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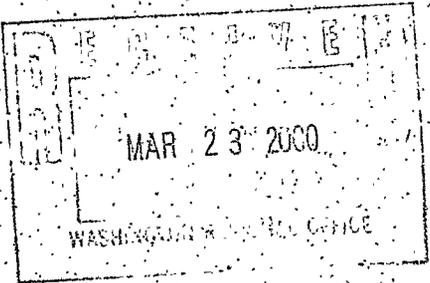
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Section SUPERFUND

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**RESPONSE TO COMMENTS IN:  
Review of Preliminary Corrective Action Plan,  
Addendum to Preliminary Corrective Action Plan, and  
The Injection Well Permit Application for Clean Ox Technology**

**Hamilton Beach◇Proctor-Silex, Inc.  
Washington, North Carolina**

Groundwater Incident No. 14338  
Site Priority Ranking B

Prepared for:

Hamilton Beach◇Proctor-Silex, Inc.  
4421 Waterfront Drive  
Glen Allen, Virginia 23060

RECEIVED / DENR  
DRC GROUNDWATER SECTION  
00 MAR 17 PM 4:15

Prepared by:

**RADIAN  
ENGINEERING, INC**

1600 Perimeter Park Drive  
Morrisville, North Carolina 27709

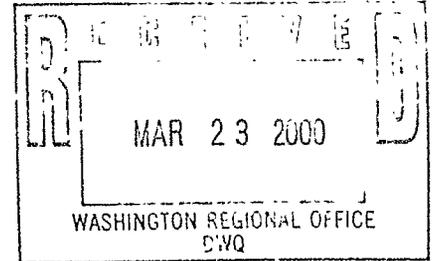
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Radian Engineering Inc.

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Morrisville, NC 27560  
(Mailing) P.O. Box 13000  
Research Triangle Park, NC 27709  
(919) 461-1100  
FAX # (919) 461-1415

March 17, 2000

Arthur Mouberry, P.E.  
Chief, Groundwater Section  
North Carolina Department of  
Environment and Natural Resources  
2728 Capital Blvd.  
Raleigh, NC 27604



**RE: Response Submittal:**  
*Review of Preliminary Corrective Action Plan, Addendum to Preliminary  
Corrective Action Plan, and the Injection Well Permit Application for  
CleanOX Technology*  
**Hamilton Beach◇Proctor-Silex, Inc., Washington, North Carolina  
Groundwater Incident No. 14338**

Dear Arthur:

This submittal is a response to two safety review comments and six technical review comments included in your letter to Hamilton Beach◇Proctor-Silex, Inc. dated January 21, 2000. The submittal also addresses several issues raised by the staff of the Washington Regional Office and the Underground Injection Control Program during our meeting at your office on February 25, 2000. These include the following:

- Identification of off-gassing parameters to be monitored and related criteria for early termination of chemical reagent application.
- General contingency procedures to be implemented in the event that one or more of the off-gassing parameters exceed specified levels or conditions.
- A tentative schedule illustrating the sequence in which the chemical oxidation and zero valance iron pilot tests will be performed.
- A figure summarizing the limited nature and extent of petroleum constituents detected in groundwater at the site.

The responses were prepared on behalf of Hamilton Beach◇Proctor-Silex, Inc. by Radian Engineering and by ManTech Environmental Corporation, providers of the CleanOX technology, and are consistent with statements made at the meeting.

Radian Engineering Inc.

Arthur Mouberry, P.E.  
March 17, 2000  
Page 2

The submittal is organized as follows:

- Certification Page
- Attachment 1 - Letter to Hamilton Beach Proctor-Silex, Inc. from NC DENR
- Attachment 2 - Response to Comments
- Attachment 3 - Bench-scale Work Plan
- Attachment 4 - Pilot-scale Work Plan
- Attachment 5 - Plume Characterization Maps

Please call Mario Kuhar at 804.527.7222 or me at 919.461.1270 if you have any questions or comments regarding this submittal.

Sincerely,  
**RADIAN ENGINEERING**



James Narkunas  
Sr. Staff Scientist

Attachments

cc: Mario Kuhar  
Brad DeVore  
Ron Adams  
File Response.doc

**ATTACHMENT 1**

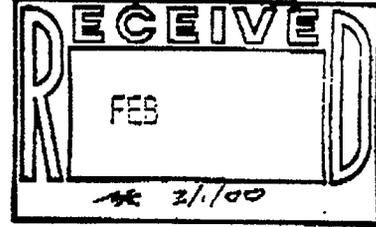
**LETTER TO HAMILTON BEACH◇PROCTOR-SILEX, INC.,  
FROM THE NCDENR, DATED JANUARY 21, 2000**



NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

DIVISION OF WATER QUALITY

Jan 21, 2000



JAMES B. HUNT JR. GOVERNOR

(CERTIFIED MAIL RETURN RECEIPT REQUESTED)

BILL HOLMAN SECRETARY

Mr. Mario Kuhar Hamilton Beach Proctor Silex 4421 Waterfront Drive Glen Allen, Virginia 23060

KERR T. STEVENS DIRECTOR

RE: Review of Preliminary Corrective Action Plan, Addendum to Preliminary Corrective Action Plan and the Injection Well Permit Application for CleanOX Technology Hamilton Beach Proctor Silex Incorporated Facility Washington, Beaufort County, North Carolina Groundwater Incident No. 10433

Dear Mr. Kuhar:

After having reviewed your Injection Well Permit application for CleanOX Technology dated July 30, 1999, the Preliminary Corrective Action Plan dated July 28, 1999 and the Addendum to the Preliminary Corrective Action Plan dated October 25, 1999, the Groundwater Section has determined that the application and the plans are incomplete. The following additional information must be received in writing before the Groundwater Section can review both documents and make a final decision. Your written response to these concerns can take the form of a single document which can then be included in both the application and the Corrective Action Plan proposal.

SUMMARY

The Groundwater Section's main concern about the proposed injection of hydrogen peroxide into an area containing both chlorinated and petroleum hydrocarbon contamination is that the resulting oxidation reaction will produce an explosive mixture of subsurface heat, pressure and oxygen. Additionally, the process yields an undesirable increase in carbon dioxide, chloride ions and acids; and the permit application does not adequately characterize the contamination plume. The Groundwater Section has organized its concerns into the two categories of safety and technical review.



## SAFETY REVIEW

The Groundwater Section is concerned about the safety of using in-situ chemical oxidation in an area of relatively complex geology where geologic and manmade preferential pathways exist under extensive asphalt and concrete surfaces. The proposed injection of hydrogen peroxide to oxidize the organic hydrocarbon contamination will produce an increase in subsurface temperature, pore pressure, and concentrations of oxygen, carbon dioxide, chloride ions and acids.

1. Explain how you will control the development of subsurface by-products so as to prevent an explosion.
2. Explain how you will control or vent excessive subsurface temperature and gases under areas extensively covered by asphalt and concrete. The Groundwater Section is concerned that the proposed passive vent points may be inefficient at venting excessive pressure, since most of the subsurface is very heterogeneous and anisotropic. Specific construction and/or placement details for the passive vent points should be included along with your explanation.

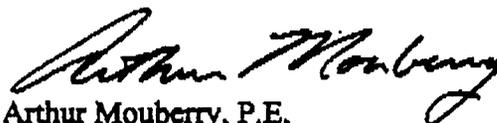
## TECHNICAL REVIEW

1. You propose injecting into the unsaturated zone to oxidize the organic hydrocarbon contamination that exists in the source area soils. The use of CleanOX<sup>®</sup> technology to oxidize or destroy the organic hydrocarbon contamination requires the addition of hydrochloric acid to bring the injected soil-matrix to a pH of less than 4, and the addition of ferrous ions to catalyze hydroxyl radical formation. How will you insure the occurrence of mixing in the unsaturated zone to promote full oxidation of the hydrocarbon contamination by the hydroxyl radicals?
2. The Injection Well Permit application has incomplete or insufficient plume characterization of the chlorinated and petroleum hydrocarbons that exist in the subsurface at this site. Specifically, your Injection Well Permit application does not show horizontal and vertical delineation with isoconcentration lines as required by NCAC 15A 2C .0211(d)(3)(B) (iv). The Groundwater Section requires pre-injection delineation for comparison with post-injection data in its assessment of the effectiveness of your proposed in-situ chemical oxidation degradation technology.
3. During the injection process, what specific measures or hydraulic controls will be used to prevent migration of both the hydrocarbon contamination and oxidation by-products into areas where groundwater is not contaminated? What hydraulic controls will be used to prevent hydrocarbon contamination or injection by-products from reaching nearby water supply wells?"
4. Present a detailed proposed monitoring schedule and develop contaminant reduction goals which will monitor the success of the in-situ chemical oxidation technology.

5. The proposed injection area is directly under the Plant Building's foundation. What actions will be taken to ensure that the formation of increased subsurface temperature, pressure, oxygen, carbon dioxide, chloride ions, acids and other by-products will not impact the integrity of the Plant Building's foundation and underlying soil matrix?
6. You have submitted two Injection Well Permit applications that make use of in-situ chemical degradation technologies. However, one submitted Injection Well Permit application makes use of chemical oxidation technology, (CleanOX®) and the other makes use of chemical reduction technology, (Zero Valence Iron.) Since both of your proposed injection systems are in close proximity of each other, how will these systems be hydraulically controlled so as not to physically or chemically interact? If these two systems do interact, how will this affect both in-situ chemical degradation technologies?

Please respond in writing to the items above within 45 days of receipt of this letter. The Groundwater Section is prepared to meet with you to discuss these safety and technical concerns. In the meantime, please direct questions to Keith Starner at (252) 946-6481 regarding the CAP, or Mark Pritzl for matters regarding the Injection Well Permits and associated pilot tests, at (919) 715-6166.

Sincerely,



Arthur Mouberry, P.E.  
Chief, Groundwater Section

cc: Radian Engineering  
WaRO

**ATTACHMENT 2**  
**RESPONSE TO COMMENTS**

## RESPONSE TO COMMENTS

### SAFETY COMMENTS

(1) Controlling subsurface by-products to prevent an explosion.

The CleanOX Process reactions are controlled during site treatment by controlling the rate at which hydrogen peroxide is applied to the treatment area by regulating the concentration and flow rate of the aqueous hydrogen peroxide solution. The first step of any project begins with bench testing so that ManTech can observe the nature of the reactions between the CleanOX reagents and the site matrix (groundwater and soil) in the controlled conditions of our testing laboratory. Important observations include, but are not limited to: peak reaction temperature, reaction delay time, water vapor generation, foaming, or unexpected reactions to the chemicals. Please refer to the Bench Test Work Plan (Attachment 3) discussions regarding the observations made during the bench test and the final bench test data review.

This information is important to our experienced field crews in approaching the pilot test in the field. Reaction delay time is particularly important because it allows ManTech to anticipate any lag time between the first application of oxidizing reagents and the first appearance of reaction indicators in the subsurface (pressure increases, bubbling in off-set wells, and changes in monitored parameters). If the reaction delay time is not anticipated, the field crew could conceivably continue to apply oxidizer under the mistaken impression that more oxidizer is needed to begin the reactions.

ManTech's standard procedure for beginning an application of the oxidizing reagents at any site is to start with a weak (8% or less) of hydrogen peroxide added at a slow feed rate (less than 0.5 gpm). Only one to five gallons is applied initially and the fluid is allowed to infiltrate into the formation. ManTech field personnel then wait from 15 to 30 minutes and make observations and measurements in the treatment area to confirm that the delay time observed in the bench test is representative of field conditions. This process is continued until approximately 30 to 50 gallons of weak oxidizer has been applied to the pilot testing application wells. The field crew supervisor will then brief the ManTech project engineer on the results of this initial addition, and in most cases an increase in oxidizer concentration to between 15% and 20% will be approved by the engineer. Please refer to Section 2.0 of the Pilot Test Work Plan in Attachment 4.

Parameters such as organic vapor concentration, oxygen, carbon dioxide, and the lower explosive limit are all monitored routinely during the field application. These parameters are monitored in the head space of off-set wells, in the application well vent lines, passive venting points, and along cracks in paved surfaces. Application well pressure is also monitored continuously. The application of oxidizer is ceased when any of these parameters exceed established limits and the project engineer is then notified. Adjustments may be made to the field application approach and then the treatment will

continue after these parameters are within acceptable limits. Please refer to Section 2.0 of the Pilot Test Work Plan in Attachment 4.

(2) Control or venting of excessive subsurface temperature or gases beneath paved surfaces.

ManTech's experience in applying the CleanOX Process is that the exothermic reactions are concentrated in the application wells, resulting in water vapor generation in the vent line from the application well. Temperature changes of less than one degree centigrade are normally observed approximately five feet from the application point due to the relatively large heat absorption capacity of the surrounding soil and aquifer material.

Likewise, subsurface pressure generated from the reactions is generally limited to the immediate area surrounding the application well as indicated by the pressure readings on the application well vent line. Excessive pressure is prevented by operating the system with the vent lines partially opened to maintain application well pressure below site specific set points. Passive vents, sometimes as simple as pre-drilled holes in the paved surface, are installed as an additional precaution to allow escape of reaction gases from beneath paved surfaces. In some cases, the CleanOX Process has been applied in tandem with a soil vapor extraction system (permanent or temporary) to induce a negative pressure gradient around the application points. Construction details and locations of proposed passive vent points are provided in Section 2.0 and the Figures of the Pilot Test Work Plan in Attachment 4.

## TECHNICAL COMMENTS

(1) Methods to ensure proper mixing and uniform oxidation of contaminants.

The CleanOX Process relies on bringing the generated hydroxyl radicals into contact with the contaminants in-situ. By proper spacing of application wells and a slow, controlled application of reagents, ManTech attempts to achieve optimum contact between the CleanOX reagents and site contaminants. Further, the vapor generation that occurs as the reactions proceed aid in this mixing process. ManTech relies on our experience and the existing site data to form a pilot testing approach which is designed to demonstrate the effectiveness of the treatment under site conditions. Interpretation of the pilot testing results is the only way to confirm that the approach used in the pilot test is viable for further treatment at the site.

(2) Plume Characterization

Maps and profiles depicting the extent of chemicals in groundwater underlying the site were submitted in the Comprehensive Site Assessment Report (CSAR), the Preliminary Corrective Action Plan (PCAP), and the Application for a Class 5I Injection Well Permit. The figures illustrate the seven volatile organic compounds (VOCs) detected most frequently at the site. Each figure shows the limits of a selected chemical in groundwater relative to its standard or practical quantitation limit (PQL). Due to the wide range in

concentration in the VOCs, only the contour line representing a chemical's groundwater standard or PQL was depicted on the figures. In response to Technical Review Comment #2, these figures have been modified to include additional contour lines and chemical concentration zones that relate to the following range of concentrations:

- Less than 100 parts per billion (ppb)
- 100 to 1,000 ppb
- 1000 to 10,000 ppb
- 10,000 to 100,000 ppb
- Greater than 100,000 ppb

The modified maps and profiles are included in this submittal as Figures 1A through 7D.

No petroleum hydrocarbon constituents were depicted in plan view or in cross section because the six petroleum constituents (benzene, ethylbenzene, naphthalene, toluene, trimethylbenzene, and xylenes) detected at the site exceeded their respective standards in only one well, which is screened in the upper hydrogeologic unit (Unit A) and located in the source area. Benzene, ethylbenzene, and naphthalene were above the standards at screen-point sampling locations adjacent to the well. In comparison to the concentration and extent of VOCs detected at the site, the petroleum constituents are of minor concern. Free product has not been detected at the site since Aggressive Fluid-Vapor Recovery was conducted in 1998. In response to Technical Review Comment #2, a map was prepared that illustrates petroleum constituent distribution in the upper hydrogeologic unit using summary tables. The map is included in this submittal as Figure 8.

The Groundwater Section's request for pre-injection delineation to compare to post-injection data overlooks the fact that sample collection from pre-established monitoring points is an integral component of pilot-scale testing. Soil and groundwater samples will be collected and analyzed before and after pilot-scale application of the technology. Comparison of these results will demonstrate the technology's effectiveness and will allow the assessment to be conducted under controlled conditions and at an optimal scale.

- (3) Measures to prevent migration of reaction byproduct/hydrocarbons from impacting uncontaminated areas and nearby potable supply wells.

There are no water supply wells near the source area where the technology will be applied. The closest water supply wells are more than 800 feet from the area selected for pilot testing. Also, application of the technology will be limited to the upper hydrogeologic unit (unit A) at the site, the base of which is less than 15 feet below ground surface (bgs). In contrast, the water supply wells are completed in the Tertiary limestone aquifer, which underlies the site at a depth of 70 feet bgs. In addition, the limestone aquifer is separated from the overlying units by a confining layer that is 30 feet thick at the site.

Furthermore, a limitation of the CleanOX Process is its effective radius of influence. ManTech has observed this distance to be at most approximately 20 feet from the

application well. By making field measurements (ORP, DO, temperature, pH, specific conductance, and water level) and by collecting groundwater and/or soil samples for hydrocarbon analysis before, during, and after the pilot application in wells inside and outside the proposed treatment areas, ManTech and Radian will demonstrate that the effects of the CleanOX Process treatment are limited to some site-specific radius of influence. By-products of the reactions include carbon dioxide and water, and in the case of chlorinated hydrocarbon contamination, hydrated chloride ions. Generation of these byproducts is limited to the treatment area, as will be demonstrated in the pilot test. Section 2.0 of the Pilot Test Work Plan (Attachment 4) identifies the monitoring points within and outside the treatment area that will be monitored to collect data to support the discussion above.

(4) Present a detailed monitoring plan and reduction goals.

Please refer to the data collection/monitoring requirements in Section 2.0 of the Pilot Test Work Plan (Attachment 4). The data collected will allow trend analysis and confirmation of effectiveness so that the full-scale treatment design can be finalized (e.g. number of wells, well spacing, reagent requirements, and on-site time needed to apply the required reagent volume).

As with other remediation technologies (e.g. in-situ air sparging, soil vapor extraction, etc.), the objective of the CleanOX pilot test is to gather site specific information necessary to develop a full-scale treatment approach at the site. This information includes: infiltration rate of reagents, radius of influence of the reagents, and the reagent volume needed to achieve a given reduction in site contaminant levels. ManTech anticipates that the contaminant reduction measured in the pilot test will range from 60% to 80% or higher. Bench testing and pilot testing are necessary to determine the contaminant reduction capability of applying the CleanOX Process at the site.

(5) What actions will be taken to ensure the integrity of the building foundation will not be impacted.

The CleanOX Process has been successfully applied at many sites where all or a portion of the treatment area is located beneath a structural foundation. It has been applied beneath parking lots, industrial buildings, commercial/retail buildings, and parking garages – all without deleterious effects on the subject structures. The type, volume, and concentration of the reagents used and the byproducts generated (see above) are such that there have been no discernable impacts on structures residing above treatment areas.

(6) Control of chemical oxidation and chemical reduction technologies.

Application of the two technologies, at both pilot-scale and full-scale, will be separated by time and space. Chemical oxidation testing will be performed first, and will be limited to (1) the unsaturated soil in the immediate source area, and (2) the groundwater within the upper hydrogeologic (Unit A) underlying the immediate source area. The effects of

chemical oxidation are anticipated to extend no more than 20 feet from each injection point.

Testing of zero valence iron (ZVI) will be conducted only after the chemical oxidation pilot test has been completed and all supplies and materials have been removed from the site. Testing of ZVI application on groundwater within Unit A will be conducted outside the source area, at least 150 feet from the location of the chemical oxidation pilot test. Testing of ZVI on groundwater within Unit B will be conducted in a different (lower) hydrogeologic unit (Unit B) than the chemical oxidation testing. This testing of ZVI within Unit B will also be conducted outside the source area, at least 50 feet, horizontally, from the location of the chemical oxidation pilot test.

A figure illustrating schedules for implementing the two technologies at pilot scale is included in this attachment. The schedule, which is based on a tentative startup date of July 1, shows that the chemical oxidation pilot test will be completed before the zero valence iron pilot test is initiated.

Full-scale application of the technologies will follow the same sequence as the pilot-scale testing. Chemical oxidation will be applied first. ZVI will not be applied until chemical oxidation is completed and until monitoring confirms that subsurface conditions have returned to equilibrium. Monitoring will include measurement of the following parameters: oxidation-reduction potential, dissolved oxygen, pH, specific conductance, temperature, and water level. The time necessary for all parameters to reach equilibrium varies from site to site. However, previous experience indicates that equilibrium is typically attained from several weeks to several months after the last application of reagent.

**HAMILTON BEACH/PROCTOR-SILEX, INC.  
BENCH- & PILOT-SCALE IMPLEMENTATION SCHEDULE**

ID	Task Name	Duration	Start	Finish	Q3 '00			Q4 '00			Q1 '01			Q2 '01			
					Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1	Bench-Scale Testing	10w	7/3/00	9/8/00		█											
2	Sample Collection	1w	7/3/00	7/7/00		█											
3	Laboratory Studies	9w	7/10/00	9/8/00		█											
4	Pilot-Scale Work Plans & H&S Plans	4w	9/11/00	10/6/00				█									
5	Pilot-Scale Test	33.2w	10/9/00	5/28/01					█								
6	Cleanox	23.2w	10/9/00	3/19/01					█								
7	Install Injection and Monitoring pts	1w	10/9/00	10/13/00					█								
8	Injection pts Stabilization	3d	10/16/00	10/18/00					█								
9	Baseline Sampling	2d	10/19/00	10/20/00					█								
10	Reagent Application - Unsaturated	3w	10/23/00	11/10/00					█								
11	Post Treatment Sampling - Unsaturat	2d	11/13/00	11/14/00					█								
12	Reagent Application - Groundwater	5w	11/15/00	12/19/00					█								
13	1st Post Treatment Samp - Groundwa	2d	12/27/00	12/28/00					█								
14	2nd Post Treatment Samp - Groundw	2d	1/12/01	1/15/01					█								
15	Interim Cleanox Results Report	6w	2/6/01	3/19/01								█					
16	ZVI & Carbon Source	33.2w	10/9/00	5/28/01					█								
17	Install Injection and Monitoring pts	1w	10/9/00	10/13/00					█								
18	Treatment & Monitoring	2w	1/23/01	2/5/01								█					
19	Continued Monitoring	13w	2/6/01	5/7/01								█					
20	Analytical & Data Validation	3w	5/8/01	5/28/01													█
21	Full-Scale WP, CAP, and UIC Permit Prep	8w	5/29/01	7/23/01													█

Project: HBPS Washington, NC  
Date: 3/15/00

Task █ Summary █

**ATTACHMENT 3**  
**BENCH-SCALE WORK PLAN**

# MANTECH ENVIRONMENTAL CORPORATION

A ManTech International Subsidiary

March 16, 2000

Mr. Jim Narkunas  
Radian Engineering  
1600 Perimeter Park Drive  
Research Triangle Park, NC 27709

RE: Bench Test Work Plan  
Hamilton Beach-Proctor Silex Site, Washington, North Carolina  
ManTech Project Number 8234-000

Dear Mr. Narkunas:

This letter presents the CleanOX<sup>®</sup> Process Bench Test Work Plan to be completed by ManTech Environmental Corporation (ManTech) for Radian Engineering (Radian). This Work Plan was prepared according to the Preliminary Corrective Action Plan for the Hamilton Beach-Proctor Silex Site, Washington, North Carolina prepared by Radian, dated July 1999. Radian will collect soil and groundwater samples from the Hamilton Beach-Proctor Silex Site (the Site) for CleanOX<sup>®</sup> Process bench testing as a preliminary step to a planned *in-situ* oxidation field application project at the site. ManTech will complete bench tests on the soil and groundwater samples submitted by Radian and forward samples to the clients designated laboratory for analysis. The discussion below describes the bench testing procedures.

## BENCH TEST OBJECTIVES

The overall objective of the bench test is to verify that the CleanOX<sup>®</sup> Process is capable of effecting substantial reductions in organic constituent concentrations in the soil and groundwater samples collected from the site. The specific objectives for the bench tests are described below.

Evaluate the Reactivity of the Samples. The application of CleanOX<sup>®</sup> reagents to soil and groundwater will result in a vigorous, exothermic reaction. The reactivity of the samples will, to some extent, govern the rate at which the oxidizing reagent (hydrogen peroxide) can be applied in pilot and full-scale CleanOX<sup>®</sup> remediation programs. During the bench test, the reaction is visually ~~observed~~ and temperature is recorded as the oxidizer is added to samples in order to obtain a qualitative measure of reactivity. This information is considered in the design of the pilot and full-scale programs.

