Supplemental Work Plan

25 Melville Park Road
Melville, New York

April 1999

Prepared for:

WHCS Real Estate Limited Partnership
600 E. Las Colinas Boulevard, Suite 1900
Irving, Texas 75039

Prepared by:

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April 30, 1999

Mr. Robert Stewart
Environmental Engineer
NYSDEC
SUNY Building 40
Stony Brook, NY 11790-2356

Subject: Transmittal of Supplemental Work Plan for
25 Melville Park Road

Dear Mr. Stewart:

Enclosed please find three (3) copies of the Supplemental Work Plan for 25 Melville Park Road. The proposed work plan tasks were designed to fill in data gaps and address NYSDEC comments to the In-situ Chemical Oxidation Pilot Test Report of Findings prepared by SECOR International.

As you know, the groundwater sampling and analytical event described in this plan was completed in early March 1999. Results were forwarded to you earlier this month.

CDM intends to implement the remaining tasks in cooperation with Sovereign Environmental (formerly SECOR), upon receipt of your department's approval.

Should you have any questions or comments regarding this work plan or the groundwater quality data generated from the March sampling event, please do not hesitate to contact me at 516-496-8400.

Very truly yours,

CAMP DRESSER & McKEE

David J. Kell

David J. Kell, P.G.
Project Manager

cc: S. O'Hara/WHCS Melville LLC
C. McKenzie/Beveridge & Diamond
P. Douglas/Archon
G. Hayes/Archon
R. Becherer/NYSDEC
J. Byrne/NYSDEC
S. McCormick/NYSDEC
W. Gilday/NYSDOH
G. Anders Carlson/NYSDOH
C. McGrath/NYSDEC
G. Fitzpatrick/SCDHS
E. O'Brecht/NYSDEC
B. Weinstein/CDM

w:archon/stewartr

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Section 1
Purpose and Scope

1.1 Introduction

Camp Dresser & McKee (CDM) has prepared this Supplemental Work Plan for the commercial property located at 25 Melville Park Road, Melville, New York. This plan describes a scope of work for additional investigation and report preparation. The investigative activities are designed to further delineate on-site chemical oxidation as a potential full-scale remediation technology. This Supplemental Work Plan is submitted to the New York State Department of Environmental Conservation (NYSDEC) for approval under the Department's Voluntary Cleanup Program. WHCS Melville, LLC (WHCS), the present site owner, has had no past history with this property or the former operations conducted there. WHCS is voluntarily pursuing the expeditious remediation of on-site source areas using the best available technologies to meet criteria that will be acceptable to WHCS and the NYSDEC.

1.2 Site Description and History

The property is located south and east of the intersection of Broadhollow Road and the Long Island Expressway (Route 495) in the Village of Melville, Suffolk County, Long Island, New York (figure 1). Surrounding properties are classified as industrial and commercial.

Presently, the property is occupied by a two-story office building and parking facilities. As of April 1999, building occupants included Northville Industries Corporation, Arrow Electronics, and Mortgage Plus. The building is served by municipal water and is heated by natural gas. The property is served by two on-site septic systems located to the south of the building. The nearest public water supply well was identified approximately one-half mile north of the site. Two additional wells are located an estimated one mile south-southwest of the site. The property is located within the South Huntington Water District.

Historically, the property was occupied by the New York Twist Drill Company (NYTD). NYTD was present on-site from 1966 (when the building was originally constructed) through 1984. NYTD manufactured high-speed carbon and carbide drills. After NYTD vacated the building, it was converted into a two-story office complex.

Review of public documents and telephone interviews conducted with former NYTD employees indicate that NYTD used chemicals in their manufacturing process, which if released to the environment, would produce the same chemical contaminant fingerprint that has been documented during the remedial investigation in on-site soils and groundwater. Appendix A contains a table summarizing documents contained in the public record which supports this conclusion. A schematic representation of NYTDs manufacturing process which has been reconstructed from Suffolk County Department of Health Services (SCDHS) records, has also been included in Attachment 1. After briefly holding the property in receivership as a secured lender to Delco Development Corporation, WHCS took title to the site in January 1998.

1.3 Site Geology and Hydrogeology

The site is underlain by thick, unconsolidated deposits of clay, silt, sand, and gravel that rest on a southward dipping crystalline bedrock. The deeper units were deposited during the Cretaceous Period (63-138 million years ago), and form (in ascending order) the Raritan and Magothy Formations. During the Tertiary Period (2 to 63 million years ago), any additional deposits overlying the Magothy Formation were eventually eroded away by glacial activity. During the Pleistocene Epoch (1.8 million years ago to 10,000 years ago), glacial melt water deposited outwash material forming what is presently known as the Upper Glacial aquifer. The Upper Glacial aquifer corresponds to the saturated, highly permeable Pleistocene deposit of sand and gravel.

A review of local well logs indicates that the overburden geology in the site area consists mostly of brown to gray fine to coarse sand with thin interbeds of clay. Solid gray clay was encountered at 293 feet below grade (fbg) in a well drilled south of Melville Park Road.

Monitoring wells installed as part of the remedial site investigation by CDM, showed the overburden materials to be primarily sand and coarse sand with minor silt lenses. Groundwater is present approximately 50 feet below ground surface. Groundwater flow is toward the south, southeast.

1.4 Investigations

Several previous environmental investigations have been performed on the subject site. These include:

- A Phase I Environmental Site Assessment performed by Aqua Terra dated March 1993;
- A Phase I Environmental Site Assessment with Subsurface Investigation performed by Fugro East, Inc. dated January 1995;
- An Additional Subsurface Investigation and Ground Penetrating Radar Letter Report by Fugro East, Inc. dated January 1995;
- An Additional Subsurface Investigation by Fugro East, Inc. dated October 1995;
- Findings of the Petrex Soil Gas Survey Report by Northeast Research Institute and Rizzo Associates dated November 1995;
- Preliminary Remedial Action Plan compiled by Environmental Remediations Inc. dated October 1996.

The main objective of each investigation was to delineate the nature and extent of contamination, and if possible, identify contaminant source area(s). Through a series of monitoring well installations, collection of subsurface soil samples and hydropunch water samples, these objectives were generally accomplished. Under the terms of the Voluntary Investigation Agreement with NYSDEC, WHCS expanded the investigations to fill identified data gaps and to produce a more thorough site characterization, with the ultimate intention of developing a sound remedial action work plan.

A description of the expanded investigations is found in section 1.5.

1.5 Expanded Investigation

CDM was retained by WHCS in 1997 to conduct a series of expanded investigations which included the following:

- A geophysical survey: using magnetic and ground penetrating radar equipment, three areas were surveyed. The first, the interior northeast corner of the building which was formerly occupied by NYTD's manufacturing and process equipment; the second, the exterior truck loading dock; and the third, requested by NYSDEC, the site of the NYTD former barium tank. Survey results revealed that no structures were found beneath NYTD's former operations area or the truck loading dock. The site of the former barium tank was located and a subsequent investigation was conducted. Results of the barium tank investigation were provided to NYSDEC, which later issued a no further action declaration for that structure.

- Subslab Investigation: using concrete coring equipment and soil augering devices, CDM explored beneath the building's interior northeastern slab in an attempt to locate potential hidden source areas. Source areas were to be delineated based on the occurrence of volatile organic vapors in shallow subsurface soils. No shallow source of VOC's was identified during these investigations.

- Hurricane Geoprobe Borings (HGB): direct push technologies were used to advance a series of geoprobe borings. Soil and groundwater samples were collected at pre-determined intervals within the borehole to delineate the vertical extent of contamination. The results of this investigation showed that contamination in the suspected source area had migrated deeper than previously suspected.

- Deep Well Installations: based on the HGB investigation, several deep wells were installed to provide permanent ports from which to sample groundwater. Using these new deep wells, supplemented by a series of existing shallow monitoring wells, a profile of groundwater contaminant contours was produced. Sampling of all the on-site wells further provided baseline water quality that could be compared to both past and future water quality sampling rounds.

- Offsite Investigations: No offsite characterizations were conducted as part of the recent expanded investigations. A survey of several offsite wells was performed by a previous consultant in 1993. According to the Voluntary Agreement with NYSDEC, WHCS is not required to investigate or remediate off-site contamination.

In December 1997, CDM issued a report to NYSDEC entitled "Voluntary Investigation Report: 25 Melville Park Road, Melville, New York". This report describes the details and results of the above referenced activities and provided conclusions and recommendations for additional assignments, which have subsequently been undertaken and are described below.

1.6 In-Situ Chemical Oxidation Pilot Test

In the spring of 1998, WHCS retained the services of SECOR International to work jointly with CDM for the implementation of a chemical oxidation pilot test. The test objective was to assess the capability of hydrogen peroxide and Fenton's Reagent to oxidize and neutralize the contaminants in on-site groundwater.

A full description of the methods, procedures, results and recommendations of this test can be found in SECOR's December 4, 1998 report entitled "In Situ Chemical Oxidation Pilot Test Report of Findings: 25 Melville Park Road". Appendix B provides a copy of the text of that report. A brief description follows.

