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ESC

ENVIRONMENTAL STRATEGIES CORPORATION
11911 Freedom Drive • Reston, Virginia 22090 • (703) 709-6500 • FAX (703) 709-8505

October 27, 1994

Ms. Debra Rossi
Remedial Project Manager
U.S. Environmental Protection Agency
Region III
841 Chestnut Street
Philadelphia, PA 19107

Re: Air Sparging Pilot Test Scope of Work, Millsboro, Delaware, NPL Site

Dear Ms. Rossi:

Enclosed is a proposal from Terra Vac to perform a soil vapor extraction/air sparging pilot test at the Millsboro, Delaware, NPL site. Environmental Strategies Corporation (ESC) on behalf of AT&T Global Information Solutions, has reviewed the proposal and finds that the scope of work is appropriate to assess the applicability of the technology to the Millsboro site and to develop parameters for design, and recommends that it be approved.

We will perform the study after the U.S. Environmental Protection Agency approves the enclosed proposal

Sincerely yours,

Reynolds B. Renshaw

Reynolds B. Renshaw
Project Manager

RBR:rbr
29842

Enclosure

cc/encl: Dr. William S. Brewer, AT&T GIS
Mr. David Langseder, Delaware Department of Natural Resources and Environmental Control
Mr. David Richardson, First National Bank of Maryland
Mr. John Mildenberger, Ruth Associates, Inc.

TERRA VAC
806 SILVIA STREET, WEST TRENTON, NEW JERSEY 08628-3239 ■TEL (609) 530-0003
■FAX (609) 530-1084

October 17, 1994

Mr. Joseph M. Califf
Environmental Strategies Corporation
11911 Freedom Drive
Reston, Virginia 22090

Re: Proposal for Pilot-scale Test Services,
Former NCR Facility, Millsboro, Delaware
Terra Vac Proposal Number 40-4216

Dear Mr. Califf:

Terra Vac is pleased to provide Environmental Strategies Corporation with this proposal for the design, installation, and operation of a pilot-scale air sparging and soil vapor extraction (AS/SVE) system at the former NCR facility in Millsboro, Delaware. This proposal is based on the data contained in the Request for Proposal (RFP) dated September 30, 1994.

1.0 INTRODUCTION

Environmental Strategies Corporation (ESC) is currently managing the investigation and remediation of Trichloroethene (TCE) contamination in the groundwater at the site. The activities are being performed under the supervision of the Environmental Protection Agency as part of the CERCLA program.

The site (Figure 1) is divided into eastern and western areas as a result of railroad tracks. The western area is in the first phase of implementation or a groundwater pump and treat remedy. The EPA has directed AT&T Global Information Systems (formerly NCR) to implement a Phase II system to remediate TCE in the groundwater in the eastern portion of the site. TCE with concentrations up to 2,300 ppb has been recorded from groundwater samples collected from monitoring wells in this portion of the site.

The site is underlain by a 10 to 12 foot thick layer of silty fine to medium grained sands followed by an interval of medium to coarse grained sands with some fine sands and silts. Within this lower interval, discontinuous layers of dense clays and fine gravels are present.

Based on measurements at the monitoring wells, the depth to groundwater varies between 12 to 16 feet below the ground surface (BGS).

2.0 AS/SVE PILOT TEST OBJECTIVES

The objectives of the AS/SVE pilot test will be to:

1. Demonstrate the effectiveness of the AS/SVE process to remediate the TCE in the groundwater east of the railroad tracks at the site.

2. Determine the design parameters for the full scale application of AS/SVE, including:

   a. spacing and depths of AS wells
   b. spacing and depth of SVE wells
   c. expected air flow from the SVE wells
   d. expected injection rates to the AS wells
   e. expected concentrations of contaminants in extracted air

3. Identify the appropriate air emissions control system for treatment of the extracted air.

4. Prepare a conceptual full scale design including:

   a. number of wells
   b. spacing of wells
   c. total expected air flow
   d. size of vacuum pump
   e. size of air compressor
   f. vapor treatment costs
   g. estimated costs
   h. estimated duration of remediation

3.0 PROCESS DESCRIPTIONS

Terra Vac proposes to design, install and operate a pilot-scale air sparging and spoil vapor extraction system west of monitoring well W32B in the eastern portion of the site (Figures 1 and 2). Process descriptions of soil vapor extraction and air sparging are given below.

3.1.1 Soil Vapor Extraction

Soil vapor extraction (SVE) induces a negative pressure gradient within the soil matrix through a nearby extraction well. As the vacuum induces subsurface air flow, liquid contaminants vaporize as air and contaminant vapors migrate to the extraction well where they are drawn to the surface for treatment. The process recovers the liquid and vapor phases of volatile organic compounds (VOCs), enhances the volatilization of VOCs in the soil matrix, and desorbs contaminants from the soil matrix over time. Normally, a no-flow boundary to vapor flow exists at the groundwater surface, or the top of the capillary fringe.

The effectiveness of the SVE process to recover VOCs is controlled by several factors. Contaminant-specific conditions such as the physical and chemical properties of the VOCs (vapor pressure, Henry's Law Constant (H_c) and solubility), the subsurface characteristics (porosity, moisture content and permeability), in addition to system operating parameters, such as well spacing and applied vacuum, make each site unique and the application of the process site-specific.

