

# SECOR

International Incorporated

May 19, 1998

Mr. David Keil  
Camp Dresser & McKee  
100 Crossways Park West Drive, Suite 415  
Woodbury, New York 11797

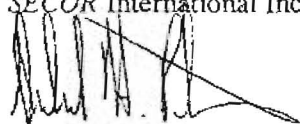
RE: Revised *In-situ* Oxidation Pilot Test Work Plan  
25 Melville Park Road, Melville, New York

Dear Mr. Keil:

Please find enclosed the Revised *In-situ* Oxidation Pilot Test Work Plan dated May 19, 1998 for the referenced site.

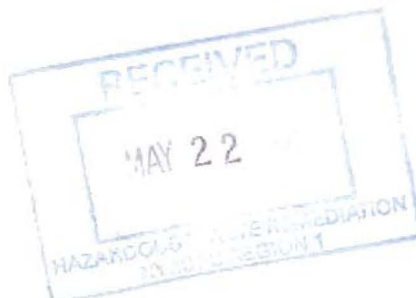
If you any questions or require additional information, please contact me or Mark Timmons at (609) 259-6424.

Sincerely,  
SECOR International Incorporated



Richard H. Peterec, P.E.

c: Shawn O'Hara, Archon Group



FINAL

Revised *In-situ* Oxidation Pilot Test Work Plan  
25 Melville Park Road  
Melville, New York

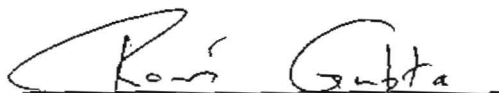
May 19, 1998

Prepared for:

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Prepared by:

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## 1.0 Introduction

SECOR International Inc. (SECOR) is pleased to submit this revised work plan to conduct an *in-situ* oxidation pilot test at 25 Melville Park Road, Melville, New York. The proposed scope of work is based on the results of the environmental investigations conducted by Environmental Remediation, Inc. (ERI) and Camp Dresser & McKee (CDM). The work scope developed will enable SECOR to collect data necessary to provide WHCS Melville, LLC (WHCS) with a cost-effective remedial strategy to address the residual contamination noted in groundwater beneath the eastern part of the site. As requested, the work plan provides a narrative description of the method for conducting the pilot test and outlines all pilot test related activities. The work plan was modified to address comments to the revised work plan dated February 5, 1998 presented in the New York State Department of Environmental Conservation (NYSDEC) letter dated March 13, 1998. It is noted that modifications to the procedures and methodologies proposed herein, may occur as a result of site-specific field conditions. All modifications will be communicated to the NYSDEC for approval.

## 2.0 Objective

The primary objective of this work scope is to conduct a short term pilot test to assess the applicability of *in-situ* chemical oxidation for the remediation of dissolved chlorinated compounds in the water bearing zone at the referenced site (Figure 1). The work scope includes the injection of Fenton's reagent into the subsurface via a series of shallow wells screened across the water table from 45 to 60 feet below grade and deep wells screened from 75 to 90 feet below grade. The proposed locations for injection and depths of injection are within the primary zone of contamination based on the residual VOC concentrations detected in soil and groundwater and/or inferred. The pilot test will be conducted well within the property boundaries and the test area will be adequately monitored by wells located on the periphery of the pilot test. The objective of introducing Fenton's reagent into the subsurface is to oxidize chlorinated compounds dissolved in groundwater.

## 3.0 Site Geology and Hydrogeology

Based on review of the information provided by CDM, the geology at the site has been characterized as glacial outwash sand and gravel to a depth of approximately 170 feet below grade, beneath which is the Magothy sand and gravel deposit. The Magothy Formation, which is approximately 300 feet thick at the site, is described

as a sand and gravel deposit with minor lenses of silt and clay concentrated in its upper portion. According to the information provided in an ERI report, below the Magothy Formation is the Raritan Clay, which is 100 to 300 feet thick. The Raritan Clay is reported to overlie the Lloyd Aquifer, which ranges in thickness from 100 to 300 feet. Competent crystalline metamorphic bedrock is reported to underlie the Lloyd Aquifer.

Groundwater at the site has been determined to be at a depth of approximately 50 feet below grade. The direction of groundwater flow has been determined to be to the south-southeast with a gradient of 0.001 in the immediate vicinity of the loading dock.

#### 4.0 *In-situ* Chemical Oxidation of Organic Compounds

In order to successfully use Fenton's reagent to remediate subsurface contamination, it should be understood that a complex geochemical environment is associated with most subsurface soil matrices, and consideration must be given to potential geochemical interferences and the associated stoichiometric relationships. Consideration of these factors will help determine the efficiency of the process and provide definition of the boundary conditions that most influence successful application of the process.

To determine the effectiveness of *in-situ* oxidation of chlorinated compounds in groundwater at the Melville site, a pilot test is necessary. Three parameters need to be evaluated for a specific test area during design of the pilot test. These include the quantification of the mass of adsorbed phase VOCs, the mass of dissolved phase VOCs, and the volume of peroxide required to oxidize same. The first two parameters can be quantified using existing soil and groundwater quality data. The third parameter can be quantified using basic stoichiometry. Other factors that affect the distribution of injected peroxide include the hydraulic conductivity of the formation and the rate of peroxide decomposition. The hydraulic conductivity of the formation can be quantified by slug tests, injection tests and pump tests. However, considering the aquifer materials beneath the site are relatively permeable, SECOR does not see the need for collecting additional hydrogeologic data at the Melville site prior to conducting the pilot test. In order to estimate the rate of peroxide decomposition, SECOR will quantify the iron content in groundwater prior to conducting the pilot test.

## 5.0 Preparatory Activities

Several preparatory activities will be conducted prior to pilot study implementation. First, injection wells will be installed to provide conduits for the introduction of the oxidants to the contaminated groundwater. Second, a round of groundwater quality samples will be collected from all injection wells and monitoring points to establish pre-test baseline water quality conditions.

### 5.1 Injection/Monitoring well Installation

Both shallow and deep injection were installed with conventional drilling equipment (hollow stem augers). All wells were constructed of schedule 40 PVC materials and have fifteen (15) feet of screen. Shallow injection wells were screened from approximately 45 to 60 feet below grade and deep injection wells were screened from approximately 75 to 90 feet below grade. An injection well schematic diagram is shown in Figure 2. The water table is located at approximately 50 feet below grade. All drill cuttings, and well development and purge water were containerized and stored on site prior to their characterization and disposal. All downhole drilling equipment was decontaminated between uses.

Based on verbal approval of certain aspects of the revised pilot test work plan dated February 5, 1998, the well installation activities were completed during the period March 3 - 13, 1998.

### 5.2 Well Sampling

Approximately fourteen (14) days after the injection were installed and developed, a groundwater quality sampling event was performed. All newly installed injection wells and existing monitoring wells used for either injection or monitoring purposes were purged and sampled to establish baseline concentrations and/or groundwater chemistry. As shown on Table 1, the baseline groundwater sampling event consisted of the following analyses:

#### Baseline Groundwater Sampling

##### *All 32 wells*

- Volatile organic compounds (VOCs) plus tentatively identified compounds (TICs) by USEPA Method 8260
- Aquifer chemistry laboratory parameters (sulfate, alkalinity, chlorides, ferrous iron, ferric iron, total iron, total dissolved solids, total organic carbon, biochemical oxygen demand, and chemical oxygen demand)

- Aquifer chemistry field parameters (dissolved oxygen, pH, Eh, temperature, specific conductance, and turbidity)
- General petroleum degraders consisting of :
  - Total Viable and Non-Viable (TVNV) Organisms*: a measurement of all bacteria, including active, dormant, and dead organisms.
  - Total Viable Organisms (TVO)*: a measurement of all viable bacteria based on microbial growth after 48 to 72 hours of incubation.
  - Fluorescent Pseudomonads (FP)*: a measurement of organisms which have been identified as possible lighter petroleum degraders after 48 to 72 hours of incubation on a pseudomonas F agar plate.
  - Phenanthrene Degraders (PD)*: a measurement of organisms which have been identified as possible heavier petroleum degraders after 6 days of incubation on a phenanthrene agar plate.

*Shallow Injection Wells (IW-1 through IW-7, MW-12 and MW-13) and Deep Injection Wells (IW-8 through IW-12 and MW-13D)*

- Cyanide

*Wells IW-3, MW-7, MW-8, MW-10, MW-11, MW-18D, MW-19D, MW-20D, and MW-23*

- 8 RCRA metals plus manganese

As requested by the NYSDEC, Category B Deliverables will be provided for wells IW-3, MW-8, and MW-23. Additionally, one (1) trip blank, field blank and duplicate sample were collected each day of the sampling event.

Similar to the comprehensive round of groundwater quality sampling conducted by CDM in April/May 1997, three to five well volumes were purged from each well. Efforts were made to sample only after turbidity values were less than 50 NTU's. Well water which did not meet this criteria was collected in a dedicated container and allowed to settle for a two to three hour period, after which time a sample aliquot was decanted (metals only). Dedicated disposable bailers were used to obtain a water sample directly from the well.

Based on verbal approval of certain aspects of the revised pilot test work plan dated February 5, 1998, the baseline groundwater sampling event was performed between March 30 and April 1, 1998.

After completing the injection phase of the *in-situ* oxidation pilot test, three post-injection groundwater sampling events will be conducted to aid in evaluating the effectiveness of the pilot test. The post-injection sampling will be performed two days, one week, and three weeks after the final injections. As shown on Table 1, the post-injection groundwater sampling events performed two days and one week after the injection phase will consist of the following analyses:

### Intermediate Post-Injection Groundwater Sampling (2 days and 1 week)

#### *All 32 wells*

- Chlorinated VOCs by USEPA Method 8260
- Aquifer chemistry field parameters (dissolved oxygen, pH, Eh, temperature, specific conductance, and turbidity)

#### *Wells IW-3, IW-11, MW-7, MW-8, MW-10, MW-11, MW-18D, MW-19D, MW-20D, and MW-23*

- Aquifer chemistry laboratory parameters (sulfate, alkalinity, chlorides, ferrous iron, ferric iron, total iron, total dissolved solids, total organic carbon, biochemical oxygen demand, and chemical oxygen demand)

The groundwater sampling procedures for the post-injection events will be similar to the baseline sampling procedures, except that no well purging will be performed during the events performed two days and one week after the final injections. No pre-sample well purging will be conducted to limit the removal of Fenton's reagent which may still be reacting with the VOCs present in groundwater.

### Final Post-Injection Groundwater Sampling (3 weeks)

As shown on Table 1, the final post-injection groundwater sampling event to be performed three weeks after the final injections will be identical to the baseline sampling event, except that the injection wells will not be analyzed for cyanide.

## 6.0 Pilot Test

SECOR will conduct a short term pilot test during which Fenton's reagent will be infiltrated to the subsurface via existing monitoring wells and recently installed injection wells. The objective of introducing Fenton's reagent to the subsurface is to oxidize VOCs dissolved in groundwater and adsorbed to soil in the saturated and unsaturated zones. During the groundwater sampling event conducted for the Voluntary Investigation, a zone of dense non-aqueous phase liquid (DNAPL) was identified in the contaminant source area. Several proposed injection wells will be used to address this zone of contamination. At this time it can not be predicted how effectively the injected oxidants will impact this zone. Pre injection and post injection water quality data will be evaluated to answer this question and to determine whether an expanded or enhanced injection program should be considered as a viable remedial alternative at this site. The subsequent *in-situ* pilot study report will present conclusions and recommendations regarding these issues.

Based upon review of available information, it has been determined that the soils in the vicinity of the east loading dock have been impacted by volatile organic compounds (VOCs), specifically tetrachloroethene (PCE). Review of the information provided also suggests that the primary zone of contamination is across the water table. However, elevated concentrations of chlorinated compounds have been noted in monitoring wells and grab groundwater samples collected between 80 and 145 feet below grade. *SECOR* proposes to conduct the pilot test in the source area, specifically in the vicinity of monitoring wells MW-20D, MW-18D, MW-13D, MW-13, MW-12, MW-8, MW-7 and MW-10. This area is within the property boundaries and has an adequate number of monitoring wells on the periphery of the pilot test area to collect performance/design data.