→ quantitative

Estimate Contaminant Reduction Potential Per Application. This will be determined primarily by the magnitude of organic constituent concentration reduction detected in the treated soil and groundwater samples. Organic constituent concentration reduction potential is important because it will determine the number of applications that will be needed to meet the expected concentration reduction on the pilot and full-scale applications. The reagent formulation will be confirmed by

conducting the bench test treatment on a small set of samples which will be treated with formulations that are slightly less than and greater than the estimated optimum amounts.

Verify Groundwater Quality Parameters. A number of soil and groundwater parameters are critical to the design and performance of the CleanOX<sup>®</sup> Process including pH, conductivity, oxidation-reduction potential (ORP), organic constituents concentration, hardness, total dissolved solids (TDS), and total organic carbon (TOC). These parameters need to be provided to ManTech prior to conducting the bench test. ManTech uses these parameters to develop the bench testing protocol. Parameters such as pH, temperature, and ORP are measured by ManTech in samples provided for bench testing. Hardness, TOC, and TDS will be measured through laboratory analysis of samples to be submitted by Radian.

### **CLEANOX<sup>®</sup> PROCESS GROUNDWATER BENCH TEST PROCEDURE**

This section describes the general procedure that will be followed in conducting the CleanOX<sup>®</sup> bench test using groundwater samples that will be provided by Radian from monitoring well MW-228 in Unit A, at the Hamilton Beach-Proctor Silex Site. The bench test procedure includes sample receipt and preparation, sample testing using the CleanOX<sup>®</sup> reagents, and laboratory analyses of the treated and untreated groundwater samples.

#### **Groundwater Sample Receipt and Preparation**

Radian will perform the following:

1. Purge and sample well MW-228 in accordance with Radian's site procedures.
2. Collect ten (10), 1 liter, un-preserved groundwater samples for shipment to ManTech's Chantilly, Virginia testing facility. *split-spawn soils*
3. Collect Field Baseline sample to be shipped to the client's designated laboratory for VOC, SVOC, hardness, TDS and TOC analysis.
4. Record depth to water, pH, specific conductance, and temperature.

#### **Groundwater Sample Testing Procedure**

Listed below is the general, stepwise procedure that will be used to complete the bench testing on the Lab Baseline and Lab Reacted samples:

1. The groundwater sample received from the site is inverted once in order to provide a homogeneous medium prior to sample separation into Lab Baseline, Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples.

Mr. Jim Narkunas

March 16, 2000

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2. Bench Test Lab Baseline, Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples are formed by separating the groundwater sample into four equal volumes into clean reaction jars. The Lab Baseline, Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 sample volume are dependent on the required volume for post-treatment laboratory analysis. The Lab Baseline, Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples will each consist of approximately 2.2 liters.
3. The reaction jar containing the Lab Baseline sample is the control for the bench test. Because the Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples will be subjected to treatment in open reaction vessels, the Lab Baseline sample is set aside, open to ambient air, for the duration of the bench testing procedure.
4. CleanOX<sup>®</sup> Process reagents are then added by pipette to the Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples in volumes estimated based on groundwater quality data (i.e. pH, conductivity, TOC, TDS, estimated target organic constituents concentration) and known hydrogeological site conditions<sup>1</sup>. The reagents include: hydrochloric acid, ferrous sulfate, and hydrogen peroxide. The Lab Reacted 1 sample will receive the least hydrogen peroxide; Lab Reacted 2 will receive the estimated optimum amount of hydrogen peroxide; and, Lab Reacted 3 will receive the most hydrogen peroxide.
5. In order to assess the progress of the conditioning process and oxidation reaction, and gauge the level of reactivity, temperature, pH, and ORP data are collected before, during (every five minutes for the first twenty minutes, then hourly until the reaction is complete), and after the addition of CleanOX<sup>®</sup> reagents to the Lab Reacted sample vessels.
6. After the reaction process is complete (determined visually, and by sample temperature, approximately six hours), the Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples are transferred from the reaction vessels to a laboratory container appropriately designated as the Lab Reacted sample (e.g. MW-228 Lab Reacted 1). At this time, the Lab Baseline sample is also transferred to a laboratory container appropriately designated as the bench test control sample (e.g. MW-228 Lab Baseline).
7. The containerized Lab Baseline and Lab Reacted groundwater samples are immediately preserved on ice and prepared for shipping via overnight carrier to the client-designated laboratory for analysis for VOC and SVOC.

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<sup>1</sup> Initial acid amount is based on initial sample pH and desired testing pH. Oxidizer amount is based on stoichiometry for oxidizing the sample contaminants plus the oxidizer needed to overcome expected chemical inefficiency (based on ManTech's experience). Catalyst amount is based on the proprietary ratio of catalyst needed per amount of oxidizer to be added.

Mr. Jim Narkunas  
March 16, 2000  
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## **CLEANOX® PROCESS SOIL BENCH TEST PROCEDURE**

This section describes the general procedure that will be followed in conducting the CleanOX® bench test using soil samples that will be provided by Radian from the Hamilton Beach-Proctor Silex Site. The bench test procedure includes sample receipt and preparation, sample testing using the CleanOX® reagents, and laboratory analyses of the treated and untreated groundwater samples.

### **Soil Sample Receipt and Preparation**

Radian will perform the following:

1. Collect a soil sample near either soil boring F-18 or F-22 from the interval approximately 2 feet above the water table.
2. One soil sample will be submitted to the client's designated laboratory for VOC, SVOC, TPH, and oil and grease analysis.
3. A duplicate soil sample (ten, 4-oz. glass jars) will be submitted to ManTech's Chantilly, Virginia Testing Facility.

### **Soil Sample Testing Procedure**

Listed below is the general, stepwise procedure that will be used to complete the bench testing on the Lab Baseline and Lab Reacted samples:

1. All ten containers of soil samples are emptied into a clean stainless-steel bowl and mixed together to ensure consistency throughout the sample.
2. The composite soil sample is then divided equally into four clean reaction jars in a quantity required for the post-treatment analytical laboratory analysis and labeled Lab Baseline and Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3.
3. The reaction jar containing the Lab Baseline sample is a control for the Lab Reacted samples. Because the Lab Reacted samples are subjected to treatment in an open reaction vessel, the Lab Baseline sample is set aside, open to ambient air, for the duration of the bench testing procedure.
4. CleanOX® Process reagents are added to the Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples in estimated volumes based on known site data and hydrogeological conditions. The reagents are added by pipette to the Reacted sample and include hydrochloric acid, ferrous

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sulfate, and hydrogen peroxide<sup>2</sup>. The Lab Reacted 1 sample will receive the least hydrogen peroxide; Lab Reacted 2 will receive the estimated optimum amount of hydrogen peroxide; and, Lab Reacted 3 will receive the most hydrogen peroxide.

5. In order to assess the progress of the oxidation reaction and gauge reactivity, parameters are measured and recorded before, during, and after addition of CleanOX<sup>®</sup> reagents. Parameters that are measured include pH, temperature, ORP, and all pertinent visual observations. O<sub>2</sub>?
6. After the reaction process is complete, the aqueous solution is decanted from Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3.
7. Soil from each Lab Baseline, Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples are transferred from the reaction vessels to appropriate laboratory containers for shipment and laboratory analysis, for VOC, SVOC, TPH, and oil and grease.
8. The containerized Lab Baseline, Lab Reacted 1, Lab Reacted 2, and Lab Reacted 3 samples are preserved on ice and shipped to the client-designated laboratory for analysis by the designated laboratory protocol.

## DATA REVIEW

Following receipt of all analytical data, ManTech and Radian will review the contaminant destruction achieved by applying estimated reagent volumes in the bench test. ManTech will also review observations made during the bench test with Radian. Data will be reviewed and evaluated as follows:

### CleanOX<sup>®</sup> Testing Facility Measurements and Observations

Measurements for pH are taken to determine if the groundwater sample is properly acidified during the bench test. A properly acidified aqueous medium is required for hydrogen peroxide to react with ferrous ions and produce hydroxyl radicals. This measurement will suggest whether the proper quantity of CleanOX<sup>®</sup> conditioning reagent was used to effectively lower the sample pH.

Specific conductance measurements are made to confirm that the addition of ferrous sulfate catalyst corresponds to the expected specific conductance values associated with a properly conditioned sample. Adequate ferrous ions are needed so that the peroxide will have sufficient catalyst sites to generate sufficient hydroxyl radicals and achieve the desired contaminant reduction in the sample.

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<sup>2</sup> Initial acid amount is based on initial sample pH and desired testing pH. Oxidizer amount is based on stoichiometry for oxidizing the sample contaminants plus the oxidizer needed to overcome expected chemical inefficiency (based on ManTech's experience). Catalyst amount is based on the proprietary ratio of catalyst needed per amount of oxidizer to be added.

→ Volume of O<sub>2</sub>

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Temperature measurements are made to confirm visual observations of peak exothermic reactions, and also to confirm when the reactions are substantially completed. Temperature is an important parameter during the bench test because it gives an indication of the exothermic extent of the reactions. Higher than expected peak temperatures indicate the presence of unexpected organic matter in the samples. The time needed to reach peak temperature is expected to be within twenty to twenty-five minutes and is a useful parameter to anticipate site response during the pilot test.

*what are expected peak temps?*

ORP measurements are taken to compare Baseline and Reacted ionic conditions during the CleanOX<sup>®</sup> Process and provide a qualitative indication of hydroxyl radical formation. This measurement will suggest whether the CleanOX<sup>®</sup> reagents can effectively change ORP to more favorable oxidative conditions.

### **Groundwater Laboratory Analytical Results**

Laboratory analytical results of parameters such as hardness, TOC, and TDS will provide information relevant to whether site groundwater conditions will interfere with the desired progress of the reactions. Excessive hardness will require larger amounts of acidifying reagent to be applied to the samples. Excessive hardness (calcium carbonate), TOC, and TDS will result in less efficient oxidation of contaminants from a given quantity of oxidizer since the compounds measured by these analyses will interact with hydroxyl radicals resulting in fewer radicals being available for contaminant destruction.

Laboratory analytical results of VOC and SVOC analyses will provide information relevant to the oxidation efficiency of contaminant destruction by the oxidizer. ManTech and Radian will compare the trend observed between the three treated samples to draw conclusions regarding the adequacy of the estimated reagent volumes. By comparing the relative contaminant destruction of the low, optimum, and high reagent doses used in the three treated samples, ManTech and Radian can either confirm that the estimated optimum oxidizer amount is either sufficient or must be adjusted up or down for the pilot testing phase of the project.

I hope the discussion above is useful in evaluating the CleanOX<sup>®</sup> Process for use at the Hamilton Beach-Proctor Silex Site. Please call me at 703-814-8366 if you need additional information or have any questions.

Sincerely,



Ronald F. Adams, P.E.  
Executive Director Remediation Operations

**ATTACHMENT 4**  
**PILOT-SCALE WORK PLAN**

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**WORK PLAN FOR *IN-SITU*  
CHEMICAL OXIDATION  
REMEDATION PILOT TEST**

**Hamilton Beach-Proctor Silex Site  
Washington, North Carolina**

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**PREPARED FOR:**

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**Project No. 8234-000**

**March 2000**

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## 1.0 INTRODUCTION

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ManTech Environmental Corporation (ManTech) has prepared this technical Pilot Test Work Plan for Radian Engineering (Radian) to apply the CleanOX<sup>®</sup> *in-situ* chemical oxidation process at the former Hamilton Beach – Proctor Silex, Incorporated (HB-PS) facility in Washington, North Carolina (Site). The pilot test is one of the initial steps in evaluating the effectiveness of the CleanOX<sup>®</sup> Process to address organic contaminants in the unsaturated soil and the upper hydrogeologic unit (Unit A) at the site.

The general scope of work associated with the chemical oxidation application process includes: 1) reviewing available site data and conducting a bench test (Bench Test Work Plan provided under separate cover) of the CleanOX<sup>®</sup> Process on soil and groundwater samples collected from the site, 2) preparing a Work Plan for applying the CleanOX<sup>®</sup> Process in pilot scale at the site, 3) assisting Radian in locating and installing CleanOX<sup>®</sup> application wells, off-set monitoring wells, and vapor points at the site, 4) conducting a pilot test using CleanOX<sup>®</sup> reagents, and 5) preparing a technical report presenting pilot test data and findings. The Work Plan presents the process and procedures for completing a pilot test of *in-situ* chemical oxidation.

This work plan is divided into three sections. Section 1 presents an introduction and overview to the CleanOX<sup>®</sup> *in-situ* chemical oxidation process, objectives for the remediation pilot test project, and a brief site background. Section 2 describes the technical approach and tasks to complete the pilot test. Section 3 presents a schedule for implementing and completing the pilot test.

### 1.1 Overview of CleanOX<sup>®</sup> *In-Situ* Chemical Oxidation Process

The CleanOX<sup>®</sup> Process is a patented *in-situ* technology that involves the staged application of Fenton-like chemistry to create oxidation-reduction reactions leading to the complete degradation of organic constituents present in groundwater. The CleanOX<sup>®</sup> Process uses a proprietary formulation of reagents that are applied through on-site application wells directly into the area of concern. The reagents then treat contaminated groundwater *in-situ*, producing no waste streams that require permitting, treatment, or disposal. Because the CleanOX<sup>®</sup> Process oxidizes organic contaminants within a short period of time, it eliminates the long-term O&M that is associated with conventional remediation technologies.

Application of the CleanOX<sup>®</sup> Process at other sites has demonstrated significant contaminant reductions for a variety of organic compounds in groundwater within a short time following treatment. Based on bench, pilot, and full-scale applications, the CleanOX<sup>®</sup> Process has been determined to be applicable for the treatment of petroleum-based fuels, chlorinated and non-chlorinated solvents, organic pesticides, and other organic contaminants in groundwater.

The CleanOX<sup>®</sup> Process is based on the well-known Fenton's Reaction wherein hydrogen peroxide reacts with ferrous ions to produce a hydroxyl radical in an acidified aqueous medium containing contaminant target compounds. The resultant hydroxyl free radical (OH•) is an extremely powerful oxidizer that progressively reacts with organic contaminants through a series of oxidation

reactions. During the process, the oxidation reactions proceed by degrading the organic constituents to progressively less complex and shorter chemical chains, ultimately yielding carbon dioxide and water. Laboratory analyses of post-treatment groundwater samples have not indicated the generation of harmful degradation by-products from the CleanOX® Process.

The principal advantage of the CleanOX® Process over other *in-situ* treatments is the very rapid and complete degradation of organic contamination in groundwater. More conventional technologies, such as dual-phase extraction, pump and treat, and air sparging, require years to produce concentration reductions of 50 to 90 percent, depending strongly on soil type and the volatility or biodegradability of the contaminant. In contrast, the CleanOX® Process has been shown to reduce on-site contamination significantly within days to weeks.

Another advantage of the CleanOX® Process is that it can be bench and pilot tested to determine the applicability of the technology for treatment of a specific contaminant at the site in question. As discussed in the Bench Test Work Plan (March 2000), bench testing will be performed on soil and groundwater collected from the site to confirm the appropriate reagent formulation for reducing contaminant concentrations. The soil and groundwater bench test results, in combination with site characteristics (e.g., hydrogeology, water chemistry, and contaminant type and concentrations) provide important information to be used during the final design and dosage application for the upcoming pilot test field application.

The sequence of data collection, bench testing, and pilot testing allows for opportunities to determine the applicability and optimization of the technology before the budget of a full-scale solution is committed. The treatment program can be customized for the site to address "hot spots" or portions of the contamination that have not been adequately addressed by selectively adding new application wells and/or providing additional rounds of treatment.

## **1.2 Pilot Test Objectives**

The *in-situ* chemical oxidation pilot test is designed to significantly reduce the mass of contaminants of concern in the subsurface in an area south of monitoring well MW-228 and near soil sample locations F22 and F18. The overall pilot test project objective is to evaluate the applicability of the CleanOX® Process as a feasible remediation technology for eliminating levels of soil and groundwater impacts, within hydrogeologic Unit A at the site. Evaluation of treatment area data collected before, during, and after the pilot test application will facilitate the pilot test objective. Results of baseline groundwater sampling and monitoring, groundwater monitoring during the treatment process, and post-treatment groundwater sampling in the proposed treatment area will provide the measure for the applicability of *in-situ* chemical oxidation at the site.

Several tasks related to the technical approach of the project will be completed during the pilot test. These tasks are presented in detail in Section 2.0 and include 1) installation of groundwater monitoring wells, CleanOX® application wells, and vapor points; 2) baseline sampling and analysis in the treatment area; 3) CleanOX® reagent application; and 4) post-treatment sampling and analysis. Following receipt of all pilot test data, a technical report will be provided presenting the

data and a discussion as to the applicability and cost of implementing *in-situ* chemical oxidation as a feasible remediation option for the site.

In addition to evaluating the overall effectiveness and contaminant reduction potential of the CleanOX® Process, evaluation of other site-specific elements will be made during the pilot test. They include 1) site permeability (observed application well radius of influence), 2) verifying site-specific CleanOX® reagent requirements and optimal flow rates, 3) well treatment volume, and 4) contaminant reduction potential per application.

Verify the permeability of the impacted formation material. This will be accomplished through the measurement of the rate at which CleanOX® conditioning agents and oxidizer can be added to the formation through the application well. Permeability is important to the effectiveness of the CleanOX® Process because it will govern the field time required for application and is a factor in determining the lateral extent of formation material that can be treated from one application well.

Validate Bench Test Assumptions for Reagent Requirements. The quantities of conditioning agents and oxidizer needed for application of CleanOX® reagents at the application well are estimated for the field application based on the results of the bench test and our experience at similar sites. The amount of conditioning agents and oxidizer needed during each application will be verified during the first reagent application event. This will be accomplished by the periodic measurements of dissolved oxygen, ORP, specific conductance, and pH during the field application.

Estimate Application Well Treatment Volume. The lateral extent of formation material that can be treated from one application well will be determined by the field measurements of dissolved oxygen, ORP, specific conductance, and pH, (and eventually, laboratory measurements of petroleum constituents in groundwater samples) at wells located at varying distances from the application wells.

Estimate Contaminant Reduction Potential Per Application. This will be determined primarily by the concentration of VOCs detected from observation wells as compared to the levels of VOCs prior to the pilot-scale CleanOX® application. Contaminant reduction potential is important because it will determine the number of applications needed to meet site-wide remediation objectives. ManTech expects that the organic contaminant reduction will range from 60% to 80% using the pilot test reagent formulation presented in Section 2.0. The reagent formulation presented in this Work Plan may be altered based on the results of the planned bench testing.

### ✓ 1.3 Site Background and History

The HB-PS facility is located at 234 Springs Road, north of the City of Washington, North Carolina (Figure 1, Appendix A). The facility and surrounding parcel are owned by the City of Washington and have been leased to HB-PS since 1990, and was previously leased by predecessor companies. The facility is involved in the final assembly, packaging, and warehousing of small electric household appliances.

Several phases of environmental investigation have been performed at the site since 1992 when constituents of concern were initially detected. The most recent investigation was a Comprehensive Site Assessment (CSA) that was completed in January 1999. Based on the CSA and operating history at the site, it is apparent impacts to soil and groundwater at the site originate from multiple sources.

Soil and water at the site contain fuel, chlorinated and non-chlorinated volatile organic compounds, and semivolatile organic compounds that are consistent with the storage and use of petroleum products and degreasing solvents. The principal constituents of concern detected in soil and groundwater at the site are volatile organic compounds (VOCs), including trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA). Some semi-volatile organic compounds (SVOCs) are detected less frequently, at lower concentrations, and over a smaller area. These principal chemicals are no longer in use at the facility. It is reported that there are no known, on-going, primary sources of TCE or 1,1,1-TCA. The specific source of petroleum hydrocarbon impacts to the site is unknown. The specific nature, volume, and time period of any release associated with these sources is also unknown. There is a "secondary source" within the soil located near the southeast corner of the plant building.

An unknown quantity of oil was observed in a drainage ditch along the south property line in 1995. HB-PS reported the incident to the appropriate state agency and responded to the release by excavating all visibly affected soil from the ditch. State approval permitted the excavated soil to be land farmed in an area east of the employee parking lot. Oil was later measured in a monitoring well and free product recovery was initiated. An aggressive Fluid-Vapor Recovery technology was implemented later in the impacted area. Recovery efforts have removed approximately 50 gallons of product, and have shown steadily diminishing returns.

For groundwater, the proposed cleanup goals (CUGs) are based on 2L Standards, interim maximum allowable concentrations (IAMCs), and proposed IMACs. For soil, CUGs are based on agency guidance values for Total Petroleum Hydrocarbons (TPH) and allowable soil contaminant concentrations that are determined by comparing chemical concentrations in leachate generated from the soil to the groundwater CUGs. Upon completion of corrective action, a synthetic precipitation leaching procedure will be performed on confirmatory soil samples. The allowable soil contaminant concentration will be that concentration of a chemical in the soil that produces a leachate at a concentration that does not exceed the groundwater CUG for that chemical.

Soil in the source area exceeds proposed CUGs for TPH, and is suspected to exceed the proposed CUGs for several VOCs and SVOCs. Soil exceeding CUGs is primarily located adjacent to the former solvent AST and encompasses an area approximately 90 feet by 150 feet in size. This area is known to extend beneath a portion of the plant building. Chemicals detected in soil outside this general area are presumed to represent transport by groundwater and subsequent adsorption onto the soil. Four abandoned underground storage tanks (UST), formerly use to store gasoline, diesel, and used oil, appear to have had only an incidental effect, if any, on chemical distribution at the site.

Groundwater underlying the site exceeds the CUGs for specific chlorinated VOCs. Groundwater also exceeds the CUGs for specific SVOCs. The extent of SVOC impacts, however, is limited to the upper hydrogeologic unit (Unit A) in the immediate source area. A dissolved VOC plume is present in Unit A, and the underlying hydrogeologic unit (Unit B). The site geology and hydrogeology is described in Section 1.4.

Within Unit A the plume extends from the source area toward the south and discharges to a drainage ditch. A lobe of the plume extends to the area east of the employee parking lot. The existence of this lobe may be due to preferential chemical migration through a former, and now buried, drainage ditch. Within Unit B the plume extends from the source area toward the northwest. The plume underlies the plant building and the leading edge is located about 700 feet from the source area and approximately 150 feet from Springs Road. A lobe of the plume extends from the source area, against the hydraulic gradient, to the south. No analytes were detected at concentrations that exceed their CUGs in samples collected from off-site monitoring points. Vertical migration of the plume is retarded by the Yorktown confining bed. No VOCs were detected in a sample collected from beneath the confining bed underlying the source area.

Based on assessment results, site constraints, and the nature of the contamination, active in-situ remediation technology was proposed for the source area.

#### **1.4 Site Geology and Hydrogeology**

Surficial Groundwater Reservoir (Unit A) consists of interbedded fine sand and clay deposits. The top of Unit A is approximately 3 to 5 feet bgs, and the bottom of Unit A is approximately 4 to 7 feet bgs. Therefore, the thickness of Unit A is typically 4 feet or less. Groundwater in Unit A is expected to generally occur under water table conditions, although water within an individual sand layer or lens may be confined. Unit A is not considered an aquifer due to its variable permeability, discontinuous nature, and thin saturated thickness. It supplies base flow to surface water and, potentially, recharge to underlying aquifers. Estimates of hydraulic conductivity (K) for Unit A range from  $3.6 \times 10^{-2}$  ft/day to  $7.4 \times 10^{-2}$  ft/day. Unit A effective porosity values vary from 3 percent for the clay deposits to 20 percent for the sand deposits. Groundwater in Unit A is reportedly corrosive and contains excessive iron. Groundwater flows towards, and discharges into, the drainage ditch that follows the Site's eastern and southern boundaries at an estimated average linear groundwater flow velocity of 0.01 to 0.04 feet/day.

Surficial Confining Bed is immediately below Unit A and consists of sandy silt and clay deposits. This confining bed separates Unit A from the underlying semi-confined aquifer. The top of the confining bed is approximately 4 to 7 feet bgs. The bottom of the confining bed is approximately 7 to 16 feet bgs. Therefore, the confining bed varies in thickness from 3 to 10 feet depending on location and appears to be continuous across the Site. A K value of  $5.7 \times 10^{-4}$  ft/day was measured. However, there are reportedly layers and lenses of more permeable deposits within the confining bed that decrease its effective thickness as a barrier to vertical groundwater flow.

