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MORRISON KNUDSEN CORPORATION
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| PREPARED: | S. Vincent | Sean Vincent | 10/16/97 |
| REVIEWED: | P. Patchin | Paul C Patchin | 10/16/97 |
| APPROVED MKES: | | | |
| - LEAD TASK ENGINEER | P. Patchin | Paul C Patchin | 10/16/97 |
| - LEAD DISCIPLINE DEPT. MGR. | R. Raymondi | [illegible] | 10/17/97 |
| - DESIGN MANAGER | J.C. Dille | J. Carl Dille | 10/22/97 |
| - ENGINEERING MANAGER | W. Gale | [illegible] | 10-17-97 |
| APPROVED: | | | |
| - OFF-SITE QUALITY MANAGER | D. Bledsoe | [illegible] | 20 OCT 97 |

# WELDON SPRING SITE REMEDIAL ACTION PROJECT

## CHEMICAL PLANT GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION
## SOIL GAS SURVEY - SOIL GAS SAMPLING RESULTS

Task 852

Technical Memorandum No. 3840TM-5029-00

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Rev. 0

Prepared By

MK-Environmental Services
720 Park Boulevard
Boise, ID 83729

for

MK-Ferguson Group
7295 Highway 94 South
St. Charles, MO 63304

**WSSRAP**
**Chemical Plant Groundwater Operable Unit Remedial Investigation**
**Technical Memorandum No. 3840TM-5029-00**
**Task No. 852**
**Soil Gas Survey - Soil Gas Sampling Results**

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## 1.0 INTRODUCTION

### 1.1 Statement of the Problem

The chlorinated solvent trichloroethylene (also known as trichloroethene or TCE) has been detected in shallow aquifer monitoring wells at the Weldon Spring Chemical Plant (WSCP) and the Weldon Spring Training Area (WSTA). The maximum concentration of 9,000 µg/l was measured in a June, 1996 groundwater sample from well MW-2038 (Figure 1-1). TCE above 500 µg/l consistently occurs in the samples from MW-2038 and from two other wells slightly upgradient (south) of Raffinate Pits 3 and 4 (MW-2037 and MWS-21 - see Figure 1-2 showing July 1995 potentiometric surface). Lower but quantifiable levels of TCE (1.2 to 59.8 µg/l) have been measured in samples from six additional monitoring wells (MW-2013, MW-2030, MW-2032, MW-3024, MW-3025, and MW-4001), although TCE has not been detected in MW-3024 since it was retrofitted from an open hole to an unweathered zone monitoring well in November of 1996. TCE is a carcinogen with a maximum contaminant level (MCL) in drinking water of 5 µg/l.

1,2-dichloroethylene (1,2-DCE), a TCE breakdown product under anaerobic conditions, has been found above the quantitation limit in 5 of the 57 wells sampled for volatile organics during the period April 1996 through August 1997 (MW-2013, MW-2032, MW-2037, MW-2038 and MWS-21). The June 1996 sample from MW-2038 also had the highest measured concentration of total 1,2-dichloroethylene (total includes cis-1,2-dichloroethylene and trans-1,2-dichloroethylene isomers) at 39.0 µg/l. The MCLs for the cis-and trans-1,2-dichloroethylene isomers in drinking water are 70 µg/l and 100 µg/l, respectively.

Soil samples have been collected at various locations adjacent to the raffinate pits, in the berms around Raffinate Pits 3 and 4, and in the former PCB drum area of Raffinate Pit 4. TCE was not detected in any of the soil and perched groundwater samples in the vicinity of the PCB drum area nor in any of 27 berm soil samples. Seven soil samples collected at two locations in an area between Raffinate Pit 3 and Building 301 had TCE ranging from 5 to 4,800 µg/kg. No other TCE soil contamination has been found.

The sludge in all four raffinate pits was sampled between 1988 and 1990 as part of the Chemical Plant Remedial Investigation. TCE was detected in one sample from Raffinate Pit 3 at 23 µg/kg. In 1990 and 1991, sludge from the southwest corner of Raffinate Pit 3 was sampled as part of the Chemical Plant Feasibility Study and was found to contain TCE at concentrations from 23 µg/kg to 110 µg/kg. Finally, sludge from Raffinate Pit 3 was also sampled in 1996/1997 at three depths in each of six locations. TCE and 1,2-DCE were not detected in these samples.

Four springs were sampled during 1996 and the first part of 1997, but TCE and 1,2-DCE were not detected. The detection limits ranged from 5 µg/l to 10 µg/l. TCE was detected at very low levels (from 1 to 2 µg/l) in the recent samples from Burgermeister Spring (6301) and Spring 6303 using an analytical method with a lower detection limit (gas chromatography).

A source area of TCE has not been identified, although previous TCE usage is indicated based on concentrations as high as 280,000 µg/kg in oily residue from drums removed from the southeast corner of Raffinate Pit 4 and up to 110 µg/kg in sludge from the southwest corner of Raffinate Pit 3. Potential areas of historical TCE usage include a locomotive maintenance facility (building S-28) and adjacent underground storage tanks (USTs) on the WSTA and the paint shop (building 417) located to the east of building 301 on the WSCP (Figure 1-3).

## 1.2 Scope

This memorandum describes a soil gas survey performed at the WSCP and the WSTA from June 17 through July 17, 1997 to define the extent of contamination by TCE and its degradation products in soil and groundwater. This work was performed under Task 2 of Work Package 476. Geotechnology, Inc. was subcontracted to perform all predrilling, direct push sampling, and borehole abandonment. Direct push soil gas and groundwater sampling was performed with a van-mounted Geoprobe® rig. Predrilling was performed with a CME 550 auger rig at selected locations to facilitate sampling where the overburden was thickest. A PMC geologist supervised the drilling, determination of sample depth, and sample collection.

## 1.3 Objectives

The general objective of the soil gas survey was to determine the source, nature, and extent of trichloroethylene (TCE) contamination. Specific objectives are as follows (MKF & JEG, 1997):

- Identify the source(s) of TCE contamination detected in the shallow aquifer.
- Determine the extent of TCE contamination in soil.
- Provide a basis for locating soil samples.
- Further define the distribution of TCE contamination in the shallow aquifer.

## 1.4 Nature of the Contaminant

TCE is a chlorinated hydrocarbon used as a solvent primarily in dry cleaning and metal degreasing. Releases of chlorinated hydrocarbons usually originate from leaking storage tanks or from poor housekeeping practices where solvents are spilled or dumped (Fetter, 1993). TCE is also a degradation product of tetrachloroethene (also known as tetrachloroethylene, perchloroethene, perchloroethylene or PCE - see Figure 1-4 for degradation pathways). The frequency of groundwater contamination problems involving TCE can be attributed to its widespread use as a solvent and physical characteristics typical of chlorinated hydrocarbons. These include (Schwille, 1988):

- Chlorinated hydrocarbons generally are immiscible with water. Immiscible fluids do not mix freely due to surface tension forces. The immiscible phase (free product) represents a potential long-term source of dissolved-phase contamination when released into the subsurface because it dissolves sparingly.
- Although immiscible, chlorinated hydrocarbons are actually quite soluble relative to regulatory cleanup criteria. For example, the solubility of TCE (1,100 mg/l) is 220,000 times the MCL (Attachment 1). A small amount of free product can therefore contaminate a large volume of aquifer.
- Chlorinated solvents generally are less viscous and more dense than water (TCE specific gravity = 1.46). The gravitational gradient can therefore cause free product to migrate beneath the water table and against the prevailing hydraulic gradient (e.g., along a sloping confining layer or the top of bedrock - Figure 1-5).
- Chlorinated hydrocarbons tend to be less biodegradable than other organic compounds and thus are relatively persistent in the subsurface.
- Chlorinated solvents tend to be quite volatile. The Henry's Law Coefficient for partitioning between air and water is approximately .01 atm*$m^3$/mole for TCE. For groundwater at atmospheric pressure with 500 µg/l TCE, the equilibrium concentration in air is 38 parts per million by volume (see Attachment 2).

## 2.0 METHODOLOGY

### 2.1 Drilling and Sampling

An attempt was made to sample soil vapor at the clay till/residuum contact and at the residuum/bedrock contact at each of 34 proposed locations. The basis for locating samples is described in Addendum 3 to the Sampling Plan for the RI/FS (MKF & JEG, 1997).

One or more soil gas samples were collected at 30 of the proposed locations (Figure 1-1). A sample was not obtained at SG-13 due to the low permeability of the overburden and at two other sample locations due to inaccessibility (SG-04 and SG-32). An in-situ sample of groundwater was collected with a small diameter stainless steel bailer in lieu of a soil gas sample at SG-14 because the target sample depth was below the water table. The coordinates and depths of sampling are provided in Table 1.

Borings were predrilled at 17 of the 34 proposed sample locations to facilitate probe sampling where the overburden was thickest (see Figure 2-1). Predrilling was performed with an all-terrain CME-550 drill rig using hollow-stem augers with an inside diameter (ID) of 3¾ inches and a 7¾-inch outside diameter (OD) lead auger. Drilling advanced to within 8 feet of the upper target sample interval. Temporary nominal 1½-inch diameter iron pipe was then driven a few feet beyond the lead auger depth to seal the bottom of the hole. A threaded cap was screwed onto the upper end of the pipe. The auger flights were retrieved and a minimum 5-foot interval of the outer annulus at the bottom of the augered hole was sealed with bentonite grout to prevent possible loss of volatiles to the atmosphere. A prefabricated wooden collar was installed around the pipe to prevent sloughing of material from the surface. Drill cuttings were mounded on top of the wooden collar and covered with plastic to prevent entry of surface water into the boring.

