	1
		0 - 13' red sandy silty clayey sand part poorly sorted		2
		12.5' beginning to get yellowish		3
		13' to x reddish brown sandy clay		4
		17' Red CLAY		5
		21' Red CLAY		6
		25' Red CLAY + SAND		7
		29' Red SAND		8
		37' Light Red SAND		9
		47' Red SAND		10
		50' Red CLAY + SAND		11
		57' Red CLAY + SAND		12
		62' Brown CLAY + SAND Stopped at 65' TRUCK 50' CLAY MISS 65'		13
WILLIE SIMMONS 7-10-98				
Technical Oversight Signature				Date

Field Geologic Log

Project <i>Hydrophobic Lance Installation</i>		Date <i>7/8/98</i>	Sheet <i>1</i> of <i>1</i>
Well Number <i>MHL-3</i>	Location <i>M Arcadia West MSB-22</i>	Drilling Subcontractor <i>EMTL</i>	
Logs Prepared By <i>RONNAB1</i>		Driller <i>J. Hall</i>	
Company <i>SRTC</i>		Drilling Method <i>Hollow Stem Auger</i>	

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	<u>Cuttings</u>	Drilling Comments/Remarks
				Sample Description	
C	0				
	1			<i>Clayey sand red brown</i>	
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
10	0				
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
20	0				

Field Geologic Log

Hydrophobic Lanic Installation		Date 7/8/98	Sheet 2 of
Well Number MHL-3	Location	Drilling Subcontractor	
Logs Prepared By		Driller	
Company		Drilling Method	

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
20	0			sandy clay brown	
	1				
	2				
	3				
	4			clayey sand	
	5			Brown	
	6				
	7				
	8				
	9				
30	0				
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
40	0				
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				

Daily Activities Report

Project		
Driller		Drilling Subcontractor
Well Number <i>MHL-3</i>	Technical Oversight	Oversight Firm
Location		Date <i>7/10/98</i> Page <i>8</i> of <i> </i>
Start	Stop	Description of Activities/Remarks
		2 samples <i>MHL-3 142.5'</i>
		2 samples <i>MHL-3 143.5'</i>
<i>11:00 AM</i>	<i>1:00 PM</i>	<i>EMTC left to take their rig back to the shop to replace another hydraulic seal. They should be back by 1:30 PM.</i>
		<i>11:55 Sample split-spoon 144' to 146' ~ 50% recovery</i>
		<i>144.0' to 144.5' brown to mottled microm, poorly sorted strong PCE aroma 144.9" fine to very coarse, clayey sand</i>
		<i>144.9" to 145' very fine sand to silt w/ kaolinite stringers brown to red sandy clay clay</i>
<i>12:00</i>	<i>1:00</i>	<i>strong PCE aroma Lunch Break</i>
<i>1:30</i>		<i>Began to lower CP split-spoon for next sample EMTC began collecting augering the hole for HML-2</i>
		<i>2:22 PM split-spoon sample 145' to 147' ~ 90% recovery HML pegged all up+down (>2000)</i>
		<i>145' to ~ 146' 10" very coarse, well sorted sand white to yellow brown</i>
		<i>146' 10" to 146' 11" 147' thin clayey sand zones in coarse to medium sand</i>
		<i>A small DNAPL sample was collected from about 145' 2". After the soil sample @ 145' was collected, and the sample had set for a few (~1 to 2) minutes, Willie Simmons noticed that DNAPL was collecting in the depression. I used a syringe to draw approximately 0.1 to 0.2 ml of the DNAPL.</i>
		<i>Yea! Hooray!</i>
		<i>This project may actually work!</i>
Technical Oversight Signature		Date <i>7/10/98</i>
<i>David M. Duck</i>		

Daily Activities Report

Project		
Driller		Drilling Subcontractor
Well Number MHL-3	Technical Oversight	
Location		Oversight Firm
Date		Page 9 of
Start	Stop	Description of Activities/Remarks
		3:52 p.m. split-spoon sample 148' to 150' ~ 20% recovery no strong DNAPL odor HNu = 26.7
		2 samples MHL-3 148'
4:00	5:00 5:15	Switched trucks. Backed the CP rig off the hole & pulled the auger rig back up. Willie, the drillers (James & Lewis), and the CP crew (Ed & Mark) lowered the lance by hand, and they lowered the CP rod using the auger boom. Pulled the CP rig back up over the hole.
5:15		Lining up the CP rig over the hole.
		Ed is going to run a tag tag line down the rod to find out how deep the lance is sitting before we start to push.
		The lance (the end of the CP rods) are at a depth of 131'. I asked Ed to push it 24'. This should place the tip of the lance at a depth of ~ 155.5' to 156'. The base of the Teflon casing will be between ~ 150' and 150.5'.
		The hydrophobic surface & will cover the interval from 140' to 150'.
~ 5:45		Damn! Damn! Damn!
6:27	6:25	It looks like we popped the sump off somewhere. We pushed approximately 6' when the CP rod kept going down a few inches but the casing stopped advancing. & Ed and Mark are pulling the CP rods out, and then pull the CP rig off the hole.
6:29		EMTC is pulling the casing out. We'll see where it broke, and go from there. We are going to leave the augers in the ground, and try to fish out the S.S. tip on Monday.
	6:50 P.M.	The Teflon lance broke off from the sump where the lower ring of "shunt" holes were drilled in the Teflon. We need to support that piece before we try again.
Technical Oversight Signature		Date
David M. Tuck		7/10/98

Daily Activities Report

Project		
Driller		Drilling Subcontractor
Well Number MHL-3	Technical Oversight David M. Tuck	Oversight Firm
Location		Date 7/13/98
		Page 10 of
Start	Stop	Description of Activities/Remarks
7:45		EMTC arrived with 3-pieces of S.S. Tri-Loc. I will use 2 pieces to make the modifications to the lance. Willie Simmons is here to oversee the drillers. Gary Exner should be out soon. Willie and I loaded the materials into his truck. I will take them over to the machine shop while the drillers get started trying to fish the S.S. sump/print out that we left in the ground on Friday.
8:00	10:30	EMTC worked on fishing out the lance sump that was left in the hole last Friday. They used the down-hole hammers to ram the "spear" into the lance. It worked! They were able to retrieve the sump.
10:30 a.m.	2:00 p.m.	EMTC on standby while we sorted out the day and organized for tomorrow.
Technical Oversight Signature		Date
David M. Tuck		7/13/98

Daily Activities Report

Project HYDROPHOBIC LANCE PROJECT		
Driller EMTC		Drilling Subcontractor
Well Number MHL-3	Technical Oversight DAVE TUCK	Oversight Firm
Location M AREA SEEPAGE BASIN		Date 7-14-98
		Page 11 of
Start	Stop	Description of Activities/Remarks
6:15		DRILLERS ARRIVED WITHOUT CONCRETE TO GROUT THE 2ND HOLE (MHL 2)
6:45		STARTING DECON OF MHL 2 AUGERS
7:30		DECON COMPLETE
7:45		DRILLERS BEGAN MOVING EQUIP. & POSITIONED RIG OVER WHAT IS TO BE THE 3RD HOLE (MHL-1).
8:20 AM		MAST UP ON RIG
8:24		1ST AUGER STICK IN
8:25		# 2
8:28		# 3
8:32	8:36	# 4
8:36	8:41	# 5
8:41	8:46	# 6
8:46	8:49	# 7
8:49	8:52	# 8
8:52		# 9
8:57		# 10
9:00		# 11
9:04		# 12
9:08	9:10	# 13
9:12	9:22	# 14
9:32	9:22	THREE AT 65' - STOPPING HERE FOR NOW DRILLERS LEAVING FOR CONCRETE TO GROUT HOLE MHL 2
1200		Arrived back from lunch. Drillers unloading cement.
12:20		ENGINE TROUBLE ON DRILL RIG - cannot use pump - vendor delay
1300		Cowboy comes out - says tank is out of gas.
1403		Truck returns.
1425		Got engine started. Brian R. brings some truck into MHL-2 area. Cannot grout. Driller will move to help another hole on site. Should be no standby.
1430		Another hole not available. Served for 1 hour standby.
Technical Oversight Signature David M. Tuck		Date

Field Geologic Log

Project		Date	Sheet <u>3</u> of <u> </u>
Well Number <u>MHL-3</u>		Location	Drilling Subcontractor
Logs Prepared By		Driller	
Company		Drilling Method	

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
40	0				
	1			SAND BROWN	
	2				
	3				
	4				
	5			SAND TAN	
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				
	19				
50	20				
	21				
	22				
	23				
	24				
	25				
	26				
	27				
	28				
	29				
60	30				
	31				
	32				
	33				
	34				
	35				
	36				
	37				
	38				
	39				

Field Geologic Log

				Date	Sheet _____ of _____
Well Number		Location		Drilling Subcontractor	
Logs Prepared By				Driller	
Company				Drilling Method	

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
60	0			<u>SAND</u>	
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
70	0				
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
80	0			<u>clayey sand band</u>	
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	0				

Field Geologic Log

Date		Sheet _____ of _____	
Well Number		Location	
Logs Prepared By		Drilling Subcontractor	
Company		Driller	
		Drilling Method	

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
80	0				
	1			SAND	
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
90	0				
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
100	0				

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APPENDIX E
DNAPL ANALYTICAL RESULTS

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EXPLANATIONS

The borehole in which the Hydrophobic Lance was installed was labeled MHL-3. The sediment samples from MHL-3 were analyzed for volatile organic contaminants (VOCs) on July 18, 1998.

