REPORT OF RESULTS OF THE VAPOR VACUUM EXTRACTION TEST AT THE RADIOACTIVE WASTE MANAGEMENT COMPLEX (RWMC) ON THE IDAHO NATIONAL ENGINEERING LABORATORY (INEL) IN THE STATE OF IDAHO[a]

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INTRODUCTION

A test-scale vapor vacuum extraction (VVE) system was installed and operated at the Radioactive Waste Management Complex (RWMC) on the Idaho National Engineering Laboratory (INEL), which is west of Idaho Falls, Idaho and is managed by the U.S. Department of Energy Idaho Field Office. The system was constructed for the purpose of demonstrating the feasibility of VVE or vapor venting technology to abate a volatile organic compound (VOC) plume located in the vadose zone below the subsurface disposal area at the complex. To date, the system has been operated for two periods, a two-week test and a four-month test. The purpose of the two-week test was to determine what would be extracted from the borehole and to verify the design of the system to handle what would be extracted. The three goals of the four-month test were:

- To provide adequate data to verify and refine a computerized flow model that is based on extrapolation of operating data obtained from existing smaller scale VVE processes and from substrata permeability data previously obtained at the RWMC site, and that will be used to baseline vadose contamination and to predict remediation results
- To verify that a large-scale VVE process would be a viable interim remedial process to remove the VOC plume
- To provide sufficient and adequate data to enable design of a scaled-up VVE production system.

This depth of recovery for VOCs is unique and should add to the information available for low depth (less than 100 ft) venting. The progress of the demonstration of this technology to abate the VOC plume in a radioactive landfill where fixed liquids were disposed and liquid vapors are migrating down toward underground water sources will be discussed.

TEST SITE DESCRIPTION

The VVE system (pilot-scale facility) is located on the INEL, which is located in southeastern Idaho. Within the INEL site is the Radioactive Waste Management Complex (RWMC), which is a landfill for radioactive solid waste disposal. The RWMC is located in the southwest corner of the INEL site and comprises approximately 150 acres of level ground in a shallow valley, about 5,000 ft above mean sea level, enclosed on three sides by low hills. The landfill is divided into primarily two areas: subsurface disposal area (SDA) and transuranic storage area (TSA). The SDA, where the VVE system is located, is 88 acres and was used from 1952 to 1970 as a radioactive and chemical waste disposal area. At various times during this period, waste was disposed from operations at the INEL and other Department of Energy facilities. A majority of the waste was contained in drums and wooden boxes. In most cases, disposal was in pits or trenches that were excavated in the surficial sediment down to just above the basalt. The waste was covered with at least 3 ft of

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soil. According to disposal records, an estimated 88,400 gal of organic waste was composed of 24,400 gal of carbon tetrachloride, 39,000 gal of oil used in machining processes, and 25,000 gal of other organic waste, including trichloroethane, trichloroethylene, perchloroethylene, and used lubricating oils. These solvents were adsorbed in calcium silicate and placed and sealed in 55-gal drums. These drums, buried at the SDA, are believed to be the source of the VOCs that are located in the vadose zone.

SUBSURFACE DESCRIPTION UNDER THE SDA

The subsurface under the SDA is comprised of surficial sediments and interbeds of sediment and basalt. The surficial sediment layer varies from 1 to over 23 ft, reflecting differences in the surface of the underlying basalt bedrock. The vadose zone beneath the SDA is primarily highly fractured basalt with many of the fractures containing clay particles transported down by water. A sequence of basalt-flow groups underlie the RWMC to 700 ft and have very similar petrographic characteristics, suggesting that they erupted from the same magma source. The basalt bedrock is interspersed with several sedimentary interbeds. Two of the largest interbeds exist at 110 and 240 ft below land surface of the SDA. The presence and thickness of these interbeds varies. The composition of these interbeds also varies from silty clays, sands, gravel, and organic rich paleosols. Located at a depth of about 600 ft from land surface at the SDA is the Snake River Plain Aquifer. The aquifer is about 206 mi long, 30 to 60 mi wide, and covers an area of about 9600 mi^2. The aquifer is generally flowing southward in the area of the SDA.