Semi-Confined Aquifer (Unit B) consists of silty to fine sand deposits, located between the overlying shallow confining bed and the underlying Yorktown confining bed. Groundwater within Unit B occurs under semi-confined conditions; its recharge is derived from leakage from the overlying units. The top of Unit B generally occurs approximately 12 to 16 feet bgs, but may be as shallow as 7 feet bgs where the overlying confining bed is thin. The bottom of Unit B is approximately 30 to 40 feet bgs. Its thickness varies considerably across the Site, ranging from approximately 15 to 35 feet, and averaging 25 feet. Pumping tests estimated K values ranging from 3.0 ft/day and 3.1 ft/day and transmissivity values of 63.4 ft<sup>2</sup>/day to 64.9 ft<sup>2</sup>/day. Similar to Unit A, groundwater in Unit B is reportedly corrosive and contains excessive iron. In contrast to Unit A, groundwater in Unit B flows toward the north and northwest. An average groundwater flow velocity of 0.05 ft/day was estimated; however, flow within more permeable deposits may approach 0.1 ft/day.

Lower (Yorktown) Confining Bed consists of clay deposits below Unit B and above the Tertiary limestone aquifer. The top of this confining bed is present at approximately 40 feet bgs, and the bottom of the bed was encountered at approximately 69 feet bgs at only one location. Its thickness is estimated to be approximately 33 feet. K values of 10<sup>-3</sup> ft/day were estimated based on textural descriptions.

Semi-Confined Tertiary Limestone (Castle Hayne) Aquifer underlies the Yorktown confining bed, consists of shell limestone, the Castle Hayne limestone, and associated calcareous sand deposits. It is present at a depth of approximately 69 feet bgs. Groundwater in the aquifer is confined and recharge occurs as leakage from overlying and underlying units. The aquifer was only investigated to a depth of approximately 75 feet bgs; however, its thickness is estimated to range from about 50 to 100 feet near the Site (Brown, 1959). Groundwater in the aquifer is reportedly very hard and exhibits moderate to high levels of dissolved solids, moderately high pH, hydrogen sulfide gas, and excessive iron.

## 2.0 TECHNICAL APPROACH

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This section provides descriptions of technical elements necessary to implement the pilot test and achieve the application objectives. Two separate pilot tests will be performed at the site. One pilot test will be conducted in the unsaturated zone soils (near former soil sampling locations F22 and F18) and the other will be conducted within the near surface impacted groundwater around MW-228 (Figure 2).

Several technical tasks will need to be completed before, during, and following the CleanOX<sup>®</sup> reagent application events at the site. These tasks include: 1) installation of groundwater monitoring wells, CleanOX<sup>®</sup> application wells, and CleanOX<sup>®</sup> vapor points; 2) baseline monitoring, sampling, and laboratory sample analysis of soil and groundwater; 3) application of conditioning and oxidizer reagents, and groundwater monitoring performed during the application, 4) groundwater monitoring, sampling, and laboratory sample analysis following the application, and 5) technical reporting. Technical elements are described within the section text below.

### 2.1 Unsaturated Zone Pilot Test

Unsaturated zone pilot testing will consist of applying the CleanOX<sup>®</sup> Process to unsaturated soils at two locations, one at former soil sampling location F18 and the other at former soil sampling location F22.

#### 2.1.1 Application Well and Vapor Point Installation

At each location, two direct push (DP) soil application wells (SAW) will be installed approximately 5 feet from each of the two former soil sampling locations. The pilot test layout schemes are presented in Figures 3 and 4.

The application wells will be completed using flush mount construction and installed to a depth of approximately 6 feet at the F22 location, and approximately 3 feet bgs at the F18 location. The wells will be constructed using 1.25-inch diameter stainless steel materials consisting of approximately 5 feet of slotted screen in F22 application wells and 2 feet of screen in F18 application wells. Unsaturated application wells will have at least 12 inches of stainless steel riser. The required CleanOX<sup>®</sup> application well construction and materials is provided in Figure 5.

Vapor points allow passive release of water and carbon dioxide vapors generated during oxidation reactions, avoiding pressure increases beneath sealed surfaces (i.e. concrete and asphalt pavements and clay capping material). Nearby groundwater monitoring wells and the highly weathered and cracked pavement in the area around F18 will serve to release vapors from subsurface reactions at that location. No vapor points are specified at the F18 pilot test location. Four DP vapor points will be installed by Radian within 5 feet of the application wells around F22 (as indicated in Figure 4). Vapor points will be constructed of 1-inch polyvinyl chloride (PVC) slotted screen to a depth of approximately 5 feet below natural grade penetrating through the concrete surface in the area of the pilot test and into the underlying porous fill material. The vapor points will have enough riser

(approximately 6 to 12 inches) to allow for suitable flush mount construction. Specifications of a typical vapor point are provided in Figure 6. Vapor points will be located within 5 to 15 feet of application wells (refer to pilot test layout scheme in Figure 4).

### 2.1.2 Baseline Soil Sampling

Radian will perform baseline sampling and laboratory analysis prior to treatment application. Unsaturated soil samples will be collected from the application well boreholes around the former soil sampling locations F18 and F22. The sampling range at both locations is estimated at 1 to 4 feet below natural grade. The samples will be analyzed for VOCs by EPA Method 8260, SVOC by EPA Method 8270, TPH by EPA Method M8015, and Oil and Grease by EPA Method E413.2. Analytical data from soil samples collected at F22 and F18 during Radian's CSA effort will be used as baseline conditions at those points. A sampling and monitoring schedule is provided in Table 2-1.

Following Radian's installation of the application wells, soil sampling and analysis, and baseline monitoring, ManTech will review the baseline data and other newly acquired site data prior to mobilizing to the site. A full review of all pertinent site data is needed to evaluate and finalize the application formulation and design.

**TABLE 2-1  
UNSATURATED ZONE PILOT TEST  
SAMPLING AND MONITORING SCHEDULE**

FIELD EVENT	SAMPLING LOCATION	LABORATORY ANALYSIS	FIELD PARAMETERS
Baseline Monitoring, Soil Sampling and Analysis	F22 and F18	8260, 8270, M8015, 413.2	Air Monitoring (breathing zone, application wells, and vent points)
Field Application Monitoring	Pilot Test Application Wells and Vent Points	Not Applicable	Air Monitoring (breathing zone, application wells, and vent points)
Post-Treatment Monitoring, Soil Sampling and Analysis	F22 and F18	8260, 8270, M8015, 413.2	Air Monitoring (breathing zone, application wells, and vent points)

8260 = EPA Method 8260

8270 = EPA Method 8270

8015M = EPA Method 8015 Modified

413.2 = EPA Method 413.2

Air Monitoring = carbon dioxide, lower explosion limit, oxygen, photo-ionization monitoring

### 2.1.3 CleanOX<sup>®</sup> Pilot-Scale Reagent Application – Unsaturated Soil

Following technical approval from the North Carolina Department of Environment and Natural Resources (NCDENR), ManTech will proceed with tasks associated with reagent application.

CleanOX® reagents will be added to the application wells to effect mass reductions of constituents of concern. ManTech's proprietary reagent formulation and the detailed steps in adding reagents are included only in company confidential copies of the Work Plan. Field guidance used during the application process is presented as Appendix B. ManTech employees will complete fieldwork under the site-specific Health and Safety Plan (HASP) to be provided following State approval of the Pilot Test Work Plan. Prior to beginning field activities, ManTech and Radian will conduct an initial health and safety meeting for all associated field personnel. The meeting will include discussions of general health and safety issues, issues specific to the Site's constituents of concern and other hazards, and issues specific to the CleanOX® Process application. A copy of the HASP will be made available to all associated field personnel prior to pilot test field activities.

Following initial monitoring, ManTech will fit each application well with a wellhead seal that includes a riser fitted with two valves. One part of this riser is attached to the aboveground containers of reagents, and the other is used as a reaction vapor off-gassing vent. Conditioning and oxidation reagents will be applied separately to the application wells.

Two cycles of CleanOX® treatment will be completed at each application well. Each cycle is estimated to be a one-week field effort with a two-day stabilization period separating the two application events. A project schedule is provided in Section 3.0. As previously indicated, ManTech will also monitor off-gassing in the headspace of vapor points, and at the venting point of the application wells.

Hydrochloric acid will be added to adjust the pH in the formation material surrounding the application wells to effect a pH change to less than 5 standard units. Based on known site data and bench test results, 125 to 200 gallons of approximately 1% to 3% aqueous hydrochloric acid solution will be added to each well per treatment event. Following pH conditioning, ferrous sulfate will be added to provide a concentration of about 100 ppm of ferrous ion in the unsaturated material surrounding the application wells. Approximately 125 to 200 gallons of 5% aqueous ferrous sulfate solution will be added to each application well per treatment event.

Following conditioning reagent application, ManTech will initiate the oxidizing reactions by applying a slow (less than 0.5 gpm) feed of diluted (approximately 5% to 10% concentration) hydrogen peroxide. Diluted hydrogen peroxide will be applied initially to observe any delay time that may be involved for reactions to begin at the site. After approximately 30 gallons of diluted hydrogen peroxide has been added to each application well, the ManTech field supervisor will contact the ManTech project engineer to relay field observations and to obtain approval of using a higher hydrogen peroxide concentration. The final step is to apply hydrogen peroxide in a quantity of 250 to 350 gallons at 15% to 20% solution to each well per treatment event.

The acidified formation matrix coupled with the proper ferrous ion density will cause the peroxide to decompose into a hydroxyl radical in an exothermic reaction. The vertical depth of travel for the reaction is generally based on the screen interval at which the CleanOX® reagents are applied, depending on site hydrogeological conditions. The reagents will be applied from approximately 1 to 5 feet below natural grade at the F22 location, and at the F18 site, from approximately 4 to 8

feet bgs (treatment zone). The application process of conditioning reagent is expected to be completed within one to two days. Application of hydrogen peroxide will be completed during the remaining scheduled fieldwork.

During the application events off-gassing will occur. ManTech will monitor off-gassing vapors in the breathing zone, headspace of vapor points, monitoring wells, and at the venting point of the application wells. Air monitoring parameters to be measured will include volatile compounds (measured with photoionization detector), percent oxygen, carbon dioxide, and the lower explosive level (LEL) using an LEL meter. Initially, air parameters will be monitored at 15-minute intervals during oxidizer reagent application. The monitoring interval will decrease as conditions warrant to no less than once per hour (as determined by ManTech's Project Engineer). In the event that any of the parameters listed in Table 2-2 below exceed specified levels, the ManTech crew leader will stop applying reagents immediately and call ManTech's Project Engineer. Specific pilot test application shut down procedures are provided in Appendix C.

Other observations made during applications include, but are not limited to, excessive pressures and temperatures, fluid short-circuiting to the surface indicating mounding of formation water, and excessive PID, O<sub>2</sub>, CO<sub>2</sub>, or LEL measurements indicated by monitoring equipment used inside the building, the head space of the monitoring wells, and the breathing zone. ManTech and Radian will then evaluate site conditions and will either: 1) continue the application; 2) continue at a reduced application rate and/or reduced oxidizer concentration; 3) attach and operate a temporary soil vapor extraction (SVE) system to test area vent points before continuing the application; or 4) terminate the pilot test.

**TABLE 2-2  
OFF-GASSING PARAMETERS**

PARAMETER	LEVEL/CONDITION
Wellhead Pressure	P > 40 psi (or excessive visible vapors or bubbling in floor or ground surface cracks/joints)
Breathing Zone	VOCs > 1 ppm O <sub>2</sub> > 25% CO <sub>2</sub> > 5% LEL > 10%

All vapor points and nearby wells, if any, will be open to the atmosphere to allow venting from the subsurface during application events.

✓ **2.1.4 Post-Treatment Sampling**

Radian will perform post-treatment soil sampling and analysis approximately one week following completion of the CleanOX<sup>®</sup> treatment. A project schedule is provided in Section 3.0. Soil will be

re-sampled from locations adjacent to each application well and both F18 and F22 at the same depths as those collected for baseline sampling (six sampling locations total). Samples will be analyzed for VOCs by EPA Method 8260, SVOC by EPA Method 8270, TPH by EPA Method M8015, and Oil and Grease by EPA Method E413.2.

## **2.2 Groundwater Pilot Test**

The groundwater pilot test will be performed in the Unit A hydrogeologic unit near existing groundwater monitoring well MW-228 as described below.

### **2.2.1 Application and Monitoring Well Installation**

Two DP CleanOX® groundwater application wells (GAW) will be installed proximate to existing groundwater monitoring well MW-228 (Figure 3). The application wells will be installed at distances of 5 and 10 feet from the monitoring well to a depth of approximately 10 feet bgs. The wells will be constructed using 1.25-inch diameter stainless steel materials consisting of 7 feet of slotted screen and approximately 3 feet of stainless steel riser. The required CleanOX® application well construction for the groundwater pilot test is provided in Figure 5.

Four additional groundwater monitoring wells will be installed at locations and distances indicated in Figure 3. Using DP installation technique and typical well construction materials, monitoring wells will be installed to approximately 10 feet bgs and constructed of 1-inch PVC materials that will include at least a 5-foot section installed across the water table, and enough riser pipe to allow well head completion. The required groundwater monitoring well construction diagram is provided in Figure 7. The monitoring wells can be completed slightly below ground surface within a flush-mount well protector or above ground with appropriate above ground well protection.

### **2.2.2 Baseline Groundwater Sampling**

Radian will perform baseline monitoring, sampling and laboratory analysis prior to ManTech's treatment application. ManTech will measure field parameters in all test area wells prior to applying CleanOX® reagents.

Groundwater will be collected from MW-228, the two newly installed application wells (GAW-1 and GAW-2, the four newly installed groundwater monitoring wells (MW-A1, MW-A2, MW-A3, MW-A4), and existing groundwater monitoring wells outside the pilot testing area including MW-208, MW-212, and MW-214. These groundwater samples will be analyzed for VOCs by EPA Method 8260 and SVOCs by EPA Method 8270. A sampling and monitoring schedule is provided in Table 2-3. Results of initial groundwater monitoring, and sampling and analysis will serve as the baseline for the chemical oxidation pilot test. Field-measured groundwater parameters will be made at the monitoring and application wells. Baseline groundwater field parameters including depth to groundwater, temperature, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, and pH will be measured at these monitoring points during this task.

Following Radian's installation of the monitoring and application wells, baseline monitoring, and groundwater sampling and analysis, ManTech will review the baseline data and other newly acquired site data prior to mobilizing to the site. A full review of all pertinent site data is needed to evaluate and finalize the application formulation and design.

**TABLE 2-3  
GROUNDWATER PILOT TEST  
SAMPLING AND MONITORING SCHEDULE**

FIELD EVENT	SAMPLING LOCATION	LABORATORY ANALYSIS	FIELD PARAMETERS
Baseline Monitoring, Groundwater Sampling and Analysis	MW-228, GAW-1, GAW-2, MW-A1, MW-A2, MW-A3, MW-A4, MW-208, MW-214, and MW-212	8260, 8270	WL, pH, ORP, SC, DO, Temp, Air Monitoring
Field Application Monitoring	MW-228, GAW-1, GAW-2, MW-A1, MW-A2, MW-A3, MW-A4, MW-208, MW-214, and MW-212	Not Applicable	WL, pH, ORP, SC, DO, Temp, Air Monitoring
	Storm Sewer Grates; Interior Conveyor Line; Breathing Zone	Not Applicable	Air Monitoring
First Post-Treatment Monitoring, Groundwater and Soil Sampling and Analysis	MW-228, GAW-1, GAW-2, MW-A1, MW-A2, MW-A3, MW-A4, MW-208, MW-214, and MW-212	8260, 8270	WL, pH, ORP, SC, DO, Temp, Air Monitoring
Second Post-Treatment Monitoring, Groundwater and Soil Sampling and Analysis	MW-228, GAW-1, GAW-2, MW-A1, MW-A2, MW-A3, MW-A4, MW-208, MW-214, and MW-212	8260, 8270	WL, pH, ORP, SC, DO, Temp, Air Monitoring

8260 = EPA Method 8260

8270 = EPA Method 8270

WL = groundwater level

ORP = oxidation reduction potential

Air Monitoring = carbon dioxide, lower explosion limit, oxygen, photo-ionization monitoring

SC = specific conductance

DO = dissolved oxygen

Temp = temperature

### ✓ 2.2.3 CleanOX® Pilot-Scale Reagent Application - Groundwater

Following technical approval from the State, ManTech will proceed with tasks associated with reagent application. CleanOX® reagents will be added to the application wells to effect mass reductions of constituents of concern. ManTech employees will complete fieldwork under the site-specific Health and Safety Plan (HASP) to be provided following State approval of the Pilot Test

Work Plan. Prior to beginning field activities, ManTech and Radian will conduct an initial health and safety meeting for all associated field personnel. The meeting will include discussions of general health and safety issues, issues specific to the Site's constituents of concern and other hazards, and issues specific to the CleanOX® Process application. A copy of the HASP will be made available to all associated field personnel prior to pilot test field activities.

Two cycles of CleanOX® treatment will be completed at each application well. Each cycle is estimated to be a one- to two-week field effort with a one-week stabilization period separating the two application events. Groundwater depth, pH, ORP, specific conductance, dissolved oxygen, and temperature will be measured by ManTech at the pilot test monitoring and application wells prior to conditioning and oxidation reagent application, and on an hourly basis in the treatment area monitoring wells during the oxidation reagent application process. The monitoring interval will decrease as conditions warrant to no less than twice per day (as determined by ManTech's Project Engineer). A sampling and monitoring schedule is provided in Section 2.3.

Following initial monitoring, ManTech will fit each application well with a wellhead seal that includes a riser fitted with two valves. One part of this riser is attached to the aboveground containers of reagents, and the other is used as a reaction vapor off-gassing vent. Conditioning and oxidation reagents will be applied separately to the application wells.

Hydrochloric acid will be added to adjust the pH in the formation material surrounding the application wells to effect a pH change to less than 5 standard units. Based on known site data and subject to bench test results, 150 to 250 gallons of approximately 1% to 3% aqueous hydrochloric acid solution will be added to each well per treatment event. Following pH conditioning, ferrous sulfate will be added to provide a concentration of about 100 ppm of ferrous ion in the formation material surrounding the application wells. Approximately 100 to 200 gallons of 5% aqueous ferrous sulfate solution will be added to each application well per well treatment event.

Following conditioning reagent application, ManTech will initiate the oxidizing reactions by applying a slow (less than 0.5 gpm) feed of diluted (approximately 5% to 10% concentration) hydrogen peroxide. Diluted hydrogen peroxide will be applied initially to observe any delay time that may be involved for reactions to begin at the site. After approximately 30 gallons of diluted hydrogen peroxide has been added to each application well, the ManTech field supervisor will contact the ManTech project engineer to relay field observations and to obtain approval of using a higher hydrogen peroxide concentration. The final step is to apply hydrogen peroxide in a quantity of 750 to 1,000 gallons at 15% to 20% aqueous solution to each well per treatment event.

The acidified matrix coupled with the proper ferrous ion density will cause the peroxide to decompose into a hydroxyl radical in an exothermic reaction. The vertical depth of travel for the reaction is generally based on the screen interval at which the CleanOX® reagents are applied, depending on site hydrogeological conditions. The reagents will be applied to the upper saturated zone, approximately 3 to 10 feet below ground surface (treatment zone). The application process of conditioning reagents is expected to be completed within one to two days. Application of hydrogen peroxide will be completed during the remaining scheduled fieldwork.

An increase in temperature due to exothermic reaction is expected to be limited to the treatment zone within a few feet of the application wells. However, changes in other groundwater parameters are expected at the pilot test monitoring wells. Following treatment, the effects of dilution by groundwater movement work to shift pH toward background levels. Long-term pH effects are avoided by using a dilute acid solution in the conditioning process. The pH effects created within the treatment volume are expected to subside within several days to a month following treatment. The iron effect is limited to the treatment area surrounding the application points and has been observed at other sites to decrease in concentration over several months to background levels. Decreased formation permeability as a result of oxidation treatment has not been observed at other CleanOX® project sites.

During the application events off-gassing will occur. ManTech will monitor off-gassing vapors in the breathing zone, headspace of monitoring wells, and at the venting point of the application wells. Air monitoring parameters to be measured will include volatile compounds (measured with photoionization detector), percent oxygen, carbon dioxide, and LEL. Initially, air parameters will be monitored at 15-minute intervals during oxidizer reagent application. The monitoring interval will decrease as conditions warrant to no less than once per hour (as determined by ManTech's Project Engineer). In the event that any of the parameters listed in Table 2-2, above, exceed specified levels, the ManTech crew leader will stop applying reagents immediately and call ManTech's Project Engineer. Specific pilot test application shut down procedures are provided in Appendix C.

Other observations made during applications include, but are not limited to, excessive pressures and temperatures, fluid short-circuiting to the surface indicating mounding of groundwater, and excessive PID, O<sub>2</sub>, CO<sub>2</sub>, or LEL measurements indicated by monitoring equipment, the head space of the monitoring wells, and the breathing zone. ManTech and Radian will then evaluate site conditions and will either: 1) continue the application; 2) continue at a reduced application rate and/or reduced oxidizer concentration; 3) attach and operate a temporary soil vapor extraction (SVE) system to test area vent points before continuing the application; or 4) terminate the pilot test.

#### **2.2.4 Post-Treatment Sampling**

Radian will perform post-treatment groundwater sampling and analysis approximately one week following completion of the CleanOX® treatment, and again at approximately three weeks following treatment. A sampling and monitoring schedule is provided in Table 2-3. Groundwater will be collected from MW-228, the two newly installed application wells (GAW-1 and GAW-2, the four newly installed groundwater monitoring wells (MW-A1, MW-A2, MW-A3, MW-A4), and existing groundwater monitoring wells outside the pilot testing area including MW-208, MW-212, and MW-214. These samples will be analyzed for VOCs by EPA Method 8260 and SVOCs by EPA Method 8270.

### 2.3 Technical Report

After receipt of all data from post-treatment sampling, ManTech will prepare a technical report presenting pilot test data and a discussion describing the results of the field application. The report will also provide an analysis of the applicability of the CleanOX<sup>®</sup> Process as a feasible remediation option for site cleanup. ManTech will provide one draft and one final document.

### 3.0 PROJECT SCHEDULE

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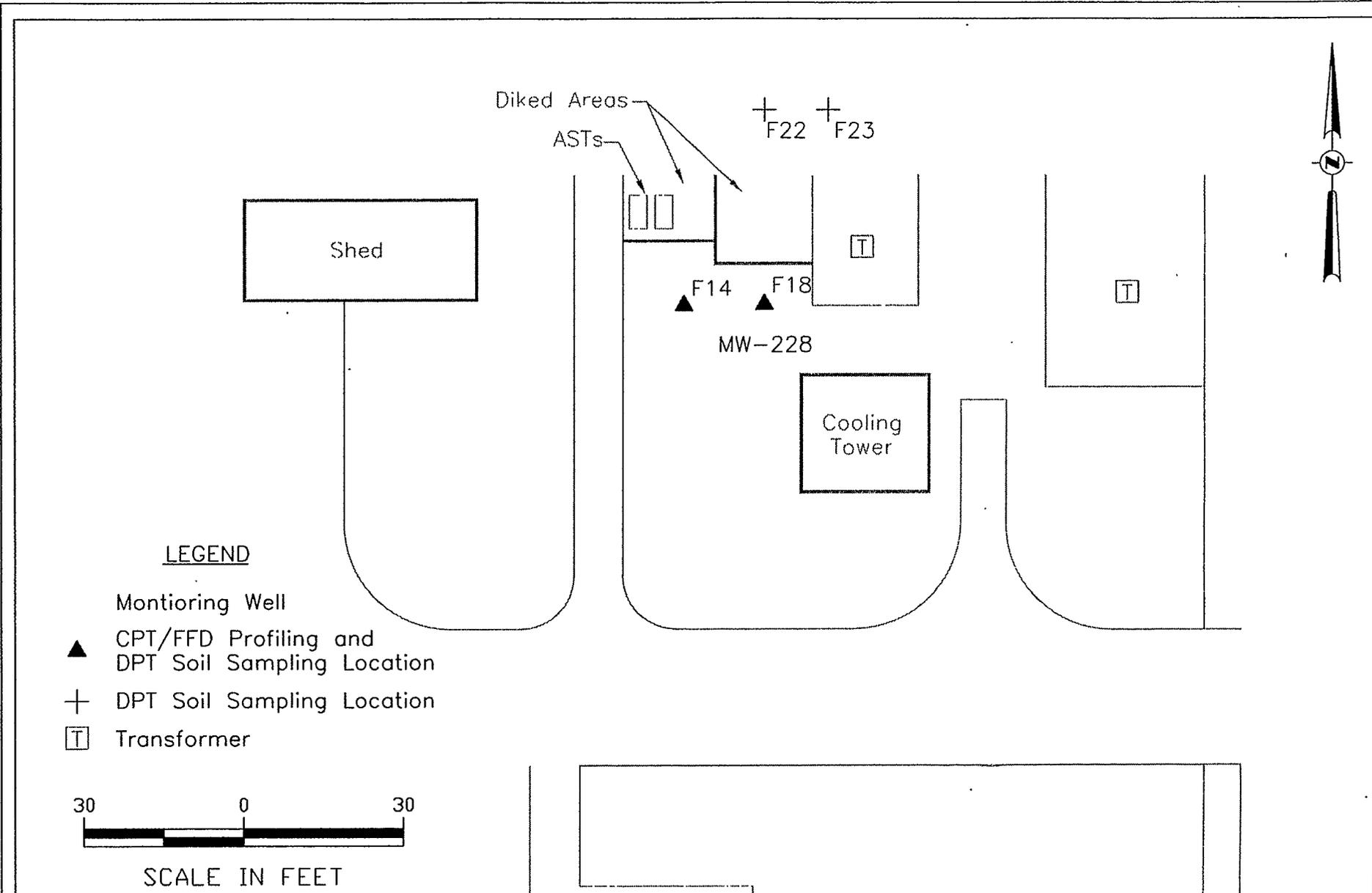
The proposed schedule for implementing the technical elements of the CleanOX<sup>®</sup> pilot test field application work plan at the site is provided below. This schedule is subject to revision based on approval of the Work Plan by Radian, technical approval by NCDENR, inclement weather, and other uncontrollable delays.