The optimal application of the technology is the recovery of VOCs with a high vapor pressure and H_c, in homogeneous soils with high porosity and permeability. High vapor pressures and H_c's allow VOCs to be quickly partitioned to the vapor phase by the induced vacuum and air flow, and readily extracted to the surface for treatment. Homogeneous soils with high porosity and permeability maximizes the capabilities of system surface equipment and reduces the number of VE wells required. A large subsurface volume available for air flow (porosity) allows the process to be driven by mass transfer rather than diffusion, greatly reducing the time frame for soil remediation.

Typically, the equipment required for the implementation of a VES includes horizontal or vertical extraction wells, a vacuum extraction unit (VEU), a liquid/vapor separator, a vapor treatment system and system controls and instrumentation. The number of extraction wells is controlled by subsurface conditions. As the porosity and permeability of the subsurface decreases, the number of extraction wells will generally increase. The VEU design is dictated by the air flow rates and vacuum levels required. A variety of units are available for use, ranging from low vacuum, single stage centrifugal blowers to high vacuum rotary vane or positive displacement blowers. Vapor can be discharged to the atmosphere, under some instances, or treated by either adsorption of extracted vapors onto vapor phase granular activated carbon (VPGAC), catalytic oxidation or thermal incineration. Figure 4 is a typical SVE Process Flow Diagram.

3.1.2 Air Sparging

Air sparging introduces contaminant-free air into the saturated zone through specially designed injection wells. As the air leaves the well and moves outward and upward through the aquifer, it creates three zones with the aquifer (Figure 5).

The innermost zone, known as the pore water displacement zone, extends radially from the well, a distance up to 1/3 the depth of the injection well below the water table. In the pore water displacement zone, almost all of the water in the soil pore spaces has been displaced by the air. VOC removal is primarily by votalization and mass transfer of the residual VOCs.

The next zone outward from the injection well is known as the micro-channel airflow zone. This zone extends from the end of the pore water displacement zone radially outward to one to two times the depth of the sparging point below the water table, dependant on the site geology. In this zone, the air travels through micro-fracture paths, displacing much less water than in the pore-water displacement zone. The primary removal mechanism is the partitioning of the VOCs from the dissolved phase to the vapor phase, followed by vapor mass transfer. Some volatization of residual VOCs also occurs. The extent of this zone can be detected by measuring air flow through monitoring points in the saturated zone.

The final zone is the dissolved oxygen zone, extending from the micro-channel air zone outward beyond three times the depth of the sparging point below the static water table. No air flow occurs in this zone; however, elevated levels of dissolved oxygen can be detected. The dissolved oxygen spreads from the micro-channel air flow through diffusion, due to the concentration gradient of dissolved oxygen produced by the sparging air flow. No significant mass transfer mechanisms exist in this zone. For certain biodegradable compounds, the increased oxygen levels result in enhanced biodegradation.

The effectiveness of the air sparging process in the micro-channel air flow zone relies on the natural equilibrium which occurs between contaminants within the saturated zone and the contaminant-free air passed through it. The vapor/dissolved phase equilibrium concentrations are based on Henry's Law constants (H_c) for the contaminants of concern. Generally, contaminants with higher H_c values will partition to the vapor phase at a faster rate than those with lower values.

In addition, the equilibrium between the adsorbed and dissolved phase contaminants must be considered. This equilibrium is expressed by the octanol-water partition coefficient (K_{ow}). Typically, the lower the value, the higher the tendency of the contaminants to dissolve. For the purposes of air sparging, contaminants with high K_{ow} values, which tend to adsorb within the soil matrix, will be remediated at a faster rate by sparging when compared to conventional pump and treat methods.

Terra Vac has successfully remediated groundwater using sparging techniques at sites with chlorinated compounds such as those found at this site. TCE has a H_c of 0.393 and a K_{ow} of 2.4×10^2 which indicate that it will readily partition from the dissolved to vapor phase. The ability of the sparging process coupled with SVE to treat contaminated groundwater and soils *in situ* reduces costs and concerns regarding liquid-phase treatment and the disposal of treated groundwater.

3.2 Proposed Treatment Systems

3.2.1 Soil Vapor Extraction System

Integral parts of the air sparging system are soil vapor extraction wells completed in the vadose, or unsaturated, zone, above that portion of the aquifer to be treated via air sparging. For this test, it is proposed to install three (3) soil vapor extraction wells to the top of the saturated zone, approximately 12 feet below the ground surface. These wells will be installed with hollow stem augers and constructed of 4"PVC screen with 0.20 slot. Approximately 5 feet of screen will be installed in each well from approximate depths of 7 to 12 feet.

The wells will be manifolded above ground to a 10 Hp vacuum extraction unit. The extracted vapors will be treated by vapor phase granular activated carbon (VPGAC) contained in two 1,000-pound canisters connected in series. One vessel will serve as the primary treatment vessel and one vessel will be the secondary, or guard vessel. Any process water (condensate) will be removed by means of an air/water separator and drummed for disposal by the site owner or his authorized representative. It is expected that only a minimal amount of condensate will be produced by the SVE system.

3.2.2 Air Sparging System

The groundwater sparging system will consist of the above-mentioned SVE wells and one groundwater sparging well. The sparge well will be installed to approximately 40 feet below ground level, with one foot of the screen at the bottom, which should be about 15 to 20 feet below the water table. The sparge well will be connected to an air compressor capable of 10-12 psi and 15 cfm.

2.2.3 Monitoring Points

The overall effectiveness of the AS/SVE system will be monitored in several ways. Specially designed probes will be installed to determine the extent of the zone aeration. A series of nested monitoring probes will be installed in both the unsaturated and saturated zones. The probes in the unsaturated zone will be used to monitor vacuum distribution and soil gas concentrations in this portion of the site. The probes installed in the saturated zone will be used to measure airflow as an indication of the effectiveness air sparging.