Direct push sampling was performed with a van-mounted model 8M Geoprobe®. An expendable 1¼-inch outside diameter drive point was driven inside the 1½-inch iron pipe to depth on 3-foot long rods. The outside diameter of the drive rods is approximately 1 inch. Upon reaching the depth of sampling, the drill string was raised thereby releasing the expendable drive point and exposing the formation for sampling. Unused ¼-inch OD polyethylene tubing was lowered through the drill string and attached to a threaded, airtight fitting at the base of the lead rod. Soil gas samples were drawn into 1-liter Tedlar bags using a portable vacuum chamber for analysis at an off-site laboratory. The air samples were analyzed for volatile hydrocarbons using EPA method TO-14 modified (the modification involves the use of 1-liter Tedlar bags in lieu of specialized stainless-steel canisters). For comparative purposes, a sample of the ambient air was collected for inclusion with each shipment of soil gas samples. Photographs of the Geoprobe® van and associated vapor sampling equipment are provided in Attachment 3.

As can be seen in Table 1, probe refusal generally occurred at an elevation above the modeled top of bedrock surface. In many instances, refusal likely was the result of encountering large relatively insoluble chert fragments (cobbles or boulders) which are typical of the residuum layer found directly above the limestone bedrock but also occasionally occur in the overlying clay till. Refusal above the modeled top of bedrock may also be attributed to the lack of

# Table 1 - Soil Gas Sampling Data

| Location | Missouri State Plane Coordinates (NAD 83) Easting (ft) | Northing (ft) | Ground Elev. (Ft) | Projected Depth to Bedrock (ft) | Refusal Depth (ft) | Refusal Depth Above Projected Top of Rock (ft) | Refusal Depth Above Projected Depth to H2O (ft) | Predrill Depth (ft) | Sample | Sample Interval (ft) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SG-01 | 753396.78 | 1042210.93 | 663.84 | | | | | | - | 38-42 | no sample - impermeable |
| | | | | 47.24 | 45.40 | 1.84 | 4.26 | 33 | SG-397001-01 | 44.8-45.4 | |
| SG-02 | 753718.61 | 1042369.66 | 664.87 | | | | | | SG-397002-01 | 29.5-30 | |
| | | | | | | | | | SG-397002-02 | 39-39.5 | sample through rods |
| | | | | 49.52 | 49.50 | 0.02 | 1.68 | 24 | SG-397002-03 | 49-49.5 | sample through rods |
| SG-03 | 753563.26 | 1042536.43 | 663.10 | | | | | | SG-397003-01 | 40.5-42.5 | |
| | | | | 50.76 | 50.50 | 0.26 | -1.35 | | SG-397003-02 | 49.5-50.5 | |
| SG-05 | 752936.81 | 1042637.13 | 642.99 | | | | | | - | 21.5-25 | no sample - moist rods |
| | | | | 33.82 | 27.00 | 6.82 | 2.83 | 15.5 | SG-397005-01 | 26-27 | |
| SG-06 | 753104.85 | 1042349.15 | 655.88 | | | | | | SG-397006-01 | 29.5-30 | |
| | | | | 34.38 | 36.80 | -2.42 | 4.36 | 25 | SG-397006-02 | 35.8-36.8 | high air flow rate |
| SG-07 | 753121.97 | 1042231.54 | 655.61 | | | | | | - | 27.5-31 | wet rods - perched water |
| | | | | 37.25 | 35.50 | 1.75 | 5.34 | 22 | SG-397007-01 | 35-35.5 | |
| SG-08 | 753180.55 | 1042052.43 | 641.06 | | | | | | SG-397008-01 | 16-17 | low air flow rate |
| | | | | 30.25 | 23.50 | 6.75 | 2.44 | 13 | SG-397008-02 | 22.5-23.5 | high air flow rate |
| SG-09 | 753212.50 | 1041985.44 | 641.54 | | | | | | - | 13.5-17 | no sample - impermeable |
| | | | | 32.55 | 23.50 | 9.05 | 2.76 | 9 | SG-397009-01 | 22.5-23.5 | |
| SG-10 | 753399.49 | 1041920.36 | 644.84 | | | | | | SG-397010-01 | 17-19 | low air flow rate |
| | | | | 27.69 | 24.00 | 3.69 | 5.83 | 11 | SG-397010-02 | 23-24 | |
| SG-11 | 753966.88 | 1041884.40 | 664.95 | | | | | | - | 35-37 | no sample- moist clay on drive rods |
| | | | | 44.17 | 39.90 | 4.27 | 11.20 | 28 | SG-397011-01 | 39-39.9 | |
| SG-12 | 754173.28 | 1042551.32 | 648.85 | | | | | | SG-397012-01 | 21-23 | |
| | | | | 29.84 | 26.60 | 3.24 | 10.03 | | SG-397012-02 | 26-26.6 | |
| SG-13 | 753712.49 | 1042824.45 | 662.63 | 48.87 | 47.50 | 1.37 | 2.82 | | - | 38.5-47.5 | no sample - impermeable |
| SG-14 | 753093.46 | 1042994.59 | 631.90 | 28.04 | 30.40 | -2.36 | -7.48 | 15 | IS-3014-071197 | 29.4-30.4 | gw sample only-dtw = 21.7' |
| SG-15 | 752820.09 | 1042795.49 | 632.98 | | | | | | SG-397015-01 | 11.5-12.5 | medium air flow rate |
| | | | | 28.23 | 14.80 | 13.43 | 8.37 | 9.5 | SG-397015-02 | 14.3-14.8 | medium air flow rate |
| SG-16 | 752812.97 | 1042487.23 | 640.01 | | | | | | SG-397016-01 | 16-17 | |
| | | | | 24.39 | 18.00 | 6.39 | 8.19 | 8.6 | SG-397016-02 | 17.5-18 | |
| SG-17 | 752846.67 | 1042252.08 | 638.14 | | | | | | SG-397017-01 | 10-12 | |
| | | | | 15.68 | 14.50 | 1.18 | 8.94 | | SG-397017-02 | 14-14.5 | |
| SG-18 | 752987.54 | 1041904.87 | 638.59 | | | | | | SG-397018-01 | 10-11 | high air flow rate |
| | | | | 28.06 | 18.00 | 10.06 | 5.55 | | SG-397018-02 | 17-18 | |
| SG-19 | 753031.80 | 1041755.31 | 642.04 | | | | | | SG-397019-01 | 11-12 | |
| | | | | 34.81 | 17.50 | 17.31 | 10.82 | | SG-397019-02 | 16-17.5 | |
| SG-20 | 753401.07 | 1041643.02 | 652.46 | | | | | | SG-397020-01 | 21-22 | |
| | | | | 43.89 | 27.00 | 16.89 | 11.88 | 14 | SG-397020-02 | 26-27 | very high air flow rate |
| SG-21 | 753403.37 | 1041353.68 | 653.79 | | | | | | SG-397021-01 | 23-24 | |
| | | | | 33.02 | 28.60 | 4.42 | 16.58 | 13.6 | SG-397021-02 | 28-28.6 | |
| SG-22 | 754415.85 | 1042714.77 | 647.23 | | | | | | SG-397022-01 | 23.5-24 | |
| | | | | 30.23 | 29.50 | 0.73 | 7.55 | 16 | SG-397022-02 | 29-29.5 | |
| SG-23 | 753922.22 | 1043331.40 | 646.24 | | | | | | SG-397023-01 | 19-21 | |
| | | | | 22.61 | 24.00 | -1.39 | 17.07 | | SG-397023-02 | 22-24 | |
| SG-24 | 753055.55 | 1043192.90 | 635.95 | 27.86 | 24.00 | 3.86 | 6.34 | 19 | SG-397024-01 | 23-24 | |

| Table 1 - Soil Gas Sampling Data | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Missouri State Plane Coordinates (NAD 83) Easting (ft) | Northing (ft) | Ground Elev. (Ft) | Projected Depth to Bedrock (ft) | Refusal Depth (ft) | Refusal Depth Above Projected Top of Rock (ft) | Refusal Depth Above Projected Depth to H2O (ft) | Predrill Depth (ft) | Sample | Sample Interval (ft) | Comments |
| SG-25 | 752540.39 | 1043089.52 | 615.07 | 7.78 | 4.00 | 3.78 | 10.15 | | SG-397025-01 | 3.5-4 | high air flow rate |
| SG-26 | 752543.85 | 1042619.33 | 626.41 | 14.55 | 7.00 | 7.55 | 9.63 | | SG-397026-01 | 3.5-5.5 | very high air flow rate |
| SG-27 | 752542.59 | 1042290.10 | 628.74 | | | | | | SG-397027-01 | 2.5-3 | connected to surface |
| | | | | 11.13 | 6.50 | 4.63 | 9.09 | | SG-397027-02 | 5.5-6.5 | very high air flow rate |
| SG-28 | 752774.36 | 1041820.30 | 638.46 | | | | | | SG-397028-01 | 8.5-10 | |
| | | | | 25.10 | 18.00 | 7.10 | 7.18 | | SG-397028-02 | 17.5-18 | |
| SG-29 | 752848.92 | 1041526.99 | 649.42 | | | | | | SG-397029-01 | 16-17.5 | |
| | | | | 37.43 | 22.00 | 15.43 | 20.32 | 8.5 | SG-397029-02 | 21-22 | |
| SG-30 | 752666.61 | 1041299.47 | 655.44 | | | | | | - | 18-21 | no sample - impermeable |
| | | | | 39.00 | 26.20 | 12.80 | 29.29 | 10.5 | SG-397030-01 | 25-26.2 | |
| SG-31 | 752106.50 | 1042953.42 | 627.58 | 19.71 | 12.00 | 7.71 | 16.81 | | SG-397031-01 | 11.5-12 | high air flow rate |
| SG-33 | 752328.47 | 1041684.42 | 650.08 | | | | | | SG-397033-01 | 14-15 | high air flow rate |
| | | | | 37.14 | 28.00 | 9.14 | 12.09 | | SG-397033-02 | 27-28 | high air flow rate |
| SG-34 | 752359.23 | 1041559.72 | 646.79 | | | | | | SG-397034-01 | 13.5-15 | medium air flow rate |
| | | | | 31.88 | 17.80 | 14.08 | 20.86 | 5.5 | SG-397034-02 | 17-17.8 | high air flow rate |

control points in certain cases. The locations for which refusal was more than 10 feet higher than bedrock are SG-15, SG-18, SG-19, SG-20, SG-29, SG-30, and SG-34. Without exception, these locations are on the WSTA where data control is relatively sparse due to the relative paucity of boreholes/monitoring wells.