The report for each sample (vial) contains analytical results from two separate detectors: an electron capture detector (ECD2 B) and a flame ionization detector (FID1 A). The electron capture detector is extremely sensitive to halogenated compounds, and hence works well for samples having very low concentrations of halogenated VOCs. This sensitivity, however, also makes it inappropriate for samples with high halogenated VOC concentrations because the detector becomes "swamped"; its response levels out at a certain concentration and does not respond any differently to higher concentrations. The historically high PCE and TCE concentrations in the ground water around the M-Area Seepage Basin are generally too high for the electron capture detector. All results used in this report are based on the flame ionization analytical results reported below.

The analytical results are reported by vial number as assigned by the analyst. The following table gives the correlation between vial number and sample depth in borehole MHL-3 and the TCE and PCE analytical results used in the report.

Table E-1. Analytical results from borehole MHL-3.

Vial Number	Depth (feet)	PCE Concentration (mg/L)	TCE Concentration (mg/L)
2	131.0	7.22	1.39
3	131.5	5.10	0.99
4	133.0	5.42	0.98
5	135.0	5.53	0.82
6	136.0	2.97	0.44
7	137.0	2.91	0.48
9	139.3	1.74	0.23
10	139.5	3.94	0.60
11	140.9	357.10	95.56
12	142.5	5.21	41.79
13	143.5	3.93	49.04
14	144.7	4.91	22.37
15	145.0	235.94	33.09
16	146.0	530.00	55.77
17	148.0	0.05	0.00

Mean Retention Times
(minutes $\pm 1\sigma$)

$n=20 \quad v=19$

Sequence

TCE: 10.60035 ± 0.00823

Sequence Parameters:

Operator: SLB
Data File Naming: Prefix/Counter
Signal 1 Prefix: fid
Counter: 00001
Signal 2 Prefix: VIAL
Counter: 0001
Data Directory: C:\HPCHEM\2\DATA\
Data Subdirectory: 071898
Part of Methods to run: According to Runtime Checklist
Barcode Reader: not used
Shutdown Cmd/Macro: none
Sequence Comment:

PCE: 13.91220 ± 0.02768

$t_{.05}[19] = 2.093$

95% Confidence Limit

TCE: 10.583 to 10.618 min

PCE: 13.854 to 13.970 min.

Sequence Table (Front Injector):

No entries - empty table!

Sequence Table (Back Injector):

Method and Injection Info Part:

Line	Vial	SampleName	Method	Inj	SampleType	InjVolume	DataFile
1	1	0 PPB	STANFID	1	Sample		
2	2	MHL 1	STANFID	1	Sample		
3	3	MHL 3	STANFID	1	Sample		
4	4	MHL 3	STANFID	1	Sample		
5	5	MHL 3	STANFID	1	Sample		
6	6	MHL 3	STANFID	1	Sample		
7	7	MHL 3	STANFID	1	Sample		
8	8	0 PPB H2O	STANFID	1	Sample		
9	9	MHL 3	STANFID	1	Sample		
10	10	MHL 3	STANFID	1	Sample		
11	11	MHL 3	STANFID	1	Sample		
12	12	MHL 3	STANFID	1	Sample		
13	13	MHL 3	STANFID	1	Sample		
14	14	MHL 3	STANFID	1	Sample		
15	15	MHL 3	STANFID	1	Sample		
16	16	MHL 3	STANFID	1	Sample		
17	17	MHL 3	STANFID	1	Sample		
18	18	0 PPB H2O	STANFID	1	Sample		
19	19	MHL 3-1	STANFID	1	Sample		
20	20	MHL 3-2	STANFID	1	Sample		
21	21	MHL 3-3	STANFID	1	Sample		
22	22	MHL 3-4	STANFID	1	Sample		
23	23	MHL 3-5	STANFID	1	Sample		

Note: The M-~~atrix~~ DNAPL composition has been/is a function of time for at least two reasons:
1) History of solvent use
2) Preference dissolution of the more soluble components (TCE preferentially dissolved faster than PCE,

If DNAPL is present, the second reason could lead to analytical results biased to relatively higher TCE concentrations and relatively lower PCE concentrations.

i.e.,

$$\frac{[TCE]_m}{[TCE]_{m-actual}} > 1 \quad \text{and}$$

$$\frac{[PCE]_m}{[PCE]_{m-actual}} < 1$$

where the subscript m indicated a measured concentration and m-actual indicates the expected measured concentration.

24	24	MHL 3-6	STANFID	1	Sample
25	25	MHL 3-7	STANFID	1	Sample
26	26	MHL 3-8	STANFID	1	Sample
27	27	MHL 3-9	STANFID	1	Sample
28	28	MHL 3-10	STANFID	1	Sample
29	29	MHL 3-11	STANFID	1	Sample
30	30	O PPB H2O	STANFID	1	Sample
31	31		BAKEOUT1	1	Sample

Calibration Part:

Line	Vial	SampleName	Method	CalLev	Update	RF	Update	RT
Interval								
=====								
=====								

Quantification Part:

Line	Vial	SampleName	SampleAmount	ISTDAmt	Multiplier
Dilution					
=====					
=====					
1	1	O PPB			1
2	2	MHL 1			1
3	3	MHL 3			1
4	4	MHL 3			1
5	5	MHL 3			1
6	6	MHL 3			1
7	7	MHL 3			1
8	8	O PPB H2O			1
9	9	MHL 3			1
10	10	MHL 3			1
11	11	MHL 3			1
12	12	MHL 3			1
13	13	MHL 3			1
14	14	MHL 3			1
15	15	MHL 3			1
16	16	MHL 3			1
17	17	MHL 3			1
18	18	O PPB H2O			1
19	19	MHL 3-1			1
20	20	MHL 3-2			1
21	21	MHL 3-3			1
22	22	MHL 3-4			1
23	23	MHL 3-5			1
24	24	MHL 3-6			1
25	25	MHL 3-7			1
26	26	MHL 3-8			1
27	27	MHL 3-9			1
28	28	MHL 3-10			1
29	29	MHL 3-11			1
30	30	O PPB H2O			1
31	31				1

Sequence Output Parameters:

Print Sequence Summary Report (SSR):	Yes
SSR to Printer:	No
SSR to File:	Yes
SSR File Name (Signal 1):	GLPrprtF.txt
SSR File Name (Signal 2):	071898.TXT
Print individual reports for each run:	Yes
Dest of individual reports for each run:	as specified here
Individual report to Printer:	No
Individual report to Screen:	No
Individual report to File:	Yes
File Type .TXT:	Yes
File Type .WMF:	No
File Type .DIF:	No
File Type .CSV:	No
File Prefix:	report

Sequence Summary Parameters:

One page header:	No
Print Configuration:	No
Print Sequence:	Yes
Print Logbook:	No
Print Method(s):	No
Print Analysis reports:	Yes
Statistic Calib. runs style:	Extended Statistic
Statistic Sample runs style:	Standard Statistic
Summary style:	Compound Summary

Activated Extended Statistic Parameters:

Item name	Limit
	Relative Standard Deviation
----- -----	
Retention time	
Peak area	
Peak height	
Amount	
Peakwidth at half height	
Peak symmetry	

Data File C:\HPCHEM\2\DATA\071898\VIAL0001.D Sample Name: 0 PPB
Instrument 2 7/19/98 10:51:33 AM SLB

DATE: 07-18-98 TIME: WT.: DEPTH:

```

=====
Injection Date   : 7/18/98 7:36:54 PM          Seq. Line :    1
Sample Name     : 0 PPB                        Vial      :    1
Acq. Operator   : SLB                          Inj       :    1
                                           Inj Volume : Manually

Sequence File    : C:\HPCHEM\2\SEQUENCE\071898.S
Method          : C:\HPCHEM\2\METHODS\STANFID.M
Last changed    : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD
=====
  
```

External Standard Report

Sorted By : Signal
 Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
 Multiplier : 1.0000
 Dilution : 1.0000
 Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
 Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.805	VV	877.97473	1.00000	877.97473	?	
3.971	VB S	4.35764e4	2.05198e-5	8.94176e-1	1	air
4.306	BB T	687.96063	1.00000	687.96063	?	
4.670	BV	2784.82471	1.00000	2784.82471	?	
4.780	VV	9679.97070	1.00000	9679.97070	?	
5.071		-	-	-	1	Freon-11
5.285	VP	5.93906e4	1.00000	5.93906e4	?	
5.465		-	-	-	1	Freon-113
5.709		-	-	-	1	11-DCE
6.307	PB	1648.08728	1.00000	1648.08728	?	
6.638		-	-	-	1	t-DCE
8.137		-	-	-	1	c-DCE
8.356		-	-	-	1	CHCl3
8.925		-	-	-	1	TCA
9.307		-	-	-	1	CCl4
10.625		-	-	-	1	TCE
13.926		-	-	-	1	PCE
Totals :				7.50703e4		

Signal 2: FID1 A,
 Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.934	VV	1793.20581	5.57660e-4	1.00000	1	air
5.432		-	-	-	1	Freon-113
5.680		-	-	-	1	11-DCE
6.607		-	-	-	1	t-DCE
8.105		-	-	-	1	c-DCE
8.329		-	-	-	1	CHCl3
8.901		-	-	-	1	TCA
9.283		-	-	-	1	CCl4
10.602		-	-	-	1	TCE
13.904		-	-	-	1	PCE
Totals :				1.00000		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		4.53696e4	1.89418	HVOCs

2 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Time reference compound(s) not found

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0002.D Sample Name: MHL 1
Instrument 2 7/19/98 10:51:36 AM SLB

