Conf-930932--1

WSRC-MS-93-039

CHARACTERIZATION AND RECLAMATION ASSESSMENT FOR THE CENTRAL SHOPS DIESEL STORAGE FACILITY, SAVANNAH RIVER SITE, AIKEN, SOUTH CAROLINA (U)

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A document prepared for:
publication in 1993 International Symposium on Subsurface Microbiology
publication in the *Waste Management and Research Journal*, Denmark
at Kant, England
from 09/93 thru

MASTER

DOE Contract No. **DE-AC09-89SR18035**

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Abstract

The contamination of subsurface terrestrial environments by organic contaminants is a global phenomenon. The remediation of such environments requires innovative assessment techniques and strategies for successful clean-ups. Central Shops Diesel Storage Facility at Savannah River Site was characterized to determine the extent of subsurface diesel fuel contamination using innovative approaches and effective bioremediation techniques for clean-up of the contaminant plume have been established.

1.0 INTRODUCTION

This report summarizes the environmental characterization data and a bioreclamation feasibility assessment for the Central Shops Diesel Storage Area at the Savannah River Site in Aiken, South Carolina, and is a part of a remedial action investigation for the contaminated soils and sediments at the Central Shops Diesel Storage Area.

1.1 Background

Large volumes of groundwater and vadose zone sediments throughout the world have become contaminated with industrial and agricultural wastes over the centuries. Abelson (1989) has tried to place the problem in perspective in that as many as 375,000 underground storage tanks in the United States have leaked and endangered groundwater systems. The problem is far more extensive than under ground storage tanks and the North American continent. The problem is not unique to American soils in that Poland has recently reported that during the last 20 years approximately 40,000 tons of highly toxic agricultural wastes have been buried in Poland (Amador, 1992). Such estimates appear highly underestimated and the real volumes are likely to be as much as 100% higher.

Abelson also points out that the clean-up of groundwater contamination will often require 20-40 years with costs in the area of $500 billion using current cost effective technologies. A technology that promises to reduce these costs, yet provide an effective clean-up, is bioremediation, the use of indigenous biological processes to destroy or immobilize contaminants. Traditionally scientists have underestimated the power, capabilities and diversity of the subsurface microbial communities. The usefulness of indigenous microorganisms for *in situ* bioremediation of groundwater and sediments pollutants has been documented as a result of the Integrated Demonstration Program at SRS (Hazen, 1991) and provides new mechanisms for the remediation of subsurface environments contaminated with organic wastes.

Underground storage tanks at the Central Shops Diesel Storage Facility at the Savannah River Site (Figure 1 and 1a) were installed in 1955. The tank farm contained ten underground carbon steel storage tanks each having a capacity of 15,000 gallons. The facility was used to store diesel fuels and on occasion gasoline. In December 1987, water that leaked from an underground water line near the Central Shops Diesel Storage Facility had considerable quantities of petroleum hydrocarbons. The contamination was presumed to be a result of handling and storage of diesel fuel, although other potential sources of contamination, such as a former lubrication and oil change area, were present in this area. Tanks suspected of leaking were taken out of service and a soil gas survey was conducted to determine whether hydrocarbons had leaked into the surrounding soil (Looney *et al.*, 1988). The soil gas survey indicated that volatile components of diesel fuel were detected in high concentrations and that large amounts of methane were also being produced (Figure 1b). The production of methane was indicative of biological degradation of the diesel fuel in the soils.

The characterization study reported here was begun in November 1988 and consisted of sampling and analyzing the shallow soils, sediments and groundwater to determine the extent, both vertical and horizontal, of the diesel fuel contamination. From such characterization the feasibility of bioremediation as an option for the site remediation was determined.

1.2 Program Overview

The remediation goal for the Central Shops Diesel Storage Facility (CSDS) is to cost effectively reduce the contamination levels of petroleum hydrocarbons in the subsurface environments to levels that are acceptable to both SRS and to the regulatory agencies. This will be accomplished in a step wise approach initiated by extensive site characterization and the use of feasibility investigations for possible remediation technologies.

The assessment portion of the investigation was separated into two sets of drilling and analyses operations. Initially, 29 boreholes were drilled from the surface to the water table (60 feet) while sampling at three (3-5) foot intervals using both conventional split spoon sampling technologies for sediments and Hydropunch® (Manchon, 1992) to collect groundwater samples. The location of each of these boreholes is given in Figure 1a with their coordinates and elevations provided in Table 1. Total Petroleum Hydrocarbons (TPH), total bacterial densities, indigenous microbiological degraders of diesel fuel and selected inorganic compounds were measured. Nine (9) boreholes (CSD-1D, CSD-2D, CSD-4, CSD-8D, CSD-9D, CSD-10D, CSD-11D, and CSD-12D, CSD-13D through CSD-13D) were continuously cored, lithologically described, and monitoring wells were installed, along with data core logging to the define the geology and hydrology of the sediments and aquifer. The data for each of these wells is given in Appendix 1. Nutrient optimization investigations were conducted to determine the best nutrients to stimulate the indigenous microbial populations and determine whether such additions were compatible with sediments at the Central Shops Diesel Storage Facility. Cone Penetrometer investigations, using fiber optic hardware, were undertaken by the U.S. Army Corp of Engineers to confirm in real time the concentrations of TPH with depth and the identification of additional contamination if present.

2.0 MATERIAL AND METHODS

2.1 Site Geological Description

The Savannah River Site is located approximately 40 km from the upper (landward) margin of the Atlantic Coastal Plain and approximately 120 km from the current ocean margin. The elevation of the land's surface at the SRS ranges from 25 to 125 m above mean sea level. The wedge of sediments beneath the SRS ranges from approximately 200 m in thickness at the northern boundary to about 400 m at the southern boundary. A generalized stratigraphic section appears in Figure 2.

The basal sedimentary unit of the Coastal Plain section is the Cape Fear Formation which rests directly on the weathered and eroded surface of the igneous and metamorphic basement complex. This formation consists of firm to indurated, poorly sorted, silty, clayey sands and sandy silts and clays. The sands range from fine to typically coarse grained with common zones of granules and pebbles. The grains are angular to subangular with feldspar a common constituent in the sands and rock fragments common in the pebble zones. These characteristics are indicative of a high-energy environment close to the sediment source. This would indicate a fluvial-continental environment on the upper delta plain. The presence of montmorillonite/bentonite clay is these sediments causes some investigators to favor a marine origin. However, this clay could also have been formed as a volcanic ash deposit. The Cape Fear formation has a very low hydraulic conductivity and thus is not considered an aquifer.

Lying above the Cape Fear is the Middendorf formation consisting largely of angular, slightly silty, fine to very coarse sands. Pebble and granule zones are common in the updip section, with clay layers more common in the downdip section. These slightly silty clastic sediments constitute the best aquifer beneath the Savannah River Site and vicinity. These sediments were deposited in an upper delta plain environment.

Lying above the Middendorf is the Black Creek formation. These sediments were deposited in a lower delta plain environment and, beneath most of SRS, are characterized by the presence of lignite and iron sulfides. The sediments are generally finer in grain size than the Middendorf and thick sequences of clay and silt are common. Some sandy zones have good aquifer properties, but the unit as a whole serves as confining unit separating the Middendorf from the overlying PeeDee aquifer.

The uppermost Cretaceous unit beneath the SRS is currently unnamed, but is time equivalent to the PeeDee formation. These sediments were deposited in an upper delta plain environment in the updip section. The sediments are subangular, slightly clayey, medium-to coarse-grained sands with interbedded thick, light-colored clay units.

The Paleocene is the lowermost epoch in the Tertiary and is represented beneath the SRS by the Ellenton and Williamsburg Formations. The Ellenton typically consists of laminated, dark, lignitic clays, silts, and very fine sands deposited in a tidal flat environment and dark to light, micaceous, medium to coarse sands deposited in fluvial channel deposits. Iron sulfides are common and the water in these sediments is sulfate rich due to' the oxidation of the sulfides. The Williamsburg formation consists of light-colored clays and light-colored, micaceous, clayey, medium to coarse sands deposited in the fluvial environment indicative of the upper delta plain-lower delta plain interface. While the sand zones within these formations constitute minor aquifers, these Paleocene nits act as the major confining unit separating the Tertiary aquifers form the Cretaceous aquifers.

The Congaree formation is the lowermost Eocene unit and represents a beachfront environment. These sediments are typically subrounded, well-sorted, clean sands ranging from fine to very coarse with some granule zones. The Congaree is the most productive aquifer within the Tertiary Coastal Plain sequence beneath SRS. The McBean formation rests on top of the Congaree. At the base of the McBean is a glauconitic clay horizon sometimes referred to as the "green clay". The significance of the glauconitic clay is that it is a reduced iron-silicate mineral indicative of deposition in a low oxygen, nearshore marine environment. This grades upward into a very fine to medium, clean "beach" sand, a calcareous sand, a marl, or a limestone. Dissolution of the calcareous material in this formation by the groundwater had in places produced solution cavities and subsequent collapse structures. These two formations are of the middle Eocene age.

The overlying late Eocene unit, the Dry Branch formation, was deposited in more open and oxidizing, shallow shelf marine conditions and consists of laminated clays and Clinchfield Sands, Griffin Landing and Irwinton Sand members. The Twiggs clay lithofacies is interbedded with these members and can appear anywhere in the section. The Twiggs clay is sometimes referred to as the "tan clay" and consists of thin, laminated clays and clayey sand. The Clinchfield Sand occurs at the base of the formation and the Irwinton Sand at the top. The Griffin Landing member consists of limestone and calcareous sands. The uppermost Eocene unit is the Tobacco Road formation, which consists of red, purple, white, and orange laminated or mottled, clayey, very fine to fine sands and sandy clays. The depositional environment is a shallow shelf as is the Dry Branch formation but represents the deeper facies on the seaward side, whereas the Dry Branch was deposited closer to the beach face.

Overlying and cutting into this uppermost Tertiary formation is the Upland unit consisting of clayey, poorly sorted, felspathich, angular, pebbly coarse sand and sandy pebble zones. Cross-bedding is evident in outcrop. These sediments represent fluvial channel cuts into the late Eocene beds probably during Oligocene or Miocene units.

2.2 Site Geology and Hydrology

The soils at the Central Shops Diesel Fuel Facility site can be characterized as containing 4 to 6 feet of topsoil which is generally underlain by 15 feet of mottled clay or sandy clay. Poorly sorted and tightly packed sands and clayey sands with numerous small silty clay seams are found beneath the clay layer. The sands become more cross bedded with depth and generally contain less clay. A perched groundwater table was encountered in several borings at approximately 25 feet below land surface at the top of a sandy clay interval.

The mineral composition of three sediment samples from CSD-9D was determined by X-ray diffraction. The samples from 62 to 64 feet and 66 to 67 feet were predominantly quartz sand with a small amount of kaolinite. The third sample, from 67 to 68 feet, is a mixture of quartz with minor amounts of hornblende, kaolinite, and aragonite. The grain size distribution is given below:

Depth (ft)	Coarse Sands	Medium Sands	Fine Sands	Very Fine Sands
62-64	30%	50%	20%	
66-67	5%	27%		68%
67-68	15%	52%		33%

2.3 Sediment analyses

On the basis of data from the soil gas survey a drilling program was conducted in December, 1988 and January, 1989 which was designed to characterize both the lateral and vertical extent of the diesel contamination in the soil. All soil samples were collected from the first 13 boreholes (Figure 1) and analyzed for total petroleum hydrocarbon by extraction with EPA Method 9071 and quantified using EPA Method 418.1. The minimum detectable limits for laboratory analyses were 1 mg/kg; however, all values less than 5 mg/kg were considered below detectable limits. Spiked recoveries for the assays averaged 80%. EPA Method 3540 was a soxhlet extraction with freon, while EPA 418.1 involved cleanup of the freon extract with silica gel to remove nonhydrocarbon components and quantify the total petroleum hydrocarbons by infrared analyzes (FTIR). All groundwater samples had less than 1.0 ppm of total petroleum hydrocarbons (Table 2).

The concentrations of selected inorganic nutrients in the groundwater were also determined by inductively coupled plasma emission spectrometry for selected metals and anions. Specific attention was given to lead concentrations since the storage tanks at the facility had on occasion contained leaded gasoline. Total lead analyses of the sediments and water were conducted using EPA 239.2 protocol with laboratory control standards within the control limits of 80-120% recovery. All water samples were processed within the holding time required by EPA's 40CFR136, although holding times for soil and sediment samples have not been promulgated by EPA at this time. The data in Table 3 indicate the concentration of lead in the sediments for the boreholes, while the data in Table 4 denote the concentration of lead in the groundwater for screened wells along with maximum concentration of lead found in the sediments of a given borehole.

There was some dissolved aluminum in the groundwaters, ranging from 1.2 to 4.6 mg/L. The only other metals to be found above the detection level were zinc at 0.06 mg/L in CSD-4D and iron at 1.26 mg/L in CSD-13D and 3.95 mg/L in CSD-11D. The presence of moderate dissolved iron in the groundwater may make it difficult to add oxygen to the system if *in situ* bioreclamation is chosen as the remedial alternative. Well CSD-4D contains higher levels of calcium, sodium, and potassium than the other two wells. Most inorganic nutrients required for microbial growth are present, although probably not at levels necessary for maximum growth and biodegradation of the organic contaminants. There was nitrogen in the form of nitrate present in the groundwater, ranging from 0.6 to 1.6 mg/L, but no nitrite was detected. Orthophosphate levels are below 5 mg/L. Other minerals required for microbial growth such as magnesium, manganese, potassium, sodium, chloride, and sulfate were found in low quantities in almost all of the samples.

2.4 Microbiological Methods

Sediment samples were collected for microbial investigations as previously describes (Phelps, *et al.*, 1989) and density and physiological characteristics of the indigenous microbial populations determined. Biological activity, as measured by colony forming units, was conducted on the soil, sediment and groundwater samples using standard microbiological plating techniques. The total heterotrophic microbial population was enumerated on Difco nutrient agar using the pour plate technique. Bacterial populations capable of using hydrocarbons were plated on mineral salts medium with diesel fuel hydrocarbons as the sole carbon source. The mineral salts medium contained washed agar and essential inorganic nutrients. Three drops of the diesel fuel were placed on a filter paper in the inverted lid of the petri dish; the diesel vapors provided the carbon for growth of the hydrocarbon-utilizing microorganisms. Groundwater from the site was filter sterilized and used as the diluent. All samples were plated within 24 to 36 hours of collection. Total heterotrophic bacteria populations were enumerated after a seven (7) day incubation period at 20 °C and the hydrocarbon-utilizers were counted after 26 days. Microbial counts for both the heterotrophic populations grown on Plate count agar and diesel-utilizing bacteria (DU) are presented in Table 5.

2.5 TREATABILITY STUDIES

2.5.1 Nutrient Study

In order to achieve maximum rates of biodegradation within a sediment and aquifer ecosystem, both inorganic nutrients as well as oxygen may be required as nutritional additives. Since each ecological habitat has different microbial consortia, the combination of inorganic nutrients necessary for maximum growth is specific for each site. A total of 34 combinations of inorganic nutrients were examined to determine which combination would give the maximum stimulation of the microbial population. Aliquots (50 ml) of the mixture of groundwater from three (3) wells, CSD-4D, CSD-11D, and CSD-13D, were placed in quart reaction bottles. The appropriate combinations of stock solutions of inorganic nutrients (Table 6) were added to each bottle, along with 50 µl of diesel fuel to serve as the sole organic carbon source. Negative controls did not contain the diesel fuel. An additional 50 µl of diesel fuel was added after one week. At the end of the two week incubation period, the vessels were acidified to dissolve any precipitates and stop microbial growth, and the cell yield was gravimetrically determined.

The groundwater in each reaction vessel was centrifuged to concentrate the cells, and the cells were collected on pre weighed filter paper. The weight of the cells and thus biological production was determined after drying the filters overnight at 105 ^{o}C.

2.5.2 Nutrient Stability Tests

A series of investigations designed to determine whether the introduction of the most effective nutrient solution would affect the permeability of the soil was conducted. The interaction between the soil and nutrient solution was determined using columns which were packed with the site soil and dosed consecutively with the groundwater, nutrient solution in groundwater, and an oxygen source (hydrogen peroxide). The nutrient stability tests were also used to determine the interaction between hydrogen peroxide and the soil.

2.5.3 Biodegradability Studies

Biodegradation studies were establish to determine the ability of the diesel contaminants to be removed biologically. Sediment samples were collected from soil boring CSD-13 (Figure 1a) at 17 feet and utilized in the mineralization study of the diesel contaminants. The sediment samples were predominantly clay and contained approximately 432 ppm of total petroleum hydrocarbon. The volatile fraction of diesel and dodecane was followed by headspace gas chromatography analyses using a Perkin-Elmer Model 8320 gas chromatograph equipped with a Model HS-6 headspace analyzer. These analyses measured an unknown fraction of diesel fuel, but demonstrated a reduction in the overall concentration of diesel fuel.

Sediment samples were heated for 10 minutes at 85 °C in the HS-6 headspace analyzer. The following gas chromatographic program was used for the analyses: initial hold at 50 °C for two minutes; temperature programmed up to 100 °C at 10 °C/minute followed by a one minute hold; a second temperature programmed up to 250 °C at 15 °C/minute and a final hold of 2 minutes. Calibration curves for the total volatile fraction were prepared by peak area analyses. The concentration of dodecane was determined from the peak area matching the retention time of dodecane standards; other compounds may have co-eluted with the dodecane and prevented an accurate determination of the dodecane concentration.

The non-volatile total petroleum hydrocarbon (TPH) fraction was measured by dewatering of the sediment sample overnight in a 105 °C oven; soxhlet extraction of the dried soil with freon (EPA Method 3540); cleanup with silica gel; and quantified by infrared analysis (EPA Method 418.1).

Four perturbation treatments for the biodegradation studies included the following 1). a nutrient amended series; 2). an unamended series; 3). a nutrient amended control series; and 4). an unamended series. A series of positive nutrient amended controls as well as a series of unamended negative controls were included. Poisoned controls accounted for losses from the system other than those due to microbial activity. Two hundred fifty grams of sediment from boring CSD-13 were placed in a large beaker and thoroughly mixed. Ten gram portions of the sediment were placed in sterile 70 ml serum bottles for the TPH test series and 1 gram portions were placed in sterile 9 ml vials for the volatile test series.

The first perturbation treatment was prepared with 100 ml of groundwater amended with 687 mg/L phosphate, 160 mg/L potassium, 336 mg/L ammonia, 57 mg/L carbonate, 3, 6 mg/L calcium, 19.5 mg/L magnesium, 4 mg/L manganese, 1 mg/L iron, 87 mg/L sulfate, 670 mg/L chloride, and 172 mg/L sodium. Ten milliliters of the groundwater nutrient solution were added to each serum bottle in the TPH series and 1 mL into the volatile series.

The second perturbation treatment received only groundwater.

The groundwater used in the third perturbation treatment was amended with the same combination of inorganic nutrients as the first series, but also received 4 mL of sulfuric acid, a poisoned control agent. The fourth perturbation treatment was prepared with 100 mL of groundwater and 4 mL of sulfuric acid.

Each serum bottle was sealed with a sterile teflon-lined rubber septa and mixed with a vortex mixer. All of the serum bottles were incubated at 22 °C.

Another biodegradation test was set up to determine whether the contaminated sediments could be treated with a vacuum system to provide the oxygen necessary for biodegradation of the diesel fuel and remove the volatile fraction of diesel. A glass column was packed with 100 grams of the contaminated sediments from CSD-13D. The sediment was periodically moistened with a nutrient solution prepared from the groundwater which was amended with the inorganic nutrients described in Table 6. A vacuum of 200 mm Hg was placed on the bottom of the column and air was drawn through the column. Samples were removed periodically and analyzed by EPA Method 418.1 for total petroleum hydrocarbon.

2.5.4 Two- and Three-Dimensional Visualization

A two dimensional contour mapping program MacGridzo® (RockWare, Wheat Ridge, CO) for the Macintosh computer was used to prepare maps of the distribution of TPH concentration from discrete ten foot thick intervals. The plots are shown in Figures 4-7. These maps suggest that the TPH plume has moved in a southwesterly direction following the land surface topography. Because of the extensive clay deposits in the vadose zone, horizontal migration has greatly exceeded vertical migration. In fact, more than 80% of the contamination is confined to the upper 20 feet of the soil column, see Figures 4-7.

In order to better visualize the distribution of contamination, three dimensional images were prepared using a three-dimensional modeling software package (Interactive Volume Modeling™ (IVM), version 5.0, Dynamic Graphics, Alameda, CA). These models were created from irregularly spaced data values specified by an x, y, and z coordinate and a property value. The data values were transformed into a regularly spaced three dimensional grid with a minimum tension gridding technique utilizing a bicubic spline algorithm. The resulting three-dimensional grid files was used to create display file shown in Figures 8a-d. Surfaces were used to define the boundaries for the three-dimensional grids. Display files were created from the grid by specifying a series of concentration surfaces to be contoured. The display files may be interactively viewed from any angle, layers and sections may be removed, and selected concentration zones may be interpreted and analyzed.

The results from the three-dimensional imaging data are shown in Figures

8a-d and give a three-dimensional perspective of the contaminant plume. The bulk of the contamination lies in a region that corresponds to a low spot in the terrain and may represent a sink for the TPH. The TPH distribution suggests that very little extends beyond the area already investigated. The hydrology, geology, topography and nature of the contaminant suggest that the diesel fuel contaminating the sediments in this area is moving very slowly or not at all and has not impacted the groundwater in the area.

3.0 RESULTS

The contamination assessment program revealed widespread contamination of the soils and sediments with TPH. The majority of the contaminants were found between the 0 to 15 foot depth interval. Sediment borings to the east of the underground fuel storage area, did not show detectable concentrations of total petroleum hydrocarbon in the intervals that were sampled. Plume analyses as depicted in Figure 8 a-d indicates that the plume is primarily associated with the top 15 feet of soil and sediments. Deep but small pockets of petroleum hydrocarbons were abserved CSD-9 and CSD-23 at depths of greater than 60 feet.

The concentration of total petroleum hydrocarbons (TPHs) in individual soil and sediment samples is given in Table 2. Sediment borings in the fuel storage area (CSD-3D, 4D, and 5D), had an average of 256 ppm in the 0-15 foot zone. Isolated zones showed contaminant concentrations of less than 160 ppm in the soils from 15 to 82 feet in CSD-4D. CSD-6D, located to the north of the diesel fuel storage area, had a concentration of 5,040 ppm at the 10-12 foot interval below land surface. Sediments from CSD-7D showed contamination above the detection limits only at 6 feet below land surface. CSD-8D appeared to be clean except for one sample at 41 to 43 feet that showed a very low level of contamination. Contaminant levels above 100 parts per million were found in CSD-9D at depths down to 72 feet. Sediments from CSD-10D and CSD-12D did not show PAH's above detectable limits and appeared to be outside the plume of contamination. Sediments from CSD-11D and 13D revealed relatively high levels of contamination in the surface soils. CSD-11D did not show any contamination below 15 feet but CSD-13D showed contamination extending to 57 feet. The presence of contaminants in CSD-9D, 11D, and 13D demonstrated that the plume is quite extensive.

Total petroleum hydrocarbon analysis revealed values ranging from 4.1 to 5040 mg/kg of sediment. Analyses of groundwater collected through HydroPunch® sampling continued to demonstrated undetectable concentrations of TPH in the groundwater, even though sediment concentrations in the unsaturated zone were often high. The TPH analysis of soils indicated that the absolute extent of contamination has not yet been determined on the western-most boundary of the area. However because the highest TPH concentrations at the boundaries were just above detection limits and coincide with the calculated outer edge of the contamination, we believe that the zone of contamination has been adequately defined.

The monitoring wells have not shown detectable levels of dissolved hydrocarbons (Appendix II). The sample from monitoring well CSD-13D did not contain any acid extractables or base neutral compounds at levels above the limit of detection except for bis (2-ethylhexyl) phthalate. The first analysis for this contaminant was reported to be 2,630 μg/L. A re-extraction showed a concentration of 50 μg/L, just above the limit of detection (40 μg/L). It is likely that the presence of this compound is a result of laboratory contamination rather than from the well itself. Analysis of the groundwater for volatile organics by EPA Method 624 showed no VOCs at levels above the limit of detection (<5-10 ppb) for the method. The field and trip blanks did not contain any volatile organics except methylene mhloride which was found in all samples including the method blank indicating that it is most likely laboratory contaminant.

The microbial count in the soils and sediments were generally quite low (Appendix III). Most of the samples contained fewer than 100 colony forming units per gram of sediments for the total bacterial counts and 200 colony forming units per gram od sediments for the hydrocarbon-utilizing bacteria. These limits of detection represent the minimum number of microorganisms that can be counted by the procedures used in the tests. In the surface soils from 0 to 15 feet, elevated total microbial counts were found for Borings 3, 4, 5, and 6 which are in the vicinity of the tank storage area. However, only Boring 5 had elevated hydrocarbon-utilizing counts. Elevated microbial counts were found in the sediment samples deeper than 15 feet in only a few instances. Boring 10 had elevated counts in the range from 45 to 60 feet.

The groundwater microbial counts were somewhat higher than the sediments for two of the three wells (Appendix III). Total plate counts ranged from $3.6X10^3$ - $4.4X10^4$, while hydrocarbon-utilizers ranged from $4.2X10^3$ -

$1.48X10^4$ per ml. Well CSD-4D had no culturable organisms. The field and trip control blanks ranged from 10-20 cfu per ml of sample. Thus aseptic control conditions during processing and shipping of samples was adequately maintained. Mineral medium plates spread with 0.1 ml of groundwater, but not incubated under diesel vapors, contained an average of 90 organisms per ml. The data show that some utilizable carbon was present in the washed agar plates or that carry-over of organic material occurred from the groundwater or dilution blanks; however, greater growth of the acclimated population was achieved in the presence of the diesel vapors.

The direct counts showed higher counts than those found in the viable plate counts except for well CSD-11D. Well CSD-13D had $1.15X10^4$ per ml by direct counts compared with $3.60X10^3$ per ml total plate counts and $4.20x10^3$ per ml diesel utilizers. Direct counts of well CSD-4D were made and averaged $7.50X10^4$ per ml. No viable plate counts were recorded for CSD-4D demonstrating that although there may be organisms present in the groundwater they are unable to grow on the media used for the viable enumerations.

The nutrient stimulation investigations demonstrated the presence of microbial populations capable of biodegrading the diesel contamination. Cell yields of up to 23% were obtained during the nutrient optimization study when the systems were supplied with the necessary inorganic nutrients. The data indicated that bacterial consortia from both the sediments and groundwater capable of degrading the TPHs can be achieved and enhanced with the addition of ammonia, phosphate, magnesium, manganese, and iron. The biodegradation studies showed that the volatile fraction of diesel was reduced by 67% within 35 days when the sediments and groundwater samples were supplemented with the necessary inorganic nutrients. Without the nutrient amendments, much less biodegradation of the volatile fraction was achieved. The investigations subsequent to the removal of the nonvolatile fraction of diesel was largely inconclusive because of problems with the extraction procedure and losses from the control probably as a result of the hydrochloric acid used as a microbial inhibitor.

The data in Table 7 show the cell yields for the nutrient study. Some growth was achieved in the system without additional inorganic nutrients (test #2). When both ammonia and phosphate were added, the cell yields increased greatly (tests 5 and 6). The greatest cell yield occurred in test 27 (nearly 10 fold) that received all the inorganic nutrients except carbonate. The second highest yield, test 28, contained ammonia, phosphate, carbonate, magnesium, manganese and iron. Test number 9 had the third highest yield and contained magnesium in addition to ammonia and phosphate. Test 26, containing all of the inorganic nutrients and gave the fourth highest yield. Test 31, which gave the fifth highest yield, received ammonia, phosphate, magnesium, manganese, and iron. The tests with the best yields appeared to contain ammonia, phosphate, and magnesium and generally manganese and iron. The amount of bacterial cell yield accounted for utilization of up to 23% of the added diesel, while much of the remaining diesel fuel was converted to carbon dioxide and water. Considerable growth occurred on the added diesel by the groundwater microbial consortia even though there did not appear to be any diesel contamination in the groundwater samples. Such data demonstrates that the indigenous microorganisms can acclimate to biodegrade the diesel when supplied with the necessary oxygen and inorganic nutrients.

The addition of a nutrient solution may cause a reaction with the minerals in the groundwater (particularly iron, magnesium, and calcium) to form a precipitate. Excessive precipitation of the nutrient solution should be avoided to prevent clogging of the soil pores with a resultant decrease in the soil permeability thus causing formation blockage. Phosphate may be adsorbed onto the soil and not be available for the microorganisms. Additional tests were run to determine the quantity of phosphate adsorbed onto the soil.

Hydrogen peroxide decomposes to form water and oxygen, and thus serves as an oxygen supply. It can provide a much greater quantity of oxygen to the subsurface than air or compressed or liquid oxygen, which are other common methods of oxygen addition. Experiments were conducted to determine the rate of hydrogen peroxide decomposition in the presence of the Central Shops Diesel Facility sediments. If the geological formation causes the hydrogen peroxide to decompose rapidly, it may need to be treated with phosphate or other agents before large quantities of hydrogen peroxide can be introduced. Phosphate plays a role in stabilizing the hydrogen peroxide solution. On the other hand if the hydrogen peroxide is very stable in the formation, then the rate of oxygen production may be too slow to support maximal aerobic microbial growth.

Tables 8 present the data from the phosphate adsorption and hydrogen-peroxide stability test. Two sediment samples used in the test showed high TPH concentrations. The first test used 20 grams of sediment collected from borehole

CSD-13D at 5 to 7 feet along with 100 ml of groundwater that was spiked with 81 ppm phosphate and 150 ppm hydrogen peroxide. The second test employed sediment from boring CSD-6D at 10 to 12 feet along with 100 mL of groundwater amended with 280 mg/L of phosphate and 265 mg/L of hydrogen peroxide. Samples were taken periodically from the liquid above the sediment, centrifuged to separate the sediment and groundwater, and checked for the remaining concentrations of phosphate and hydrogen peroxide. Phosphate was measured colorometrically with ammonium moblydate and ascorbic acid. Hydrogen-peroxide concentrations were determined colorometrically with titanium sulfate.

Phosphate adsorption to the CSD-13D sediment sample was relatively rapid (Table 8). The phosphate levels were reduced by more than half within 2 hours and by 90% after 5 hours. When additional phosphate was added, the concentration in solution was reduced by 30% within 4 hours and by 67% within the next 20 hours. The phosphate demand for this sediment was high at approximately 2.3 pounds per cubic yard. The sample from CSD-6D showed less phosphate adsorption (Table 8). The phosphate concentration was reduced by 50% after 8 hours. The phosphate adsorption for this sample amounted to 1.7 pounds per cubic yard.

The hydrogen peroxide concentrations dropped rapidly from 150 mg/L down to 9 mg/L within 21 hours in the sediment sample from CSD-13D (Table 8). A similar rate of hydrogen peroxide breakdown was observed following the addition of more hydrogen peroxide and phosphate to the soil and groundwater solution. The concentration of hydrogen peroxide fell by a little more than one quarter within eight hours in the sample from boring CSD-6D (Table 8). The stability of the hydrogen peroxide solution in the soil was good. It appears that hydrogen peroxide can be used as the oxygen source if the phosphate demand is satisfied and the other site conditions are favorable for use of *in situ* bioreclamation.

The results of the column test are given in Table 9. Two sediment columns were prepared; one with 40 grams of a sediment from soil boring CSD-6D at a depth of 10 to 12 feet; the second with 40 grams of a sediment from boring CSD-13D at a depth of 5 to 7 feet. The columns were wetted with 200 mL of groundwater, and the time for 50 mL of the groundwater plus any amendments to pass through the column was recorded. Reasonable rates of infiltration were achieved in both columns for the groundwater. The sample from boring CSD-13D had an average infiltration rate of 13 mL/min with only groundwater (Table 9) and the sample from CSD-6D had an average flow rate of 18 mL/min (Table 9). However, the sediments were subject to plugging with the addition of the inorganic nutrients. The nutrients also appeared to flush out fines from the columns. The flow rates were increased initially for both columns when the inorganic nutrient were first added to the groundwater, but then the flow rates began to decline. The addition of hydrogen peroxide resulted in decreased flow rates for both columns. The sample CSD-13D became plugged, and the flow through the CSD-6D column was reduced to 1 mL/min. Additional testing is required to determine whether a chelation amendment could prevent plugging. The high clay content of the soils samples probably rules against solving this problem. The sample from CSD-13D at 5 to 7 feet consisted of sand with clay and silt with an estimated 25% clay and 15% silt. The sample from CSD-6D at 10 to 12 feet consisted of cohesive, medium plasticity clay with approximately 15% sand.

During the nutrient amended treatments, the volatile fraction of diesel was reduced by 67%, from 180 ppm down to approximately 60 to 70 ppm (treatment #1-AT; Figure 9). Treatment #2-UT, which did not receive any nutrients, showed a reduction in the total volatile organics of only 18%. This test demonstrated that the addition of inorganic nutrients increased the biological removal of the volatile fraction of the diesel fuel over simply the addition of oxygen. There was no reduction in the volatile fraction in the nutrient amended controls (treatment #3-AC) or unamended controls (treatment #4-UC), although there was some variability in the measured concentrations of volatiles.

The nonvolatile biodegradation study was largely inconclusive (Figure 10). The total petroleum hydrocarbon concentration in the nutrient amended series (treatment #1-AT) was reduced by less than 20%.