These probes will be installed in the array as shown on Figure 3. The locations of the monitoring probe clusters are planned to be installed at distances of 5,10,20 and 30 feet from the sparge point. These probe clusters will be nested in the saturated zone and should not be influenced by changed in pressure as a consequence of vapor extraction in the unsaturated zone. The location of these probes is focussed on the presumed location of the zone of aeration created by the air sparging process.

Nearby monitoring wells will also be tested for vacuum and dissolved oxygen.

3.0 Health and Safety

All Terra Vac personnel assigned to this project trained in accordance with OSHA regulations 29CFR1910.120 as they pertain to vacuum extract operations. Terra Vac's personnel are also involved in a corporate-wide medical monitoring program which exceeds that required by OSHA.

Terra Vac will comply with the Health and Safety requirements outlined in the RFP. It is assumed that ESC will provide a health and safety plan which will be reviewed by Terra Vac personnel prior to beginning work on-site. Terra Vac will provide training documentation for its employees assigned to the project.

4.0 SCOPE OF WORK

The following activities will be performed by Terra Vac as part of the proposed scope of work:

4.1 Task One - Design and Work Plan Preparation

The design of the pilot test system will be completed, and a site plan showing the equipment and piping layout will be prepared. A site-specific Health and Safety Plan and a Work Plan will be prepared at this time. Terra Vac will prepare a work plan which will document the detail of the activities to be performed as part of the pilot test program.

4.2 Task Two - Equipment Procurement, Mobilization and Installation

The VEU, the activated carbon vessels, the air/water separator and the air compressor will be procured from Terra Vac's standing inventory. Consumable materials required for the project will be purchased. Once all of the supplies and equipment are gathered together they will be mobilized to the site. Drilling services will be subcontracted for the installation of the vacuum extraction wells and the air sparge well, which should take no more than three days.

Three vertical SVE wells will be installed to approximately 1 (one) foot above the seasonal high water table, approximately 12 feet deep. These wells will be constructed with four-inch well screen and connected to a four-inch manifold. The VE wells will be constructed with 4-inch Schedule 40 PVC pipe, have 5 feet of 0.02 slotted PVC screen, backfilled with Moire #2 sand, sealed with bentonite and grouted to the surface. The SVE wells will be manifolded to the air/water separator followed by the vapor phase granular activated carbon (VPGAC) vessels and the 10 Hp VEU.

The air sparge well will be installed to an approximate depth of 38 feet. This well will be constructed of two-inch Schedule 40 PVC pipe, screened with one foot of 0.010 slotted PVC screen, packed with Moire #2 sand and sealed with bentonite. The sparge well will be connected to an air compressor capable of approximately 5 psi and 45 cfm. The VPGAC vessels will also be put on-line. Figure 4 is a schematic of the proposed pilot scale AS/SVE system.

Monitoring probes will be installed to measure soil vacuum/pressure in order to determine the radius of influence for each well and to ensure the complete capture of all of the sparge air and VOC-laden vapors. Each probe will be constructed of 1/2-inch steel pipe with 1/8-inch holes evenly spaced at 90 degrees along the bottom twelve inches of the pipe. The probes will be fitted with steel points and driven to the respective depths with a vibrating hammer.

The monitoring probes will be installed in clusters of up to 3 probes at each location as discussed in Section 2.2.3 and shown on Figure 3. The shallowest probe will be driven to a depth of approximately 8 to 10 feet and will be used to monitor vacuum levels and soil gas concentrations in the unsaturated zone.

Another probe will be driven to approximately 15-18 feet of depth and will be used to monitor pressure changes in the upper portion of the aquifer. These probes will also be used to monitor changes in water table elevations and in the groundwater, as the pilot test proceeds.

The third probe will be driven to an approximate depth of 38 feet and will be used to monitor pressure and changes in this part of the aquifer.

Construction of the SVE/system will be concurrent with the well installations; therefore, the estimated time frame for the complete installation of the SVE/sparging system is three days.

4.3 Task Three - Start-up and Operations

The SVE and groundwater sparging systems will be brought on-line and operated for about five days or until the VPGAC is exhausted, whichever comes first. Initially, the vacuum extraction unit will be started and vacuum will be placed on the VE wells. The vacuum will be increased gradually until the wells are under maximum vacuum and air flow stabilizes. Once the VE wells are under maximum vacuum, then zones of influence will be monitored at the probe clusters to insure that the unsaturated zone above the sparge point is under vacuum. Once the VE wells are developed, the air sparging system will be turned on and operated in accordance with the work plan.

The vacuum applied to the VE wells will be increased in a step-wise fashion until the wells are fully developed. Vacuum and flow will be monitored and this data will be used to determine the zone of influence of the wells and the air permeability of the unsaturated zone. Similarly, the injected air flow and zone of influence of the sparging well will be monitored at different injection pressures. This will allow Terra Vac to determine the maximum injection pressures and flows in order to optimize the number of sparge wells for the full scale remediation.

The following measurements will be taken on a routine basis (at a minimum, daily) during the pilot test:

- Air contaminant concentrations at each wellhead,
- Contaminant concentrations at the inlet to the activated carbon and at the outlet of the primary and guard activated carbon units,
- Air contaminant concentrations at the soil probe in the unsaturated zone,

- Dissolved oxygen and pH in the water samples collected from probes below the water table,
- Vacuum at each wellhead,
- Extracted vapor flow from each wellhead,
- Vapor flow rates at various points in the manifold system,
- Pressure measurements at the probe clusters and at W33A and W33B,
- Dissolved oxygen measurements in the groundwater monitoring wells and,
- Flow and injection pressure at the AS injection well.