SAMPLE DATE: 07-10-98 TIME 00:00 WT.25.70 DEPT 13
1 HYDROPHOBIC SAMPLES

Injection Date : 7/18/98 8:05:48 PM Seq. Line : 2
Sample Name : MHL 1 Vial : 2
Acq. Operator : SLB Inj : 1
Inj Volume : Manually
Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000
Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.986	VB S	3.56186e4	2.05198e-5	7.30886e-1	1	air
4.817	BV	2762.00122	1.00000	2762.00122	.	?
5.066		-	-	-	1	Freon-11
5.343	VP	6.19336e4	1.00926e-7	6.25069e-3	1	Freon-113
5.722	VB	1787.61646	7.86274e-7	1.40556e-3	1	11-DCE
6.312	PB	1811.74487	1.00000	1811.74487	?	?
6.632		-	-	-	1	t-DCE
8.129		-	-	-	1	c-DCE
8.348		-	-	-	1	CHCl3
8.920	BP	1.04166e4	7.26537e-8	7.56807e-4	1	TCA
9.298		-	-	-	1	CCl4
10.616	PB +	7.02138e6	1.97707e-7	1.38818	1	TCE
13.521	PP	7505.90771	1.00000	7505.90771	?	?
13.737	VV	1.29652e4	1.00000	1.29652e4	?	?
13.860	VV f	1.04433e7	1.00000	1.04433e7	?	?
13.979	VB +	2.94729e7	4.79367e-8	1.41283	1	PCE
15.524	BB	5.89284e4	1.00000	5.89284e4	?	?
16.360	PB	3677.00146	1.00000	3677.00146	?	?
Totals :				1.05310e7		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.960	VV	3157.53589	3.16703e-4	1.00000	1	air
5.427		-	-	-	1	Freon-113
5.675		-	-	-	1	11-DCE
6.600		-	-	-	1	t-DCE
8.097		-	-	-	1	c-DCE
8.321		-	-	-	1	CHCl3
8.892		-	-	-	1	TCA
9.274		-	-	-	1	CCl4
10.592	VV X+	6.10469e4	2.27631e-5	1.38962	1	TCE
12.383	VV X	376.87103	1.00000	376.87103	?	
12.411	VV X	642.71442	1.00000	642.71442	?	
12.438	VV X	1073.43494	1.00000	1073.43494	?	
12.451	VB X	1622.29626	1.00000	1622.29626	?	
13.896	VV X+	3.10920e5	2.32119e-5	7.21706	1	PCE
14.084	VV X	744.97412	1.00000	744.97412	?	
16.421	VV X	7511.87744	1.00000	7511.87744	?	
Totals :				1.19818e4		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		3.69791e7	13.14698	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0003.D Sample Name: MHL 3
Instrument 2 7/19/98 10:51:40 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:25.38 DEPTH131-132'

Injection Date : 7/18/98 8:34:41 PM Seq. Line : 3
Sample Name : MHL 3 Vial : 3
Acq. Operator : SLB Inj : 1
Inj Volume : Manually

Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000

Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,

Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.985	BB S	5.21796e4	1.91646e-5	1.00000	1	air
5.070	BV	2.26849e4	2.37733e-8	5.39297e-4	1	Freon-11
5.339	VP	5.70074e4	1.00926e-7	5.75352e-3	1	Freon-113
5.722	VV	4156.31152	7.86274e-7	3.26800e-3	1	11-DCE
6.310	VB	1.00792e4	1.00000	1.00792e4		?
6.633		-	-	-	1	t-DCE
8.130		-	-	-	1	c-DCE
8.348		-	-	-	1	CHCl3
8.922	BB	8717.72070	7.26537e-8	6.33374e-4	1	TCA
9.299		-	-	-	1	CCl4
10.618	PB +	5.04780e6	1.95773e-7	9.88223e-1	1	TCE
13.522	PP	5931.54492	1.00000	5931.54492		?
13.738	VV	1.05091e4	1.00000	1.05091e4		?
13.867	VV f	5.62193e6	1.00000	5.62193e6		?
13.978	VB +	3.02029e7	4.78928e-8	1.44650	1	PCE
15.526	BB	4.43117e4	1.00000	4.43117e4		?
16.361	BB	2112.25317	1.00000	2112.25317		?
Totals :				5.69488e6		

Signal 2: FID1 A,

Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.946	VV	959.06921	6.15522e-4	5.90328e-1	1	air
3.976	VV	583.80524	1.00000	583.80524		?
4.144	VV S	3.92387e4	1.00000	3.92387e4		?
5.428		-	-	-	1	Freon-113
5.676		-	-	-	1	11-DCE
6.601		-	-	-	1	t-DCE
8.098		-	-	-	1	c-DCE
8.322		-	-	-	1	CHCl3
8.893		-	-	-	1	TCA
9.275		-	-	-	1	CCl4
10.593	VV X+	4.31604e4	2.30074e-5	9.93009e-1	1	TCE
13.896	VBAS+	2.19191e5	2.32718e-5	5.10096	1	PCE
16.481	VV X	846.85571	1.00000	846.85571		?
Totals :				4.06760e4		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		3.56588e7	10.12922	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)

Warning : Calibrated compound(s) not found

Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0004.D Sample Name: MHL 3
Instrument 2 7/19/98 10:51:44 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT. 25.21 DEPTH:13
2-134'

Injection Date : 7/18/98 9:03:30 PM Seq. Line : 4
Sample Name : MHL 3 Vial : 4
Acq. Operator : SLB Inj : 1
Inj Volume : Manually
Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000
Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.983	BB S	3.59120e4	2.05198e-5	7.36906e-1	1	air
4.866	VV T	5731.24072	1.00000	5731.24072	?	
5.068	VV T	1.74999e4	2.37733e-8	4.16030e-4	1	Freon-11
5.337	VV T	5.58486e4	1.00926e-7	5.63657e-3	1	Freon-113
5.705		-	-	-	1	11-DCE
6.307	PB	9872.91992	1.00000	9872.91992	?	
6.634		-	-	-	1	t-DCE
8.131		-	-	-	1	c-DCE
8.350		-	-	-	1	CHCl3
8.920	BB	7520.48047	7.26537e-8	5.46391e-4	1	TCA
9.301		-	-	-	1	CCl4
10.618	PB +	4.91601e6	1.95588e-7	9.61515e-1	1	TCE
13.523	PP	5906.93018	1.00000	5906.93018	?	
13.739	VV	1.07557e4	1.00000	1.07557e4	?	
13.867	VV f	7.17654e6	1.00000	7.17654e6	?	
13.978	VB +	2.91056e7	4.79597e-8	1.39590	1	PCE
15.526	BB	4.59115e4	1.00000	4.59115e4	?	
16.361	BB	3810.11133	1.00000	3810.11133	?	
Totals :				7.25853e6		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
------------------	------	------------------	----------	----------------------	-----	------

3.959	VV	1319.43298	6.15522e-4	8.12140e-1	1	air
3.966	VV	896.20135	1.00000	896.20135	?	
5.429		-	-	-	1	Freon-113
5.676		-	-	-	1	11-DCE
6.602		-	-	-	1	t-DCE
8.099		-	-	-	1	c-DCE
8.323		-	-	-	1	CHCl3
8.894		-	-	-	1	TCA
9.276		-	-	-	1	CCl4
10.594	VV X+	4.25254e4	2.30199e-5	9.78930e-1	1	TCE
13.898	VBAS+	2.32941e5	2.32598e-5	5.41815	1	PCE
16.479	VV X	576.86530	1.00000	576.86530	?	
16.487	VV X	557.90125	1.00000	557.90125	?	
Totals :				2038.17712		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		3.44152e7	10.31014	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
 Warning : Calibrated compound(s) not found
 Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0005.D Sample Name: MHL 3
 Instrument 2 7/19/98 10:51:47 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.24.96 DEPTH 135

Injection Date : 7/18/98 9:32:16 PM Seq. Line : 5
 Sample Name : MHL 3 Vial : 5
 Acq. Operator : SLB Inj : 1
 Inj Volume : Manually
 Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
 Method : C:\HPCHEM\2\METHODS\STANFID.M
 Last changed : 6/17/98 2:41:40 PM by TRJ
 standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
 Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
 Multiplier : 1.0000
 Dilution : 1.0000
 Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
 Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
---------------	------	---------------	----------	-------------------	-----	------

RetTime	Type	Area	Amt/Area	Amount	Grp	Name
[min]		counts*s		ppm (mg/l)		
3.983	BB S	3.46199e4	2.05198e-5	7.10391e-1	1	air
5.069	BV T	1.05781e4	2.37733e-8	2.51478e-4	1	Freon-11
5.338	VV T	5.49596e4	1.00926e-7	5.54684e-3	1	Freon-113
5.722	PV T	1799.39502	7.86274e-7	1.41482e-3	1	11-DCE
6.310	PB T	1.65987e4	1.00000	1.65987e4	?	
6.634		-	-	-	1	t-DCE
8.131		-	-	-	1	c-DCE
8.350		-	-	-	1	CHCl3
8.922	PP	5730.57764	7.26537e-8	4.16348e-4	1	TCA
9.301		-	-	-	1	CCl4
10.619	PB +	4.13744e6	1.94259e-7	8.03735e-1	1	TCE
13.523	PP	5006.96436	1.00000	5006.96436	?	
13.739	VV	9415.08789	1.00000	9415.08789	?	
13.867	VV f	4.45586e6	1.00000	4.45586e6	?	
13.980	VB +	3.19472e7	4.77960e-8	1.52695	1	PCE
15.526	BB	3.98026e4	1.00000	3.98026e4	?	
16.360	BB	3088.61011	1.00000	3088.61011	?	
Totals :				4.52977e6		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime	Type	Area	Amt/Area	Amount	Grp	Name
[min]		counts*s		ppm (mg/l)		
3.927	VV	660.49866	1.00000	660.49866	?	
3.957	VV	425.09927	6.15522e-4	2.61658e-1	1	air
3.967	VV	488.00314	1.00000	488.00314	?	
3.989	VV	343.84808	1.00000	343.84808	?	
4.155	VV S	4.46724e4	1.00000	4.46724e4	?	
5.429		-	-	-	1	Freon-113
5.676		-	-	-	1	11-DCE
6.602		-	-	-	1	t-DCE
8.099		-	-	-	1	c-DCE
8.323		-	-	-	1	CHCl3
8.894		-	-	-	1	TCA
9.276		-	-	-	1	CCl4
10.594	VV X+	3.51418e4	2.31977e-5	8.15208e-1	1	TCE
13.897	VBAS+	2.37904e5	2.32558e-5	5.53266	1	PCE
16.481	VV X	1122.70105	1.00000	1122.70105	?	
Totals :				4.72941e4		