Using existing on-site monitoring wells, SECOR introduced approximately 30,000 gallons of acidified water and 3% hydrogen peroxide with Fenton's reagent to both the water table aquifer (45-60 feet below grade) and a deeper aquifer zone (75-90 feet below grade). This series of injections took place over a period of three to four days. Groundwater quality samples collected at designated monitoring wells two, seven and twenty-one days after the injection were compared to baseline water quality results collected several months earlier. SECOR concluded that the overall reduction in contaminant mass (particularly evident in the shallower water table zone) between the baseline and post injection water quality sampling rounds indicated that additional injections would continue to reduce the mass of contamination dissolved in groundwater.

Based upon the pilot test results, supplemented by comments and recommendations from NYSDEC in a correspondence dated February 11, 1999, additional work tasks are proposed. Section 2 describes the scope and objectives of these tasks.

Section 2
Supplemental Work Plan

2.1 Introduction

Based upon the mass reduction in groundwater contaminants reported by SECOR in the December 1998 "In-Situ Chemical Oxidation Pilot Test Report", and comments to that report provided by NYSDEC on February 11, 1999, a supplemental work plan has been developed. Major work tasks include:

- the collection and analysis of groundwater from the injection and monitoring well network
- expansion of the injection and monitoring well network
- conducting a series of additional hydrogen peroxide and Fenton's reagent injections

2.2 Additional Groundwater Sampling and Analysis

One round of groundwater sampling will be conducted before any additional chemicals are introduced to the aquifer system. During this event, selected existing monitoring and injection wells will be sampled. Table 1 provides a list of wells to be sampled.

Groundwater samples will be analyzed for EPA Method 8260 volatile organic compounds (VOC's) plus tentatively identified compounds (TICs) and chlorides, EPA Method 325.2. NYSDEC also recommended that all wells be analyzed for alkalinity, sulfate, ferric, ferrous and total iron. Selected wells are also being analyzed for ethane, also requested by NYSDEC. Three of the samples will be reported as NYSDEC Category B deliverables. These three samples (IW-3, MW-8 and MW-23I) were also reported as Category B deliverables during earlier sampling rounds.

Results of this sampling event will be expected in twenty-one days after sample collection. Data analysis will determine whether the well installation program (described below) will be modified in any fashion.

(On March 1 and 2, 1999 with the approval of NYSDEC, CDM conducted the above referenced sampling of monitoring and injection wells listed in Table 1. Analytical data has been received, tabulated and transmitted to NYSDEC and other interested parties. The concentrations of VOC's and other groundwater analytes were generally as expected. As such, a determination was made to continue with the plans to implement the following tasks of this supplemental work plan).

2.3 Installation of Unsaturated (Vadose) Zone Injection Wells

The distribution of shallow groundwater contaminants beneath the suspected source area indicates that a mass of contamination potentially exists at the water table, in the capillary fringe, or in the vadose zone above the water table. Left untreated, this contaminant mass will slowly release contamination to the shallow groundwater system.

As a means to further assess the feasibility of in-situ chemical oxidation and, ultimately to remediate this area, up to four (4) vadose zone injection wells are proposed for installation. Vadose zone injection well locations appear in figure 2. Table 2 provides construction details of the proposed wells. These vadose zone wells are to be screened above the water table. The exact screened interval will be determined based on field observation and measurements (PID readings) collected during well installation. These wells will be designated vadose zone (VZ) wells, VZ-1, VZ-2, VZ-3 and VZ-4 (figure 2). Liquid oxidants introduced at these wells, will slowly percolate through the unsaturated sands, desorb and neutralize contaminants adhering to soil particles and reduce or eliminate the volume of contaminant mass that might otherwise infiltrate the groundwater system.

2.4 Expansion of Shallow Injection Well Network

Implementation of this task requires no additional well installations. Existing shallow wells, used as monitoring points in the In-situ Chemical Oxidation Pilot Test, will now be used as injection points. These wells include MW-7, MW-8, MW-9, MW-10 and MW-11. During future injections, each well will be outfitted with temporary piping and metering devices so that they can be used for injections. The immediate benefit is the direct application of oxidation chemicals to a larger volume of contaminated groundwater.

2.5 Installation of Additional Observation and Injection Wells

Assessing the effects of the chemical injections in the deep groundwater zone during the pilot test, was limited by the lack of adequate injection and monitoring points. Installation a series of four (4) deep zone wells screened from 75-90 feet below grade is proposed. These wells will form a general north to south trending line and will provide adequate monitoring and injection capability. These four (4) deep zone wells will be designated MW-25D, MW-26D and MW-27D and MW-28D. Locations appear on figure 2. Table 2 provides construction details of these proposed wells.

Several wells formerly used as shallow zone observation points during the pilot test are now proposed for use as injection wells. To compensate for the lack of observation points, one new well is proposed. Located equidistant between existing wells MW-10 and MW-16D, this well will be screened from approximately 45 to 60 feet below grade. Tentatively designated MW-29, the approximate location appears on figure 2, construction details appear in Table 2.

2.6 Injection Sequence

A tentative schedule identifying time frames and durations of each proposed injection appears in table 3. It is estimated that approximately 60,000 gallons of hydrogen peroxide and Fenton's Reagent will be injected during each 5 day event. A total of 2 injection events conducted over the next ten months is proposed. The first injection will be initiated within four (4) weeks of the approval of this plan.

Following the second injection event, groundwater quality samples will be collected and analyzed. An assessment of the data will be made to determine whether the remediation goals can be met through continued additional injections or whether alternate remedial strategies should be employed. Based upon the sample results collected at that time, modifications to this schedule and future planned injections will be made, if necessary. The objective will be to optimize the distribution of oxidants into each well and each aquifer zone.

While the sequence of injections will be subject to change based upon post-injection evaluations, the general injection sequence will be as follows:

Phase 1: injection into proposed unsaturated zone wells. This includes proposed wells designated VZ-1, VZ-2, VZ-3 and VZ-4.

Phase 2: injection into the shallow injection well network through wells, IW-1 through IW-7, MW-7, MW-8, MW-9, MW-10, MW-11, MW-12 and MW-13.

Phase 3: injection into deep groundwater injection wells. This includes deep wells used as injection points during the pilot test including IW-8 through IW-12, and MW-13D. Included in the list will be proposed deep zone wells MW-25D, MW-26D, MW-27D and MW-28D.

Phase 4: post-injection groundwater quality sampling

Wells designed to monitor each aquifer zone will be sampled sixty (60) days to ninety (90) days following the injection event. This sixty (60) to ninety (90) day time period was selected for several reasons including the following:

- all chemical reactions from the preceding injection will have been completed and therefore, will not interfere with the analytical results;
- adequate time will have elapsed between the injection and the sampling event to negate the effects of dilution.
- adequate time will have elapsed between the injection and the sampling event to allow upgradient groundwater to migrate to, and replace treated water from the injection event, sixty to ninety days prior.
- with standard laboratory turnaround times of twenty-one (21) days, analytical results could be reviewed and appropriate adjustments made to the next injection event without negatively impacting the injection schedule.

In summary, Phases 1, 2 and 3 would be conducted during a one week (5 day) period. Phase 4 would take place sixty (60) to ninety (90) days after the start of Phase 1. The subsequent injection event would begin approximately thirty (30) days after the Phase 4 collection of groundwater samples. A tentative schedule for this assignment is presented in Table 4.

It is noted that before, during and after each injection event, and again, before the post injection groundwater sampling event, all onsite wells will be monitored for the presence/absence of free phase product. If against expectation, product is identified, NYSDEC will be immediately notified and appropriate modifications to this plan will be made.

Section 3
Supplemental Tasks

3.1 Introduction

Several supplemental tasks will be conducted during and following the implementation of the Supplemental Work Plan. Each task will be carried out to address a specific requirement of the NYSDEC Voluntary Cleanup Program or a specific directive of the Department. These tasks include:

- develop a Remedial Action Work Plan
- develop a Citizens Participation Plan
- conduct an Exposure Assessment

3.2 Remedial Action Work Plan

Evaluation of the analytical data collected as part of the Supplemental Work Plan will provide the basis for development of a Remedial Action Work Plan. Supplemental Work Plan data will be referenced to data collected during the chemical oxidation pilot test (April to August 1998), and data collected in April 1997.