Based on review of available data, *SECOR* proposes to inject Fenton's reagent into nine (9) shallow monitoring wells screened between 45 and 60 feet below grade and six (6) deep monitoring wells screened between 75 and 90 feet below grade. It is anticipated that the injected reagent will migrate, due to the natural and imposed hydraulic gradients, from the injection points into the impacted zone. The wells which will be used for injection and monitoring during the oxidation pilot study are discussed in further detail below and are summarized in Table 1. The locations of the proposed injection and monitoring wells are shown on Figure 1.

#### 6.1 Shallow Zone Injection Wells/Points

In order to ensure that the reagent has been injected in the primary zone of contamination, *SECOR* proposes to inject the Fenton's reagent in the following monitoring and newly installed injection wells: (i) two newly installed shallow injection wells identified as IW-1 and IW-2, placed 10 to 15 feet apart near former piezometer/boring location P-1/HP-8; (ii) existing shallow well MW-13; (iii) two newly installed shallow injection wells identified as IW-3 and IW-4, placed 10 and 20 feet east of monitoring well MW-13; (iv) one newly installed shallow injection well identified as IW-5, placed 10 to 15 feet west of existing monitoring well MW-12; (v) existing well MW-12; and (vi) two newly installed shallow injection wells designated as IW-6 and IW-7, placed 10 and 20 feet east of existing monitoring well MW-12. All newly installed shallow injection wells were screened from 45 to 60 feet below grade. An injection well schematic is shown in Figure 2.

## 6.2 Deep Zone Injection Wells/Points

In order to evaluate the effectiveness of the *in-situ* oxidation technology in the deep zone, *SECOR* proposes to inject the Fenton's reagent in: (i) a newly installed deep zone injection well identified as IW-8, screened from 75 to 90 feet below grade and placed within 10 feet north of existing well MW-18D; (ii) existing well MW-13D; (iii) a newly installed deep zone injection well identified as IW-9, screened from 75 to 90 feet below grade and placed 10 feet east of existing monitoring well MW-20D; and (vi) three newly installed deep zone injection wells identified as IW-10, IW-11 and IW-12, screened from 75 to 90 feet below grade and placed 10 feet apart (east-west line) along the series of shallow zone wells recently installed near monitoring well MW-12.

## 6.3 Observation Wells

*SECOR* proposes to use wells MW-2, MW-3, MW-4, MW-7, MW-8, MW-9, MW-10, MW-11, MW-14, MW-15, MW-16D, MW-17, MW-18D, MW-19D, MW-20D, and MW-21D as observation wells during the pilot test and as monitoring wells to collect performance/design data. As recommended by the NYSDEC, in order to avoid a data gap in the intermediate portion of the plume downgradient of the treatment area, a new monitoring well was installed. Well MW-23, screened below the water table between 70 and 85 feet below grade, was installed in March 1998.

## 6.4 Assumptions and Calculations

As discussed above, the pilot test will be conducted in the source area, specifically in the vicinity of monitoring wells MW-20D, MW-18D, MW-13D, MW-13, MW-12, MW-8, MW-7 and MW-10. The average depth to water in this area is 50 feet below grade. Based on the soil and groundwater data collected in this area, it is anticipated that the primary zone of contamination is near the water table and that approximately 50 feet of the shallow zone below the water table is impacted. Based on an areal extent of the impacted zone of approximately 3,900 square feet (30 feet x 130 feet), a 50 foot thickness, and a formation porosity of approximately 25%, it is estimated that approximately 350,000 gallons of impacted water are present in the test area (shallow zone). Additionally, based on an average groundwater concentration of 50 mg/L of VOCs in the area, it is estimated that approximately 66,500 grams of VOCs are present in this zone (not including

adsorbed phase VOCs).

Similarly, assuming that an additional zone of 30 feet by 40 feet by 40 feet below the shallow zone is impacted by chlorinated solvents, it is estimated that approximately 90,000 gallons of impacted water is present in the deeper zone. Based on an average groundwater concentration of 15 mg/L of VOCs in the deep wells, it is estimated that approximately 5,100 grams of VOCs are present in this zone (not including adsorbed phase VOCs).

Based on a review of data from the bench scale testing conducted at other sites and *SECOR*'s experience at other sites (see Appendix B), it is anticipated that samples containing chlorinated solvents would require 0.03 % to 3% hydrogen peroxide plus Fe(II) at a level of 0.5 millimole (mM). *SECOR* has evaluated the site specific data and has estimated that approximately 2,300 gallons of 35% hydrogen peroxide will effectively reduce the VOC concentrations in the test area. The stoichiometric equations of Fenton's reagent and other calculations are provided in Appendix A. During peroxide injection, which is anticipated to last for approximately five to eight days, *SECOR* personnel will monitor the injection process, collect field data, adjust equipment and conduct safety inspections. *SECOR* will maintain detailed records of all injections including injection locations, type of solution, solution concentration and volume, and all other pertinent information.

## 6.5 Methodology

As discussed above, approximately 2,300 gallons of 35% hydrogen peroxide are needed to perform the oxidation pilot test. However, because peroxide is a strong oxidizer, dilute solutions of peroxide (less than 5%) are typically used to perform *in-situ* chemical oxidation. Therefore, the oxidation pilot test can be performed by either diluting 35% peroxide on-site with potable water, or purchasing peroxide at the desired concentration. Solutions containing more than 8% hydrogen peroxide are classified by the U.S. Department of Transportation (DOT) as an oxidizer. Due to the health and safety concerns associated with handling concentrated peroxide, 3% hydrogen peroxide (pH≈6.0) will be delivered to the site for injection into the aquifer (3% hydrogen peroxide is used to treat open wounds and as a gargle and mouthwash). Therefore, approximately 27,000 gallons of 3% peroxide (equivalent to 2,314 gallons of 35% peroxide) will be used for the pilot test. The 3% peroxide will be delivered by tanker truck and transferred into two (2) 6,500 gallon polyethylene storage tanks. Therefore, a maximum of 13,000 gallons of 3% peroxide will be stored on-site

at any time during the pilot test. A certificate of hydrogen peroxide purity and tanker truck cleanliness has been requested from the peroxide supplier. Additionally, a sample of the 3% hydrogen peroxide will be collected upon delivery and analyzed to confirm the purity certification. After transfer to the 6,500 gallon poly tanks, the 3% peroxide will be acidified to a pH=3 to 4 using sulfuric acid ( $H_2SO_4$ ). The storage tanks will be manifolded to the injection points using flexible hose and the peroxide will be gravity drained to the wells. Each well will be equipped with a totalizing flowmeter and ball valve to control the peroxide injection rate and flexible hose will extend down the injection wells to below the static depth to water.

A ferrous sulfate solution acidified to a pH $\approx$  2 will be injected into the wells along with the peroxide to produce a 0.5 mM solution of Fenton's reagent. The ferrous sulfate solution will be mixed on-site in several 55 gallon polyethylene drums (or several 230 gallon polyethylene tanks) by adding approximately 530 grams of crystalline iron (II) sulfate heptahydrate ( $FeSO_4 \cdot 7H_2O$ ) for every 50 gallons of potable water. The sulfuric acid will be used to acidify the solution to a pH $\approx$ 2 to keep the ferrous sulfate in solution. Based on the amount of hydrogen peroxide (27,000 gallons) which will be injected, approximately 14.3 kilograms (31.5 pounds) of ferrous sulfate will be dissolved into solution and injected. The ferrous sulfate solution will be gravity drained from the 55 gallon drums (or 230 gallon tanks) into the injection points either continuously or in small batches during injection of hydrogen peroxide. *SECOR* estimates that approximately 30 liters (8 gallons) of sulfuric acid will be used to acidify the hydrogen peroxide and ferrous sulfate solution.

Since carbon dioxide ( $CO_2$ ) and water are the by-products of the oxidation of hydrocarbons, *SECOR* personnel will measure gaseous  $CO_2$  in the well heads of site monitoring wells using a hand held GasTech model 402 LEL/ $O_2$ / $CO$ / $CO_2$  air monitoring instrument. Additionally, since introduction of peroxide will increase the concentration of dissolved oxygen, *SECOR* will periodically collect groundwater samples from site wells for field measurement of dissolved oxygen concentrations. Finally, periodic liquid level measurements will be collected to enable adjustment of the peroxide injection rate, evaluation of the radius-of-influence of peroxide injection, and enable mounding analysis in the event that long term peroxide injection is considered.

In order to streamline the injection process and determine the optimal rate of injection of the hydrogen peroxide and ferrous sulfate solution, the injection portion of the pilot test will be conducted in three phases. The first phase of injection will include injection of approximately 9,000 gallons of potable water acidified to a pH $\approx$ 3 to 4 into select injection wells and collection of liquid level, dissolved oxygen and pH measurements

in the observation wells. The acidified water will be injected into multiple wells at varying rates up to 5 gallons per minute (gpm) per well. This first phase is anticipated to take two days.

The second phase of injection testing will include injection of Fenton's reagent in the nine (9) shallow zone wells (see Table 1) and the collection of liquid levels and dissolved oxygen concentrations in shallow and deep zone injection and observation wells. During this phase, approximately 9,000 gallons of hydrogen peroxide (pH $\approx$ 3 to 4) and 450 gallons of ferrous sulfate solution (pH $\approx$ 2) will be injected into the nine (9) shallow injection wells at rates of 0.5 to 2 gpm per well. This phase of the pilot test is anticipated to be completed in one to two days.

The final or third phase of injection testing will include simultaneous injection of Fenton's reagent in the nine (9) shallow and six (6) deep injection wells (Table 1). During this phase, approximately 18,000 gallons of hydrogen peroxide (pH $\approx$ 3 to 4) and 900 gallons of ferrous sulfate solution (pH $\approx$ 2) will be injected into the fifteen (15) injection points at rates of 0.5 to 2 gpm per well. This phase of the pilot test is anticipated to be completed in two to three days. Detailed records of the volume and nature (concentration, pH) of injected materials will be maintained by *SECOR*. A summary of the solutions to be injected during each phase of the pilot test is provided below:

■ First Phase

- 1) 9,000 gallons of potable water acidified to pH $\approx$ 3 to 4 using 2 to 3 gallons of sulfuric acid.

■ Second Phase

- 1) 9,000 gallons of 3% hydrogen peroxide acidified to pH $\approx$ 3 to 4 using 2 to 3 gallons of sulfuric acid.
- 2) 450 gallons of ferrous sulfate solution (containing approximately 11 pounds ferrous sulfate) acidified to pH $\approx$ 2 using approximately  $\frac{1}{4}$  gallon of sulfuric acid.

■ Third Phase

- 1) 18,000 gallons of 3% hydrogen peroxide acidified to pH $\approx$ 3 to 4 using 4 to 5 gallons of sulfuric acid.
- 2) 900 gallons of ferrous sulfate solution (containing 21 pounds ferrous sulfate) acidified to pH $\approx$ 2 using approximately  $\frac{1}{2}$  gallon of sulfuric acid.

CDM will collect post-injection groundwater samples from the injection and observation wells two days after completion of the third phase of injection, and then one and three weeks following the injection of Fenton's reagent. A discussion of the sampling parameters is provided in Section 5.2. A schedule for the proposed pilot test is provided as Table 2.

## 6.6 Health and Safety

The Health and Safety Plan (HASP; *SECOR*, February 1998) for the site has been modified (April 1998) to incorporate information specific to the storage and handling of hydrogen peroxide, sulfuric acid, and ferrous sulfate to be used during the oxidation pilot test. A copy of the updated HASP was forwarded under separate cover on April 27, 1998. The revised HASP also includes provisions and procedures to control public/building employee access to the pilot study area. Additionally all local (County, Town, Fire District) requirements for bulk chemical storage will be adhered to.

In accordance with NYSDEC comments to the *SECOR* and CDM HASPs provided in an April 9, 1998 correspondence, the following health and safety provisions will be implemented:

- The Town of Huntington Fire Marshal will inspect the chemical storage and handling facilities prior to delivery of the hydrogen peroxide.
- Physical barriers will be erected to prevent unauthorized access to the site during the injection phase of the pilot test.
- A security company will be hired to prevent unauthorized access to the site during the injection phase of the pilot test when *SECOR* personnel are not on-site.
- The building manager will be notified in advance of all on-site activities and will be involved in preparing a building evacuation plan in the unlikely event that indoor air monitoring results indicate the need for evacuation of personnel from the building (see Section 6.6).