Group summary :

Group	Use	Area	Amount	Group Name
ID		counts*s	ppm (mg/l)	
1		3.64658e7	9.65823	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0006.D Sample Name: MHL 3

Instrument 2 7/19/98 10:51:51 AM SLB

SAMPLE DATE: 07-10-98 TIME 00:00 WT. 24.19 DEPTH 136

```
=====
Injection Date   : 7/18/98 10:00:56 PM          Seq. Line :    6
Sample Name      : MHL 3                        Vial       :    6
Acq. Operator    : SLB                          Inj        :    1
                                           Inj Volume : Manually

Sequence File    : C:\HPCHEM\2\SEQUENCE\071898.S
Method           : C:\HPCHEM\2\METHODS\STANFID.M
Last changed     : 6/17/98 2:41:40 PM by TRJ
standard gc run  - FID/ECD
=====
```

External Standard Report

```
=====
Sorted By       : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier      : 1.0000
Dilution        : 1.0000
Uncalibrated peaks RF : 1.00000
=====
```

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.983	VB S	4.02963e4	2.05198e-5	8.26870e-1	1	air
4.587	PV	2209.12451	1.00000	2209.12451	?	
4.896	VV	6855.77686	1.00000	6855.77686	?	
5.068	VV	1.63443e4	2.37733e-8	3.88559e-4	1	Freon-11
5.339	VP	5.84171e4	1.00926e-7	5.89579e-3	1	Freon-113
5.706		-	-	-	1	11-DCE
6.308	VB	1.91153e4	1.00000	1.91153e4	?	
6.635		-	-	-	1	t-DCE
8.132		-	-	-	1	c-DCE
8.351		-	-	-	1	CHCl3
8.921	BP	3692.21558	7.26537e-8	2.68253e-4	1	TCA
9.302		-	-	-	1	CCl4
10.620	PB +	2.38456e6	1.87153e-7	4.46279e-1	1	TCE
13.523	PP	2870.44727	1.00000	2870.44727	?	
13.739	VV	4322.45117	1.00000	4322.45117	?	
13.877	VV f	6.60578e6	1.00000	6.60578e6	?	
13.962	VB +	2.49465e7	4.82664e-8	1.20408	1	PCE
15.525	BB	1.84146e4	1.00000	1.84146e4	?	
Totals :				6.65957e6		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.957	BV	1680.91260	5.94915e-4	1.00000	1	air
5.430		-	-	-	1	Freon-113
5.678		-	-	-	1	11-DCE
6.603		-	-	-	1	t-DCE
8.101		-	-	-	1	c-DCE

8.325	-	-	-	1	CHCl3		
8.896	-	-	-	1	TCA		
9.278	-	-	-	1	CCl4		
10.597	VV	+	1.86424e4	2.35663e-5	4.39331e-1	1	TCE
13.899	PV	+	1.27023e5	2.34190e-5	2.97476	1	PCE
16.488	PB		649.89301	1.00000	649.89301	?	
Totals :					654.30710		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		2.75972e7	6.89787	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0007.D Sample Name: MHL 3
Instrument 2 7/19/98 10:51:55 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:24.47 DEPTH: 13
7

Injection Date : 7/18/98 10:29:35 PM Seq. Line : 7
Sample Name : MHL 3 Vial : 7
Acq. Operator : SLB Inj : 1
Inj Volume : Manually

Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000
Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.981	BB S	3.48357e4	2.05198e-5	7.14819e-1	1	air
5.068	BV	1.21444e4	2.37733e-8	2.88714e-4	1	Freon-11
5.335	VP	5.54054e4	1.00926e-7	5.59183e-3	1	Freon-113
5.732	VV	4683.04297	7.86274e-7	3.68215e-3	1	11-DCE
6.309	VB	1.43735e4	1.00000	1.43735e4	?	

6.635	-	-	-	1	t-DCE
8.132	-	-	-	1	c-DCE
8.351	-	-	-	1	CHCl3
8.922 BP	3459.05273	7.26537e-8	2.51313e-4	1	TCA
9.302	-	-	-	1	CCl4
10.620 PB +	2.55857e6	1.88803e-7	4.83067e-1	1	TCE
13.523 PP	3131.62939	1.00000	3131.62939	?	
13.738 VV	5149.76123	1.00000	5149.76123	?	
13.877 VV f	6.49529e6	1.00000	6.49529e6	?	
13.962 VB +	2.48651e7	4.82734e-8	1.20032	1	PCE
15.526 BB	2.14837e4	1.00000	2.14837e4	?	
Totals :			6.53943e6		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.957	BV	2321.85474	4.30690e-4	1.00000	1	air
5.430		-	-	-	1	Freon-113
5.677		-	-	-	1	11-DCE
6.603		-	-	-	1	t-DCE
8.101		-	-	-	1	c-DCE
8.325		-	-	-	1	CHCl3
8.896		-	-	-	1	TCA
9.278		-	-	-	1	CCl4
10.596	VV +	2.01770e4	2.37942e-5	4.80097e-1	1	TCE
13.898	VV +	1.24368e5	2.34265e-5	2.91351	1	PCE
Totals :				4.39361		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		2.76811e7	6.80163	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0008.D Sample Name: O PPB H2O
Instrument 2 7/19/98 10:51:58 AM SLB

SAMPLE DATE:07-18-98 TIME 00:00 WT.:00.00 DEPTH: 0
0.0

Injection Date	: 7/18/98 10:58:16 PM	Seq. Line	: 8
Sample Name	: O PPB H2O	Vial	: 8
Acq. Operator	: SLB	Inj	: 1
		Inj Volume	: Manually
Sequence File	: C:\HPCHEM\2\SEQUENCE\071898.S		
Method	: C:\HPCHEM\2\METHODS\STANFID.M		

Last changed : 6/17/98 2:41:40 PM by TRJ
 standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
 Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
 Multiplier : 1.0000
 Dilution : 1.0000
 Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
 Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.981	VB S	3.30673e4	2.05198e-5	6.78534e-1	1	air
5.069		-	-	-	1	Freon-11
5.335	BP	6.07784e4	1.00926e-7	6.13411e-3	1	Freon-113
5.708		-	-	-	1	11-DCE
5.943	VV	5566.01123	1.00000	5566.01123		?
6.309	VB	7359.63281	1.00000	7359.63281		?
6.637		-	-	-	1	t-DCE
8.134		-	-	-	1	c-DCE
8.353		-	-	-	1	CHCl3
8.922		-	-	-	1	TCA
9.305		-	-	-	1	CCl4
10.625		-	-	-	1	TCE
13.922	BB +	4985.74805	3.57331e-8	1.78156e-4	1	PCE
Totals :				1.29263e4		

Signal 2: FID1 A,
 Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.954	VV	1579.47339	6.15522e-4	9.72201e-1	1	air
5.431		-	-	-	1	Freon-113
5.679		-	-	-	1	11-DCE
6.605		-	-	-	1	t-DCE
8.103		-	-	-	1	c-DCE
8.327		-	-	-	1	CHCl3
8.898		-	-	-	1	TCA
9.280		-	-	-	1	CCl4
10.602		-	-	-	1	TCE
13.904		-	-	-	1	PCE
Totals :				9.72201e-1		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		1.00411e5	1.65705	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)

Warning : Time reference compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0009.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:02 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.24.64 DEPTH:139.
5

Injection Date : 7/18/98 11:26:53 PM Seq. Line : 9
Sample Name : MHL 3 Vial : 9
Acq. Operator : SLB Inj : 1
Inj Volume : Manually
Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000
Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.980	VB S	4.68163e4	2.05198e-5	9.60658e-1	1	air
4.278	BV T	375.40503	1.00000	375.40503	?	
4.428	VV T	2591.48535	1.00000	2591.48535	?	
4.654	VV T	2994.11914	1.00000	2994.11914	?	
4.740	VV T	3601.24341	1.00000	3601.24341	?	
5.068	VV T	5.34434e4	2.37733e-8	1.27053e-3	1	Freon-11
5.326	VV T	6.14909e4	1.00000	6.14909e4	?	
5.463		-	-	-	1	Freon-113
5.707		-	-	-	1	11-DCE
6.307	VB	1.97284e4	1.00000	1.97284e4	?	
6.636		-	-	-	1	t-DCE
8.134		-	-	-	1	c-DCE
8.352		-	-	-	1	CHCl3
8.920	BP	2820.05078	7.26537e-8	2.04887e-4	1	TCA
9.304		-	-	-	1	CCl4
10.621	PB +	1.49686e6	1.72765e-7	2.58605e-1	1	TCE
13.524	PP	1606.82581	1.00000	1606.82581	?	
13.739	VP	2255.67627	1.00000	2255.67627	?	
13.887	VV f	3.81973e6	1.00000	3.81973e6	?	
13.952	VB +	2.26921e7	4.84796e-8	1.10011	1	PCE
15.526	BB	1.25054e4	1.00000	1.25054e4	?	
Totals :				3.92688e6		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area ppm (mg/l)	Amount ppm (mg/l)	Grp	Name
3.957	VB S	5442.38818	1.83743e-4	1.00000	1	air
5.430		-	-	-	1	Freon-113
5.678		-	-	-	1	11-DCE
6.604		-	-	-	1	t-DCE
8.102		-	-	-	1	c-DCE
8.326		-	-	-	1	CHCl3
8.897		-	-	-	1	TCA
9.279		-	-	-	1	CCl4
10.598	PV +	1.06847e4	2.17607e-5	2.32507e-1	1	TCE
13.899	VV +	7.36148e4	2.36730e-5	1.74269	1	PCE
16.487	VV	876.38629	1.00000	876.38629	?	
Totals :				879.36148		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		2.43818e7	5.29604	HVOCs