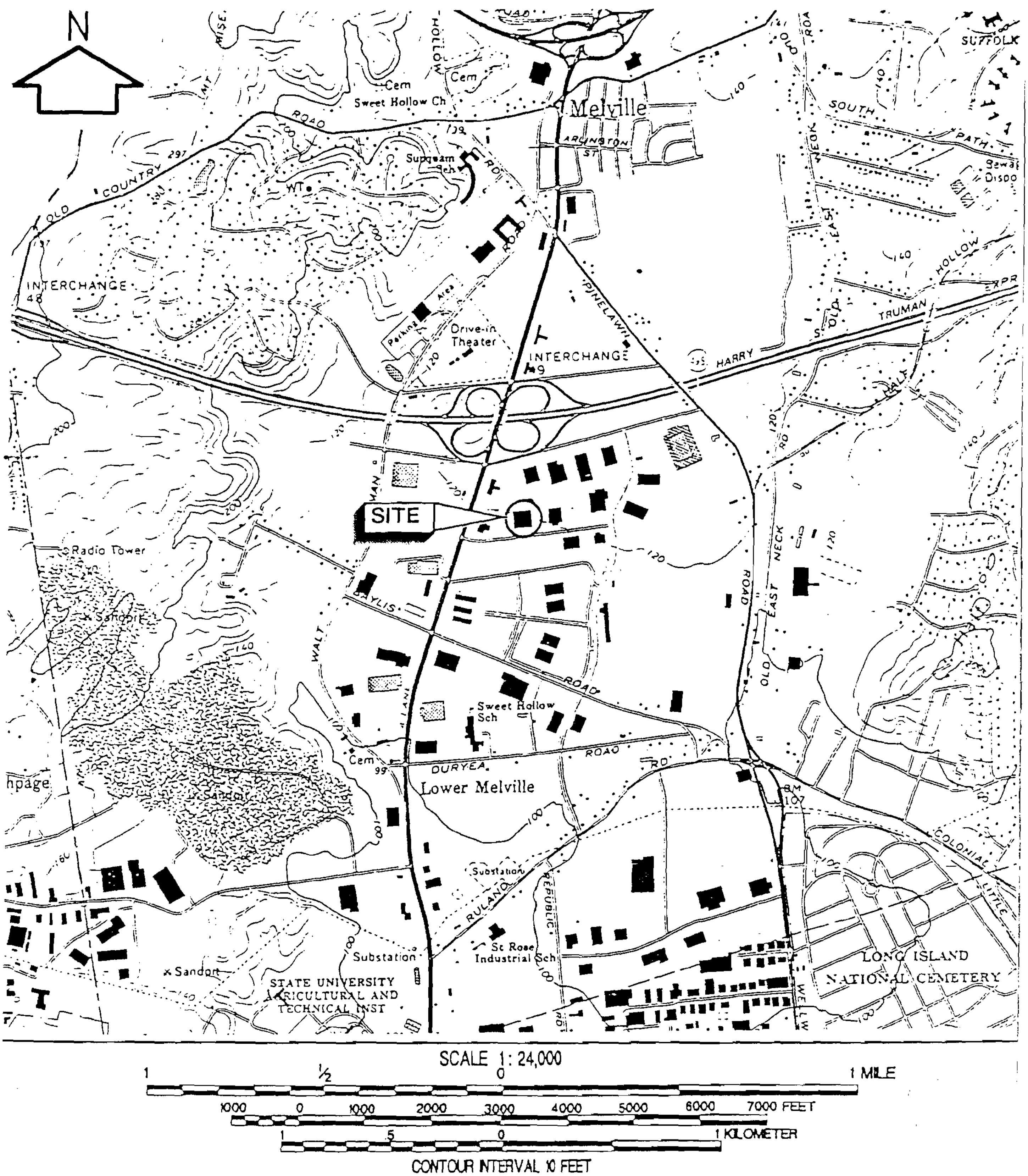
Decisions to continue or modify the sequence of chemical oxidations will be made at that time. Installation of additional source area injection wells, compliance point monitoring wells or other measures to determine achievable groundwater cleanup objectives, will be appropriately evaluated and recommended at this juncture.

3.3 Citizens Participation Plan

A Citizens Participation Plan (CPP) will be completed during the implementation of the Supplemental Work Plan. The CPP will describe the project and its history, identify issues of community interest and concern and provide a mechanism whereby the average citizen can learn, comment upon and participate in the decision making process for site cleanup and ultimate closure. The CPP encourages public comment at specific intervals in the life of the project, before final irreversible decisions are made. Repositories for public review of this and other documents will be established.

3.4 Exposure Assessment

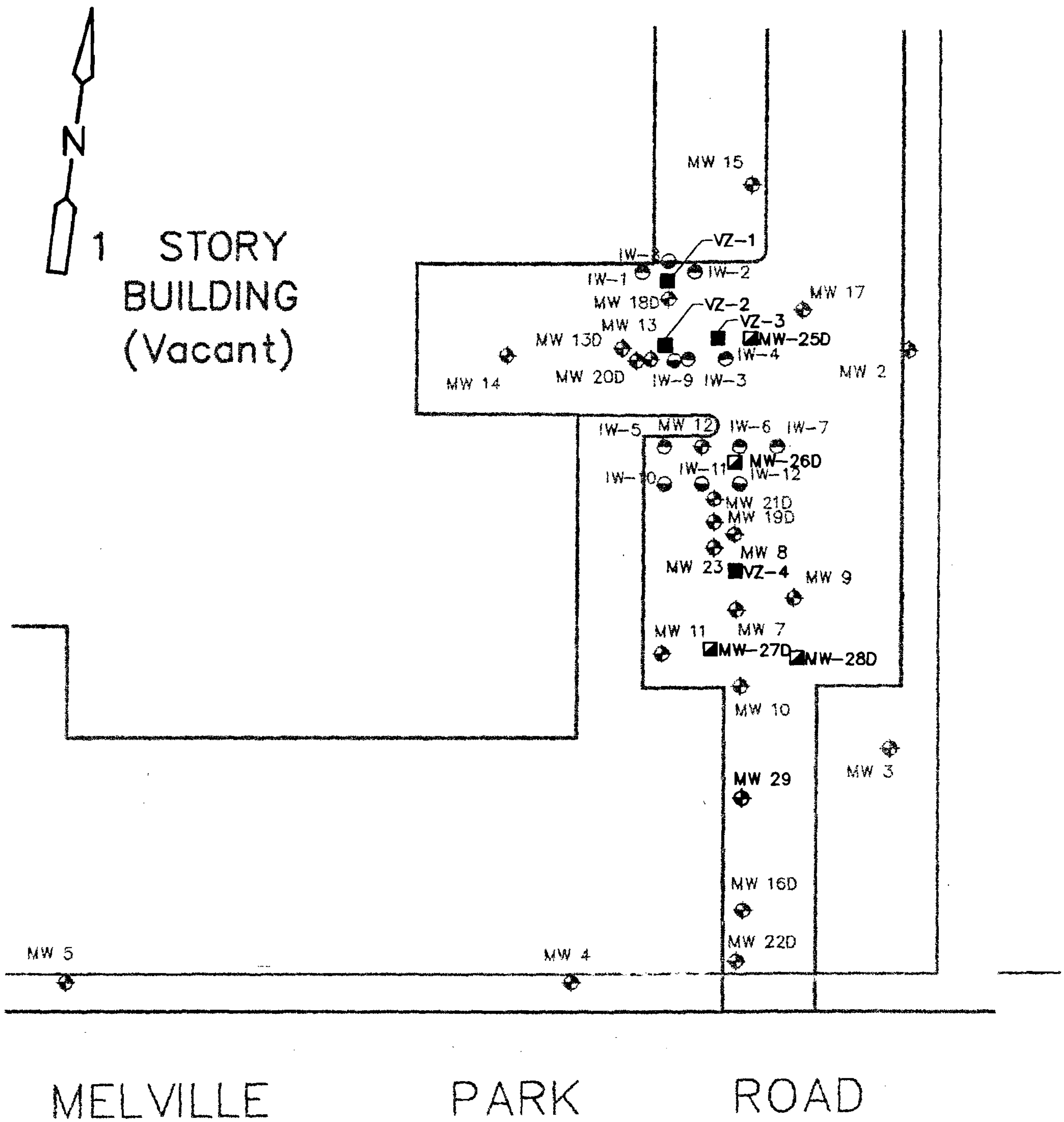
Under the terms of the Voluntary Cleanup Program and in accordance with a NYSDEC correspondence dated March 13, 1998, an Exposure Assessment (EA) will be conducted. This assessment will identify specific onsite contaminant exposure pathways which potentially exist, and through which hypothetical individuals could be exposed. The EA is designed to determine which potential contaminant exposure pathways are complete to ensure that the implemented remedial action contains provisions that would eliminate those pathways. Typical exposure pathways include ingestion of contaminated groundwater, inhalation of contaminant vapors and exposure to contaminated soils.



SOURCE: Fugro.

Figure 1
Site Location
25 Melville Park Road, Melville, New York

CDM Camp Dresser & McKee



LEGEND

MW 13 - MONITORING WELL

IW-6 - SHALLOW INJECTION WELL

IW-10 - DEEP INJECTION WELL

VZ-1 - PROPOSED VADOSE ZONE WELL

MW-25D - PROPOSED DEEP ZONE WELL

SCALE: 1" = 50'

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CDM Camp Dresser & McKee

Figure 2
Location Site Map
Supplemental Work Plan, 25 Melville Park Road, Melville, New York