SAMPLING TO MONITOR MIGRATION OF CONTAMINANTS

Concern of the migration of contaminants from the SDA to adjacent soil, bedrock, and eventually to the aquifer prompted the monitoring of the area around the SDA as early as 1960. In 1987, measurable concentrations of VOCs were present in well water samples in and near the SDA, and measurable concentrations of VOCs were present in soil gas samples taken from 2000 to 3400 ft from the SDA boundary. Soil gas samples collected at various depths beneath the SDA indicated a maximum gas concentration at around 100 ft and measurable concentrations at 576 ft. Sampling and modeling to define the plume of VOCs beneath the surface were performed. Analysis has identified five major VOC contaminants: carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, chloroform, and tetrachloroethylene.

DESCRIPTION OF TEST SCALE VAPOR VACUUM EXTRACTION SYSTEM

The test-scale vapor vacuum extraction system (TSVVE) consists of an extraction well, an extraction blower and vapor treatment equipment, five monitoring wells, a data acquisition system (DAS), and a gas sampling and analysis system. The extraction well is connected to a centrifugal blower through an in-line heater, cyclone separator, prefilter, high-efficiency particulate air (HEPA) filter, carbon bed adsorber, and after filter (see Figure 1). The in-line heater provides relative humidity control to minimize water vapor condensation in filters and carbon beds. The cyclone separator, prefilter, and HEPA filters are designed to remove particulates that are as small as 15 μm. The carbon beds remove the VOCs from the extraction stream prior to release of the air and vapors to the atmosphere. The layout of the five monitoring wells, denoted as 8801D, 8902D, D02, 78-4, and WWW-1, are 82, 175, 443, 1398, and 3914 ft from the center of the extraction well (8901D), respectively. The extraction well was drilled to a depth of 241 ft, cased from ground surface to 90 ft, and screened from 90 to 220 ft. The monitoring wells were drilled to depth of 235 to 258 ft and had five, seven, eight, or nine sampling ports installed at various levels from 30 to 240 ft. All sample ports were constructed by centering a short length of stainless steel well screen at the desired depth and packing a 5-ft section with gravel. The gravel pack was capped with a bentonite plug and the wellbore was filled with cement

to the elevation of the next sample port. Each well screen was connected to the ground surface by 3/8-in. stainless steel tubing.

MODELING OF VAPOR PLUME UNDER THE SDA

Modeling has defined the VOC plume as illustrated in Figures 2, 3, and 4. Figure 2 illustrates the concentration of carbon tetrachloride at about 75 ft below the surface of the SDA. The contour lines radiate uniformly from the point of high concentration and indicate that the soil characteristics are assumed homogeneous. Figure 3 and 4 are cross-sections, A-A' and B-B', that are looking toward the north and west, respectively. The soil characteristic in this direction is heterogeneous in that the migration is blocked by the intersoil layer at 110 and 240 ft. The characteristics of the basalt layers in the model are homogeneous, anisotropic.

TWO-WEEK TEST RESULTS

To verify the operation of the TSVVE system and to verify the gas stream VOC concentration and radiation concentration, a two-week test was proposed and operated during November 3–15, 1989. The two-week test results indicated that (a) the concentration of all five VOCs (carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, chloroform, and tetrachloroethylene) were initially measured and decreased through the test until only carbon tetrachloride and trichloroethylene were detectable; (b) the total VOC concentration was less than expected or design concentration; (c) no radionuclides were noticed in any of the particulate separation units; and (d) traces of daughter products of radon were noticed in carbon bed samples.

FOUR-MONTH TEST RESULTS

After the evaluation of the two-week test data, a four-month test was scheduled for April 12, 1990, and operated somewhat continuously (two major outages occurred) until August 13, 1990.

In the closest monitoring well, 8801 (82 ft from the extraction well), the concentration of carbon tetrachloride at the 131- and 167-ft levels decreased (see Figure 5). This area is described as a rubble zone or area where the basalt rock is fractured significantly to allow the flow of the interstitial gases and vapors. The high levels indicated an increase in concentration. This area is in a different layer and is nearer to the source contamination. According to the mass balance data on the carbon bed, about 600 kg of VOCs were removed from the vadose zone under the SDA. These data indicate that removal of VOCs is possible. Comparison of the modeling data and the data from the testing was good qualitatively and quantitatively (see Figure 6). The original prediction for the removal of VOCs from the vadose zone was after three months of operation there should be a very noticeable decrease in the gas concentration upwards to 200 ft in a radial direction from the extraction well. However, the test data indicated very little change in concentration at the monitoring well at 82 ft. The modeling parameters required to be adjusted in the model cannot be determined from the test data. Therefore, information for design of a remediation facility is also lacking and further testing is required.