2 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0010.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:06 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:25.42 DEPTH:13
9.5'

```

=====
Injection Date   : 7/18/98 11:55:26 PM          Seq. Line : 10
Sample Name     : MHL 3                        Vial       : 10
Acq. Operator   : SLB                          Inj        : 1
                                           Inj Volume : Manually

Sequence File    : C:\HPCHEM\2\SEQUENCE\071898.S
Method          : C:\HPCHEM\2\METHODS\STANFID.M
Last changed    : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD
=====

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External Standard Report

```

=====
Sorted By      : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier     : 1.0000
Dilution       : 1.0000
Uncalibrated peaks RF : 1.00000
=====

```

Signal 1: ECD2 B,

Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.981	BB S	4.33976e4	2.05198e-5	8.90509e-1	1	air
4.428	BV T	690.75189	1.00000	690.75189	?	
4.682	VV T	6266.42578	1.00000	6266.42578	?	
4.825	VV T	2627.00537	1.00000	2627.00537	?	
5.069	VV T	5.14011e4	2.37733e-8	1.22198e-3	1	Freon-11
5.324	VV T	6.05736e4	1.00000	6.05736e4	?	
5.463	-	-	-	-	1	Freon-113
5.707	-	-	-	-	1	11-DCE
6.307	BB	1.83186e4	1.00000	1.83186e4	?	
6.636	-	-	-	-	1	t-DCE
8.134	-	-	-	-	1	c-DCE
8.353	-	-	-	-	1	CHCl3
8.923	BB	7064.00830	7.26537e-8	5.13226e-4	1	TCA
9.304	-	-	-	-	1	CCl4
10.621	PB +	3.09757e6	1.91440e-7	5.92999e-1	1	TCE
13.525	PP	3587.13477	1.00000	3587.13477	?	
13.741	VV	5977.49951	1.00000	5977.49951	?	
13.873	VV f	8.79077e6	1.00000	8.79077e6	?	
13.978	VB +	2.52122e7	4.82438e-8	1.21633	1	PCE
15.528	BB	2.93884e4	1.00000	2.93884e4	?	
Totals :				8.91820e6		

Signal 2: FID1 A.

Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.960	VV	3639.47241	2.74765e-4	1.00000	1	air
5.431	-	-	-	-	1	Freon-113
5.678	-	-	-	-	1	11-DCE
6.604	-	-	-	-	1	t-DCE
8.102	-	-	-	-	1	c-DCE
8.326	-	-	-	-	1	CHCl3
8.897	-	-	-	-	1	TCA
9.279	-	-	-	-	1	CCl4
10.598	VV +	2.52520e4	2.35988e-5	5.95916e-1	1	TCE
13.901	BB +	1.68981e5	2.33321e-5	3.94268	1	PCE
16.488	BB	403.27487	1.00000	403.27487	?	
Totals :				408.81347		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		2.86095e7	8.24017	HVOCs

2 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)

Warning : Calibrated compound(s) not found

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0011.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:09 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:24.95 DEPTH 140.
9

```
=====
Injection Date   : 7/19/98 12:23:55 AM      Seq. Line : 11
Sample Name      : MHL 3                    Vial       : 11
Acq. Operator    : SLB                      Inj        : 1
                                           Inj Volume : Manually
```

```
Sequence File    : C:\HPCHEM\2\SEQUENCE\071898.S
Method           : C:\HPCHEM\2\METHODS\STANFID.M
Last changed     : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD
```

External Standard Report

```
=====
Sorted By       : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier      : 1.0000
Dilution        : 1.0000
Uncalibrated peaks RF : 1.00000
```

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.978	VB S	3.31917e4	2.05198e-5	6.81086e-1	1	air
4.134	BB X	3501.00415	1.00000	3501.00415	?	
4.374	BV X	2607.51660	1.00000	2607.51660	?	
5.067	BV	9.53432e4	2.37733e-8	2.26663e-3	1	Freon-11
5.327	VV	5.50307e4	1.00000	5.50307e4	?	
5.458	VP	4.13932e4	1.00926e-7	4.17764e-3	1	Freon-113
5.704	VP	817.59174	7.86274e-7	6.42851e-4	1	11-DCE
6.086	VV	1052.35474	1.00000	1052.35474	?	
6.304	VB	3.28151e4	1.00000	3.28151e4	?	
6.639		-	-	-	1	t-DCE
8.137		-	-	-	1	c-DCE
8.355	BB	4.57331e4	1.76127e-7	8.05482e-3	1	CHCl3
8.924	BB	5.01084e4	7.46692e-8	3.74156e-3	1	TCA
9.307	BB	4.08258e5	2.20394e-8	8.99775e-3	1	CCl4
10.543	VV f	9.19332e6	1.00000	9.19332e6	?	
10.718	PV +	4.79959e7	2.01931e-7	9.69188	1	TCE
12.759	VB	7.76928e4	1.00000	7.76928e4	?	
13.533	BV	1.06242e5	1.00000	1.06242e5	?	
13.680	VV f	2.02944e4	1.00000	2.02944e4	?	
13.751	VV +	2.92745e5	3.63209e-8	1.06328e-2	1	PCE
14.218	VV	1.18084e8	1.00000	1.18084e8	?	
15.213	VV b	3467.68213	1.00000	3467.68213	?	
15.528	VV	3.11975e6	1.00000	3.11975e6	?	
15.989	VV	1.42400e6	1.00000	1.42400e6	?	
16.359	VV	1.62038e6	1.00000	1.62038e6	?	
16.858	VBA	9.20759e5	1.00000	9.20759e5	?	
Totals :				1.34665e8		

Signal 2: FID1 A.

Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.954	VV	2766.38257	3.61483e-4	1.00000	1	air
4.084	VB S	5813.27832	1.00000	5813.27832	?	
4.341	BV T	2106.14600	1.00000	2106.14600	?	
5.433		-	-	-	1	Freon-113
5.681		-	-	-	1	11-DCE
6.607		-	-	-	1	t-DCE
7.142	VV	681.08881	1.00000	681.08881	?	
8.105		-	-	-	1	c-DCE
8.329		-	-	-	1	CHCl3
8.901		-	-	-	1	TCA
9.273	VV	423.92853	5.81120e-5	2.46353e-2	1	CCl4
9.822	VV	4.29143e5	1.00000	4.29143e5	?	
10.370	VV	9.61762e4	1.00000	9.61762e4	?	
10.602	VV +	4.30801e6	2.21819e-5	95.55974	1	TCE
10.892	VV	1.45437e4	1.00000	1.45437e4	?	
11.431	VB	2023.60278	1.00000	2023.60278	?	
12.819	BV	1429.74426	1.00000	1429.74426	?	
13.052	VB	1051.04102	1.00000	1051.04102	?	
13.734	VV	504.73868	1.00000	504.73868	?	
13.974	VV +	1.54780e7	2.30717e-5	357.10333	1	PCE
15.018	VV	1676.93298	1.00000	1676.93298	?	
15.132	VV	2029.84692	1.00000	2029.84692	?	
15.262	VV	2327.68945	1.00000	2327.68945	?	
15.420	VV	3240.46680	1.00000	3240.46680	?	
15.506	VV	2115.30786	1.00000	2115.30786	?	
15.615	VV	1209.57800	1.00000	1209.57800	?	
15.809	VV	1105.34912	1.00000	1105.34912	?	
15.912	VV	1692.50684	1.00000	1692.50684	?	
16.070	VV	1246.12366	1.00000	1246.12366	?	
16.184	VV	1556.00110	1.00000	1556.00110	?	
16.416	VV	1946.32935	1.00000	1946.32935	?	
16.493	VV	1998.53430	1.00000	1998.53430	?	
16.723	VV	1679.01294	1.00000	1679.01294	?	
16.836	VV	1054.07324	1.00000	1054.07324	?	
Totals :				5.78804e5		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		6.87527e7	464.09919	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0012.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:13 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:25.59 DEPTH 142
.5

```
=====
Injection Date   : 7/19/98 12:52:25 AM      Seq. Line : 12
Sample Name      : MHL 3                    Vial      : 12
Acq. Operator    : SLB                      Inj       : 1
                                           Inj Volume : Manually

Sequence File    : C:\HPCHEM\2\SEQUENCE\071898.S
Method           : C:\HPCHEM\2\METHODS\STANFID.M
Last changed     : 6/17/98 2:41:40 PM by TRJ
standard gc run  - FID/ECD
=====
```

External Standard Report