CDM has provided the Suffolk County Department of Health Services (SCDHS) and the Town of Huntington Fire Marshal with information pertaining to the type, concentration and storage of chemicals for this test. As on-site chemical storage will be less than thirty (30) days, SCDHS does not require registration pursuant to Suffolk County Sanitary Code Article 12. The Town of Huntington Fire Marshal is in the process of reviewing the information to determine whether permits or fire prevention measures are required.

Field personnel will perform indoor and outdoor air monitoring to ensure the safety of site workers and building occupants. However, it should be noted that the entire eastern portion of the building closest to the pilot test area is vacant and only the western half of the building is occupied. Indoor and outdoor air monitoring will be performed for organic vapors using a photoionization detector (PID) and for other air quality parameters (LEL, O<sub>2</sub>, CO, CO<sub>2</sub>, hydrogen sulfide [H<sub>2</sub>S], and hydrogen cyanide [HCN]) using the

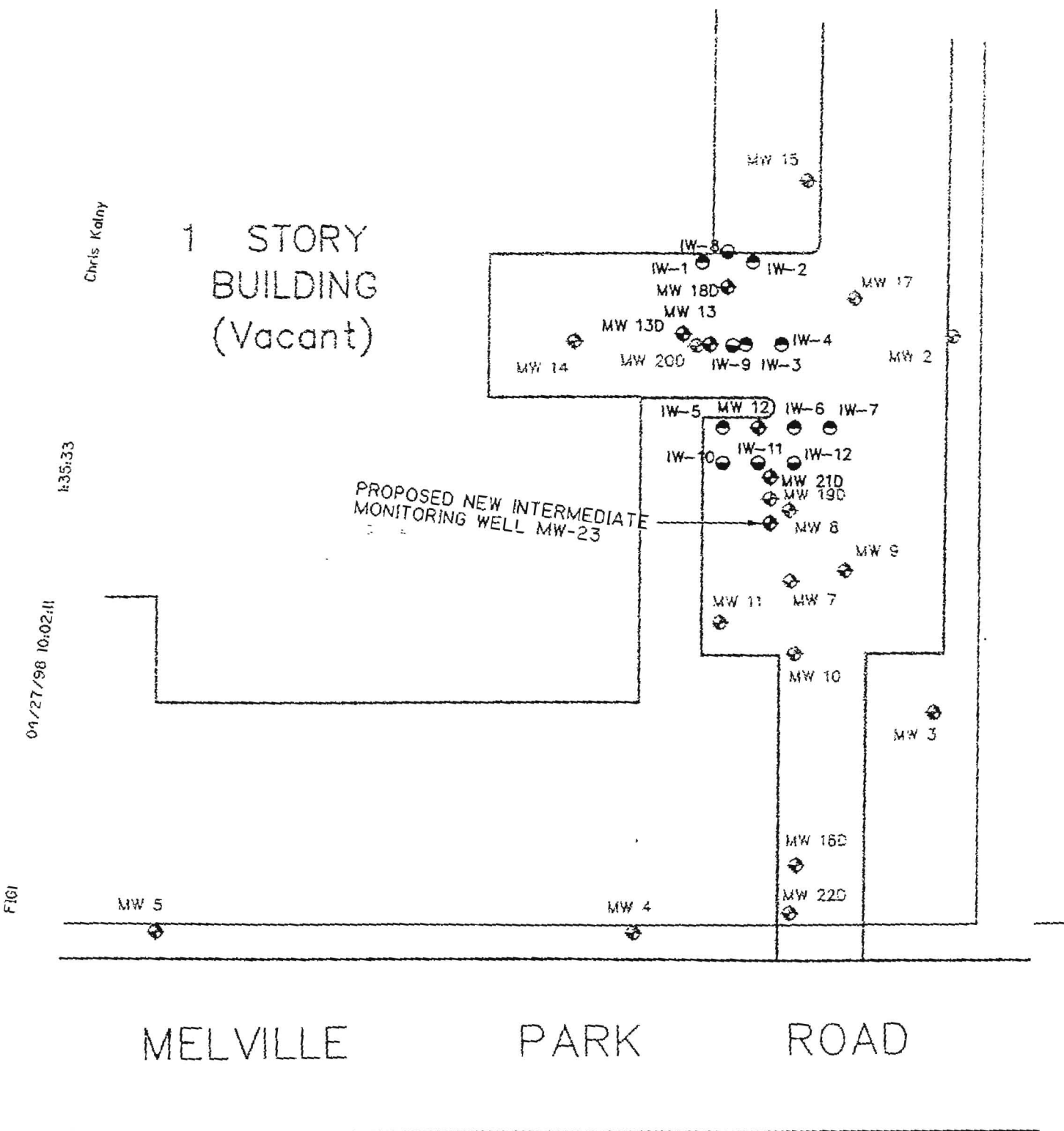
appropriate hand held instruments. Baseline indoor air monitoring will be performed prior to any injections. During the active injection phases of the test, indoor air monitoring will be performed at a minimum frequency of once every two hours. Both the *SECOR* and CDM HASPs have been revised to reflect these provisions.

## 6.7 Reporting

Upon completion of the pilot test, *SECOR* will prepare and submit the findings of the pilot test in a progress report to WHCS. This progress report will include a discussion of the pilot test procedures and post-injection groundwater sampling results. In order to determine the degree of success of the pilot study injections, the groundwater quality results from the baseline and three post-injection sampling events will be compared. The comparisons will include evaluating changes in VOC concentrations in wells and changes in the areal extent and mass distribution. The effects of dilution as a result of the injections will be considered in the evaluation of the baseline and post-injection groundwater quality results when determining reduction in concentration. Additionally, indicator parameters (i.e. pH, DO, water level) will be used to evaluate the effectiveness of the oxidation pilot test.

In the event the pilot test results indicate a significant reduction of volatile organic compounds in the source area wells (greater than 25%), *SECOR* will submit a proposal to WHCS for future remedial action at the site using *in-situ* oxidation, which could be considered as a proposed alternative for full-scale remediation of the site.

## Figures



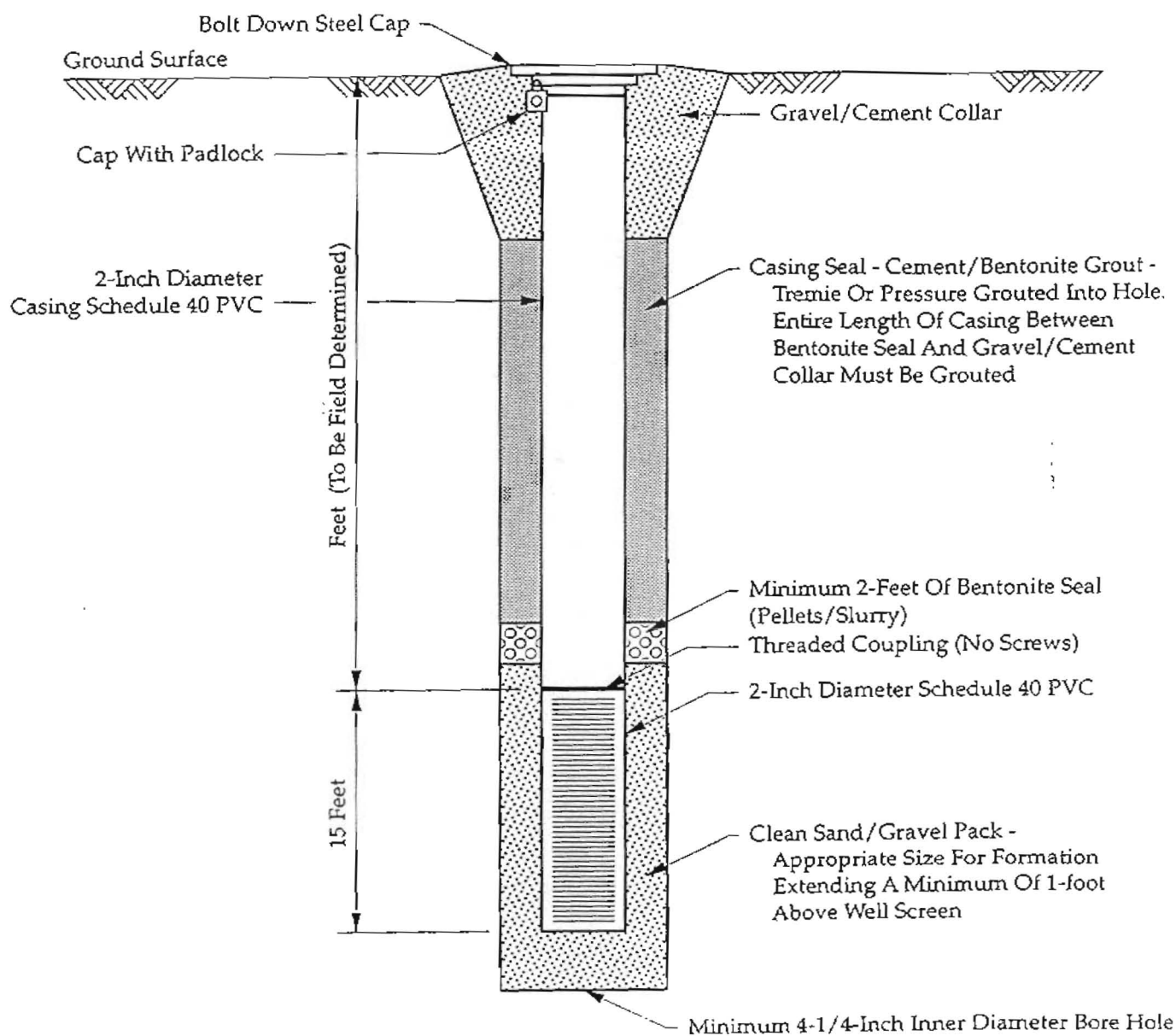
# LEGEND

- MW 13 - MONITORING WELL
- IW-8 - PROPOSED SHALLOW INJECTION WELL
- IW-10 - PROPOSED DEEP INJECTION WELL

SCALE: 1" = 50'

CDM Camp Dresser & McKee

Figure No. 1



Note: Shallow Injection Well  
Screen Zone 45 to 60 fbg.  
Deep Injection Well  
Screen 75 to 90 fbg.

Not To Scale

Figure 2  
Shallow And Deep Zone Injection Well Specifications

## Tables

Table 1  
In-Situ Oxidation Pilot Test  
Injection / Monitoring Well Sampling Program  
25 Melville Park Road  
Melville, New York

Well	Screened Interval (ft bgs)	Baseline and Final Post-Injection (3 weeks)						Intermediate Post-Injection (2 days, 1 week)		
		VOCs & TICs	Cyanide (baseline only)	8 RCRA Metals & Mn	General Petrol. Degraders	Aquifer Chemistry		Chlorinated VOCs	Aquifer Chemistry	
						Lab	Field		Lab	Field
Shallow Injection Wells										
IW-1	45 - 60	x	x		x	x	x	x		x
IW-2	45 - 60	x	x		x	x	x	x		x
IW-3	45 - 60	x	x	x	x	x	x	x	x	x
IW-4	45 - 60	x	x		x	x	x	x	x	x
IW-5	45 - 60	x	x		x	x	x	x		x
IW-6	45 - 60	x	x		x	x	x	x		x
IW-7	45 - 60	x	x		x	x	x	x		x
MW-12	46.5 - 56.5	x	x		x	x	x	x		x
MW-13	48 - 58	x	x		x	x	x	x		x
Shallow Monitoring Wells										
MW-2	40 - 60	x			x	x	x	x		x
MW-3	40 - 60	x			x	x	x	x		x
MW-4	40 - 60	x			x	x	x	x		x
MW-7	40 - 60	x		x	x	x	x	x	x	x
MW-8	40 - 60	x		x	x	x	x	x	x	x
MW-9	45 - 60	x			x	x	x	x	x	x
MW-10	45 - 60	x		x	x	x	x	x	x	x
MW-11	45 - 60	x		x	x	x	x	x	x	x
MW-14	46 - 56	x			x	x	x	x		x
MW-15	48.5 - 58.5	x			x	x	x	x		x
MW-17	50 - 60	x			x	x	x	x		x
Deep Injection Wells										
IW-8	75 - 90	x	x		x	x	x	x		x
IW-9	75 - 90	x	x		x	x	x	x		x
IW-10	75 - 90	x	x		x	x	x	x		x
IW-11	75 - 90	x	x		x	x	x	x	x	x
IW-12	75 - 90	x	x		x	x	x	x		x
MW-13D	80 - 90	x	x		x	x	x	x		x
Deep Monitoring Wells										
MW-16D	79.5 - 89.5	x			x	x	x	x		x
MW-18D	133 - 143	x		x	x	x	x	x	x	x
MW-19D	160 - 170	x		x	x	x	x	x	x	x
MW-20D	175 - 185	x		x	x	x	x	x	x	x
MW-21D	50 - 160	x			x	x	x	x		x
MW-23	70 - 85	x		x	x	x	x	x	x	x
Totals		32	15	9	32	32	32	32	10	32

Notes:

1) Category B Deliverables will be provided for samples from wells IW-3, MW-8, and MW-23.