TASK	PROJECTED COMPLETION DATE
Installation of Monitoring Wells, Application Wells, and Vapor Points	October 13, 2000
Baseline Monitoring and Sampling	October 20, 2000
CleanOX <sup>®</sup> Reagent Application – Unsaturated Zone	November 10, 2000
Post Treatment Sampling – Unsaturated Zone	November 14, 2000
CleanOX <sup>®</sup> Reagent Application – Groundwater	December 19, 2000
First Post-Treatment Sampling - Groundwater	December 28, 2000
Second Post Treatment Sampling - Groundwater	January 15, 2001
Technical Report	March 19, 2001

**APPENDIX A**

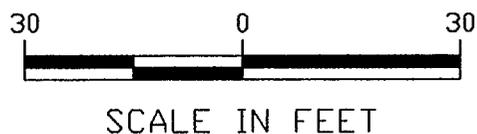
**FIGURES**





LEGEND

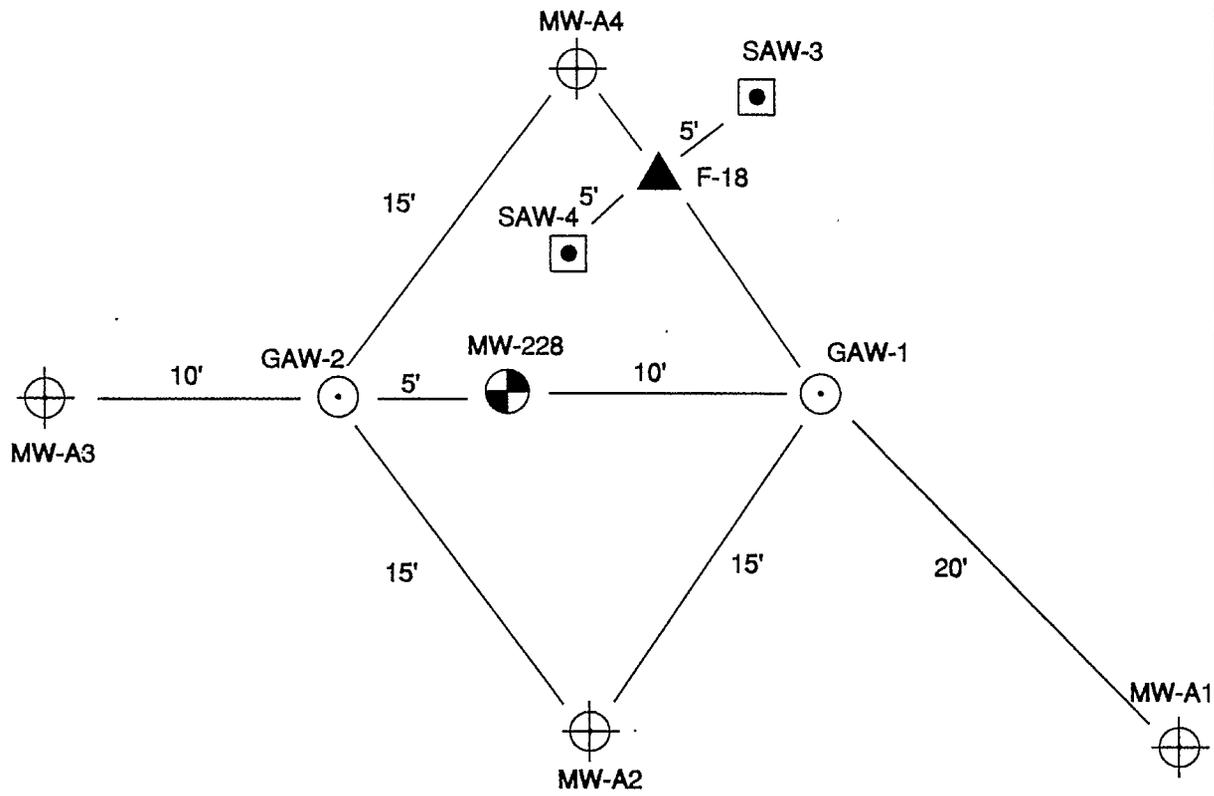
- ▲ Monitoring Well
- ▲ CPT/FFD Profiling and DPT Soil Sampling Location
- + DPT Soil Sampling Location
- Transformer



**FIGURE 2**

**PILOT TEST AREA MAP**

CLIENT: RADIAN ENGINEERING	DATE: 3/6/00	DWG. FILE: FIGURE2.DWG	DRWN BY: RADIAN	FIG. NO.: 2
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LEGEND	
	EXISTING MONITORING WELL
	SOIL SAMPLE BORING
	PROPOSED SOIL APPLICATION WELL
	PROPOSED GROUNDWATER APPLICATION WELL
	PROPOSED PILOT TEST MONITORING WELL

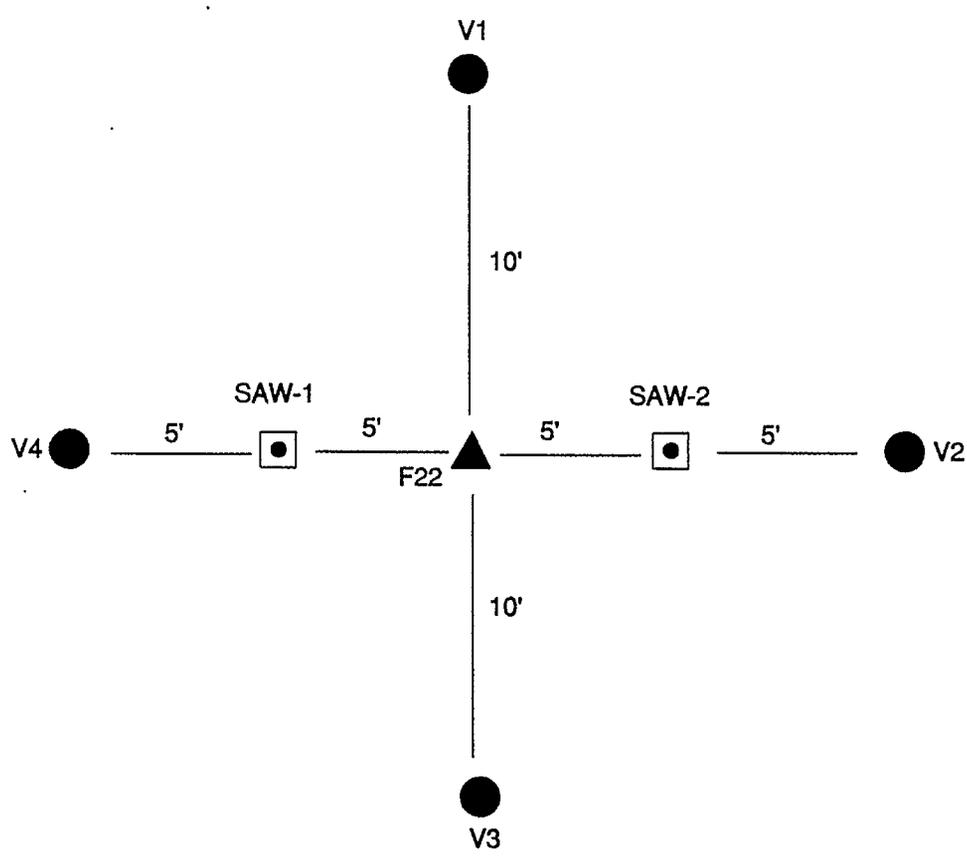
DRAWING NOT TO SCALE

 **MANTECH ENVIRONMENTAL CORPORATION**  
14000 RALLYFIELD CIRCLE, SUITE 100  
CHANTILLY, VIRGINIA 20151

FIGURE 3

MW-228/F18 PILOT TEST LAYOUT

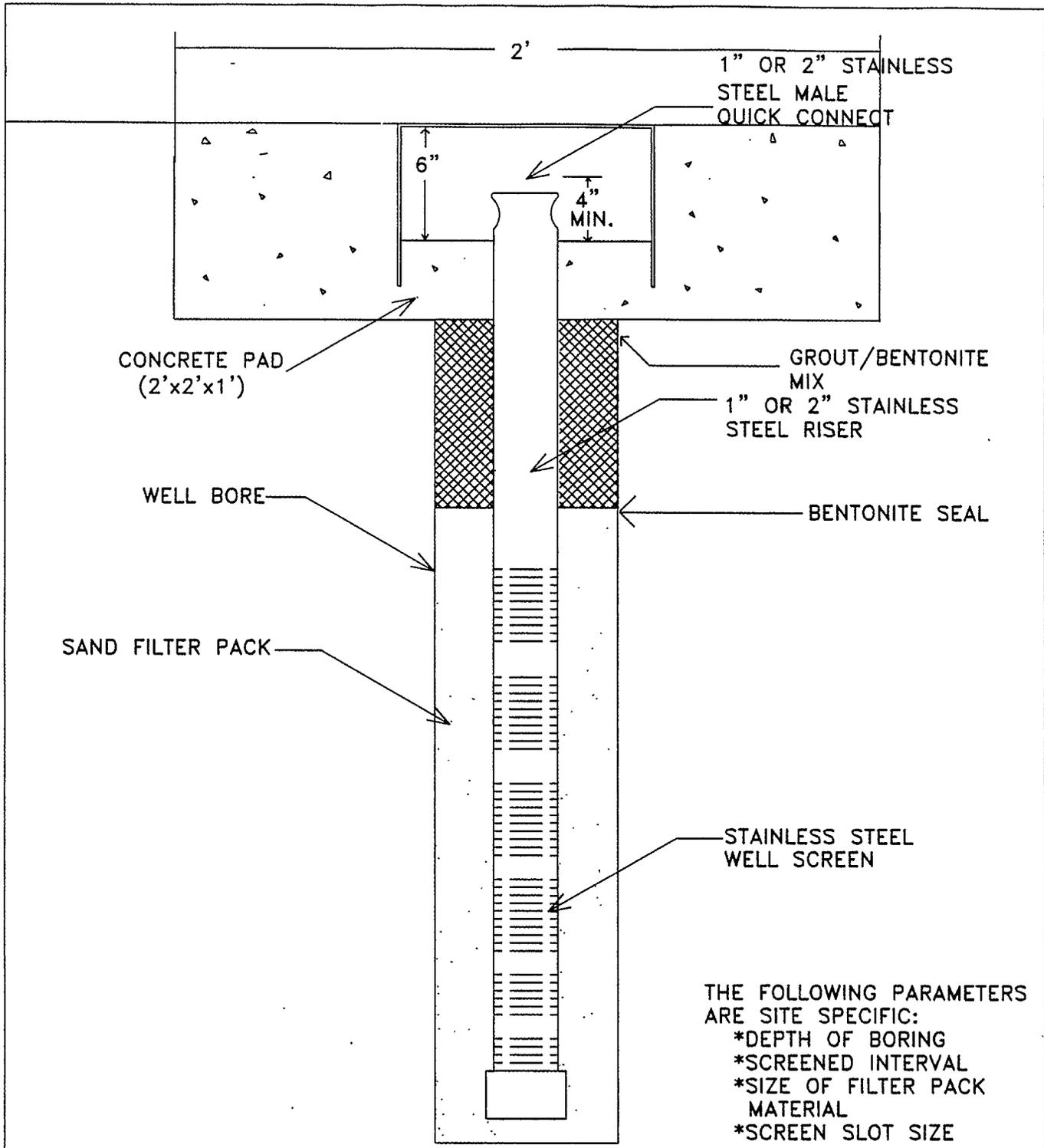
CLIENT: <b>RADIAN ENGINEERING</b>	DATE: 3/6/00	DWG. FILE: FIGURE3.DWG	DRWN BY: CT	REV'D BY: TR	FIG. NO.: 3
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LEGEND	
	PROPOSED VENT
	SOIL SAMPLE BORING
	PROPOSED SOIL APPLICATION WELL

DRAWING NOT TO SCALE

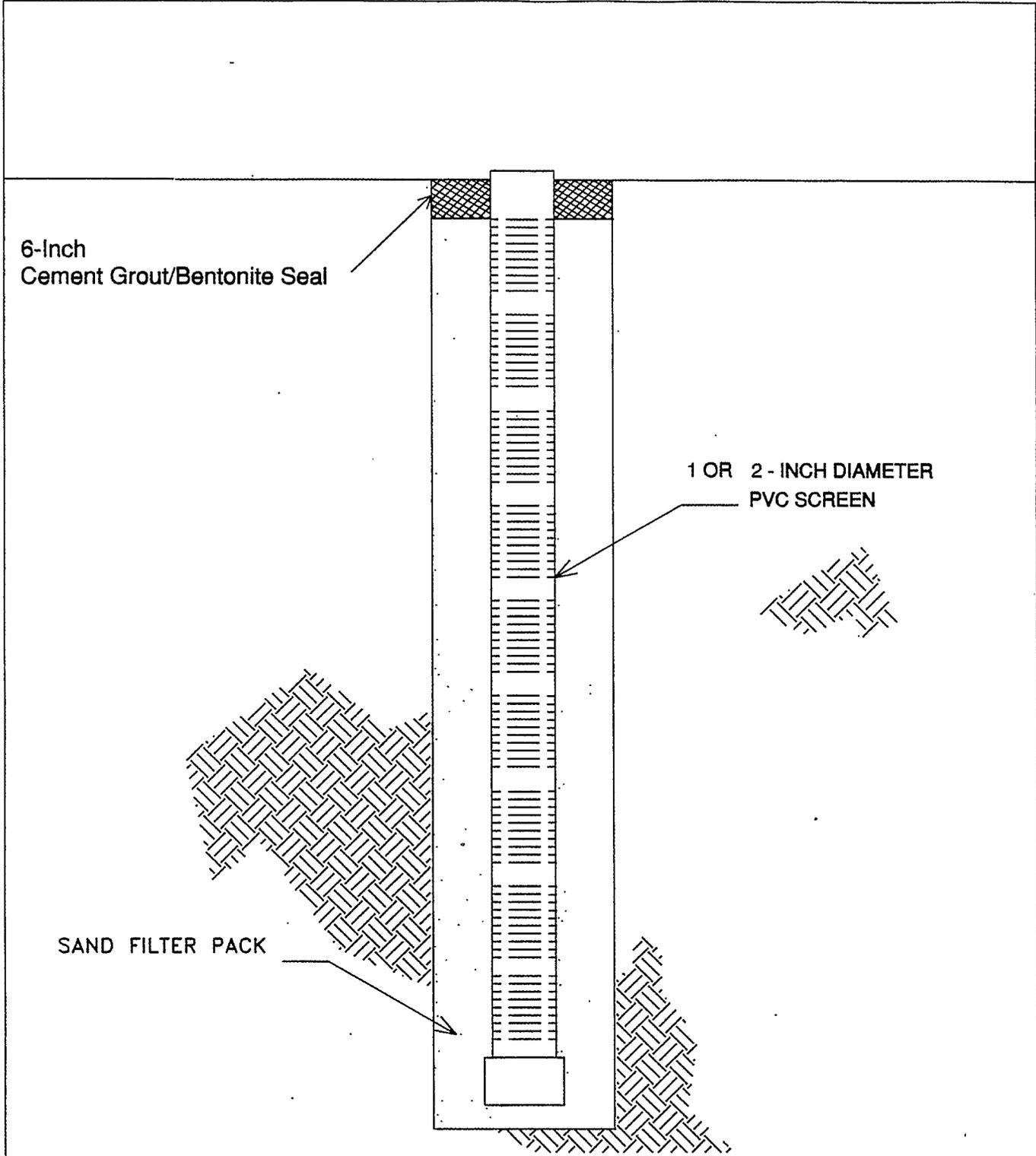
 <b>MANTECH ENVIRONMENTAL CORPORATION</b> <small>1499 BULLYFIELD CIRCLE, SUITE 100 CHANTILLY, VIRGINIA 20151</small>	FIGURE 4				
	F22 PILOT TEST LAYOUT				
CLIENT: <b>RADIAN ENGINEERING</b>	DATE: 3/6/00	DWG. FILE: FIGURE4.DWG	DRWN BY: CT	REV'D BY: TR	FIG. NO.: 4



THE FOLLOWING PARAMETERS ARE SITE SPECIFIC:  
 \*DEPTH OF BORING  
 \*SCREENED INTERVAL  
 \*SIZE OF FILTER PACK MATERIAL  
 \*SCREEN SLOT SIZE

\*DRAWING NOT TO SCALE\*

 <p><b>MANTECH ENVIRONMENTAL CORPORATION</b></p> <p>14290 SULLYFIELD CIRCLE, SUITE 100        CHANTILLY, VIRGINIA 20151</p>	<p>CLEANOX<sup>®</sup> APPLICATION WELL CONSTRUCTION DIAGRAM</p>				
	<p>MANTECH ENVIRONMENTAL CORPORATION</p>				
<p>CLIENT: RADIANT ENGINEERING</p>	<p>DATE: 3/6/00</p>	<p>DWG. FILE: FIGURE5.DWG</p>	<p>DRWN BY: CT</p>	<p>REV'D BY: MP</p>	<p>FIG. NO.: 5</p>



\*DRAWING NOT TO SCALE\*

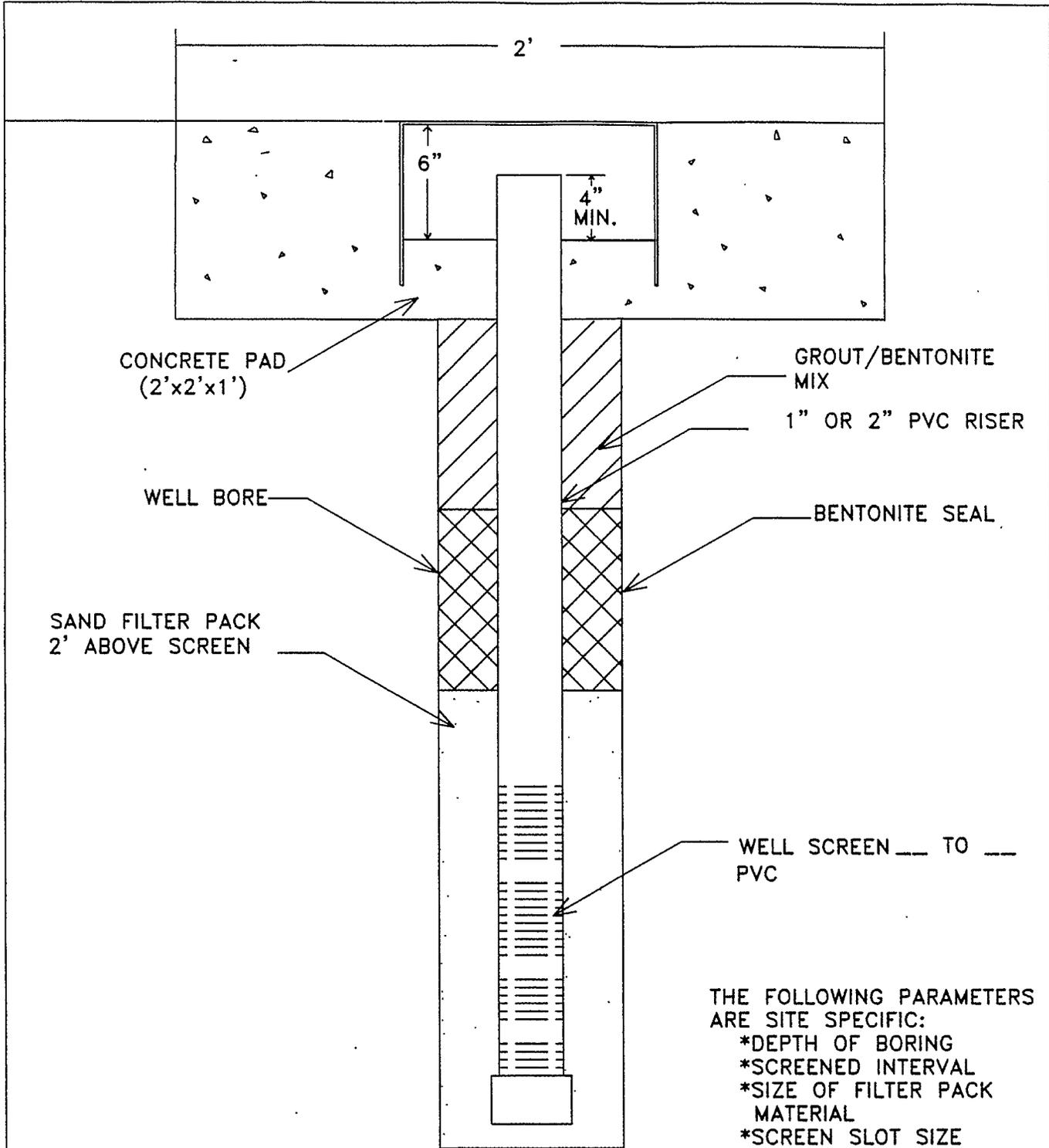


**MANTECH ENVIRONMENTAL CORPORATION**  
 14290 SULLYFIELD CIRCLE SUITE 100  
 CHANTILLY, VIRGINIA 20151

**CLEANOX® VENT (TYPICAL)  
 CONSTRUCTION DIAGRAM**

**MANTECH ENVIRONMENTAL CORPORATION**

CLIENT: <b>RADIAN ENGINEERING</b>	DATE: <b>5/7/99</b>	DWG. FILE: <b>FIGURE6.DWG</b>	DRWN BY: <b>CT</b>	REV'D BY: <b>CC</b>	FIG. NO.: <b>6</b>
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THE FOLLOWING PARAMETERS  
ARE SITE SPECIFIC:  
\*DEPTH OF BORING  
\*SCREENED INTERVAL  
\*SIZE OF FILTER PACK  
MATERIAL  
\*SCREEN SLOT SIZE

\*DRAWING NOT TO SCALE\*

 <b>MANTECH ENVIRONMENTAL CORPORATION</b>  14290 SULLYFIELD CIRCLE, SUITE 100 CHANTILLY, VIRGINIA 20151	<b>MONITORING WELL CONSTRUCTION DIAGRAM</b>				
	<b>MANTECH ENVIRONMENTAL CORPORATION</b>				
CLIENT: <b>RADIAN ENGINEERING</b>	DATE:	DWG. FILE: <b>FIGURE7.DWG</b>	DRWN BY: <b>CT</b>	REV'D BY: <b>MP</b>	FIG. NO.: <b>7</b>

**APPENDIX B**  
**SITE CONTROL PROCEDURES**

## SITE CONTROL PROCEDURES

1. Identify chemical storage needs, confirm location with site contacts.
2. Construct chemical storage area containment using six-mil black plastic tarp. Use sorbent booms under perimeter of tarp to form a berm.
3. Receive and unload chemicals.  
Inspect all containers for damage or leakage.  
Verify order is complete and quantities, containers, and concentrations are correct.
4. Establish site controls.  
Position traffic cones, barricades, and caution tape (each as needed) to direct traffic away from work area and to keep onlookers from approaching storage/work areas.
4. Identify and inspect application wells, observation/monitoring wells, and above or below grade structures.
5. Develop not-to-scale map of work area showing distances to important features.
7. Collect baseline site data.  
Monitoring wells: pH, conductivity, temperature, DO, DTW and OVA.  
General area and nearby structures (buildings, storm drains, etc): OVA, wind direction and weather conditions.
8. Attach well head(s) to application well(s).
9. Apply reagents in proper sequence at proper rate as per the calculated site recipe worksheet.
10. Measure groundwater and general area parameters after applying each of the conditioning and oxidizing reagents, and at the beginning and end of each day in the field.