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DISCLAIMER

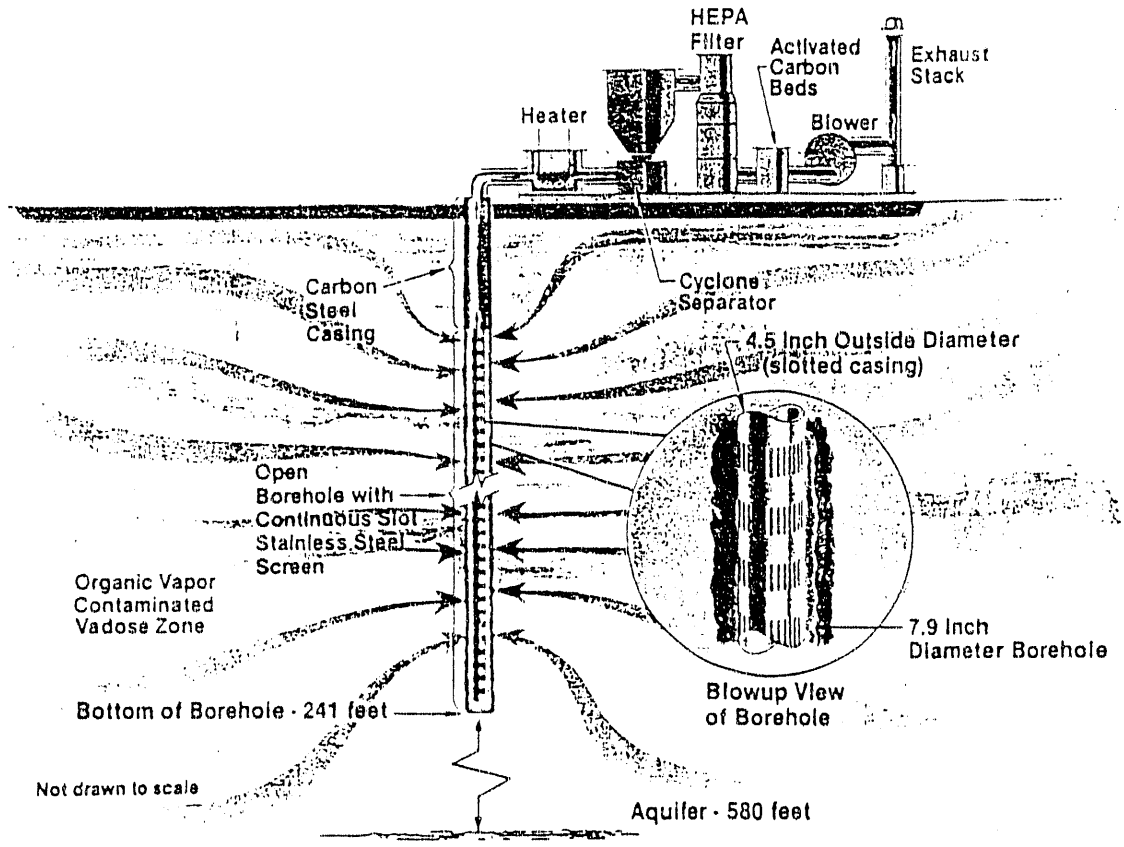

Figure 1. Vapor vacuum extraction demonstration.