Experiments were also conducted to demonstrate the biotransformation and complete mineralization to carbon dioxide of dodecane, one of the components of diesel fuel. Mineralization studies were conducted with soils from CSD-13D at a depth of 2 to 4 feet and with sediments from depths of 6 to 19 feet. Dodecane biotransformation experiments were also conducted with sediments from CSD-13D at a depth of 17 feet. Up to 4.4% of the added ^{14}C label was mineralized in the soil from CSD-13D at a depth of 2 to 4 feet when amended with 80 ppm phosphate and 50 ppm ammonia. Some mineralization of dodecane occurred with addition of phosphate by itself, but not for ammonia alone. No more than 7.6% of the label was mineralized in these studies. The high concentrations of other biodegradable contaminants and the location of the ^{14}C label on only the first carbon of dodecane contributed to the apparent low percentage conversion of the dodecane to carbon dioxide.

There was a 35% reduction in the unamended series (treatment #2-UT), and 37% in the nutrient amended control series (treastment #4-UC). The microcosms were prepared with 10 grams of sediments and 10 mL of groundwater. The EPA Method 3540 used for the extraction requires that the sediments be dry before extraction. The sediments were dried in an 105°C oven overnight which removed the water, but also volatilized some components of the diesel. The compounds with higher boiling points were concentrated in the nonvolatile fraction of diesel remaining after drying. These compounds are likely to be more difficult to biodegrade. The boiling range of the contaminants was shifted to between 153° and 256°C from the normal boiling range of diesel of 90° to 195°C. This extraction and quantitation method also exhibited a fairly high degree of variability with the initial TPH concentrations ranging from 255 to 563 ppm. The acid used in the preparation of the control may have reacted with the diesel and reduced the concentration of total petroleum hydrocarbon that could be recovered by this procedure.

In the biotransformation experiment, 80% of the dodecane was removed in 35 days when the soils were amended with ammonia, phosphate, and other inorganic nutrients and incubated under aerobic conditions. Without any additional nutrients; 69% of the dodecane were biotransformed. Approximately 50% of the dodecane was lost in the nutrient amended and unamended controls. These losses may be a result of interaction between the acid used as a biological inhibitor and the dodecane. The following may have contributed to the higher percentage of dodecane removal in the biotransformation experiment than seen in the mineralization experiment: 1) The biotransformation experiment only followed the loss of the parent compound and not complete conversion to carbon dioxide. 2) The headspace quantification method may be subject to interferences with compounds which have similar retention times to that of dodecane. 3) The biotransformation experiment was carried out for a longer period. 4) The mineralization experiments were carried out with dodecane which was only labeled on the first carbon.

The TPH levels were reduced from 467 ppm down to 70 ppm after 24 days (Figure 11). Some of the removal was probably the result of volatilization of the lighter fraction of diesel. While this technique was successful in the laboratory, it may be difficult to apply in the field. The clayey soils found throughout much of the site will make it difficult to draw the nutrients and air through the contaminated zone.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The hydrology, geology, topography and the nature of the contaminant suggest that the diesel fuel contaminating the sediments in this area are moving very slowly or not at all and are not having an impact on the groundwater in the area. Small areas of perched water are found at depths of approximately 25 feet below ground surface overlying a low permeability sandy clay unit, but these are of limited extent. The static water table across the site is between elevation 244 to 238 feet msl (approximately 45 to 75 feet below ground surface) as shown in Figure 3. Groundwater flow directions vary depending on location; however, the dominant direction is to the west in the direction of the lowest elevation (Figure 3).

In situ bioreclamation was chosen as one of the remediation alternatives for further investigation, since bioremediation works by supplying the necessary oxygen and inorganic nutrients to the microbial consortia which in turn degrade of the organic contaminants. The oxygen and nutrients are added to the groundwater and circulated through the contaminated soils by means of horizontal or injection wells, infiltration galleries, and withdrawal wells Conventional treatment relies on the use of liquid additions to supply the necessary nutrients to the subsurface environments. To determine if *in situ* bioreclamation is an appropriate technology for cleanup of this site soil, sediment and groundwater samples were collected for laboratory analyses. The studies involved determination of the microbial distribution of both the total bacterial and hydrocarbon-utilizing populations, the nutrient requirements for maximum growth rate, the rate and extent of biodegradation of the organic contaminants, and compatibility of the nutrient mixture with the subsurface soils.

The Bioreclamation Feasibility Assessment Study revealed that indigenous microorganisms that degrade significant quantities of diesel fuel are present in the soil at the Central Shop Diesel Storage Facility site. A nutrient mix for stimulating the indigenous microorganisms was tested on sediment core samples, and optimum concentrations were established for yielding the most microbial cells.

There are problems that may well arise with the addition of the inorganic nutrients and oxygen to the Central Shops Diesel Storage Facility soils and sediments. There is a relatively high phosphate demand by the soils, ranging from 1.7 pounds to 2.3 pounds per cubic yard, which must be met before an oxygen source such as hydrogen peroxide can be added to the soil without creating plugging problems. The rate of hydrogen peroxide decomposition in the presence of the soils was reasonable. When nutrients are added to the groundwater, they appear to release fines from the soil which can act to plug the formation. Even with pretreatment of the soils with the nutrient solution, the rates of groundwater flow through the soil columns were restricted when hydrogen peroxide was added.

However, soil column studies suggested that injection of this nutrient mix would plug the soil, through microbial biomass and/or inorganic precipitates from chemical reactions. This plugging of the formation seriously limits the use of conventional liquid nutrient infiltration galleries for the enhancement of the indigenous microbial populations present in these soils. The location of the majority of the diesel contaminants in the unsaturated soil above the groundwater table, the relatively low permeability of the soils, and the problems with addition of hydrogen peroxide and nutrients to the soils will probably preclude the use of *in situ* bioreclamation for the site. Thus conventional *in situ* biodegradation through injection of liquid nutrients via infiltration galleries may not be appropriate; however, if plume containment was desirable these studies indicated that biomass plugging of the soil could inhibit subsurface water flow and may be appropriate as a method of containment.

The investigation that allowed the removal of the total petroleum hydrocarbon by vacuum extraction and enhanced biodegradation through bioventing indicated that this method may be useful. It will probably not be difficult to draw the necessary oxygen and nitrogen through the clayey soils using pressurized air. The nitrogen present in the compressed air will serve as a nutrient source for the microbial consortia present in the soils. Field scale demonstrations of the vacuum extraction enhanced bioventing biodegradation processes have been accomplished for TCE contaminated soils at M-Area and are expected to be work favorably at the Central Shops Diesel Storage Facility (Eddy *et al.*, 1991; Looney *et. al.* 1991).

The most economical and technically feasible option of cleanup of the diesel contaminated soil at the Central Shops Diesel Storage Facility can be approached in two ways. Initially small vertical injection and vacuum extraction wells would be inserted into the most contaminated and shallowest areas of the plume to biovent and bioremediate the plume. This would allow the bioremediation of the greatest concentration of the TPH's with the least cost. Since the contamination has not entered the groundwater, an immediate bioventing procedure would enhance the degradation without excavation. This phase of the bioremediation may well continue for 12-18 months followed by an evaluation of the residual plume. Core samples would be collected for comparison of the bioremediated plume with the initial conditions.

Since these studies indicated that the CSDSF site may not be suitable for some conventional types of *in situ* bioremediation, a second approach is to excavate the shallow contaminated soils landfarm them. A prepared bed treatment facility (sOils Facility) for all oil-contaminated soils at SRS is being constructed at D-Area. Much of the contaminated soil from the Central Shops Diesel Storage Facility, due to its shallow nature, would be excavated and treated in this facility. The excavated material would be mixed with nutrients at the controlled site (sOils Facility) and brought to acceptable levels of TPH by the indigenous microflora in a rapid and cost effective manner. The facility is to be used to treat all petroleum contaminated surface soil at SRS now and in the future. The clayey nature of much of the soils will not be as much of a restriction to landfarming as they would be for an *in situ* bioreclamation project because the nutrients can be added directly to soils and mixed manually. Aeration is by rototilling the soils rather than transportation through the contaminated soils by circulation of groundwater. Whereas the bulk of the contaminated soils are confined to a narrow and shallow depth (<20 ft), removal of the highly contaminated material may be the most effective remediation of the site. Microbial populations are present in much of the contaminated soils that are acclimated to the diesel contaminants or can become acclimated to diesel once the proper inorganic nutrients are available as seen in the nutrient optimization studies.

The small pools of deeper contamination (>30 feet) will require more innovative treatment, e.g., bioventing as discussed above. Bioremediation would be achieved by placing vertical wells into the heaviest contaminated area and provide a vacuum extraction process that would help remove the volatile portion of the TPH but also establish a bioventing regime where the indigenous microbial populations would be stimulated to degrade the TPH's *in situ*

Since this plume has probably existed for more than 20 years at this site and there is no evidence of immediate danger to groundwater supplies in the area, we propose using this site to test innovative technologies for *in situ* bioremediation. These studies could significantly improve our ability to cleanup similar sites by decreasing remediation time and costs and improving terminal destruction of the contaminants with minimal environmental disturbance.

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Table 1. Bore Hole Coordinates and Elevation for Central Shops Diesel Facility

Borehole	SRS-E	SRS-N	Elevation	Longitude	Latitude	Last survey
CSD-1D	50170	63256	313.4	81-39-27.27	33-14-51.13	8/16/90
CSD-2D	50143	63126	308.8	81-39-26.58	33-14-49.94	8/16/90
CSD-3D	50116.77	63198.43		81-39-27.34416	33-14-50.35488	10/88
CSD-4D	50059	63144	306.5	81-39-27.51	33-14-49.58	8/16/90
CSD-5D	50026.15	63146.71		81-39-27.84168	33-14-49.41096	10/88
CSD-6D	50058.92	63266.97		81-39-28.3716	33-14-50.5608	10/88
CSD-7D	49974.61	63206.71		81-39-28.74924	33-14-49.58592	10/88
CSD-8D	49902	63195	301.8	81-39-29.34	33-14-49.07	3/6/89
CSD-9D	49838	63081	296.2	81-39-29.16	33-14-47.79	3/6/89
CSD-10D	49805	63094	294.5	81-39-29.55	33-14-47.7	3/6/89
CSD-11D	49763	62956	290.9	81-39-29	33-14-46.35	3/6/89
CSD-12D	49937	63005	299.5	81-39-27.69	33-14-47.76	3/6/89
CSD-13D	49665	62898	287.4	81-39-29.52	33-14-45.3	3/6/89
CSD-14D	49665	62898	287.4	81-39-29.52	33-14-45.31	10/88
CSD-15D	50066	63353	313	81-39-28.9	33-14-51.29	8/16/90
CSD-16D	49904	63238	303.8	81-39-29.64	33-14-49.42	8/16/90
CSD-17D	50003	63098	301.4	81-39-27.72	33-14-48.89	8/16/90
CSD-18D	49642	63176	292	81-39-31.69	33-14-47.39	8/16/90
CSD-19D	49848	63003	293.7	81-39-28.52	33-14-47.23	8/16/90
CSD-20D	49733	62993	290	81-39-29.54	33-14-46.46	8/16/90
CSD-21D	49818	62916	291	81-39-28.19	33-14-46.35	8/16/90
CSD-22D	49599	62890	284.9	81-39-30.09	33-14-44.86	8/16/90
CSD-23D	49744	62877	289	81-39-28.63	33-14-45.6	8/16/90
CSD-24D	49637	62810	289.1	81-39-29.18	33-14-44.44	8/16/90
CSD-25D	49588	62703	285.1	81-39-28.89	33-14-43.31	8/16/90
CSD-26D	49474	62844	285.5	81-39-30.96	33-14-43.75	8/16/90
CSD-27D	49472	62951	284.8	81-39-31.72	33-14-44.6	8/16/90
CSD-28D	49517	63020	286	81-39-31.78	33-14-45.41	8/16/90
CSD-29D	49333	63077	280.8	81-39-33.92	33-14-44.79	8/16/90

Table 2. Concentration of TPHs (ppm/gdw)in Sediments at Central Shops Diesel Fuel Facility

DEPTH (ft)	CSD-1D	CSD-2D	CSD-3D	CSD-4D	CSD-5D	CSD-6D	CSD-7D	CSD-8D	CSD-9D	CSD-10D	CSD-11D	CSD-12D	CSD 13D
1 - 3			665	<50	<50	<50	<50						
5 - 7			75	887	603	<50	273		383		2413		437
10 - 12			<50	74	<50	5040	<50				468		475
15 - 17				<50					229		<50		965
20 - 22				156									492
23 - 25				<50							<50		
26 - 28		<50		<50				<50					136
29 - 31		<50		<50				<50	265	<50	<50	<50	392
32 - 34		<50		91									
35 - 37		<50		132				<50	<50		<50	<50	<50
38 - 40				<50									101
41 - 43				<50				57		<50	<50	<50	
44 - 46	<50	<50		<50									69
47 - 48	<50			<50					.<50		<50	<50	
50 - 52	<50			<50						<50			84
53 - 55	<50			<50					269		<50		
56 - 58	<50			<50				<50		<50			94
59 - 61				87					<50		<50	<50	
62 - 64				70						<50			<50
65 - 67				76				<50	384			<50	
68 - 70				<50							<50		
71 - 73				<50					301				
74 - 76				<50				<50	<50				
77 - 79				<50					<50				
80 - 82				<50									

Detection limit 50 ppm. 63-83% recovery.

TABLE 3. Concentration of Lead in the Sediments of Central Shop Diesel Storage Facility

Well ID	Depth (ft)	Concentration	Detection limit
CS-15D	3-5	5.7 Mg/Kg	0.68
CS-15D	8-10	3.8 Mg/Kg	0.71
CS-15D	13-15	20.9 Mg/Kg	2.90
CS-15D	18-20	19.3 Mg/Kg	2.80
CS-15D	23-25	7.7 Mg/Kg	0.68
CS-15D	28-30	5.0 Mg/Kg	0.67
CS-15D	33-35	4.6 Mg/Kg	0.68
CS-15D	38-40	15.5 Mg/Kg	2.80
CS-15D	43-45	5.0 Mg/Kg	0.74
CS-15D	48-50	5.8 Mg/Kg	0.73
CS-15D	53-55	8.9 Mg/Kg	0.72
CS-15D	58-60	9.2 Mg/Kg	0.69
CS-15D	63-65	4.0 Mg/Kg	0.67
CS-15D	68-70	4.7 Mg/Kg	0.65
CS-15D	73-75	3.8 Mg/Kg	0.70
CS-15D	78-80	2.1 Mg/Kg	0.71
CS-16D	3-5	17.5 Mg/Kg	2.90
CS-16D	8-10	3.2 Mg/Kg	0.69
CS-16D	13-15	9.7 Mg/Kg	0.72
CS-16D	18-20	10.2 Mg/Kg	0.72
CS-16D	23-25	11.1 Mg/Kg	0.72
CS-16D	28-30	3.3 Mg/Kg	0.66
CS-16D	33-35	7.4 Mg/Kg	0.69
CS-16D	38-40	5.6 Mg/Kg	0.70
CS-16D	43-45	6.7 Mg/Kg	0.71
CS-16D	48-50	3.1 Mg/Kg	0.68
CS-16D	53-55	4.3 Mg/Kg	0.67
CS-16D	58-60	2.2 Mg/Kg	0.66
CS-16D	63-65	1.6 Mg/Kg	0.69
CS-16D	68-70	3.2 Mg/Kg	0.73
CS-17D	3-5	6.1 Mg/Kg	0.68
CS-17D	8-10	4.2 Mg/Kg	0.72
CS-17D	13-15	6.3 Mg/Kg	0.72

CS-17D	18-20	8.4 Mg/Kg	0.70
CS-17D	23-25	5.5 Mg/Kg	0.68
CS-17D	28-30	2.9 Mg/Kg	0.71
CS-17D	33-35	3.1 Mg/Kg	0.68
CS-17D	38-40	2.9 Mg/Kg	0.71
CS-17D	43-45	12.8 Mg/Kg	1.40
CS-17D	48-50	5.4 Mg/Kg	0.67
CS-17D	53-55	4.6 Mg/Kg	0.73
CS-17D	58-60	2.8 Mg/Kg	0.71
CS-17D	63-65	136 Mg/Kg	14.2
CS-17D	68-70	4.7 Mg/Kg	0.71
CS-17D	73-75	4.2 Mg/Kg	0.72
CS-17D	78-80	2.1 Mg/Kg	0.69
CS-17D	83-85	4.9 Mg/Kg	0.72
CS-17D	88-90	5.8 Mg/Kg	0.71
CS-18D	3-5	6.5 Mg/Kg	0.67
CS-18D	8-10	9.3 Mg/Kg	0.66
CS-18D	13-15	8.9 Mg/Kg	0.71
CS-18D	18-20	5.9 Mg/Kg	0.70
CS-18D	23-25	5.6 Mg/Kg	0.69
CS-18D	28-30	6.6 Mg/Kg	0.65
CS-18D	33-35	5.3 Mg/Kg	0.66
CS-18D	38-40	3.6 Mg/Kg	0.68
CS-18D	43-45	1.4 Mg/Kg	0.65
CS-18D	48-50	3.0 Mg/Kg	0.71
CS-18D	53-55	3.1 Mg/Kg	0.62
CS-19D	3-5	7.4 Mg/Kg	0.71
CS-19D	8-10	6.4 Mg/Kg	0.69
CS-19D	13-15	10.8 Mg/Kg	0.74
CS-19D	18-20	10.0 Mg/Kg	0.72
CS-19D	23-25	7.2 Mg/Kg	0.67
CS-19D	28-30	16.2 Mg/Kg	1.3.0
CS-19D	33-35	4.2 Mg/Kg	0.64
CS-19D	38-40	4.4 Mg/Kg	0.68
CS-19D	43-45	4.0 Mg/Kg	0.68
CS-19D	48-50	6.3 Mg/Kg	0.67

CS-19D	53-55	2.7 Mg/Kg	0.71
CS-20D	3-5	5.2 Mg/Kg	0.71
CS-20D	8-10	4.6 Mg/Kg	0.71
CS-20D	13-15	5.3 Mg/Kg	0.72
CS-20D	18-20	4.6 Mg/Kg	0.68
CS-20D	23-25	8.3 Mg/Kg	0.68
CS-20D	28-30	6.4 Mg/Kg	0.69
CS-20D	33-35	4.6 Mg/Kg	0.68
CS-20D	38-40	5.0 Mg/Kg	0.68
CS-20D	43-45	6.0 Mg/Kg	0.68
CS-20D	48-50	5.5 Mg/Kg	0.69
CS-20D	53-55	2.7 Mg/Kg	0.73
CS-21D	3-5	7.1 Mg/Kg	0.67
CS-21D	8-10	10.4 Mg/Kg	0.74
CS-21D	13-15	6.2 Mg/Kg	0.71
CS-21D	18-20	5.4 Mg/Kg	0.71
CS-21D	23-25	10.1 Mg/Kg	0.70
CS-21D	28-30	30.9 Mg/Kg	6.80
CS-21D	33-35	8.2 Mg/Kg	0.69
CS-21D	38-40	4.0 Mg/Kg	0.66
CS-21D	43-45	6.3 Mg/Kg	0.69
CS-21D	48-50	5.1 Mg/Kg	0.71
CS-21D	53-55	4.5 Mg/Kg	0.73
CS-21D	58-60	4.8 Mg/Kg	0.73
CS-22D	3-5	7.1 Mg/Kg	0.71
CS-22D	6-8	9.7 Mg/Kg	1.60
CS-22D	9-11	5.0 Mg/Kg	1.40
CS-22D	12-14	7.0 Mg/Kg	1.40
CS-22D	15-17	15.0 Mg/Kg	1.40
CS-22D	18-20	10.2 Mg/Kg	1.50
CS-22D	21-23	12.3 Mg/Kg	1.40
CS-22D	28-30	5.5 Mg/Kg	1.40
CS-22D	33-35	11.1 Mg/Kg	1.40
CS-22D	38-40	7.1 Mg/Kg	1.40
CS-22D	43-45	4.3 Mg/Kg	1.40
CS-23D	3-5	4.0 Mg/Kg	0.67

CS-23D	8-10	9.1 Mg/Kg	0.71
CS-23D	13-15	13.1 Mg/Kg	1.40
CS-23D	18-20	6.2 Mg/Kg	0.70
CS-23D	23-25	5.4 Mg/Kg	0.70
CS-23D	28-30	8.8 Mg/Kg	0.70
CS-23D	33-35	5.6 Mg/Kg	0.72
CS-23D	38-40	5.0 Mg/Kg	0.72
CS-23D	43-45	11.0 Mg/Kg	0.72
CS-23D	48-50	7.4 Mg/Kg	0.76
CS-24D	3-5	6.6 Mg/Kg	1.40
CS-24D	8-10	7.7 Mg/Kg	1.30
CS-24D	13-15	11.6 Mg/Kg	1.40
CS-24D	18-20	4.7 Mg/Kg	1.40
CS-24D	23-25	7.2 Mg/Kg	1.40
CS-24D	28-30	4.9 Mg/Kg	0.70
CS-24D	33-35	3.8 Mg/Kg	0.70
CS-24D	38-40	4.3 Mg/Kg	0.70
CS-24D	43-45	3.2 Mg/Kg	0.71
CS-24D	48-50	4.2 Mg/Kg	0.72
CS-25D	3-5	6.3 Mg/Kg	0.67
CS-25D	8-10	17.0 Mg/Kg	1.50
CS-25D	13-15	5.3 Mg/Kg	0.73
CS-25D	18-20	5.1 Mg/Kg	0.68
CS-25D	23-25	9.0 Mg/Kg	0.67
CS-25D	28-30	9.8 Mg/Kg	0.95
CS-25D	33-35	13.5 Mg/Kg	1.40
CS-25D	38-40	4.5 Mg/Kg	0.68
CS-25D	43-45	10.1 Mg/Kg	0.72
CS-25D	48-50	5.0 Mg/Kg	0.72
CS-26D	3-5	12.6 Mg/Kg	1.40
CS-26D	8-10	6.6 Mg/Kg	0.74
CS-26D	13-15	5.9 Mg/Kg	0.72
CS-26D	18-20	6.8 Mg/Kg	0.71
CS-26D	23-25	5.4 Mg/Kg	0.72
CS-26D	28-30	5.0 Mg/Kg	0.71
CS-26D	33-35	11.1 Mg/Kg	0.70

CS-26D	38-40	3.9 Mg/Kg	0.68
CS-26D	43-45	6.2 Mg/Kg	0.69
CS-26D	48-50	5.0 Mg/Kg	0.73
CS-27D	3-5	10.9 Mg/Kg	0.70
CS-27D	8-10	6.0 Mg/Kg	0.72
CS-27D	13-15	5.6 Mg/Kg	0.70
CS-27D	18-20	1.7 Mg/Kg	0.69
CS-27D	23-25	5.3 Mg/Kg	0.74
CS-27D	28-30	5.0 Mg/Kg	0.69
CS-27D	33-35	3.6 Mg/Kg	0.74
CS-27D	38-40	2.9 Mg/Kg	0.71
CS-27D	43-45	4.1 Mg/Kg	0.70
CS-27D	48-50	7.0 Mg/Kg	0.77
CS-28D	3-5	6.0 Mg/Kg	0.66
CS-28D	8-10	7.8 Mg/Kg	0.70
CS-28D	13-15	6.9 Mg/Kg	0.69
CS-28D	18-20	5.2 Mg/Kg	0.70
CS-28D	23-25	7.6 Mg/Kg	0.71
CS-28D	28-30	8.5 Mg/Kg	0.70
CS-28D	33-35	5.6 Mg/Kg	0.70
CS-28D	38-40	5.4 Mg/Kg	0.74
CS-28D	43-45	10.7 Mg/Kg	0.75
CS-28D	48-50	5.1 Mg/Kg	0.73
CS-28D	53-55	5.6 Mg/Kg	0.75
CS-29D	3-5	8.7 Mg/Kg	0.71
CS-29D	8-10	8.4 Mg/Kg	0.70
CS-29D	13-15	6.9 Mg/Kg	0.72
CS-29D	18-20	4.2 Mg/Kg	0.71
CS-29D	23-25	5.2 Mg/Kg	0.72
CS-29D	28-30	4.5 Mg/Kg	0.70
CS-29D	33-35	7.2 Mg/Kg	0.73
CS-29D	38-40	5.8 Mg/Kg	0.75
CS-29D	43-45	6.1 Mg/Kg	0.75
CS-29D	48-50	8.1 Mg/Kg	0.76
mean	**7.494857**	**stdev**	**10.48541**

TABLE 4. Maximum Concentration of Lead in the Groundwater and Sediments of Central Shop Diesel Storage Facility

Well #	Screened Depth (ft)	Maximum Lead Concentration in water (ug/L)	Maximum Lead Concentration in sediemnts (ug/KG)	Detection limits (ug/L)
CS15D	83-84	780.0	126	300.0
CS16D	73-74	15.4	89.1	3.0
CS17D	ND	ND	222.7	ND
CS18D	58-59	4.4	59.2	4.4
CS19D	58-59	13.6	79.6	3.0
CS20D	54-55	30.0	58.2	30.0
CS21D	64-65	11.7	103	3.0
CS22D	50-51	600.0	94.3	300.0
CS23D	ND	86.0	75.6	30.0
CS24D	54-55	4.7	58.2	3.0
CS25D	54-55	3.0	85.6	3.0
CS26D	52-53	120.0	68.5	30.0
CS27D	53-54	40.0	52.1	30.0
CS28D	58-59	84.0	74.4	12.0
CS29D	53-54	26.1	65.1	3.0
mean		137.91	87.44	
standard deviation		242.54	42.31	

ND No Data

TABLE 5. Densities of Total Heterotrophic and Diesel Utilizing Bacteria in Sediments Containing TPH (ppm) from Central Shops Diesel Fuel Facility with Respect to TPH Concentrations.

TPH Concentrations in Sediments (ppm/gdw)	Total Heterotrophs (cfu/gdw)	Diesel Utilizers (cfu/gdw)
665	2800	200
75	1000	200
887	1000	200
74	100	200
156	100	200
91	100	200
132	100	200
87	100	200
70	400	200
76	100	200
603	520000	22400
5040	100	200
273	100	200
57	100	200
383	200	200
229	100	200
265	100	200
269	1000	400
384	300	200
301	100	200
79	100	200
2413	300	200
468	100	200
4377	300	200
475	100	200
965	600	200
492	200	1000
136	100	200
392	100	200

101	100	200
69	100	200
84	100	200
94	100	200

Table 6. Amendments and Their Concentrations Used in Biodegradability Investigations

Amendments	Concentrations mg/L
phosphate	687
potassium	160
ammonia	336
carbonate	57
calcium	3.6
magnesium	19.5
manganese	4
iron	1
sulfate	87
chloride	670
sodium	172

TABLE 7. Cell Yields (mg/L) for Combinations of Inorganic Nutrients

Test #	PO_4	NH_4	CO_3	Ca	Mg	Mn	Fe	Diesel Fuel	Cell Yield (mg/L)
1									24
2								+	26
3	+							+	38
4		+						+	42
5	+	+						+	170
6	+	+						+	158
7	+	+	+					+	178
8	+	+		+				+	154
9	+	+			+			+	268
10	+	+				+		+	218
11	+	+					+	+	94
12	+	+	+	+				+	142
13	+	+	+		+			+	132
14	+	+	+			+		+	78
15	+	+	+				+	+	100
16	+	+		+	+			+	132
17	+	+		+		+		+	98
18	+	+		+			+	+	60
19	+	+			+	+		+	158
20	+	+			+		+	+	224
21	+	+				+	+	+	162
22	+	+	+	+	+			+	52
23	+	+	+	+	+	+		+	116
24	+	+	+	+	+	+	+	+	122
25	+	+	+	+	+	+	+	+	152
26	+	+	+	+	+	+	+	+	262
27	+	+		+	+	+	+	+	396
28	+	+	+		+	+	+	+	288
29	+	+	+	+		+	+	+	166
30	+	+	+	+	+		+	+	188
31	+	+			+	+	+	+	254
32	+	+		+		+	+	+	218
33	+	+		+	+		+	+	234
34	+	+		+	+	+		+	240
35	+	+	+				+	+	196
36	+	+	+		+		+	+	206
37	+	+	+		+	+		+	214
38	+	+	+	+			+	+	134

Table 8. Nutrient Stability Tests for Borings CSD 13 (5-7 feet) and CSD 6 (10-12 feet)

Borehole	Time (hr)	Phosphate (mg/L)	Hydrogen Peroxide (mg/L)
CSD-13D	0	81	150
CSD-13D	0.5	59	105
CSD-13D	1	28	130
CSD-13D	3	14	95
CSD-13D	5	9	85
CSD-13D	21	4	<1
CSD-13D**	21	140	150
CSD-13D	25	90	100
CSD-13D	43	44	25
CSD-6D	0	280	265
CSD-6D	4	195	230
CSD-6D	8	150	109

** Additional phosphate and hydrogen peroxide added.

Table 9. Column Investigations of Groundwater Flow Rate Through Columns Packed with CSD-13D and CSD-6D Soils, Respectively.