The depth to refusal was less than 10 feet at SG-25, SG-26, and SG-27. These locations trend approximately south-north and are adjacent a tributary of Schote Creek (Figure 1-3). Although TCE contamination along this reach is not indicated, the shallow aquifer is vulnerable to contamination by surface runoff at this and other locations where the vadose zone is thin.

Sampler refusal above the anticipated target depth resulted in the inability to sample groundwater at nine proposed locations (see MKF & JEG, 1997) because the water table was not reachable with the sampling probe. The only groundwater sample collected during the soil gas survey was at the SG-14 location. The sample was analyzed using EPA CLP methodology for volatile organic compounds.

Soil samples were collected to evaluate the potential for soil contamination at three soil gas sampling locations (SG-10, SG-20, and SG-21). Very low level concentrations of TCE (<3 parts per billion by volume) were detected in soil gas at these locations. SG-10 and SG-20 were the locations with the highest TCE concentrations in soil vapor (Section 3.2). The soil samples were analyzed using EPA CLP methodology for volatile organic compounds.

Chain-of-custody forms and seals for all environmental samples were prepared by Environmental Documentation personnel in accordance with ES&H Procedure 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain of Custody.*

### 2.2 Environmental Safety and Health

Drilling and sample collection was performed in accordance with the subcontractor's Safe Work Plan under the authority of PMC's site health and safety plan. A safety inspection was performed by PMC safety personnel on the Geoprobe® van and the drill rig. Work in unrestricted areas was performed in Level D personal protective equipment consisting of coveralls, steel-toed boots, inner cotton work gloves with outer nitrile gloves, safety glasses, hard hats, and hearing protection as required. Fluorescent safety vests were worn by all non-drilling personnel at the drill site. Latex gloves were worn during the collection of environmental samples. No safety-related incidents or accidents occurred during the soil gas survey. All drill cuttings and environmental samples were screened with a Ludlham 44-9 survey meter for radionuclide contamination and with a PE Photovac 2020 photoionization detector (PID) for volatile organic compounds (VOCs). The PID was calibrated daily in accordance with ES&H procedure 3.1.1. No detections above background occurred during screening of samples and cuttings.

### 2.3 Equipment Decontamination and Waste Management

Drilling and sampling equipment were decontaminated to prevent cross-contamination between boreholes. Upon entering the site, the drill rig, Geoprobe®, and sampling equipment were steam cleaned by the drilling subcontractor at the Building 434 decontamination pad. Between each borehole the augers and downhole sampling devices were steam cleaned and allowed to air dry. All sample containers were unused and factory clean.

Soil cuttings from the predrilling of SG-02 were contained in 55-gallon drums and disposed of at the Ash Pond Storage Area (APSA) due to the proximity of this location to Raffinate Pit 3 and to monitoring wells with contaminated groundwater (MW-2037 and MW-2038). Waste minimization procedures were implemented to reduce drilling-related trash, which was bagged and placed in the appropriate container at the Temporary Storage Area (TSA) access control.

### 2.4 Boring Abandonment

Soil gas borings were abandoned by pulling the temporary 1½-inch iron pipe, if present, and grouting in accordance with requirements for temporary monitoring wells in Chapter 4 of 10 CSR 23 *Missouri Well Construction Rules*. Grout-Well® high solids bentonite grout with a minimum density of 9.4 lb/gal was emplaced using a tremie pipe and a positive displacement pump.

## 3.0 RESULTS

A total of fifty-seven vapor samples were collected including six samples of ambient air at ground surface. The list of analytes comprises forty-five volatile organics. Table 2 presents a summary of the analytical results with concentrations expressed in parts per billion by volume (ppbv). Included for comparative purposes are average and median concentrations of selected volatile organics in ambient outdoor air from a nationwide database (see Shah and Singh, 1988). The

## Table 2 - Soil Gas Sampling Statistics

| Parameter | Number of Detections | | Maximum Concentration (ppbv) | | | Average Concentration (ppbv) | | Conc. from Database for Outdoor Air in U.S (ppbv) | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil Vapor | Ambient Air | Soil Vapor | | Ambient Air Conc. | Soil Vapor | Ambient Air | Avg. | Median |
| | | | Sample | Conc. | | | | | |
| 1,1-Dichloroethane | 0 | 0 | | – | – | – | – | | |
| 1,1-Dichloroethene | 3 | 1 | SG-397005-01 | 8.34 | 1.40 | 0.20 | 0.23 | | |
| 1,1,1-Trichloroethane | 0 | 0 | | – | – | – | – | 0.91 | 0.16 |
| 1,1,2-Trichloroethane | 2 | 0 | SG-397011-01 | 4.75 | – | 0.12 | – | 1.10 | 0.00 |
| 1,1,2,2-Tetrachloroethane | 13 | 0 | SG-397011-01 | 8.17 | – | 0.53 | – | 0.10 | 0.00 |
| 1,2-Dibromoethane | 0 | 0 | | – | – | – | – | | |
| 1,2-Dichlorobenzene | 0 | 0 | | – | – | – | – | 1.30 | 0.00 |
| 1,2-Dichloroethane | 17 | 0 | SG-397011-01 | 6.29 | – | 0.74 | – | 0.38 | 0.00 |
| 1,2-Dichloropropane | 0 | 0 | | – | – | – | – | 0.16 | 0.02 |
| 1,2,4 Trimethylbenzene | 50 | 4 | SG-397002-01 | 13.49 | 3.52 | 4.00 | 1.26 | | |
| 1,2,4-Trichlorobenzene | 0 | 0 | | – | – | – | – | | |
| 1,3-Dichlorobenzene | 0 | 0 | | – | – | – | – | 0.89 | 0.03 |
| 1,3,5-Trimethylbenzene | 30 | 1 | SG-397010-02 | 5.71 | 1.29 | 1.14 | 0.22 | | |
| 1,4-Dichlorobenzene | 0 | 0 | | – | – | – | – | 1.00 | 0.04 |
| 4-Ethyltoluene | 11 | 0 | SG-397011-01 | 3.99 | – | 0.44 | – | | |
| Benzene | 48 | 4 | SG-397001-01 | 26.95 | 2.39 | 3.07 | 1.12 | 2.80 | 1.67 |
| Benzylchloride | 0 | 0 | | – | – | – | – | 0.01 | 0.01 |
| Bromodichloromethane | 13 | 0 | SG-397002-01 | 3.00 | – | 0.40 | – | | |
| Bromoform | 0 | 0 | | – | – | – | – | | |
| Bromomethane | 0 | 0 | | – | – | – | – | 3.10 | 0.18 |
| cis-1,2-Dichloroethene | 0 | 0 | | – | – | – | – | 0.33 | 0.04 |
| cis-1,2-Dichloropropene | 0 | 0 | | – | – | – | – | | |
| Carbon disulfide | 47 | 4 | SG-397037-01 | 19.20 | 10.77 | 5.66 | 3.88 | | |
| Carbon tetrachloride | 1 | 0 | SG-397012-02 | 1.21 | – | 0.02 | – | 0.17 | 0.12 |
| Chlorobenzene | 0 | 0 | | – | – | – | – | 0.33 | 0.06 |
| Chloroethane | 0 | 0 | | – | – | – | – | 3.96 | 0.05 |
| Chloroform | 3 | 0 | SG-397030-01 | 3.28 | – | 0.14 | – | 0.63 | 0.06 |
| Chloromethane | 10 | 1 | | 2.69 | 2.69 | 0.33 | 0.45 | 0.74 | 0.65 |
| Dibromochloromethane | 1 | 0 | SG-397010-01 | 1.65 | – | 0.03 | – | | |
| Dichlorodifluoromethane (F-12) | 1 | 0 | SG-397023-01 | 1.22 | – | 0.02 | – | 0.44 | 0.33 |
| Ethylbenzene | 47 | 1 | SG-397002-02 | 10.36 | 2.15 | 2.26 | 0.36 | | |
| Freon 113 | 2 | 0 | SG-397005-01 | 1.79 | – | 0.06 | – | | |
| Freon 114 | 1 | 0 | SG-397023-01 | 1.90 | – | 0.04 | – | | |
| Hexachlorobutadiene | 0 | 0 | | – | – | – | – | 0.04 | 0.00 |
| Methylene chloride | 27 | 1 | SG-397037-02 | 24.89 | 22.18 | 8.82 | 3.70 | 1.62 | 0.77 |
| M&P Xylene | 51 | 5 | SG-397011-01 | 18.93 | 3.59 | 5.52 | 2.00 | | |
| O Xylene | 48 | 2 | SG-397011-01 | 7.67 | 1.48 | 2.45 | 0.44 | | |
| Styrene | 45 | 3 | SG-397010-02 | 23.46 | 2.98 | 4.65 | 1.36 | | |
| trans-1,2 Dichloroethene | 0 | 0 | | – | – | – | – | | |
| trans-1,3-Dichloropropene | 2 | 0 | SG-397016-02 | 1.62 | – | 0.05 | – | | |
| Tetrachloroethene (PCE) | 2 | 0 | SG-397010-02 | 185.47 | – | 3.73 | – | 0.85 | 0.35 |
| Toluene | 51 | 6 | SG-397016-02 | 143.95 | 65.18 | 33.05 | 15.14 | 7.78 | 1.89 |
| Trichloroethene (TCE) | 7 | 0 | SG-397020-01 | 2.93 | – | 0.30 | – | 0.50 | 0.16 |
| Trichlorofluoromethane (F-11) | 9 | 1 | SG-397021-01 | 58.44 | 1.04 | 1.76 | 0.17 | 0.25 | 0.20 |
| Vinyl chloride | 0 | 0 | | – | – | – | – | 3.28 | 0.00 |