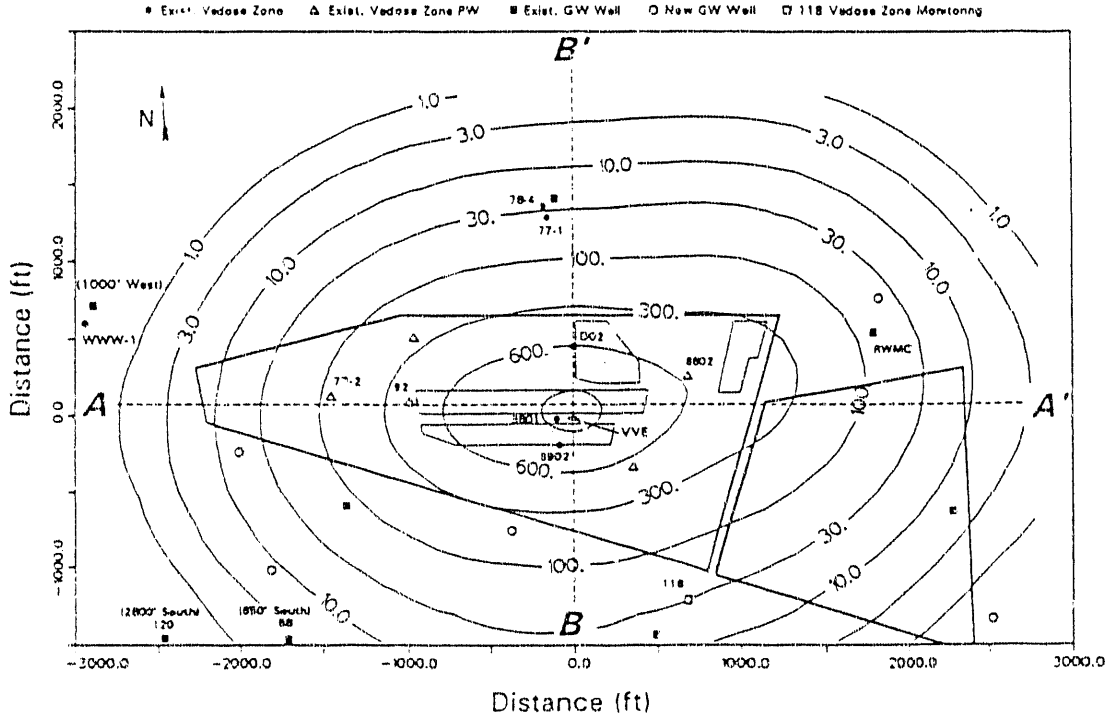

Figure 2. Simulated CCl_4 concentrations (ppm) at approximately 75-ft depth.

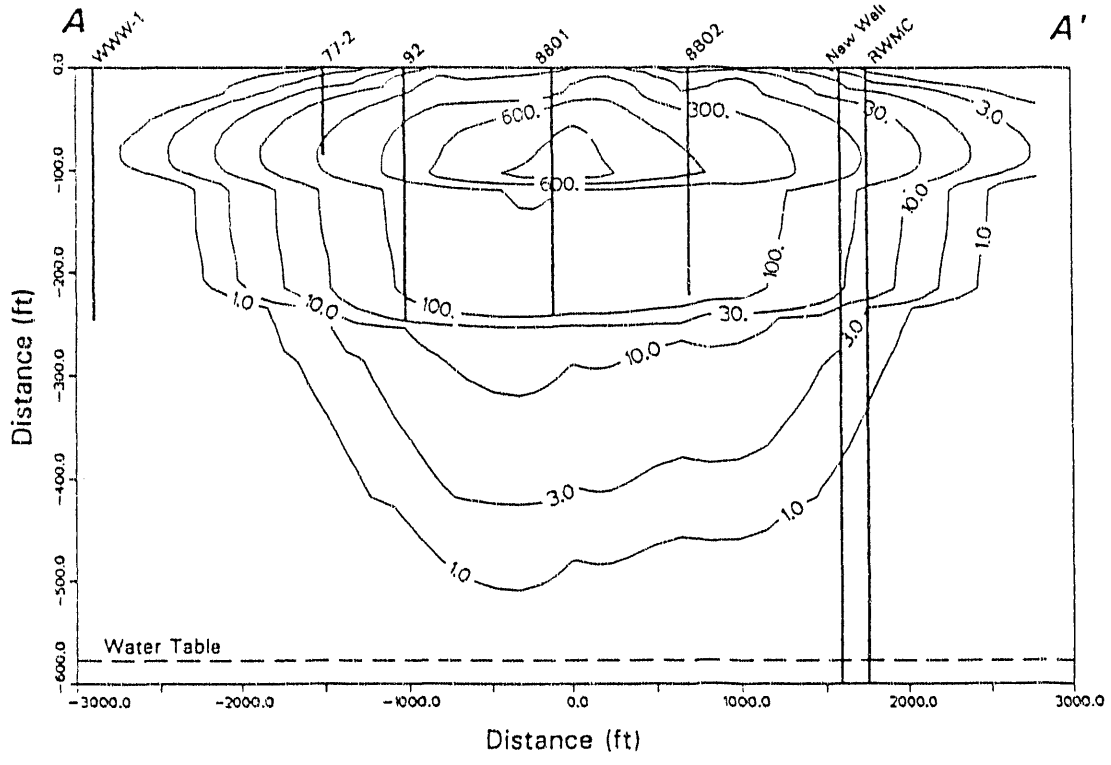

Figure 3. Simulated CCl_4 concentrations (ppm); cross-section A-A' looking north.