Borehole	Treatment	Flow Rate (mL/min)
CSD-13D	1	17
CSD-13D	2	15
CSD-13D	3	14
CSD-13D	4	11
CSD-13D	5	11
CSD-13D	6	10
CSD-13D*	7	22 soil fines in effluent
CSD-13D	8	10
CSD-13D	9	4
CSD-13D	10	2
CSD-13D	11	1
CSD-13D**	12	1
CSD-13D	13	1.4
CSD-13D	14	Plugged
CSD-6D	1	18
CSD-6D	2	18
CSD-6D	3	17
CSD-6D	4	46
CSD-6D	5	21
CSD-6D	6	13
CSD-6D	7	12
CSD-6D	8	10 soil fines in effluent
CSD-6D	9	10
CSD-6D***	10	4
CSD-6D	11	2
CSD-6D	12	1
CSD-6D	13	

* $PO_4+NH_4+Ca+Mg+Mn+CO_3+Fe$

** $PO_4+NH_4+Ca+Mg+Mn+CO_3+Fe+160$ ppm H_2O_2

*** $PO_4+NH_4+Ca+Mg+Mn+CO_3+Fe+210$ ppm H_2O_2

Table ???. Concentration of Petroleum Hydrocarbons at Depth

WELL	ALL DEPTHS	0-19 ft.	20-39 ft.	40-59 ft.	>60 ft.
CSD-1D	50	0	0	50	0
CSD-2D	50	0	50	50	0
CSD-3D	665	665	0	0	0
CSD-4D	887	887	156	50	87
CSD-5D	603	603	0	0	0
CSD-6D	5040	5040	0	0	0
CSD-7D	273	273	0	0	0
CSD-8D	57	0	50	57	50
CSD-9D	384	383	265	269	384
CSD-10D	50	0	50	50	50
CSD-11D	2413	2413	50	50	50
CSD-12D	50	0	50	50	50
CSD-13D	4377	4377	492	94	50
CSD-15D	85	85	4.7	4.7	4.8
CSD-16D	6.7	5.8	6.7	4.7	4.8
CSD-17D	1700	1700	8.2	4.7	6.1
CSD-18D	34	11	34	8.5	0
CSD-19D	69	69	7.1	4.8	0
CSD-20D	65	65	7.5	4.9	0
CSD-21D	1000	1000	58	14	0
CSD-22D	1500	1500	43	89	0
CSD-23D	2600	2600	510	110	0
CSD-24D	5.1	5.1	4.8	4.8	0
CSD-25D	5	4.9	5	4.9	0
CSD-26D	840	840	5	4.9	0
CSD-27D	230	230	5.5	5	0
CSD-28D	32	32	5.1	5.1	0
CSD-29D	170	170	4.9	5	0
		maximum	5040		
		minimum	4.1		

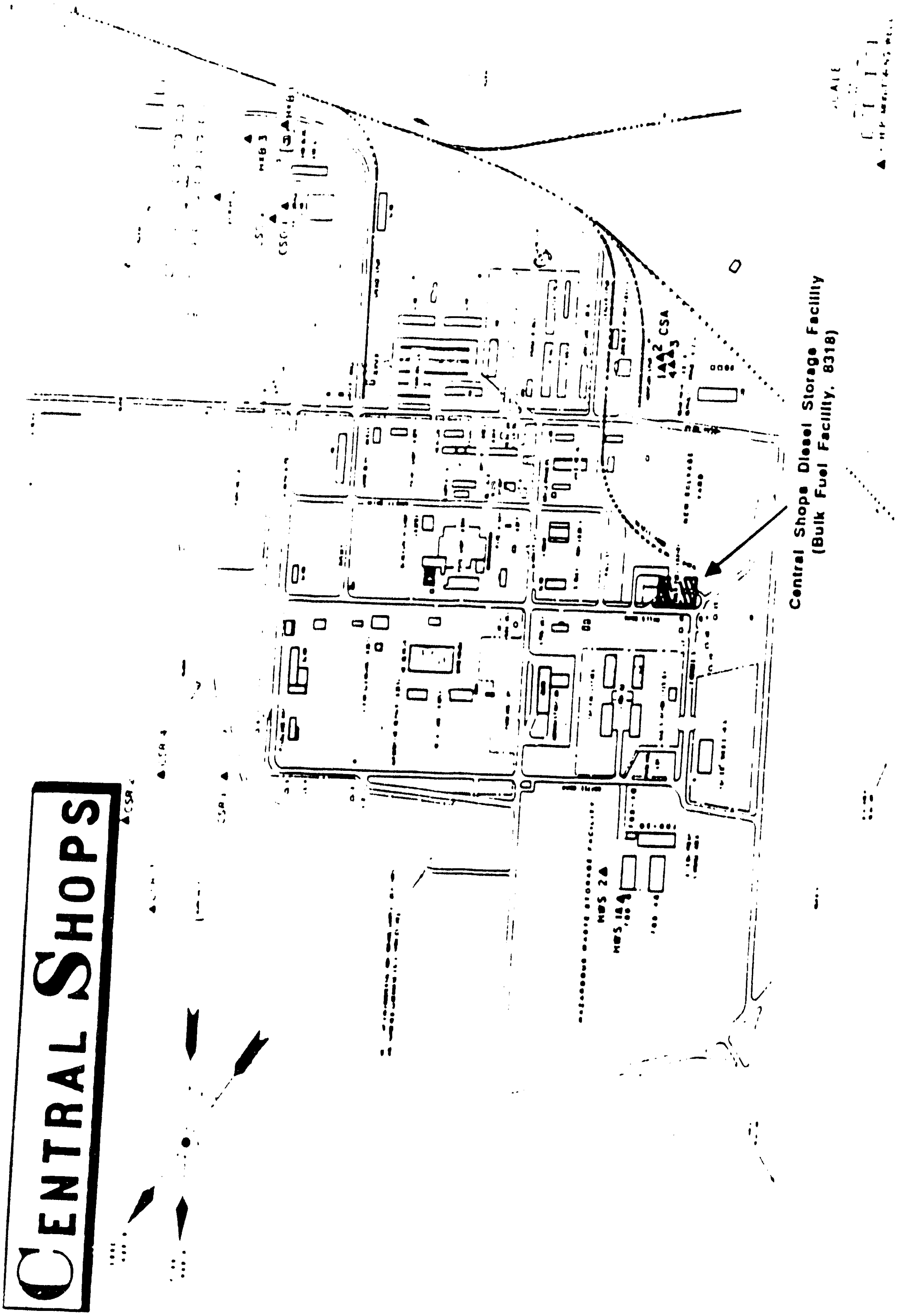


Figure 1. Location of the CS Diesel Storage Facility (Bulk Fuel Facility, 8318)

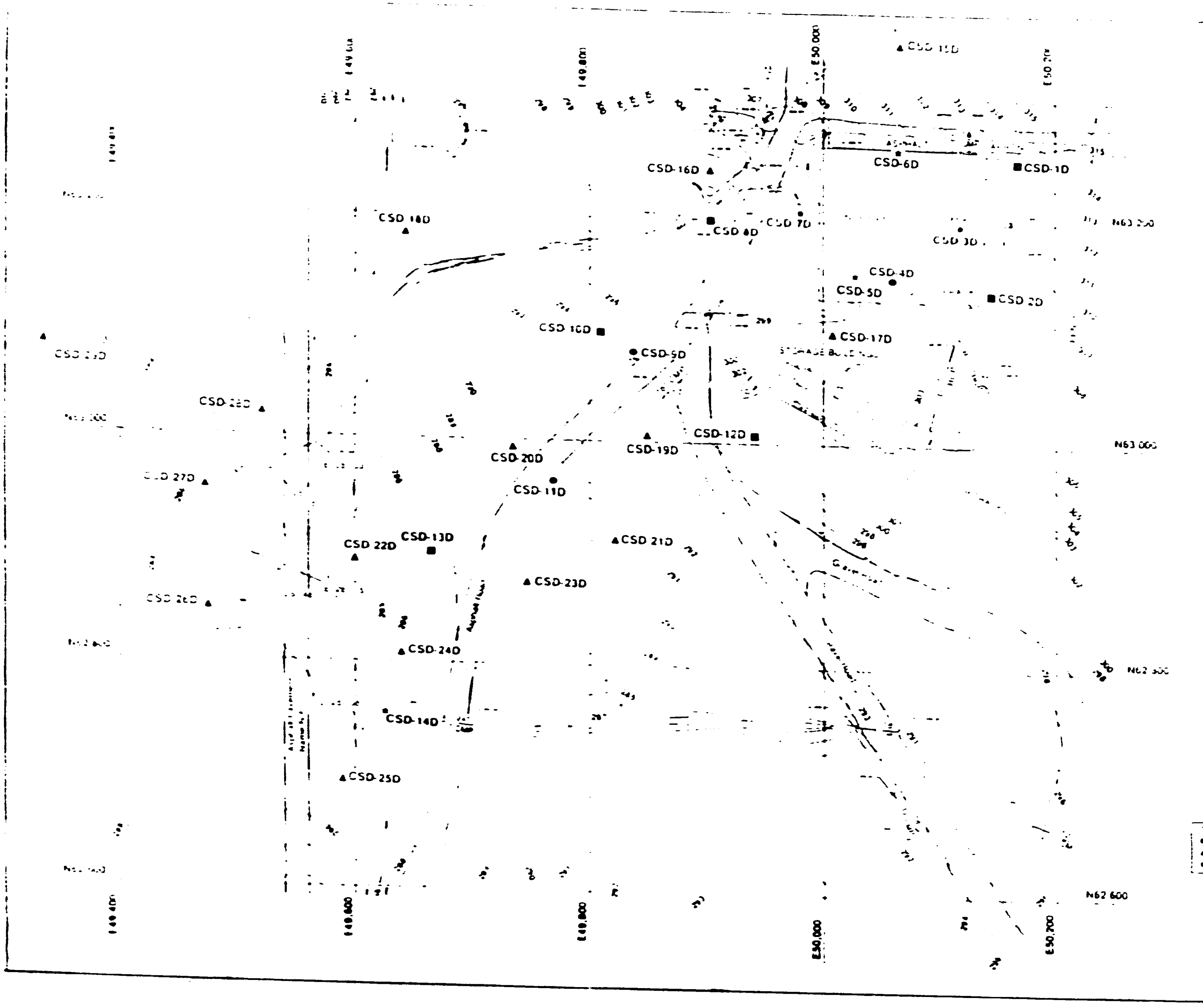

CSD-1D
CSD 2D
CSD 3D
CSD-4D
CSD-5D
CSD-6D
CSD 7D
CSD 8D
CSD-9D
CSD 10D
CSD-11D
CSD-12D
CSD-13D
CSD-14D
CSD 15D
CSD-16D
CSD-17D
CSD 18D
CSD-19D
CSD-20D
CSD 21D
CSD 22D
CSD-23D
CSD-24D
CSD-25D
CSD 26D
CSD 27D
CSD 28D
CSD 29D
STORAGE BUILDING
ASPHALT
E50,000
E50,200
E49,800
E49,600
E49,400
N63 200
N63 000
N62 800
N62 600
Soil Boring
Soil Boring & Well Location
Soil Boring & Hydropunch
Monitoring Well
0 15 30 60 90
M91jan025 01

Fig 1a

Figure 6. Concentration of Methane in Soil Gas, percent

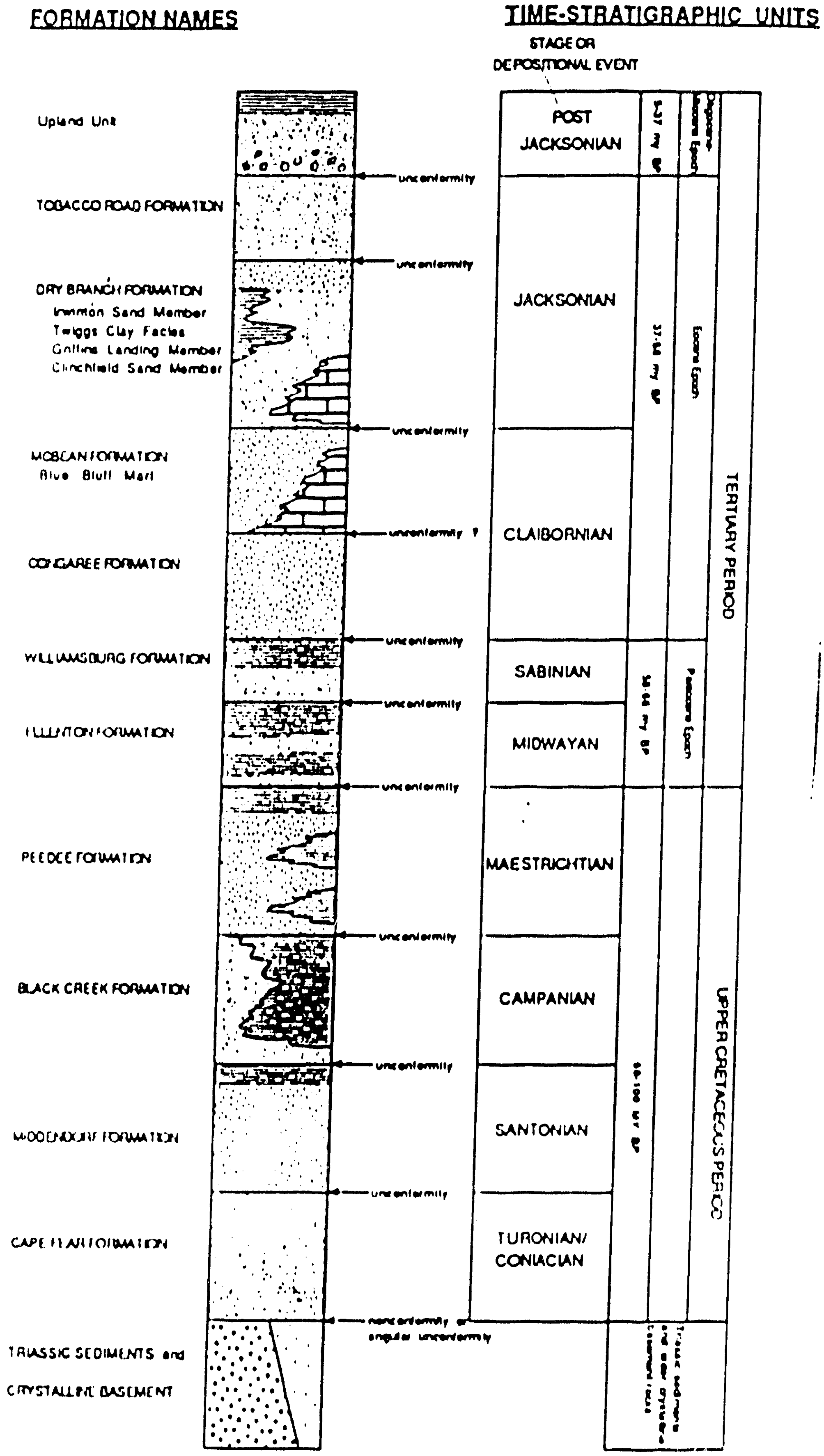
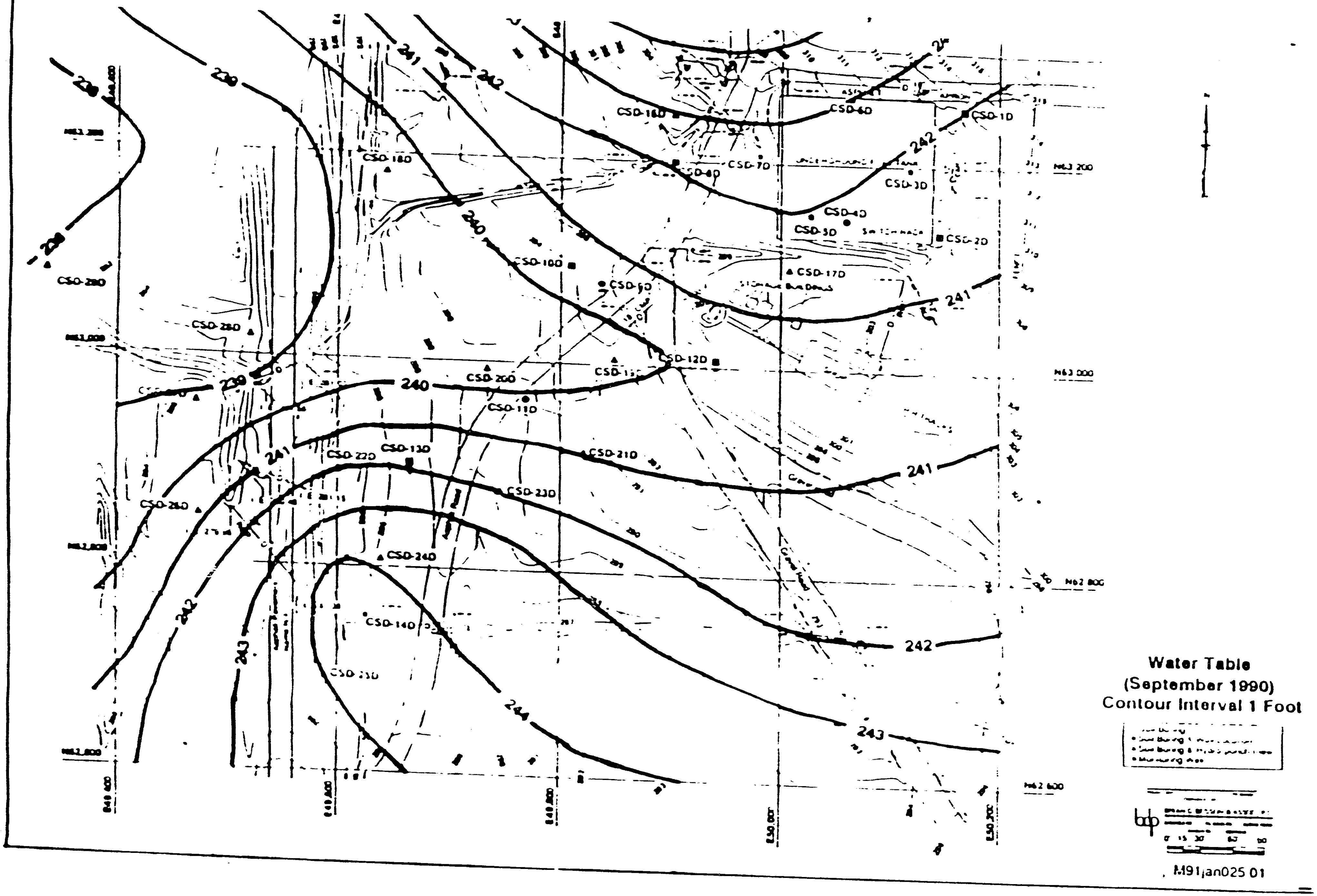


Figure 2. Generalized stratigraphic section at the Savannah River Plant.

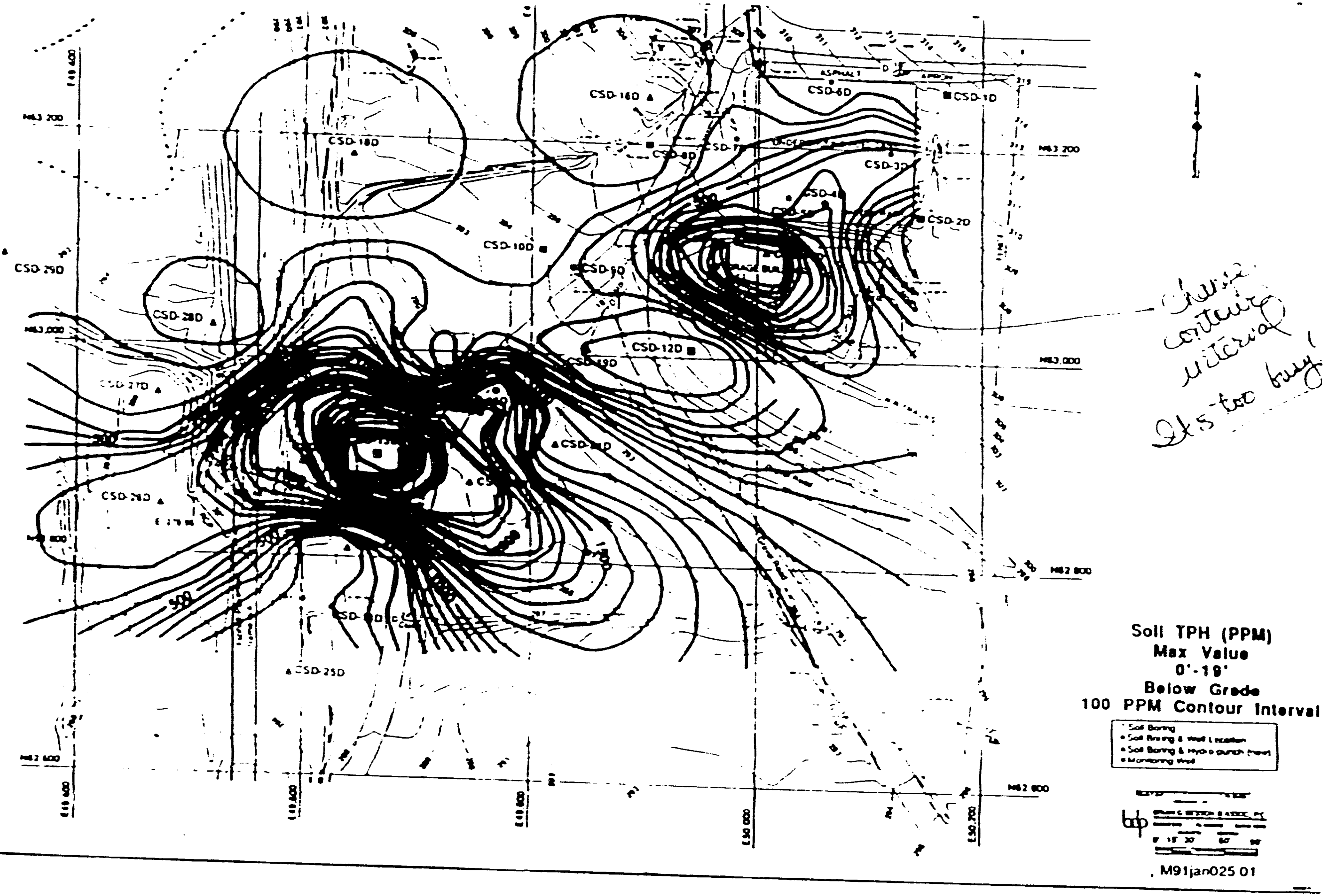
September 1990.



Water Table
(September 1990)
Contour Interval 1 Foot

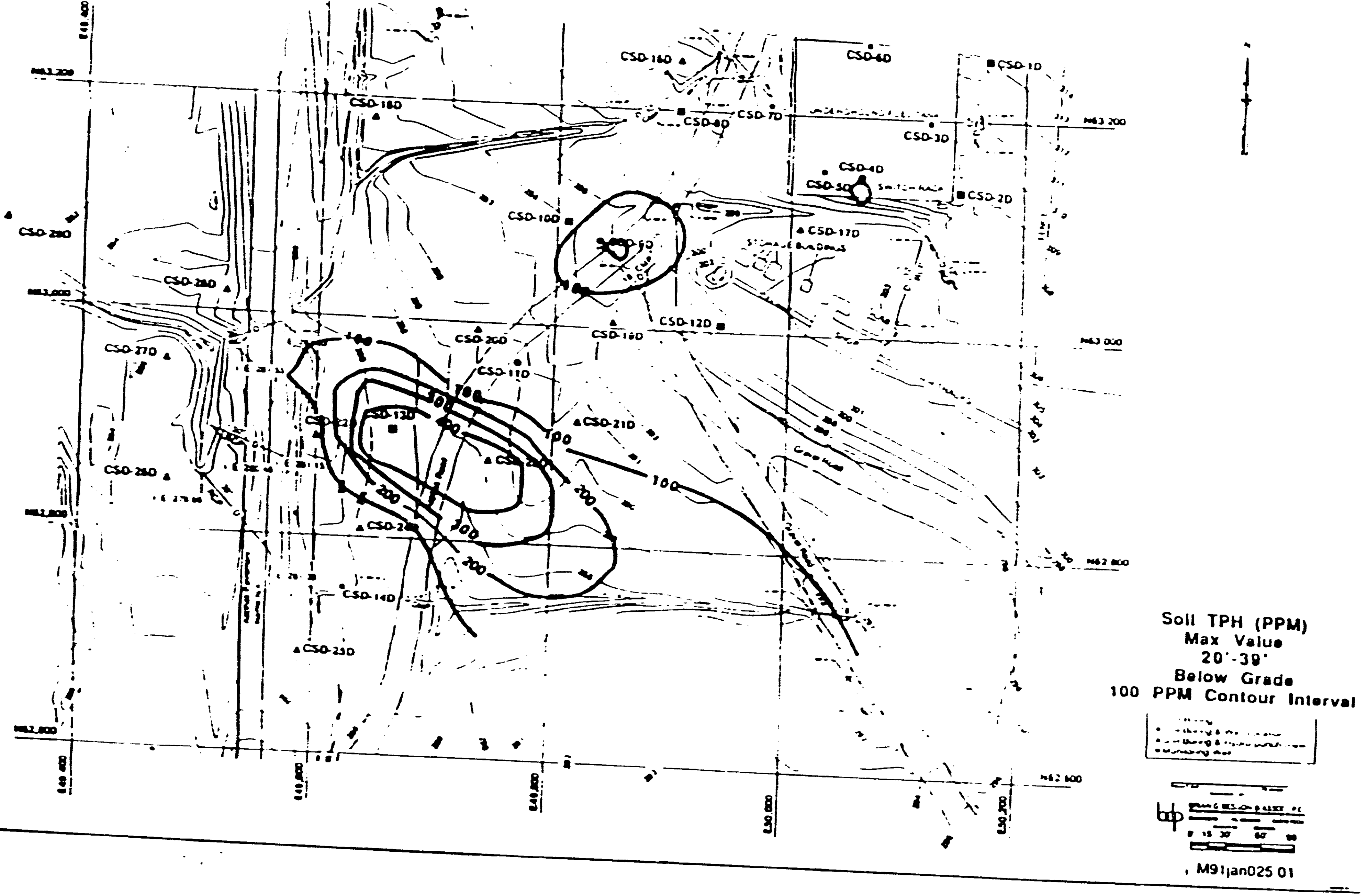
M91jan025 01

Figure 4. Two-Dimensional Contour Mapping of Maximum Total Petroleum Hydrocarbons at 100 ppm Intervals for Sediments 0-19' Below the Soil Surface.

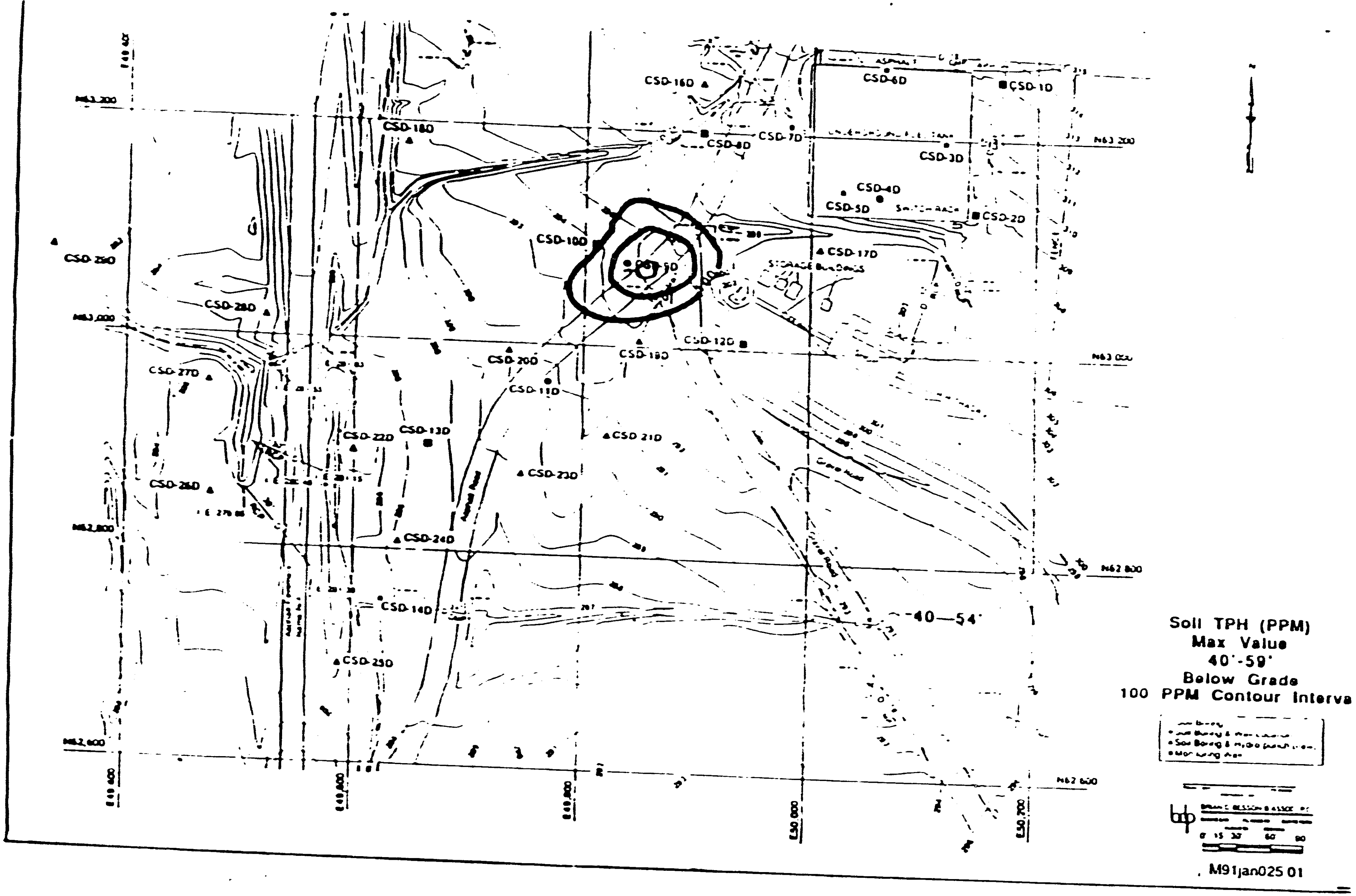


Change contour interval
It's too busy!

[illegible] Contour Mapping of Maximum Total Petroleum Hydrocarbons at 100 ppm Intervals for Sediments 20-39' Below the Soil Surface.



…ns at 100 ppm Intervals for Sediments 40-59'
Below the Soil Surface.



pping of Maximum Total
Petroleum Hydrocarbons at 100 ppm Intervals for Sediments >60'
Below the Soil Surface.

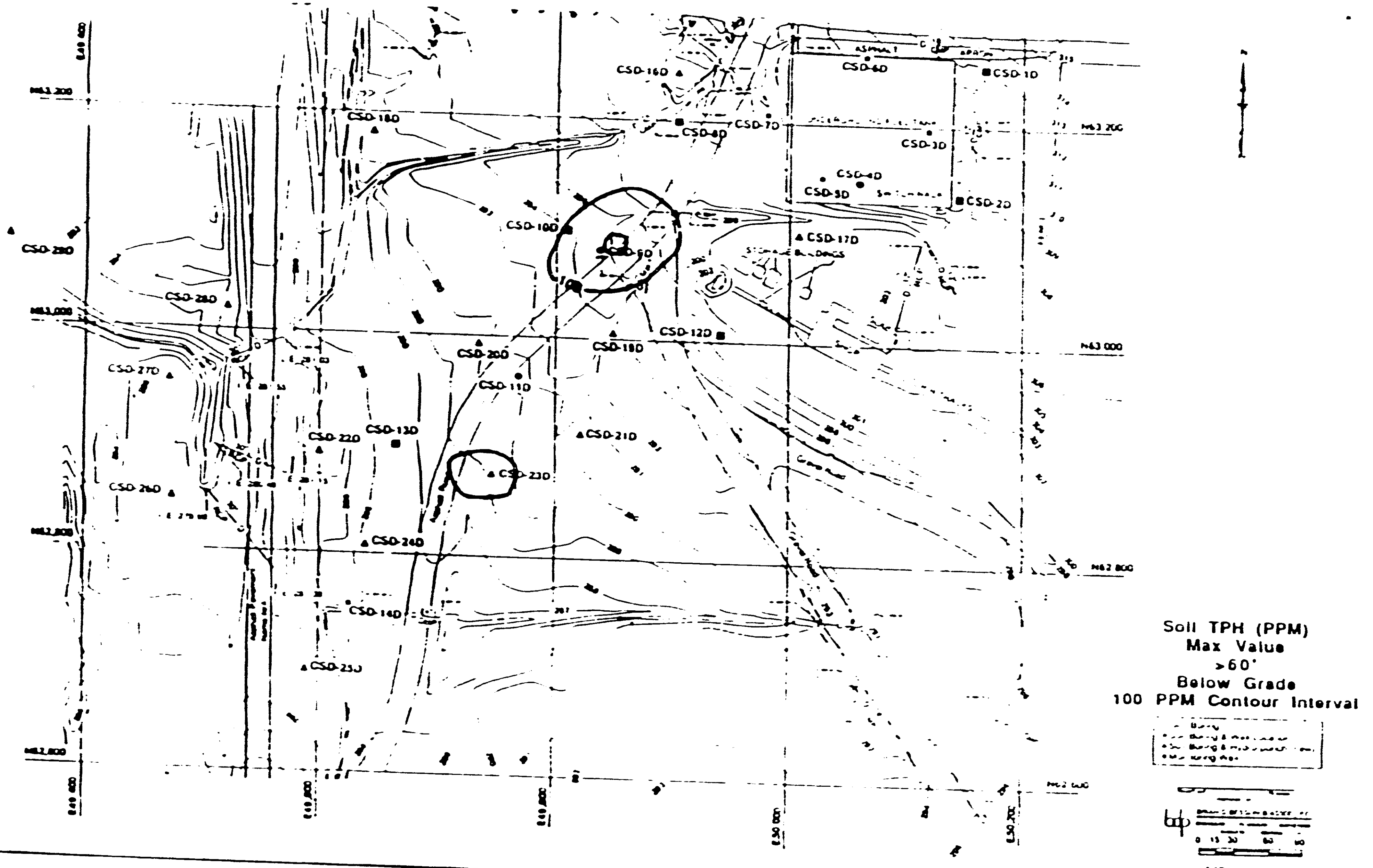
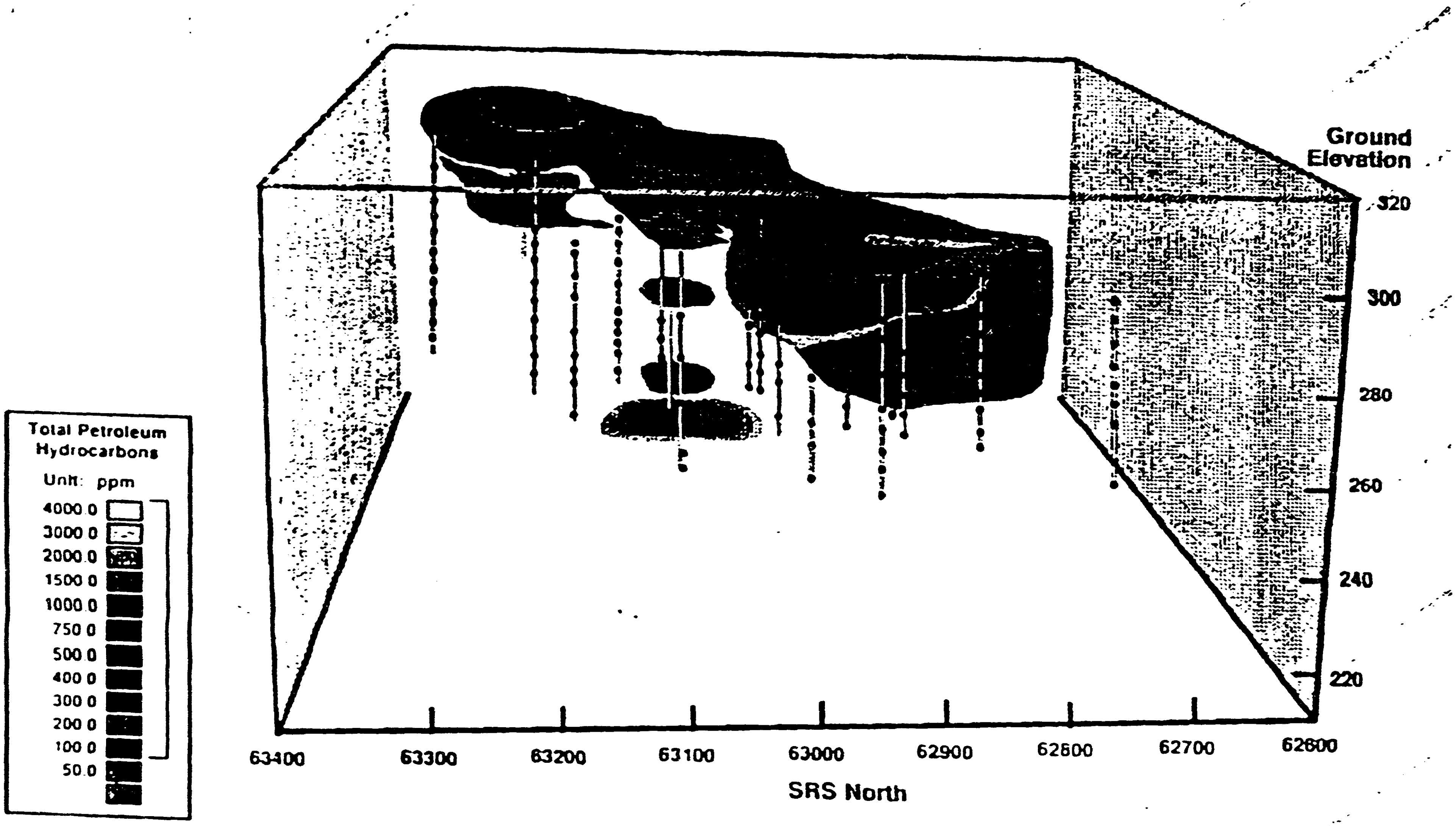
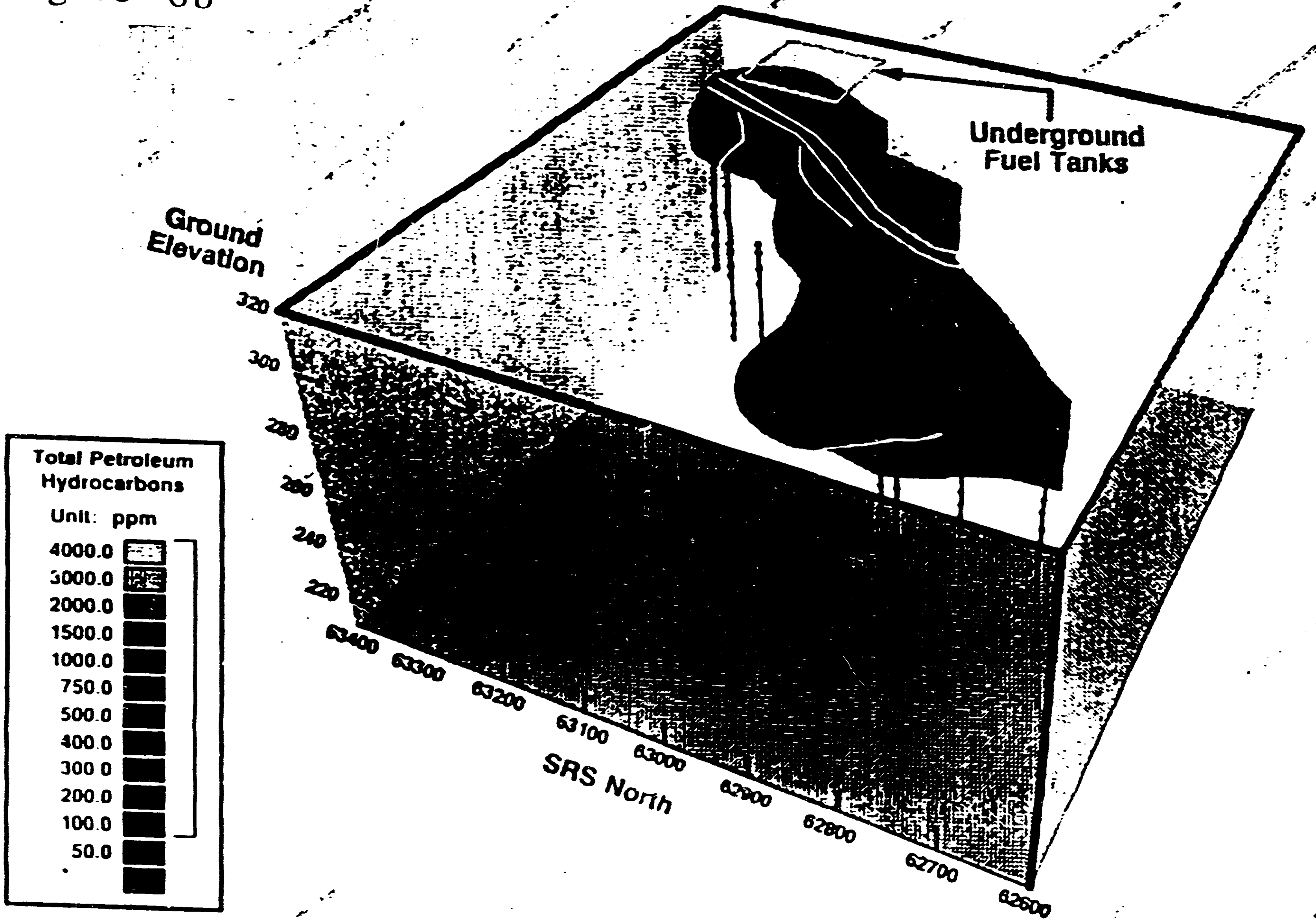


Figure 5a-d. Three-Dimensional Contour Mapping of ~~Maximum~~ Total Petroleum Hydrocarbons at 100 ppm Intervals for Sediments at Depth Below the Soil Surface.