– = analyte not detected

outdoor sample locales are described as being a combination of "urban, rural, suburban, remote, and near source". It can be seen that part per billion levels of several volatile organic compounds, including chlorinated solvents such as TCE, vinyl chloride, and PCE, are typical of outdoor air in the United States.

### 3.1 VOCs

Twenty-seven of the forty-five analytes were detected in the soil gas, fourteen of which were not detected in ambient air samples. Sample SG-11 (next to southwest corner of raffinate pit 2) had the highest concentration of six of these analytes (1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, 1,2-dichloroethane, 4-ethyltoluene, m&p-xylene, and o-xylene). SG-10 had the highest concentrations of four analytes (PCE, styrene, dibromochloromethane, and 1,3,5-trimethylbenzene) and the second highest concentration of TCE (2.79 ppbv), carbon disulfide (17.5 ppbv), and 4-ethyltoluene (2.97 ppbv).

Thirteen of the forty-five analytes were detected in ambient air samples. All thirteen of these analytes were also detected in soil gas. With the exceptions of 1,1-DCE and chloromethane, the average concentration of VOCs in soil gas was higher than the average concentration in ambient air. There was only one ambient air detection in both cases.

The levels of volatile compounds in the air samples are not considered atypical for outdoor air and soil gas affected by outdoor air quality based on comparison with summary statistics for a VOCs database (Shah and Singh, 1988). The exchange of air between the atmosphere and vadose zone may occur at WSCP and WSTA either directly through the soils or indirectly through monitoring wells. The migration of air through the soil is affected by the interconnectedness of the vapor phase, the vertical permeability, and by fluctuations in barometric pressure. The high soil water saturation levels (>90%) and low permeability of the clay till and the Ferrelview Formation (MKES, 1993) would tend to retard the movement of ambient air directly through the upper soil layers.

The maximum measured concentration of any individual compound (185 ppbv) was for PCE in the deep sample (23 to 24 feet below ground surface) at SG-10. SG-10 is immediately to the east of a concrete foundation which likely served as an unloading area based on its position at the southern terminus of a historical tramway (Figure 1-3). The estimated depth to water at SG-10 is 29.83 feet below ground surface which is 5.83 feet below the base of the deep sample interval. PCE was not detected in ambient air samples. The only other detection of PCE (4.98 ppbv) in soil vapor was in the shallow sample (17 to 19 feet below ground surface) at SG-10.

The increase in PCE concentration with depth at SG-10 suggests volatilization from groundwater rather than from a vadose zone source although significantly, it has not been detected in groundwater samples in nearby monitoring wells with a 10 µg/l detection limit. The MCL for PCE in groundwater is 5 µg/l. The difference in concentration with depth also points out that significant vertical chemical concentration gradients may occur in the vadose zone, which is attributable to the generally low vertical permeability of overburden sediments (see MKES, 1993). The elevation of the sample interval with respect to the water table (Table 1) should therefore be

considered when using soil gas data to draw inferences about groundwater contamination (i.e., the further the sample interval from the water table, the lower the confidence in attributing the results to volatilization from groundwater). Also, the difference in concentration indicates that the data cannot be used directly to define groundwater chemistry.

Other analytes elevated above national average and site average ambient air quality include toluene and methylene chloride. Both are common laboratory contaminants (EPA, 1992). Toluene was detected in all fifty-one soil vapor and all six ambient air samples at concentrations ranging from 3.67 to 144 ppbv. Elevated concentrations of toluene may be related to the historical use of this compound in the processing of nitroaromatics and its transport across the WSTA and WSCP in wooden pipelines (Figure 1-3). The highest concentration was in the deep soil vapor sample at the SG-16 location, which is adjacent the intersection of the end of a toluene pipeline and a tramway. Toluene also is a relatively abundant compound in outdoor ambient air with a published average concentration of approximately 8 ppbv and a median concentration of approximately 2 ppbv (Shah and Singh, 1988).

Several components of fuel and/or fuel combustion products in addition to toluene were detected in the majority of soil vapor samples. These include benzene, ethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and xylenes. The only other compounds detected in the majority of samples were methylene chloride, styrene, and carbon disulfide. Styrene is used mainly in the manufacture of synthetic rubber, resins, and plastics. Carbon disulfide occurs naturally in association with geothermal sources and as a product of anaerobic biodegradation. Carbon disulfide is used as a fumigant, a solvent, and in the production of rayon, cellophane, and carbon tetrachloride.

### 3.2 TCE and Degradation Products

TCE was detected in soil gas at very low concentrations (<3 ppbv) in seven samples at five locations on the WSTA. Detections occurred in both interval samples from SG-21 and SG-16. The maximum concentration (2.93 ppbv at SG-20) is approximately four orders of magnitude lower than the concentration for vapor at chemical equilibrium with groundwater from the three most contaminated monitoring wells (MW-2037, MW-2038, and MWS-21 - see Attachment 2). TCE was not detected in any ambient air samples.

The five locations where TCE was detected (SG-21, SG-20, SG-10, SG-9, and SG-16) trend approximately north-south from the southwest corner of the WSCP fence (Figure 3-1). The orientation of the trend is approximately coincident with the direction of groundwater flow, although the hydraulic gradient is relatively low based on July 1995 water level data (Figure 1-2). Upslope surface runoff at these locations would have originated on the chemical plant based on the 1987/1989 surface topography (Figure 1-3). TCE was not detected in ambient air samples.

Soil gas detections of TCE occurred in the general vicinity of well MWS-21, where groundwater samples have an average TCE concentration of 651 µg/l for the period February through August of 1997. MWS-21 is located in an area in which the bedrock top structure is depressed (see Figures 1-5 and 3-1). TCE was not, however, detected in the soil gas samples closest to two

other monitoring wells with high TCE concentrations in groundwater (MW-2037 and MW-2038). The distance from SG-01 to MW-2037 and from SG-02 to MW-2038 are 73.5 feet and 170.3 feet, respectively (Figure 1-1). The deep sampling intervals are within five feet of the predicted water table in both cases. Lack of TCE detections at these locations suggests a tenuous correlation between soil vapor sample results and groundwater concentrations, although this result could also be attributed to a discontinuous TCE distribution caused by multiple source areas and/or aquifer heterogeneities.

Neither cis- nor trans-1,2-DCE were detected in any of the soil vapor or ambient air samples. However, 1,1-DCE, another TCE degradation product (Figure 1-4), was detected in three soil gas samples and in one ambient air sample. The maximum concentration occurred in the SG-05 sample (8.34 ppbv). TCE was not detected in this sample, although this location is near SG-16 (194 feet north), where TCE was detected in both soil gas samples (Figure 3-1).

The in-situ groundwater sample (IS-3014-071197) collected at SG-14 was below detection for all CLP volatiles including TCE (detection limit = 1 µg/l) and total 1,2-DCE (detection limit = 10 µg/l). No volatile compounds were detected in the soil samples at SG-10, SG-20, and SG-21 with a 10 µg/kg detection limit (wet weight basis).

## 4.0 SUMMARY AND CONCLUSIONS

A soil gas survey was performed at the WSCP and the WSTA from June 17 through July 17, 1997. The general objective was to determine the source, nature, and extent of trichloroethylene (TCE) contamination in the shallow aquifer. Direct push soil gas and groundwater sampling was performed with a van-mounted Geoprobe® rig. A total of fifty-seven vapor samples were collected including six samples of ambient air at ground surface. The air samples were analyzed for volatile hydrocarbons using EPA method TO-14 modified. Very low levels of TCE (<3 ppbv) were detected in soil gas at five locations in the vicinity of the WSTA adjacent the WSCP.

While the location of these detections correlates generally with the distribution of TCE in groundwater (Figure 1-1), the correlation between soil gas results and groundwater quality is tenuous: TCE was not detected in the soil gas samples collected nearest two of the monitoring wells with the highest TCE concentrations. The maximum concentration of TCE in soil gas (2.93 ppbv) also is approximately four orders of magnitude less than the concentration of air at equilibrium with the groundwater in these two wells. Factors which may have contributed to the tenuous correlation between the soil gas and groundwater chemistries are the inability to reach the target depth at all sample locations combined with the generally low vertical permeability and high soil moisture content of the overburden soil strata.