**APPENDIX C**

**CLEANOX® APPLICATION SHUT DOWN PROCEDURES**

## CLEANOX® APPLICATION SHUT DOWN PROCEDURES

In the event that field-monitored parameters exceed specified levels, CleanOX® application will be shut down using the following procedure:

### Excessive Pressure

1. Place reagent pump switch to “off” position.
2. CleanOX® oxidizer reagent application valve(s) will be closed.
3. All wellhead assembly exhaust valves/lines will be opened to relieve reaction pressures.
4. Mobilize field project personnel to predetermined muster point.
5. Ensure all unauthorized personnel remain clear of treatment area.
6. Monitor for pressure excursions using PID, LEL, CO2, and O2 meters.
7. Notify Project Engineers.

### Exceed Specified Air Monitoring Parameters

1. Place reagent pump switch to “off” position.
2. CleanOX® oxidizer reagent application valve(s) will be closed.
3. Mobilize field project personnel to predetermined muster point.
4. Ensure all unauthorized personnel remain clear of treatment area.
5. Notify Project Engineers.
6. If indoors, increase ventilation (e.g. open doors/windows, apply fans to blow fresh air into treatment area).

**ATTACHMENT 5**  
**PLUME CHARACTERIZATION MAPS**

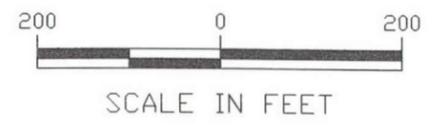
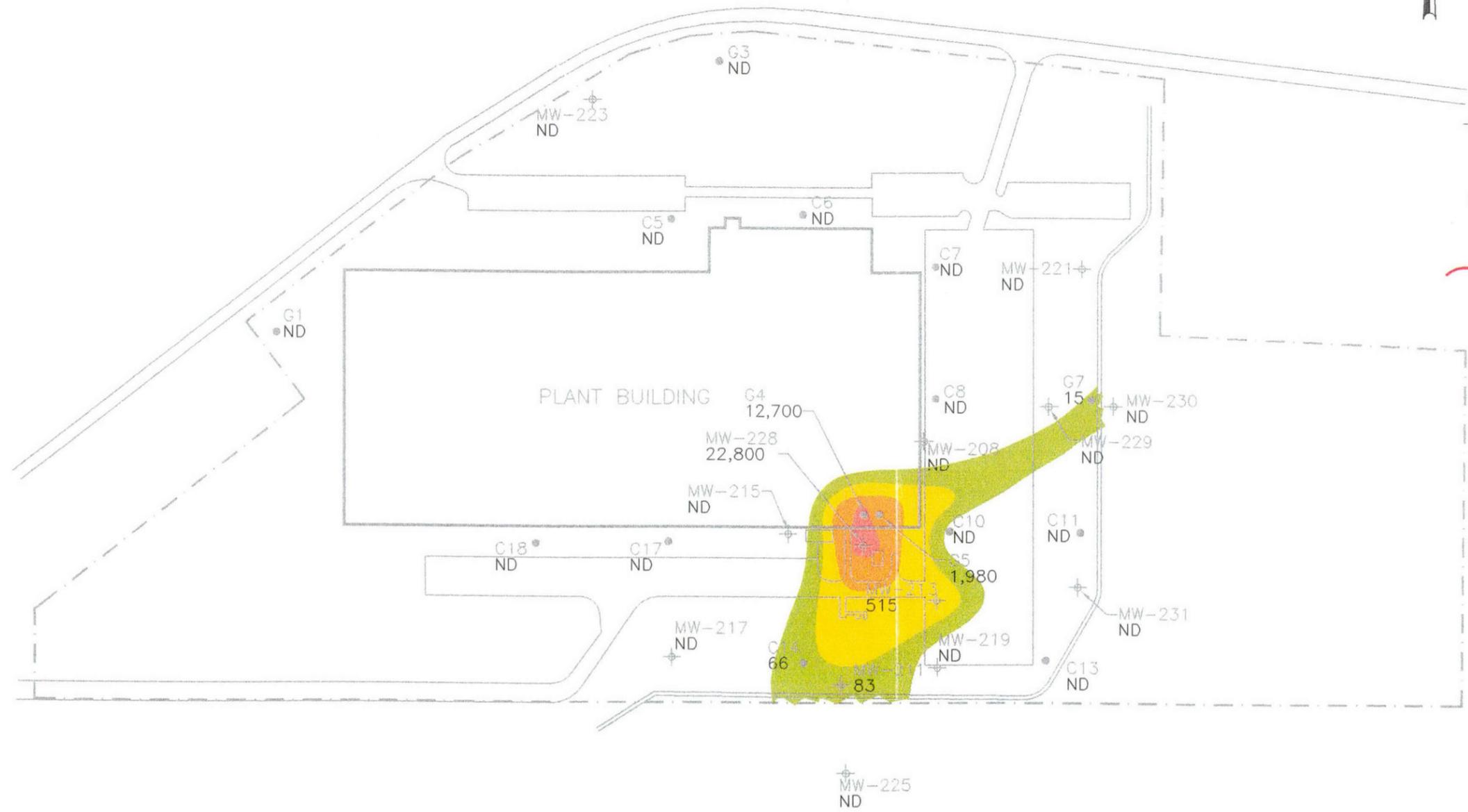


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- Outer Contour Line Indicates Estimated Quantitation Limit of 5 ug/L

**Color Key**

- <100 ppb
- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb

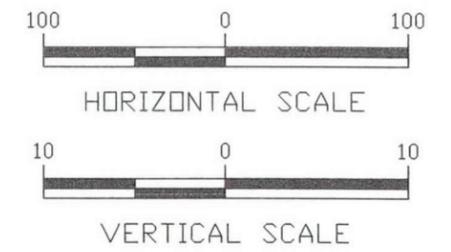
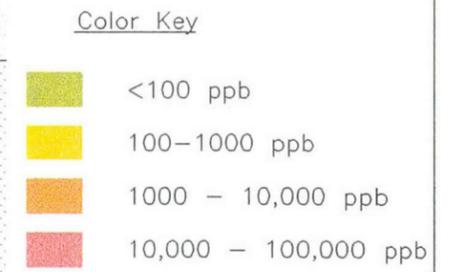
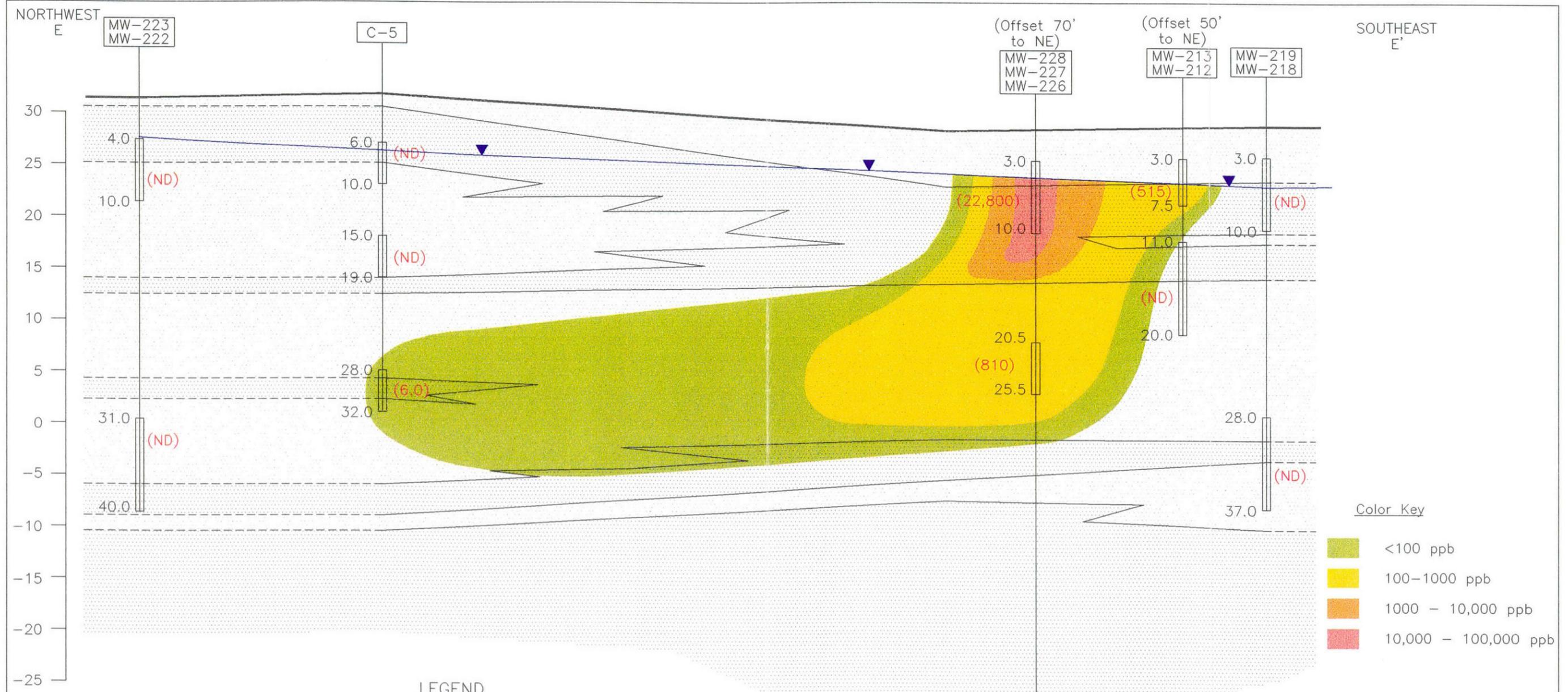


SCALE	AS SHOWN	DESIGNED BY	JN	DATE	28DEC98	DRAWING TITLE	Figure 1A. Approximate Distribution of Trichloroethene in Unit A Hamilton Beach & Proctor Silex, Inc.		
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	28DEC98				
	<b>RADIAN INTERNATIONAL</b>	CHECKED BY	BPG	DATE	08JAN99				
	A DAWES & JACOBE GROUP COMPANY	APPROVED BY		DATE		CONTRACT NO.	650138.0601	DRAWING NO.	UNITA-TCE
	RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709								REV.
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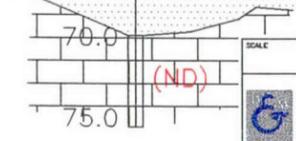






**LEGEND**

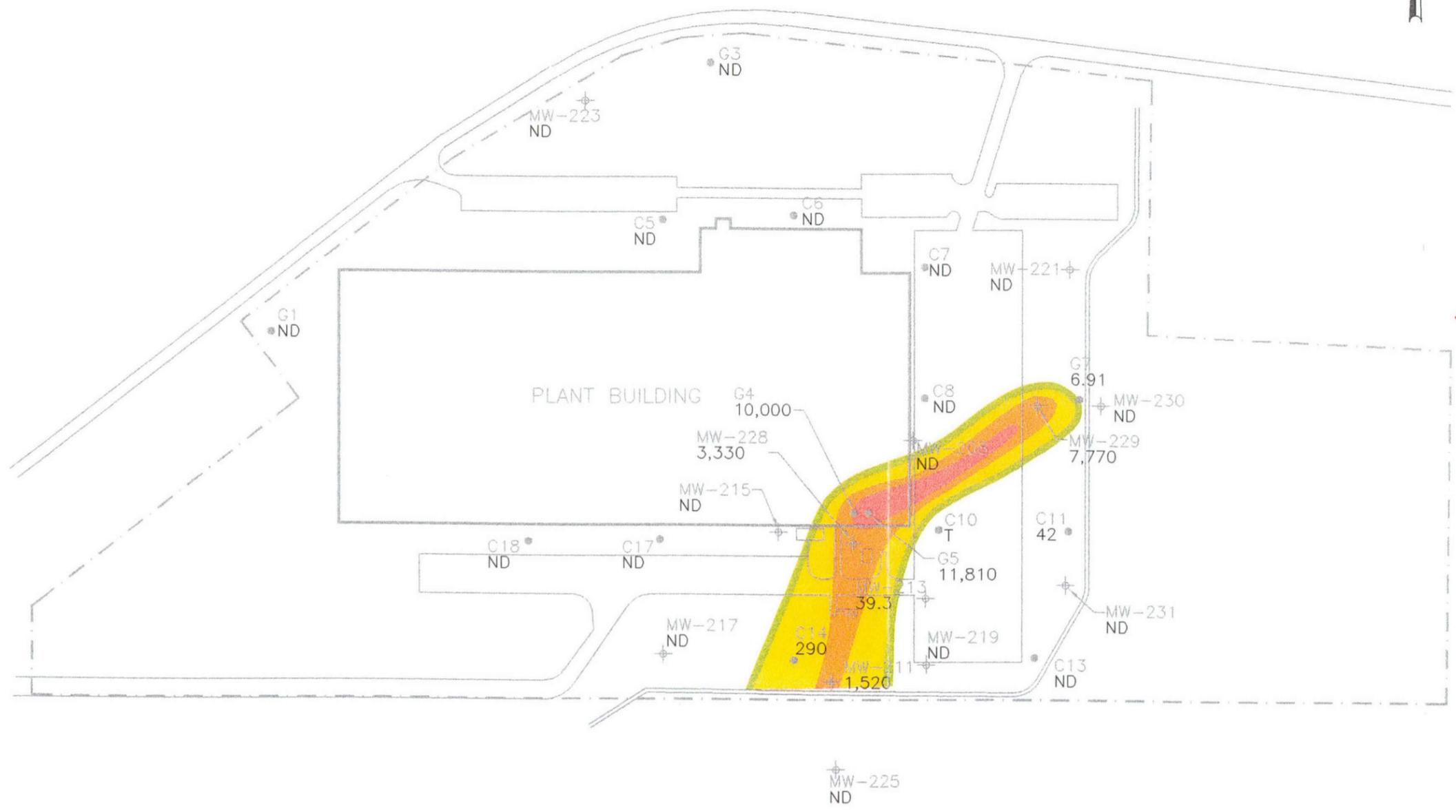
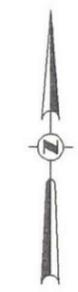
- C-1 Location Number
- Ground Surface Elevation
- 3.0 Top of Screen Depth
- 7.0 Bottom of Screen Depth
- ▼ Water Level Elevation
- Outer Contour Line Indicates Estimated Quantitation Limit of 5 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits



SCALE	AS SHOWN	DESIGNED BY	JN	DATE	30DEC98	DRAWING TITLE	Figure 1D. Approximate Distribution of Trichloroethene, E-E'		
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	30DEC98	Hamilton Beach & Proctor-Silex Inc.			
	<b>RADIAN INTERNATIONAL</b>	CHECKED BY	BPG	DATE	08JAN99	CONTRACT NO.	650138.0601	DRAWING NO.	TCE-EE
	A DAIKIN & MCCOY GROUP COMPANY	APPROVED BY		DATE		REV.			0

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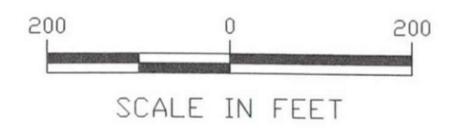


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- T Trace Concentration
- Outer Contour Line Indicates 2L Standard of 70 ug/L

**Color Key**

- <100 ppb
- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb



SCALE AS SHOWN	DESIGNED BY JN	DATE 28DEC98	DRAWING TITLE Figure 2A. Approximate Distribution of cis-1,2-Dichloroethene in Unit A Hamilton Beach Proctor Silex, Inc.
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF <b>RADIAN INTERNATIONAL</b> A DANZON & MCGEE GROUP COMPANY	DRAWN BY TSH	DATE 28DEC98	CONTRACT NO. 650138.0601
	CHECKED BY BPG	DATE 08JAN99	DRAWING NO. UNITA-CIS
	APPROVED BY	DATE	REV. 0

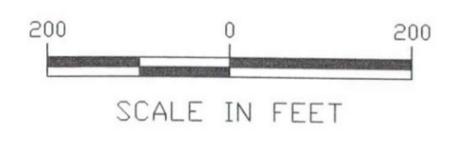


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- Outer Contour Line Indicates 2L Standard of 70 ug/L

**Color Key**

- <100 ppb
- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb



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 <small>A DANIEL &amp; JOHNSON GROUP COMPANY</small> <small>RESOUR TOWNE PARK, WEST GARDEN, CT 07093</small>	AS SHOWN	DESIGNED BY JN	DATE 28DEC98	DRAWING TITLE <b>Figure 2B.</b> Approximate Distribution of cis-1,2-Dichloroethene in Unit B Hamilton Beach & Proctor Silix, Inc.
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY TSH	DATE 28DEC98	
		CHECKED BY BPG	DATE 08JAN99	
		APPROVED BY	DATE	
		CONTRACT NO.	DRAWING NO.	REV.
		650138.0601	B-CIS	0

SOUTHWEST  
D

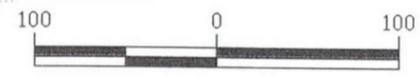
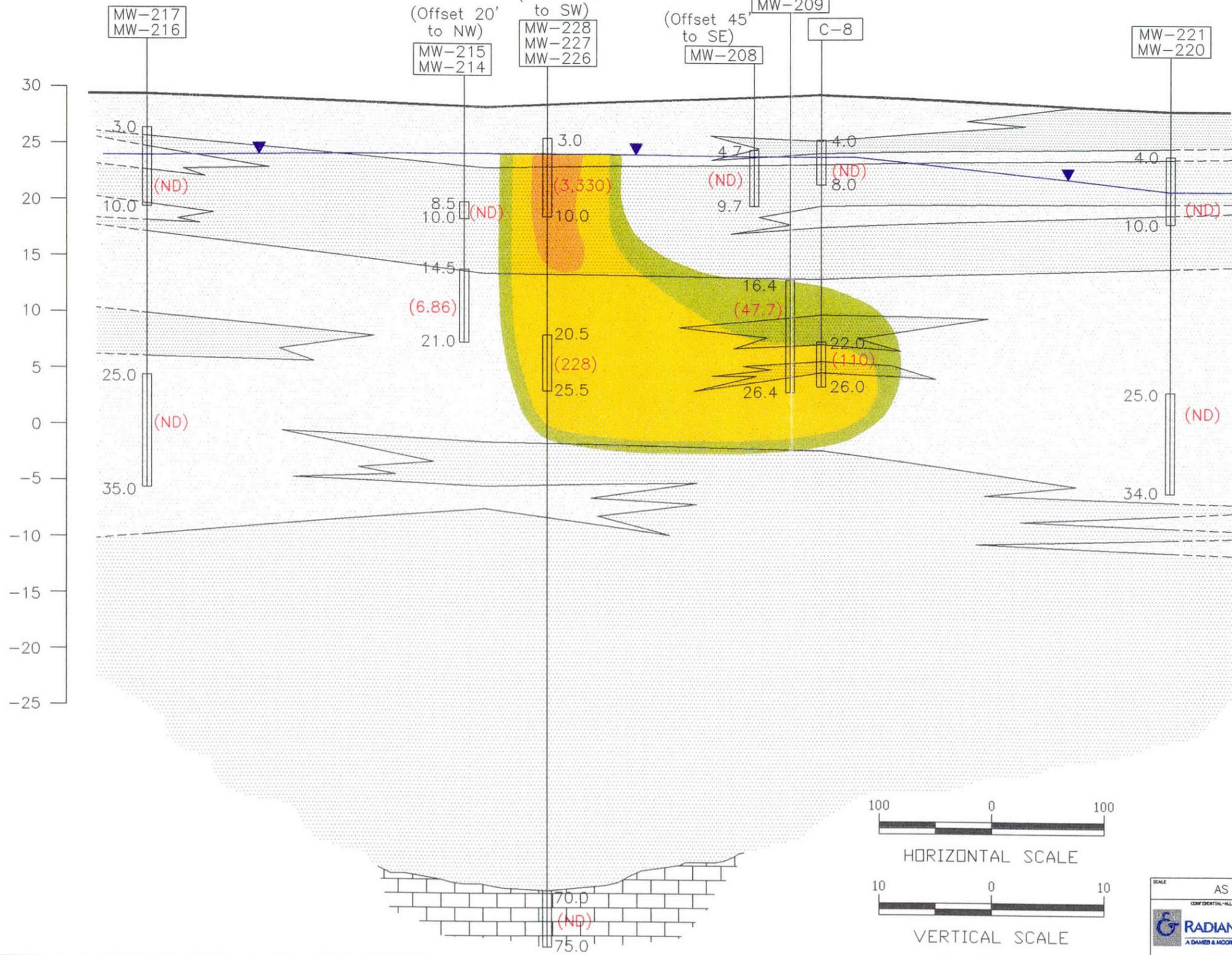
NORTHEAST  
D'

**LEGEND**

-  Location Number
-  Ground Surface
-  Top of Screen Depth
-  Bottom of Screen Depth
-  Water Level Elevation
-  Outer Contour Line Indicates 2L Standard of 70 ug/L
-  Dashed Line Indicates that Plume is Offset from Section Shown
-  Reported concentration in ug/L
-  Not Detected
-  Higher permeability deposits including Sand, Fine Sand, and Silty Sand
-  Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
-  Shell Limestone Deposits

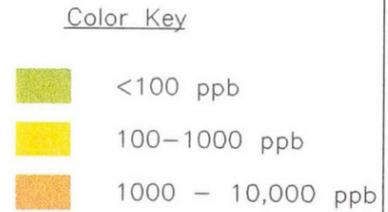
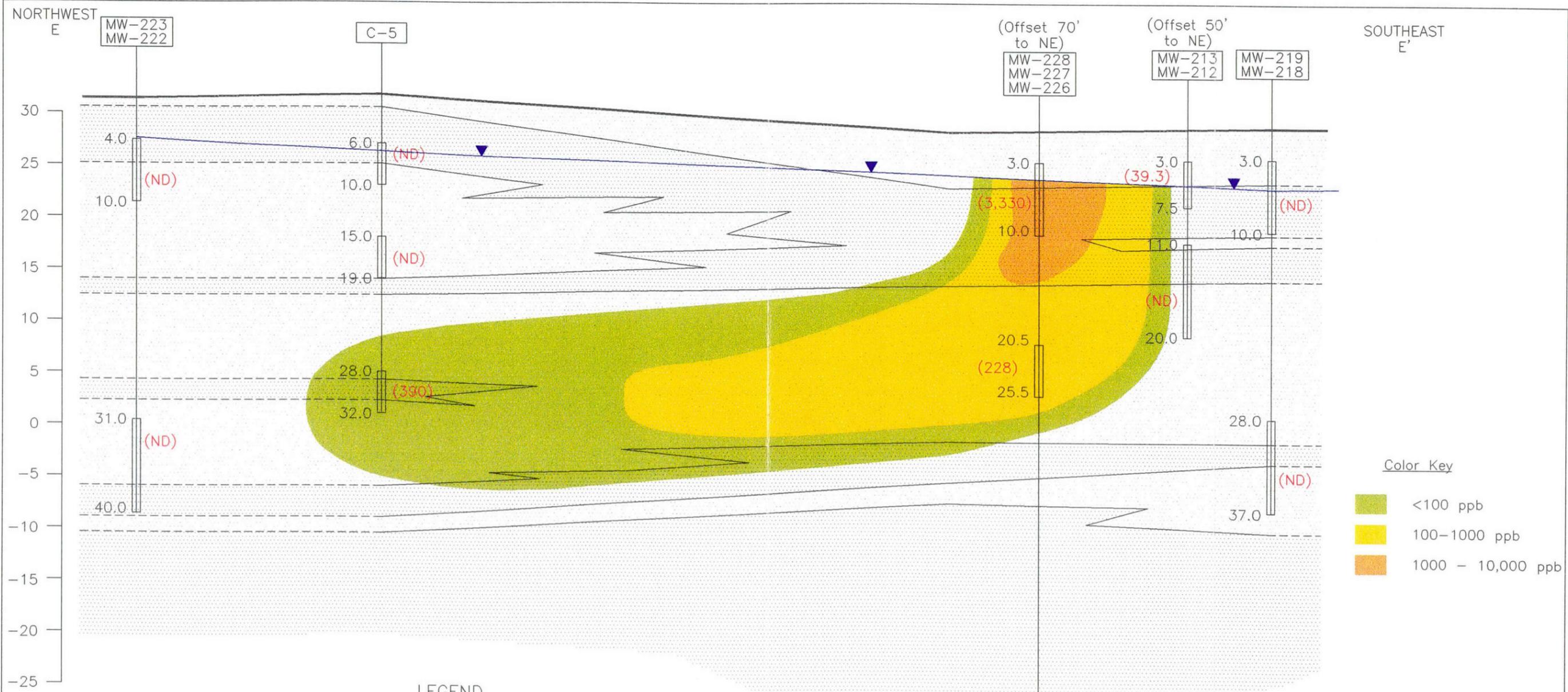
**Color Key**