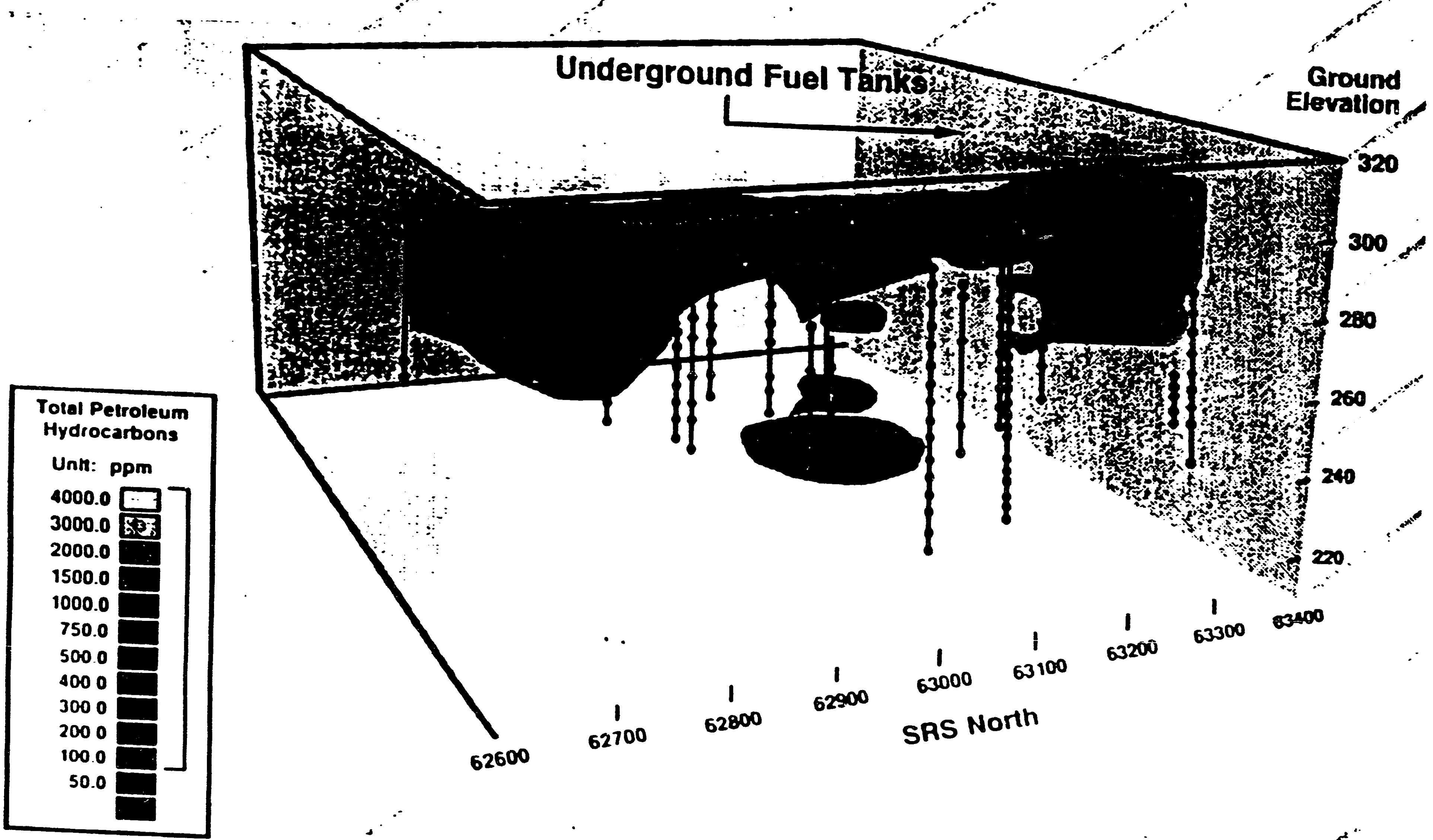
G90M013.04

Figure 8b



G90M013.05

Figure 8c



G90M013.05

Figure 8d

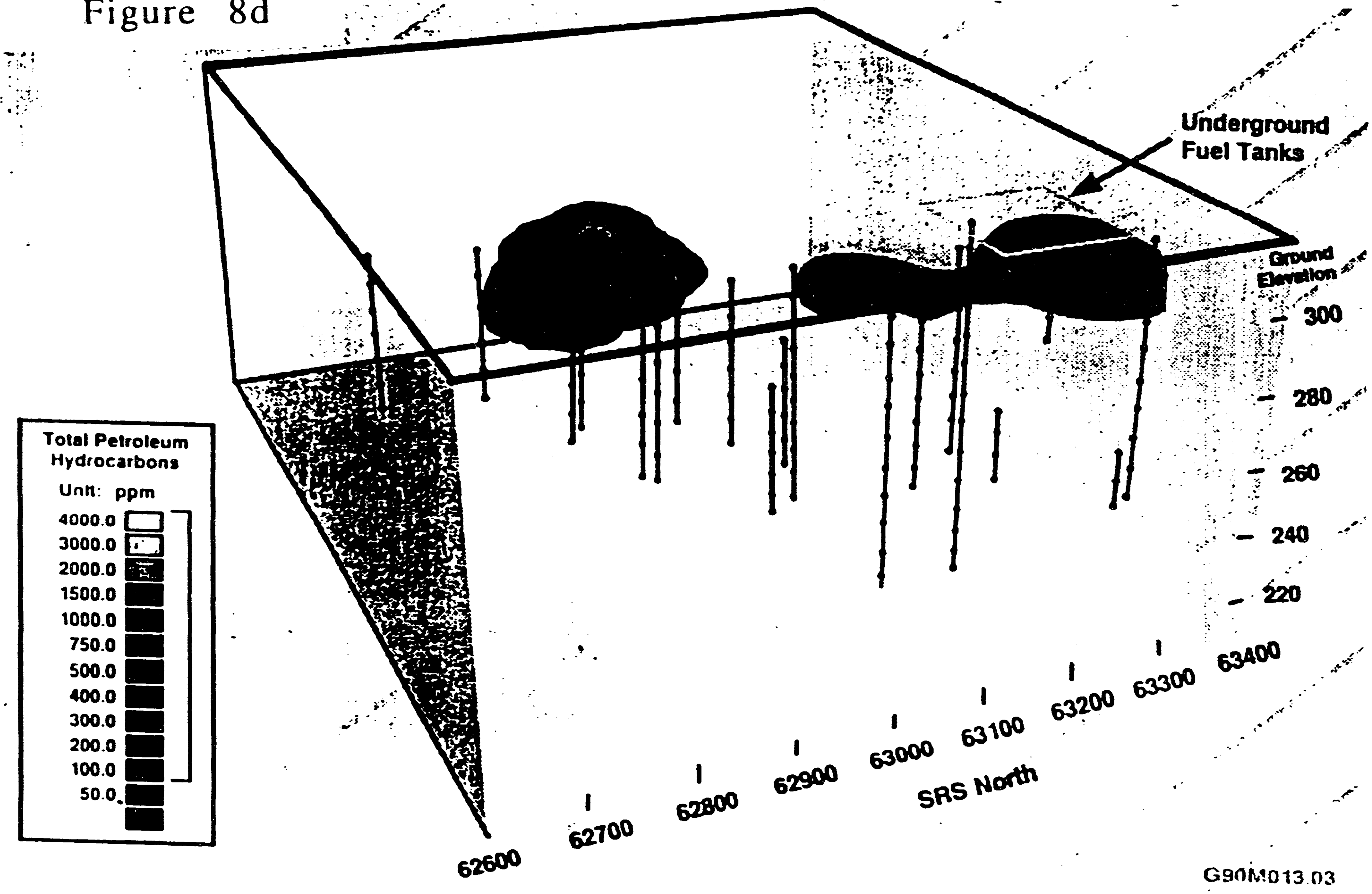

Underground Fuel Tanks
Ground Elevation
300
280
260
240
220
62600
62700
62800
62900
63000
63100
63200
63300
63400
SRS North
Total Petroleum Hydrocarbons
Unit: ppm
4000.0
3000.0
2000.0
1500.0
1000.0
750.0
500.0
400.0
300.0
200.0
100.0
50.0
G90M013.03

Figure 9. Biological Degradation of Biological Degradation of Volatile TPH in Laboratory Microcosms with a Variety of Amendments.

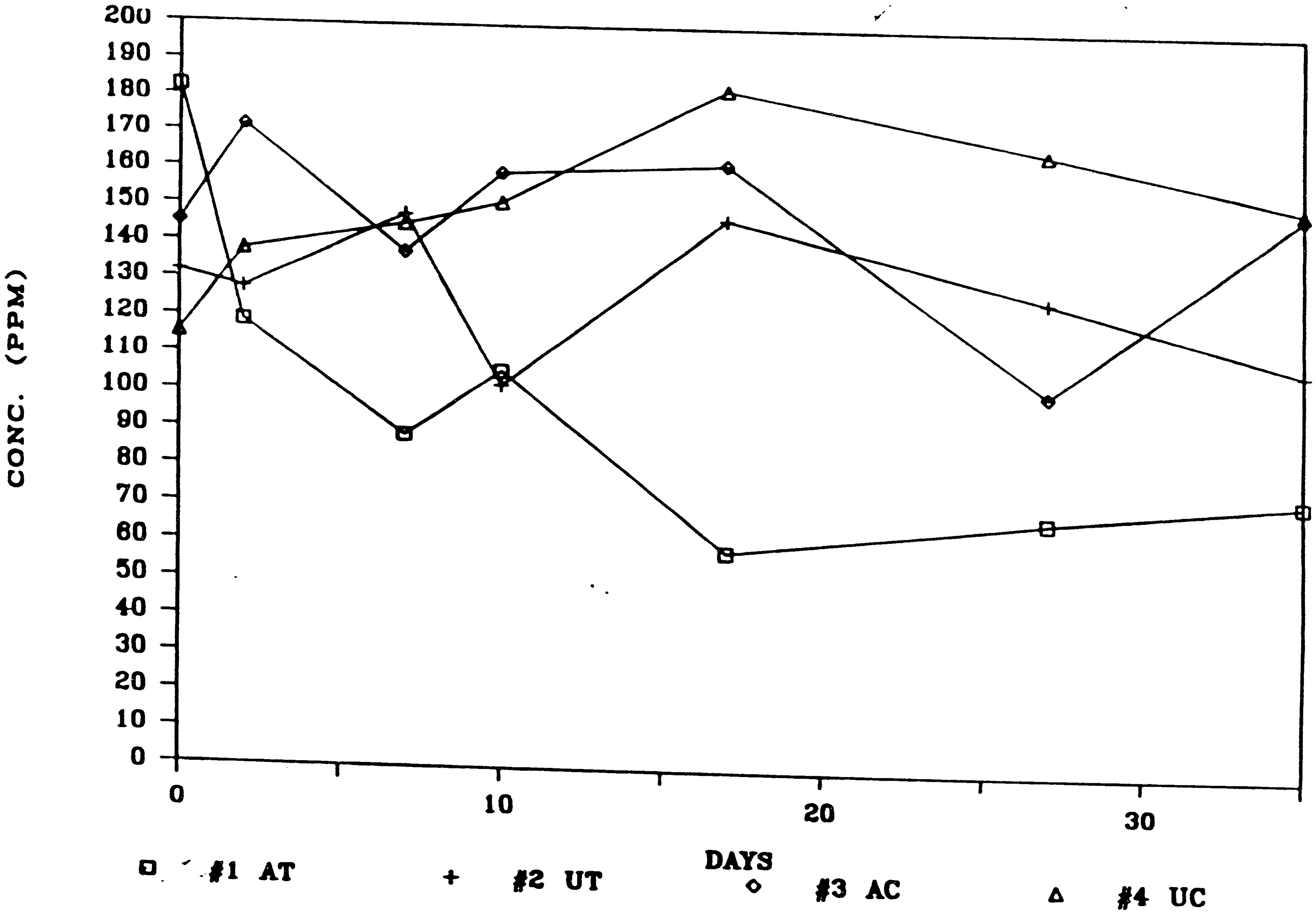


Figure 10. Biological Degradation of TPH in Laboratory Microcosms with a Variety of Amendments.

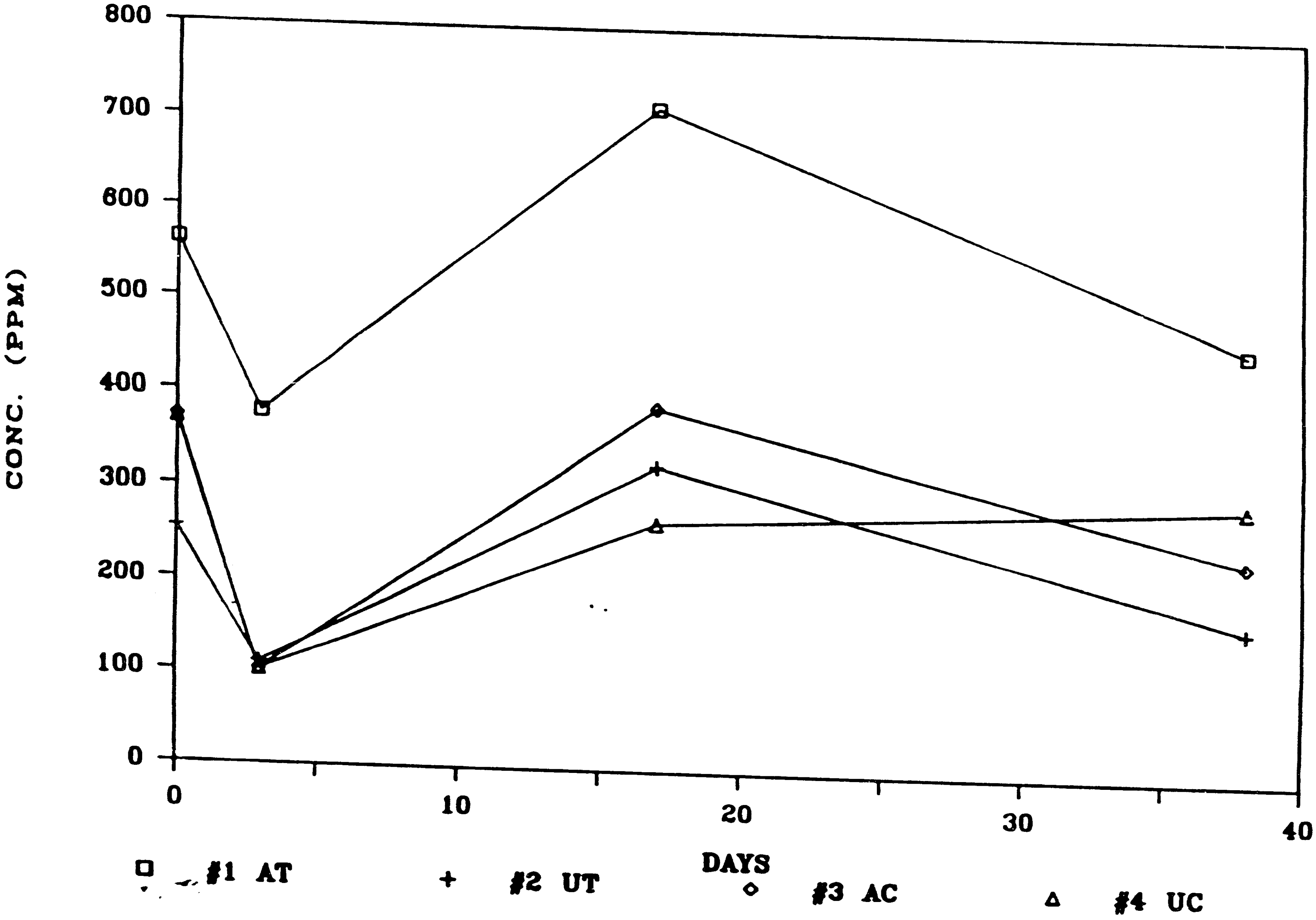
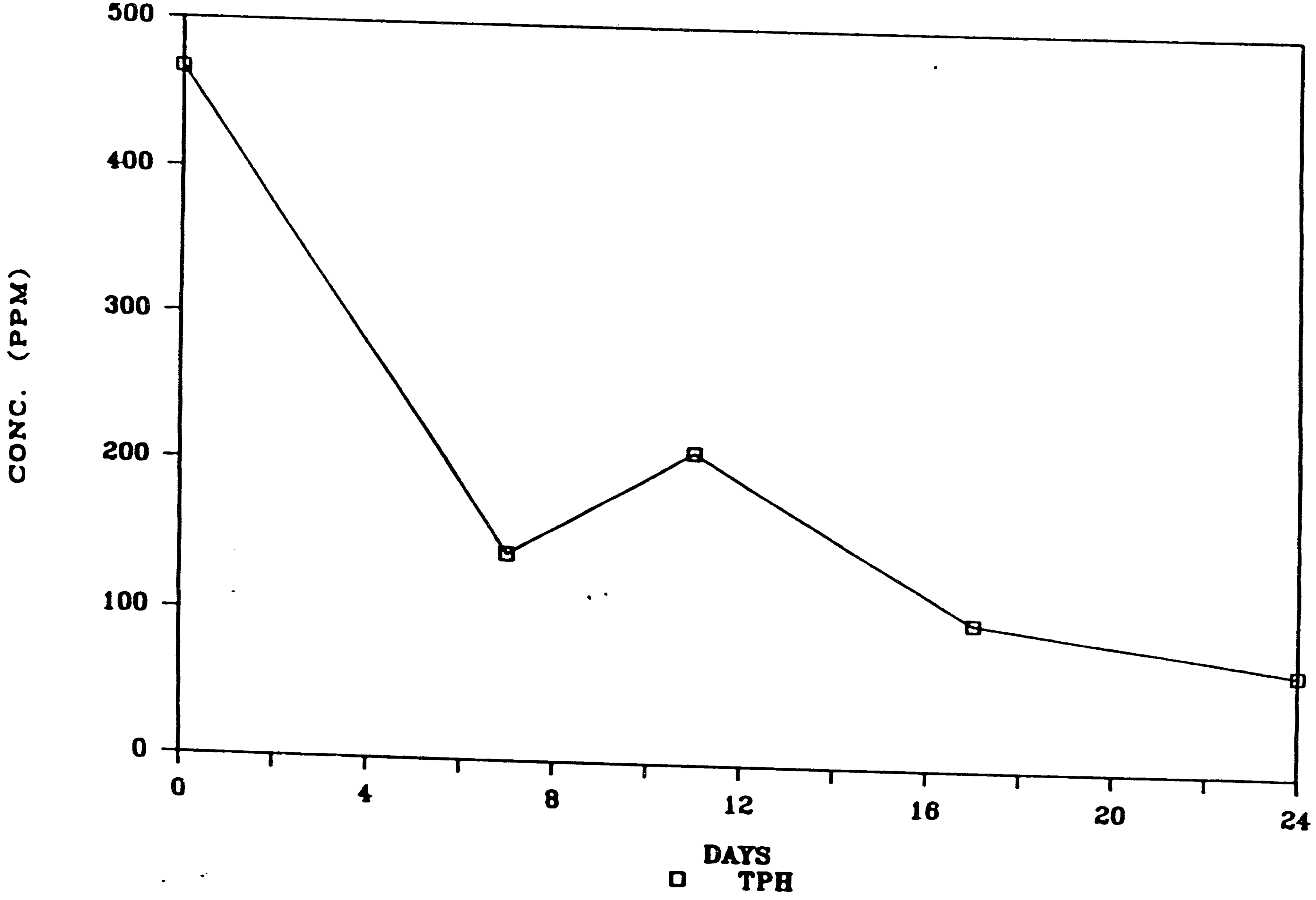


Figure 11. Vacuum extraction of CSD-13D soils containing TPH.



APPENDIX I

BOREHOLE LOGS

LEGEND

LITHOLOGY

- ∾ FILL
- ░ SAND
- ▥ SILT
- ▨ CLAY
- ▦ SILTSTONE
- ≋ SHELLS
- ▤ CROSS-BEDDING
- ▥ SILT AND SAND
- ▧ SILT AND CLAY
- ▨ SAND AND CLAY
- ▩ SILT, SAND AND CLAY

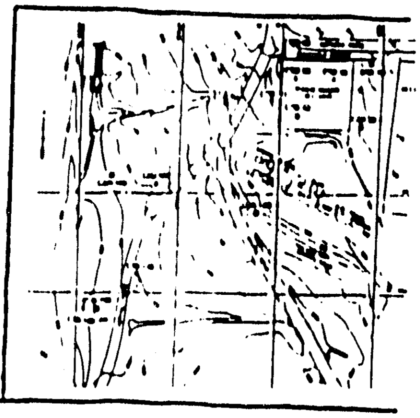
WELL CONSTRUCTION

- ○ GROUT
- ■ BENTONITE
- ▓ FINE SAND
- ░ FILTER SAND
- ▤ WELL SCREEN
- □ WELL RISER AND SUMP

DuPont Biosystems

Soil Boring CSD-10

Project 88127
Owner Savannah River Plant
Location Aiken, SC
Bore/Well
Date Drilled 12/19/88 Total Depth 70 ft/81 ft Diameter 10 in.
Surface Elevation ______ Water Level ______
Screen: Dia 4 in. Length 35 ft. Slot Size 0.015 in.
Casing: Dia 4 in. Length 40 ft. Type Sch. 40 PVC
Drilling Company MTC Drilling Method SS/Hollow Auger/MVD
Driller G. Lierman/S. Reese Log by Jim Jordan



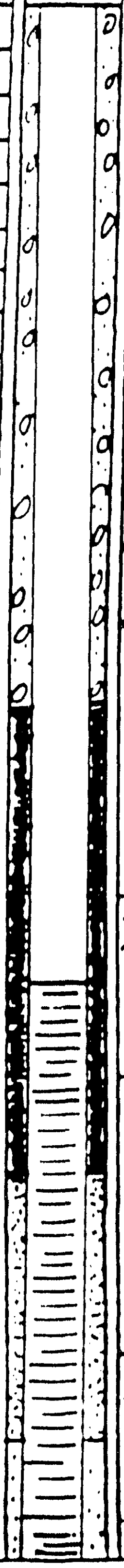
Depth (feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	% Recovery	Description/Soil Classification
			S1		90	Top 6 in. gravel and pavement SAND W/Silt, 25% silt, dark yellowish orange, sand is 75% med. gr., 25% coarse, subangular, qtz.
5			S2	0.5	90	SAND w/Silt and Clay, 15% silt, 20% clay, trace fine gravel, primarily moderate reddish orange w/mottled dark yellows, sand is fine to very coarse. poorly sorted, subangular to subrounded.
10			S3		95	CLAY W/Sand, 10% fine to med. gr. qtz. sand, subrounded, clay is mottled moderated reddish brown to white, some laminations, very hard, dense, brittle.

DuPont Biosystems

CSD-1D

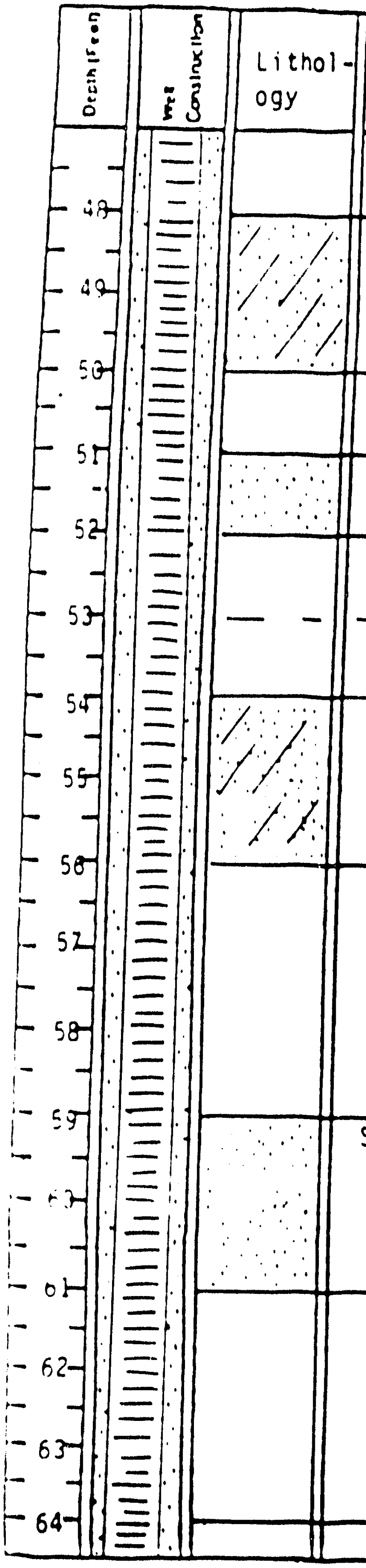
Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
14						
15		▨	S4		95	CLAY W/Sand, 10% sand, fine to med gr. qtz. sand, subrounded, clay is mottled moderate reddish brown to white, very hard and brittle.
16		▨				
17						
18						
19						
20		▨	S5		95	CLAY W/Sand, trace mica, 10% sand, grayish red purple to dark yellowish orange to white, sand is subangular, med. gr. qtz., hard, brittle, some limonite staining.
21		▨				
22						
23						
24						
25		▨	S6	1.0	95	SAND W/Clay, 20% clay, trace mica, 5% hydrated feldspars, whitish gray clay, med to coarse subangular qtz. sand, pinkish sandy clay at top grading to a whitish sand with clay at bottom, tight, hard.
26		▨				
27						
28						
29						
30						

CSD-10



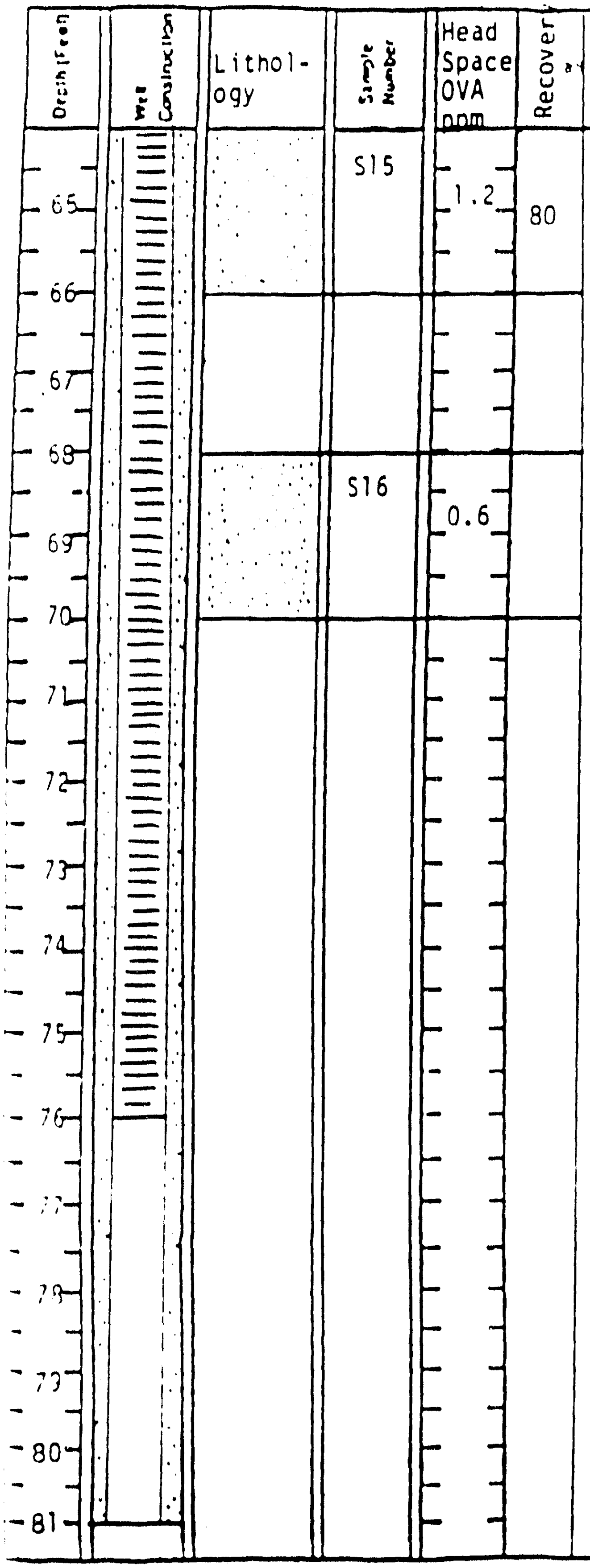
Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
31		▨	S7		90	CLAY, 5% qtz., sand, yellowish gray clay, fine, rounded, qtz. sand, very hard, dense, brittle clay.
32 33 34						
35 36		▨	S8		85	CLAY W/Sand, 15% qtz. sand, trace hydrated feldspars, yellowish gray clays with moderate reddish brown mottling, hard and brittle, sand is med. gr., subangular.
37 38 39						
40 41		▨	S9		90	SANDS W/Clay and Mica, 20% clay, 10% mica, 5% hydrated feldspar, mottled clays: white, gray, dark red, yellow, limonitic stained leaching zones, slightly moist, tight, dense clayey micaceous sand.
42 43 44						
45 46		▨	S10		85	SANDS W/Clay, 10% clay, 25% hydrated feldspars, yellowish-gray sands, 50% med. gr. subangular qtz. sand, tight with inter-sticial clays.
47						

CSD-1D



Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
S11		80	SANDS W/Clay, mica, 20% clay, trace mica and hydrated feldspars, sand is mostly med. gr., subangular qtz., slightly moist.
S12		50	SAND 5% clay with trace hydrated feldspar, pale greenish yellow moderately sorted, subround to subangular, moderately clean sand.
S13		50	SAND, fine sand with Clay, 20% clay, trace dark heavy minerals and mica, pale greenish yellow, moderately sorted, subrounded to subangular, slightly moist.
S14		95	SAND, 5% clay, trace silt, trace mica, trace hydrated feldspar, 95% fine to trace coarse, qtz. sand, subround, yellowish gray, moist, tight.

CSD-10



Description/Soil Classification

SAND, 5% silt, trace clay, trace hydrated feldspar, yellowish gray, mostly clean, well sorted, fine sand, qtz., subround, wet. tight.

SAND, 5% silt, trace clay and hydrated feldspars and mica, yellowish gray, mostly clean, tight, fine gr. qtz., sand, wet.