Wells	VOCs TICs	Sulfate	Chlorides And Alkalinity	Ferric Ferrous Total Iron	Cyanide	Ethane	8 RCRA Metals & Manganese	Category B Deliverables	Field Parameters					
									pH	Eh	Temp.	D.O.	S.C.	Turbidity
Shallow Injection Wells														
- IW-1	X	X	X	X					X	X	X	X	X	X
- IW-2	X	X	X	X					X	X	X	X	X	X
- IW-3	X	X	X	X		X		X	X	X	X	X	X	X
- IW-4	X	X	X	X					X	X	X	X	X	X
- IW-5	X	X	X	X					X	X	X	X	X	X
- IW-6	X	X	X	X		X			X	X	X	X	X	X
- IW-7	X	X	X	X					X	X	X	X	X	X
- MW-12	X	X	X	X					X	X	X	X	X	X
- MW-13	X	X	X	X					X	X	X	X	X	X
Shallow Monitoring Wells														
- MW-2	X	X	X	X					X	X	X	X	X	X
- MW-3	X	X	X	X					X	X	X	X	X	X
- MW-4	X	X	X	X					X	X	X	X	X	X
- MW-7	X	X	X	X					X	X	X	X	X	X
- MW-8	X	X	X	X				X	X	X	X	X	X	X
- MW-9	X	X	X	X		X			X	X	X	X	X	X
- MW-10	X	X	X	X		X			X	X	X	X	X	X
- MW-11	X	X	X	X					X	X	X	X	X	X
- MW-14	X	X	X	X					X	X	X	X	X	X
- MW-15	X	X	X	X					X	X	X	X	X	X
- MW-17	X	X	X	X					X	X	X	X	X	X
Deep Injection Wells														
- IW-8	X	X	X	X					X	X	X	X	X	X
- IW-9	X	X	X	X		X			X	X	X	X	X	X
- IW-10	X	X	X	X					X	X	X	X	X	X
- IW-11	X	X	X	X		X			X	X	X	X	X	X
- IW-12	X	X	X	X					X	X	X	X	X	X
- MW-13D	X	X	X	X					X	X	X	X	X	X
Deep Monitoring Wells														
- MW-16D	X	X	X	X					X	X	X	X	X	X
- MW-18D	X	X	X	X					X	X	X	X	X	X
- MW-19D	X	X	X	X					X	X	X	X	X	X
- MW-20D	X	X	X	X					X	X	X	X	X	X
- MW-21D	X	X	X	X					X	X	X	X	X	X
- MW-23I	X	X	X	X		X		X	X	X	X	X	X	X
Total Samples	32	32	32	32	0	7	0	3	32	32	32	32	32	32

NOTE: Table does not include QA/QC samples.

Table 1
Sample Parameters - March 1999
25 Melville Park Road, Melville, New York

Well Number	Type	Material Of Construction	Minimum Borehole Diameter (inches)	Well Diameter (inches)	Depth Of Well (feet)*	Screened Interval (feet)*	Screen Length (feet)*	Screen Slot Size (inches)	Sand Pack Interval (feet)*	Bentonite Pellet Seal (feet)*	Grouted Interval (feet)*
VZ-1	Shallow Vadose Zone Injection	Schedule 40 PVC	4	2	40	25-40	15	0.020	23-40	22-23	0-22
VZ-2	Shallow Vadose Zone Injection	Schedule 40 PVC	4	2	40	25-40	15	0.020	23-40	22-23	0-22
VZ-3	Shallow Vadose Zone Injection	Schedule 40 PVC	4	2	40	25-40	15	0.020	23-40	22-23	0-22
VZ-4	Shallow Vadose Zone Injection	Schedule 40 PVC	4	2	40	25-40	15	0.020	23-40	22-23	0-22
MW-25D	Deep Injection/Monitoring	Schedule 40 PVC	4	2	90	75-90	15	0.020	73-90	72-73	0-72
MW-26D	Deep Injection/Monitoring	Schedule 40 PVC	4	2	90	75-90	15	0.020	73-90	72-73	0-72
MW-27D	Deep Injection/Monitoring	Schedule 40 PVC	4	2	90	75-90	15	0.020	73-90	72-73	0-72
MW-28D	Deep Injection/Monitoring	Schedule 40 PVC	4	2	90	75-90	15	0.020	73-90	72-73	0-72
MW-29	Shallow Monitoring	Schedule 40 PVC	4	2	60	45-60	15	0.020	43-60	42-43	0-42

LEGEND:
* All depths are estimated from grade, actual depths will be determined in the field.

NOTES:
1. Expected depth to water is 50 feet below grade.
2. Stainless Steel wire wrapped screen or prepacked screens may be substituted for the PVC well screen provided the contractor notifies Engineer prior to mobilization.
3. All injection wells to be completed flush with grade

Table 2
Injection And Monitoring Well Installations
Supplemental Work Plan, 25 Melville Park Road, Melville, New York

Well	Well ID
Vadose Zone	
Injection Wells	VZ-1*, VZ-2*, VZ-3*, VZ-4*,
Shallow Aquifer Zone	
Injection Wells	IW-1, IW-2, IW-3, IW-4, IW-5, IW-6, IW-7 MW-7, MW-8, MW-9, MW-10, MW-11, MW-12, MW-13
Shallow Aquifer Zone	
Observation Wells	MW-2, MW-3, MW-4, MW-14, MW-15, MW-17, MW-29*
Deep Aquifer Zone	
Injection Wells	IW-8, IW-9, IW-10, IW-11 IW-12, MW-13D, MW-25D*, MW-26D*, MW-27*, MW-28*
Deep Aquifer Zone	
Observation Wells	MW-16D, MW-18D, MW-19D, MW-20D, MW-21D, MW-22D, MW-23I

KEY:
* - Well to be installed as part of the Supplemental Work Plan.

Table 3
Schedule Of Additional Chemical Oxidation Injections For 1999

Task	Weeks																																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Submittal Of Supplemental Work Plan	■																																		
Approval Of Work Plan By NYSDEC					■																														
Installation Of Proposed Wells							■	■																											
Pre-Injection Groundwater Sampling											■																								
Receipt Of Analytical Data														■																					
Mobilization For Injections															■																				
Conduct First Quarterly Injections *(Phase 1, 2, 3)*																■																			
Post Injection Groundwater Sampling *(Phase 4)*																									■										
Receipt Of Analytical Data																												■							
Conduct Next Injection *(Phase 1, 2, 3)*																															■				

Table 4
Schedule Of Additional Chemical Oxidation Injections For 1999
Supplemental Work Plan, 25 Melville Park Road, Melville, New York

Appendix A

Document	Date	To	From	Contents
Correspondence	01/12/73	New York Twist Drill	T.E. Quinn, Division of Pure Waters	Correspondence informs recipient that Mr. N. Curry has been assigned to the Industrial Wastewater Treatment Facility at New York Twist Drill.
Correspondence	01/17/73	R.T. Burns, Bensin & Burns	N A. Curry, Division of Pure Waters	With regard to a 02/03/72 engineering report requesting reinstatement of the NYTD Treatment System, this correspondence seeks clarification to several matters including volume of ferrocyanide in wastewater and concern about a sample with 2.0 mg/l barium.
Correspondence	03/14/73	P. Tobin, NYTD	T.E. Quinn, Division of Pure Waters	Correspondence approves that engineering report to reactivate the treatment plant but cites the need of NYTD to apply for a permit to operate the facility.
Memorandum	03/23/73	Mr. Machlin, NYSDEC	Mr. Bruce, NYSDEC	Informs recipient that NYTD was recently issued an approval to operate a treatment facility and advises recipient to establish a sampling and analysis program with NYTD.
Correspondence	10/15/73	C. Santurino, SCDEC	D. Hedtrich, NYTD	Informs recipient that since his 09/04/73 visit, NYTD pumped dry and cleaned several process tanks with contents disposed out-of-state. Letter also indicates that all PVC piping in the nitride waste water system was replaced with cast iron piping.
Industrial Waste Discharge Summary Report For 10/73	11/26/73	NYSDEC	D. Hedtrich, NYTD	Report acknowledges that several parameters exceeded acceptable limits but that corrective measures have been taken.
Industrial Waste Discharge Summary Report For 11/73	12/19/73	NYSDEC	D. Hedtrich, NYTD	Submittal of report apparently showing all parameters to be within acceptable limits.
Industrial Waste Discharge Summary Report For 12/73	01/10/74	NYSDEC	D. Hedtrich, NYTD	Report lists volume discharged, pH, barium, cyanide and total solids results for four (4) sampling events.

Document	Date	To	From	Contents
Industrial Waste Discharge Summary Report For 01/74	02/04/74	NYSDEC	D. Hedtrich, NYTD	Report lists volume discharged pH, barium, cyanide and total solids results for four (4) sampling events.
Industrial Waste Discharge Summary Report For 02/74	03/06/74	NYSDEC	D. Hedtrich, NYTD	Report lists volume discharged pH, barium, cyanide and total solids results for four (4) sampling events.
Industrial Waste Discharge Summary Report For 03/74	04/09/74	NYSDEC	D. Hedtrich, NYTD	Results for one (1) sampling event.
Industrial Waste Discharge Summary Report For 05/74	06/03/74	NYSDEC	D. Hedtrich, NYTD	Results for one (1) sampling event.
Industrial Waste Discharge Summary Report For 09/74	10/01/74	NYSDEC	D. Hedtrich, NYTD	Results for one (1) sampling event.
Industrial Waste Discharge Summary Report For 10/74	11/11/74	NYSDEC	D. Hedtrich, NYTD	Results for one (1) sampling event.
Notification Of Unsatisfactory Industrial Waste Sampling Report	04/28/75	NYSDEC	R. Gilbert, SCDEC	Report indicates that during a 03/31/75 sampling of the NYTD final leaching pool, barium levels (50 mg/L) were above the acceptable limits (2 mg/L). Report requests that conditions be corrected.