-  <100 ppb
-  100-1000 ppb
-  1000 - 10,000 ppb



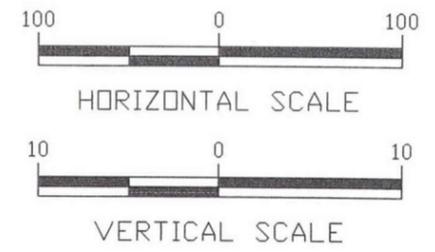
SCALE	AS SHOWN	DESIGNED BY	JN	DATE	29DEC98	DRAWING TITLE	Figure 2C. Approximate Distribution of cis-1,2-Dichloroethene, D-D' Hamilton Beach & Proctor-Sillex Inc.		
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	29DEC98				
		CHECKED BY	BPG	DATE	08JAN99				
	A DANIEL & JOHNSON GROUP COMPANY	APPROVED BY		DATE					
	RECORD SYMBOL INC. 1001 CAROLINA 2710					CONTRACT NO.	650138.0601	DRAWING NO.	CIS-DD
								REV.	0

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**LEGEND**

- C-1 Location Number
- Ground Surface Elevation
- Top of Screen Depth
- Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates 2L Standard of 70 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits



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SCALE	AS SHOWN	DESIGNED BY	JN	DATE	30DEC98	DRAWING TITLE	Figure 2D.
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	30DEC98	Approximate Distribution of cis-1,2-Dichloroethene, E-E'	
		CHECKED BY	BPG	DATE	08JAN99	Hamilton Beach & Proctor-Sillex Inc.	
	<small>© 1998 RADIANT INTERNATIONAL INC. 1770</small>	APPROVED BY		DATE		CONTRACT NO.	650138.0601
						DRAWING NO.	CIS-EE
						REV.	0

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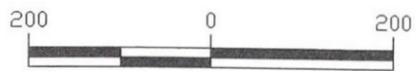


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- ⤵ Outer Contour Line Indicates 2L Standard of 7 ug/L

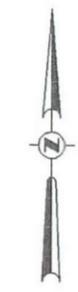
**Color Key**

- <100 ppb
- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb



SCALE IN FEET

SCALE AS SHOWN	DESIGNED BY JN	DATE 28DEC98	DRAWING TITLE Figure 3A. Approximate Distribution of 1,1-Dichloroethene in Unit A Hamilton Beach Proctor Sillex, Inc
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF <b>RADIAN INTERNATIONAL</b> A DANIEL & JOHNSON GROUP COMPANY	DRAWN BY TSH	DATE 28DEC98	
	CHECKED BY BPG	DATE 08JAN99	
	APPROVED BY	DATE	CONTRACT NO. 650138.0601
			DRAWING NO. UNITA-DCE
			REV. 0

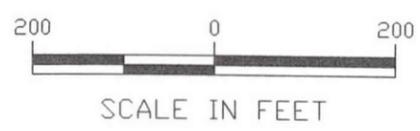


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- Outer Contour Line Indicates 2L Standard of 7 ug/L

**Color Key**

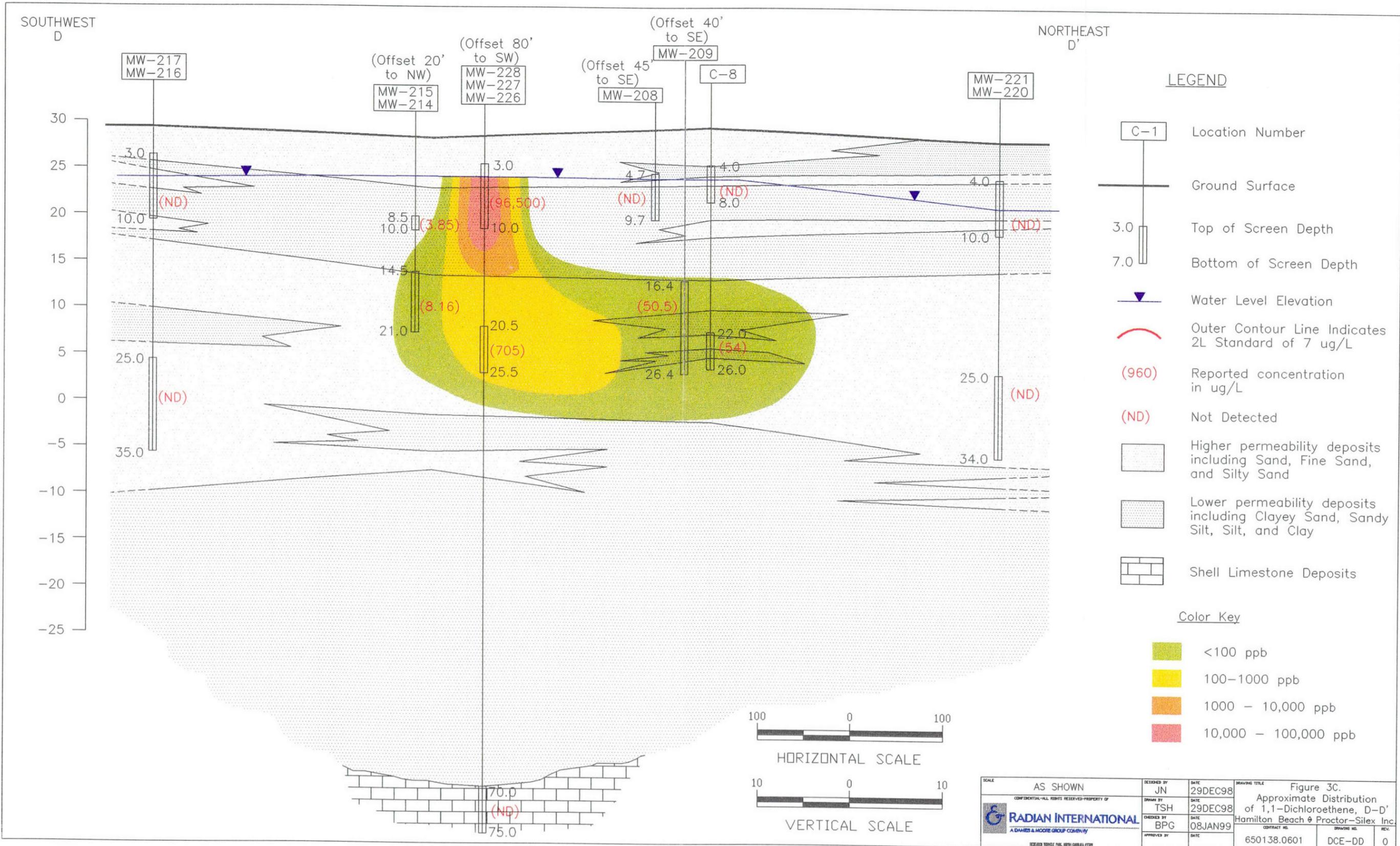
- <100 ppb
- 100-1000 ppb



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SCALE	AS SHOWN	DESIGNED BY	JN	DATE	28DEC98	DRAWING TITLE	Figure 3B. Approximate Distribution of 1,1-Dichloroethene in Unit B Hamilton Beach & Proctor Silex, Inc.
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	28DEC98		
	 <b>RADIAN INTERNATIONAL</b> A DANIEL & MCGEE GROUP COMPANY	CHECKED BY	BPG	DATE	08JAN99		
	DESIGNED BY: JN, DATE: 28DEC98	APPROVED BY		DATE		CONTRACT NO.	650138.0601
						DRAWING NO.	B-11DCE
						REV.	0

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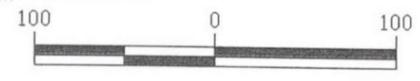


**LEGEND**

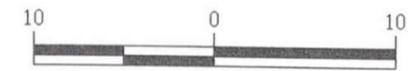
- C-1 Location Number
- Ground Surface
- 3.0 Top of Screen Depth
- 7.0 Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates 2L Standard of 7 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits

**Color Key**

- <100 ppb
- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb

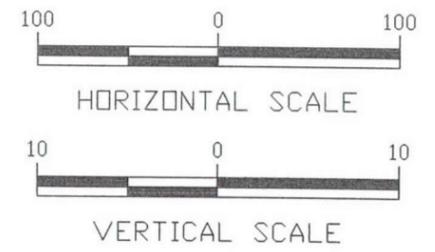
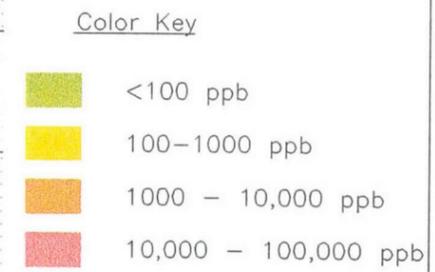
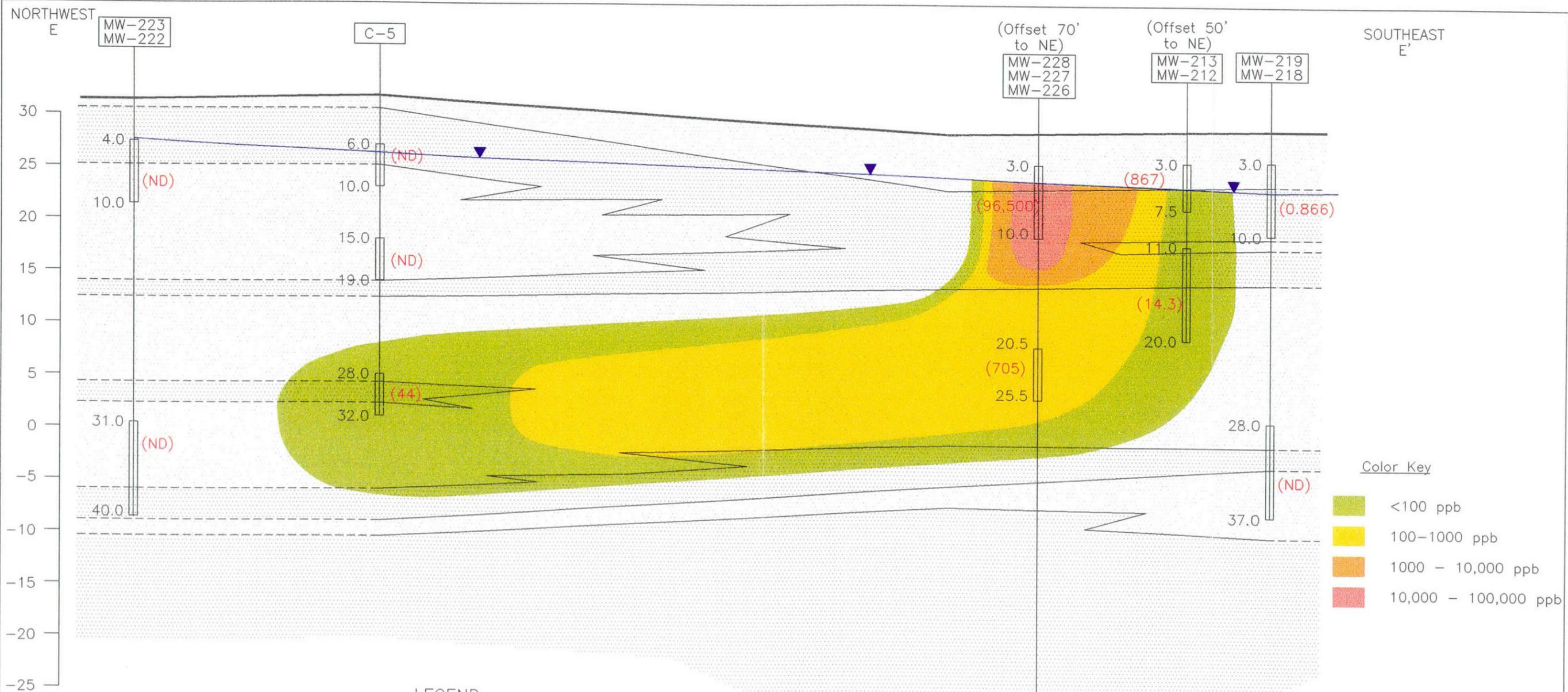


HORIZONTAL SCALE



VERTICAL SCALE

SCALE	AS SHOWN	DESIGNED BY	JN	DATE	29DEC98	DRAWING TITLE	Figure 3C. Approximate Distribution of 1,1-Dichloroethene, D-D'		
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	29DEC98	Hamilton Beach & Proctor-Sillex Inc.			
		CHECKED BY	BPG	DATE	08JAN99	CONTRACT NO.	650138.0601	DRAWING NO.	DCE-DD
	<small>REVISION TABLE FOR THIS DRAWING</small>	APPROVED BY		DATE				REV.	0



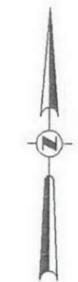
D:\HBPS\WASHINGTON\DCE-EE\30DEC98

**LEGEND**

	Location Number		Higher permeability deposits including Sand, Fine Sand, and Silty Sand
	Ground Surface Elevation		Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
	Top of Screen Depth		Shell Limestone Deposits
	Bottom of Screen Depth		Outer Contour Line Indicates 2L Standard of 7 ug/L
	Water Level Elevation		Reported concentration in ug/L
			Not Detected

SCALE		AS SHOWN		DESIGNED BY	JN	DATE	30DEC98	DRAWING TITLE Figure 3D. Approximate Distribution of 1,1-Dichloroethene, E-E' Hamilton Beach & Proctor-Sillex Inc.	
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF		RADIANT INTERNATIONAL		DRAWN BY	TSH	DATE	30DEC98		
A DAVENPORT & MOORE GROUP COMPANY		RADIANT INTERNATIONAL		CHECKED BY	BPG	DATE	08JAN99		
RADIANT TOOLS INC. 8001 ORIGIN 1700		RADIANT TOOLS INC. 8001 ORIGIN 1700		APPROVED BY		DATE			
				CONTRACT NO.	650138.0601	DESIGNED NO.	DCE-EE	REV.	0



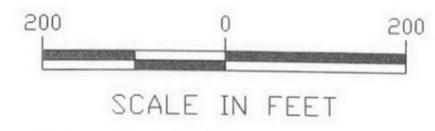
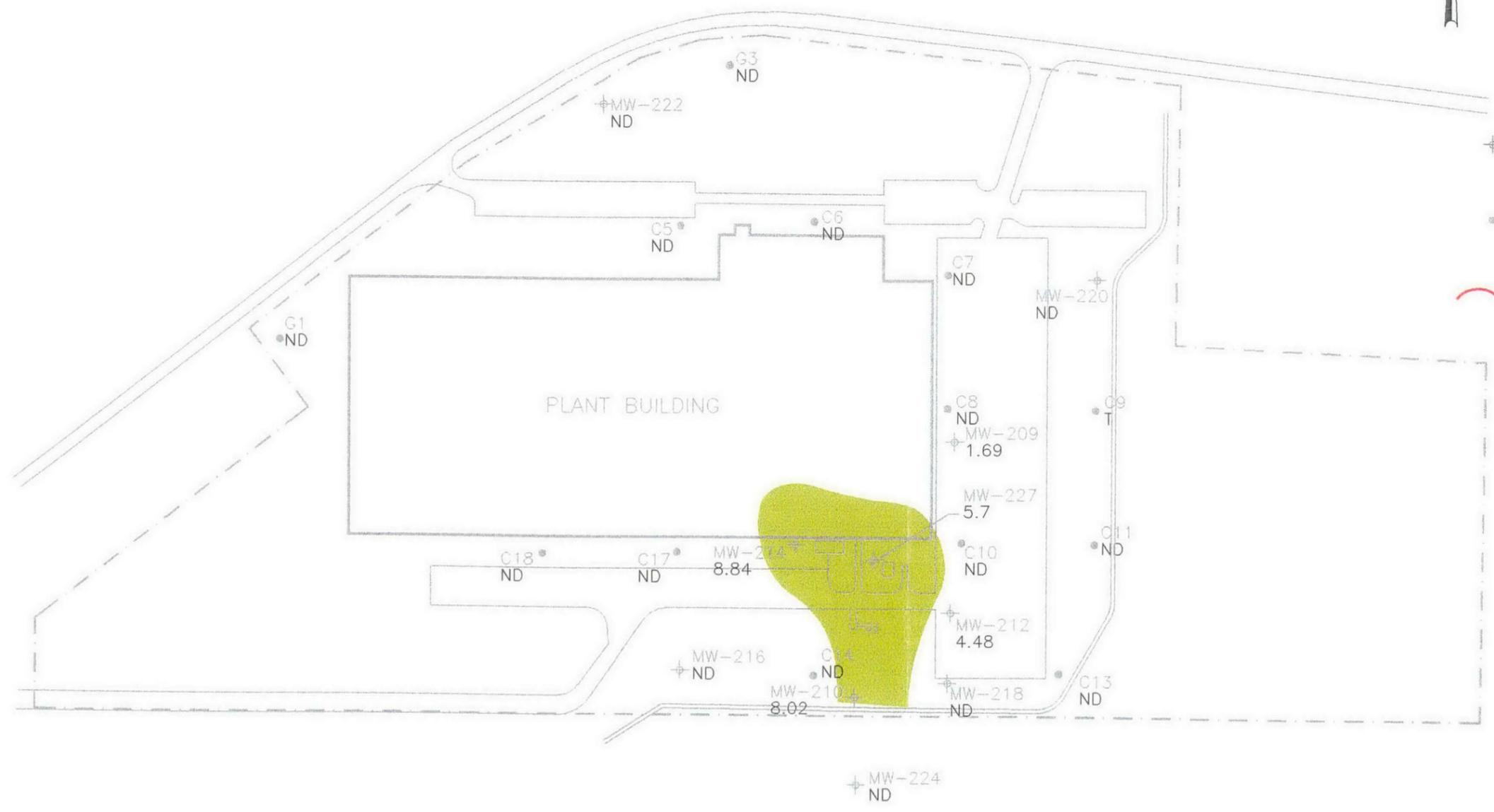


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- Outer Contour Line Indicates Estimated Quantitation Limit of 5 ug/L

**Color Key**

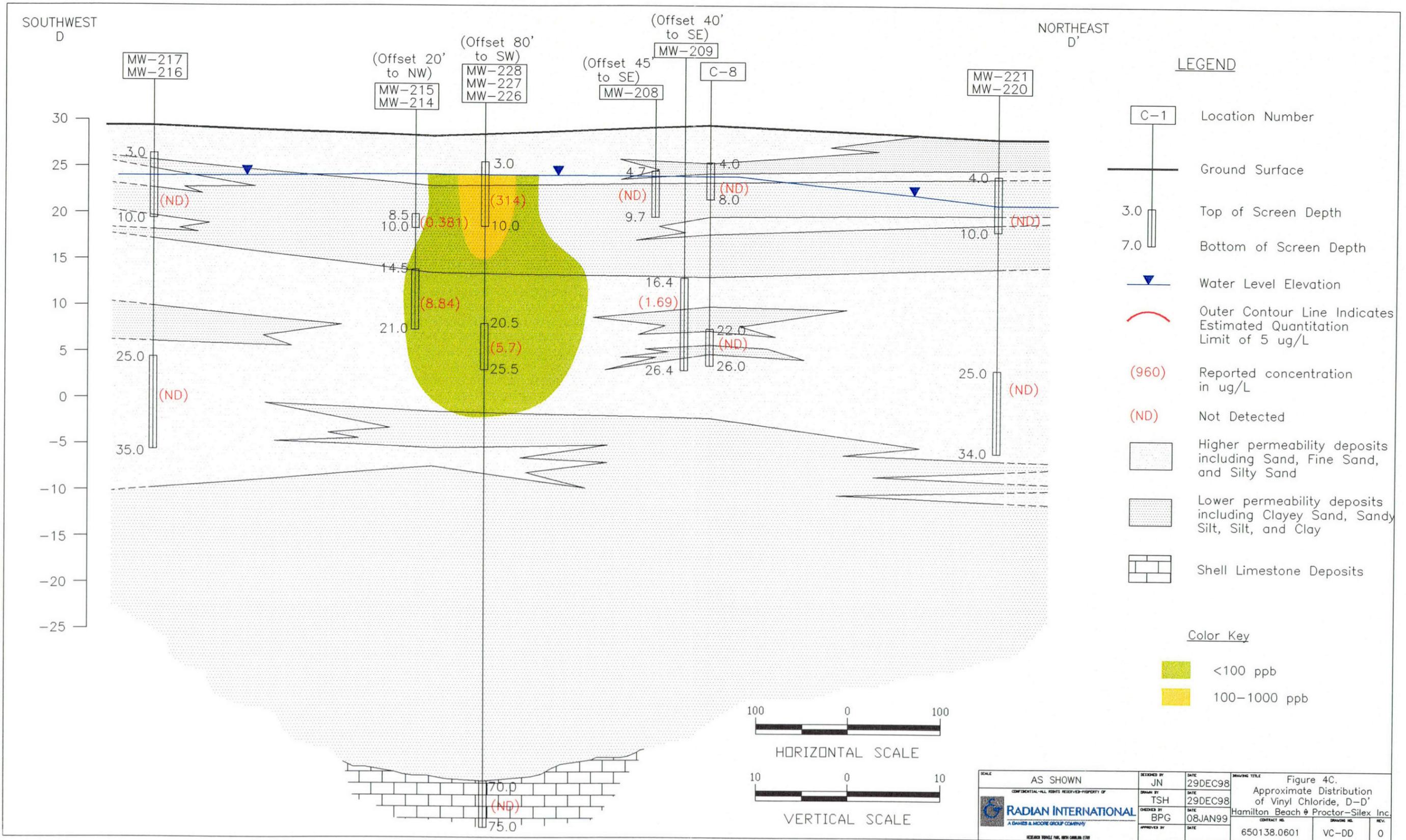
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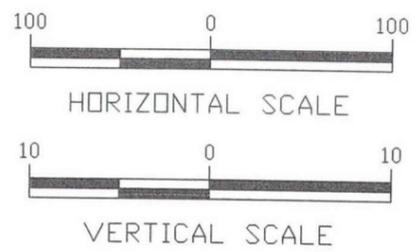
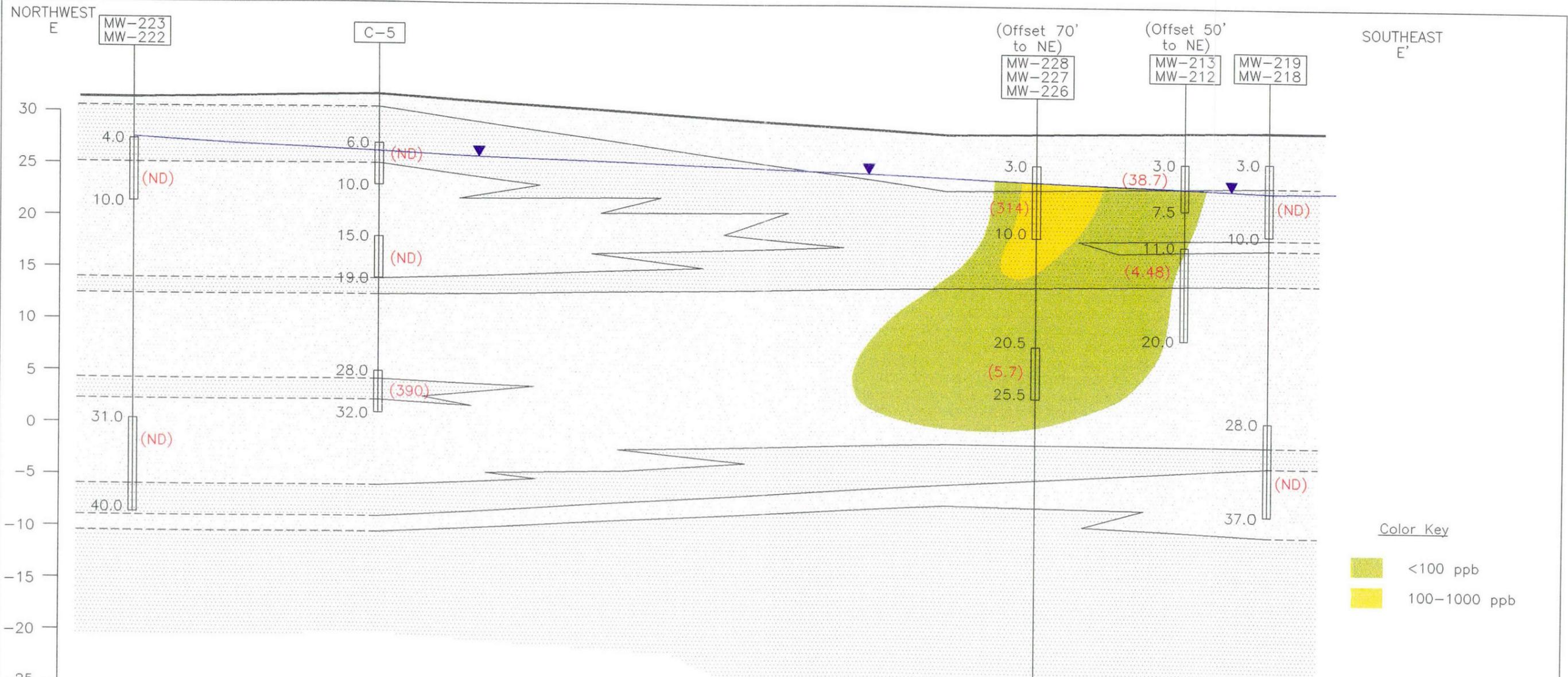