```
=====
Sorted By       : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier      : 1.0000
Dilution        : 1.0000
Uncalibrated peaks RF : 1.00000
=====
```

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.979	VB S	3.76307e4	2.05198e-5	7.72172e-1	1	air
4.632	BV	3258.12549	1.00000	3258.12549	?	
4.751	VV	1683.54736	1.00000	1683.54736	?	
4.814	VB	4128.51855	1.00000	4128.51855	?	
5.068	BV	3.15873e4	2.37733e-8	7.50935e-4	1	Freon-11
5.324	VP	6.95106e4	1.00000	6.95106e4	?	
5.463		-	-	-	1	Freon-113
5.707		-	-	-	1	11-DCE
5.973	VV	3803.67407	1.00000	3803.67407	?	
6.307	VB	1.37636e4	1.00000	1.37636e4	?	
6.636		-	-	-	1	t-DCE
8.134		-	-	-	1	c-DCE
8.353		-	-	-	1	CHCl3
8.922		-	-	-	1	TCA
9.307	BB	3.67459e4	2.40856e-8	8.85049e-4	1	CCl4
10.553	VV f	1.30323e7	1.00000	1.30323e7	?	
10.695	PB +	3.35401e7	2.01619e-7	6.76233	1	TCE
13.528	BP	1.02317e4	1.00000	1.02317e4	?	
13.744	VV	1.29924e4	1.00000	1.29924e4	?	
13.870	VV f	9.13928e6	1.00000	9.13928e6	?	
13.978	VB +	2.72910e7	4.80820e-8	1.31220	1	PCE
15.529	BB	2.84438e4	1.00000	2.84438e4	?	
16.364	PP	3921.88770	1.00000	3921.88770	?	
Totals :				2.23233e7		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.953	VV	1725.64282	5.79494e-4	1.00000	1	air
5.431		-	-	-	1	Freon-113

5.679	-	-	-	1 11-DCE
6.605	-	-	-	1 t-DCE
8.103	-	-	-	1 c-DCE
8.327	-	-	-	1 CHCl3
8.898	-	-	-	1 TCA
9.280	-	-	-	1 CC14
10.599 VV	+	1.88319e6	2.21927e-5	41.79295 1 TCE}
13.902 PB	+	2.23849e5	2.32675e-5	5.20841 1 PCE}
16.484 BB		2472.38525	1.00000	2472.38525 ?
Totals :				2520.38661

magnitude of concentrations are reversed from usual.
Is it misreading/assigning the peak(s)?
Assignments appear correct based on the Retention Time statistics presented on the first page of this data set.

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		6.30458e7	56.84971	HVOCs

2 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0013.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:17 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:25.58 DEPTH 14
3.5.

Injection Date : 7/19/98 1:20:54 AM Seq. Line : 13
Sample Name : MHL 3 Vial : 13
Acq. Operator : SLB Inj : 1
Inj Volume : Manually
Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000
Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.728	BV	1264.17700	1.00000	1264.17700	?	
3.980	VB S	2.74231e4	2.05198e-5	5.62715e-1	1	air
4.132	BB X	703.57886	1.00000	703.57886	?	

4.378	BV	T	2261.99072	1.00000	2261.99072	?
4.599	VV	T	4147.91455	1.00000	4147.91455	?
4.902	VV	T	8614.14746	1.00000	8614.14746	?
5.068	VV	T	3.81265e4	2.37733e-8	9.06394e-4	1 Freon-11
5.320	VV	T	6.92188e4	1.00000	6.92188e4	?
5.464			-	-	-	1 Freon-113
5.708			-	-	-	1 11-DCE
6.307	PB	T	1.96425e4	1.00000	1.96425e4	?
6.637			-	-	-	1 t-DCE
8.135			-	-	-	1 c-DCE
8.354			-	-	-	1 CHCl3
8.923			-	-	-	1 TCA
9.308	BB		3.81747e4	2.40856e-8	9.19461e-4	1 CCl4
10.550	VV	f	6.81387e6	1.00000	6.81387e6	?
10.708	PB	+	4.16670e7	2.01821e-7	8.40929	1 TCE
13.528	PV		1.07644e4	1.00000	1.07644e4	?
13.744	VV		1.51359e4	1.00000	1.51359e4	?
13.873	VV	f	8.69557e6	1.00000	8.69557e6	?
13.978	VB	+	2.51577e7	4.82483e-8	1.21382	1 PCE
15.529	BB		3.15951e4	1.00000	3.15951e4	?
16.365	BB		6562.46338	1.00000	6562.46338	?
Totals :					1.56794e7	

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.951	VV	1611.56519	6.15522e-4	9.91954e-1	1	air
5.432		-	-	-	1	Freon-113
5.680		-	-	-	1	11-DCE
6.606		-	-	-	1	t-DCE
8.098	VV	354.98050	2.37578e-5	8.43357e-3	1	c-DCE
8.328		-	-	-	1	CHCl3
8.899		-	-	-	1	TCA
9.281		-	-	-	1	CCl4
10.600	VV	2.21027e6	2.21898e-5	49.04542	1	TCE
10.954	VV	1959.31494	1.00000	1959.31494	?	
12.481	BB	415.02496	1.00000	415.02496	?	
13.902	BV	1.68624e5	2.33326e-5	3.93444	1	PCE
15.425	BV	346.97913	1.00000	346.97913	?	
16.483	VV	1737.61914	1.00000	1737.61914	?	
Totals :				4512.91842		

magnitudes of these
concentrations are reversed
from usual.

Is it misreading/assigning
the peak(s)?

Assignments appear correct
based on the Retention Time
statistics presented in the
first page of this data set

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		6.93093e7	64.16789	HVOCs

2 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0014.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:21 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:25.55 DEPTH 144.

7

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=====
Injection Date   : 7/19/98 1:49:15 AM           Seq. Line :   14
Sample Name      : MHL 3                       Vial       :   14
Acq. Operator    : SLB                         Inj        :    1
                                           Inj Volume : Manually

Sequence File    : C:\HPCHEM\2\SEQUENCE\071898.S
Method           : C:\HPCHEM\2\METHODS\STANFID.M
Last changed     : 6/17/98 2:41:40 PM by TRJ
standard gc run  - FID/ECD
=====
```

External Standard Report

```
=====
Sorted By       : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier      : 1.0000
Dilution        : 1.0000
Uncalibrated peaks RF : 1.00000
=====
```

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.633	BB	1658.37891	1.00000	1658.37891	?	
3.979	BB S	5.39856e4	1.85235e-5	1.00000	1	air
4.579	BV T	862.16492	1.00000	862.16492	?	
4.653	VV T	1441.81641	1.00000	1441.81641	?	
4.847	VV T	5913.06396	1.00000	5913.06396	?	
5.068	VV T	2.66348e4	2.37733e-8	6.33199e-4	1	Freon-11
5.321	VV T	6.84420e4	1.00000	6.84420e4	?	
5.463		-	-	-	1	Freon-113
5.707		-	-	-	1	11-DCE
6.308	VB	1.17360e4	1.00000	1.17360e4	?	
6.636		-	-	-	1	t-DCE
8.133		-	-	-	1	c-DCE
8.352		-	-	-	1	CHCl3
8.921		-	-	-	1	TCA
9.305	BB	1.52897e4	2.40856e-8	3.68263e-4	1	CCl4
10.560	VV f	1.11125e7	1.00000	1.11125e7	?	
10.688	PB +	2.87922e7	2.01448e-7	5.80015	1	TCE
13.528	PP	5607.65479	1.00000	5607.65479	?	
13.743	VV	6574.91113	1.00000	6574.91113	?	
13.870	VV f	9.32572e6	1.00000	9.32572e6	?	
13.985	VB +	2.65565e7	4.81363e-8	1.27833	1	PCE
15.529	BB	1.97299e4	1.00000	1.97299e4	?	
16.364	BB	3854.17554	1.00000	3854.17554	?	
Totals :				2.05641e7		

Signal 2: FID1 A,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
------------------	------	------------------	----------	----------------------	-----	------

Time (min)	Use	Area (counts*s)	Amount (ppm)	Group Name
3.959	VV	2159.11108	4.63154e-4	1 air
5.430		-	-	1 Freon-113
5.678		-	-	1 11-DCE
6.604		-	-	1 t-DCE
8.102		-	-	1 c-DCE
8.326		-	-	1 CHCl3
8.897		-	-	1 TCA
9.279		-	-	1 CC14
10.598	VV +	1.00734e6	2.22093e-5	22.37218 1 TCE
13.903	PB +	2.10745e5	2.32799e-5	4.90612 1 PCE
16.490	BB	554.06555	1.00000	554.06555 ?
Totals :				582.34384

*- Is it misassigning peak(s)
Retention time assignments appear correct based on the Retention Time statistics on the front page of these this data set.*

Group summary :

Group ID	Use	Area (counts*s)	Amount (ppm)	Group Name
1		5.66649e7	36.35777	HVOCs

2 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0015.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:24 AM SLB

SAMPLE DATE: 07-10-98 TIME 00:00 WT. 25.69 DEPTH 14
5.0

Injection Date : 7/19/98 2:17:40 AM Seq. Line : 15
Sample Name : MHL 3 Vial : 15
Acq. Operator : SLB Inj : 1
Inj Volume : Manually

Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000
Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area (counts*s)	Amt/Area	Amount (ppm)	Grp	Name
---------------	------	-----------------	----------	--------------	-----	------