Document	Date	To	From	Contents
SPDES Permit	04/02/75	D. Mangogna, NYTD	A.R. Yerman, NYSDEC	Issuance of SPDES Permit No. NY0075575 to NYTD includes monitoring and sampling requirements.
Blueprint	05/19/75	----	----	Process diagram of NYTD process train by Bensin and Burns.
Correspondence	05/19/75	R.E. Strzepek, SCDEC	D Mangogna, NYTD	Acknowledges difficulties in complying with barium discharge limits and proposes a modified treatment system including storage of barium in tanks No. 1 and 2; route contaminated water to leaching pool 4 and 5; and dispose of cyanide in settling tank No. 3 and then to leaching pool No. 6.
Correspondence	05/29/75	R.E. Strzepek, SCDEC	P. Barbato, NYSDEC	Letter seeks a decision from NYSDEC as to whether the proposed disposal system modifications at NYTD are acceptable.
Correspondence	06/13/75	R.E. Strzepek, SCDEC	P. Barbato, NYSDEC	Requests recipient to prepare a revised permit (SPDES) to reflect the proposed disposal system changes made by NYTD.
Correspondence	07/15/75	D. Mangogna, NYTD	D. Moran, NYSDEC	Transmittal letter forwarding SPDES industrial discharge monitoring report forms. Requests that all listed analytical parameters be monitored.
Correspondence	07/17/75	P. Barbato, NYSDEC	R.E. Strzepek, SCDEC	Transmittal of revised permit for NYTD including diagram of treatment process which included a previously unmentioned 7,000 gallon waste oil holding tank.
Industrial Waste Inspection Sheet	10/31/79	File	E. Gavernale, SCDEC	Comments contain references to an 8,000 gallon holding tank, nitrate process, cyanide salts, barium salts, waste holding tank and a note that a new building has been acquired across street.
Order Of Consent	12/28/79	D. Mangogna, NYTD	D. Middeton, NYSDEC	The Order of Consent (File No. 1-0375) imposes a fine against NYTD for violation of emissions in excess of permitted limits. Consent Order also defines other actions which must be taken by NYTD.
SCDHS Material Waste Control Report	08/28/80	File	F. Gavernale	Describes indoor chemical storage as having no problems. Notes outdoor storage room as having 10 full drums. Cites need to obtain building blue prints.

Document	Date	To	From	Contents
SCDHS Material Waste Control Report	09/02/80	File	F. Gavernale	No noted problems. Recommends that NYTD maintain chemical disposal records for inspection.
Memorandum	05/14/81	File	J. Glady, SCDHS	Facility inspection report describing deficiencies including inaccurate diagram of the SPDES outfall, cyanide treatment needs to be included in schematic, include general layout of the building, diagram to include floor drains, leaching pool received oil but was supposed to receive only non-contact cooling water, need to note storage tanks.
Correspondence	08/04/81	D. Mangagno, NYTD	A. Yerman, NYSDEC	Forwards copy of SPDES permit for NYTD.
Engineers Drawing	12/15/81	----	----	Drawing entitled "Existing Waste Water Distribution System" for NYTD. Drawing shows chemical processing facility and all chemical storage and holding tanks.
SCDHS Industrial Waste And Hazardous Materials Control Report	01/05/82	File	D. Obrig, SCDHS	Report was intended to verify data contained in the Engineering Report. The field report noted several discrepancies including number of structures, description of barium tanks and no cooling tower.
SCDHS Notice Of Violation	01/28/82	NYTD	J. Finkenberg, SCDHS	Report cites exceedances of TCE (74 ppb) from SPDES discharge point #001 (first pool) on 01/06/82. Notifies recipient that exceedance violates NYS ECL and SC Sanitary Code, Article 12. NYTD subject to fine.
Correspondence	02/22/82	A. Adamczyk, NYSDEC	O. Reneberg, SCDHS	Correspondence informs recipient of deficiencies in the required engineering report for NYTD. Suggest that the report include updated building and storage facility modifications, leaching facilities, and industrial waste disposal systems. Recommends new report specific to the site including suggestions for all discharges to be compatible to current effluent standards.
SCDHS Notice Of Violation	03/11/82	NYTD	J. Finkenberg, SCDHS	Report cites exceedances of TCE (72 ppb) from SPDES discharge point #002 (first pool) on 01/06/82. Notifies recipient that exceedance violates NYS ECL and SC Sanitary Code, Article 12. NYTD subject to fine.

Document	Date	To	From	Contents
Correspondence	03/16/82	D. Mangagno, NYTD	E. Blackwell, NYSDEC	Correspondence informs recipient that no updated engineering report has been received as required under the reviewed SPDES permit of 08/01/81. Letter also cites the 02/22/82 letter from SCDHS to NYSDEC which serves as the basis for the report revisions.
Engineer Drawing	06/22/82 (Rev. 03/12/84)	----	----	Engineers drawing of NYTD "Waste Water Treatment System".
Correspondence	09/16/82	A. Machlin, NYSDEC	J. Paetz, NYTD	Letter seeks NYSDEC approval/direction regarding the disposal of dry waste sludges from NYTD grinding machine cooling systems by private garbage cartage to county incinerators.
SCDHS Industrial Waste And Hazardous Materials Control Report	09/22/82	File	E. Jenglive (?), SCDHS	Report notes 50 empty drums behind building, 30 drums in building and cites violations of SC Sanitary Code, Article 12 - storage of toxic material without berms and storage without a roof.
SCDHS Industrial Waste And Hazardous Materials Control Report	10/04/82	File	B.C. Stark (?), SCDHS	Report notes a complaint of smells in the drum storage area behind a robotic jack (?). Notes fluid in bermed tank area, smells and an apparent leak to the storm drain.
Correspondence	10/05/82	J. Paetz, NYTD	P. Akras, SCDHS	Correspondence notifies recipient of Article 12 violations pertaining to drum storage of toxic or hazardous material. Correspondence includes a 09/20/82 SCDHS Industrial Waste And Hazardous Materials Control Report citing the Article 12 violations.
Engineering Report	02/83	SCDHS	J. Mahoney, Consulting Engineer	Report describes a history of NYTD operations between 1966 and 1982 and details improvements in the NYTD process and disposal operations during that period.

Document	Date	To	From	Contents
SCDHS Industrial Waste And Hazardous Materials Control Report	04/05/83	File	D. Obrig, SCDHS	Inventory of drums associated with NYTD operations.
Correspondence	05/11/83	D. Mangagno, NYTD	J. Harrington, NYSDEC	Letter acknowledges receipt of the Engineering Report and notes several comments to the report including lack of sampling data, discrepancy between specific pipe connections and outfall #003, and a rust stripping process.
Correspondence	04/16/84	J. Mahoney, Consulting Engineer	J. Harrington, NYSDEC	Correspondence notifies recipient that no response has yet been received to the 05/11/83 correspondence by NYSDEC.
SCDHS Industrial Waste And Hazardous Materials Control Report	05/31/84	File	D. Obrig, SCDHS	Report identifies scavenger companies used by NYTD to dispose of waste material.
SCDHS Inspection Request Form	06/21/84	File	D. Obrig, SCDHS	Describes results of the test of the barium tank indicating a loss of product (water) and recommends use of a high level alarm and the prevention of rain water into the tank if it is to be used in the future.
Correspondence	06/27/84	J. Paetz, NYTD	P. Akras, NYSDEC	Draft letter informs recipient of the loss of inventory during the barium tank test.. Recommends that the tank be pumped and no longer utilized until all requirements for a double-walled containment area are met. Leak detection systems would also be required. Recommends testing the cyanide waste tank within 30 days.
Correspondence	09/04/84	NYSDEC	J. Paetz, NYTD	Transmittal of SPDES Discharge Monitoring Report for 03/01/84 through 08/31/84 and advises NYSDEC of NYTD's plans to close the facility in Melville by December 1984.
SCDHS Inspection Request Form	12/28/84	----	----	Report seeks verification that NYTD has suspended operations and describes NYTD's plans to relocate and/or dispose of process materials and wastes.

Document	Date	To	From	Contents
Correspondence	01/31/85	J. Paetz, NYTD	D. DeRidder, NYSDEC	Informs recipient that SPDES permit has been deleted based on the cessation of NYTD operations.
Correspondence	02/12/85	NYSDEC	J. Paetz, NYTD	Transmittal of SPDES Discharge Monitoring Report. Correspondence reiterates that NYTD has ceased operations and completed relocation on 12/15/84. Requests that NYSDEC remove NYTD from its directory of manufacturers.
SCDHS Industrial Waste And Hazardous Materials Control Report	06/07/85	File	D. Obrig, SCDHS	Report verifies the removal of former NYTD equipment, identifies new site owner, identifies waste manifests, identifies potential need to properly abandon UST's (waste oil, cyanide, barium) and dispose of drums.
Correspondence	06/24/85	Mr. Yudell, Delco Development	V. Frisina, SCDHS	Draft letter informs recipient that former NYTD tanks must either be reregistered or properly abandoned. Letter describes procedures to comply.
Correspondence	04/18/86	V. Frisina, SCDHS	J. Paetz, NYTD	Letter returns a tank replacement notice and informs recipient of the cessation of NYTD operations in 12/84. Indicates that NYTD maintains only an office and warehousing facility is in Ronkonoma. Requests removal of NYTD name from NYSDEC files.
Correspondence	08/19/92	K. Clunie, SCDHS	D. Galligan, API	Letter informs SCDHS that the management of the property at 25 Melville Park Road was assumed by API on 10/01/89. API became the owner on 01/17/91. Correspondence states that several tanks within the building were removed during construction as were several exterior to the building.
Article 12 Tank Registry	02/25/97	----	----	Tank inventory list shows eleven tanks formerly associated with NYTD. Nine of the eleven removed, two abandoned in place. Last action pertaining to tanks was completed on 09/30/91.

NOTE:
[*] This section provides a brief summary of the contents of each selected document. The reader is advised to thoroughly examine the complete document and/or file for complete evaluation, interpretation and intent of said document and/or file. It is further noted that Suffolk County Department of Health Services prohibited CDM access to several public records.