Aquifer Chemistry Lab Parameters	
1) Sulfate (SO <sub>4</sub> )	5) Total Dissolved Solids (TDS)
2) Alkalinity (as CaCO <sub>3</sub> )	6) Total Organic Carbon (TOC)
3) Chlorides (Cl)	7) Biochemical Oxygen Demand (BOD)
4) Ferric, Ferrous & Total Iron	8) Chemical Oxygen Demand (COD)

Aquifer Chemistry Field Parameters	
1) Dissolved Oxygen (DO)	4) Temperature
2) pH	5) Specific Conductance (SC)
3) Eh	6) Turbidity

Table 2  
In-situ Oxidation Pilot Test Schedule  
25 Melville Park Road  
Melville, New York

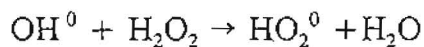
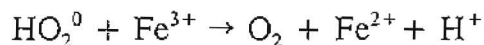
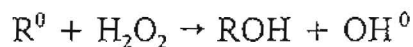
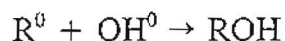
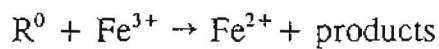
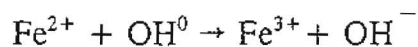
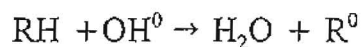
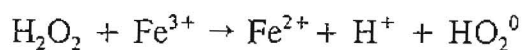
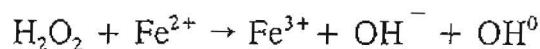
Task	Week 1					Week 2					Week 3					Week 4					Week 5					Week 6					Week 7					Week 16				
	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F	M	T	W	Th	F					
1. Injection well/monitoring well installation	Completed March 3 – 13, 1998																																							
2. Baseline groundwater sampling	Completed March 30 – April 1, 1998																																							
3. Injection equipment set-up	■																																							
4. First phase of pilot test injections				■																																				
5. Second phase of pilot test injections						■																																		
6. Third phase of pilot test injections											■																													
7. Post-injection groundwater sampling															2 days				1 week										3 weeks											
8. Submit Pilot Test Report																																				■				

**2 days** = Post-injection groundwater sampling conducted 2 days after final injections.

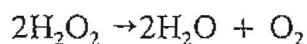
Appendix A  
Stoichiometry and Calculations

## STOICHIOMETRY AND CALCULATIONS

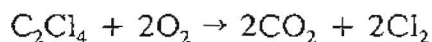
### 1. Hydrogen Peroxide Reaction with Iron (Both Ferrous and Ferric) and Organic Compounds



### 2. Decomposition of Hydrogen Peroxide



### 3. Oxidation of PCE ( $\text{C}_2\text{Cl}_4$ )



Based on the assumption that 72,500 grams of PCE is present in the dissolved phase and stoichiometric equation (3) showing that 2 moles of oxygen are needed for every mole of PCE, it is estimated that approximately 27,986 grams of oxygen is needed to oxidize the PCE present in the dissolved phase (shallow and deep zones). Considering equation (2), it is estimated that in order to generate 27,986 grams of oxygen, approximately 150 gallons of 10% hydrogen peroxide will be needed. It should be noted that the estimated volume of hydrogen peroxide calculated above does not take into consideration the adsorbed phase or the organic content of the soils present in the subsurface.

Appendix B  
Bench Scale Testing and *In-situ* Oxidation Case Histories

DESTRUCTION OF CHLORINATED ORGANIC COMPOUNDS  
IN SOIL AND WATER WITH HYDROGEN PEROXIDE  
OR FENTON'S REAGENT

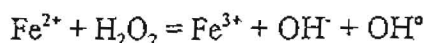
BENCH-SCALE RESULTS

OCTOBER 12, 1995

Submitted by:  
William J. Walker, Ph.D.  
SECOR International, Inc  
1734 34th Street  
Sacramento, CA 95816

## Introduction

The use of hydrogen peroxide ( $H_2O_2$ ) or  $H_2O_2$  with ferrous iron salts (Fenton's reagent) for the destruction of organic contaminants has received considerable attention in recent years. The reaction by which oxidation of organic material occurs is primarily through the generation of hydroxyl radicals via:



In the presence of target contaminants the hydroxyl radicals generated are capable of detoxifying the contaminants via oxidation. The hydroxyl radicals can be generated by small amounts of iron, using concentrations as low as 0.05mM. In instances where complete oxidation occurs, the major by-products of the reaction will be water, carbon dioxide and inorganic salts.

Several hazardous pollutants can be oxidized by the hydroxyl radicals generated using Fenton's reagent. The scientific literature has noted the oxidation of phenol, TCE, PCE, chlorophenols, dinitro-o-cresol, formaldehyde, PAHs, chlorobenzene and nitrophenols.

In this study, the broad objective was to determine the success with which soil and water contaminated with chlorinated organic compounds (primarily PCE and TCE) could be oxidized by peroxide alone or with ferrous salts. Specific objectives included:

- 1.) Determine if the target compounds could be oxidized to below regulatory limits by application of Fenton's reagent.
- 2.) Determine the extent of the reactions and compare the results of samples treated with peroxide to those treated with Fenton's reagent.
- 3.) Begin an assessment of the reaction mechanism involved such that important rate controlling parameters could be identified.

## Methods and Materials

Four samples (2 water and 2 soil samples) were shipped to the SECOR Geochemistry Laboratory in Sacramento, CA under chain of custody from the SECOR New Jersey office. The sample collection and location information is described by field personnel from the SECOR New Jersey Office. Samples arrived chilled to 4°C in ice. Water samples were contained within amber glass bottles to minimize loss due to photodecomposition.

The following tests were performed on the soil and water samples:

### Test 1: Composition of the Samples:

Initial testing included examination of the chemical composition of the samples prior to testing. Organic analyses were provided by Accutest while several inorganic parameters were determined in the SECOR laboratory. These included Eh, pH, total Fe and Fe (II).

### Test 2: Oxidation of Water and Soil

In the first test, three of the samples (both water samples and 1 soil sample) were treated with peroxide with or without Fe (II) added to test the difference between samples oxidized by peroxide alone compared to those treated with Fenton's reagent. The samples and treatment scenarios are presented in Table 1.

Table 1.

Sample	Media	ID	Treatment
1	Water	MW-1	10 ml Sample + 1 ml H <sub>2</sub> O <sub>2</sub> + 1 ml Fe
2	Water	MW-1	10 ml Sample + 0.1 ml H <sub>2</sub> O <sub>2</sub> + 1 ml Fe
3	Water	MW-1	10 ml Sample + 0.1 ml H <sub>2</sub> O <sub>2</sub> , no Fe added
4	Soil	BST-1	10 g Sample + 10 mL H <sub>2</sub> O + 10 mL H <sub>2</sub> O <sub>2</sub> + 5 mL Fe

The final concentration of peroxide in the water samples was either 3 M or 0.3 M (or about 0.3 to 3%) while the Fe typically was 1 to 5 mM. These dosages were chosen based on literature treatments for samples similar in composition. Treatment of soil was expected to be difficult since the target analyte concentration was over 1000 mg/kg in the soil. Hence, excess peroxide was added with the expectation that excess peroxide would at least bring about a measurable decrease in chlorinated compounds.

### Test 3: Defining Optimal Conditions for Oxidation

Test 3 was similar to test 1 except that the ratios of peroxide to iron were varied in order to find the optimal dosing conditions. In addition, only MW-1 was examined since it contained the highest concentrations of contaminants.

## Results

### Test 1: Composition of Samples:

The results of test 1 are noted below.

Table 1.

Sample	pH	Eh	Fe (total)	Fe (dissolved)	Fe (III)
MW-1	7.03	+600	1mg/L	0.028 mg/L	nd*
MW-2	6.89	+490	0.6 mg/L	< 0.01 mg/L	nd
BST-1	5.56	+222	4.12 wt%	na*	na
BST-2	5.04	+101	1.3 wt%	na	na

\* none detected = nd  
not applicable = na

The water samples, MW-1 and MW-2, were near neutral in pH, well oxidized and contained no detectable amounts of Fe (II). Dissolved Fe was generally low, near detection limits, but contained some suspended material that tended to settle out over time, thus yielding initially high total Fe contents. Soil samples were lower in pH, near 5, and contained normal amounts of Fe (from 0.5 to 5% by weight). Due to the oxidizing conditions observed in all samples, significant amounts of Fe (II) were not detected or expected.

### Test 2: Oxidation of Soil and Water

The results of test 2 are noted in Table 2 below where the concentrations of major chlorinated compounds before and after treatment are compared. As noted, only the water sample to which peroxide alone was added (treatment 3), still had significant quantities of chlorinated organics after treatment. However, the fact that these concentrations could be reduced from over 160 mg/L to less than 20 mg/L still represents a major effect. All treatments with Fenton's reagent for the water samples were effective in reducing the concentrations of the target analyses. Note also that dosages of only 0.3% were effective in completely reducing the concentrations of all chlorinated compounds

Table 2.

Compound	1(water)		Sample 2 (water)		3(water)		4 (soil)	
	before	after	before	after	before	after	before	after
	(ug/L)		(ug/L)		(ug/L)		(mg/kg)	
TCA	6000	nd	6000	7	6000	nd	nd	nd
DCE	68000	nd	68000	nd	68000	12000	nd	nd
TCE	17000	nd	17000	nd	17000	2000	15	nd
PCE	92000	6	92000	9	92000	5800	1000	5 ug/kg
Vinyl Chloride	1100	nd	1100	nd	1100	nd	nd	nd

### Test 3: Defining Optimal Conditions

We also examined the effect of pH on the extent of oxidation when sufficient peroxide and iron were present in all of the samples (Figure 1). As noted, the optimum pH range occurs from about pH 4 to pH 2.5. Oxidation at higher pH is slow, but will go to completion within a day. Reactions conducted at low pH (1.2) are severely inhibited. Based on this, water at the site could be treated without significantly lowering pH, but the rate of reaction will be slower, on the order of hours compared to minutes at pH 3.