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SCALE	AS SHOWN	DESIGNED BY	JN	DATE	28DEC98	DRAWING TITLE	Figure 4B. Approximate Distribution of Vinyl Chloride in Unit B Hamilton Beach & Proctor Sillex, Inc.		
	CONFIDENTIAL-ALL RIGHTS RESERVED PROPERTY OF	DRAWN BY	TSH	DATE	28DEC98				
	 <b>RADIAN INTERNATIONAL</b>	CHECKED BY	BPG	DATE	08JAN99				
	A DANIEL & JOHNSON GROUP COMPANY	APPROVED BY		DATE					
	REVISED TO: 1/15/99 (L&E) (7/99)					CONTRACT NO.	650138.0601	DRAWING NO.	B-VC
						REV.			0

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LEGEND

- C-1 Location Number
- Ground Surface Elevation
- Top of Screen Depth
- Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates Estimated Quantitation Limit of 5 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits

SCALE	AS SHOWN	DESIGNED BY	JN	DATE	30DEC98	DRAWING TITLE	Figure 4D. Approximate Distribution of Vinyl Chloride, E-E'
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	30DEC98		Hamilton Beach & Proctor-Sillex Inc.
	RADIANT INTERNATIONAL	CHECKED BY	BPG	DATE	08JAN99		
	A DAMON & MOORE GROUP COMPANY	APPROVED BY		DATE			
	SEARCH TABLE FILE: 8074 G0101 (7/9)					CONTRACT NO.	650138.0601
						DRAWING NO.	VC-EE
						REV.	0

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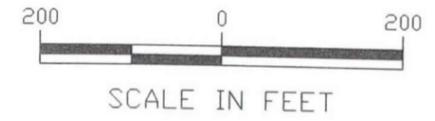
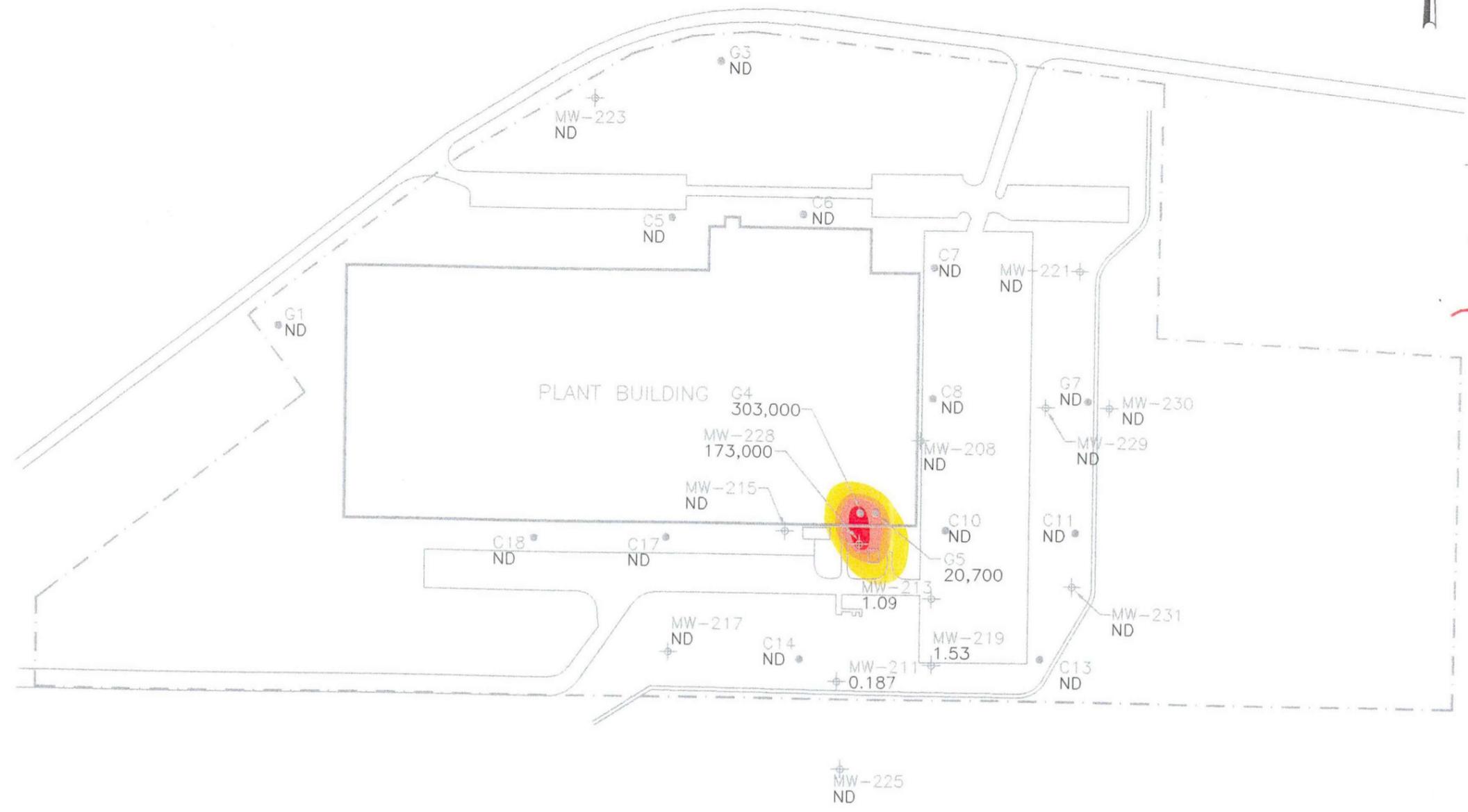


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- Outer Contour Line Indicates 2L Standard of 200 ug/L

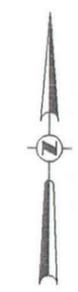
**Color Key**

- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb
- >100,000 ppb



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SCALE AS SHOWN	DESIGNED BY JN	DATE 28DEC98	DRAWING TITLE Figure 5A. Approximate Distribution of 1,1,1-Trichloroethane in Unit A Hamilton Beach & Proctor Silex, Inc	
CONFIDENTIAL - ALL RIGHTS RESERVED PROPERTY OF <b>RADIAN INTERNATIONAL</b> A DOW AND MOORE GROUP COMPANY	DRAWN BY TSH	DATE 28DEC98	CONTRACT NO. 650138.0601	DRAWING NO. UNITA-TCA
	CHECKED BY BPG	DATE 08JAN99	REV. 0	
	APPROVED BY	DATE		

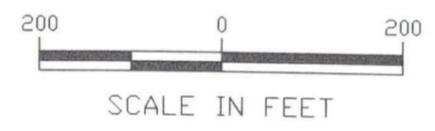
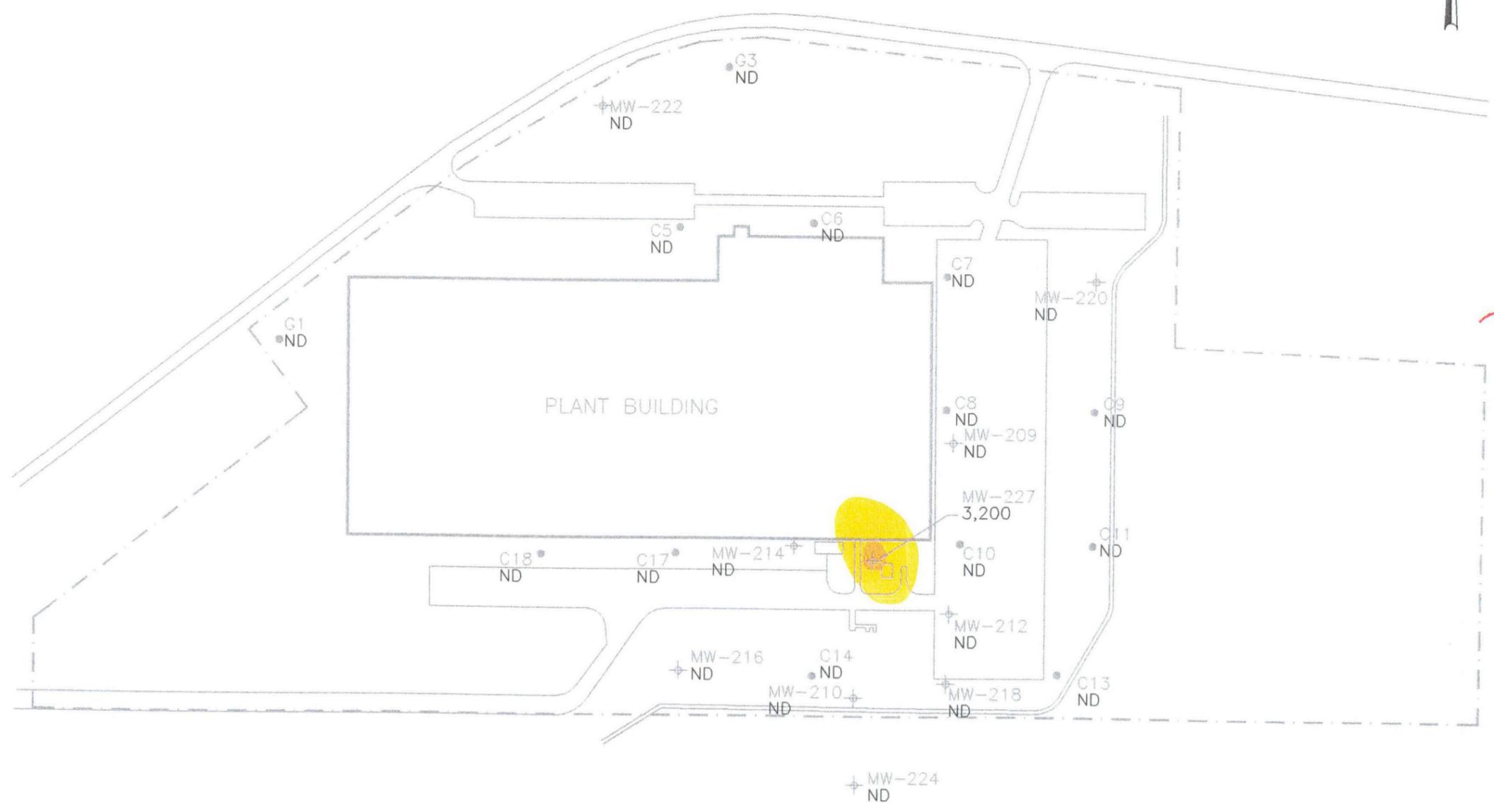


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- Outer Contour Line Indicates 2L Standard of 200 ug/L

**Color Key**

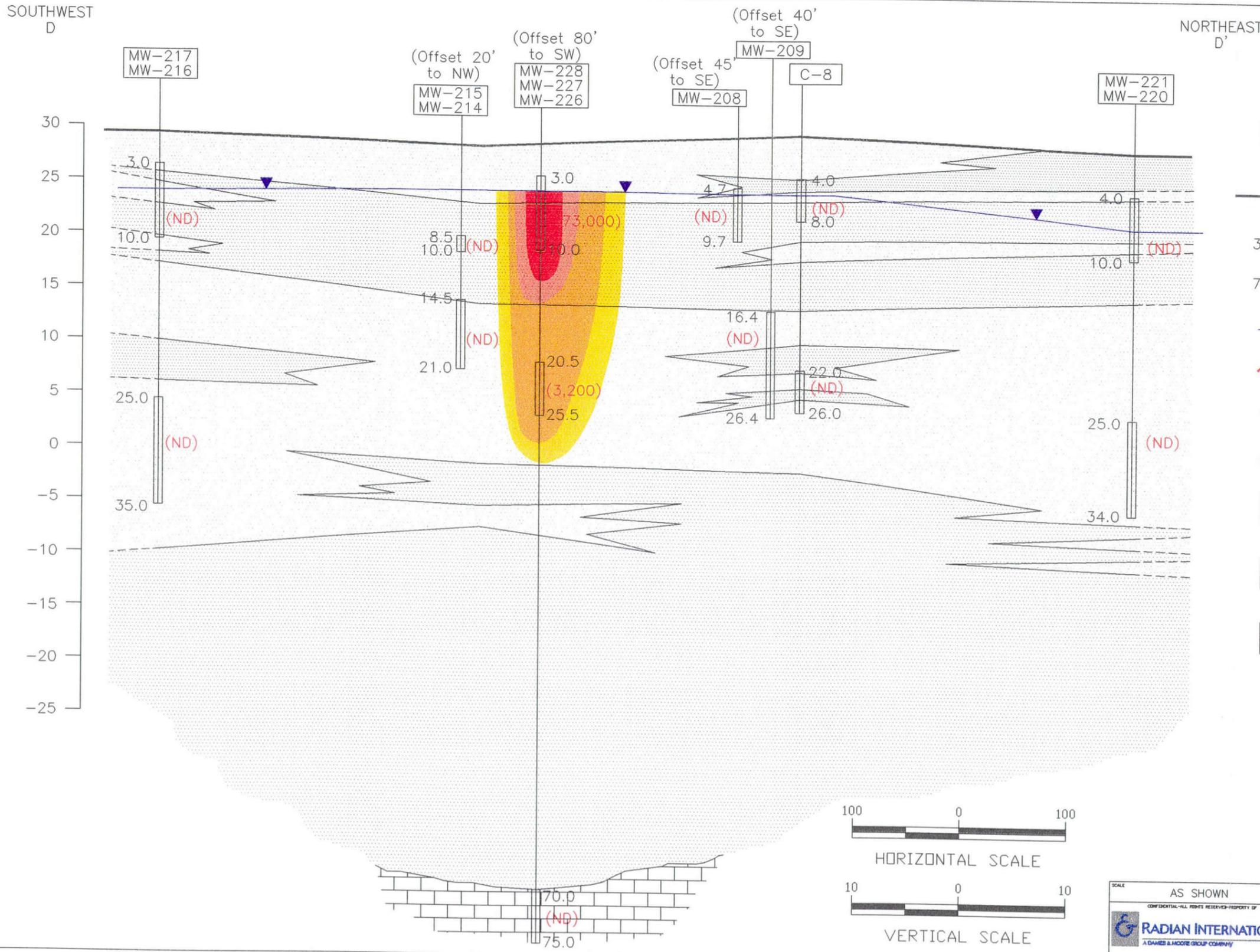
- 100-1000 ppb
- 1000 - 10,000 ppb



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SCALE AS SHOWN	DESIGNED BY JN	DATE 28DEC98	DRAWING TITLE Figure 5B. Approximate Distribution 1,1,1-Trichloroethane in Unit B Hamilton Beach & Proctor Silex, Inc
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF <b>RADIAN INTERNATIONAL</b> A DAMAS & MOORE GROUP COMPANY	DRAWN BY TSH	DATE 28DEC98	
	CHECKED BY BPG	DATE 08JAN99	
	APPROVED BY	DATE	CONTRACT NO. 650138.0601
			DRAWING NO. B-TCA
			REV. 0

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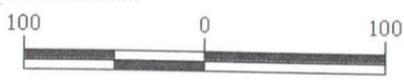


**LEGEND**

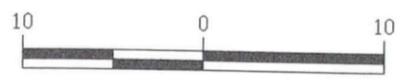
- C-1 Location Number
- Ground Surface
- 3.0 Top of Screen Depth
- 7.0 Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates 2L Standard of 200 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits

**Color Key**

- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb
- >100,000 ppb

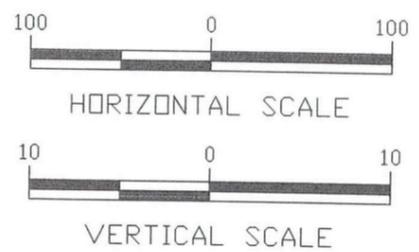
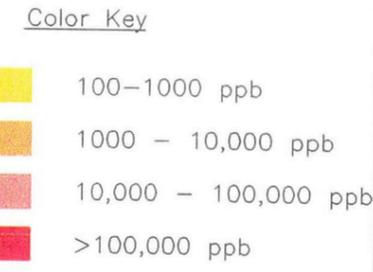
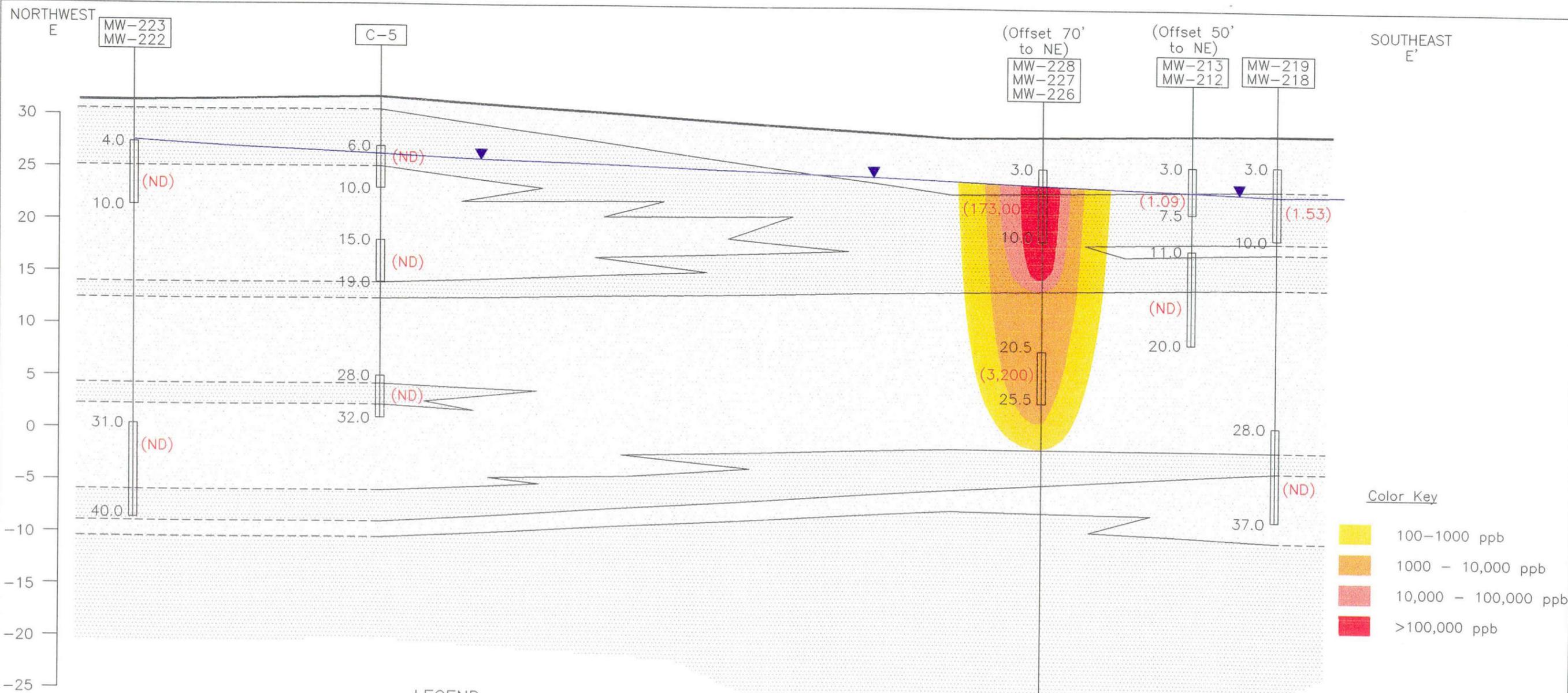


HORIZONTAL SCALE



VERTICAL SCALE

SCALE AS SHOWN	DESIGNED BY JN	DATE 29DEC98	DRAWING TITLE Figure 5C. Approximate Distribution of 1,1,1-Trichloroethane, D-D'
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF <b>RADIAN INTERNATIONAL</b> A CHAMBER & MCKAY GROUP COMPANY	DRAWN BY TSH	DATE 29DEC98	Hamilton Beach & Proctor-Silex Inc.
	CHECKED BY BPG	DATE 08JAN99	CONTRACT NO. 650138.0601
	APPROVED BY	DATE	DRAWING NO. TCA-DD
			REV. 0



**LEGEND**

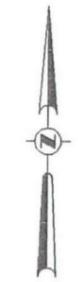
- C-1 Location Number
- Ground Surface Elevation
- Top of Screen Depth
- Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates 2L Standard of 200 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits

SCALE AS SHOWN		DESIGNED BY JN	DATE 30DEC98	DRAWING TITLE Figure 5D. Approximate Distribution of 1,1,1-Trichloroethane, E-E' Hamilton Beach & Proctor-Sillex Inc.
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF RADIANT INTERNATIONAL A DANAHER & MCCORMICK GROUP COMPANY		DRAWN BY TSH	DATE 30DEC98	
		CHECKED BY BPG	DATE 08JAN99	CONTRACT NO. 650138.0601
		APPROVED BY	DATE	DRAWING NO. TCA-EE
				REV. 0

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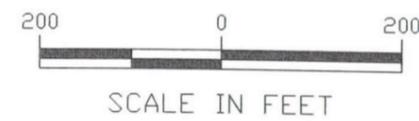


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- ⋄ Outer Contour Line Indicates Estimated Quantitation Limit of 5 ug/L