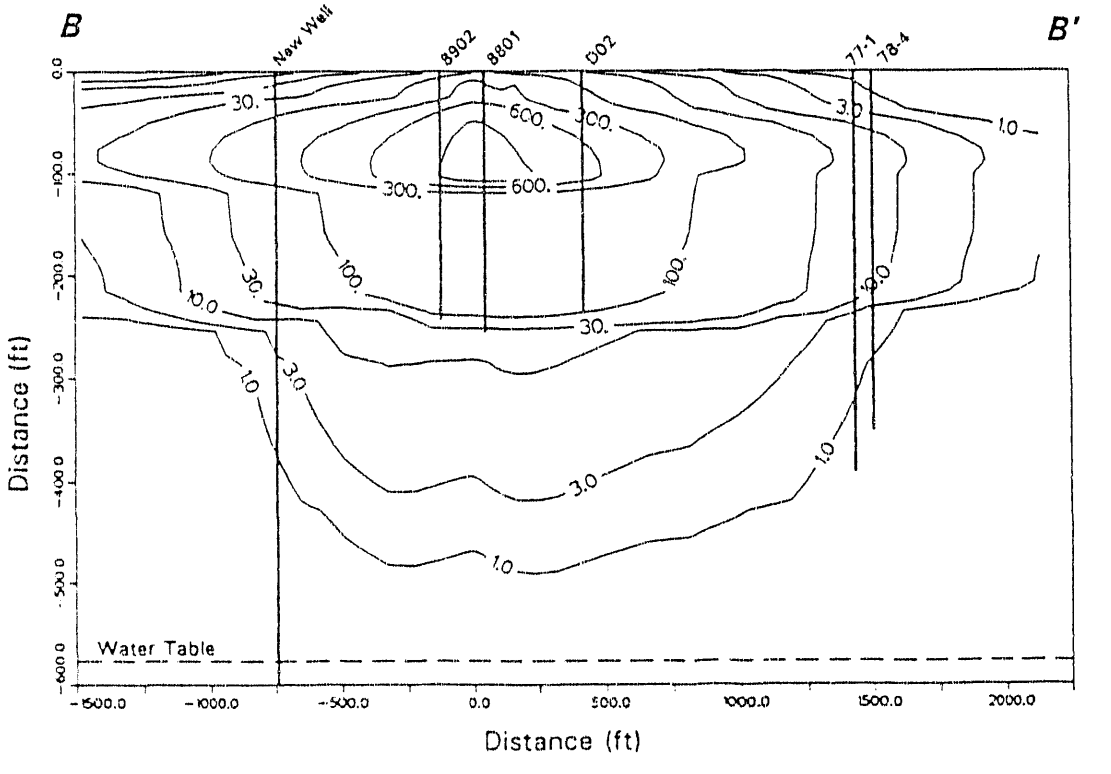

Figure 4. Simulated CCl_4 concentrations (ppm); cross-section B-B' looking west.