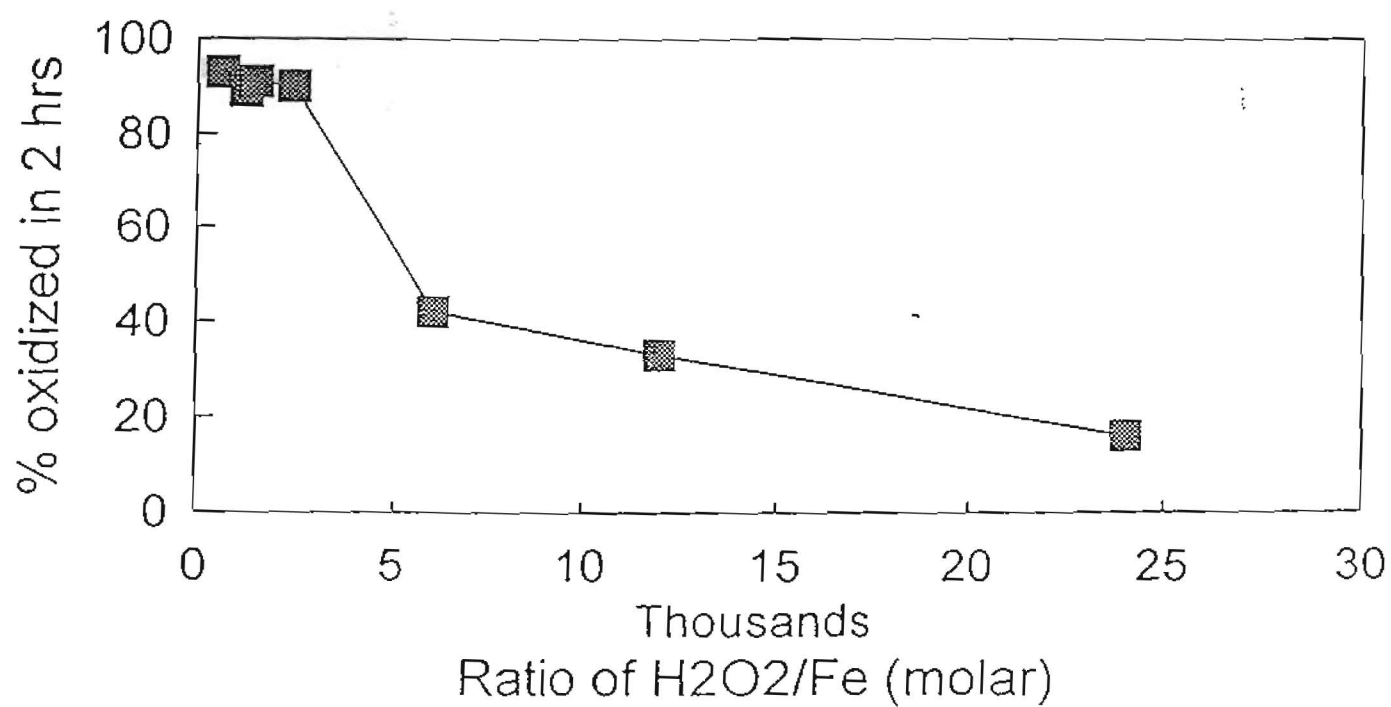
Figure 2 shows the effect of different peroxide to Fe (II) ratios on the extent of oxidation over a 2hr time period. Again, reaction rates appear to be highest at the lowest peroxide to Fe (II) ratio. As the Fe content decreases, the overall oxidation rate and extent of reaction both decrease as well.

Based on this, it appears reasonable that oxidation can occur at pH greater than 5, but with much slower rates to completion. Iron (II) is a critical component for complete oxidation. However, it appears that the addition of Fe (II) to water or soil treated with peroxide only requires a mole ratio of 10,000 (peroxide to Fe(II)) which seems sufficient to complete oxidation.

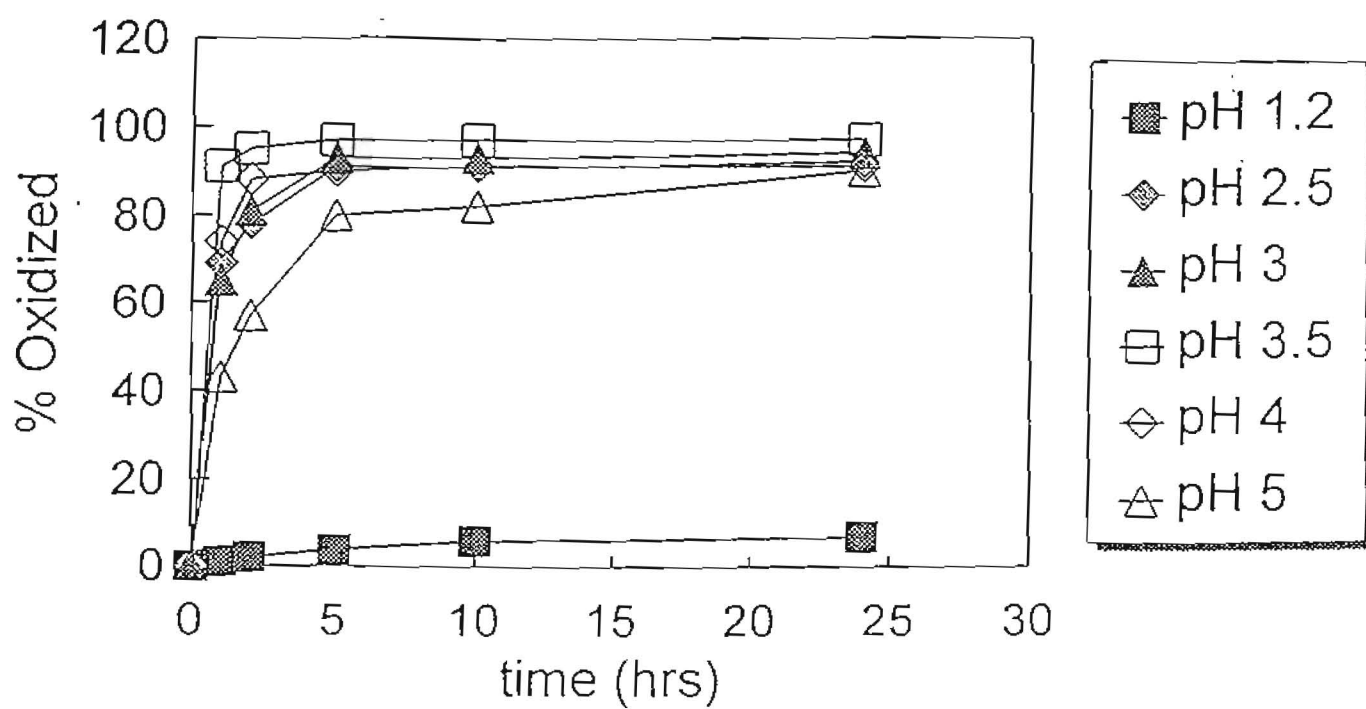
## Recommendations

- 1.) Soil and water samples from the site appear to be well oxidized and contain no detectable amounts of Fe (II).
- 2.) Samples with Fe (II) added with hydrogen peroxide (ie Fenton's Reagent) were effective in decreasing chlorinated compounds to below detection limits in all samples. The one sample that was treated with only hydrogen peroxide showed significant decreases in chlorinated compounds (decrease from 160 mg/L to <20 mg/L) but was still at unacceptably high concentrations.
- 3.) Literature based dosages of hydrogen peroxide and Fe (II) appear to be reasonable estimates for efficient oxidation of chlorinated compounds. Typically samples containing as much as 200 mg/L may require from 0.3% to 3% hydrogen peroxide plus Fe at levels of 0.5 to 5 mM.
- 4.) The rate of oxidation is strongly pH dependent. Initial observations suggest that rates are fastest from pH 1.8 to about pH 4. Below pH 1.8, the reaction is severely inhibited while above pH 4 the rate is much slower but the reaction still goes to completion.
- 5.) The rate of reaction is also highest at low peroxide to Fe (II) ratios suggesting that the rate is also strongly dependent on the concentration of Fe (II). If Fe (II) is kept low, the reaction will proceed, but at a much reduced rate.

Effect of Peroxide/Fe Ratio  
pH 4



Effect of pH on Oxidation  
3 M Peroxide/5 mM Fe (II)



# American Environmental Network

## Certificate of Analysis

DOHS Certification: 1172

AIHA Accreditation: 11134

PAGE 1

SECOR  
1734 34TH STREET  
SACRAMENTO, CA 95816

ATTN: WILLIAM WALKER  
CLIENT PROJ. ID: SB047

REPORT DATE: 09/22/95

DATE(S) SAMPLED:

DATE RECEIVED: 09/13/95

AEN WORK ORDER: 9509174


### PROJECT SUMMARY:

On September 13, 1995, this laboratory received 4 (3 water and 1 soil) sample(s).

Client requested sample(s) be analyzed for organic parameters. Results of analysis are summarized on the following page(s). Please see quality control report for a summary of QC data pertaining to this project.

Samples will be stored for 30 days after completion of analysis, then disposed of in accordance with State and Federal regulations. Samples may be archived by prior arrangement.

If you have any questions, please contact Client Services at (510) 930-9090.

  
Larry Klein  
Laboratory Director

SECOR

SAMPLE ID: VOA #1  
 AEN LAB NO: 9509174-01  
 AEN WORK ORDER: 9509174  
 CLIENT PROJ. ID: S8047

DATE SAMPLED:  
 DATE RECEIVED: 09/13/95  
 REPORT DATE: 09/22/95

ANALYTE	METHOD/ CAS#	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED
Volatile Organic Compounds	EPA 8240				
Acetone	67-64-1	ND	100	ug/L	09/18/95
Benzene	71-43-2	ND	5	ug/L	09/18/95
Bromodichloromethane	75-27-4	ND	5	ug/L	09/18/95
Bromoform	75-25-2	ND	5	ug/L	09/18/95
Bromomethane	74-83-9	ND	10	ug/L	09/18/95
2-Butanone	78-93-3	ND	100	ug/L	09/18/95
Carbon Disulfide	75-15-0	ND	10	ug/L	09/18/95
Carbon Tetrachloride	56-23-5	ND	5	ug/L	09/18/95
Chlorobenzene	108-90-7	ND	5	ug/L	09/18/95
Chloroethane	75-00-3	ND	10	ug/L	09/18/95
2-Chloroethyl Vinyl Ether	110-75-8	ND	10	ug/L	09/18/95
Chloroform	67-66-3	ND	5	ug/L	09/18/95
Chloromethane	74-87-3	ND	10	ug/L	09/18/95
Dibromochloromethane	124-48-1	ND	5	ug/L	09/18/95
1,1-Dichloroethane	75-34-3	ND	5	ug/L	09/18/95
1,2-Dichloroethane	107-06-2	ND	5	ug/L	09/18/95
1,1-Dichloroethene	75-35-4	ND	5	ug/L	09/18/95
cis-1,2-Dichloroethene	156-59-2	ND	5	ug/L	09/18/95
trans-1,2-Dichloroethene	156-60-5	ND	5	ug/L	09/18/95
1,2-Dichloropropane	78-87-5	ND	5	ug/L	09/18/95
cis-1,3-Dichloropropene	10061-01-5	ND	5	ug/L	09/18/95
trans-1,3-Dichloropropene	10061-02-6	ND	5	ug/L	09/18/95
Ethylbenzene	100-41-4	ND	5	ug/L	09/18/95
2-Hexanone	591-78-6	ND	50	ug/L	09/18/95
Methylene Chloride	75-09-2	ND	20	ug/L	09/18/95
4-Methyl-2-pentanone	108-10-1	ND	50	ug/L	09/18/95
Styrene	100-42-5	ND	5	ug/L	09/18/95
1,1,2,2-Tetrachloroethane	79-34-5	ND	5	ug/L	09/18/95
Tetrachloroethene	127-18-4	6 *	5	ug/L	09/18/95
Toluene	108-88-3	ND	5	ug/L	09/18/95
1,1,1-Trichloroethane	71-55-6	ND	5	ug/L	09/18/95
1,1,2-Trichloroethane	79-00-5	ND	5	ug/L	09/18/95
Trichloroethene	79-01-6	ND	5	ug/L	09/18/95
Vinyl Acetate	108-05-4	ND	50	ug/L	09/18/95
Vinyl Chloride	75-01-4	ND	10	ug/L	09/18/95
Xylenes, Total	1330-20-7	ND	10	ug/L	09/18/95