Sampling and monitoring during the test shall also include the following:

- Daily samples of the vapors extracted from each well will be collected for analyses by an on-site chromatograph for the compounds of concern. The analyses will quantify the concentration of each compound and the total VOC concentration will be reported.

- Daily samples of the vapors after the primary and secondary VPGAC adsorbers will be analyzed with the on-site GC. The tests will be used to determine breakthrough of the adsorbers.

- Daily vacuum measurement at each well, after the primary VPGAC adsorbers, and after the secondary VPGAC adsorbers. The measurements will be taken with a pressure gauge and will be reported in inches of Mercury.

- Daily flow measurements of the extracted and treated vapors shall be taken at each well, after the primary VPGAC adsorber and after the secondary VPGAC adsorber. The measurements will be made with a self-averaging pilot tube. The flow rates will be reported as standard cubic feet per minute (SCFM).

- Daily vacuum measurements at the vapor monitoring probes (VMPs) will be taken with a water manometer. The data will be used to determine the effectiveness of the SVE wells and their zones of influence. During the startup of the system, the system will be operated at three different vacuums, thus creating different flow rates. Subsurface vacuum measurements will be taken at each vacuum to be used for vacuum isopleths at different operation conditions.

- Daily monitoring of the injected air pressure and flow at the AS well.

Terra Vac will use an on-site gas chromatograph equipped with a flame ionization detector (FID) to analyze samples of the extracted vapors taken during the start-up period. Terra Vac maintains a staff of qualified chemists who are thoroughly familiar with the sampling requirements for the pilot testing program proposed herein. Terra Vac has extensive experience in formulating, implementing, and verifying analytical and QA/QC requirements for projects of this type. QA/QC procedures will be consistent with those recommended by federal and state analytical guidelines. QA/QC procedures will include appropriate QA/QC samples such as field blanks, trip blanks, and replicates that will verify the accuracy, representativeness, and completeness of the analytical program.

4.4 Reporting

Following completion of the AS/SVE field operations, a detailed report will be prepared which summarizes the result of the pilot test. This report will be prepared with the following format:

- EXECUTIVE SUMMARY
- PROJECT DESCRIPTION AND CHRONOLOGY
  - Vacuum Extraction Process Description
  - Groundwater Sparging Process Description
  - System Installation
  - System Operations - Monitoring
  - Samples and Analyses
- SUMMARY OF FINDINGS
  - Subsurface Vacuum and flow
  - Groundwater Sparging Monitoring
  - Extracted Vapor Concentrations
  - Zone of Influence/Air Permeability
  - Treatment of Extracted Vapors
- CONCLUSIONS AND RECOMMENDATIONS
  - Site conditions
  - Vapor Flow Rates
  - Mass Recovery Rates
  - Recommendations for Full-scale Application

4.5 Conceptual Full-scale Design

Based on the results of the pilot test, Terra Vac will prepare a conceptual full-scale design for the area of concern. This design will address the following:

- number and spacing of SVE wells
- number and spacing of sparging wells
- expected total air flow
- size of vacuum extraction pump
- size of air compressor
- type of air treatment system

Terra Vac will prepare design drawings as appropriate to illustrate the conceptual full scale design.

5.0 SCHEDULE

Terra Vac can begin work (Task 1) within five days of notice to proceed. (Design and Work Plan preparation will require about one week to complete.) Task 2, Equipment Procurement, Mobilization and System Installation, will take two weeks. It is proposed to operate the AS/SVE pilot test system for up to 5 days, or until the VPGAC is consumed, whichever occurs first. Terra Vac currently has all equipment required to perform the work described herein as off-the-shelf items. It is anticipated that the report for the pilot test operations will be submitted within 30 days from completion of the field activities.

6.0 COST ESTIMATE

Terra Vac has prepared the following cost estimate based on the information provided by Environmental Strategies Corporation. The following assumptions were made in the preparation of this cost estimate:

- The depth to groundwater is approximately 14 feet below grade.
- Terra Vac will supply a portable electric generator to provide power for the duration of the test. The costs are included in the cost estimate.
- The cost for 2,000 pounds of fresh activated carbon is included within this cost estimate. Additional carbon can be provided at a cost of $2.75 per pound. These prices include the costs for round trip transportation and regeneration. The waste classification fee for new sites is also not included in the provided cost estimate.
- The disposal of all drill cuttings, drummed process water and residuals is the responsibility of the site owner, and is not included within the scope of work for the cost estimate provided.
- All hazardous waste manifests and paperwork will be prepared and signed by the site owners or their designated representatives as generator of the work.

All work will be performed on a time and materials basis, and will be billed in accordance with Terra Vac's Standard Fee Schedule. Invoices of work performed will be prepared and submitted on a monthly basis. It is further assumed an agreement similar to the existing agreement between Terra Vac and the Environmental Strategies Corporation will be used to model the contract for work and that Terra Vac's Standard Terms and Conditions and insurance will be in effect for the duration of this project.

Task One - System Design and Permitting

Task Two - Equipment Procurement, Mobilization and Installation

Task Three - AS/SVE Pilot Test Operations

Task Four - Reporting and Conceptual Full-scale Design

[1] Assumes that air discharge permit is not required.

[2] Includes the cost of leasing the vacuum extraction system including 2,000 pounds of VPGAC.

Terra Vac appreciates the opportunity to be of further service to the Environmental Strategies Corporation. If you have any questions, please contact us at (609) 530-0003.