DuPont Biosystems

Soil Boring CSD-2D

Project 88127

Owner Savannah River Plant

Location Aiken, SC

Date Drilled 12/20-21/88

Total Depth Bore/Well 51ft/84ft

Diameter 10 in.

Surface Elevation

Water Level

Screen: Dia. 4 in. Length 25 ft. Slot Size 0.015 in

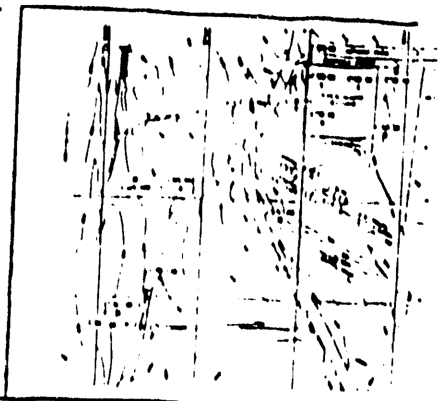
Casing: Dia. 4 in. Length 50 ft. Type Sch. 40 PVC

Drilling Company NTC

Drilling Method SS/Hollow Auger/Mud

Driller G. Lierman/S. Reese

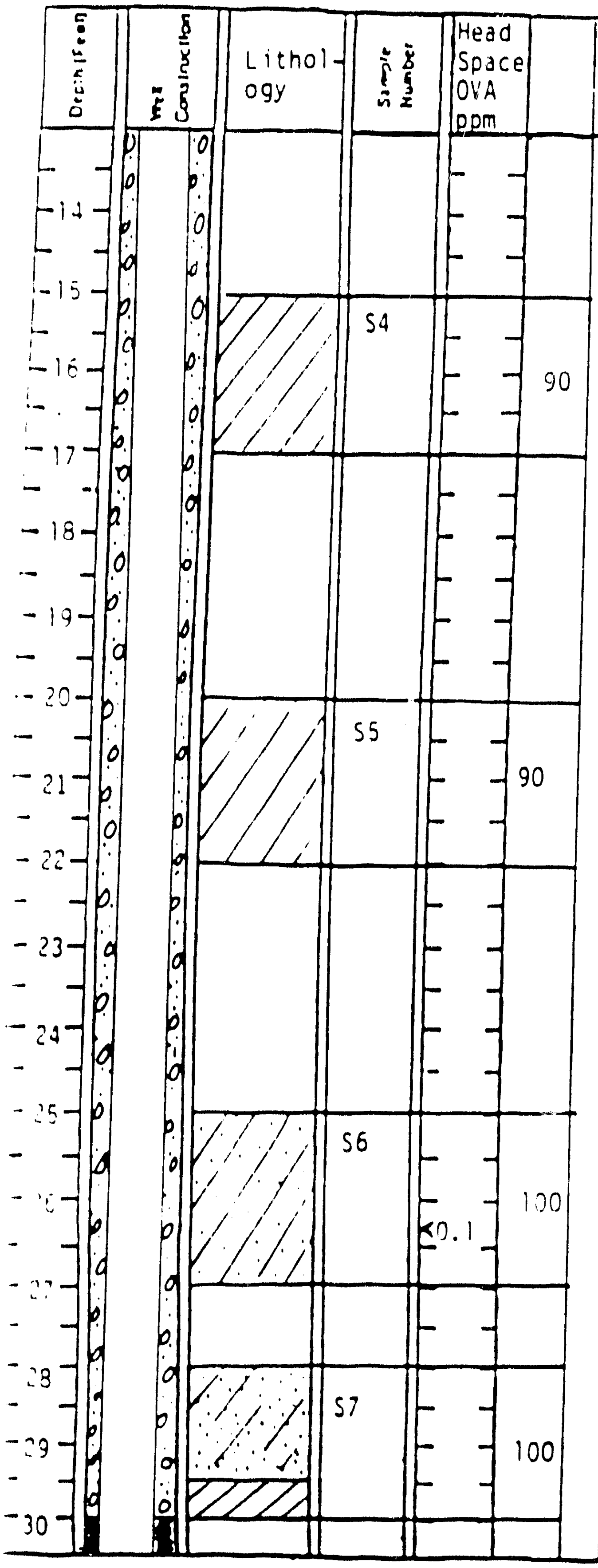
Log by Kevin Garon



Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
1			S1	6	100	SAND, 5% silt, moderate yellowish brown, moderate sorting, predominantly fine gr. qtz. sand, subrounded, trace coarse sand.
2						
3						
4						
5						
6			S2		80	SANDY CLAY, 60% clay, 30% sand, silt. Mottled moderate red to pale yellow to white, poorly sorted, cohesive, stiff, sand is med. gr. qtz., subrounded.
7						
8						
9						
10						
11			S3		80	CLAY, 10% sand, trace silt, grayish red purple clays mottled with light brown staining, sand is med. to fine qtz., sample is stiff, cohesive, heavily oxidized.
12						
13						

DuPont Biosystems

CSD-2D



Description/Soil Classification

CLAY, 10% silt, trace sand, mottled moderate red to pale yellow to white clays, cohesive, stiff.

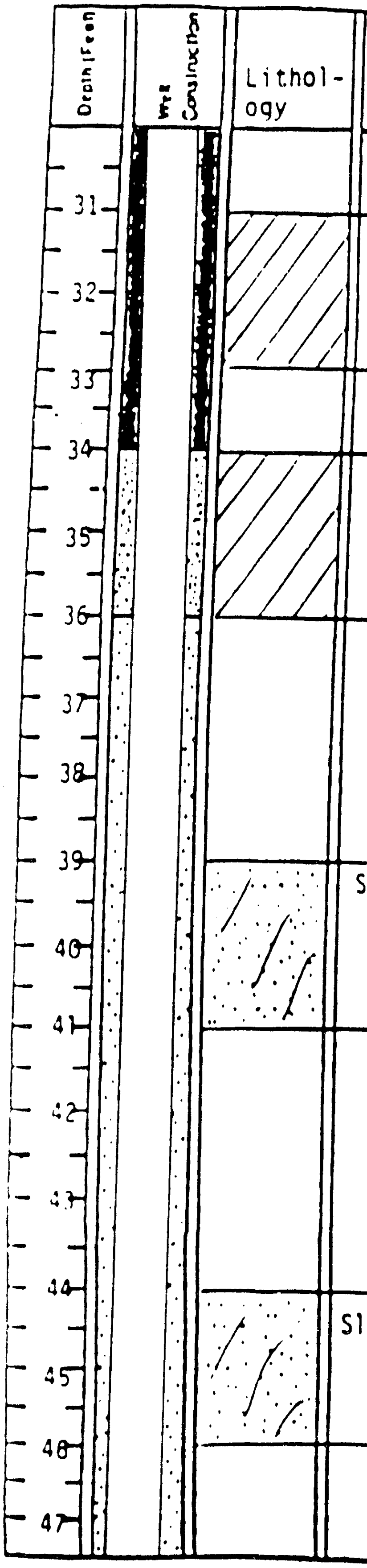
CLAY, 10% silt, trace sand, mottled moderate red to pale yellow to white, stiff, cohesive, trace Kaolinite, mica.

SANDY CLAY, 50% clay, 40% sand, silt, trace mica, grayish-orange pink, poorly sorted sample, sand is 75% med. gr. qtz., subangular, some feldspars.

Top 1.5 ft. Clayey SAND, 70% sand, 20% clay, silt, grayish-orange pink with some reddish purple mottling, med. gr. subangular qtz.

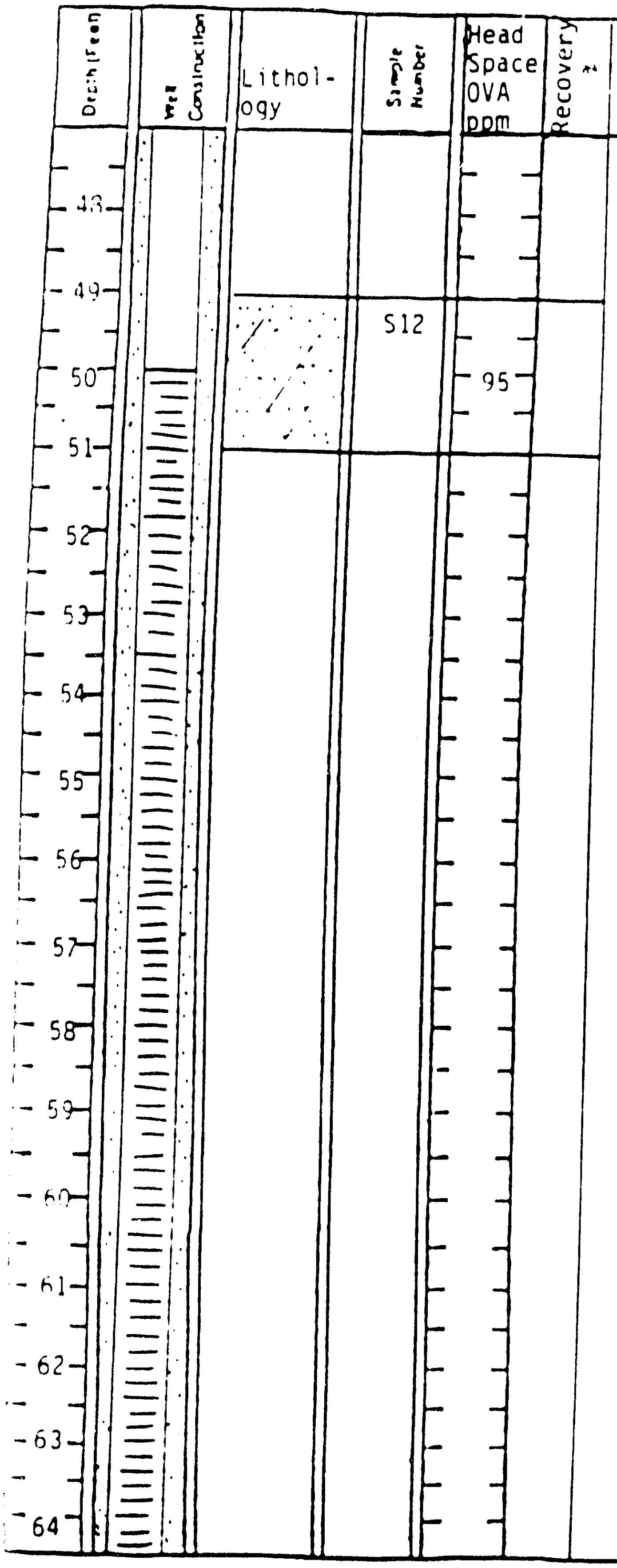
Bottom 0.5 ft. CLAY, trace sand.

CSD-2D



Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
			Mottled white to dark red dense clay, moist, cohesive, highly plastic
S8		90	CLAY, 15% sand, trace silt, mottled color but overall yellowish-gray, cohesive, stiff, highly plastic, heavy Fe oxidation, 2 to 3 small (1cm to 5 cm) sandy seams throughout sample
S9		100	CLAY, 5% qtz. sand, trace silt, mottled yellowish gray to dark yellowish orange to moderate red. Heavy, Fe oxidation, stiff, cohesive, highly plastic.
S10		90	SAND, 10% clay, trace silt, yellowish-gray overall color with some orange mottling, poorly sorted sands, fine to coarse, 80% gtz. 15% feldspars, trace mica and heavy minerals, subangular, tightly packed with intersticial clay.
S11		95	SAND, 15% clay, 5% silt, same color and makeup as above sample but with a little more fines (clay and silt) some purplish banding.

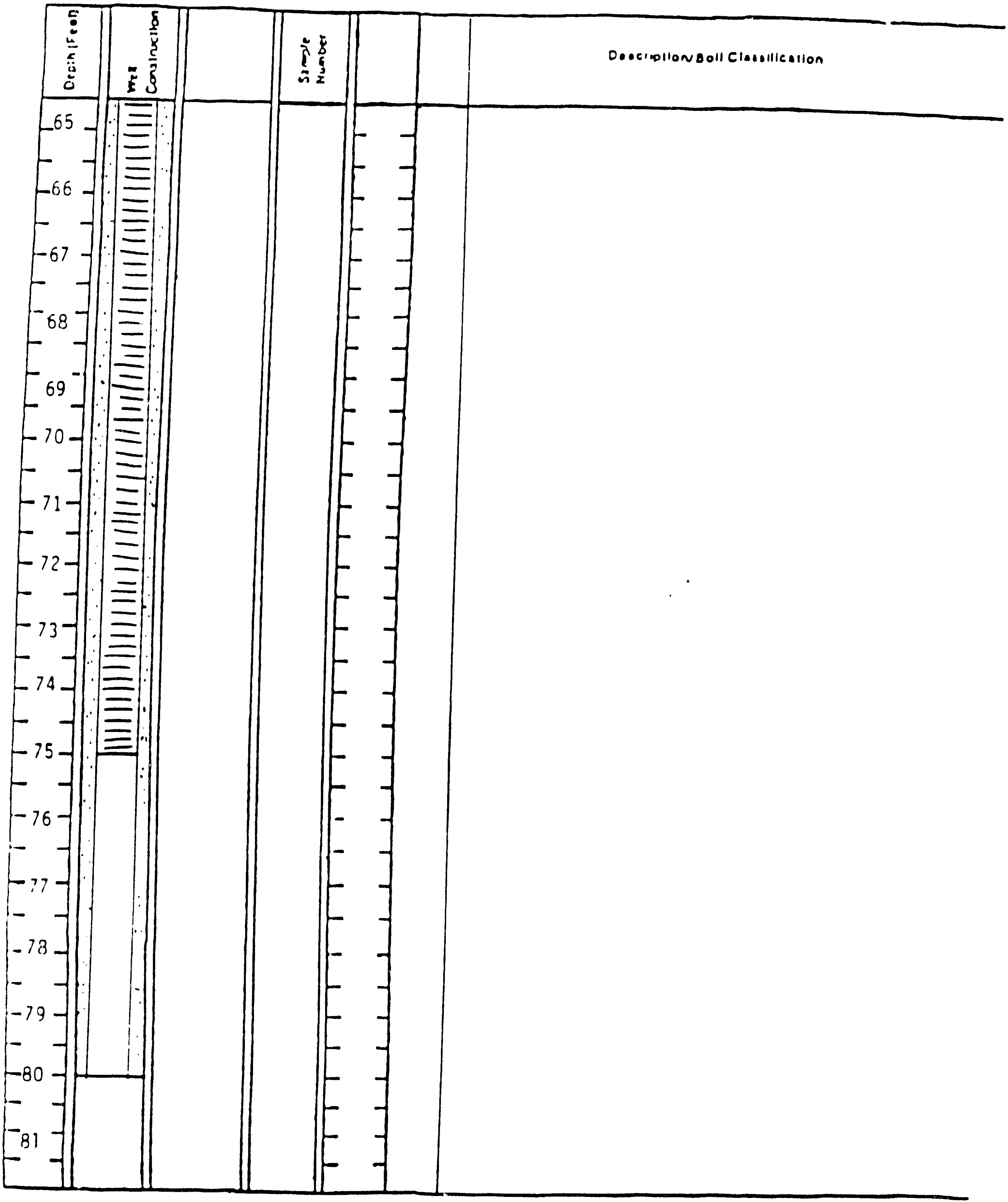
CSD-2D



Description/Soil Classification

SAND, 10% clay, 10% silt, yellowish gray, moderate to poorly sorted, sand is predominantly med. gr., subangular, 75% qtz., 15% feldspar, 5% mica, trace heavy minerals, sample is cohesive.

CSD-2D


Depth (Feet)
Well Construction
Sample Number
Description/Soil Classification
65
66
67
68
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77
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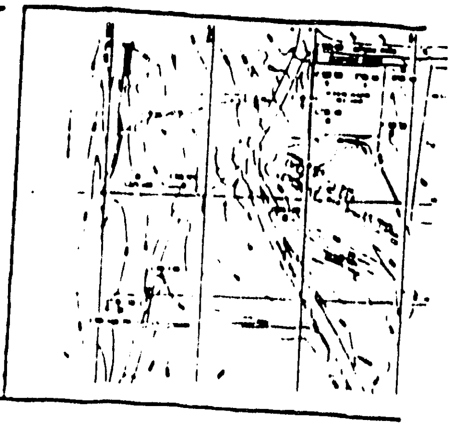
79
80
81

DuPont Biosystems

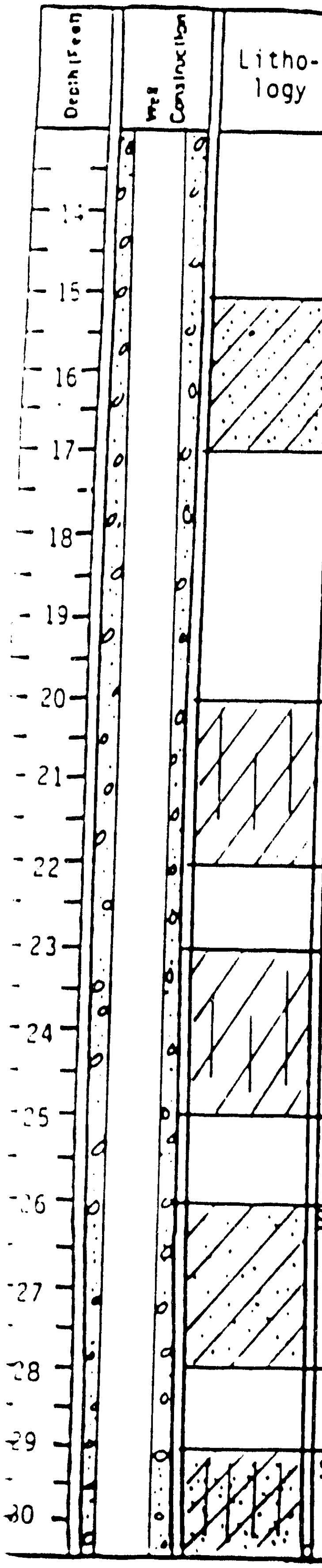
Soil Boring CSD-4D

Project 88127
Owner Savannah River Plant
Location Aiken, SC
Bore/Well
Date Drilled 12/15/88-1/10/89
Total Depth 192ft/98ft
Diameter 10 in.
Surface Elevation
Water Level
Screen: Dia. 4 in.
Length 50 ft.
Slot Size 0.015 in.
Casing: Dia. 4 in.
Length 43 ft.
Type Sch. 40 PVC
Drilling Company MTC
Drilling Method SS/Hollow Auger/Mud
Driller Corder/Kemper/Reese
Log by K. Garon/J. Gillespie



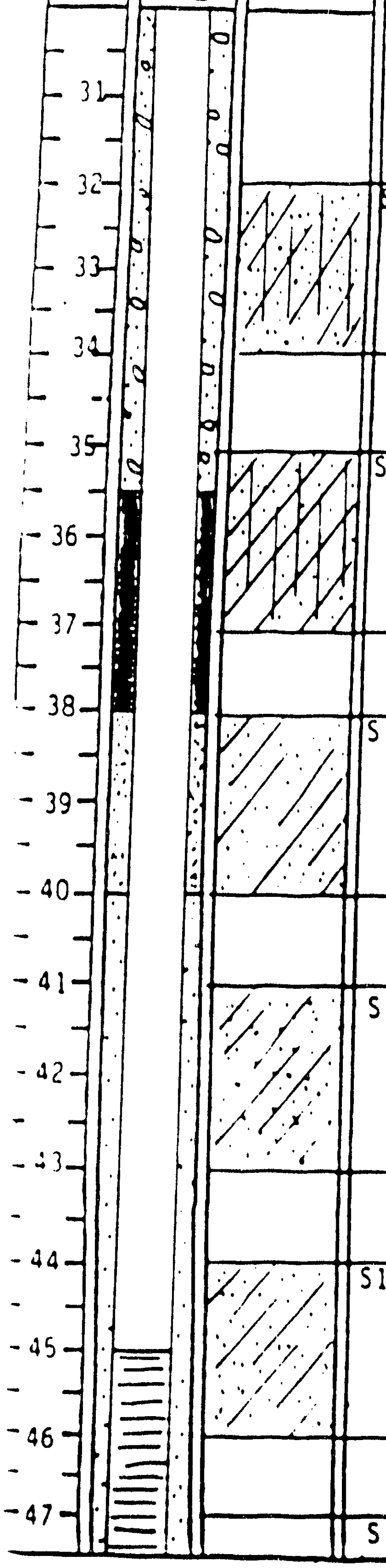
Depth (Feet)	Well Construction	Litho- logy	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
						Gravel fill material
1			S1	80	90	SAND w/Silt, 20% silt, moderate yellowish brown, fine to med. gr. qtz. sand, diesel odor, fill material.
2						
3						
4						
5			S2	380	60	CLAY w/Sand, 10% sand, med, gr. qtz., moderate reddish orange to grayish red mottled clay, cohesive, heavy diesel staining and odor.
6						
7						
8						
9						
10			S3	220	75	CLAY w/Sand, 40% med. to coarse aubangular qtz. san same mottled colors as above, cohesive.
11						
12						
13						

CSD-4D



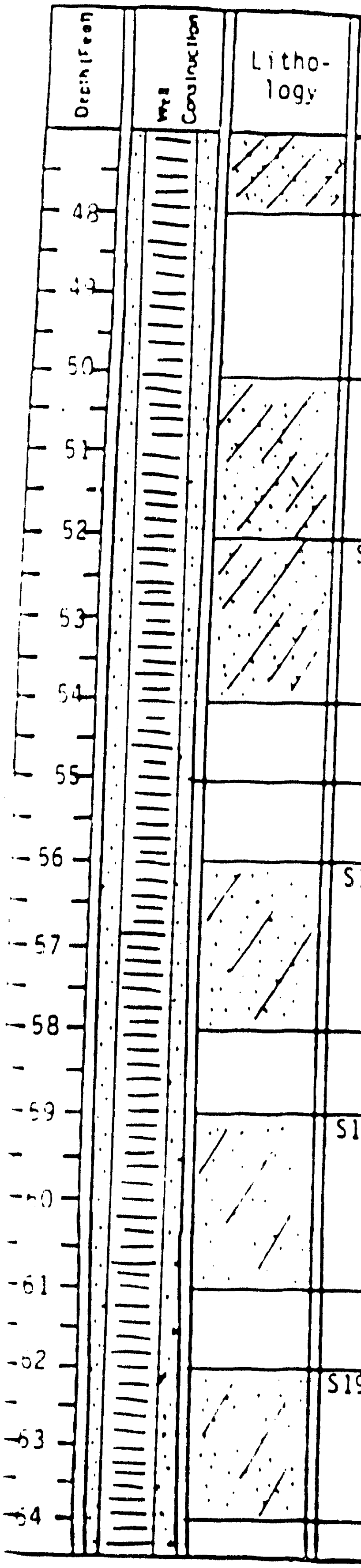
Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
S4		75	<u>CLAY w/Sand,</u> 40% Sand, mottled colors white to dusky red, hard, brittle, cohesive, sand is med. to coarse, subangular qtz. sand, some mica and feldspars present in sample, some laminae structure.
S5		85	CLAY, 10% Silt, mottled white to dusky red, fine silty laminae horizontally throughout sample, dense, hard, cohesive, brittle
S6			<u>CLAY,</u> 10% Silt, trace fine sand, same as above sample with a little sand included.
S7		80	<u>CLAY w/Sand,</u> 40% coarse, subangular, qtz. sand, white to pink to purplish mottled color, stiff, cohesive.
S8		70	<u>SAND w/ Clay and Silt,</u> Poorly sorted clayey, silty, light gray to dusky red mottled color, laminated zones of silty clay and clayey sands, qtz. and small amounts of mica and feldspar.

CSD-40



Sample Number	Head Space OVA (ppm)	[illegible]	Description/Soil Classification
S9		80	SAND w/ Clay and Silt, sample becoming more sandy towards bottom, middle zone of pink-white feldspar (Kaolinite), mostly poorly sorted qtz sand and interstical clay, overall color white-gray with the pink banding.
S10		90	CLAY w/ Silt and Sand, white, poorly sorted, laminated sand, silt, and intersticial clay. Clay content, 50%, sand is predominantly fine to med. gr. qtz., trace mica, feldspar, cohesive.
S11		60	SAND w/Clay, same as above, but w/ alittle more sand content, a few pink bands (1mm to 5mm) running horizontally through sample.
S12		85	SAND w/Clay, same as previous sample, moisture content increasing slightly.
S13	3.0	70	SAND w/Clay, fine to med. gr. qtz. sand packed tight in a whitish-gray to yellowish green intersticial clay, clay content almost 50% as previous samples, tight, moist, cohesive, brittle break, trace mica, heavy minerals, feldspars.
S14			

CSD-4D



Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
S14		25	SAND w/Clay, same as above.
S15	1.8	75	SAND w/Clay, same as previous sample butsand content is increasing with depth.
S16	0.3	80	SAND w/Clay, white to grayish yellow color, sample contains much more sand than previous samples (70% sand and 30% clay), sand is mainly med gr., subangul to subround, qtz. red FE oxidation laminations throu out
S17	2.0	80	SAND w/Clay, 15% Clay. white to grayish yellow, fine to coarse, poorly sorted qtz. sand and intersticial clay, heavy bands of pinkish red FE oxidation, small (5mm) band of heavy minerals.
S18	2.2	70	SAND w/Clay, 15% clay, trace silt, trace mica, heavv minerals, feldspars, pale greenish yellow, moderatel sorted coarse gr. qtz. sand, several red oxidation bands.
S19	2.2	80	SAND w/Clay, 15% Clay, well sorted med to coarse qtz. sand with some intersticial clay, color and laminations same as above.

CSD-4D

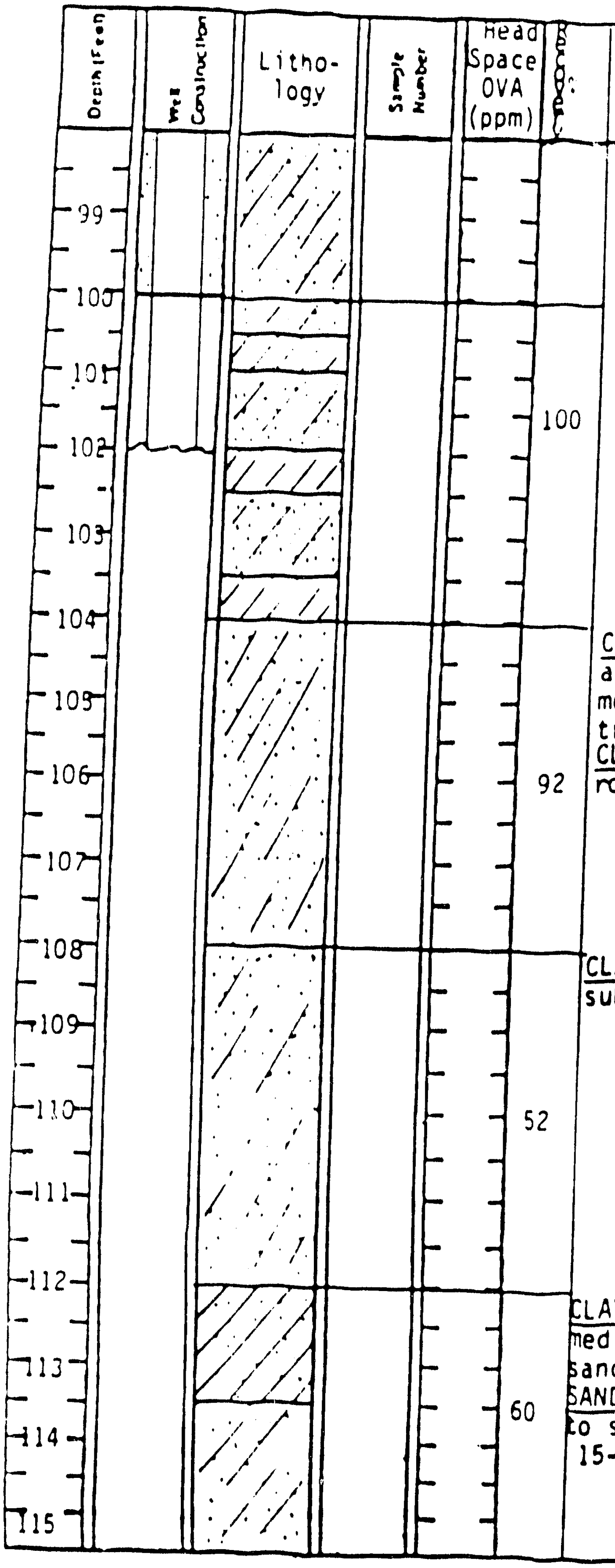
Depth (Feet)	Well Construction	Litho-logy	Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
			S20	1.8	80	SAND, 10% Clay, same as above but slightly less clay, trace silt.
			S21		80	SAND, 10% clay, banded colors of red to orange with overall white sands as above, 3cm layer of oxidized heavy minerals in middle of sample, sand is well sorted med. to coarse gr. qtz., loose wet.
			S22	1.4	80	SAND, 5% Clay, white well sorted sands x-bedded with layers of poorly sorted sand and clay balls, heavy red and orange oxidation laminae. Heavily stained areas are generally more coarse grained.
			S23		80	SAND, 5% Clay appearing as small (1mm to 5mm) clay laminations, white, red and reddish purple color banc poorly sorted fine to very coarse sands x-bedded witr clays, clay balls.
			S24			SAND w/Silt and Clay, poorly sorted sands and clay laminae as above, color more purple than red, more clay laminations than previous sample.
			S25		85	SAND, 5% Clay, trace silt, trace feldspar, mica, heavy minerals, pale yellow upper 6 in. of samples, rest is red-purple, well sorted, med. to coarse, subangular qtz, sand, wet.

CSD-4D

Start logging by J. Gillespie of Sirrine Env.

Depth (Feet)	Well Construction	Litho-logy	Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
82						
83 84					50	SAND, SILT - fine to medium moderate yellow to pale reddish brown subangular - subrounded sands with 15-20% silt and 15-20% white mica, pale reddish brown banding.
85 86 87 88					100	SAND, coarse to very coarse, moderately sorted; angular to subrounded, mod. red dark yellowish orange, very pale orange w/10-20% clay and trace mica, color, banding, clay balls.
89 90 91 92					90	SAND, Clay fine to med., poorly sorted angular to subrounded moderate red brown, moderate yellow sands, minor 15-20% clay, trace mica, color banding.
93 94 95 96					67	SAND-CLAY, Fine to med., poorly sorted subangular-subrounded sands w/ purplish red-moderate yellow clays, i.e. moving into a clay confining bed, clay beds thicken in middle.
97					65	SAND, CLAY Med. to coarse; angular to subrounded qtz. sand mod. to poorly sorted. Moderate red to grayish pink - moderate yellow; 15-25%; clays color banding, top moist, more compact and dry at bottom.

CSD-4D



Description/Soil Classification

CLAY, SAND Dark reddish brown <6"layers w/15-25% fine to medium moderately sorted; subangular to subrounded sands, trace coarse pebbles, dark yellow limonite staining throughout.

CLAY, SAND, dark reddish brown clay w/ dark yellowis and dark reddish staining w/ 15-20% fine to medium; moderately sorted; subangular to subrounded sands, trace coarse pebbles

CLAY, SAND, fine to medium; moderately sorted; sub-rounded, dark yellowish-orange sand.

CLAY, SAND med.-fineoderately sorted, moderately rec subangular to subrounded sands w/ minor 15-20% clay.

CLAY, SAND, dark reddish brown clay w/15-20% fine to medium; moderately sorted; subangular to subrounded sands.

SAND, CLAY, Med. - fine; moderately sorted; subangula to subrounded dark yellowish orange sands w/minor 15-20% clay.