ND = Not detected at or above the reporting limit

\* = Value at or above reporting limit

SECOR

SAMPLE ID: VOA #3  
 AEN LAB NO: 9509174-02  
 AEN WORK ORDER: 9509174  
 CLIENT PROJ. ID: SB047

DATE SAMPLED:  
 DATE RECEIVED: 09/13/95  
 REPORT DATE: 09/22/95

ANALYTE	METHOD/ CAS#	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED
Volatile Organic Compounds	EPA 8240				
Acetone	67-64-1	ND	100	ug/L	09/18/95
Benzene	71-43-2	ND	5	ug/L	09/18/95
Bromodichloromethane	75-27-4	NO	5	ug/L	09/18/95
Bromoform	75-25-2	ND	5	ug/L	09/18/95
Bromomethane	74-83-9	ND	10	ug/L	09/18/95
2-Butanone	78-93-3	ND	100	ug/L	09/18/95
Carbon Disulfide	75-15-0	ND	10	ug/L	09/18/95
Carbon Tetrachloride	56-23-5	NO	5	ug/L	09/18/95
Chlorobenzene	108-90-7	ND	5	ug/L	09/18/95
Chloroethane	75-00-3	NO	10	ug/L	09/18/95
2-Chloroethyl Vinyl Ether	110-75-8	ND	10	ug/L	09/18/95
Chloroform	67-66-3	NO	5	ug/L	09/18/95
Chloromethane	74-87-3	NO	10	ug/L	09/18/95
Dibromochloromethane	124-48-1	ND	5	ug/L	09/18/95
1,1-Dichloroethane	75-34-3	NO	5	ug/L	09/18/95
1,2-Dichloroethane	107-06-2	ND	5	ug/L	09/18/95
1,1-Dichloroethene	75-35-4	NO	5	ug/L	09/18/95
cis-1,2-Dichloroethene	156-59-2	ND	5	ug/L	09/18/95
trans-1,2-Dichloroethene	156-60-5	NO	5	ug/L	09/18/95
1,2-Dichloropropane	78-87-5	ND	5	ug/L	09/18/95
cis-1,3-Dichloropropene	10061-01-5	NO	5	ug/L	09/18/95
trans-1,3-Dichloropropene	10061-02-6	NO	5	ug/L	09/18/95
Ethylbenzene	100-41-4	NO	5	ug/L	09/18/95
2-Hexanone	591-78-6	NO	50	ug/L	09/18/95
Methylene Chloride	75-09-2	NO	20	ug/L	09/18/95
4-Methyl-2-pentanone	108-10-1	NO	50	ug/L	09/18/95
Styrene	100-42-5	NO	5	ug/L	09/18/95
1,1,2,2-Tetrachloroethane	79-34-5	NO	5	ug/L	09/18/95
Tetrachloroethene	127-18-4	9 *	5	ug/L	09/18/95
Toluene	108-88-3	NO	5	ug/L	09/18/95
1,1,1-Trichloroethane	71-55-6	7 *	5	ug/L	09/18/95
1,1,2-Trichloroethane	79-00-5	NO	5	ug/L	09/18/95
Trichloroethene	79-01-6	NO	5	ug/L	09/18/95
Vinyl Acetate	108-05-4	NO	50	ug/L	09/18/95
Vinyl Chloride	75-01-4	NO	10	ug/L	09/18/95
Xylenes, Total	1330-20-7	NO	10	ug/L	09/18/95

ND = Not detected at or above the reporting limit

\* = Value at or above reporting limit

SECOR

SAMPLE ID: VOA #5  
 AEN LAB NO: 9509174-03  
 AEN WORK ORDER: 9509174  
 CLIENT PROJ. ID: S8047

DATE SAMPLED:  
 DATE RECEIVED: 09/13/95  
 REPORT DATE: 09/22/95

ANALYTE	METHOD/ CAS#	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED
Volatile Organic Compounds	EPA 8240				
Acetone	67-64-1	ND	10000	ug/L	09/18/95
Benzene	71-43-2	ND	500	ug/L	09/18/95
Bromodichloromethane	75-27-4	ND	500	ug/L	09/18/95
Bromoform	75-25-2	ND	500	ug/L	09/18/95
Bromomethane	74-83-9	ND	1000	ug/L	09/18/95
2-Butanone	78-93-3	ND	10000	ug/L	09/18/95
Carbon Disulfide	75-15-0	ND	1000	ug/L	09/18/95
Carbon Tetrachloride	56-23-5	ND	500	ug/L	09/18/95
Chlorobenzene	108-90-7	ND	500	ug/L	09/18/95
Chloroethane	75-00-3	ND	1000	ug/L	09/18/95
2-Chloroethyl Vinyl Ether	110-75-8	ND	1000	ug/L	09/18/95
Chloroform	67-66-3	ND	500	ug/L	09/18/95
Chloromethane	74-87-3	ND	1000	ug/L	09/18/95
Dibromochloromethane	124-48-1	ND	500	ug/L	09/18/95
1,1-Dichloroethane	75-34-3	ND	500	ug/L	09/18/95
1,2-Dichloroethane	107-06-2	ND	500	ug/L	09/18/95
1,1-Dichloroethene	75-35-4	ND	500	ug/L	09/18/95
cis-1,2-Dichloroethene	156-59-2	12,000 *	500	ug/L	09/18/95
trans-1,2-Dichloroethene	156-60-5	ND	500	ug/L	09/18/95
1,2-Dichloropropane	78-87-5	ND	500	ug/L	09/18/95
cis-1,3-Dichloropropene	10061-01-5	ND	500	ug/L	09/18/95
trans-1,3-Dichloropropene	10061-02-6	ND	500	ug/L	09/18/95
Ethylbenzene	100-41-4	ND	500	ug/L	09/18/95
2-Hexanone	591-78-6	ND	5000	ug/L	09/18/95
Methylene Chloride	75-09-2	ND	2000	ug/L	09/18/95
4-Methyl-2-pentanone	108-10-1	ND	5000	ug/L	09/18/95
Styrene	100-42-5	ND	500	ug/L	09/18/95
1,1,2,2-Tetrachloroethane	79-34-5	ND	500	ug/L	09/18/95
Tetrachloroethene	127-18-4	5,800 *	500	ug/L	09/18/95
Toluene	108-88-3	ND	500	ug/L	09/18/95
1,1,1-Trichloroethane	71-55-6	ND	500	ug/L	09/18/95
1,1,2-Trichloroethane	79-00-5	ND	500	ug/L	09/18/95
Trichloroethene	79-01-6	2,000 *	500	ug/L	09/18/95
Vinyl Acetate	108-05-4	ND	5000	ug/L	09/18/95
Vinyl Chloride	75-01-4	ND	1000	ug/L	09/18/95
Xylenes, Total	1330-20-7	ND	1000	ug/L	09/18/95

ND = Not detected at or above the reporting limit

\* = Value at or above reporting limit

SECOR

SAMPLE ID: VOA #6  
 AEN LAB NO: 9509174-04  
 AEN WORK ORDER: 9509174  
 CLIENT PROJ. ID: SB047

DATE SAMPLED:  
 DATE RECEIVED: 09/13/95  
 REPORT DATE: 09/22/95

ANALYTE	METHOD/ CAS#	RESULT	REPORTING LIMIT	UNITS	DATE ANALYZED
Volatile Organic Compounds	EPA 8240				
Acetone	67-64-1	ND	200	ug/kg	09/18/95
Benzene	71-43-2	ND	5	ug/kg	09/18/95
Bromodichloromethane	75-27-4	ND	5	ug/kg	09/18/95
Bromoform	75-25-2	ND	5	ug/kg	09/18/95
Bromomethane	74-83-9	ND	10	ug/kg	09/18/95
2-Butanone	78-93-3	ND	100	ug/kg	09/18/95
Carbon Disulfide	75-15-0	ND	10	ug/kg	09/18/95
Carbon Tetrachloride	56-23-5	ND	5	ug/kg	09/18/95
Chlorobenzene	108-90-7	ND	5	ug/kg	09/18/95
Chloroethane	75-00-3	ND	10	ug/kg	09/18/95
2-Chloroethyl Vinyl Ether	110-75-8	ND	10	ug/kg	09/18/95
Chloroform	67-66-3	ND	5	ug/kg	09/18/95
Chloromethane	74-87-3	ND	10	ug/kg	09/18/95
Dibromochloromethane	124-48-1	ND	5	ug/kg	09/18/95
1,1-Dichloroethane	75-43-3	ND	5	ug/kg	09/18/95
1,2-Dichloroethane	107-06-2	ND	5	ug/kg	09/18/95
1,1-Dichloroethene	75-35-4	ND	5	ug/kg	09/18/95
cis-1,2-Dichloroethene	156-59-2	ND	5	ug/kg	09/18/95
trans-1,2-Dichloroethene	156-60-5	ND	5	ug/kg	09/18/95
1,2-Dichloropropane	78-87-5	ND	5	ug/kg	09/18/95
cis-1,3-Dichloropropene	10061-01-5	ND	5	ug/kg	09/18/95
trans-1,3-Dichloropropene	10061-02-6	ND	5	ug/kg	09/18/95
Ethylbenzene	100-41-4	ND	5	ug/kg	09/18/95
2-Hexanone	591-78-6	ND	50	ug/kg	09/18/95
Methylene Chloride	75-09-2	ND	20	ug/kg	09/18/95
4-Methyl-2-pentanone	108-10-1	ND	50	ug/kg	09/18/95
Styrene	100-42-5	ND	5	ug/kg	09/18/95
1,1,2,2-Tetrachloroethane	79-34-5	ND	5	ug/kg	09/18/95
Tetrachloroethene	127-18-4	5 *	5	ug/kg	09/18/95
Toluene	108-88-3	ND	5	ug/kg	09/18/95
1,1,1-Trichloroethane	71-55-6	ND	5	ug/kg	09/18/95
1,1,2-Trichloroethane	79-00-5	ND	5	ug/kg	09/18/95
Trichloroethene	79-01-6	ND	5	ug/kg	09/18/95
Vinyl Acetate	108-05-4	ND	50	ug/kg	09/18/95
Vinyl Chloride	75-01-4	ND	10	ug/kg	09/18/95
Xylenes Total	1330-20-7	ND	10	ug/kg	09/18/95

ND = Not detected at or above the reporting limit

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AEN (CALIFORNIA)  
QUALITY CONTROL REPORT

AEN JOB NUMBER: 9509174

CLIENT PROJECT ID: SB047

Quality Control and Project Summary

All laboratory quality control parameters were found to be within established limits.

Definitions

Laboratory Control Sample (LCS)/Method Spike(s): Control samples of known composition. LCS and Method Spike data are used to validate batch analytical results.

Matrix Spike(s): Aliquot of a sample (aqueous or solid) with added quantities of specific compounds and subjected to the entire analytical procedure. Matrix spike and matrix spike duplicate QC data are advisory.

Method Blank: An analytical control consisting of all reagents, internal standards, and surrogate standards carried through the entire analytical process. Used to monitor laboratory background and reagent contamination.

Not Detected (ND): Not detected at or above the reporting limit.

Relative Percent Difference (RPD): An indication of method precision based on duplicate analysis.

Reporting Limit (RL): The lowest concentration routinely determined during laboratory operations. The RL is generally 1 to 10 times the Method Detection Limit (MDL). Reporting limits are matrix, method, and analyte dependent and take into account any dilutions performed as part of the analysis.

Surrogates: Organic compounds which are similar to analytes of interest in chemical behavior, but are not found in environmental samples. Surrogates are added to all blanks, calibration and check standards, samples, and spiked samples. Surrogate recovery is monitored as an indication of acceptable sample preparation and instrumental performance.

0: Surrogates diluted out.

#: Indicates result outside of established laboratory QC limits.



## QUALITY CONTROL DATA

METHOD: EPA 8240

AEN JOB NO: 9509174  
 INSTRUMENT: 13  
 MATRIX: WATER

## Surrogate Standard Recovery Summary

Date Analyzed	Client Id.	Lab Id.	Percent Recovery		
			1,2-Dichloroethane-d <sub>4</sub>	Toluene-d <sub>8</sub>	p-Bromofluorobenzene
09/18/95	VOA #1	01	101	91	97
09/18/95	VOA #3	02	104	91	101
09/18/95	VOA #5	03	95	95	90
QC Limits:			76-114	88-110	86-115

DATE ANALYZED: 09/12/95  
 SAMPLE SPIKED: 9509039-01  
 INSTRUMENT: 13

## Matrix Spike Recovery Summary

Analyte	Spike Added (ug/L)	Average Percent Recovery	RPD	QC Limits	
				Percent Recovery	RPD
1,1-Dichloroethene	50	133	<1	59-155	25
Trichloroethene	50	95	1	71-157	25
Benzene	50	107	2	37-151	25
Toluene	50	102	6	47-150	25
Chlorobenzene	50	99	3	37-160	25

Daily method blanks for all associated analytical runs showed no contamination at or above the reporting limit.