We look forward to working with you on this important project.

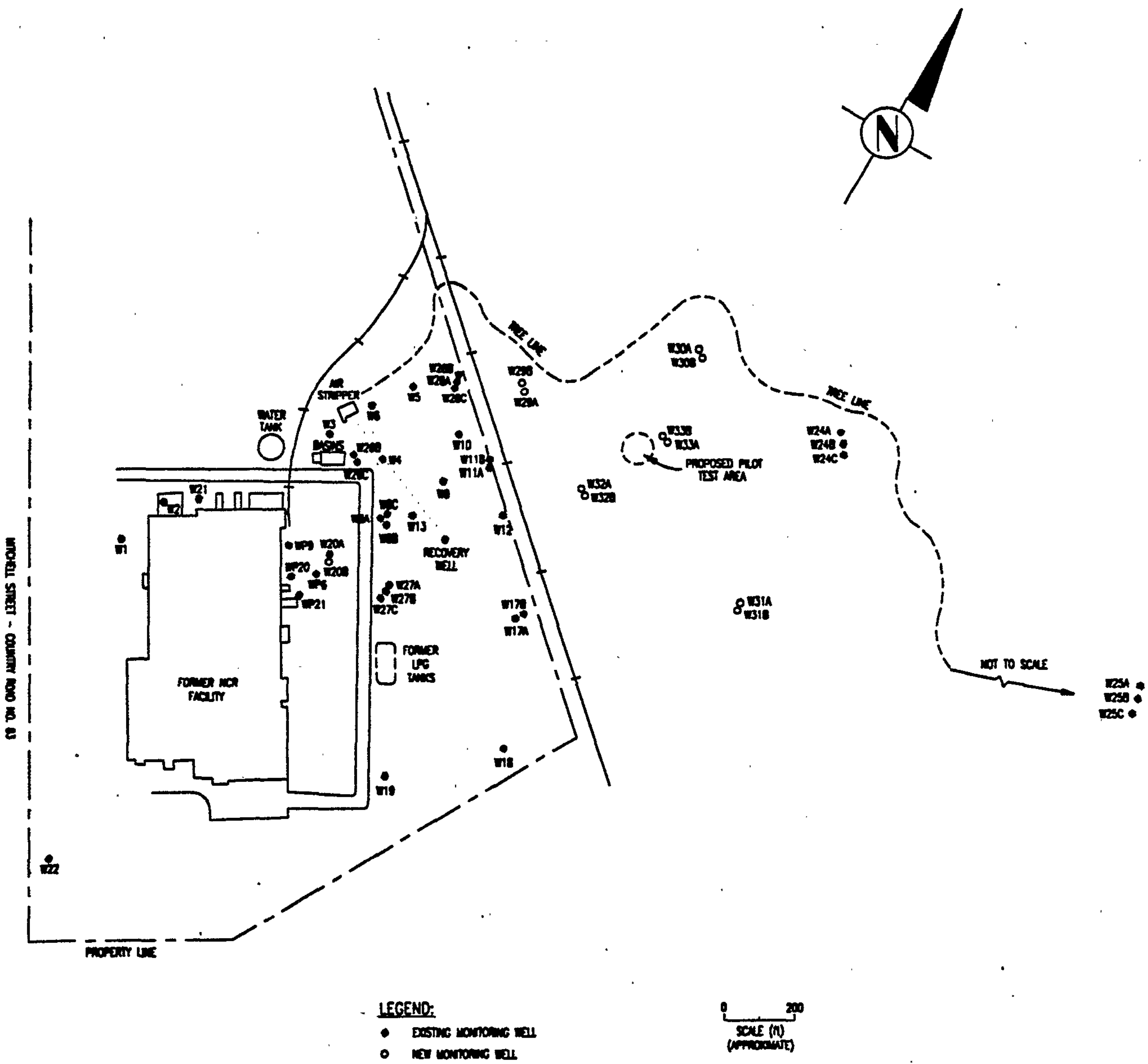
Very truly yours,

Terra Vac

R. Michael Peterson, Ph.D.
Division Manager

Ed Malmanis
Vice President

c: J. Malot
R. Piniewski
R. Ross



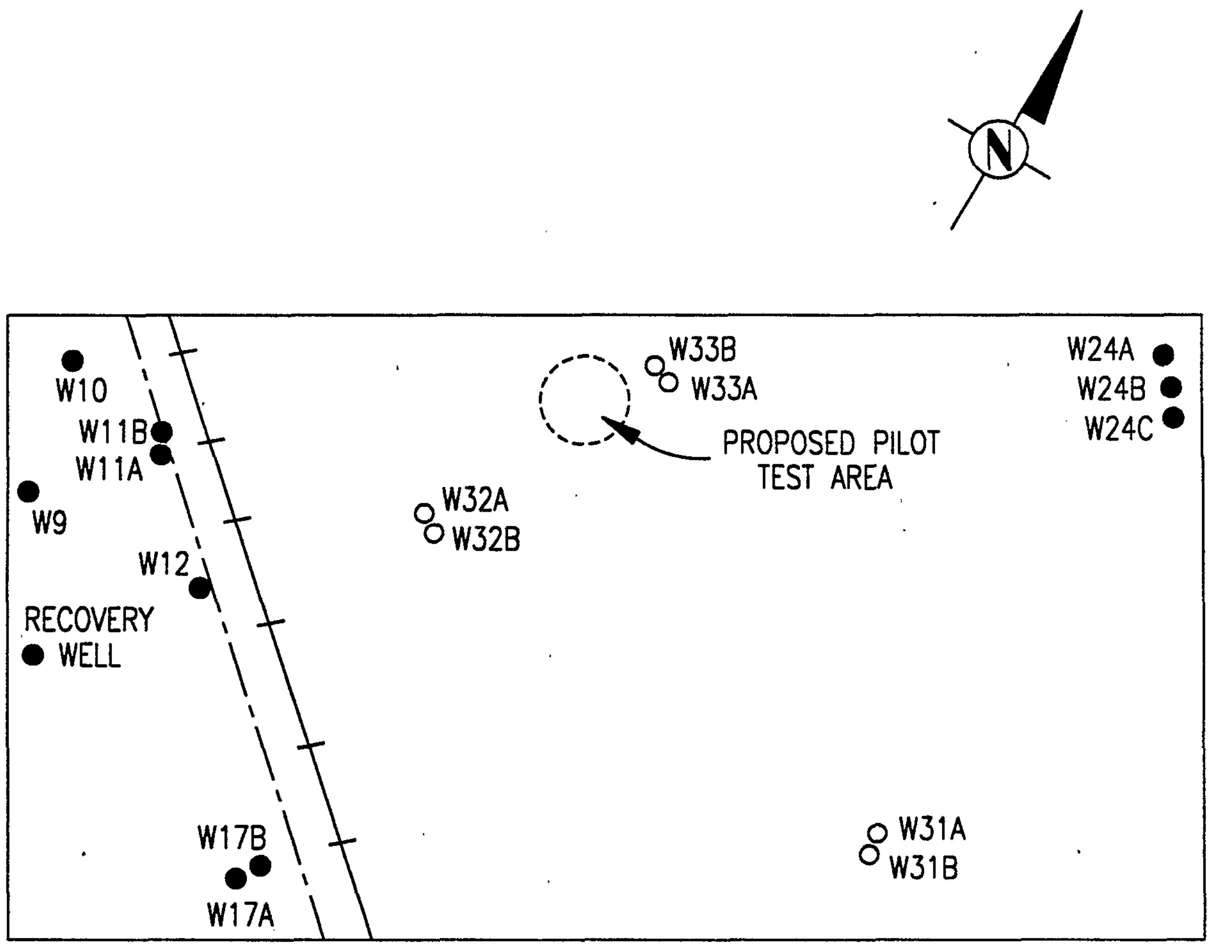
TERRA VAC

FORMER NCR CORPORATION FACILITY
MILLSBORO, DELAWARE

SITE PLAN

DESIGNED BY:	CHECKED BY:	DWG. NO: 40-4216	SHEET: 1
DRAWN BY: C CONNOLLY	PROJECT MANAGER:	DATE: 10/7/94	SCALE: AS SHOWN