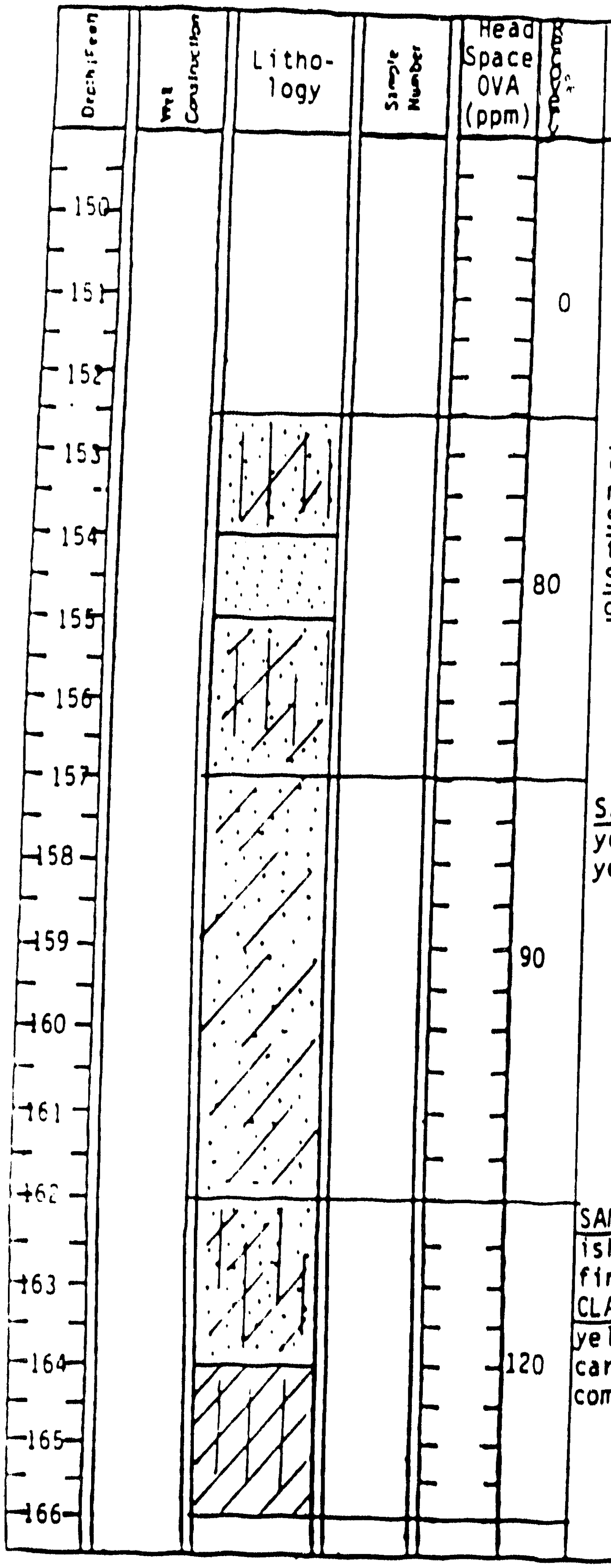
CSD-4D

Depth (Feet)	Well Construction	Litho-logy	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
			.			
116 117 118 119					62	CLAY, SAND, dark reddish brown clav w/15-20% fine to medium; moderately sorted, subangular to subrounded sands. SAND, CLAY, med. - fine moderately sorted; subangular to subrounded sands, dark yellowish orange w/minor 15-20% clay.
120 121					75	SAND, Clayey, fine to med.: moderately sorted, subangular to subrounded sands, dark yellowish orange w/minor 10-20% clay.
122 123 124 125					25	SAND, Clayey fine to medium; moderately sorted subangular to subrounded sands, dark yellowish orange 15-20% Clay
126 127					50	SAND, Clayey, fine to medium; moderately sorted, subangular to subrounded sands, dark yellowish-orange w/minor 20-30% clay, very dark red staining 1 form of strand running vertically through sample.
128 129 130 131 132					0	NO RECOVERY

CSD-4D

Depth (Feet)	Well Construction	Litho-logy	Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
133 134					30	SAND, Coarse to very coarse; poorly sorted subangular to subrounded, dark reddish brown 15-20% silt.
135 136 137 138					80	SAND, SILTY, 15-25% silt, dusky red, med. coarse subangular to subrounded, moderately sorted, moist.
139 140 141 142					90	SAND, SILTY, 10-15% silt, dusky red - pale yellowish orange, coarse, subrounded, well sorted, moist.
143 144 145 146					90	SAND, SILTY, 20-25% silt, 15% clay, mod. red to dark yellowish orange to yellowish gray; trace rounded <1CM granules; med. to coarse sands? 4-5cm cherty bed at 144.5 angular.
147 148					50	SAND, trace silt; pale yellowish orange to black; subrounded; well sorted dark yellowish orange <2mm clay beds separating paly yellowish orange from black sand
149						

CSD-4D



Description/Soil Classification

NO RECOVERY

SAND, SILT, 20-30 % silt, 5-10% clay, moderate reddish brown, subangular to subrounded, poorly sorted med.-coarse.

SAND, Trace silt, pale yellowish orange, subangular to subrounded well sorted, coarse.

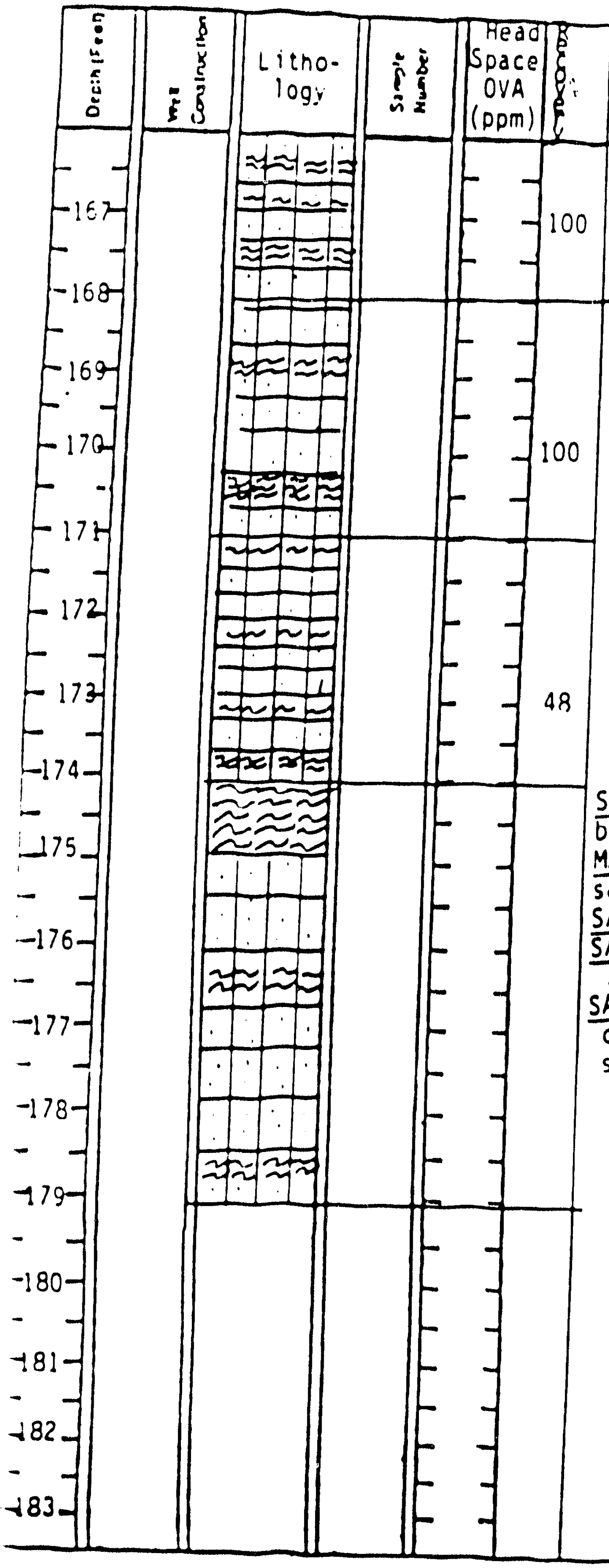
SAND, CLAY, 15-20% Clay, 10-15% silt, pale yellowish green poorly sorted, fine to med. grain.

SAND, CLAY, 25-30% clay; trace silt, moderate greenis yellow; poorly sorted, fine to med. grain, dark yellow orange banding.

SAND, CLAY, 20-25% Clay, 10-15% silt, moderate greenish yellow subangular to subrounded, poorly sorted, fine-med. grain.

CLAY, 10-15% silt moderate greenish yellow w/dark yellowish orange banding, 164-166 marl w/shells carcareous reacts w/ HCL crossostrea, hard well compacted.

CSD-4D



Description/Soil Classification

SILT, trace clay, greenish gray, well compacted w/ large shells, reacts strongly to HCL.

SILT, SAND, 10-15% sand; 5-10% clay, greenish gray, hard, well compacted w/ shell beds, reacts w/HCL

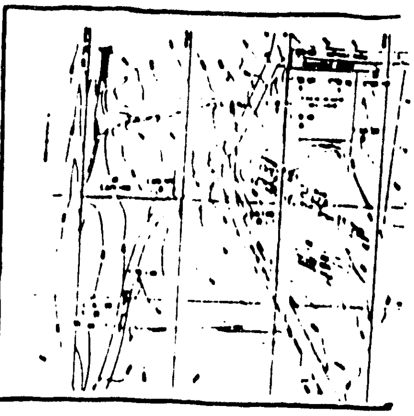
SILT, 10-15% clay, trace sand greenish gray, hard, well compacted.

SHELL LAYER on bottom white shells calcareous layer broken.
MARL, SAND large shell fragments 35-40& silt, 20% sand, very hard calcareous.
SAND, 20% silt, 5% clay, yellowish green, trace shel
SAND, med.-coarse, yellowish green, samll shell frag .5-1cm.
SAND, 25% clay, 15% silt, yellowish green, med.-coarse poorly orted subangular-subrounded-trace shells.

DuPont Biosystems

Soil Boring CSD-8D

Project 88127
Owner Savannah River Plant
Location Aiken, SC
Bore Well
Date Drilled 1/3-4/89
Total Depth 77 ft/80 ft
Diameter 10 in.
Surface Elevation
Water Level
Screen: Dia. 4 in.
Length 30 ft.
Slot Size 0.015 in.
Casing: Dia. 4 in
Length 45 ft.
Type Sch. 40 PVC
Drilling Company MTC
Drilling Method SS/Hollow Auger/Mud
Driller G. Lierman/S. Reese
Log by Kevin Garon



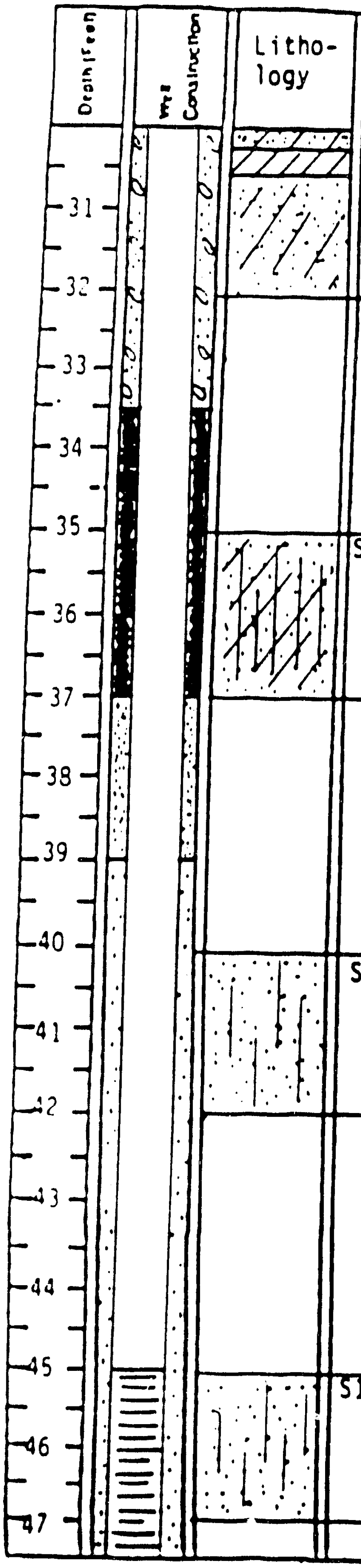
Depth (feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
0–1						Gravel Road bed and fill
1–3			S1	-	100	CLAY, w/sand and silt, 25% sand, 5% silt, grades in color from dark yellowish orange to light brown to moderate brown at bottom. Sand is med. to coarse gr. quartz; subangular, sample is poorly sorted, cohesive, med. plasticity.
5–7			S2	4.2	95	CLAY, w/sand, 40% sand, mottled very dark, red to pale yellow to light brown, poorly sorted, cohesive, sand is med. to coarse qtz., sunangulat, 80% gtz., rest is feldspar and mica.
10–12			S3	32	95	CLAY, w/sand, top 4 in. of sample is 40% sand, rest of sample if 90% clay, 10% sand, mottled very dark red to pale yellow to white, poorly sorted, sand is fine gr. qtz., trace mica and feldspar.

DuPont Biosystems

CSD-8D

Depth (Feet)	Well Construction	Litho-logy	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
14						
15		▨	S4	6.2	95	**CLAY**, 10% sand, trace silt, mottled pale red to yellowish gray to very dark red, very stiff, cohesive, hard, highly plastic
16		▨				
17						
18						
19						
20		▨	S5	1.8	100	**CLAY**, 5% qtz. sand, same color and texture as sample above.
21		▨				
22		▨				**CLAY**, 5% qtz. sand, same color and texture as sample above
23		▨				
24						
25						
26						
27		▨	S6	0.6	90	**CLAYEY SAND**, overal 75% sand, 25% clay, mottled and banded color range from gray to moderate red brown to light gray to light red brown, sands are poorly sorted fine to med. gr. qtz. packed tightly with intersticial clays, cohesive.
28		▨				
29						
30						

CSD-8D

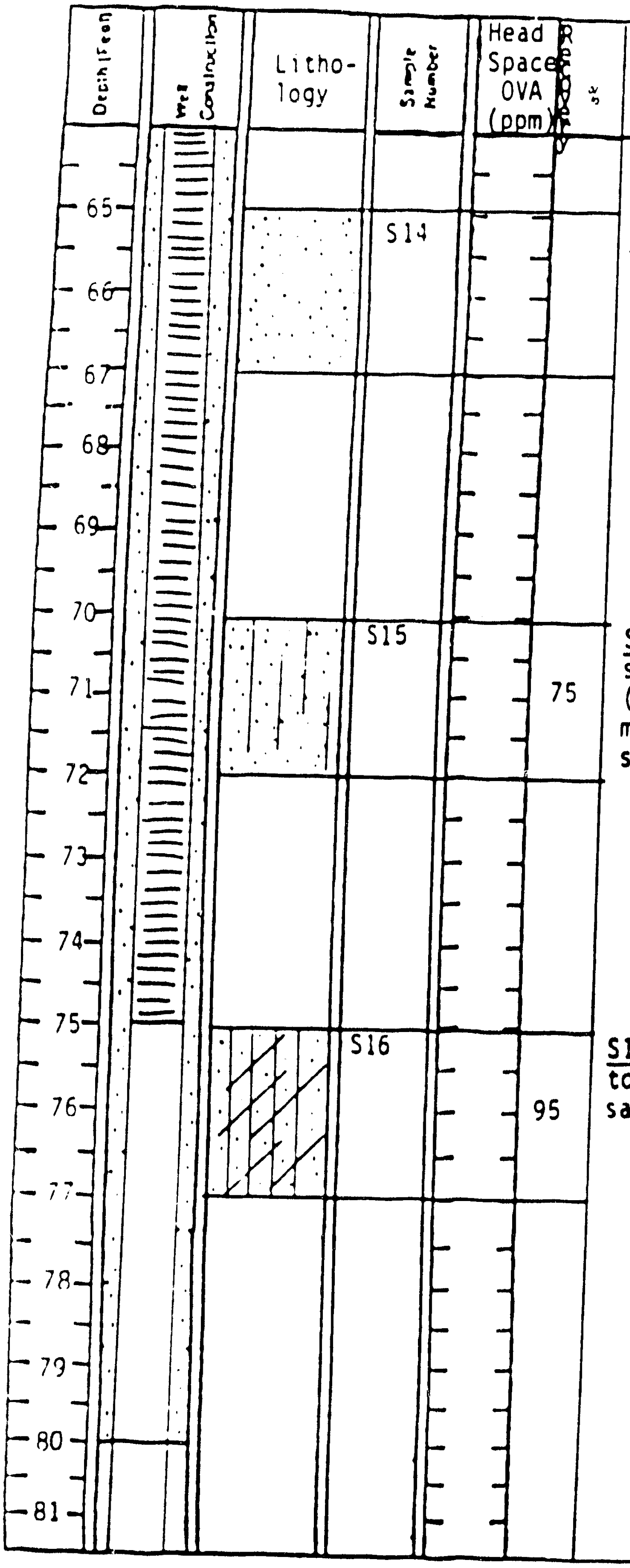


Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
S7	<0.1	70	SAND AND CLAY, top 2 in. banded red and gray clayey sand, poorly sorted, next 4 in. is a yellowish gray stiff, cohesive clay, rest of sample is clayey sand, 70% sand, fine gr. predominantly qtz., some feldspar, mica, trace heavy minerals.
S8	<0.1	70	SAND, w/Clay and Silt, 20% clay, 20% silt, grayish yellow with moderate red-brown mottling, sand is fine to med. gr. subangular to subrounded qtz., some feldspars, micas, heavy minerals present, poorly sorted sample.
S9	<0.1	70	SAND w/Silt, 20% silt, trace clay, very pale to pale yellow orange sands, fine (50%) to med. (45%) gr. qtz. w/trac coarse gr. sand, subround to subangular, mica, feldspars present.
S10		70	SAND w/Silt, 20% silt, trace clay, pale yellowish orange and moderate red-brown banding, composition same as above sample.

CSD-8D

Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
48						
49						
50			S11		50	SAND, Trace silt, yellowish gray, well sorted, 85% fine gr., 15% med. gr. qtz. sand, subrounded, feldspar and mica present in trace amounts
51						
52						
53						
54		-- WATER	--			
55			S12		90	SAND, trace silt, yellowish gray, same as above sample with just a little more med. gr. sand.
56						
57						
58						
59						
60			S13		80	SAND, trace silt, trace mica and feldspar, cross bedded horizontal lamination, color ranges white to pale yellow to pale pink to pale red purple to dark red qtz. sand, 75% med. gr., 10% coarse, 15% fine, subrounded, moderate sorting
61						
62						

CSD-8D



Description/Soil Classification

SAND. trace silt, same as above sample, but with (5) small (1cm to 5cm) clay seams running horizontally through the sample.

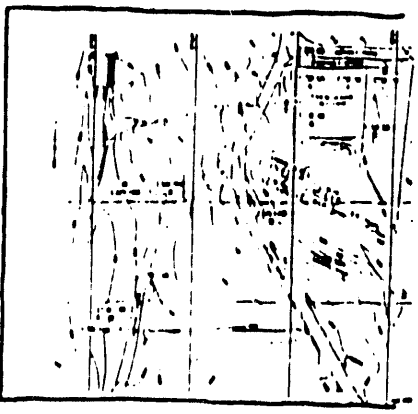
SILTY SAND, 35% silt, pale pink sands, trace feldspars and heavy minerals, med. gr. (70%), (20%)fine, (10%) coarse qtz. sand, subangular to subrounded, moderately sorted sample, few clay seams as above sample.

SILT w/sand and clay, 25% sand, 25% clay, pale pink to pale red purple, cross bedded lamination, qtz. sand, fine gr., a few c;ay seams as above samples.

DuPont Biosystems

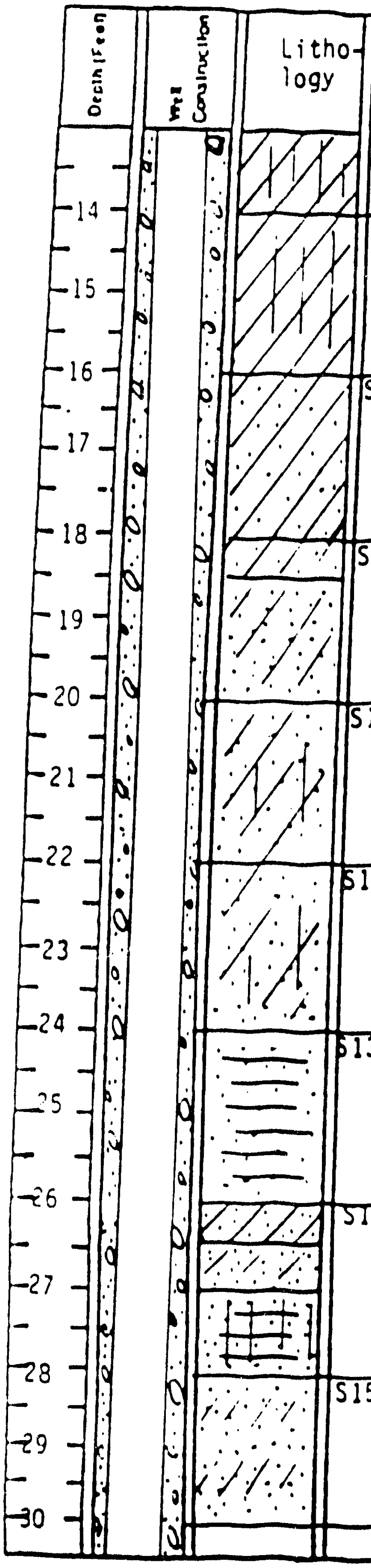
Soil Boring CSD-9D

Project 88127
Owner Savannah River Plant
Location Aiken, SC
Bore Well
Date Drilled 1/5,6,9/89
Total Depth 80 ft/75 ft
Diameter 10 in
Surface Elevation
Water Level
Screen: Dia. 4 in.
Length 30 ft.
Slot Size 0.015 in.
Casing: Dia. 4 in.
Length 40 ft.
Type Sch. 40 PVC
Drilling Company MTC
Drilling Method ss/Hollow Auger/Mud
Driller G. Lierman/S. Reese
Log by K. Garon/T. Lounsbury



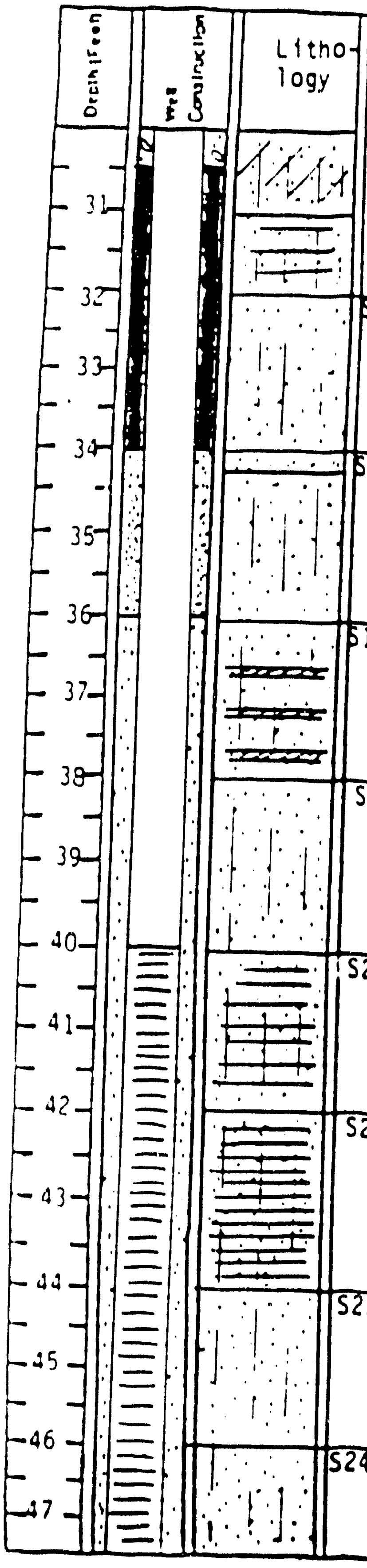
Depth (feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
1			S1	280	95	Brown, silty, sandy backfill material.
2 3			S2	160	70	Brown poorly sorted sand, silt, clay, cohesive, backfill.
4 5			S3	180	80	CLAY, trace sand, mottled reddish gray, moderate brown, stiff, cohesive, diesel odor.
6 7			S4	84	90	CLAY, Same composition as above, trace sand.
8 9			S5	80	90	CLAY, 20% silt, trace sand, color and texture same as above.
10 11			S6	40	90	CLAY w/Silt 25% Silt, 10% Sand, Same color as sample above, each sample increasing in silt content.
12			S7	9	75	CLAY, 15% Silt, trace sand, same colors as above but moderate red color is being replaced with reddish purple color, stiff, cohesive.

CSD-9D



Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
S8	2	100	CLAY, 10% Silt, Trace sand, trace mica, color and composition basically same as above sample.
S9	5	90	CLAY w/Sand, 20% sand, 10% silt, pale reddish purple and yellowish gray mottling, stiff, cohesive, sand is med. gr. subangular to subround qtz.
S10		90	CLAY w/Sand, Top 1 ft. same as above SAND w/Clay, 30% Clay, trace, silt, trace feldspar, mica, heavy mineral moderate red to yellow gray, med. gr. subround qtz.
S11		90	SAND w/Clay, 20% clay, 10% silt, light red to mod. red brown, graded beds of fine silty sands then coarse sands, poorly sorted sample qtz., trace mica, feldspar.
S12		100	SAND w/Clay, 20% clay, 10% silt, same as above sampl..
S13		100	SAND w/Clay, Graded bedding, 2 in. coarse, 2 in. fine subangular qtz. sand same as above sample.
S14		90	SANDY CLAY, Yellowish gray, Top 6 in. CLAYEY SAND, 15% clay, Light brown to reddish brown, qtz. sand, fine gr. middle 6 in. SILTY SAND, 15% silt, trace clay, rest of sample, reddish brown, horizontal cross bedded lamination, mainly fine gr. qtz. sand
S15		90	SAND, varying amounts of clay (10%-20%), moderate reddish brown and yellowish gray, mostly med. gr. sand, moderate sorting.

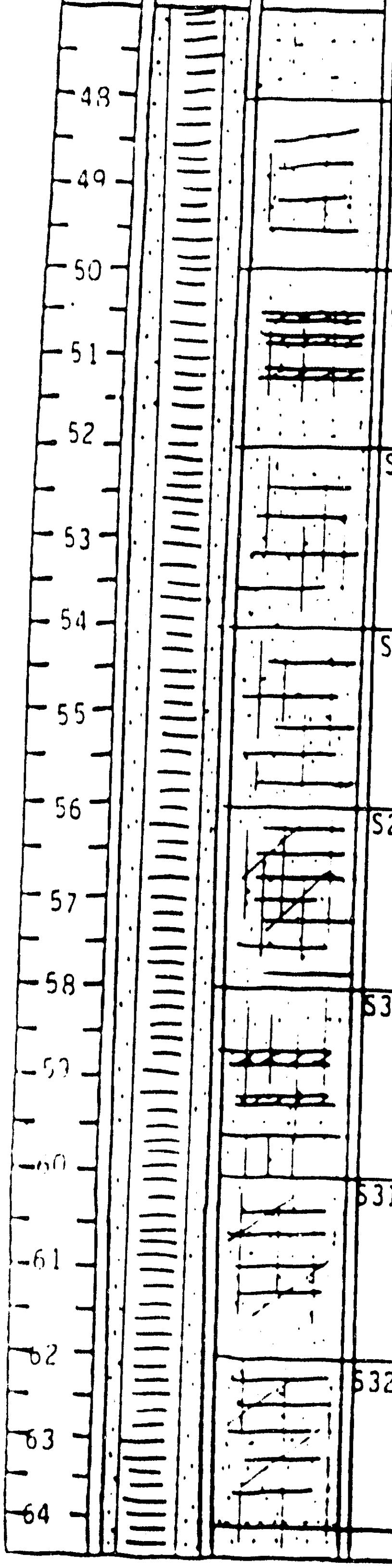
CSD-9D



Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
S16		90	SAND w/Silt and Clay, 15% Silt, 10% clay, moderate red brown, sand is mostly med. gr. qtz., subround. SAND w/Silt, 15% Silt, cross bedded, alternating color yellow brown to pale orange, 25%Kaolinite, rest med gr. qtz.
S17	18	70	SAND w/Silt, same as bottom of previous sample, much more feldspar than other samples.
S18	9	70	SAND, Top 4 In. Same as above SAND w/Silt, 10% silt, trace clay reddish brown, 80 of sand is subround med. gr. qtz.
S19	9	80	SAND w/Silt, 10% silt, 5% clay, same as bottom of previous sample but with 8 to 10 small clayey sand seams (1 to 5 cm) horizontally crossing throughtout sample.
S20	1.8	60	SAND w/Silt, 10% silt, trace clay, trace feldspar and mica, color and landing grayish pink to moderate red hematite staining, 80% med. gr. subround qtz. sand.
S21	0.9	90	SAND w/Silt, 10% silt, trace clay, same as above but with same cross bedding and more limonitic staining, than the hematite in above sample.
S22		70	SAND w/Silt, Same as above, slightly more cross beddi grayish-pink with moderate pink banding, slightly more coarse gr. material than above sample.
S23		65	SAND w/Silt, Same as above
S24		75	SAND w/Silt, 10% silt, pinkish gray w/ dark reddish purple banding, trace mica, feldspar, heavy minerals 10% fine gr. pebbles, 70% med. gr. subangular qtz. sand.

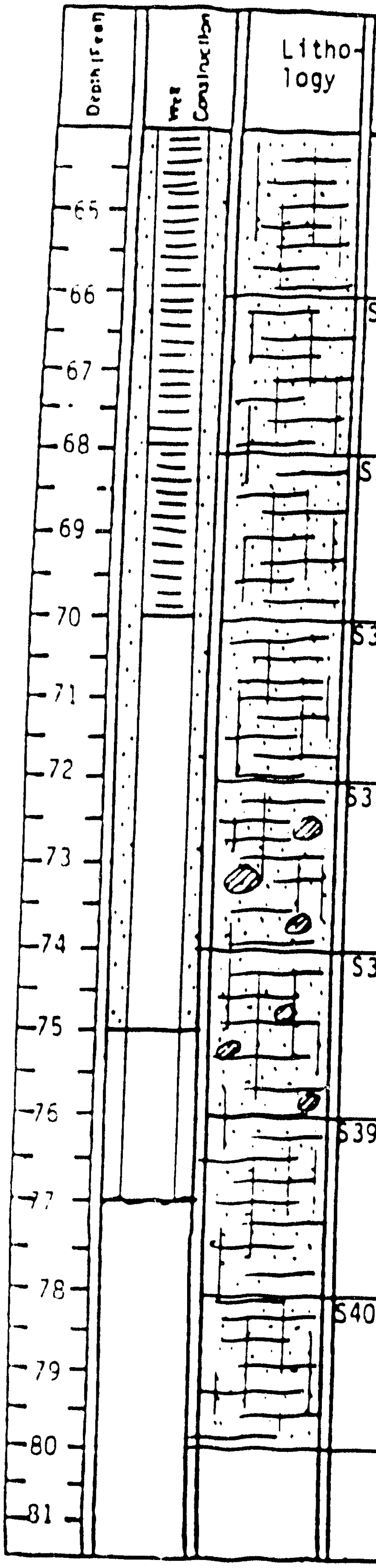
CSD-9D

Depth (Feet) | Well Construction | Litho-logy



Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
S25		90	SAND w/Silt, 10% silt, pale pink sands with grayish red purple banding, dusky red lamination throughout, 60% med. gr., 25% coarse, 5% fine, subangular qtz. sand
S26		80	SAND w/Silt, 20% Silt, trace clay, trace mica, same colors as above, 3 clayey sand seams in middle of sample, 50% med. gr. qtz. sand 30% coarse, subangular
S27		90	SAND w/Silt, 25% silt, colors same as above, banding as above, 70% coarse, subangular sand, almost half of sand is hydrated feldspar (Kalonite), rest qtz.
S28		90	SAND w/Silt, 30% silt, grayish pink and yellow brown with bands of pale reddish brown, 60% med. gr. sand, 10% fine gr., 80% isqtz., rest is feldspar, mica, heavy minerals
S29		90	SAND w/ Silt, 35% silt, 10% clay, poorly sorted heavily laminated gray-pink, red-brown, yellow-orang to red purple, moist, 30% med. gr., 20% fine, 5% coarse qtz. sand.
S30		80	SAND w/silt, 25% silt grading to 40% silt at bottom, trace clay, pale red, very coarse subangular qtz. sa grading to pale red purple med. to fine qtz. sand at bottom, two clay seams in middle of sample.
S31		70	SAND w/Silt, 20% silt, 10% clay, trace mica, pale red purple to grayish red purple w/moderate yellow, grade from coarse to fine qtz., sand (top to bottom) clay ball present.
S32		90	SAND w/Silt, 25% silt, 10% clay, pale red purple to yellowish gray, 50% fine, 40% med., 10% coarse sand qtz., subangular, black linitic sand at bottom.

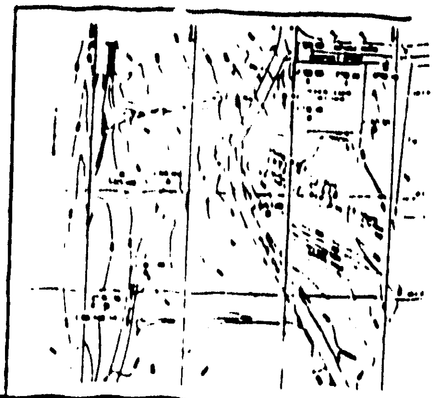
CSD-9D



Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
S33		90	SAND w/Silt, 35% silt, banding color range from pale yellowish orange to moderate reddish brown to pale red purple, sand is 50% med. gr., 25% coarse, 25% fine qtz., some lignite.
S34		90	SAND w/Silt, 35% silt, top half moderate red, bottom dark yellowish orange, cross lamination, sand is predominantly med. gr., subangular to subround qtz., trac clay, lignite
S35		90	SAND w/Silt, 40% silt, trace clay, poorly sorted ligh to moderate red w/ grayish pink and moderate red-brown lamination, fine to med. gr. sand, qtz., trace mica, lignite.
S36		95	SAND w/Silt, 40% silt, trace clay, dusky red to moderate red w/ light gray lamination, same as above.
S37		90	SAND w/Silt, 35% silt, trace clay as clay balls, same as above but no lignite, color changes from mostly red-purple at top to dark purple at bottom.
S38		75	SAND w/Silt, 25% silt, trace clay, coarse to very coarse qtz. sand, poor sorting, clay balls and lamina grayish red purple, loose laminated dusky red and dark yellow orange zones.
S39		60	SAND w/Silt, 25% silt, trace clay, same as above exce more med. gr. sand than coarse, qtz., subangular, loose
S40		80	SAND w/Silt, 35% silt, trace clay, color grades (bottom to top) dark yellowish orange to pale red purple to grayish red purple, mostly med. gr. qtz., some soarse sand, some feldspar and mica

DuPont Biosystems

Soil Boring CSD-10D



Project 88127 Owner

Location Aiken, SC

Date Drilled 1/4-5/89 Total Depth Bore/Well 72ft/75ft Diameter 10 in.

Surface Elevation Water Level

Screen: Dia. 4 in. Length 30 ft. Slot Size 0.015 in.