3.979	VB S	4.86473e4	2.05198e-5	9.98231e-1	1	air
4.628	BV	2066.77246	1.00000	2066.77246	?	
4.696	VV	1498.53967	1.00000	1498.53967	?	
5.068	VV	3.05697e4	2.37733e-8	7.26745e-4	1	Freon-11
5.319	VV	6.42888e4	1.00000	6.42888e4	?	
5.461	VP	3.93750e4	1.00926e-7	3.97396e-3	1	Freon-113
5.710	VP	1311.01318	7.86274e-7	1.03082e-3	1	11-DCE
6.307	VP	1.30862e4	1.00000	1.30862e4	?	
6.637		-	-	-	1	t-DCE
8.135		-	-	-	1	c-DCE
8.359	PB	1.06367e4	1.58157e-7	1.68227e-3	1	CHCl3
8.926	BB	1.73313e4	7.26537e-8	1.25918e-3	1	TCA
9.310	BB	8.13112e4	2.40856e-8	1.95843e-3	1	CCl4
10.557	VV f	1.19587e7	1.00000	1.19587e7	?	
10.692	PB +	3.20992e7	2.01573e-7	6.47032	1	TCE
12.766	PP	4236.33594	1.00000	4236.33594	?	
13.534	BV	1.03635e5	1.00000	1.03635e5	?	
13.683	VV f	1.75835e4	1.00000	1.75835e4	?	
13.752	VV	2.84595e5	1.00000	2.84595e5	?	
13.847	VV f+	7.97703e6	5.12676e-8	4.08964e-1	1	PCE
14.169	VV	9.61314e7	1.00000	9.61314e7	?	
15.530	VV	3.76866e6	1.00000	3.76866e6	?	
16.360	VV	1.35379e6	1.00000	1.35379e6	?	
16.860	VBA	6.29273e5	1.00000	6.29273e5	?	
Totals :					1.14333e8	

Signal 2: FID1 A,

Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.961	BB S	3853.05591	2.59534e-4	1.00000	1	air
5.432		-	-	-	1	Freon-113
5.679		-	-	-	1	11-DCE
6.606		-	-	-	1	t-DCE
8.104		-	-	-	1	c-DCE
8.328		-	-	-	1	CHCl3
8.899		-	-	-	1	TCA
9.281		-	-	-	1	CCl4
9.830	VP	1.32182e4	1.00000	1.32182e4	?	
10.375	VV	3874.26904	1.00000	3874.26904	?	
10.600	VV +	1.49052e6	2.21977e-5	33.08605	1	TCE
12.821	BB	358.75122	1.00000	358.75122	?	
13.731	VV	349.60934	1.00000	349.60934	?	
13.957	VB +	1.02259e7	2.30732e-5	235.94397	1	PCE
15.424	PV	752.37054	1.00000	752.37054	?	
15.509	VB	749.08508	1.00000	749.08508	?	
16.493	BB	515.75568	1.00000	515.75568	?	
Totals :					2.00880e4	

*Is it misidentifying peak(s)?
Not likely given the retention time
analysis statistics reported on
the front page of this set of data.*

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		5.20257e7	277.91816	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)

Warning : Calibrated compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0016.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:28 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.:25.04 DEPTH: 1
46.0

Injection Date : 7/19/98 2:46:01 AM Seq. Line : 16
Sample Name : MHL 3 Vial : 16
Acq. Operator : SLB Inj : 1
Inj Volume : Manually
Sequence File : C:\HPCHEM\2\SEQUENCE\071898.S
Method : C:\HPCHEM\2\METHODS\STANFID.M
Last changed : 6/17/98 2:41:40 PM by TRJ
standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
Multiplier : 1.0000
Dilution : 1.0000
Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.702	BV	2443.91333	1.00000	2443.91333	?	
3.979	VB S	8.72754e4	1.14580e-5	1.00000	1	air
4.452	VV X	742.66754	1.00000	742.66754	?	
4.830	BV T	426.14923	1.00000	426.14923	?	
4.924	VV T	982.15936	1.00000	982.15936	?	
5.069	VV T	4.00978e4	2.37733e-8	9.53258e-4	1	Freon-11
5.317	VV T	5.74461e4	1.00000	5.74461e4	?	
5.463	VV T	1.26494e5	1.04400e-7	1.32060e-2	1	Freon-113
5.708	PB T	2321.92041	7.86274e-7	1.82567e-3	1	11-DCE
6.306	VB	1.60698e4	1.00000	1.60698e4	?	
6.639		-	-	-	1	t-DCE
8.137		-	-	-	1	c-DCE
8.360	PB	1.69659e4	1.58157e-7	2.68328e-3	1	CHCl3
8.928	BB	6.69849e4	7.67889e-8	5.14370e-3	1	TCA
9.312	BB	2.62101e5	2.29562e-8	6.01683e-3	1	CCl4
10.553	VV f	1.26714e7	1.00000	1.26714e7	?	
10.707	PB +	3.74660e7	2.01728e-7	7.55792	1	TCE
12.771	BB	5.04860e4	1.00000	5.04860e4	?	
13.539	BV	2.94731e5	1.00000	2.94731e5	?	
13.687	VV f	6.22148e4	1.00000	6.22148e4	?	
13.756	VV +	8.31117e5	4.17678e-8	3.47139e-2	1	PCE
14.275	VV	1.32569e8	1.00000	1.32569e8	?	
15.532	VV	6.69300e6	1.00000	6.69300e6	?	

16.364	VV	2.26052e6	1.00000	2.26052e6	?
16.862	VBA	1.06615e6	1.00000	1.06615e6	?
Totals :				1.55746e8	

Signal 2: FID1 A,

Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.960	VV	2825.85547	3.53875e-4	1.00000	1	air
5.432	VP	427.18555	5.83909e-6	2.49437e-3	1	Freon-113
5.681		-	-	-	1	11-DCE
6.607		-	-	-	1	t-DCE
8.106		-	-	-	1	c-DCE
8.330		-	-	-	1	CHCl3
8.901		-	-	-	1	TCA
9.283		-	-	-	1	CCl4
9.830	VV	3.71346e4	1.00000	3.71346e4	?	
10.376	VV	1.04586e4	1.00000	1.04586e4	?	
10.603	VB +	2.51345e6	2.21879e-5	55.76807	1	TCE
11.427	BB	1539.60132	1.00000	1539.60132	?	
12.825	PB	930.58136	1.00000	930.58136	?	
13.513	PP	672.63269	1.00000	672.63269	?	
13.738	VV	1115.87463	1.00000	1115.87463	?	
14.003	VB +	2.29729e7	2.30708e-5	530.00296	1	PCE
15.425	BV	1870.35925	1.00000	1870.35925	?	
15.508	VV	2330.48804	1.00000	2330.48804	?	
16.495	VB	339.55569	1.00000	339.55569	?	
Totals :				5.69791e4		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
1		6.43889e7	595.39599	HVOCs

3 Warnings or Errors :

Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found
Warning : Elution order of calibrated compounds may have changed

*** End of Report ***

Data File C:\HPCHEM\2\DATA\071898\VIAL0017.D Sample Name: MHL 3
Instrument 2 7/19/98 10:52:32 AM SLB

SAMPLE DATE:07-10-98 TIME 00:00 WT.24.98 DEPTH: 148
.0

Injection Date	: 7/19/98 3:14:18 AM	Seq. Line	: 17
Sample Name	: MHL 3	Vial	: 17
Acq. Operator	: SLB	Inj	: 1
		Inj Volume	: Manually
Sequence File	: C:\HPCHEM\2\SEQUENCE\071898.S		
Method	: C:\HPCHEM\2\METHODS\STANFID.M		

Last changed : 6/17/98 2:41:40 PM by TRJ
 standard gc run - FID/ECD

External Standard Report

Sorted By : Signal
 Calib. Data Modified : Wednesday, July 15, 1998 11:46:10 AM
 Multiplier : 1.0000
 Dilution : 1.0000
 Uncalibrated peaks RF : 1.00000

Signal 1: ECD2 B,
 Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.758	PV	724.21057	1.00000	724.21057		?
3.988		-	-	-	1	air
4.234	BB X	4632.46240	1.00000	4632.46240		?
4.487	BV	2690.64795	1.00000	2690.64795		?
4.672	VV	1804.29248	1.00000	1804.29248		?
4.763	VV	4517.05127	1.00000	4517.05127		?
4.909	VV	8925.95508	1.00000	8925.95508		?
5.077		-	-	-	1	Freon-11
5.316	VP	7.96937e4	1.00000	7.96937e4		?
5.471		-	-	-	1	Freon-113
5.716		-	-	-	1	11-DCE
6.038	VV	4307.57617	1.00000	4307.57617		?
6.646		-	-	-	1	t-DCE
8.146		-	-	-	1	c-DCE
8.365		-	-	-	1	CHCl3
8.935		-	-	-	1	TCA
9.318		-	-	-	1	CCl4
10.638	BB +	6.11494e4	1.08022e-7	6.60551e-3	1	TCE
13.931	BB +	1.26856e6	4.30481e-8	5.46092e-2	1	PCE
Totals :				1.07296e5		

Signal 2: FID1 A,
 Results obtained with standard integrator!

RetTime [min]	Type	Area counts*s	Amt/Area	Amount ppm (mg/l)	Grp	Name
3.963		-	-	-	1	air
5.439		-	-	-	1	Freon-113
5.687		-	-	-	1	11-DCE
6.614		-	-	-	1	t-DCE
8.114		-	-	-	1	c-DCE
8.339		-	-	-	1	CHCl3
8.911		-	-	-	1	TCA
9.293		-	-	-	1	CCl4
10.602		-	-	-	1	TCE
13.909	VV +	2072.79712	2.57620e-5	5.33994e-2	1	PCE
Totals :				5.33994e-2		

Group summary :

Group ID	Use	Area counts*s	Amount ppm (mg/l)	Group Name
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APPENDIX F
DNAPL SATURATION CALCULATIONS

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Calculating DNAPL Saturation from Analytical Results

The following derivation leads to equations for calculating DNAPL saturation for a two-component DNAPL in a sediment sample from the analytical results for the components. This is applicable to the SRS M-Area DNAPL which is composed of tetrachloroethylene, PCE (~95%) and trichloroethylene, TCE (~5%). The derivation requires four assumptions: 1) that volumes of the two components (PCE and TCE, for the M-Area DNAPL) add ideally, 2) that DNAPL and water are the only two fluids that can be present in the pore space, 3) that DNAPL and water are completely immiscible, and 4) that both fluids are incompressible. PCE and TCE will be assumed to be the two components with respect to choice of symbols in the following derivation. These assumptions can be expressed mathematically as follows.