TV\10-19-94\SITE1.DWG



LEGEND:

- ● EXISTING MONITORING WELL
- ○ NEW MONITORING WELL

0 — 200
SCALE (ft)
(APPROXIMATE)

TERRA VAC

FORMER NCR CORPORATION FACILITY
MILLSBORO, DELAWARE

PROPOSED PILOT TEST AREA

DESIGNED BY:	CHECKED BY:	DWG. NO: 40-4216	SHEET: 2
DRAWN BY: C CONNOLLY	PROJECT MANAGER:	DATE: 10/7/94	SCALE: AS SHOWN

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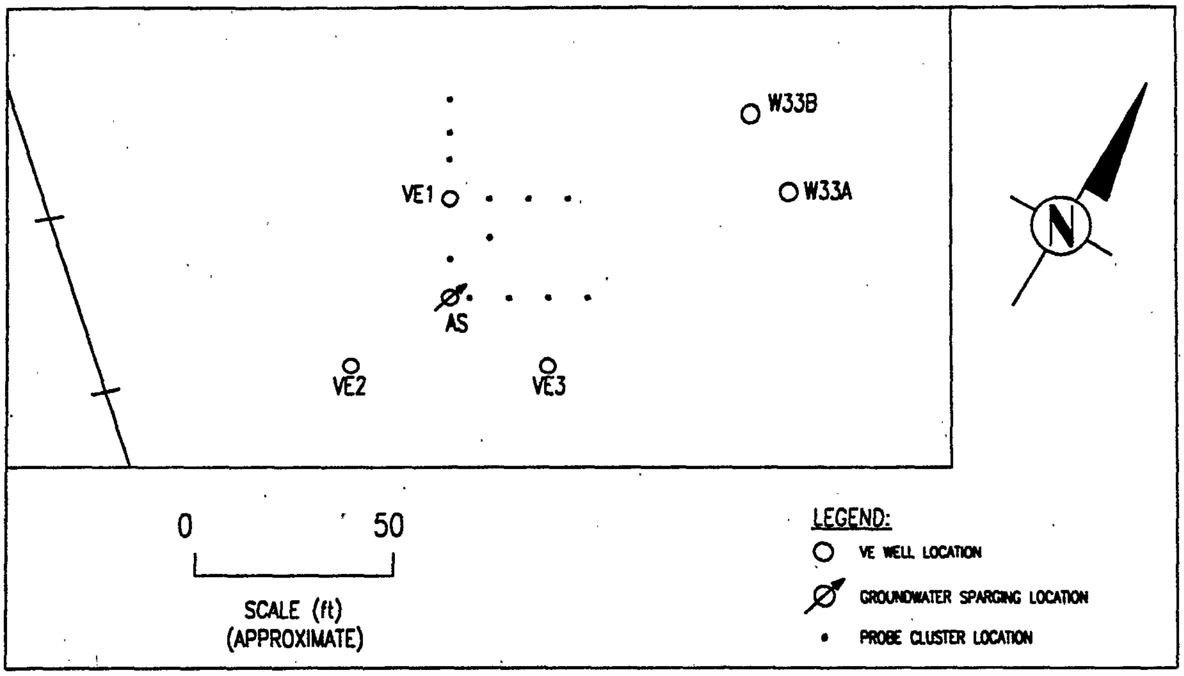