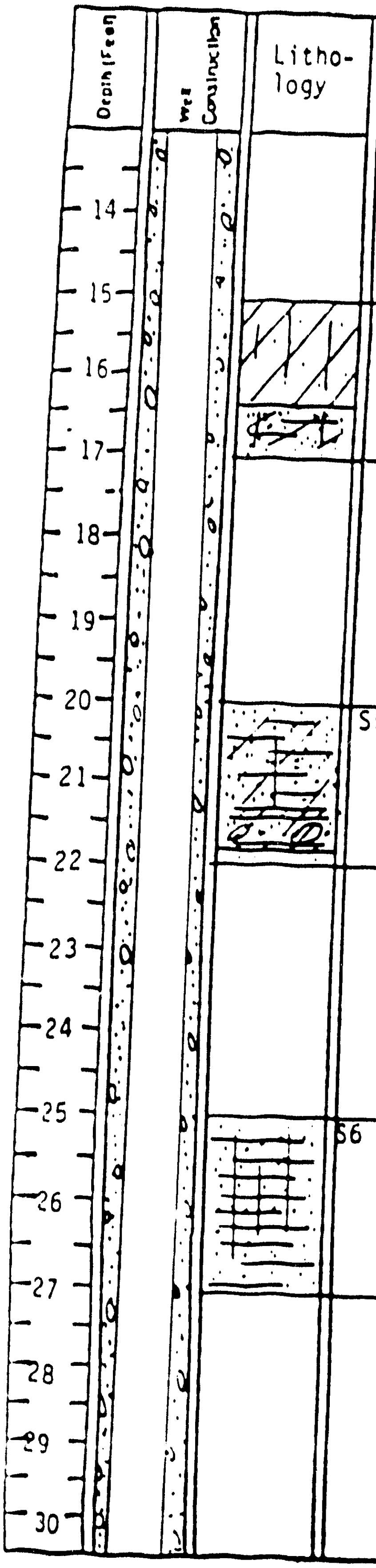
Casing: Dia. 4 in. Length 40 ft. Type Sch. 40 PVC

Drilling Company MTC Drilling Method ss/Holow Auger/Mud

Driller S.Burris/Lierman/Reese Log by Kevin Garon

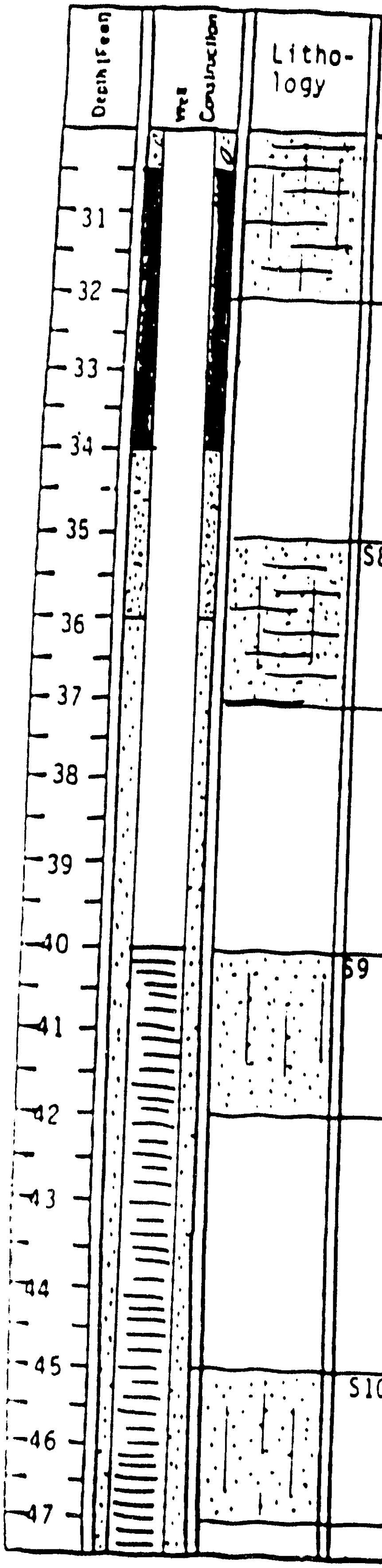
Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
1 2		▨	S1	0.1	90	CLAYEY SILT, 30% clay, 20% sand, light brown top, moderate yellowish brown to bottom, irregular shapec qtz., sand, silt, clay fill material.
3 4						
5 6 7		▨	S2	<0.1	55	CLAY, 10% qtz. sand, mottled clay dusky red to dark orange to yellowish gray, extremely stiff and hard.
8 9						
10 11 12		▨	S3			CLAY, Top 6 in. has 20% silt, 10% qtz. sand, bottor 16 in of sample same clay as above.
13						

CSD-10D



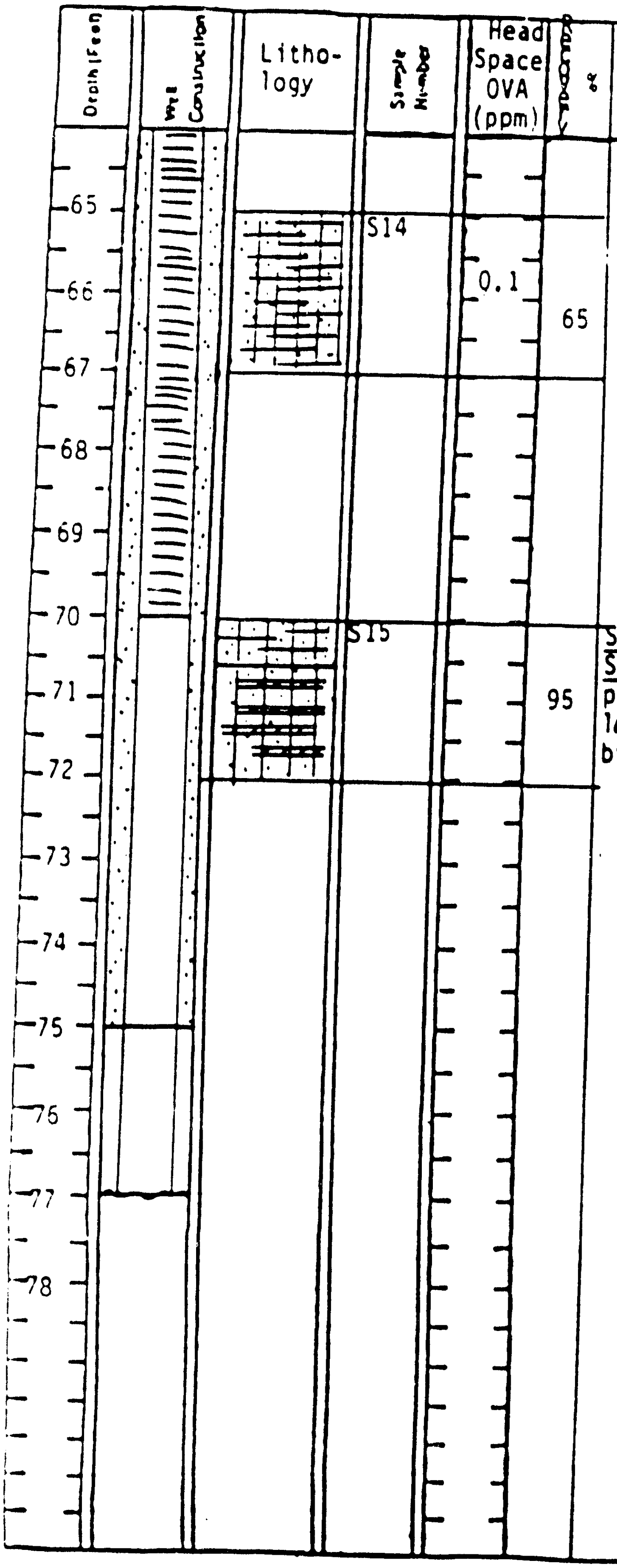
Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
S4	0.1	90	CLAY, 10% silty sand qtz., same as above. SAND w/Clay, bottom 8 in. 20% clay, 10% silt, moderate red to mod. reddish brown, poorly sorted w/ some cross bedding, zones of preferentially aligned elongated, subangular qtz. grains, very coarse, majority of sample is med. gr., subangular qtz., trace mica, feldspar.
S5	0.2	90	SAND w/Clay, 25% clay, 10% silt, moderate reddish brown to reddish orange cross laminated w/ light gray zones, clay balls and clay seams at bottom of sample, predominantly med. gr. subangular qtz., trace mica, feldspar
S6	0.6	85	SAND w/Silt, 30% silt, trace clay, pale yellowish orange w/dark yellowish orange banding, moderate red smears near bottom, x-bedded lamination, sand is 90% fine gr., moderately sorted qtz.

CSD-10D



Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
S7	0.2	90	SAND w/Silt, 30% silt, trace clay, same composition as above, color is a little lighter than above.
S8	1.2	90	SAND w/Silt, 15% silt, trace clay, very pale orange w/ light to moderate red horizontal banding, moderately sorted, subangular qtz., some feldspar and trace mica.
S9	0.2	90	SAND, 10% silt, trace clay, trace heavy minerals, orange pink at top grading to pale yellow at bottom, sand is 50% fine, 50% Med. Gr., predominantly qtz., some feldspar, well sorted at bottom, moderate sorting at top.
S10			SAND w/Silt, 20% silt, moderate orange pink, sands ar well sorted, 75% med. gr. subrounded qtz., some feldspar, mica, heavy minerals

CSD-10D



Description/Soil Classification

SILT w/Sand, 25% sand, 10% clay, pinkish orange and moderate red banding (very fine striations) x-bedded, very fine qtz. sand, well sorted sample.

SILT w/Sand, Top 8 in. of sample same as above. SILT w/Clay, 30% clay, 20% sand, poorly sorted pale pink to pale purple clayey silts with numerous clay laminae seams. Two in. section in middle is orange brown, lignitic sand and silt.

DuPont Biosystems

Soil Boring CSD-11D

Project 88127
Owner Savannah River Plant
Location Aiken, SC
Date Drilled 1/10-11/89
Bore/Well Total Depth 70ft/75ft
Diameter 10 in.
Surface Elevation
Water Level
Screen: Dia. 4 in. Length 30 ft. Slot Size 0.015 in.
Casing: Dia. 4 in Length 40 ft. Type Sch. 40 PVC
Drilling Company MTC
Drilling Method SS/Hollow Auger/Mud
Driller G. Lierman/S. Reese
Log by T. Lounsbury

Depth (Feet)	Well Construction	Lith-ology	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
1			S1	280	100	SAND w/Silt, 10% silt, dark yellowish brown to moderate brown, 70% med. gr. qtz., 10% fine, moderat sorting, fill material, diesel odor near bottom.
2 3			S2	400	95	SAND, 20% silt, dusky yellowish brown to dusky brow trace clay, 70% fine to med. gr. qtz. Sand, sub-rounded, poorly sorted, diesel odor.
4 5			S3	≥1000	100	CLAY, 10% silt, 5% sand, mottled moderate yellowish brown and medium gray to grayish red, brittle, stiff diesel odor and staining.
6 7			S4	≥1000	100	CLAY, basically same as above, stiffening w/depth, mica flakes throughout, strong diesel odor
8 9			S5	940	95	CLAY, same as above.
10 11			S6	≥1000	100	CLAY, w/Sand, 30% sand, trace silt, mottled dark yellow orange, grayish red purple, very pale orange, cohesive, moist, sand is fine gr., mica present.
12 13			S7	≥1000	100	CLAY, w/Sand, 40% sand, similiar to above with increasing sand content towards bottom.

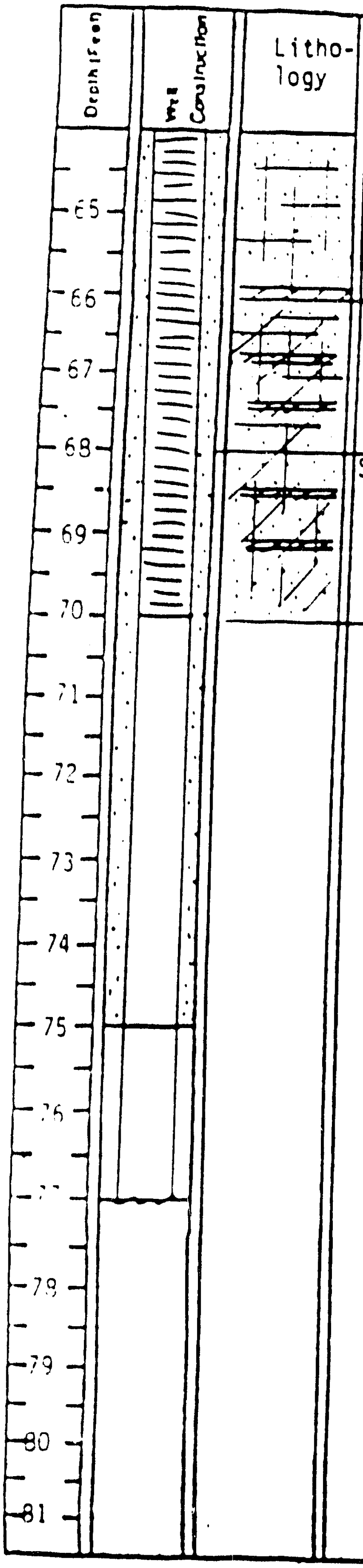
CSD-11D

Depth (Feet)	Well Construction	Litho-logy	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
31			S16	10	95	SAND w/Silt, 15% silt, light red, basically same as above.
32 33			S17	5	95	SAND w/Silt, 25% silt, light red coarse feldspar grains present, similiar to above sample w/ x-beds c 6 in. fine zone, then 6 in. coarse zone and fine again
34 35			S18	6	95	SAND w/Silt, 30% silt, same as above sample.
36 37			S19	4.6	95	SAND w/Silt, 20% Silt, grayish pink w/moderate reddi brown laminae, x-bedding increases towards bottom, sand mainly qtz. subangular, 50% coarse, 40% med., 10% fine gr.
38 39			S20	1.8	95	SAND w/Silt, 30% Silt, banded color zones, light red to moderate red, then zones of dark yellowish orange. then red again. 60% subangular med. gr qtz., 40% coarse gr. qtz.
40 41			S21	0.6	95	SAND w/Silt, 20% silt, moderate red w/dusky red silt laminae, bottom 6 in. dark yellowish orange, 50% med. gr., 50% coarse qtz., moist
42 43			S22	2.0	95	SAND w/Silt, 20% silt, moderate red w/ dusky red banding, 12 in middle is moderate pink, yellowish orange bottom, composition is same as above sample.
44 45			S23	2.8	95	SAND w/Silt, 20% silt, banded color of pale pink and moderate orange, similiar composition to sample above. trace hydrated feldspar, mica.
46 47			S24	1.8	95	SAND w/Silt, 30% silt, same as above, moisture content increases.

CSD-11D

Depth (Feet)	Well Construction	Litho-logy	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
48			S24	1.8	95	
49 50			S25	0.6	95	SAND w/Silty, 35% silt, top 4 in. same as above but darker yellow orange color, bottom part of sample x-bedded sands, moderate orange pink and pale yellow predominantly fine to med. gr. qtz. sand.
51 52			S26	1.0	95	SAND w/Silt, 25% silt, pale yellow to moderate pale pink sands, qtz. sand, 50% fine, 50% med. gr. x-bedded, more at top, pink at bottom, wet, loose sands.
53 54			S27	0.1	95	SAND w/Silt, 40% silt, basically same as above but w/ more silt, moderate orange pink to moderate pink.
55 56			S28	0.1	95	SAND w/Silt, 40% silt, <5% clay, trace heavy minera pale yellow to pinkish white, to moderate pale pink, clay laminae seams, predominantly fine to med. gr. qtz. sand.
57 58			S29		50	SAND w/Silt, 40% silt, 5 to 10 % clay, dark yellowi orange and pale pink silts w/fine to med. gr. qtz. sand, pale orange to light gray clay balls, x-bedded. loose
59 60			S30			AUGERED THROUGH NO SAMPLE
61 62			S31		95	SAND, w/Silt, sands pale red to purple to dark yellow orange (at bottom 5in. of sample) sand is 90% fine to med. gr. qtz. subrounded, wet x-bedded silty sands, 1 small clay seam at bottom.
63 64			S32		95	SILT w/Sand, 40% sand top half of sample, fine silty sands, dark yellowish orange, bottom half is SAND w/ Silt, pale red purple, med. gr. qtz. sand, some clay laminae, some fine gravel, poorly sorted sample

CSD-11D

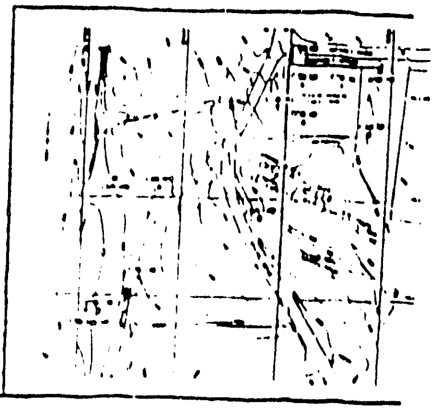


Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
S33		100	<u>SAND w/Silt</u>, 35% silt, pale red purple banded with moderate red med. gr. sand. 80% med. gr. and 20% coarse qtz. sand, gray clay seam at bottom of sample
S34		100	<u>SAND w/Silt</u>, 25%, 15% clay x-bedded dusky red, moderate red, dark yellowish orange, med. gr. qtz. sand, subrounded horizontal grayish pink clay laminations throughout.
S35		70	<u>SAND w/Silt and Clay</u>, 20% silt, 25% clay, pale red purple w/grayish pink and pale gray clay laminations sand is 70% coarse, 30% med. gr. qtz. with yellow "spots" (1-5mm) throughout, poorly sorted.

DuPont Biosystems

Soil Boring CSD-12D

Project 88127 Owner Savannah River Plant
Location Aiken, SC
Date Drilled 1/2/89 Total Depth Bore/Well 72ft/80ft. Diameter 10 in.
Surface Elevation ______ Water Level ______
Screen: Dia. 4 in. Length 30 ft. Slot Size 0.015 in.
Casing: Dia. 4 in. Length 45 ft. Type Sch. 40 PVC
Drilling Company MTC Drilling Method SS/Hollow Auger/Mud
Driller G. Lierman/S. Reese Log by Kevin Garon

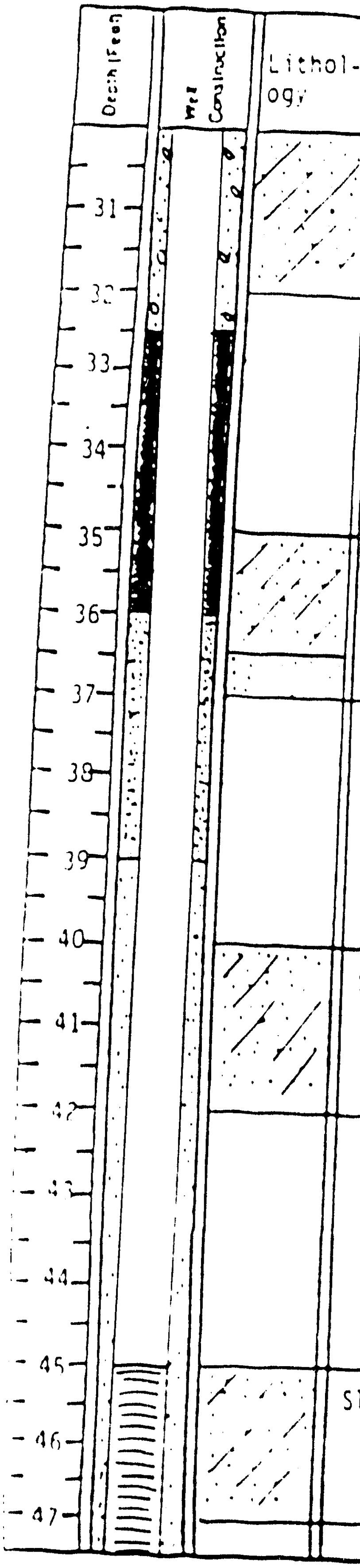


Depth (feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery	Description/Soil Classification
						Gravel fill
1 2 3			S1	<0.1	75	CLAY W/Sand and Silt, 15% sand, 15% silt, mottled moderate reddish brown, qtz., sand, subangular, moderate to poor sorting, cohesive, moderately dense, bottom 6 inches of sample brown silty sand.
4 5						
6 7			S2	0.1	90	CLAY W/Sand and Silt, 15% sand, 15% silt, same as top of previous sample, brittle, cohesive.
8 9 10						
11 12			S3	30	100	CLAY W/Sand, 25% sand, trace silt, mottled moderate reddish brown to light brown color, poorly sorted, brittle, sand is med. gr., subangular qtz., some feldspar.
13						

CSD-12D

Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery	Description/Soil Classification
14						
15		▨	S4			
16		▨		2.8	95	CLAY W/Silt and Sand, 10% silt, 10% sand, moderate sorting, mottled moderate red, to dusky red to very pale orange to light brown, brittle, dense, cohesive, sand is fine to med. gr. qtz.
17						
18						
19						
20		▨	S5			
21		▨		0.6	90	CLAY W/Sand, 30% Sand, 5% silt, sand is 10% mica, 10% feldspar, color bands in thick sections (top to bottom) moderate red to yellowish gray to moderate red and pale red purple, cohesive, majority of sand is fine to med. gr. qtz.
22						
23						
24						
25		▨	S6			
26		▨		0.1	90	SAND W/Silt, 20% silt, 10% clay, overall color, pale red purple, some yellowish gray mottling, sand is fine to med. gr., mostly qtz., with some feldspars and mica, trace heavy minerals, moderate sorting, very damp, no odor.
27						
28						
29						
30						

CSD-12D

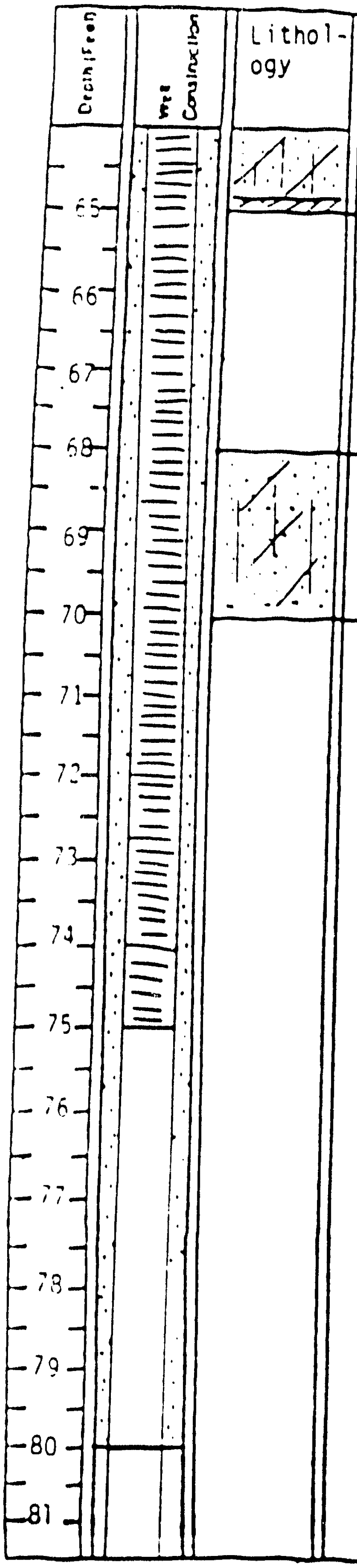


Sample Number	Head Space OVA ppm	Recovery	Description/Soil Classification
S7		90	SAND W/CLAY, 30% intersticial clay, trace silt, grayish pink to grayish pink orange w/some orange and moderate red oxidation staining, moderately sorted fine grained qtz. (80%) sand with feldspars and micas, trace heavy minerals.
S8		95	Top 1.4 feet Sand w/Clay, 25% clay, mottled yellowish gray and orange, poorly sorted qtz. sand also containing feldspars and mica, intersticial clay. Bottom 0.5 feet SAND, 5% clay, 5% silt, 90% fine, clean, moderate to well sorted yellowish gray qtz. sand. Middle heavily x-bedded.
S9		95	SAND, 10% clay, poorly sorted, white to yellowish gray sand, 80% fine gr. sand, 20% med. gr., predominantly subrounded qtz. feldspar and mica present, humerous clay seams 1 to 5 cm thick running horizontally throughout sample.
S10		75	SAND, 10% clay intersticially, basically same as previous sample, sample becomes cleaner and more well sorted towards bottom, primary color is grayish orange pink.

CSD-12D

Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
48						
49						
50			S11		80	SAND, 10% intersticial clay (white), grayish orange pink sands, 75% fine gr., 20% med. gr. 5% coarse, predominantly qtz., some hydrated feldspars and mica present, packed together with clay.
51						
52						
53						
54						
55			S12		80	SAND, 10% clay, clay is intersticial and also forms several small seams running horizontally throughout sample, basically same as above sample, poorly sorted, overall grayish pink with mottled reds, x-bedded.
56						
57						
58			S13		80	SAND, banded gray to gray pink to moderate reddish brown to pale red purple, wet, poorly sorted qtz., sands, 20% feldspars and 5% mica, x-bedded with 2 clay seams (2 to 5 cm) thick tracking horizontally through sample.
59						
60						
61						
62						
63			S14		90	SAND w/Silt and clay, 30% silt, 10% clay, pale red purple to pale purple, sand is
64						

CSD-12D



Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
S14		90	90% fine to very fine rounded to subrounded qtz., some feldspar and mica, numerous silty, cla. seams horizontally throughout sample.
S15		100	<u>SAND</u>, 10% silt and clay, 3 distinct color zones -- top 1.0 pale yellowish orange, next 0.5 ft. very pale orange, bottom 0.5 ft. yellowish orange, sample is poorly sorted sands, subangular qtz., fine to very coarse, x-bedded, intersticial silt and clay.

DuPont Biosystems

Soil Boring CSD-13D

Project 88127 Owner Savannah River Plant

Location Aiken, SC

Bore/Well

Date Drilled 12/22/88 Total Depth 62ft/90ft Diameter 12 in.

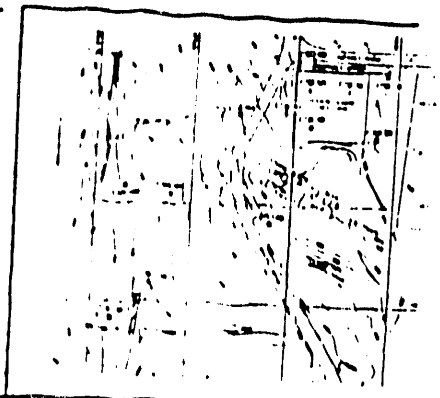
Surface Elevation ______ Water Level ______

Screen: Dia. 6 in. Length 49 ft. Slot Size 0.015 in.

Casing: Dia 6 in. Length 36 ft Type Sch. 40 PVC

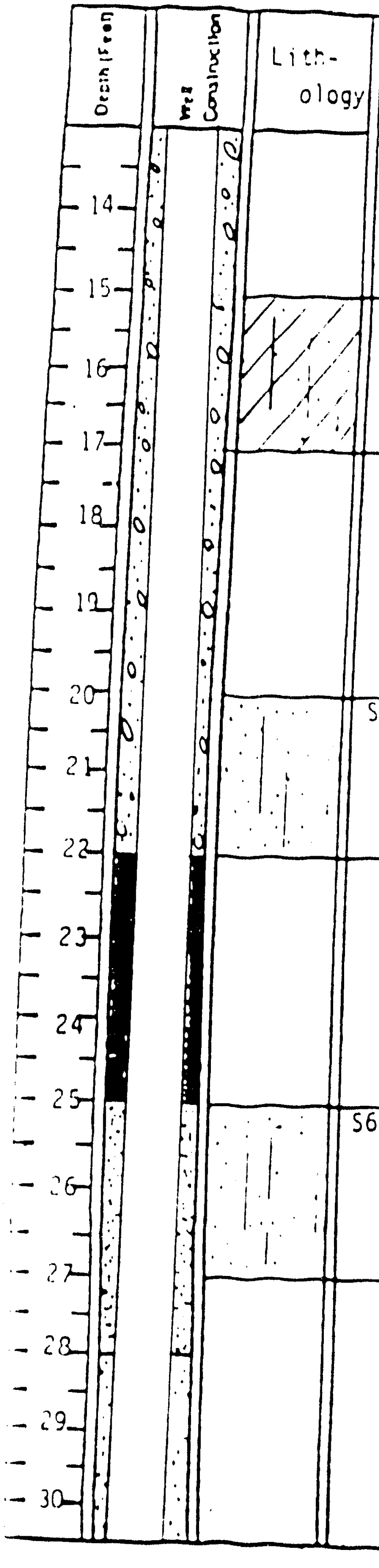
Drilling Company MTC Drilling Method SS/Hollow Auger/Mud

Driller G.Lierman/S. Reese Log by Kevin Garon



Depth (Feet)	Well Construction	LITHOLOGY	Sample Number	Head Space OVA (ppm)	Recovery	Description/Soil Classification
			S1		100	SAND, 20% silt, dark yellowish orange, unconsolidat well sorted fine gr. qtz. sand (95%) (Bottom 3 in. saturated w/diesel).
1						
2						
3						
4						
5			S2	>1000	95	SAND w/Clay and Silt, 25% clay, 15% silt, grayish brown stained fine to med. gr. qtz. sand, moist and saturated with diesel.
6						
7						
8						
9						
10			S3	200	90	CLAY, 15% sand, 10% silt, moderate to dark reddish brown, stiff, dense, cohesive, sand is fine to med. gr. qtz., some feldspar and mica, diesel staining.
11						
12						
13						

CSD-13D



Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
S4	250	90	CLAY w/Silt, 20% silt, 10% sand, mottled clay, white to pale yellow to dark reddish brown, laminated, sar is fine to med. gr. qtz., perched water w/diesel sheen.
S5			SAND w/Silt, 25% silt, trace clay, mottled colors, from white to moderate red to grayish orange pink, 75% fine gr., 25% med. gr qtz. sand, some feldspar, trace mica, moderate sorting, diesel odor.
S6			SAND w/Silt, trace clay, moderate red and grayish orange pink mottled color in horizontal bands, well sorted very fine qtz. sands, some feldspar ard mica present.

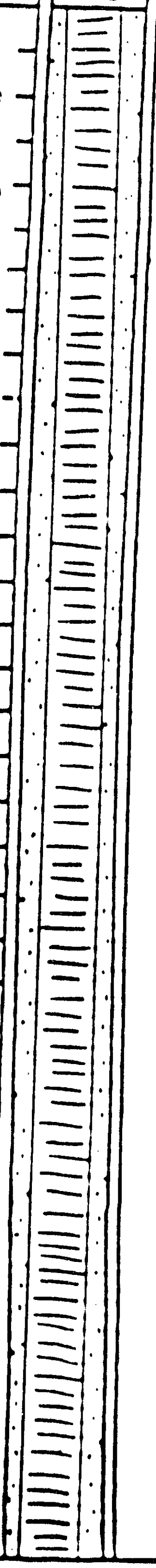
CSD-13D

Depth (Feet)	Well Construction	Lith-ology	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
			S7	380	70	SAND w/Silt, 20% silt, trace clay, grayish orange to pale red, well sorted very fine qtz. sand, same as above sample.
31						
32						
33						
34						
35			S8	180	50	SAND, 10% silt, mottled light brown to moderate reddish orange, horizontal laminar structure, small black (1mm to 30mm diameter) stains throughout, subround, well sorted very fine qtz. sands, mica and feldspars included, trace heavy minerals
36						
37						
38						
39						
40			S9	180	70	SAND, 10% silt, trace clay, mottled reddish brown color, basically same composition as previous sample
41						
42						
43						
44						
45			S10	180	60	SAND, 10% silt, same fine sands as above. Color more reddish orange than brown like above.
46						
47						

CSD-13D

Depth (Feet)	Well Construction	Lith-ology	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
48						
49						
50			S11	50	70	SAND, 10% silt, basically same as above, color more grayish pink, several small clay balls (3 to 5 mm diameter) sands are getting coarser and less well sorted than samples above.
51						
52						
53						
54						
55			S12	1.4	90	SAND, 10% silt, water, grayish pink with moderate re bands horizontally, well sorted med. gr. subround to subangular qtz. sands, some feldspar, mica, heavy mineral trace.
56						
57						
58						
59						
60			S13	0.3	80	CLAY, convaluted stiff, dense, cohesive gray clay, top 0.5 ft., bottom 1.0 ft. of sample. SAND, 10% silt, saturated pale yellowish orange, wel sorted med. gr. subangular qtz. sand.
61						
62						
63						
64						

CSD-13D

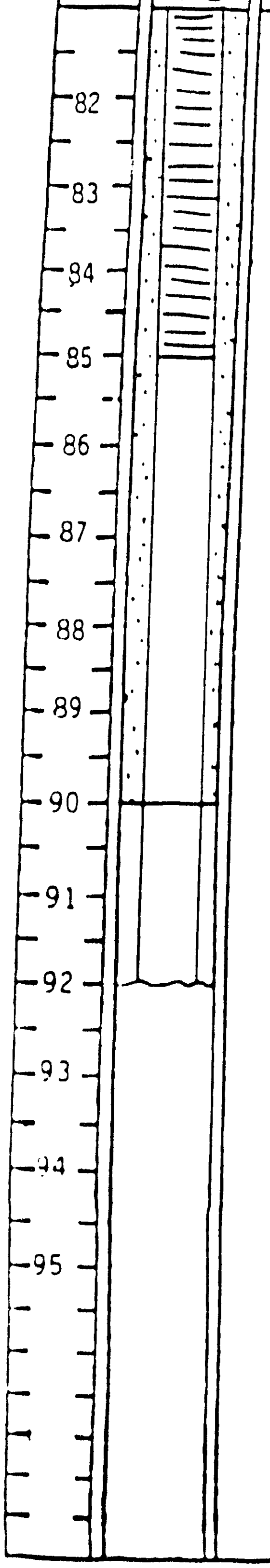


Depth (Feet)	Well Construction	Lith-ology	Sample Number	Head Space OVA (ppm)	Recovery %	Description/Soil Classification
65						
66						
67						
68						
69						
70						
71						
72						
73						
74						
75						
76						
77						
78						
79						
80						
81						

DuPont Biosystems

CSD-13D

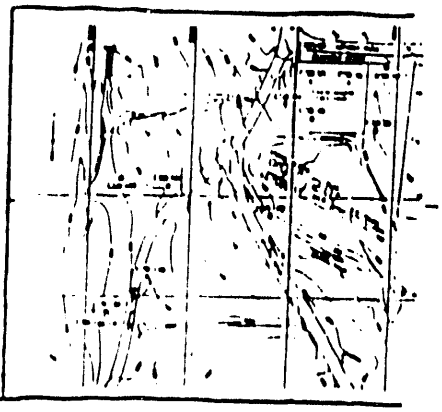
Depth (Feet)	Well Construction	Lith-ology	Sample Number	Head Space OVA (ppm)	Recovery	%	Description/Soil Classification



Page 6 of 6

DuPont Biosystems

Soil Boring BH-14



Project 88127 Owner Savannah River Plant

Location Aiken, SC

Date Drilled 1/11/89 Total Depth 19 ft. Diameter 8 in.