Specific conclusions based on the soil gas survey results are as follows:

- A TCE source area was not identified in either soil or groundwater. Possible but unverified TCE source areas include historical facilities on both the WSCP and WSTA. Primary among these are a locomotive repair facility (S-28) and an unloading area at the of end of a tramway on the WSTA, and the paint shop

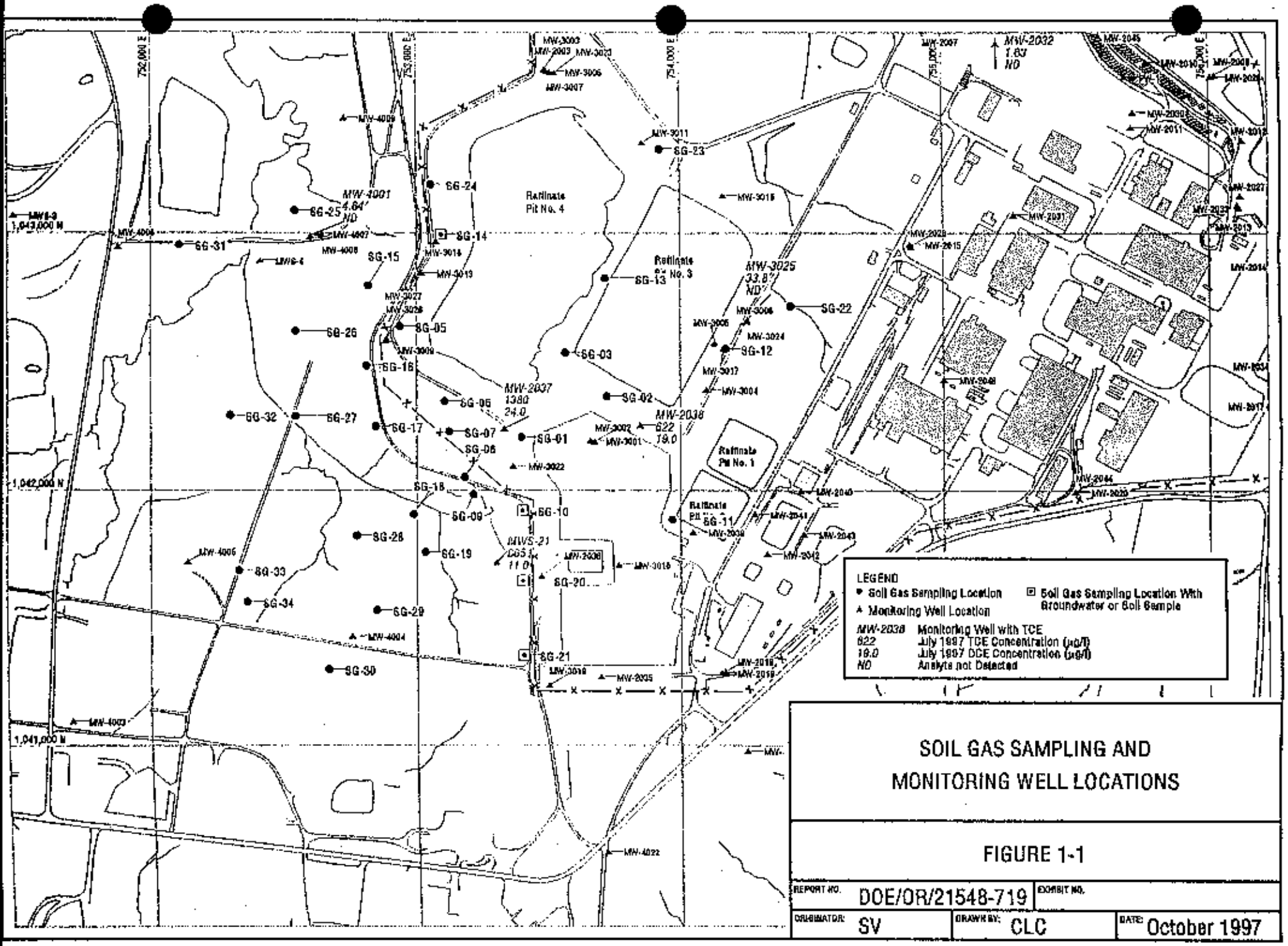
located east of building 301 and a historical drum storage area in the vicinity of Raffinate Pits 3 and 4 on the WSCP. TCE also is a breakdown product of PCE under anaerobic conditions.

- Soil samples were collected immediately adjacent to three of the five borings in which TCE was detected in soil gas (SG-10, SG-20, and SG-21). No volatile compounds were detected in any of the soil samples.

- The in-situ groundwater sample collected at SG-14 was below detection for all CLP volatiles including TCE (detection limit = 1 µg/l) and total 1,2-DCE (detection limit = 10 µg/l). This result indicates that the shallow aquifer immediately west of Raffinate Pit 4 is not contaminated with volatile organic compounds.

- Tetrachloroethylene (PCE) was detected at only one location, but at a higher concentration than any other volatile analyte (185 ppbv). The PCE appears to be very localized and it has not been detected in groundwater samples from nearby monitoring wells.

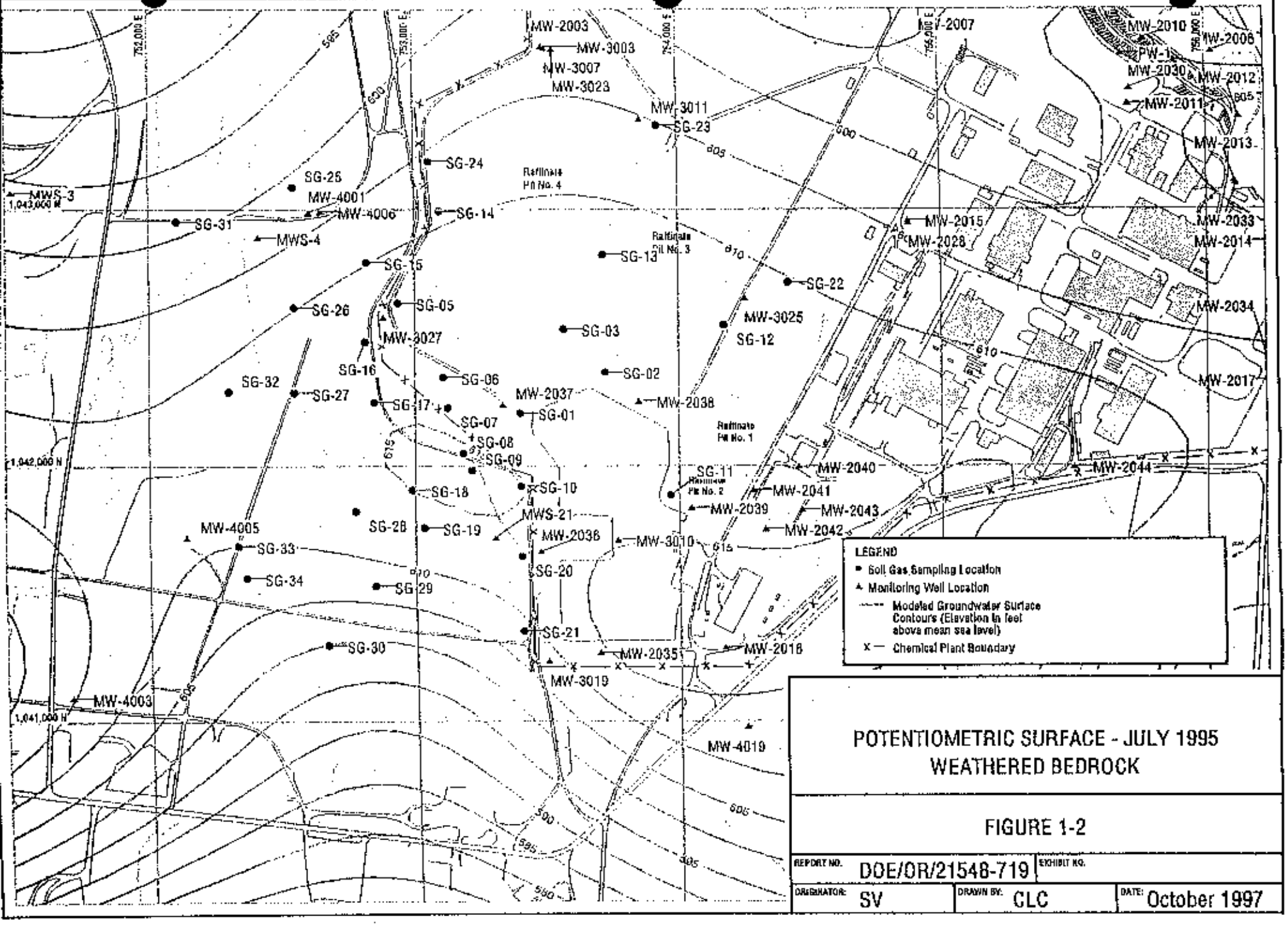
- Low levels of many volatile compounds were detected in both ambient air and soil vapor samples. The levels are not considered atypical for outdoor air and soil gas affected by outdoor air quality based on comparison with summary statistics for a VOCs database (Shah and Singh, 1988). The exchange of air between the atmosphere and vadose zone may occur at WSCP and WSTA either directly through the soils or indirectly through monitoring wells.