## QUALITY CONTROL DATA

METHOD: EPA 8240

AEN JOB NO: 9509174  
 INSTRUMENT: 13  
 MATRIX: SOIL

## Surrogate Standard Recovery Summary

Date Analyzed	Client Id.	Lab Id.	Percent Recovery		
			1,2-Dichloroethane-d <sub>4</sub>	Toluene-d <sub>8</sub>	p-Bromofluorobenzene
09/18/95	VOA #6	04	119	86	98
QC Limits:			70-121	81-117	74-121

DATE ANALYZED: 08/30/95  
 SAMPLE SPIKED: 9508343-02  
 INSTRUMENT: 13

## Matrix Spike Recovery Summary

Analyte	Spike Added (ug/kg)	Average Percent Recovery	RPD	QC Limits	
				Percent Recovery	RPD
1,1-Dichloroethene	50	108	7	59-155	25
Trichloroethene	50	102	<1	71-157	25
Benzene	50	101	3	37-151	25
Toluene	50	102	2	47-150	25
Chlorobenzene	50	105	1	37-160	25

Daily method blanks for all associated analytical runs showed no contamination at or above the reporting limit.

\*\*\* END OF REPORT \*\*\*

R-3, S-1

Chain-of Custody Number:

## SECOR Chain-of Custody Record

9509174

Field Office:

SAC AMICO 60

Address:

1734 34th St  
SACRAMENTO, CA☐ Additional documents are attached, and are a part of this Record.

Job Name:

Location:

Project # SB047 Task #

Project Manager

Laboratory AEN

Turnaround Time 3 Day - 9/18/95

Sampler's Name Bill Walker

Sampler's Signature

## Analysis Request

Sample ID	Date	Time	Matrix	HCID	TPH/TEX/WT/PH-G 8015 (modified)/8020	TPH/WT/PH-O 8015 (modified)	TPH 418.1/WT/PH 418.1	Aromatic Volatiles 602/8020	Volatile Organics 624/8240 (GC/MS)	Halogenated Volatiles 601/8010	Semi-volatile Organics 625/8270 (GC/MS)	Pesticides/PCBs 608/8080	Total Lead 7421	Priority Pollutant Metals (13)	TCLP Metals	Comments/ Instructions	Number of Containers
Q1A VOC# 1	9/1	—	H <sub>2</sub> O						X								1
Q2A VOC# 3	9/1	—	H <sub>2</sub> O						X								1
Q3A VOC# 5	9/1	—	H <sub>2</sub> O						X								1
Q4A VOC# 6	9/1	—	Soil						X								1

Special Instructions/Comments:

Please fax results  
ASAP

Relinquished by: A. Beards

Sign A. Beards

Print A. Beards

Company SECOR

Time 1400 Date 9/13/95

Relinquished by: Jim Paladino

Sign Jim Paladino

Print Jim Paladino

Company AEN

Time 1520 Date 9/13/95

Received by: J. Paladino

Sign J. Paladino

Print J. Paladino

Company AEN

Time 1400

Date 9/13/95

Received by: Gina M. Bellucci

Sign Gina M. Bellucci

Print Gina M. Bellucci

Company AEN

Time 1520

Date 9/13/95

## Sample Receipt

Total no. of containers: 4

Chain of custody seals:

Rec'd. in good condition/cold:

Conforms to record:

Client: SECOR

Client Contact: Bill Walker

(916) 456-4333

Client Phone:

## IN-SITU CHEMICAL OXIDATION CASE STUDIES

### Case #1 : Holmdel, Monmouth, New Jersey

Facility :	Former industrial facility (manufacturer of dental equipment).
Contaminants:	Spent solvents (PCE & TCE) from historical waste disposal practices.
Subsurface Conditions:	Several feet of fill (sand) underlain by silty, sandy clay. Groundwater @ 20 feet.
Sensitive Receptors:	Potable groundwater and adjoining stream.
Regulatory Status:	Memorandum of Agreement (MOA) / Former ISRA Case and RCRA Closure.
Project Phase:	Remedial Investigation Report (RIR) & Remedial Action Workplan (RAW) submitted to NJDEP in December 1996 (approval pending).
Pilot-Testing:	Two injection events (approximately 1,000 gallons and 2,000 gallons, respectively) of Fenton's Reagent (3% hydrogen peroxide and ferrous sulfate). Injection events performed in former spent solvent disposal area. (source previously excavated) which was the location of the highest dissolved-phase concentrations of VOCs. Observed significant decreases in dissolved-phase concentrations of VOCs in groundwater to point where further active remediation was not proposed.
Proposed RAW:	Natural attenuation of dissolved-phase plume (i.e. monitoring-only) with establishment of a Classification Exception Area (CEA).

### Groundwater Analytical Results Summary

Compound	Pre-test groundwater concentrations ( $\mu\text{g/l}$ )	Post-test groundwater concentrations ( $\mu\text{g/l}$ )
cis-1,2-DCE	ND	ND
1,1,1-TCA	ND	ND
PCE	170 (E)	280 (D)
TCE	1,600	460

Case #2 : Linden, Union County, New Jersey

Facility : Former industrial facility (disassembly, cleaning, inspection, repair and painting of motor parts).

Contaminants: Chlorinated VOCs (primarily PCE & TCE) from leaking USTs.

Subsurface Conditions: Silt and clay. Bedrock @ 9-13 feet. Groundwater @ 3 feet.

Sensitive Receptors: None identified.

NJDEP Program: ISRA.

Project Phase: Preparation of a RIR & RAW for submittal to the NJDEP.

Pilot-Testing: Two injection events (approximately 3,500 gallons each) of Fenton's Reagent (3% hydrogen peroxide and ferrous sulfate). Injection events performed in source area where high residual concentrations of VOCs exist in soil and groundwater. Observed significant decreases in dissolved-phase concentrations of PCE, TCE and breakdown/daughter products in groundwater.

Proposed RAW: Continuous or batch feeding of Fenton's Reagent to further reduce concentrations of VOCs in source area soil and groundwater. Natural attenuation of dissolved-phase plume (i.e. monitoring-only) with establishment of a CEA.

Groundwater Analytical Results Summary

Compound	Pre-test groundwater concentrations ( $\mu\text{g/l}$ )	Post-test groundwater concentrations ( $\mu\text{g/l}$ )
cis-1,2-DCE	62,200	6,170
1,1,1-TCA	6,370	795
PCE	111,000	60,200
TCE	20,000	9,830

Case #3 : Flemington, Hunterdon County, New Jersey

Facility :	Former industrial facility (manufacturer of PVC).
Contaminants:	Primarily vinyl chloride, TCE, methylene chloride and DCE from various sources including lagoons and settling ponds.
Subsurface Conditions:	Silt and clay. Fractured bedrock @ 10 feet. Perched groundwater (in unconsolidated sediments) @ 2-10 feet. Groundwater at xx feet in bedrock
Sensitive Receptors:	Potable groundwater
NJDEP Program:	ISRA, RCRA Closure and NJPDES permit
Project Phase:	RAW submitted to the NJDEP. Existing pump and treat system upgraded from 20 to 40 gpm with on-site treatment capabilities (previously discharged to POTW).
Pilot-Testing:	Two injection events. The first injection event consisted of injecting approximately 25,000 gallons of Fenton's Reagent (1% hydrogen peroxide and ferrous sulfate) in six wells around source area and existing groundwater recovery wells. Due to complexities of groundwater flow within fractured bedrock, distance of observation points from the injection wells, insufficient sampling frequency and the size of the pilot test area, the effectiveness of the injection test could not be evaluated. The second injection event consisted of injecting approximately 1,000 gallons of Fenton's reagent in a smaller test area. The application of 1,000 gallons of Fenton's reagent solution was capable of reducing VOC concentrations by 79% (compared to pre-test conditions).
Proposed RAW:	Batch feeding of Fenton's Reagent to further reduce concentrations of VOCs. in source area groundwater. Pump and treat (carbon) for dissolved-phase plume with establishment of a CEA.

Case #4 : Hackettstown, Morris County, New Jersey

Facility : Active industrial facility (manufacturer of electrical equipment).  
Contaminants: Primarily TCA, PCE and TCE (source not identified).  
Subsurface Conditions: Glacial till underlain by fractured bedrock at depths ranging from 1 to 90 feet. Groundwater @ 20 to 40 feet.  
Sensitive Receptors: Numerous potable wells.  
NJDEP Program: MOA.  
Project Phase: RAW (no further action) and Remedial Action Report (RAR) approved by the NJDEP.  
Pilot-Testing: Two injection events (approximately 8,000 gallons each) of Fenton's Reagent (3-5% hydrogen peroxide and ferrous sulfate). Injection event performed in area of highest dissolved-phase VOC concentrations. Observed significant decreases in dissolved-phase concentrations of VOCs in groundwater to point where further active remediation was not required.  
Approved RAW: No further action with establishment of a CEA.

Groundwater Analytical Results Summary

Compound	Pre-test groundwater concentrations ( $\mu\text{g/l}$ )	Post-test groundwater concentrations ( $\mu\text{g/l}$ )
1,1-DCA	2,500	2,150
1,1,1-TCA	11,000	2,800
PCE	10	ND
TCE	130	ND

Appendix C  
Resumes of Key *SECOR* Personnel

## RAVI GUPTA Principal-in-Charge

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B.S. Chemical Engineering, 1984  
City College of New York

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Mr. Gupta has over 12 years of professional experience in the environmental consulting industry. His previous experience has included serving as the Technical Director of large industrial projects in the State of New Jersey, New York, Alabama, and Michigan. As ECRA/ISRA Program Director for an environmental firm in New Jersey, he was responsible for the technical management and program development of ECRA/ISRA projects. He has extensive knowledge of NJDEP and NYSDEC compliance requirements, and has provided cost-effective solutions to ECRA/ISRA, RCRA, and underground storage tank (UST) issues. Mr. Gupta's diversified experience has encompassed all phases of site evaluation and environmental risk assessment/management. His previous experience has also included supervision and case management of High Environmental Concern (HEC) cases for the NJDEP ECRA/ISRA program. In this capacity, Mr. Gupta has assisted in establishing procedures for performing ECRA/ISRA program functions, and directed and coordinated case management teams for development of investigative plans, evaluation of hazardous sites, and selection of remedial technologies. Additionally, Mr. Gupta is the Principal-in-Charge of SECOR's office in Robbinsville ("Trenton"), New Jersey. His project experience is presented below.

### Project Experience

- Provided expert testimony regarding consistency with NCP and NJDEP requirements for a large ECRA/ISRA project in New Jersey which was impacted by chlorinated solvents/DNAPLs. Involved preparing an expert report which evaluated the environmental investigation and remediation activities conducted by others and the consistency with NCP's and NJDEP's ECRA/ISRA requirements. Prepared cost estimates for settlement negotiation and provided litigation support/assistance in cross-examination of plaintiff's experts.
- Served as Project Manager/Project Director for a large ECRA/ISRA project in New Jersey. Developed a risk-based remediation plan and conducted extensive negotiations with the NJDEP for plan approval. Included addition of chemical reagents and shredding of soils to strip volatile organic compounds (VOCs) present in the soils, stabilization of leachable metals, biotreatment of extracted groundwater, and placement of a cap/cover over a landfill.
- Served as Project Manager/Project Director for a large ECRA/ISRA project in New Jersey. Successfully negotiated alternate remediation standards for volatile, semi-volatile, and metal compounds in soils. Currently petitioning for compliance for soils issues. Also obtained approval of a statistical-evaluation-based natural remediation plan for groundwater.
- Served as Project Director for an assessment/remediation project in New Jersey which involved chlorinated solvents and PCBs. Conducted extensive soil and groundwater sampling to determine the source of contamination. Evaluated several groundwater treatment technologies and discharge options.