FILE SOURCE:
Suffolk County Department of Health Services, Farmingville, New York
New York State Department of Environmental Conservation, Stony Brook, New York

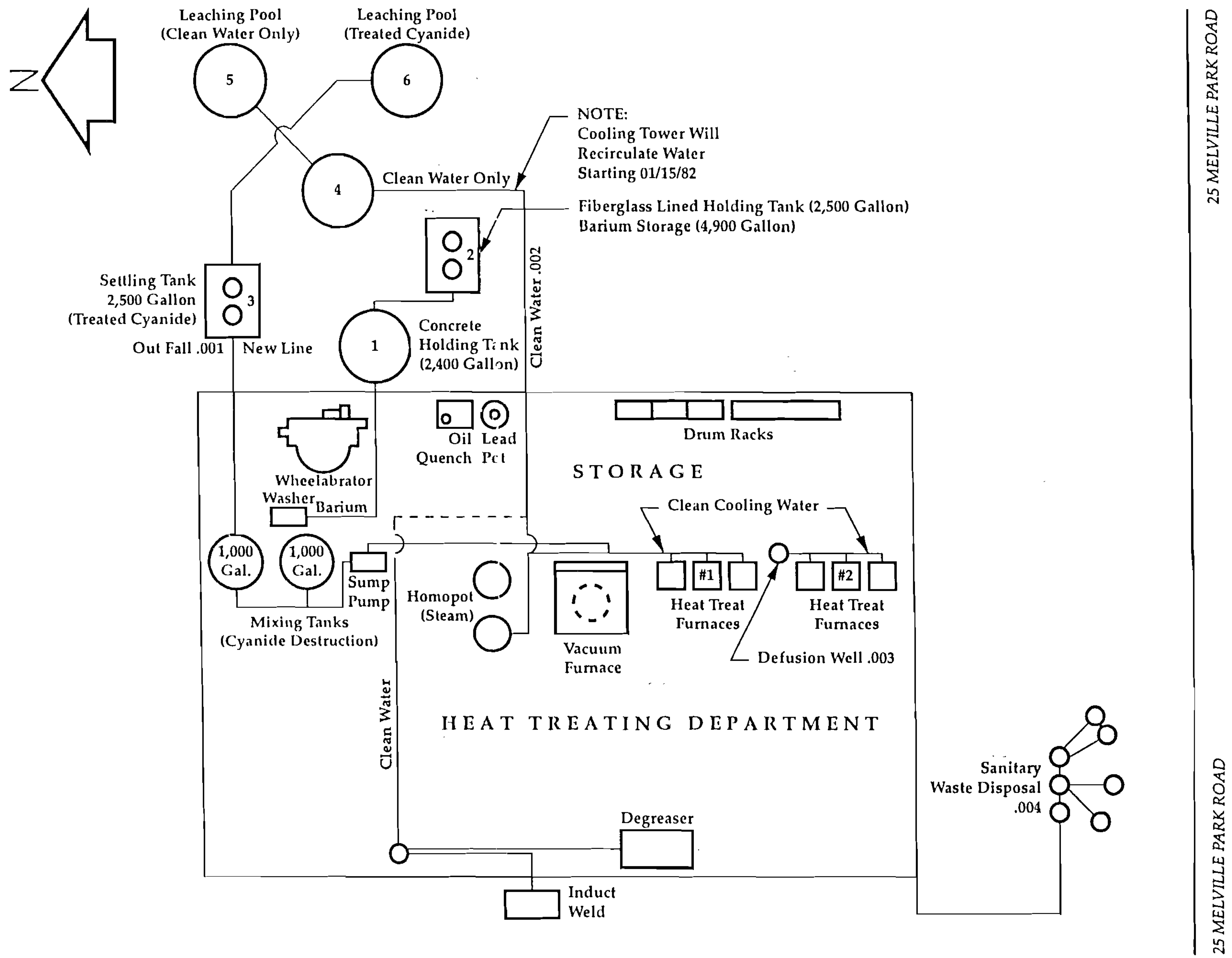

Figure 1-9
Schematic Of New York Twist Drill Manufacturing Process
25 Melville Park Road, Suffolk County, New York

Appendix B

SECOR
International Incorporated

In-situ Chemical Oxidation Pilot Test Report of Findings
25 Melville Park Road
Melville, New York

December 4,1998

Prepared for:

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STATE OF NEW YORK
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LICENSED PROFESSIONAL ENGINEER

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FIGURES

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APPENDICES

1.0 INTRODUCTION

On behalf of WHCS Melville, LLC (WHCS), *SECOR* International Inc. (*SECOR*) is pleased to submit this report of findings for the *in-situ* chemical oxidation pilot test conducted at 25 Melville Park Road, Melville, New York in July 1998. The pilot test was performed to evaluate the effectiveness of using Fenton's reagent to chemically oxidize the residual contamination present in groundwater beneath the eastern portion of the site. The pilot test was conducted in accordance with the Revised *In-situ* Oxidation Pilot Test Work Plan (May 19, 1998) approved by the New York State Department of Environmental Conservation (NYSDEC) in June 1998. All modifications to the approved work plan were communicated to the NYSDEC for approval prior to implementation.

2.0 OBJECTIVE

The primary objective of the pilot test was to assess the applicability of *in-situ* chemical oxidation to remediate dissolved and adsorbed chlorinated volatile organic compounds (VOCs) in the water bearing zone at the referenced site. Fenton's reagent (hydrogen peroxide and ferrous sulfate) produces hydroxyl radicals which result in the oxidation of organic material (i.e organic contaminants). The pilot test consisted of injecting Fenton's reagent into the subsurface using 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 locations and depths of injection were within the primary zone of contamination based on the residual VOC concentrations detected in soil and groundwater. The pilot test was conducted within the property boundaries and the test area was monitored using wells located on the periphery of the area of injection.

3.0 SITE GEOLOGY AND HYDROGEOLOGY

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. 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 is encountered at a depth of approximately 45 to 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 vicinity of the loading dock.

4.0 PILOT TEST PROCEDURES

The *In-situ* Chemical Oxidation Pilot Test injections were conducted from July 9 - 12, 1998. During the pilot test, water and Fenton's reagent were injected into nine shallow and six deep wells. Groundwater quality monitoring was performed in eleven shallow and six deep observation wells. Prior to conducting the pilot test, a groundwater sampling event was performed from March 30 - April 1, 1998 to establish baseline VOC concentrations and groundwater chemistry. After completing the pilot test injections, three groundwater sampling events were performed on July 15th, July 20th, and August 3 - 4, 1998 to evaluate the effectiveness of the pilot test. Details regarding implementation of the pilot test are provided below.

4.1 Injection and Observation Wells

Construction details for the injection and observation wells used during the pilot test are provided in further detail below and are summarized in Table 1. The locations of the injection and observation wells are shown on Figure 1.

4.1.1 Shallow Zone Injection Wells

Two existing wells (MW-12 and MW-13) and seven injection wells (IW-1 through IW-7) were used to introduce Fenton's reagent into the primary zone of contamination, the upper 20 feet of the saturated zone east of the loading dock. Well MW-12 is screened from 46.5 to 56.5 feet below grade, well MW-13 is screened from 48 to 58 feet below grade, and injection wells IW-1 through IW-7 are screened from 45 to 60 feet below grade. The locations of the nine wells used during the pilot test to inject into the shallow zone are shown on Figure 1.

4.1.2 Deep Zone Injection Wells

One existing well (MW-13D) and five injection wells (IW-8 through IW-12) were used to introduce Fenton's reagent into the deep zone of contamination. Well MW-13D is screened from 80 to 90 feet below grade and injection wells IW-8 through IW-12 are screened from 75 to 90 feet below grade.

The locations of the six wells used during the pilot test to inject into the deep zone are shown on Figure 1.

4.1.3 Observation Wells

Eleven monitoring wells were used as shallow zone observation wells during the pilot test. Wells MW-7, MW-8, MW-9, MW-10, and MW-11 served as downgradient observation wells and wells MW-2, MW-3, MW-4, MW-14, MW-15, and MW-17 served as perimeter observation wells. The shallow zone observation wells are screened from a minimum of 40 feet to a maximum of 60 feet below grade. Six monitoring wells (MW-16D, MW-18D, MW-19D, MW-20D, MW-21D, and MW-23) were used as deep zone observation wells during the pilot test. With the exception of well MW-21D, the deep zone observation wells are screened from a minimum of 70 feet to a maximum of 185 feet below grade. Well MW-21D, which is screened from 50 to 160 feet below grade, monitors both the shallow and deep zones.

4.2 Groundwater Sampling

A groundwater sampling event was performed from March 30 - April 1, 1998 to establish baseline VOC concentrations and groundwater chemistry prior to conducting the pilot test (July 9 - 12, 1998). After completing the pilot test, three post-injection groundwater sampling events were conducted to evaluate the effectiveness of the pilot test. The post-injection sampling was performed three days (July 15th), one week (July 20th), and three weeks (August 3 - 4, 1998) after the final injection.