SOIL GAS SAMPLING AND MONITORING WELL LOCATIONS

FIGURE 1-1

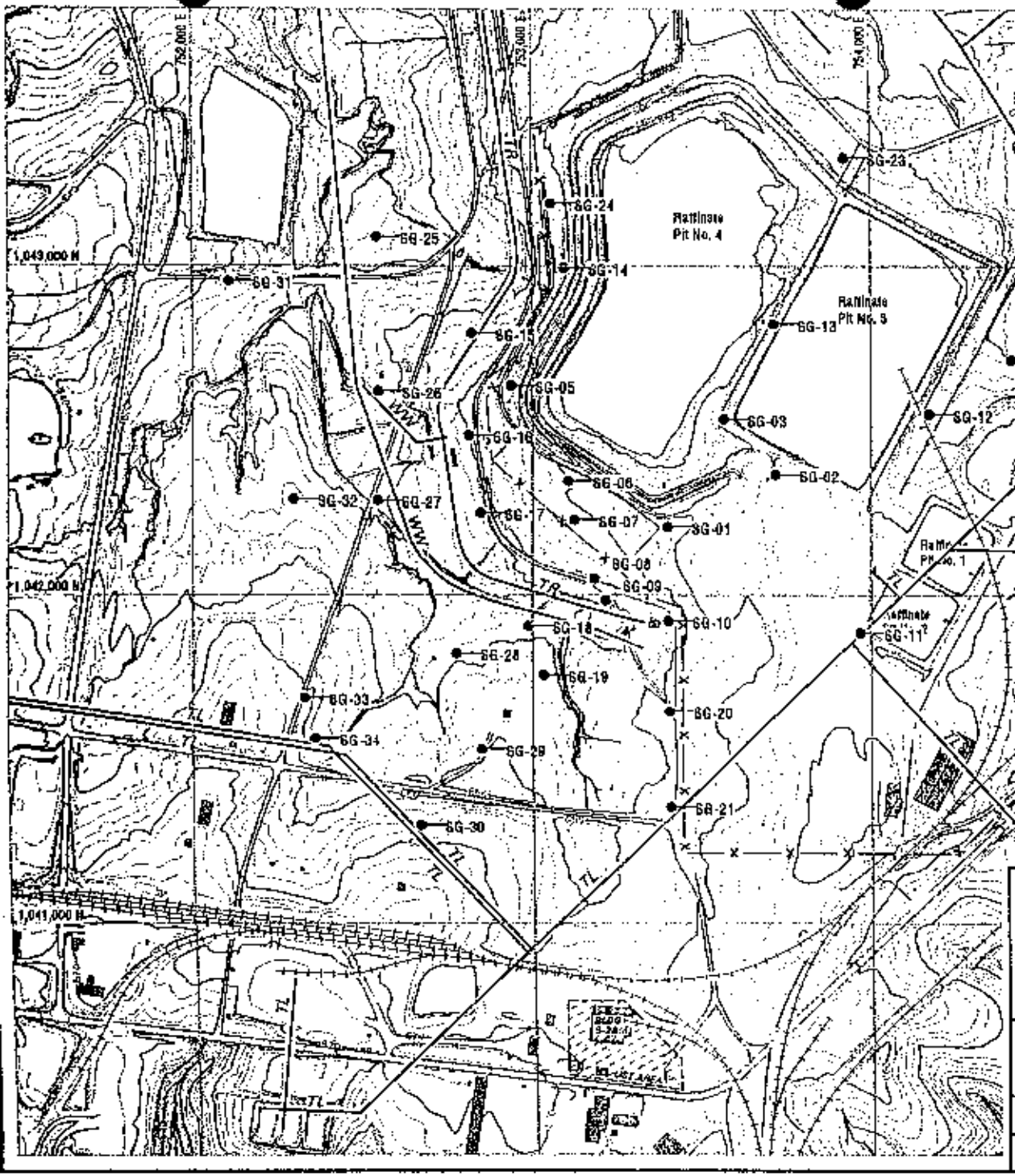
| | | | |
|---|---|---|---|
| REPORT NO. DOE/OR/21548-719 | | EXHIBIT NO. | |
| ORIGINATOR: SV | DRAWN BY: CLC | DATE: October 1997 | |




POTENTIOMETRIC SURFACE - JULY 1995
WEATHERED BEDROCK

FIGURE 1-2

| REPORT NO. | DOE/OR/21548-719 | EXHIBIT NO. | |
|---|---|---|---|
| ORIGINATOR: SV | DRAWN BY: CLC | DATE: October 1997 | |




HISTORICAL UTILITY FEATURES AND 1987/1989 SURFACE TOPOGRAPHY

FIGURE 1-3

| | | | |
|---|---|---|---|
| REPORT NO. DOE/OR/21548-719 | | EXHIBIT NO. | |
| ORIGINATOR: SV | DRAWN BY: CLC | DATE: October 1997 | |

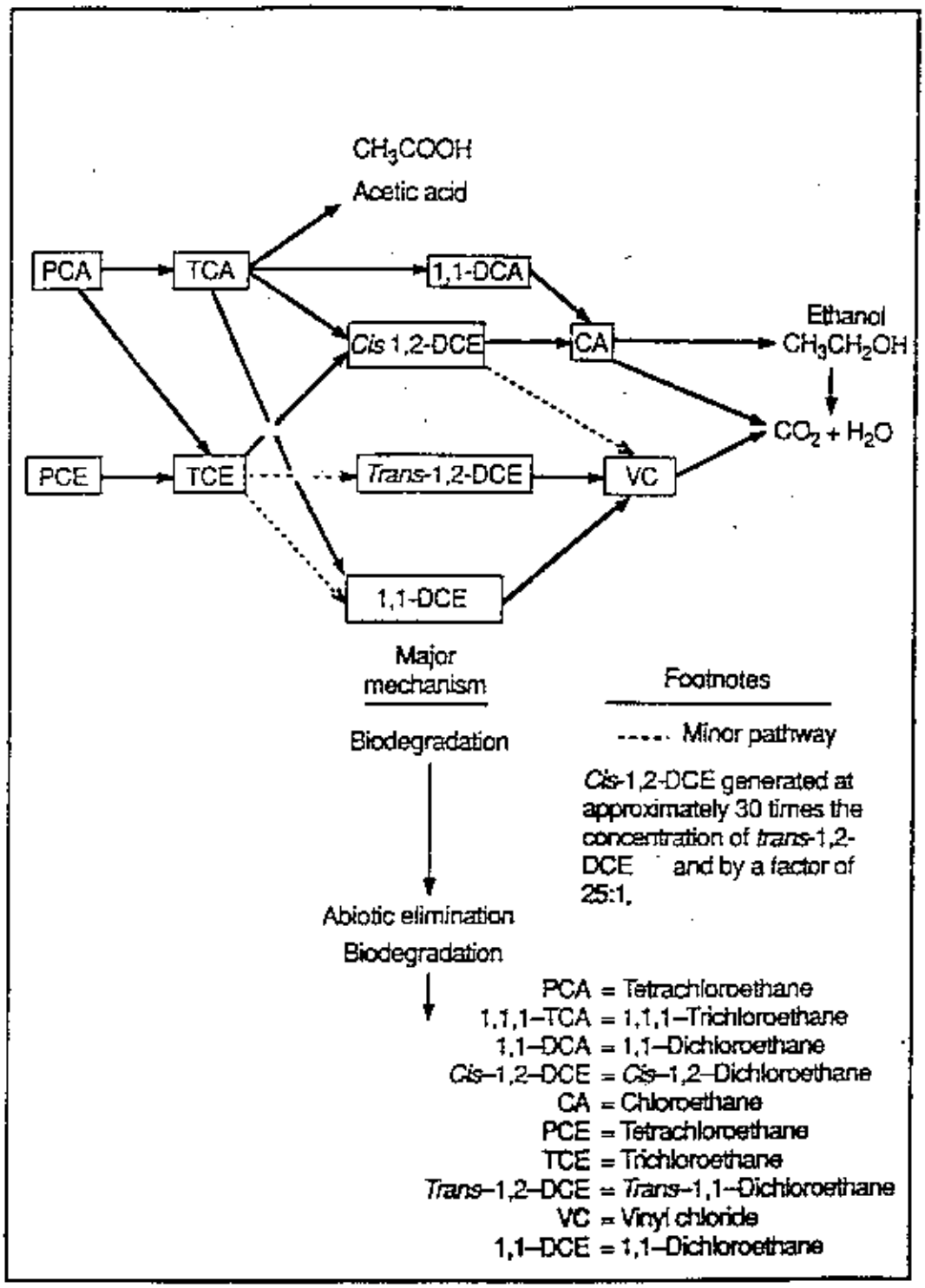
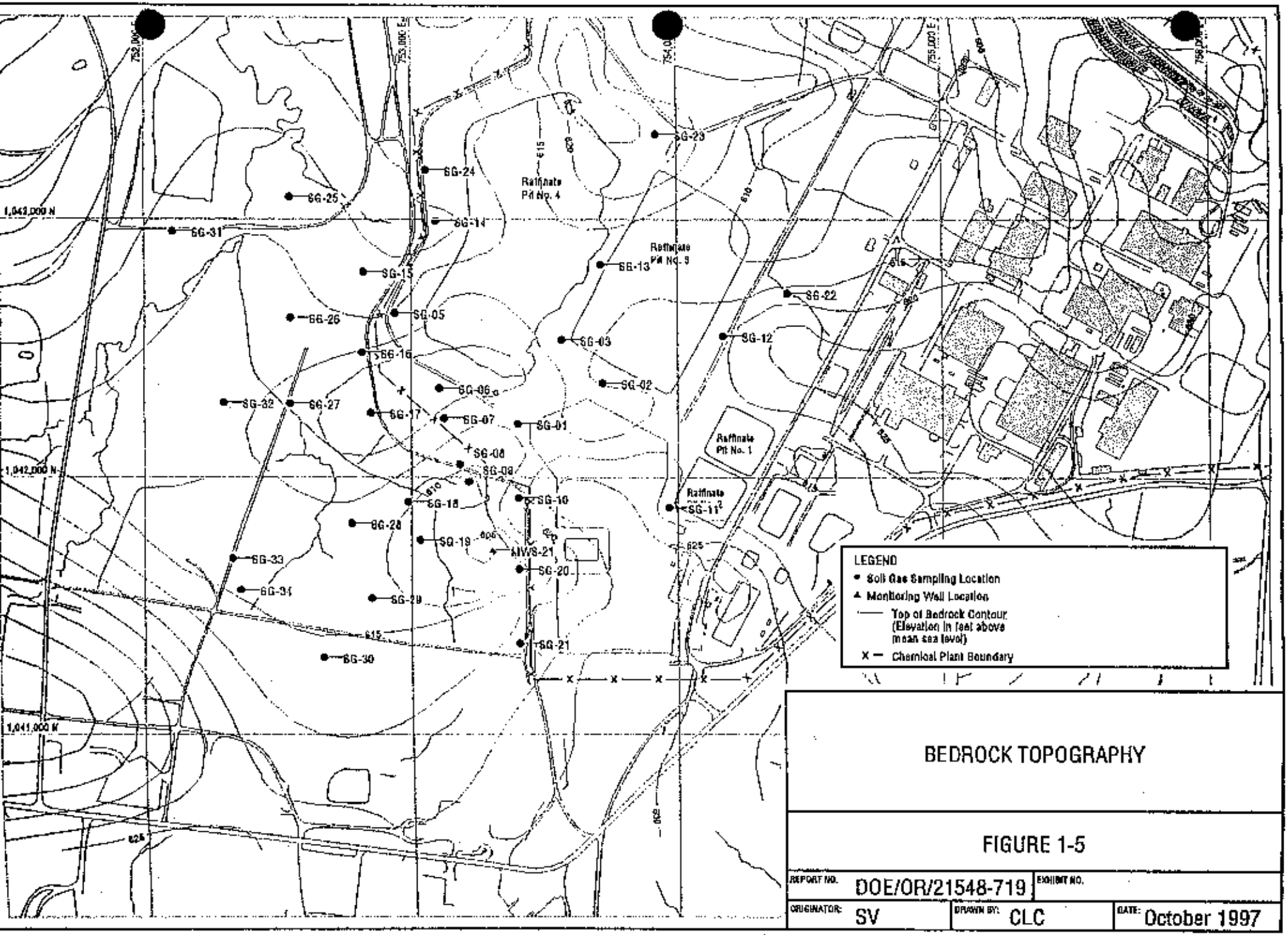