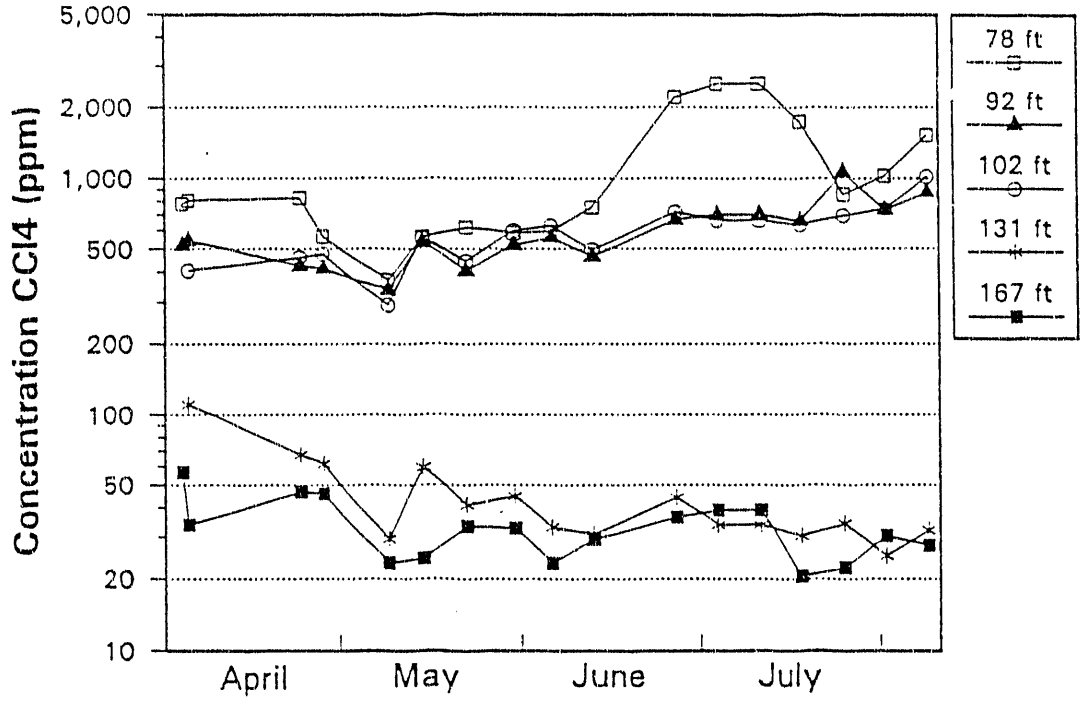

Figure 5. CCl_4 concentration at monitoring well 8801 (four-month test).

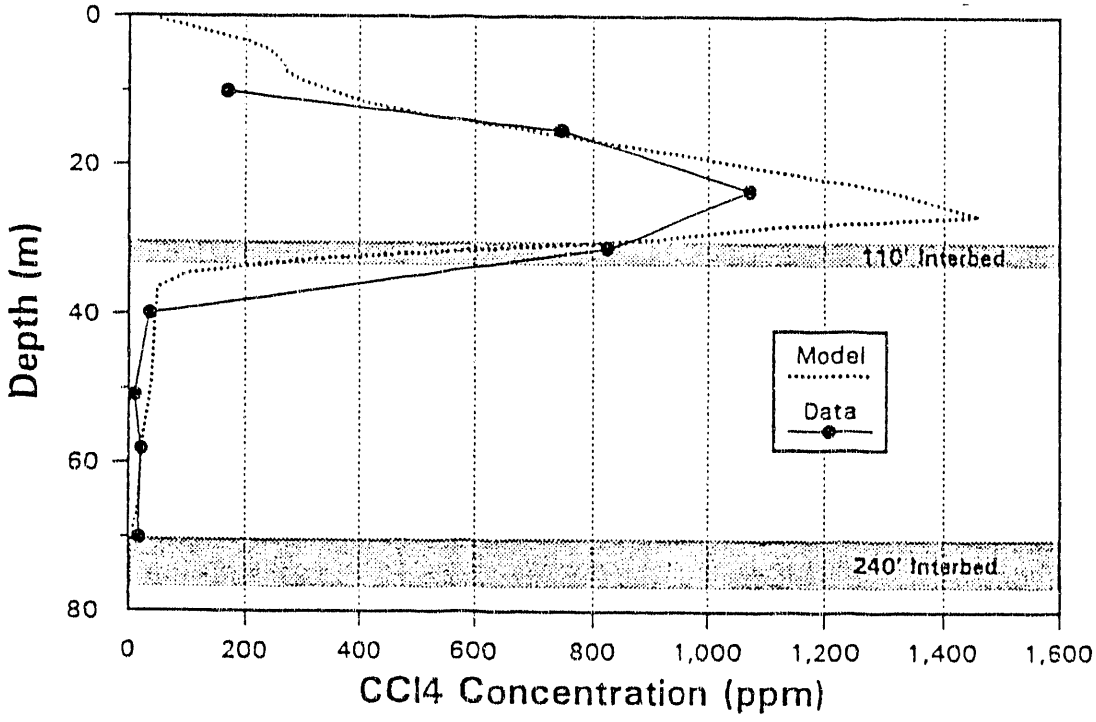

Figure 6. CCl_4 concentration profile at monitoring well 8801D.

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