- Served as Project Manager for a remediation project in New Jersey which involved chlorinated solvents. Completed air sparging, vapor extraction, and a high-vacuum pumping pilot study to determine the feasibility of removing the chlorinated solvents from clay soils interbedded with sand stringers.
- Served as a Case Manager for the NJDEP, and reviewed and approved Sampling Plans, Cleanup Plans, Interim Cleanup Plans, and Negative Declarations at approximately 100 industrial sites requiring ECRA/ISRA compliance. Frequently assisted the Bureau of ECRA/ISRA Applicability and Compliance (BEAC) in applicability matters and issuance of Letters of Non-Applicability (LNAs).
- Compiled case-pertinent information for the office for the Attorney General for a regulatory compliance project in New Jersey. Prepared depositions and certificates for the attorneys representing the State of New Jersey and ECRA at hearings and other court procedures. Negotiated Administrative Consent Orders (ACOs) and Notices of Violation.
- Provided community relations for a multi-jurisdictional site in Bergen County, New Jersey. Involved investigation of disposal areas, areas of separate-phase hydrocarbons, and off-site groundwater contamination. Scheduled and conducted public meetings regarding the findings of the preliminary investigation and the impact on public health.
- Performed a site assessment in Edison, New Jersey, to determine the hydrogeologic impact resulting from dry well discharges at a major chemical facility. Included a detailed study of past operations and processes with emphasis on industrial waste streams and discharge lines, as well as evaluation of aerial history.
- Developed Sampling Plans and Interim Cleanup Plans to define the extent of contamination at a former aeronautical engine manufacturing site in New Jersey. Included soil, groundwater, surface water, sediment, hazardous waste, chip, wipe, and air sampling.
- Performed a Remedial Investigation/Feasibility Study (RI/FS) to define the contamination resulting from manufacturing operations at a former machine fabricating plant. Included soil testing, on- and off-site groundwater quality assessment, and impact on public water wells. Evaluated various remedial options using the data generated, including air stripping, soil venting, and in-situ bioremediation.
- Performed a preliminary investigation which involved the evaluation of contaminant migration from a chemical plant as part of remedial investigation in Warren, New Jersey. Included investigation of contaminated ponds, surface impoundments, lagoons, a landfill with buried drums, and areas of historical dumping. Also included an in-depth study of historical information, plumbing diagrams, process flow charts, and aerial history over 40 years.
- Performed a preliminary investigation of a site to define contamination at a chemical manufacturing plant as part of site investigation in Carlstadt, New Jersey. Included soil testing, groundwater quality assessment, influence of tides, and sediment sampling to evaluate stream and pond contamination. Also included historical information evaluation using aerial photos to identify off-site dumping areas.

- Participated on a site assessment project in Monmouth, New Jersey. Included identification of potential source location of contaminants, evaluation of migration paths, evaluation of mitigation alternatives, and development of abatement strategies.
- Participated on a remedial investigation in Edison, New Jersey, to evaluate the extent of soil and groundwater contamination from a UST area. Developed strategy to implement interim containment measures and evaluate remedial techniques.
- Participated on an environmental condition survey in Morristown, New Jersey. Also included a soil gas survey of the site, which indicated groundwater contamination of the neighboring domestic wells existed (mixed chlorinated solvents). Involved interim strategy, evaluation of contaminant migration paths, and exposure routes.

#### Professional Memberships

American Chemical Society  
American Institute of Chemical Engineers (AIChE)

#### Professional Certifications and Registrations

NJDEP-BUST-Certified Subsurface Evaluator  
40-Hour OSHA Health & Safety Certification (29 CFR 1910.120), 1986  
8-Hour OSHA Health & Safety Update Certification, 1995  
8-Hour OSHA Supervisor's Certification, 1994

## RICHARD H. PETEREC, P.E.

Senior Engineer

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M.S. Mechanical Engineering, 1988  
Bucknell University

B.S. Mechanical Engineering, 1986  
Bucknell University

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Mr. Peterec has over eight years of professional experience in mechanical and environmental engineering. In his present position as Senior Engineer, he is responsible for the development of Remedial Action Workplans (RAWs), pilot testing of soil and groundwater remediation systems, design and permitting of remediation systems, management of system installations, and supervision of the operation and maintenance (O&M) of remedial systems. He has also worked as Project Manager of retail petroleum sites. Previously, Mr. Peterec has worked as a Mechanical Engineer for an international Department of Defense contractor designing rotating and structural components of commercial and military aircraft engines. Other responsibilities have included the development of programs and processes to perform stress and life analyses of engine components. As a Design Engineer, Mr. Peterec received numerous achievement awards and an award for excellence in customer support. He has also worked as a Transportation Construction Inspector for the New York State Department of Transportation where he was responsible for on-site supervision of contractors during construction of roads and drainage systems. Other responsibilities have included field testing and progress reporting. Mr. Peterec's project experience is presented below.

### Project Experience

- Served as a Project Engineer for the pilot testing, design, installation, and operation of an air sparge/soil vapor extraction (AS/SVE) system to remediate separate-phase heptane and dissolved-phase petroleum hydrocarbons at a manufacturing facility. Systems consisted of 26 co-located sparge and vent wells and a horizontal SVE well (beneath a building) that extracted soil vapor at a flow of 1,500 cfm, as well as a thermal oxidizer for vapor treatment prior to discharge. Removed approximately 33,000 pounds of non-methane hydrocarbons during the first three months of operation.
- Served as Project Engineer for a Remedial Investigation (RI) and design of four remediation systems at a former manufacturing facility. Performed air injection pilot tests in the saturated zone to enhance in-situ biodegradation and SVE pilot tests using horizontal wells. Designed a groundwater recovery and treatment system to remediate impacted groundwater which had migrated off site and to prevent the dissolved-phase plume from migrating to a nearby river. Designed an AS/SVE system which consisted of 25 vertical AS wells and approximately 1,000 feet of horizontal SVE wells. Additionally, designed two other systems which consisted of 12 vertical wells and two 300-foot-long horizontal wells to inject air into the saturated zone to enhance in-situ biodegradation.
- Served as Project Engineer for the redesign/modification and installation of a groundwater recovery and treatment system to address chlorinated volatile organic compounds (VOCs) at a former PVC manufacturing facility. Additionally, performed pilot tests to determine the

- Participated on a site assessment project in Monmouth, New Jersey. Included identification of potential source location of contaminants, evaluation of migration paths, evaluation of mitigation alternatives, and development of abatement strategies.
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## Project Experience

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- Served as Project Engineer for a Remedial Investigation (RI) and design of four remediation systems at a former manufacturing facility. Performed air injection pilot tests in the saturated zone to enhance in-situ biodegradation and SVE pilot tests using horizontal wells. Designed a groundwater recovery and treatment system to remediate impacted groundwater which had migrated off site and to prevent the dissolved-phase plume from migrating to a nearby river. Designed an AS/SVE system which consisted of 25 vertical AS wells and approximately 1,000 feet of horizontal SVE wells. Additionally, designed two other systems which consisted of 12 vertical wells and two 300-foot-long horizontal wells to inject air into the saturated zone to enhance in-situ biodegradation.
- Served as Project Engineer for the redesign/modification and installation of a groundwater recovery and treatment system to address chlorinated volatile organic compounds (VOCs) at a former PVC manufacturing facility. Additionally, performed pilot tests to determine the

applicability of dual-phase vacuum extraction (DPVE) technology to address unsaturated soils and perched groundwater at two locations at the site.

- Served as Project Engineer for an RI and design of a remediation system for a manufacturing facility. Performed SVE and AS/SVE with helium tracer and groundwater pump tests to evaluate remedial alternatives. Designed an AS/SVE system to address the soil and groundwater impacted with adsorbed and dissolved-phase chlorinated VOCs.
- Served as Project Engineer for an RI at a former electric motor repair facility. Evaluated remedial options to address soil and groundwater impacted with chlorinated VOCs, including performing AS/SVE and peroxide injection pilot tests.
- Served as Project Engineer for several sites impacted with petroleum hydrocarbons. Performed pilot tests and designed, installed/modified, and supervised the O&M of soil and groundwater remediation systems.
- Served as a Project Manager of retail petroleum sites. Prepared proposals, developed monitoring plans and RAWs, prepared work scopes, coordinated field activities (O&M) of soil and groundwater remediation systems, and tracked budgets and billings. Also provided liaison with client and the New Jersey Department of Environmental Protection (NJDEP).
- Provided technical support for other project managers. Prepared RIs, RAWs, UST closure plans and summaries, quarterly reports, air emissions reports, and air and water Discharge Monitoring Reports (DMRs). Also provided construction management, vendor/contractor screening, bid solicitation, and equipment specification.

#### Professional Certifications and Registrations

Registered Professional Engineer (Mechanical), New York (No. 075060), 1997  
Registered Professional Engineer (Mechanical), Pennsylvania (No. 45866-E), 1996  
Registered Professional Engineer (Mechanical), New Jersey (No. GE39814) 1996  
40-Hour OSHA Health & Safety Certification (29 CFR 1910.120), 1993  
8-Hour OSHA Health & Safety Update Certification, 1995  
8-Hour OSHA Supervisor's Certification, 1995  
First Aid/CPR Certification, 1995  
CPR Update and Bloodborne Pathogen Training, 1996

#### Professional Training and Continuing Education Courses

"Site Remediation Technology," Tufts University, 1992  
"Environmental Geotechnology," Bucknell University, 1987  
"Engineering Geology," Bucknell University, 1985  
Remediation of NAPL-contaminated Sites Seminar sponsored by the EPA, NJIT and Stevens, March 1994  
New England Environmental Expo, 1992 and 1993

#### Professional Awards

Three Achievement Awards as an Analytical Engineer, General Electric, 1991-1993  
Engineer's Day Award for excellence in customer support, General Electric, 1992

MARK E. TIMMONS, P.G.  
Principal Hydrogeologist

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B.S. Geology, 1985  
Boston College

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Mr. Timmons has 11 years professional experience in the environmental consulting field. This experience has included projects involving underground storage tanks (USTs); petroleum bulk storage terminals; chemical manufacturing plants; and real estate transfers of residential, commercial, and industrial properties. He has served as a Field Geologist, Project Manager, Territory Manager, and Principal Hydrogeologist. His area of expertise have included hydrogeologic site investigation and evaluation, data acquisition, aquifer characterization, groundwater/solute transport modeling, and remediation system design. Mr. Timmons' selected project experience is presented below.

## Project Experience

- Served as a Project Manager implementing site investigations, remedial investigations, and Remedial Action Workplans (RAWs) at numerous retail service stations and other UST sites.
- Involved in multiple Phase I Environmental Site Assessments (ESAs) for real estate acquisitions and divestitures in Delaware, New Jersey, Pennsylvania, and New York. Conducted assessments in accordance with ASTM standard practice for ESAs for Commercial Real Estate (E1527-94) and New Jersey Department of Environmental Protection (NJDEP) Technical Requirements (N.J.A.C. 7:26E).
- Designed and conducted aquifer tests in various hydrogeologic settings, including tidally influenced and bedrock aquifers. Utilized multi-channel data logging equipment to collect groundwater and surface water levels, and barometric pressure and pumping rate data for periods up to one month. Compiled data and performed data evaluation to characterize aquifer conditions.
- Performed two-dimensional groundwater flow modeling as part of the design of numerous groundwater recovery and reinjection systems. Utilized models to determine the number and spacing of multiple pumping wells to contain groundwater impacted with dissolved hydrocarbons and to optimize recovery of floating product.
- Conducted one- and two-dimensional solute transport modeling at several sites to evaluate the migration potential of compounds dissolved in groundwater. Utilized model results to support "No Action" scenarios and to estimate remediation time frames for pump-and-treat systems.
- Performed soil vapor extraction (SVE) and air sparge (AS) pilot tests at various sites to determine the applicability of these technologies to remediate soil and groundwater impacted by organic compounds. Involved with the design and installation of full-scale SVE and AS systems at several sites.

### Professional Memberships

Association of Groundwater Scientists and Engineers (AGWSE)  
Association of Engineering Geologists, New York/Philadelphia Section

### Professional Certifications and Registrations

Professional Geologist, Pennsylvania, 1995  
New Jersey-licensed Industrial Wastewater Treatment Operator (N-2), 1989  
New Jersey-certified UST Subsurface Evaluator, 1993  
40-Hour OSHA Health & Safety Certification (29 CFR 1910.120), 1987  
8-Hour OSHA Health & Safety Annual Update Certification, 1996  
8-Hour OSHA Supervisor's Certification, 1994

### Professional Training and Continuing Education Courses

M.S. program, Engineering Geology, Drexel University, 1988 to present  
Graduate-level course work, Environmental Science, Rutgers University, 1986-1987  
Completed several short courses in Hydrogeology, NGWA