**Color Key**

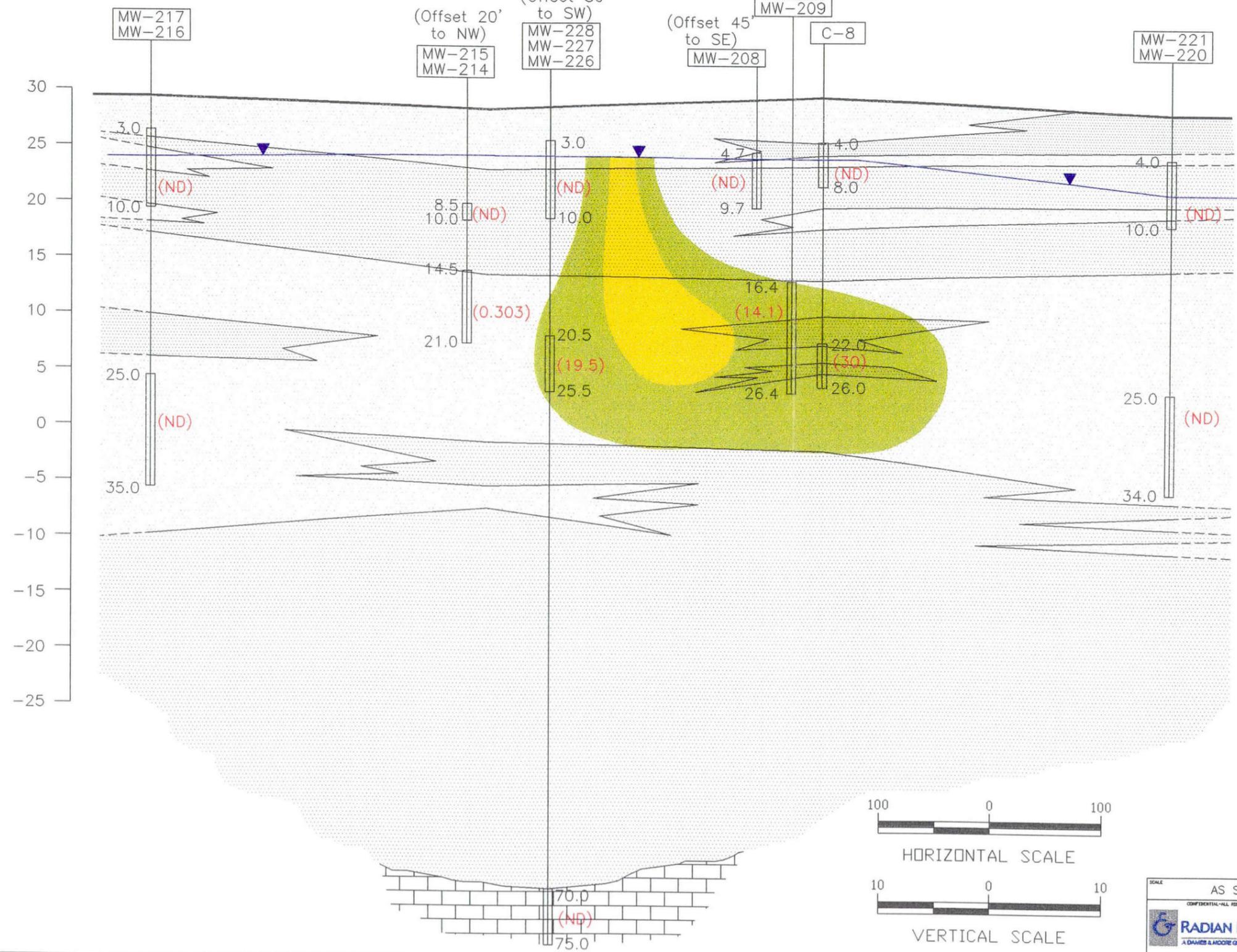
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SCALE AS SHOWN	DESIGNED BY JN	DATE 28DEC98	DRAWING TITLE Figure 6B. Approximate Distribution of 1,2-Dichloroethane in Unit B Hamilton Beach & Proctor Silex, Inc.
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY TSH	DATE 28DEC98	
<b>RADIAN INTERNATIONAL</b> A DANVERS & MOORE GROUP COMPANY	CHECKED BY BPG	DATE 28DEC98	
REVISIONS: 01/98 (REV. 01/98)	APPROVED BY	DATE	CONTRACT NO. 650138.0601
			DRAWING NO. B-12DCA
			REV. 0

SOUTHWEST  
D

NORTHEAST  
D'



LEGEND

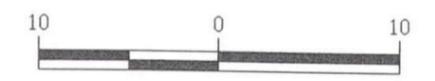
- C-1 Location Number
- Ground Surface
- 3.0 Top of Screen Depth
- 7.0 Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates Estimated Quantitation Limit of 5 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits

Color Key

- <100 ppb
- 100-1000 ppb



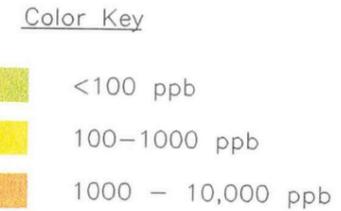
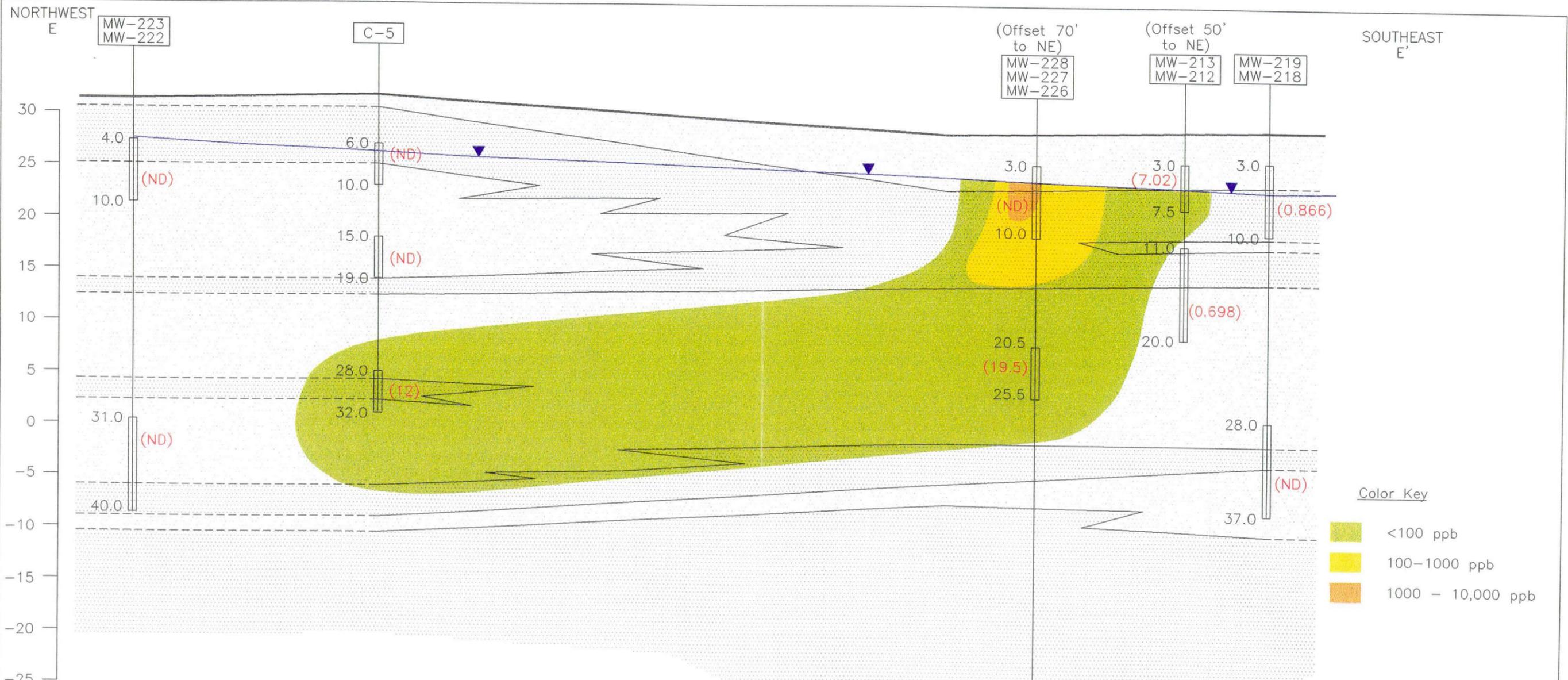
HORIZONTAL SCALE



VERTICAL SCALE

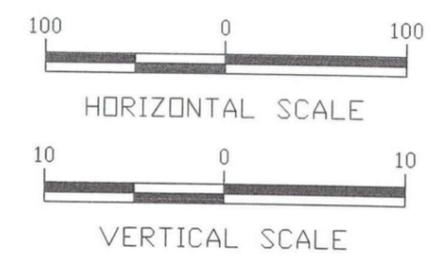
D:\HBPS\WASHINGTON\12DCA-DD\31DEC98

SCALE AS SHOWN	DESIGNED BY JN	DATE 29DEC98	DRAWING TITLE Figure 6C. Approximate Distribution of 1,2-Dichloroethane, D-D' Hamilton Beach & Proctor-Sillex Inc.
CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF <b>RADIAN INTERNATIONAL</b> A DAIHAR & ANDRE GROUP COMPANY	DRAWN BY TSH	DATE 29DEC98	CONTRACT NO. 650138.0601
	CHECKED BY BPG	DATE 08JAN99	DRAWING NO. 12DCA-DD
	APPROVED BY	DATE	REV. 0



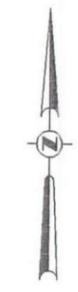
**LEGEND**

- C-1 Location Number
- Ground Surface Elevation
- Top of Screen Depth
- Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates Estimated Quantitation Limit of 5 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits



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SCALE	AS SHOWN	DESIGNED BY	JN	DATE	30DEC98	DRAWING TITLE	Figure 6D.
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	30DEC98	Approximate Distribution of 1,2-Dichloroethane, E-E' Hamilton Beach & Proctor-Silex, Inc.	
	RADIANT INTERNATIONAL	CHECKED BY	BPG	DATE	08JAN99	CONTRACT NO.	650138.0601
	A CHAMBER & MCGREW GROUP COMPANY	APPROVED BY		DATE		DRAWING NO.	12DCA-EE
	RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709					REV.	0

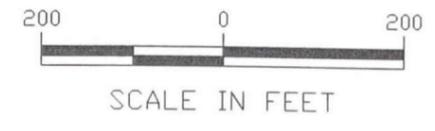
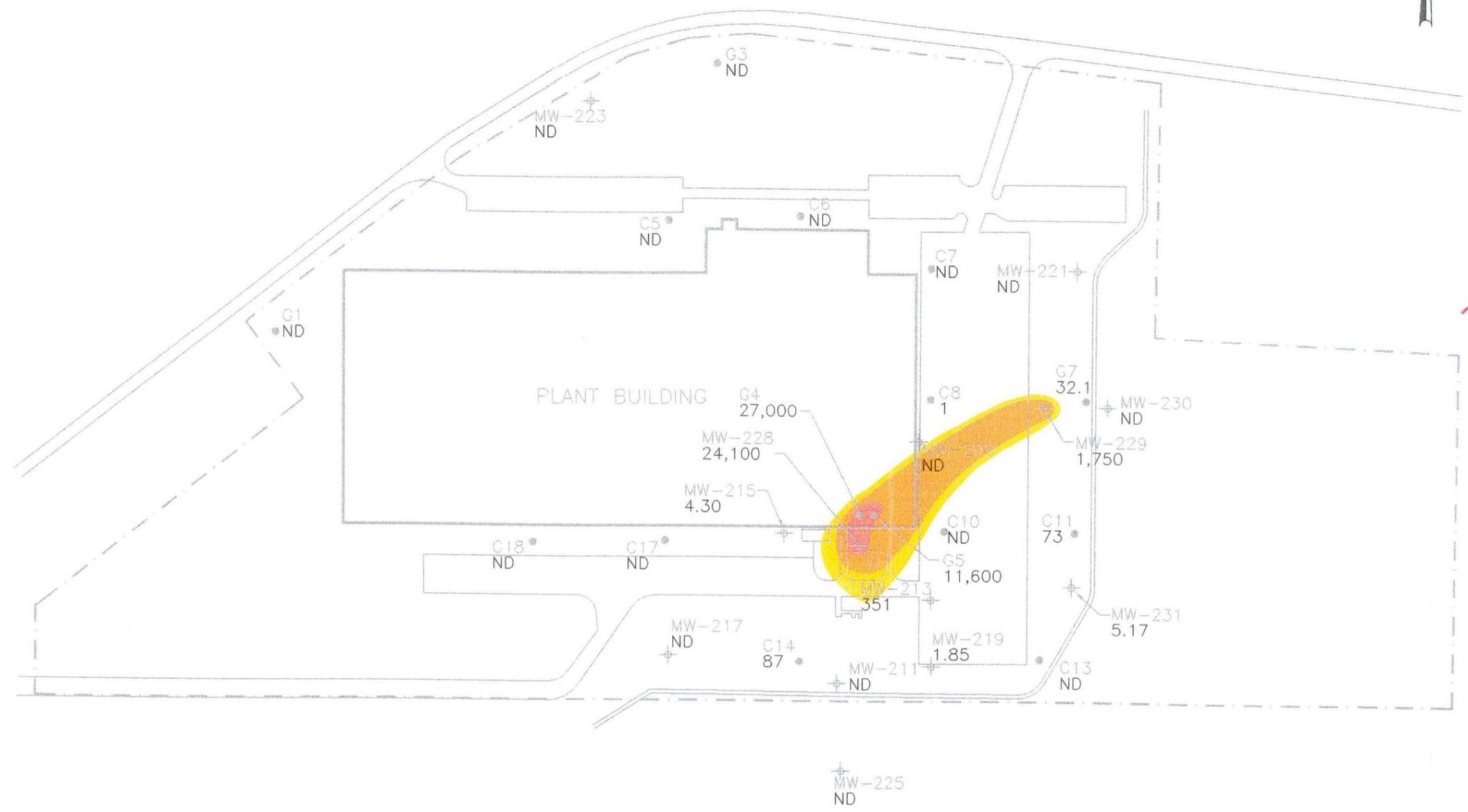


**LEGEND**

- ⊕ Monitoring Well Location and Reported Concentration in ug/L (Nov. 1998)
- Groundwater Screening Location and Reported Concentration in ug/L (Various Dates)
- Outer Contour Line Indicates 2L Standard of 700 ug/L

**Color Key**

- 100-1000 ppb
- 1000 - 10,000 ppb
- 10,000 - 100,000 ppb

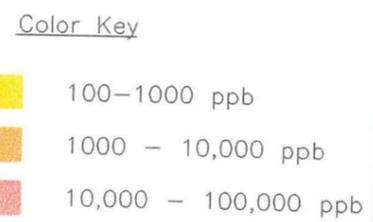
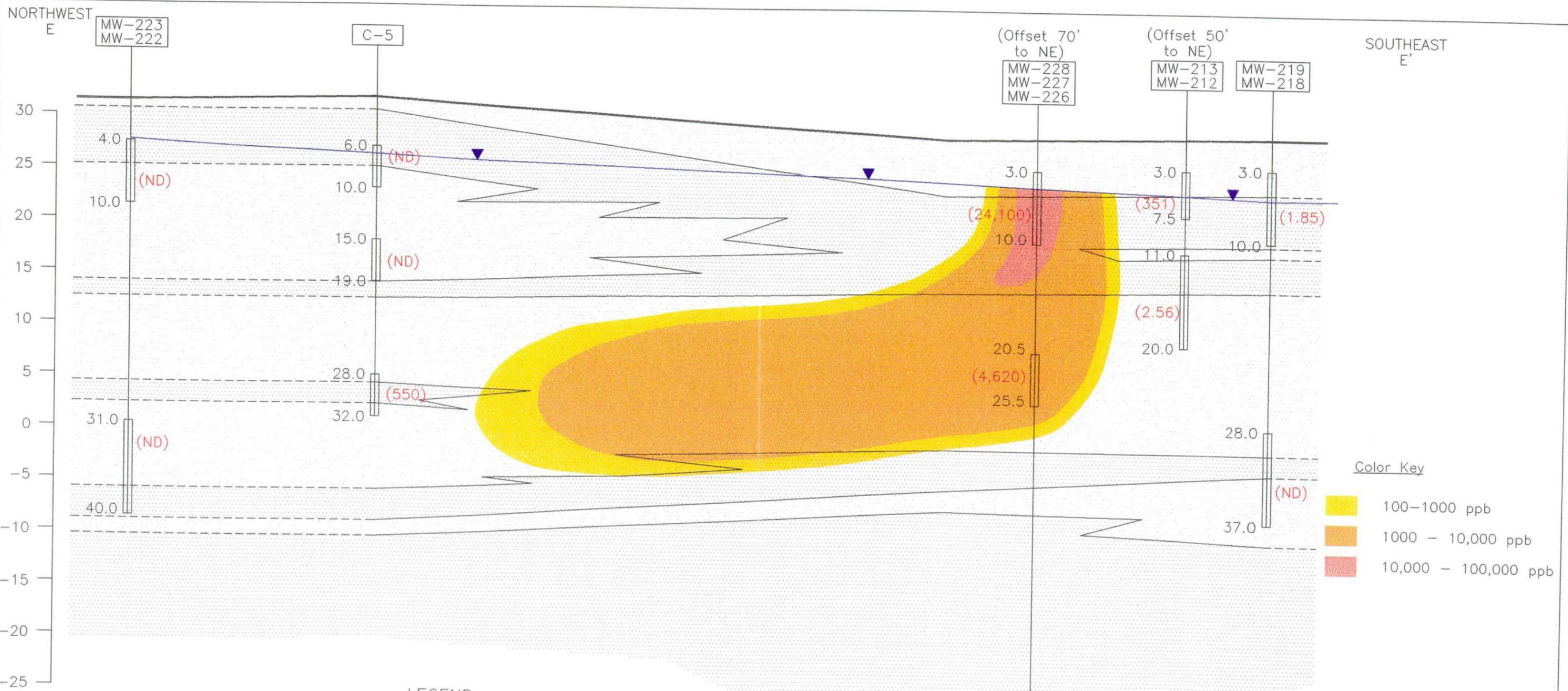


SCALE	AS SHOWN	DESIGNED BY	JN	DATE	28DEC98	DRAWING TITLE	Figure 7A. Approximate Distribution of 1,1-Dichloroethane in Unit A Hamilton Beach & Proctor Silex, Inc		
	CONFIDENTIAL-ALL RIGHTS RESERVED-PROPERTY OF	DRAWN BY	TSH	DATE	28DEC98				
	 <b>RADIAN INTERNATIONAL</b> A DANES & MOORE GROUP COMPANY	CHECKED BY	BPG	DATE	08JAN99				
	REVISION SYMBOL AND DESCRIPTION	APPROVED BY		DATE		CONTRACT NO.	650138.0601	DRAWING NO.	A-11DCA
									REV. 0

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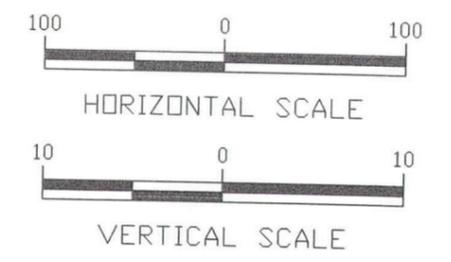
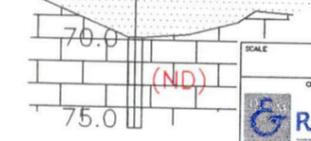






**LEGEND**

- C-1** Location Number
- Ground Surface Elevation
- 3.0 Top of Screen Depth
- 7.0 Bottom of Screen Depth
- Water Level Elevation
- Outer Contour Line Indicates 2L Standard of 700 ug/L
- (960) Reported concentration in ug/L
- (ND) Not Detected
- Higher permeability deposits including Sand, Fine Sand, and Silty Sand
- Lower permeability deposits including Clayey Sand, Sandy Silt, Silt, and Clay
- Shell Limestone Deposits



AS SHOWN	DESIGNED BY JN	DATE 30DEC98	DRAWING TITLE Figure 7D. Approximate Distribution of 1,1-Dichloroethane, E-E' Hamilton Beach & Proctor-Sillex Inc.
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<b>RADIAN INTERNATIONAL</b> A DANIELS & MCCREY GROUP COMPANY	CHECKED BY BPG	DATE 08JAN99	
SEARCH TABLE FILE: 8881 (08/01/97)	APPROVED BY	DATE	
			CONTRACT NO. 650138.0601
			DRAWING NO. DCA-EE
			REV. 0

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Constituent	Groundwater Standard (ug/L)
Benzene	1
Ethylbenzene	29
Napthalene	21
Toluene	1000
1,2,4-Trimethylbenzene (TMB)	350
Xylenes	530

Constituents not listed at a sampling point were not detected.

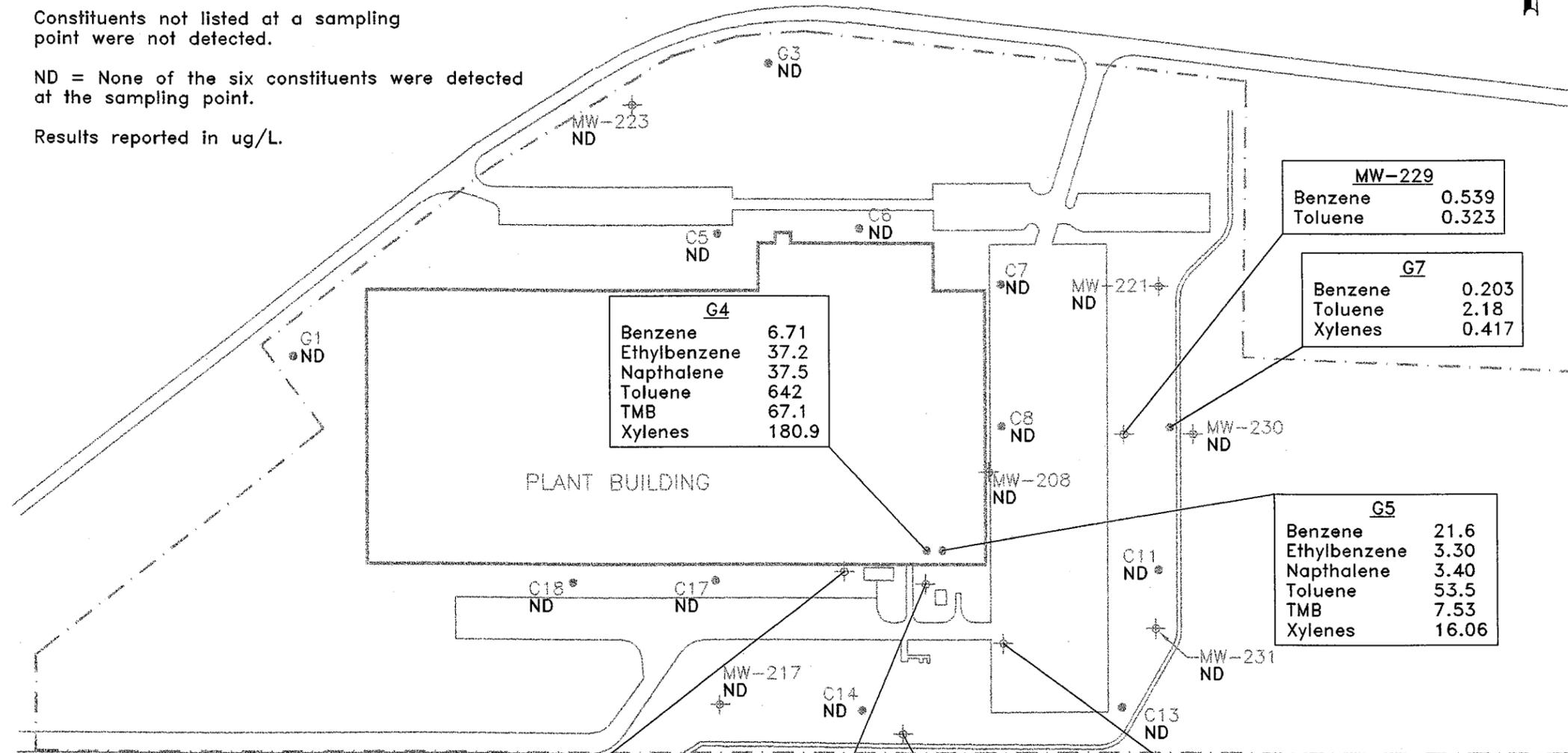
ND = None of the six constituents were detected at the sampling point.

Results reported in ug/L.



**LEGEND**

- ⊕ Monitoring Well Location (November 1998)
- ⊙ Groundwater Screening Location (Various Dates)



**G4**

Benzene	6.71
Ethylbenzene	37.2
Napthalene	37.5
Toluene	642
TMB	67.1
Xylenes	180.9

**MW-229**

Benzene	0.539
Toluene	0.323

**G7**

Benzene	0.203
Toluene	2.18
Xylenes	0.417

**G5**

Benzene	21.6
Ethylbenzene	3.30
Napthalene	3.40
Toluene	53.5
TMB	7.53
Xylenes	16.06

**MW-215**

Benzene	0.0963
Ethylbenzene	0.0601
Xylenes	0.0885

**MW-228**

Benzene	51.3
Ethylbenzene	544
Napthalene	608
Toluene	1,460
TMB	1,270
Xylenes	2,870

**MW-211**

Toluene	15.6
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**MW-213**

Benzene	0.724
Ethylbenzene	2.03
Napthalene	15.7
Toluene	1.48
Xylenes	5.0



SCALE IN FEET

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SCALE	AS SHOWN	DESIGNED BY	DATE	DRAWING TITLE
		DRWN BY	DATE	Figure 8. Approximate Distribution of Petroleum Constituents in Unit A Hamilton Beach Proctor Silex, Inc.
		CHECKED BY	DATE	
		APPROVED BY	DATE	
<b>RADIAN INTERNATIONAL</b> <small>A DANBARD &amp; MOORE GROUP COMPANY</small>		CONTRACT NO.	DRAWING NO.	REV.
		650138.0701	UNITA-PETR	0