For the baseline (March/April) and final post-injection (August) sampling events, a minimum of three well volumes were purged from each well. Efforts were made to sample only after turbidity values were less than 50 NTUs. Dedicated disposable bailers were used to obtain the groundwater samples directly from the wells. For the sample collected from monitoring well MW-11 on July 20th in which the turbidity value was greater than 50 NTUs, the sample for metals analyses 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. For the July 15th and 20th post-injection sampling events, the wells were not purged prior to sampling to limit the removal of residual Fenton's reagent which was still reacting with the VOCs present in groundwater. As requested by the NYSDEC, Category B Deliverables are provided for samples collected from wells IW-3, MW-8, and MW-23. Details of the four groundwater sampling events are provided below and summarized in Table 2.

4.2.1 Baseline Groundwater Sampling

The baseline groundwater sampling event performed from March 30 - April 1, 1998 consisted of the following wells and sample analyses:

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 (pH, conductivity, turbidity, dissolved oxygen, temperature, and oxidation-reduction potential); and
- General petroleum degraders (Total Viable and Non-Viable Organisms, Total Viable Organisms, Fluorescent Pseudomonades, Phenanthrene Degraders).

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.

4.2.2 Intermediate Post-Injection Groundwater Sampling

The two intermediate post-injection groundwater sampling events performed on July 15 and 20, 1998 consisted of the following wells and sample analyses:

All 32 wells:

- VOCs plus TICs by USEPA Method 8260; and
- Aquifer chemistry field parameters.

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.

4.2.3 Final Post-Injection Groundwater Sampling

The final post-injection groundwater sampling event performed from August 3 - 4, 1998 consisted of the following wells and sample analyses:

All 32 wells:
- VOCs plus TICs by USEPA Method 8260;
- Aquifer chemistry laboratory parameters; and
- Aquifer chemistry field parameters.

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.

4.3 Injection of Water and Fenton's Reagent

During the pilot test, water and Fenton's reagent were injected by gravity drainage into the nine shallow and six deep injection wells from two temporary 6,500 gallon polyethylene storage tanks. The storage tanks were connected to the injection wells using flexible hose, PVC manifolds, and clear vinyl tubing. Each well was equipped with a totalizing flowmeter and ball valve to control the injection rate. Flexible tubing was extended down the injection wells to below the static water level to enable accurate water level measurements and to minimize aeration of the injected solution.

The pilot test was conducted in three phases which consisted of injection of the following: water into the shallow zone (Phase I), Fenton's reagent into the shallow zone (Phase II), and Fenton's reagent into the shallow and deep zones (Phase III). The three phases of the pilot test are summarized on Table 3 and discussed in the following sections.

4.3.1 Phase I - Water Injection (Shallow Zone)

The first phase of the pilot test was performed on July 9, 1998 by injecting approximately 9,302 gallons of potable water acidified with laboratory grade sulfuric acid (H_2SO_4) into the nine shallow injection wells. Phase I was performed to determine appropriate injection rates for subsequent phases and the extent of mounding. The water was injected into the nine shallow injection wells in approximately 9 hours at rates of approximately 2 to 3 gallons per minute (gpm) per well (18 to 27 gpm total). The water level rise in the injection wells as a results of injecting at rates of 2 to 3 gpm was approximately 0.5 to 1 feet. As shown on Table 3, the amount of water injected into the wells during Phase I ranged from 873 gallons into IW-1 to 1,197 gallons into MW-12. Given the injection wells accepted injection rates of 3 gpm with only minimal mounding in the injection wells, it was apparent that Fenton's reagent could be injected at similar rates with only minimal mounding.

4.3.2 Phase II - Fenton's Reagent Injection (Shallow Zone)

The second phase of the pilot test was performed on July 10, 1998 by injecting 8,867 gallons of 3% hydrogen peroxide and 92 gallons of ferrous sulfate solution into the nine shallow injection wells. The tanker trucks used to deliver the hydrogen peroxide to the site are dedicated by the manufacturer for transporting only hydrogen peroxide. A certificate of analysis was provided by the supplier with each tanker truck delivery of hydrogen peroxide. Copies of the certificates are provided in Appendix A. Additionally, a sample of hydrogen peroxide was collected from the first tanker truck delivery and was submitted to H2M Labs, Inc. for VOC analysis. The hydrogen peroxide sample contained no detectable concentrations of targeted VOCs, although one tentatively identified compound (2-methoxy-2-methyl-propane) was detected at an estimated concentration of 10 ug/l.

The 8,959 gallons of Fenton's reagent was injected into the nine shallow injection wells in approximately 4.5 hours at rates of approximately 3 to 5 gallons per minute (gpm) per well (27 to 45 gpm total). The water level rise in the injection wells as a result of injecting at rates of 3 to 5 gpm was approximately 2 to 4 feet. As shown on Table 3, the amount of Fenton's reagent injected into the wells during Phase II ranged from 562 gallons into IW-1 to 1,116 gallons into IW-3.

4.3.3 Phase III - Fenton's Reagent Injection (Shallow and Deep Zones)

The third phase of injection was performed on July 11 and 12, 1998 by injecting 11,708 gallons of Fenton's reagent into the nine shallow injection wells and 6,504 gallons of Fenton's reagent into the six deep injection wells over a two day period.

Shallow Zone Injection

The 11,708 gallons of Fenton's reagent injected into the nine shallow wells during Phase III was composed of 11,481 gallons of 3% hydrogen peroxide and 228 gallons of ferrous sulfate solution. The 11,708 gallons of Fenton's reagent was injected in approximately 5 hours on July 11th and 4 hours on July 12th at rates of approximately 2 to 4 gpm per well (18 to 36 gpm total). The water level rise in the injection wells as a result of injecting at rates of 2 to 4 gpm was approximately 1 to 3 feet. As shown on Table 3, the amount of Fenton's reagent injected into the shallow wells during Phase III ranged from 1,121 gallons into IW-2 to 1,388 gallons into IW-4.

Deep Zone Injection

The 6,504 gallons of Fenton's reagent injected into the six deep wells during Phase III was composed of 6,473 gallons of 3% hydrogen peroxide and 31 gallons of ferrous sulfate solution. The 6,504 gallons of Fenton's reagent was injected into the six deep injection wells in 5 hours on July 11th and 4 hours on July 12th at rates of approximately 2 to 3 gallons per minute (gpm) per well (18 to 27 gpm total). The water level rise in the injection wells as a result of injecting at rates of 2 to 3 gpm was approximately 2 to 10 feet. As shown on Table 3, the amount of Fenton's reagent injected into the deep wells during Phase III ranged from 898 gallons into IW-9 to 1,246 gallons into IW-12.

4.3.4 Summary of Pilot Test Injections

Table 3 provides a summary of the amount of water and Fenton's reagent injected during the pilot test. A total of approximately 9,302 gallons of water and 20,667 gallons of Fenton's reagent were injected into the nine shallow injection wells during the pilot test. Additionally, approximately 6,504 gallons of Fenton's reagent were injected into the six deep injection wells during the pilot test. The quantity of water and Fenton's reagent injected during the pilot test was consistent with the approved work plan.

However, the amount of ferrous sulfate used to mix the Fenton's reagent was increased from approximately 31 pounds to 167 pounds. This work scope modification was pre-approved by the NYSDEC.

4.4 Groundwater and Air Quality Monitoring

Groundwater quality monitoring was performed during the pilot test using field instruments to determine the zone of influence associated with the injection of water and Fenton's reagent. The groundwater monitoring was performed at the eleven shallow and six deep observation wells prior to, during, and immediately following the injections, and included depth to water, pH, conductivity, turbidity, dissolved oxygen, temperature, oxidation-reduction potential, and hydrogen peroxide. Groundwater samples were collected from the observation wells using dedicated bailers several times per day during the injection phase of the pilot test. The primary parameters which would be indicative of influence associated with the injection of Fenton's reagent include water level rise, decreased pH, increased dissolved oxygen, and detection of hydrogen peroxide at parts per million (ppm) concentrations.

Since the reaction of Fenton's reagent also releases gases, air quality monitoring was performed during the pilot test using field instruments. Air monitoring was performed for VOCs using a photoionization detector (PID), for explosive vapors and oxygen using an LEL/ O_2 meter, and for carbon monoxide (CO), carbon dioxide (CO_2), hydrogen sulfide (H_2S), chlorine (Cl_2), and hydrogen cyanide (HCN) using single or multi-gas monitors calibrated in accordance with manufacturers recommendations. Air monitoring was performed during the injection phase of the pilot test on a near continuous basis by alternating between outdoor and indoor monitoring stations and recording instrument readings.

Indoor air monitoring was performed inside the eastern portion of the building adjacent to the pilot test area to ensure that unacceptable concentrations of gases did not infiltrate or collect within the adjacent office building as a result of the pilot test activities. At the time the pilot test was conducted (July 9 - 12, 1998), the eastern portion of the building was undergoing renovation which included activities such as dry wall spackling and painting. Outdoor air monitoring was performed to ensure worker safety in accordance with the Health and Safety Plan prepared for the pilot test. Air monitoring was also performed within injection and observation wells approximately one foot below grade to monitor off gases resulting from the reaction of Fenton's reagent with the contaminants in groundwater.

The Suffolk County Department of Health Services (SCDHS) also performed air monitoring within the adjacent office building and at several injection wells prior to, during, and following the pilot test injections.

5.0 PILOT TEST RESULTS

The pilot test was performed to determine the effectiveness of using *in-situ* chemical oxidation to remediate the dissolved and adsorbed phase VOCs present at the site. The results of groundwater monitoring performed prior to, during, and after the shallow and deep zone injections as well as air monitoring performed during the injections are presented in this section.