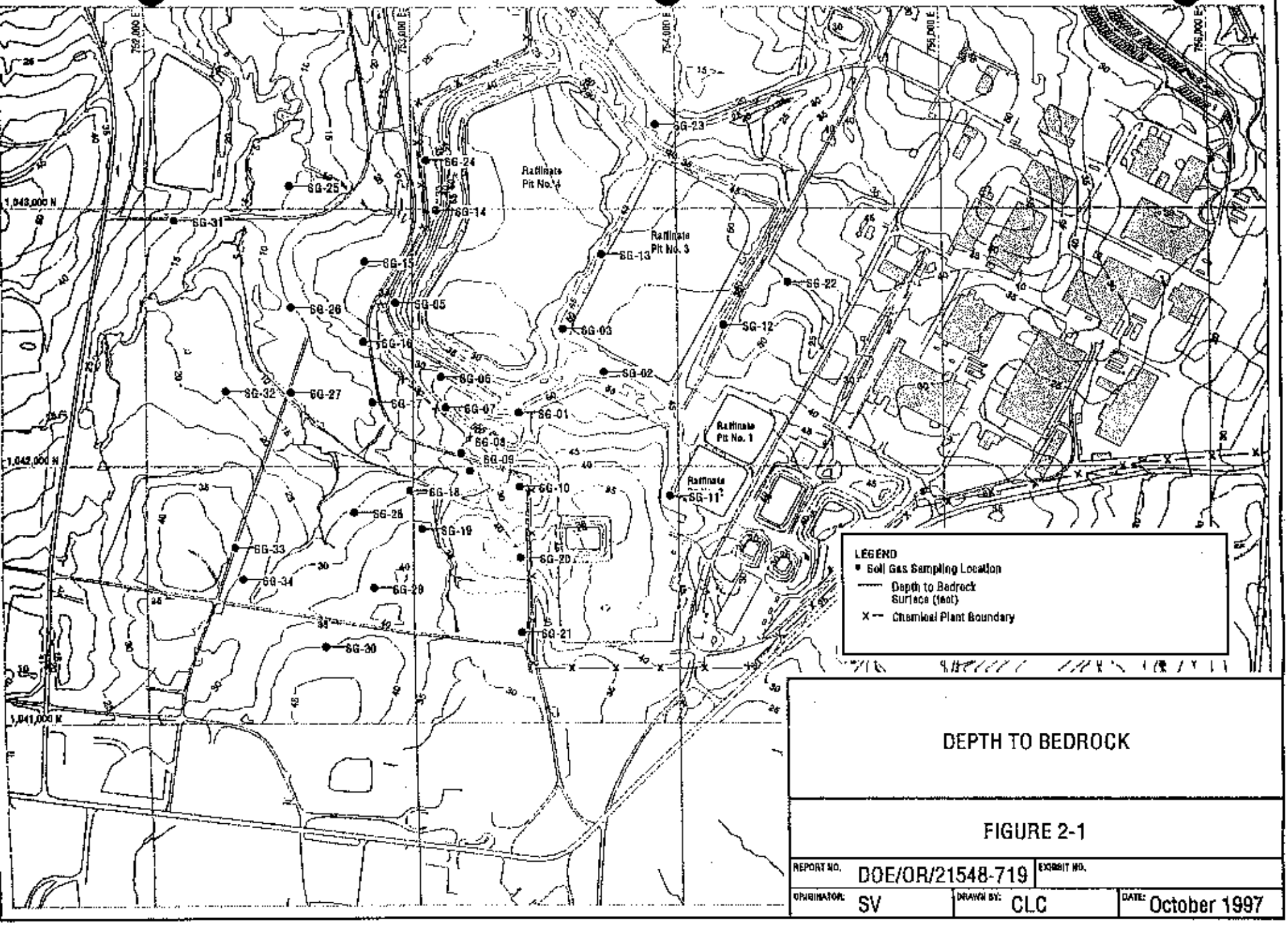

Figure 1-4 - Transformations of Chlorinated Aliphatic Hydrocarbons. Reprinted from Davis and Olsen (1990).




BEDROCK TOPOGRAPHY

FIGURE 1-5

| REPORT NO. | DOE/OR/21548-719 | EXHIBIT NO. | |
|---|---|---|---|
| ORIGINATOR: SV | DRAWN BY: CLC | DATE: October 1997 | |




DEPTH TO BEDROCK

FIGURE 2-1

| | | | |
|---|---|---|---|
| REPORT NO. DOE/OR/21548-719 | | EXHIBIT NO. | |
| ORIGINATOR: SV | DRAWN BY: CLC | DATE: October 1997 | |

HSDB
Topic: TRICHLOROETHYLENE

CHEMICAL & PHYSICAL PROPERTIES
Color/Form:
1. CLEAR, COLORLESS, OR BLUE MOBILE LIQUID **PEER REVIEWED** [Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 986
2. Colorless liquid (unless dyed blue). **UNREVIEWED** [NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 316

Odor:
1. Ethereal odor **PEER REVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1132
2. CHLOROFORM-LIKE ODOR **PEER REVIEWED** [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272
3. Sweet odor **PEER REVIEWED** [Health and Safety Executive Monograph: Trichloroethylene #6 p.3 (1982)
4. Chloroform-like odor. **UNREVIEWED** [NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 316

Boiling Point:
1. 87 DEG C **PEER REVIEWED** [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272

Melting Point:
1. -73 DEG C **PEER REVIEWED** [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272

Molecular Weight:
1. 131.40 **PEER REVIEWED** [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272

Corrosivity:
1. Non-corrosive **PEER REVIEWED** [Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 883

Critical Temperature and Pressure:
1. Critical temperature 271 deg C; Critical pressure 49.7 atm **PEER REVIEWED** [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V5 746 (1979)

Density/Specific Gravity:
1. 1.4649 @ 20 DEG C/4 DEG C **PEER REVIEWED** [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516

Heat of Combustion:

HSDB
Topic: TRICHLOROETHYLENE

1. 1.751 Kcal/g **PEER REVIEWED** [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V5 746 (1979)

Heat of Vaporization:

1. 8,314.7 gcal/gmole **PEER REVIEWED** [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-671

Octanol/Water Partition Coefficient:

1. log Kow= 2.29 **PEER REVIEWED** [Hansch, C., A. Leo. Substituent Constants for Correlation Analysis in Chemistry and Biology. New York, NY: John Wiley and Sons, 1979. 174

Solubilities:

1. SOL IN CHLOROFORM, ACETONE, ALCOHOL, ETHER **PEER REVIEWED** [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272
2. 1,100 mg/l water at 25 deg C **UNREVIEWED** [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1132
3. Miscible in oil. **PEER REVIEWED** [Health and Safety Executive Monograph: Trichloroethylene #6 p.2 (1982)

Spectral Properties:

1. SADTLER REF NUMBER: 185 (IR, PRISM); MAX ABSORPTION: LESS THAN 200 NM (VAPOR) **PEER REVIEWED** [Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-298
2. INDEX OF REFRACTION: 1.4773 @ 20 DEG C/D **PEER REVIEWED** [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-272
3. IR: 62 (Sadtler Research Laboratories IR Grating Collection) **PEER REVIEWED** [Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627
4. NMR: 9266 (Sadtler Research Laboratories Spectral Collection) **PEER REVIEWED** [Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627
5. MASS: 583 (Atlas of Mass Spectral Data, John Wiley & Sons, New York) **PEER REVIEWED** [Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627
6. Intense mass spectral peaks: 60 m/z, 95 m/z, 130 m/z **PEER REVIEWED** [Pfleger, K., H. Maurer and A. Weber. Mass Spectral and GC Data of Drugs, Poisons and their Metabolites. Parts I and II. Mass Spectra Indexes. Weinheim, FederalRepublic of Germany. 1985. 167

Surface Tension:

1. 29.3 dynes/cm = 0.0293 N/m at 20 deg C **PEER REVIEWED** [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.