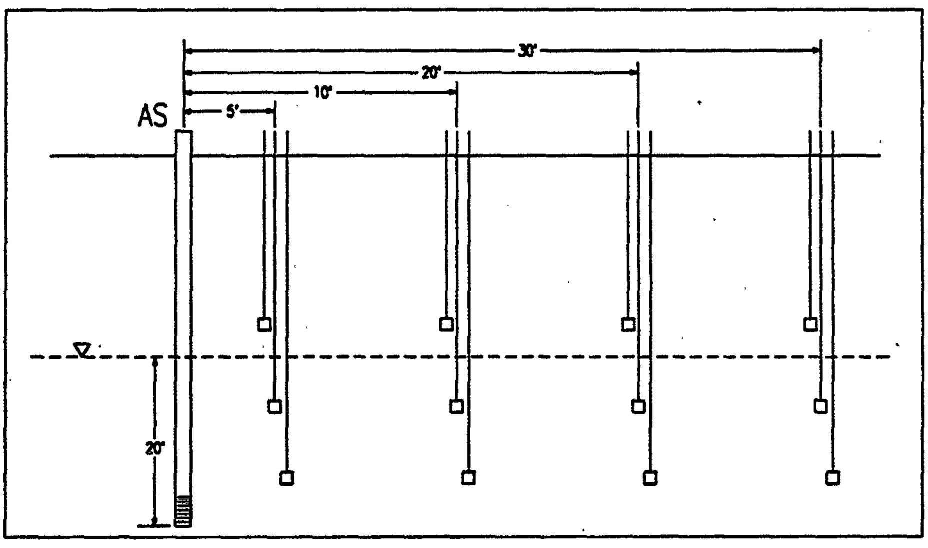

FORMER NCR CORPORATION FACILITY MILLSBORO, DELAWARE			
PROPOSED PILOT TEST AREA			
DESIGNED BY:	CHECKED BY:	DWG. NO: 40-4216	SHEET: 3
DRAWN BY: C CONNOLLY	PROJECT MANAGER:	DATE: 10/7/94	SCALE: AS SHOWN

TERRA VAC

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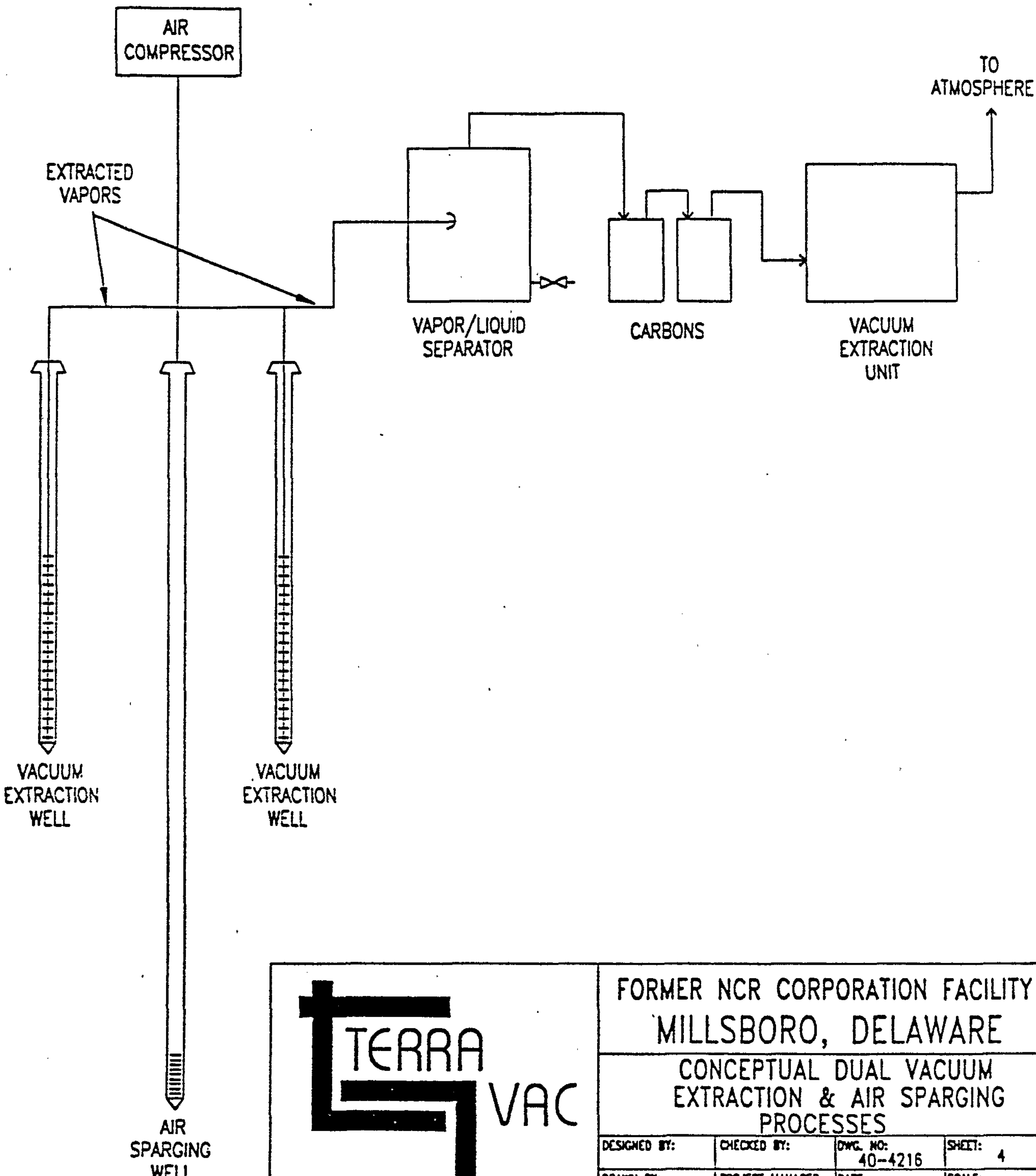