Surface Elevation ______ Water Level ______

Screen: Dia. NA Length NA Slot Size NA

Casing: Dia. NA Length NA Type NA

Drilling Company MTC Drilling Method SS/Hollow Auger

Driller George Lierman Log by Jim Jordan

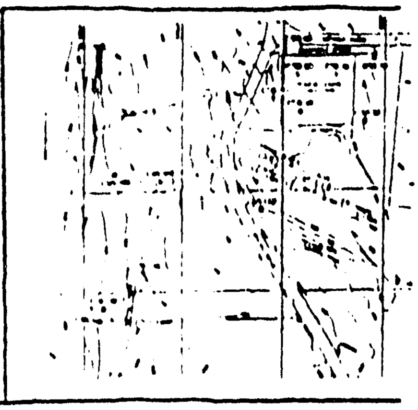
Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery	Description/Soil Classification
1						Silty Sand
2						
3						
4						
5						Sand W/Silt and Clay, heavy oil staining
6						
7						
8						
9						
10						CLAY W/Sand, heavy oil staining
11						
12						
13						
14						
15						
16						
17						
18						CLAY W/Sand, Oil odor, very little staining
19						
20						

Note: This additional borehole was sampled for Haskell -- Stine labs in Newark, DE. This was in addition to the scope of work.

DuPont Biosystems

Soil Boring BH-7

Project 88127 Owner Savannah River Plant
Location Aiken, SC
Date Drilled 12/14/88 Total Depth 12 ft. Diameter 8 in.
Surface Elevation NA Water Level
Screen: Dia. NA Length NA Slot Size NA
Casing Dia NA Length NA Type NA
Drilling Company MTC Drilling Method SS/Hollow Auger
Driller George Lierman Log by Kevin Garon



Depth (feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
1						Gravel, rock, sand, silt backfill material
2 3		▨	S1	1.5	80	Clayey, Silty Sand, dark yellow, poorly sorted sample becoming more clayey towards bottom, silty near top, sand is subangular fine to med. gr. qtz., no odor
4 5						
6 7		▨	S2	38	90●	Sandy Clay, 20% sand, 5% silt, poorly sorted sample becoming more clayey towards bottom, laminations in clays, mottled pale yellowish orange to dusky red mottled clays, heavy oil staining @ 7 ft. mark.
8 9						
10 11		▨	S3	2.5	75	Clay W/Sand, 15% sand, mottled pale yellowish orange to dusky red, same as above with a little less sand, no oil staining or odor.
12						

DuPont Biosystems

Soil Boring BH-6

Project 88127 Owner Savannah River Plant

Location Aiken, SC

Date Drilled 12/14/88 Total Depth 12 ft. Diameter 8 in.

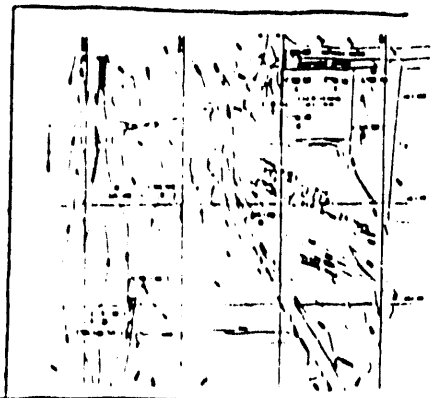
Surface Elevation ______ Water Level ______

Screen: Dia. NA Length NA Slot Size NA

Casing: Dia. NA Length NA Type NA

Drilling Company MTC Drilling Method SS/Hollow Auger

Driller G. [illegible]erman Log by Kevin Garon

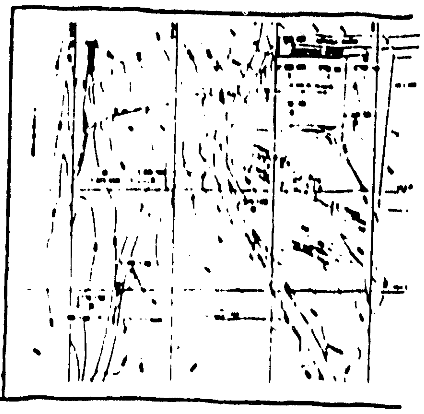


Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery	Description/Soil Classification
						Asphalt, rock, sand fill material
1 2			S1	22	75	Sand W/Silt and Clay, 30% clay, 10% silt, trace qtz. gravel, moderate reddish brown Qtz. sand, mostly med. gr., sub angular, slightly cohesive, slight diesel odor.
3 4						
5 6			S2	54	75	Sand and Clay, top 75% of sample is clayey, sand, mottled dark yellow to moderate reddish brown, sand is subangular, med. gr. qtz., some gravel, bottom 25% of sample is clay, blue-black oil stains.
7 8 9						
10 11 12			S3	280	60	Clay W/Sand, 15% sand, med gr., qtz., trace mica, mottled white to dark yellow to dusky red, cohesive, med. plasticity, diesel staining and strong odor.

DuPont Biosystems

Soil Boring BH-5

Project 88127
Owner Savannah River Plant
Location Aiken, SC
Date Drilled 12/13-14/88
Total Depth 12 ft.
Diameter 8 in.
Surface Elevation
Water Level
Screen: Dia. NA
Length NA
Slot Size NA
Casing: Dia. NA
Length NA
Type NA
Drilling Company MTC
Drilling Method SS/Hollow Auger
Driller G. Lierman
Log by Kevin Garon

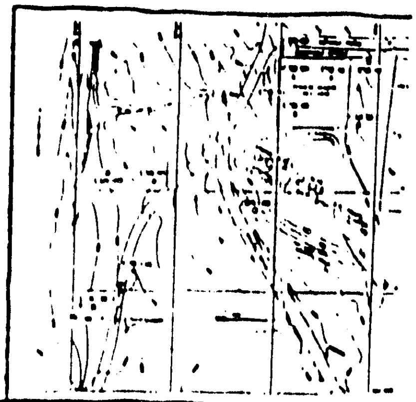


Depth (Feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
1				-		Gravel, sand fill material
2 3			S1	3.8	50	Top 6 in. loose, brown sand and gravel, bottom 6 in. reddish brown sandy clay backfill material
4 5						
6 7			S2	5	0	No sample retrieved
8 9			S3	420	60	Clayey Sand. 60% sand, dark yellowish orange to mottled dusky red, qtz. sand med. to coarse gr., cohesive, low plasticity, heavy diesel staining at 8.5 ft. mark
10						
11 12			S4		90	Clay W/Sand. 10% sand, trace mica, mottled dark yellowish orange to dusky red, cohesive, low to med. plasticity, no odor.

DuPont Biosystems

Soil Boring BH-3

Project 88127
Owner Savannah River Plant
Location Aiken, SC
Date Drilled 12/14/88
Total Depth 12 ft.
Diameter 8 in.
Surface Elevation
Water Level
Screen: Dia. NA
Length NA
Slot Size NA
Casing Dia. NA
Length NA
Type NA
Drilling Company MTC
Drilling Method SS/Hollow Auger
Driller George Lierman
Log by Kevin Garon



Depth (feet)	Well Construction	Lithology	Sample Number	Head Space OVA ppm	Recovery %	Description/Soil Classification
1						Gravel, sand, silt fill material
2			S1	260	90	Clayey Sand, 2 in. clay layer near top of sample (red and white), sand is dark yellowish brown fine to med. gr., qtz., sample poorly sorted, cohesive, diesel stains and odor abundant.
3 4 5						
6			S2	210	75	Silty Sandy Clay, sand with clay as above, clay mottled white to moderate red, dense, cohesive, sandy lenses of fine qtz., heavy oil staining in these lenses, clay shows some lamination.
7 8 9 10						
11			S3	100	75	Silty Sandy Clay, same as 5. to 7. ft. with slightly more sand, heavy Fe precipitation much less diesel odor than samples above.
12						

APPENDIX II

GROUNDWATER ORGANIC CONTAMINANT ANALYSES

ANALYSIS REPORT

ancaster Laboratories INCORPORATED

New Holland Pike, Lancaster, PA 17601-5994 (717) 656-2301

[illegible] WK9096 [illegible]

Well CSD-13[illegible]

Biosystems, Inc.
500 West Dutton Mill Road
Suite 102
Aston, PA 19014-[illegible]
[illegible] Water Sample
[illegible] on [illegible]

LLI Sample No. WW 1326373

Date Reported 5/ [illegible]/89
Date Submitted 5/ 6/89
Discard Date 5/11/89
Collected by [illegible]
P.O. [illegible]
Rel.

Extractables	RESULT AS RECEIVED		LIMIT OF QUANTITATION	LAB CODE
lorophenol	< 20.	ug/l	20.	064600000N
nol	< 20.	ug/l	20.	065500000N
trophenol	< 20.	ug/l	20.	065100000N
dimethylphenol	< 20.	ug/l	20.	064800000N
dichlorophenol	< 20.	ug/l	20.	064700000N
loro 3 methylphenol	< 20.	ug/l	20.	065300000N
trichlorophenol	[illegible]	ug/l	[illegible]	[illegible]
dinitrophenol	< 50.	ug/l	50.	065000000N
trophenol	< 50.	ug/l	50.	065200000N
thyl 4,6 dinitrophenol	< 50.	ug/l	50.	064900000N
tachlorophenol	< 50.	ug/l	50.	065400000N

PY TO Biosystems, Inc. ATTN Richard L. Raymond

See Reverse Side For Explanation
Of Symbols And Abbreviations And
Our Standard Terms And Conditions

Respectfully Submitted
Lancaster Laboratories, Inc.
Reviewed and Approved by:

Timothy S. Oostdyk, B.A.
Group Leader, GC/MS

ANALYSIS REPORT

ancaster Laboratories INCORPORATED
New Holland Pike, Lancaster, PA 17601-5994 (717) 656-2301

Well CSD-137

Biosystems, Inc.
100 West Dutton Mill Road
Suite 102
Aston, PA 19014-3004
Water Sample
Collected on 04/05/89

LLI Sample No. WW 1376373

Date Reported 5/ 1/89
Date Submitted 4/ 6/89
Discard Date 5/11/89
Collected by 076
P.O. 907
Rel.

Neutrals	RESULT AS RECEIVED		LIMIT OF QUANTITATION	LAB CODE
rosodimethylamine	< 20.	ug/l	20.	069700000N
chloroethyl) ether	< 20.	ug/l	20.	066700000N
ichlorobenzene	< 20.	ug/l	20.	067700000N
chlorobenzene	< 20.	ug/l	20.	067800000N
chlorobenzene	< 20.	ug/l	20.	067600000N
chloroisopropyl) ether	< 20.	ug/l	20.	066800000N
loroethane	< 20.	ug/l	20.	069200000N
rosodi-n-propylamine	< 20.	ug/l	20.	069800000N
benzene	< 20.	ug/l	20.	069600000N
orone	< 20.	ug/l	20.	069400000N
chloroethoxy) methane	< 20.	ug/l	20.	066600000N
trichlorobenzene	< 20.	ug/l	20.	070200000N
halene	< 20.	ug/l	20.	069500000N
lorobutadiene	< 20.	ug/l	20.	069000000N
lorocyclopentadiene	< 20.	ug/l	20.	069100000N
oronaphthalene	< 20.	ug/l	20.	067200000N
phthylene	< 20.	ug/l	20.	065800000N
yl phthalate	< 20	ug/l	20.	068100000N
nitrotoluene	< 20.	ug/l	20.	068400000N
phthene	< 20.	ug/l	20.	065700000N
nitrotoluene	< 20.	ug/l	20.	068300000N
ene	< 20.	ug/l	20.	068800000N
rophenyl phenyl ether	< 20.	ug/l	20.	067300000N
yl phthalate	< 20.	ug/l	20.	068000000N
phenylhydrazine	< 20.	ug/l	20.	068600000N
osodiphenylamine	< 20	ug/l	20.	069900000N
ophenyl phenyl ether	< 20.	ug/l	20.	067000000N
lorobenzene	< 20.	ug/l	20.	068900000N
hrene	< 20.	ug/l	20.	070000000N

To Biosystems, In ATTN: Richard [illegible] Raymond

See Reverse Side For Explanation
Of Symbols And Abbreviations And
Our Standard Terms And Conditions

Respectfully Submitted
Lancaster Laboratories, Inc.
Reviewed and Approved by:

Timothy S. Oostdyk, B.A.
Group Leader, GC/MS

ANALYSIS REPORT

ncaster Laboratories INCORPORATED

w Holland Pike, Lancaster, PA 17601-5994 (717) 656-2301

215780 RRP

PK9098

Well CGD-130

Biosystems, Inc.
500 West Dutton Hill Road
Suite 102
Aston, PA 19014 3004
Water Sample
ted on 04/05/89

LLI Sample No. WW 1376373

Date Reported 5/ 3/89
Date Submitted 4/ 6/89
Discard Date 5/11/89
Collected by 076
P.O. 907
Rel.

Neutrals (cont)	RESULT AS RECEIVED		LIMIT OF QUANTITATION	LAB CODE
acene	< 20.	ug/l	20.	065900000N
butyl phthalate	< 20.	ug/l	20.	068200000N
anthene	< 20.	ug/l	20.	068700000N
e	< 20.	ug/l	20.	070100000N
dine	< 50.	ug/l	50.	066000000N
benzyl phthalate	< 20.	ug/l	20.	067100000N
(a) anthracene	< 20.	ug/l	20.	066100000N
ene	< 20.	ug/l	20.	067400000N
dichlorobenzidine	< 50.	ug/l	50.	067900000N
2 ethylhexyl) phthalate	2,630.	ug/l	20.	066900000N
octyl phthalate	< 20.	ug/l	20.	068500000N
(b) fluoranthene	< 20.	ug/l	20.	066300000N
(k) fluoranthene	< 20.	ug/l	20.	066500000N
(a) pyrene	< 20.	ug/l	20.	066200000N
o (1,2,3 cd) pyrene	< 20.	ug/l	20.	069300000N
zo (a,h) anthracene	< 20.	ug/l	20.	067500000N
(ghi) perylene	< 20.	ug/l	20.	066400000N

to suspected contamination, this sample was re-extracted and re-
alyzed for bis(2 ethylhexyl)phthalate. The result from the re-analysis
r this compound is 50. ug/l. The detection limit for this compound in the
extract is 40. ug/l(increased due to limited volume for re-analysis).
nce the holding time had been exceeded, data from both extractions is
ported.

Y TO Biosystems, Inc. ATTN: Richard L. Raymond

Respectfully Submitted
Lancaster Laboratories, Inc.
Reviewed and Approved by:

Timothy S. Oostdyk, B.A.
Group Leader, GC/MS

See Reverse Side For Explanation
Of Symbols And Abbreviations And
Our Standard Terms And Conditions

DATE: April 28, 1989
WELL NUMBER: CSD-13D
LABORATORY NUMBER: M856
SAMPLE DESCRIPTION: Water Sample
DATE RECEIVED: March 28, 1989
SAMPLE FROM: Savannah River Plant, Aiken, SC
CHAIN OF CUSTODY: Yes

COMPOUND	CONCENTRATION µg/l		LIMIT OF DETECTION µg/l
Chloromethane	<10		10
Bromomethane	<10		10
Vinyl Chloride	<10		10
Chloroethane	<10		10
Methylene Chloride	7	(B=2)	5
1,1-Dichloroethene	<5		5
1,1-Dichloroethane	<5		5
trans-1,2-Dichloroethene	1	(J)	5
Chloroform	<5		5
1,2-Dichloroethane	<5		5
1,1,1-Trichloroethane	1	(J)	5
Carbon Tetrachloride	<5		5
Bromodichloromethane	<5		5
1,2-Dichloropropane	<5		5
cis-1,3-Dichloropropene	<5		5
Trichloroethene	3	(J)	5
Dibromochloromethane	<5		5
1,1,2-Trichloroethane	<5		5
Benzene	5		5
trans-1,3-Dichloropropene	<5		5
2-Chloroethylvinylether	<10		10
Bromoform	<5		5
Tetrachloroethene	<5		5
1,1,2,2-Tetrachloroethane	<5		5
Toluene	<5		5
Chlorobenzene	<5		5
Ethylbenzene	<5		5
Total Xylenes	<5		5

J - Below detection limit.
B = Found in method blank at level indicated.

METHOD OF ANALYSIS: EPA Method 624 + Xylenes using HP 5970 Gas Chromatograph/Mass Spectrometer.

ANALYST:

APPROVED: Michael D. Cox, Ph.D.

LABORATORY MANAGER

DATE: April 25, 1989
WELL NUMBER: Field Blank
LABORATORY NUMBER: M857
SAMPLE DESCRIPTION: Water Sample
DATE RECEIVED: March 28, 1989
SAMPLE FROM: Savannah River Plant, Aiken, SC
CHAIN OF CUSTODY: Yes

COMPOUND	CONCENTRATION µg/l	LIMIT OF DETECTION µg/l
Chloromethane	<10	10
Bromomethane	<10	10
Vinyl Chloride	<10	10
Chloroethane	<10	10
Methylene Chloride	2 (J,B=2)	5
1,1-Dichloroethene	<5	5
1,1-Dichloroethane	<5	5
trans-1,2-Dichloroethene	<5	5
Chloroform	<5	5
1,2-Dichloroethane	<5	5
1,1,1-Trichloroethane	<5	5
Carbon Tetrachloride	<5	5
Bromodichloromethane	<5	5
1,2-Dichloropropane	<5	5
cis-1,3-Dichloropropene	<5	5
Trichloroethene	<5	5
Dibromochloromethane	<5	5
1,1,2-Trichloroethane	<5	5
Benzene	<5	5
trans-1,3-Dichloropropene	<5	5
2-Chloroethylvinylether	<10	10
Bromoform	<5	5
Tetrachloroethene	<5	5
1,1,2,2-Tetrachloroethane	<5	5
Toluene	<5	5
Chlorobenzene	<5	5
Ethylbenzene	<5	5
Total Xylenes	<5	5

J = Below detection limit.
B = Found in method blank at level indicated.

METHOD OF ANALYSIS: EPA Method 624 + Xylenes using HP 5970 Gas Chromatograph/Mass Spectrometer.

ANALYST:

APPROVED: Michael D. Lee Ph.D.

DATE: April 28, 1989
WELL NUMBER: CSD-11D
LABORATORY NUMBER: M858
SAMPLE DESCRIPTION: Water Sample
DATE RECEIVED: March 28, 1989
SAMPLE FROM: Savannah River Plant, Aiken,SC
CHAIN OF CUSTODY: Yes

COMPOUND	CONCENTRATION µg/l	LIMIT OF DETECTION µg/l
Chloromethane	<10	10
Bromomethane	<10	10
Vinyl Chloride	<10	10
Chloroethane	<10	10
Methylene Chloride	15 (B=2)	5
1,1-Dichloroethene	<5	5
1,1-Dichloroethane	<5	5
trans-1,2-Dichloroethene	<5	5
Chloroform	<5	5
1,2-Dichloroethane	<5	5
1,1,1-Trichloroethane	3 (J)	5
Carbon Tetrachloride	<5	5
Bromodichloromethane	<5	5
1,2-Dichloropropane	<5	5
cis-1,3-Dichloropropene	<5	5
Trichloroethene	2 (J)	5
Dibromochloromethane	<5	5
1,1,2-Trichloroethane	<5	5
Benzene	<5	5
trans-1,3-Dichloropropene	<5	5
2-Chloroethylvinylether	<10	10
Bromoform	<5	5
Tetrachloroethene	<5	5
1,1,2,2-Tetrachloroethane	<5	5
Toluene	<5	5
Chlorobenzene	<5	5
Ethylbenzene	<5	5
Total Xylenes	<5	5

J = Below detection limit.
B = Found in method blank at level indicated.

MEHTOD OF ANALYSIS: EPA Method 624 + Xylenes using HP 5970 Gas Chromatograph/Mass Spectrometer.

ANALYST:

APPROVED:

LABORATORY MANAGER

DATE: April 28, 1989
WELL NUMBER: CSD-4D
LABORATORY NUMBER: M859
SAMPLE DESCRIPTION: Water Sample
DATE RECEIVED: March 28, 1989
SAMPLE FROM: Savannah River Plant, Aiken, SC
CHAIN OF CUSTODY: Yes

COMPOUND	CONCENTRATION µg/l	LIMIT OF DETECTION µg/l
Chloromethane	<10	10
Bromomethane	<10	10
Vinyl Chloride	<10	10
Chloroethane	<10	10
Methylene Chloride	1 (J,B=2)	5
1,1-Dichloroethene	<5	5
1,1-Dichloroethane	<5	5
trans-1,2-Dichloroethene	<5	5
Chloroform	<5	5
1,2-Dichloroethane	<5	5
1,1,1-Trichloroethane	<5	5
Carbon Tetrachloride	<5	5
Bromodichloromethane	<5	5
1,2-Dichloropropane	<5	5
cis-1,3-Dichloropropene	<5	5
Trichloroethene	8	5
Dibromochloromethane	<5	5
1,1,2-Trichloroethane	<5	5
Benzene	<5	5
trans-1,3-Dichloropropene	<5	5
2-Chloroethylvinylether	<10	10
Bromoform	<5	5
Tetrachloroethene	3 (J)	5
1,1,2,2-Tetrachloroethane	<5	5
Toluene	<5	5
Chlorobenzene	<5	5
Ethylbenzene	<5	5
Total Xylenes	<5	5

J = Below detection limit.
B = Found in method blank at level indicated.

METHOD OF ANALYSIS: EPA Method 624 + Xylenes using HP 5970 Gas Chromatograph/Mass Spectrometer.

ANALYST:

APPROVED:

LABORATORY MANAGER

DATE: April 28, 1989
WELL NUMBER: Trip Blank
LABORATORY NUMBER: M860
SAMPLE DESCRIPTION: Water Sample
DATE RECEIVED: March 28, 1989
SAMPLE FROM: Savannah River Plant, Aiken SC
CHAIN OF CUSTODY: Yes

COMPOUND	CONCENTRATION µg/l	LIMIT OF DETECTION µg/l
Chloromethane	<10	10
Bromomethane	<10	10
Vinyl Chloride	<10	10
Chloroethane	<10	10
Methylene Chloride	3 (J,B=2)	5
1,1-Dichloroethene	<5	5
1,1-Dichloroethane	<5	5
trans-1,2-Dichloroethene	<5	5
Chloroform	<5	5
1,2-Dichloroethane	<5	5
1,1,1-Trichloroethane	<5	5
Carbon Tetrachloride	<5	5
Bromodichloromethane	<5	5
1,2-Dichloropropane	<5	5
cis-1,3-Dichloropropene	<5	5
Trichloroethene	<5	5
Dibromochloromethane	<5	5
1,1,2-Trichloroethane	<5	5
Benzene	<5	5
trans-1,3-Dichloropropene	<5	5
2-Chloroethylvinylether	<10	10
Bromoform	<5	5
Tetrachloroethene	<5	5
1,1,2,2-Tetrachloroethane	<5	5
Toluene	<5	5
Chlorobenzene	<5	5
Ethylbenzene	<5	5
Total Xylenes	<5	5

J = Below detection limit.
B = Found in method blank at level indicated.

METHOD OF ANLAYSIS: EPA Method 624 + Xylenes using HP 5970 Gas Chromatograph/Mass Spectrometer.

ANALYST:

APPROVED: Michael D. Lee, Ph.D.

LABORATORY MANAGER

DATE: May 23, 1989

LABORATORY NUMBER: 038100 M856 to M860

SAMPLE DESCRIPTION: Water Samples

DATE RECEIVED: March 28, 1989

SAMPLE FROM: Savannah.River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

LOG #	Well #	Total Petroleum Hydrocarbon PPM
M856	13	<1*
M857	FB	<1
M858	11	<1
M859	4	<1
M860	TB	<1

* = DETECTION LIMIT 1 PPM
FB = FIELD BLANKE
TB = TRIP BLANK

METHOD OF ANALYSIS: Analyzed by EPA 418.1

ANALYST:

APPROVED:

LABORATORY MANAGER

APPENDIX III

and [illegible]

SOIL MICROBIOLOGY COUNTS

DATE: February 2, 1989

LABORATORY NUMBER: 038035 & 038037 - M506 to M543

SAMPLE DESCRIPTION: Core Samples

DATE RECEIVED: December 20, 21, and 22 1988

SAMPLE FROM: Savannah River Plant, Aiken, SC

ANALYSIS REPORT:

			CFU/g	
Log #	CORE #	Depth Feet	TOTAL COUNTS*	DIESEL UTILIZERS**
534	1-1	47	<100	<200
535	1-2	50	<100	<200
536	1-3	52	<100	<200
537	1-4	55	100	<200
538	1-5	61	<100	<200
538D	1-5	61	<100	<200
539	2-1	27	1400	<200
540	2-2	30	1200	<200
541	2-3	31	500	<200
542	2-4	36	<100	<200
543	2-5	46	200	<200
543D	2-5	46	100	<200
506	3-1	3	2800	200
507	3-2	7	1000	<200
508	3-3	12	<100	2200

* 100 is the minimum number of total bacteria that can be counted by this procedure

**200 is the minimum of diesel utilizers that can be counted by this procedure

D indicates laboratory duplicate

ANALYST:

APPROVED:

LABORATORY MANAGER

DATE: February 1, 1989

LABORATORY NUMBER: 38036 - M509 to M533

SAMPLE DESCRIPTION: Core Samples

DATE RECEIVED: December 17, 1988

SAMPLE FROM: Savannah River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

Log #	CORE #	Depth Feet	CFU/g TOTAL COUNTS*	CFU/g DIESEL UTILIZERS**
509	4-1	2.5	4600	<200
510	4-2	4	1000	<200
511	4-3	12	<100	<200
512	4-4	17	<100	200
513	4-5	22	<100	200
514	4-6	25	<100	<200
515	4-7	28	<100	200
516	4-8	31	<100	200
517	4-9	34	<100	200
518	4-10	37	<100	200
519	4-11	40	<100	<200
520	4-12	43	100	<200
521	4-13	46	<100	<200
522	4-14	48	<100	<200
523	4-15	52	<100	<200
524	4-16	55	<100	<200
525	4-17	58	<100	<200
526	4-18	61	100	<200
527	4-19	64	400	<200
528	4-20	67	<100	<200
529	4-21	70	<100	<200
530	4-22	73	<100	<200
531	4-23	76	<100	200
532	4-24	79	<100	<200
533	4-25	82	<100	<200

* 100 is the minimum number of total bacteria that can be counted by this procedure.

**200 is the minimum number of diesel utilizers that can be counted by this procedure.

ANALYST:

APPROVED: Michael D. Lee, Ph.D.
LABORATORY MANAGER:

DATE: January 31, 1989

LABORATORY NUMBER: 038035 & 036038 M496 to M569

SAMPLE DESCRIPTION: Core Samples

DATE RECEIVED: December 15, 16, 1988 & January 4, 1989

SAMPLE FROM: Savannah River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

			CFU/g	
Log #	CORE #	Depth Feet	TOTAL COUNTS*	DIESEL UTILIZERS**
496	5-1	1-3	2800	200
497	5-2	3	520000	22400
498	5-2	7-9	400	<200
499	5-3	10-12	1000	<200
500	6-1	2.5	1500	<200
501	6-2	7	4000	<200
502	6-3	12	<100	<200
503	7-1	4	<100	<200
504	7-2	8	<100	<200
505	7-3	12	<100	400
562	8-1	27	2000	800
563	8-2	32	<100	<200
564	8-3	37	100	<200
565	8-4	42	<100	<200
566	8-5	57	<100	<200
567	8-6	67	<100	<200
567D	8-6	67	<100	<200
569	8-7	77	<100	<200

* 100 is the minimum number of total bacteria that can be counted by this procedure

**200 is the minimum number of diesel utilizers that can be counted by this procedure.

D indicates laboratory duplicate

ANALYST:

APPROVED: Michael D. Lee, Ph.D.

LABORATORY MANAGER

DATE: February 16, 1989

LABORATORY NUMBER: 038038 - 038046- M570 to M586

SAMPLE DESCRIPTION: Core Samples

DATE RECEIVED: January 6, 9, & 11, 1989

SAMPLE FROM: Savannah River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

			CFU/g	
Log #	CORE #	Depth Feet	TOTAL COUNTS*	DIESEL UTILIZERS**
M576	9-1	8	200	200
M577	9-2	20	<100	<200
M578	9-3	30	<100	<200
M579	9-4	38	<100	<200
M580	9-5	50	100	<200
M581	9-6	56	1000	400
M582	9-7	60	100	<200
M583	9-8	66	300	200
M584	9-9	72	<100	200
M585	9-10	76	<100	<200
M586	9-11	80	100	<200
570	10-1	32	<100	<200
571	10-2	42	<100	<200
572	10-3	52	100	<200
573	10-4	57	4200	3800
574	10-5	62	<100	600
575	10-6	67	<100	<200

* 100 is the minimum number of total bacteria that can be counted by this procedure

**200 is the minimum number of diesel utilizers that can be counted by this procedure

ANALYST:

APPROVED:

LABORATORY MANAGER

DATE: February 16, 1989

LABORATORY NUMBER: 038047 - M593 to M603

SAMPLE DESCRIPTION: Core Samples

DATE RECEIVED: January 12, 1989

SAMPLE FROM: Savannah River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

			CFU/g	
Log #	CORE #	Depth Feet	TOTAL COUNTS*	DIESEL UTILIZERS**
M593	11-1	6	300	<200
M594	11-2	10	<100	<200
M595	11-3	16	100	<200
M596	11-4	24	<100	200
M597	11-5	30	<100	2400
M598	11-6	36	<100	200
M599	11-7	42	<100	200
M600	11-8	48	<100	<200
M601	11-9	54	100	<200
M602	11-10	62	<100	<200
M603	11-11	70	100	<200

* 100 is the minimum number of total bacteria that can be counted by this procedure

**200 is the minimum number of diesel utilizers that can be counted by this procedure

ANALYST:

APPROVED: Michael D. Lee, Ph.D.

LABORATORY MANAGER

DATE: February 2, 1989

LABORATORY NUMBER: 038037 & 038038 - M544 to M561

SAMPLE DESCRIPTION: Core Samples

DATE RECEIVED: December 23, 1988 & January 4, 1989

SAMPLE FROM: Savannah River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

			CFU/g	
Log #	CORE #	Depth Feet	TOTAL COUNTS*	DIESEL UTILIZERS**
556	12-1	32	<100	<200
557	12-2	37	<100	<200
558	12-3	42	<100	200
559	12-4	47	300	<200
560	12-5	60	100	200
561	12-6	65	<100	200
544	13-1	7	300	<200
545	13-2	12	<100	200
546	13-3	17	600	200
547	13-4	22	200	1000
548	13-5	27	<100	<200
549	13-6	32	<100	<200
550	13-7	37	100	<200
551	13-8	42	<100	<200
552	13-9	47	100	<200
553	13-10	52	<100	<200
554	13-11	57	<100	<200
555	13-12	62	<100	<200

* 100 is the minimum number of total bacteria that can be counted by this procedure

**200 is the minimum number of diesel utilizers that can be counted by this procedure

ANALYST:

APPROVED: Michael D. Lee, Ph.D.

LABORATORY MANAGER

DATE: May 23, 1989

LABORATORY NUMBER: 038089 - M856 to M860

SAMPLE DESCRIPTION: Water Samples

DATE RECEIVED: March 28, 1989

SAMPLE FROM: Savannah River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

Log #	Well #	TOTAL COUNTS	DIESEL UTILIZERS
M856	13	3600	4200
M857	FB*	9	20
M858	11	44000	14800
M859	4	0	<10[1]
M859D	4	0	<10
M860	TB*	0	<10

STANDARD DILUTION METHOD.

[1] Minimum number of diesel utilizer which can by counted by this procedure is 10 organisms per ml.

* FB = Field Blank
* TB = Trip Blank

ANALYST: Mary Sams

APPROVED:

LABORATORY MANAGER

DATE: May 23, 1989

LABORATORY NUMBER: 038089 - M856 to M860

SAMPLE DESCRIPTION: Water Samples

DATE RECEIVED: March 28, 1989

SAMPLE FROM: Savannah River Plant, Aiken, SC

CHAIN OF CUSTODY: Yes

ANALYSIS REPORT:

Log #	Well #	Direct Counts
M856	13	11498
M857	FB*	<40[1]
M858	11	5970
M859	4	5105
M859D	4	9894
M860	TB*	<40

Cells stained with acridine orange, collected on a 0.45 um Erglan black prestained filter, and counted by epiflourescent microscopy.

[1] Minimum number of direct counts which can by made by this procedure is 40 organisms per ml.

* FB = Field Blank
* TB = Trip Blank

NALYST:

PPROVED: , Ph.D.

LABORATORY MANAGER

END

DATE FILMED

2/2/94