Vapor Density:

1. 4.53 /Air=1/ **PEER REVIEWED** [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516

Vapor Pressure:

1. 19.9 MM HG @ 0 DEG C; 57.8 MM HG @ 20 DEG C **PEER REVIEWED** [National Research Council. Prudent Practices for Handling Hazardous Chemicals in Laboratories. Washington, DC: National Academy Press, 1981. 149

Viscosity:

1. 0.00550 poise at 25 deg C **PEER REVIEWED** [Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 143

Other Chemical/Physical Properties:

1. PERCENT IN SATURATED AIR: 10.2 (25 DEG C); EQUIVALENCIES: 1 MG/L= 185.8 PPM AND 1 PPM= 5.38 MG/CU M @ 25 DEG C, 760 MM HG) **PEER REVIEWED** [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3553
2. Ratio of Specific Heats of Vapor (gas) : 1.116 **PEER REVIEWED** [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.
3. Volatile liquid: 94 torr at 30 deg C. **PEER REVIEWED** [USEPA; Health Assessment Document: Trichloroethylene (Draft) p.3-25 (1983) EPA-600/8-82-006B
4. Oil/water coefficient 900:1 **PEER REVIEWED** [Waters EM et al; J Toxicol Envir Health 2: 671-707 (1977) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.3-3 (1983) EPA-600/ 8-82-006B
5. Olive oil/water partition coefficient 522:1 at 37 deg C. **PEER REVIEWED** [Sato A, Nakajima T; Arch Envir Health 43: 69-75 (1979) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p. 3-3 (1983) EPA-600/8-82-006B
6. DENSITY OF SATURATED AIR: 1.35 (AIR= 1) **PEER REVIEWED** [Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1309
7. Liquid heat capacity: 0.231 Btu/lb-F; saturated vapor pressure: 1.166 lb/sq in; saturated vapor density: 0.02695 lb/cu ft (all at 70 deg F) **PEER REVIEWED** [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous

HSDB
Topic: TRICHLOROETHYLENE

Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.
8. Saturated liquid density: 90.770 lb/cu ft; ideal gas heat capacity: 0.146 Btu/lb-F (All at 75 deg F) **PEER REVIEWED** [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.
9. Weight per gallon @ 20 deg C: 12.20 lb. **PEER REVIEWED** [Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 143
10. Partition coefficients at 37 deg C for trichloroethylene into blood = 9.5; into oil = 718. **PEER REVIEWED** [Sato A, Nakajima T; Scand J Work Environ Health 13: 81-93 (1987)
11. Dielectric constant @ 16 deg C 3.42; coefficient of cubic expansion 0.00119 (at 0-40 deg C); heat of formation 0.999 kcal/mole; latent heat of vaporization 57.4 cal/g. **PEER REVIEWED** [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V5 746 (1979)
12. Henry's Law Constant is 1X10-2 atm-cu m/mole. **PEER REVIEWED** [Eisenreich SJ et al; Environ Sci Technol 15: 30-8 (1981)

HSDB
Topic: 1,2-DICHLOROETHYLENE

CHEMICAL & PHYSICAL PROPERTIES
Color/Form:
1. Mobile liquid **PEER REVIEWED** [Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 36
2. Colorless **PEER REVIEWED** [National Fire Protection Association. Fire Protection Guide on Hazardous Materials. 9th ed. Boston, MA: National Fire Protection Association, 1986.,p. 49-39
3. Colorless liquid (usually a mixture of cis & trans isomers). **QC REVIEWED** [NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 98
Odor:
1. ETHEREAL, SLIGHTLY ACRID **PEER REVIEWED** [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 15
2. PLEASANT **PEER REVIEWED** [Hawley, G.G. The Condensed Chemical Dictionary. 10th ed. New York: Van Nostrand Reinhold Co., 1981. 335
3. Chloroform-like **PEER REVIEWED** [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.
4. Slightly acrid, chloroform-like odor. **QC REVIEWED** [NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 98
Melting Point:
1. -50 deg C **PEER REVIEWED** [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3551
Molecular Weight:

1. 96.95 **PEER REVIEWED** [Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 15

Corrosivity:

1. 1,2-Dichloroethylene will attack some forms of plastics, rubber, and coatings. **PEER REVIEWED** [Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) PublicationNo. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981. 2

Density/Specific Gravity:

1. 1.27 at 25 deg C (liquid) **PEER REVIEWED** [U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous

# Attachment 2

# Calculation of Equilibrium Soil Gas Concentration

Calculation of equilibrium soil gas concentration for TCE in groundwater at 500 μg/L

$\mu g \equiv gm \cdot 10^{-6}$

$H := 1 \cdot 10^{-2} \cdot \frac{atm \cdot m^3}{mole}$ ...Henry's Law Coefficient (Attachment 1)

$Cw := 500 \cdot \frac{\mu g}{liter}$ ...concentration in water

$MW := 131.4 \cdot \frac{gm}{mole}$ ...molecular weight of TCE

$R := 0.08206 \cdot \frac{liter \cdot atm}{K \cdot mole}$ ...gas constant

$T := 293 \cdot K$ ...temperature

$Cair := Cw \cdot \frac{H}{R \cdot T}$ ...Henry's law (Fetter, 1993)

$Cair = 208 \cdot \frac{mg}{m^3}$ $Cair = 208 \cdot \frac{\mu g}{liter}$

$P := 1 \cdot atm$ ...assume air pressure is 1 atm

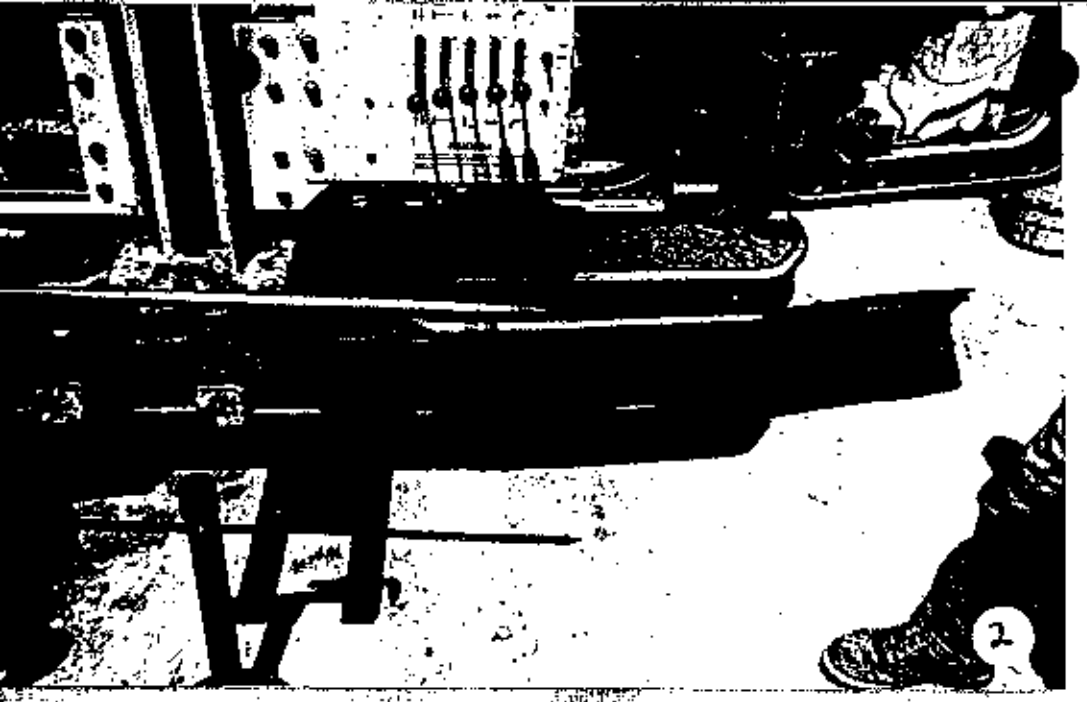
$PPMair := Cair \cdot \frac{R \cdot T}{MW \cdot P} \cdot 10^6$ $PPMair = 38.1$ ...concentration expressed in ppm

# Attachment 3

# Photographs

## Photo Log

1. View of van at SG-02 looking southwest.
2. Drive rod with expendable drive point laying horizontal beneath control panel and above black temporary iron pipe at SG-02.
3. Geoprobe® van at SG-02 with Raffinate Pit 3 in background.
4. Steam cleaning drive rods at the Building 434 decon pad.
5. Pressure gages inside Geoprobe® van.
6. Pushing the sample probe at SG-29.
7. Drawing a soil gas sample with portable vacuum chamber.
8. Portable vacuum chamber.
9. Sample of soil gas in 1-liter Tedlar bag.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