TERRA VAC

FORMER NCR CORPORATION FACILITY
MILLSBORO, DELAWARE

CONCEPTUAL DUAL VACUUM EXTRACTION & AIR SPARGING PROCESSES

DESIGNED BY:	CHECKED BY:	DWG. NO: 40-4216	SHEET: 4
DRAWN BY: C CONNOLLY	PROJECT MANAGER:	DATE: 10/6/94	SCALE: N.T.S.

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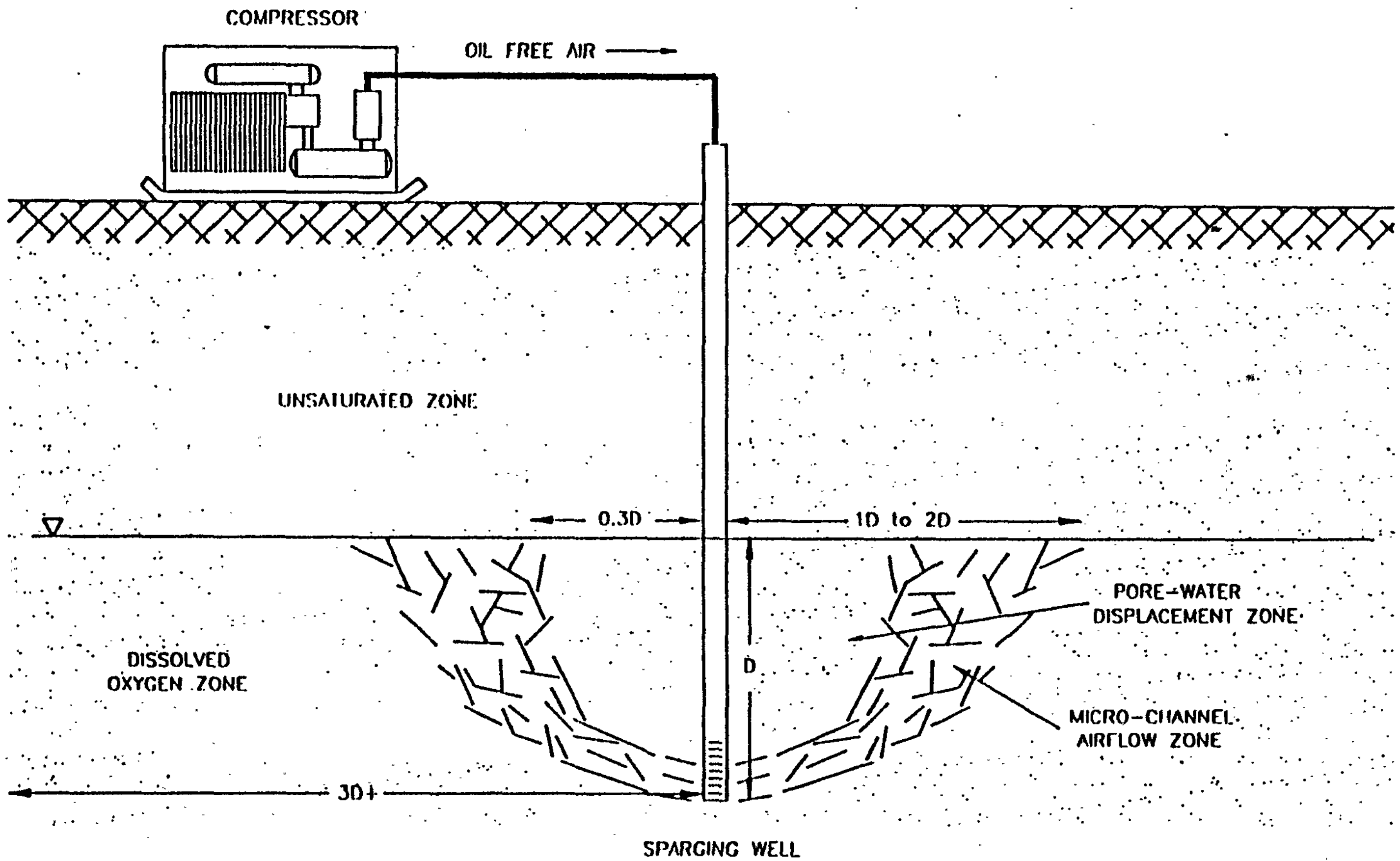

TERRA VAC	FORMER NCR CORPORATION FACILITY MILLSBORO, DELAWARE
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	DRAWN BY: C. CONNOLLY · DATE: 10/7/94 · 10-4218 · SHEET 5 · SCALE: AS SHOWN

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