Assumptions

assumption 1

$$V_{P+T} = V_P + V_T$$

assumptions 1, 2, 3, & 4

$$\phi V_b = V_w + V_P + V_T$$

where

V_{P+T} is the total volume of DNAPL comprised of a mixture of PCE and TCE,
 V_P and V_T are the volumes of PCE and TCE in the DNAPL mixture, respectively,
 V_w is the volume of water in the sediment sample pore space,
 ϕ is the porosity of the sediment sample, and
 V_b is the bulk volume of the sediment sample.

In addition to the symbols above, the following symbols are also used.

M_P is the total mass of PCE contained in the sediment sample,
 M_T is the total mass of TCE contained in the sediment sample,
 $C_{P/w}$ is the dissolved concentration of PCE in the sediment pore water,
 $C_{T/w}$ is the dissolved concentration of TCE in the sediment pore water,
 ρ_P is the density of PCE,
 ρ_T is the density of TCE,

Several of the quantities above are either known (V_b , ρ_P , and ρ_T), can be calculated from the analytical results (M_P and M_T), or reasonable assumptions can be made for them (ϕ , $C_{P/w}$, and $C_{T/w}$). The following equations are true by definition or the assumptions.

$$M_P = C_{P/w} V_w + V_P \rho_P \quad (F.1)$$

$$M_T = C_{T/w} V_w + V_T \rho_T \quad (F.2)$$

$$\phi V_b = V_w + V_P + V_T \quad (F.3)$$

We have three equations and three unknowns (V_w , V_P , and V_T), therefore the system can be solved. We first rearrange equations (1) and (2) to obtain expressions for V_P and V_T , respectively.

$$V_P = \frac{M_P - C_{P/w} V_w}{\rho_P} \quad (F.4)$$

$$V_T = \frac{M_T - C_{T/W} V_W}{\rho_T} \quad (F.5)$$

We next substitute equations (4) and (5) into equation (3), and proceed to solve for V_W .

$$\phi V_b = V_W + \frac{M_P - C_{P/W} V_W}{\rho_P} + \frac{M_T - C_{T/W} V_W}{\rho_T} \quad (F.6)$$

$$\rho_P \rho_T \phi V_b = \rho_P \rho_T V_W + \rho_T (M_P - C_{P/W} V_W) + \rho_P (M_T - C_{T/W} V_W) \quad (F.6a)$$

$$\rho_P \rho_T \phi V_b - \rho_T M_P - \rho_P M_T = V_W (\rho_P \rho_T - \rho_T C_{P/W} - \rho_P C_{T/W}) \quad (F.6b)$$

$$V_W = \frac{\rho_P \rho_T \phi V_b - \rho_T M_P - \rho_P M_T}{\rho_P \rho_T - \rho_T C_{P/W} - \rho_P C_{T/W}} \quad (F.7)$$

Equation (7) can be solved for the volume of water in the pore space. The result can then be applied in equations (4) and (5) to obtain the volumes of free, separate phase PCE, V_P , and TCE, V_T , respectively. By assumption 1, the total DNAPL volume is then the sum of the PCE and TCE volumes, V_{P+T} . The DNAPL saturation can now be solved using the definition of a fluid's saturation.

$$S_N = \frac{V_{P+T}}{\phi V_b} \quad (F.8)$$

Analytical results expressed as equivalent water concentrations are used to calculate the total mass of each DNAPL component in a sample. The sampling and analytical procedure used by the Environmental Remediation & Technology Section of the Savannah River Technology Center (SRTC) to measure sediment concentrations of PCE and TCE is as follows. A plug of the sediment is taken from a split-spoon sampler using a cut-off syringe. The volume of this sample (generally 2.0 cm³) is the bulk volume, V_b . A known and consistent volume of water, V_{add} , is pipetted into the sample vial along with the sediment (generally 5.0 cm³). The samples are analyzed using a purge and trap technique with quantification done by gas chromatography. The gas chromatograph is calibrated using a sequence of standards that range in concentration up to the solubility limit of the component. The volume of the standard placed in a vial, V_{cal} , is approximately the same as that expected in a saturated soil sample with the added water. This covers all samples with concentrations below the solubility limit. A second set of standards was prepared for samples with DNAPLs present. These were prepared by injecting a known volume of excess DNAPL component (either PCE or TCE) into a vial containing the standard volume, V_{cal} , of a solution at the solubility limit for the component. The results are expressed as equivalent water concentrations, C_{Peq} for PCE and C_{Teq} for TCE. The total mass of the components in the sample are calculated as follows.

$$M_P = C_{Peq} [V_{add} + \phi V_b] \quad (F.9)$$

$$M_T = C_{Teq} [V_{add} + \phi V_b] \quad (F.10)$$

Assumptions must be made for the dissolved concentrations of PCE and TCE in the pore water, and for the sediment porosity in order to solve these equations. Since the expectation is that there will be a DNAPL phase, it is reasonable that the pore water will be at the solubility limit for both DNAPL components, PCE and TCE. Here we make the assumption that the presence of one component dissolved in the pore water does not interfere with the solubility of the other and vice versa, i.e., the dissolved concentration of each component is its solubility limit in water. Hence $C_{P/W}$ is $150 \mu\text{g}/\text{cm}^3$, and $C_{T/W}$ is $1500 \mu\text{g}/\text{cm}^3$.

Reasonable values of porosity can be assessed from previous work. Eddy-Dilek, et al. (1993) reported values of porosity for 18 sediment samples taken in the A/M Area in their Table 17 (page 25). This table includes soil classification descriptions. The zone at the Hydrophobic Lance site where DNAPL was encountered (~145 ft. to 147 ft.) can be described as a very fine to coarse sand with some silt. Thirteen (13) samples listed in Eddy-Dilek, et al.'s Table 17 are described as sand samples, with descriptions ranging from "clayey sand" to "poorly graded sand with silt" to "silty sand". Some of the Shelby tube samples had two samples collected from them at different locations, resulting in a total of twenty (20) porosity measurements made on representative samples. The porosity values from these samples is assumed to cover the range of porosity which might be expected in the DNAPL layer in the Hydrophobic Lance boring location. The results are listed in Table 1.

Table 1. Representative porosity values from the A/M Area. (Source: Eddy-Dilek, et al. 1993)

Sample (depth range in ft.)	Soil Classification Description	Porosity 1	Porosity 2
MHB-1T (31-33)	clayey sand	0.396	0.429
MHB-1T (56-58)	silty sand	0.448	0.382
MHB-1T (80-82)	poorly graded sand with silt	0.366	
MHB-1T (100-102)	poorly graded sand with silt	0.415	
MHB-1T (130-131.1)	poorly graded sand with silt	0.395	
MHB-4T (60-62)	clayey sand	0.389	
MHB-4T (70-72)	clayey sand	0.433	
MHB-4T (80-82)	poorly graded sand with silt	0.390	
MHB-8T (155-157)	silty sand	0.358	0.355
MHT-10B (201-201.7)	poorly graded sand with silt	0.402	0.369
MHT-11C (165-167.7)	clayey sand	0.381	0.360
MHT-11C (200-202.4)	poorly graded sand with silt	0.415	0.369
MHT-12C (200-202.2)	poorly graded sand	0.394	0.354
mean		0.390	
standard deviation		0.027	
coefficient of variation		7.02%	

As indicated in Table 1, the mean porosity of representative samples was 0.390 with a standard deviation of 0.027. The 95% confidence limits for porosity in sandy sediments in the A/M Area can be calculated using Student's t-distribution (Sokal and Rohlf 1969). The t-value for 19 degrees of freedom and a p-value of 0.05 is 2.093 (Rohlf and Sokal 1969). The 95% confidence interval for porosity in sand samples from the A/M Area is 0.333 to 0.446. A sequence of five porosity values starting with a low of 0.33 and increasing by 0.03 ending with 0.45 covers more than the 95% confidence interval.

Under the above assumptions, a separate NAPL phase is indicated if the equivalent water concentrations for one or more of the components exceed those of the standards prepared with solutions at the solubility limit. The solution leading to equation (8) will yield a negative value for DNAPL saturation if the equivalent water concentrations are less than the solubility-limit standards. Samples with such results are assigned a saturation of zero since negative saturations are physically impossible.

References

- Eddy-Dilek, C. A., B. B. Looney, T. C. Hazen, R. L. Nichols, C. B. Fliermans, W. H. Parker, J. M. Dougherty, D. S. Kaback and J. L. Simmons. 1993. *Post-test evaluation of the geology, geochemistry, microbiology, and hydrology of the in situ air stripping demonstration site at the Savannah River Site* ^(U). Technical Report WSRC-TR-93-369. Westinghouse Savannah River Company.
- Rohlf, F. J. and R. R. Sokal. 1969. *Statistical Tables*. W. H. Freeman and Company, San Francisco. 253 pp.
- Sokal, R. R. and F. J. Rohlf. 1969. *Biometry: The Principles and Practice of Statistics in Biological Research*. W. H. Freeman and Company, San Francisco. 776 pp.

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