5.1 Shallow Zone Injection

During the pilot test approximately 9,302 gallons of water and 20,667 gallons of Fenton's reagent (hydrogen peroxide and ferrous sulfate solution) were injected into nine shallow injection wells. Baseline groundwater quality data, pilot test field parameter data, and post-injection groundwater quality data were collected from the nine shallow injection wells and from eleven nearby shallow monitoring wells. An analysis of the data and a discussion of the results are provided below.

5.1.1 Data Analysis (Shallow Zone)

Pilot Test Field Parameters

Prior to, during and immediately following the pilot test injections, field parameters (depth to water, pH, conductivity, turbidity, dissolved oxygen, temperature, oxidation-reduction potential, and hydrogen peroxide concentration) were measured in the eleven shallow observation wells. The pilot test field parameter data is provided in Appendix B. The pre-injection depth to water was approximately 45 feet below ground surface, the pH ranged from 5.66 to 6.18, and the dissolved oxygen concentration ranged from 0.95 to 6.34 milligrams per liter (mg/L). The data collected during and immediately following the injections remained unchanged from the pre-injection data with the following exceptions:

- the dissolved oxygen concentration increased from 1.63 to 9.92 mg/L in MW-7;
- the dissolved oxygen concentration increased from 2.74 to 8.12 mg/L and the pH decreased from 5.90 to 5.58 in MW-8;

- the dissolved oxygen concentration increased from 1.67 to 3.70 mg/L and the pH decreased from 6.07 to 4.00 in MW-9;

- the dissolved oxygen concentration increased from 0.95 to 3.23 mg/L in MW-10;

- the dissolved oxygen concentration increased from 5.08 to 10.81 mg/L in MW-11; and

- the dissolved oxygen concentration increased from 3.99 to greater than 20 mg/L and hydrogen peroxide was detected during and after the pilot test at concentrations ranging from 0.2 to 6 mg/L in MW-17.

Based on the field parameters monitored during the injections, downgradient observation wells MW-7, MW-8, MW-9, MW-10, and MW-11 and perimeter observation well MW-17 showed a response to the injection of Fenton's reagent.

Groundwater Sampling Event Field Parameters

During the baseline and final post-injection groundwater sampling events, field parameters (depth to water, temperature, pH, conductivity, dissolved oxygen, and oxidation-reduction potential) were measured in the nine shallow injection wells and eleven shallow observation wells. The pH and dissolved oxygen results from the groundwater sampling events is summarized in Table 4. The following appreciable changes were observed in the pH and dissolved oxygen concentration in the observation wells from the pre-injection to the post-injection events:

- the pH decreased from 6.14 to 5.34 in MW-7;

- the pH decreased from 6.10 to 5.08 in MW-9;

- the pH decreased from 5.92 to 5.44 in MW-10;

- the pH decreased from 6.18 to 5.35 and the dissolved oxygen concentration increased from 3.2 to 6.0 mg/L in MW-11; and

- the pH decreased from 6.04 to 5.74 and the dissolved oxygen concentration increased from 3.4 to 5.3 mg/L in MW-17.

These changes, while minor, are consistent with the field parameter data collected during and immediately following the pilot test. While changes were observed in the downgradient observation wells and perimeter observation well MW-17, no appreciable changes in field parameters were observed in perimeter observation wells MW-2, MW-3, MW-4, MW-14, and MW-15.

In the shallow injection wells the pH ranged from 5.57 (IW-3) to 6.34 (IW-1) prior to the test, from 2.1 (IW-1, IW-3, and IW-4) to 2.3 (IW-2, IW-5, and MW-13) immediately after the test, and from 3.22 (IW-1) to 5.00 (IW-7) three weeks after the test. Therefore, in just three weeks the pH has partially returned to the pre-injection levels. Dissolved oxygen concentrations ranged from 1.5 (MW-12) to 4.7 mg/L (IW-2) prior to the test. The dissolved oxygen concentrations were greater than 20 mg/L in all the injection wells immediately after the test and ranged from 6.6 (IW-7) to greater than 20 mg/L (IW-1, IW-2, IW-5, and MW-12) three weeks after the test. These elevated dissolved oxygen levels three weeks after the test will help to continue the oxidation process.

Groundwater Sampling Event Chemistry Data

In order to determine the areal extent of influence and monitor the geochemical effects of injection, a significant amount of aquifer chemistry data was collected from the injection and observation wells at the site. During the baseline and final post-injection groundwater sampling events, groundwater samples from the nine shallow injection wells and eleven shallow observation wells were analyzed for aquifer chemistry parameters (sulfate, alkalinity, chloride, ferrous iron, ferric iron, total iron, TDS, TOC, BOD, and COD). Groundwater samples from IW-3, MW-7, MW-8, MW-10, and MW-11 were analyzed for RCRA metals (plus manganese). During the two intermediate post-injection sampling events, shallow injection well IW-3 and shallow observation wells MW-7, MW-8, MW-10, and MW-11 were analyzed for aquifer chemistry parameters. The groundwater sampling event chemistry data is summarized in Table 4. The following trends were observed in these parameters in the observation wells:

- ferrous iron concentrations increased in MW-7, MW-8, MW-9, and MW-10;
- total iron concentrations increased in MW-3, MW-7, MW-8, MW-9, MW-10, and MW-15;
- sulfate concentrations increased in downgradient observation wells MW-7, MW-8, MW-9,

MW-10, and MW-11 to a maximum concentration during the final post-injection sampling event of 130 mg/L;

- sulfate concentrations increased in perimeter observation wells MW-2, MW-3, MW-4, MW-14, MW-15, and MW-17 to a maximum concentration during the final post-injection sampling event of 45 mg/L; and

- no significant changes in concentrations of RCRA metals were observed, with the exception of an increase in the manganese concentration from 157 ug/L to 1,960 ug/L in MW-8.

The injection of Fenton's reagent resulted in increased iron and sulfate concentrations in the injection wells. Consistent with the field parameter data, changes in aquifer chemistry parameters, specifically iron and sulfate, were observed in the downgradient observation wells, and to a lesser extent, in the perimeter observation wells. The analytical data suggest that the pilot test system was able to deliver the reagents to a large portion of the pilot study area. However, more importantly, the aquifer chemistry data indicate that the pilot test injections did not adversely alter the aquifer chemistry.

Groundwater Sampling Event VOC Data

Groundwater samples collected from the shallow injection and observation wells during the baseline and three post-injection sampling events were analyzed for VOCs plus tentatively identified compounds. Historically, the primary VOCs of concern at the site have been 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethene (1,2-DCE), 1,1,1-trichloroethane (1,1,1-TCA), trichloroethene (TCE), and tetrachloroethene (PCE). The historical groundwater sample results for these five VOCs are summarized in Table 5 and presented as bar graphs in Appendix C. A comparison of the pre- and post-injection results for the five primary VOCs is provided in Table 6. The results of the VOCs detected other than the five primary compounds are summarized in Table 7. The following observations were made for the five primary VOCs in the shallow wells:

Six Shallow Perimeter Observation Wells

- the total concentration ranged from 70 to 598 ug/l in April 1997, from 22 to 239 ug/l in April 1998, and from 18 to 207 ug/l in August 1998;

- the average total concentration was 209 ug/l in April 1997, 104 ug/l in April 1998, and 114 ug/l in August 1998;

- the above data indicate the pilot test injections had no significant affect on the six shallow perimeter observation wells.

Five Shallow Downgradient Observation Wells

- the total concentration ranged from 1,379 to 23,260 ug/l in April 1997, from 676 to 7,572 ug/l in April 1998, and from 350 to 4,280 ug/l in August 1998;

- the average total concentration was 11,855 ug/l in April 1997, 3,051 ug/l in April 1998, and 1,673 ug/l in August 1998;

- as shown on Table 5, 1,2-DCE (a breakdown product of PCE and TCE) typically represented less than 10% of the total concentration of the five primary VOCs prior to the pilot test, but represented in excess of 50% of the total in downgradient observation wells MW-7, MW-8, and MW-9 after the pilot test injections;

- the above data indicate the pilot test injections had a positive affect on the five shallow downgradient observation wells as total concentrations in these five wells decreased by an average of 1,378 ug/l (45%) from April to August 1998.

Nine Shallow Injection Wells

- the total concentration ranged from 313 to 50,258 ug/l in April 1998 and from 212 to 12,224 ug/l in August 1998;

- the average total concentration was 12,802 ug/l in April 1998 and 2,024 ug/l in August 1998;

- the above data indicates the pilot test injections had a positive affect on the nine shallow injection wells as total concentrations in these nine wells decreased by an average of 10,777 ug/l (84%) from April to August 1998.

Review of the data suggests that there is a significant decrease in concentrations in the majority of the shallow observation wells between April 1997 and the pre-injection baseline sampling in April 1998. Although the cause for this decrease is unknown, it represents a favorable trend towards the overall remediation of the site. However, as discussed in the following section, the decrease in the estimated contaminant mass between April 1997 and April 1998 (22 pounds over a period of 1 year) is comparable to the decrease between April 1998 and August 1998 (39 pounds over a period of 3 months), although the rate of decline was greater from April to August 1998.

As shown on Table 7, VOCs other than the five primary chlorinated VOCs were only detected sporadically and at relatively low concentrations. The exception to this is acetone, which was detected in the baseline and post-injection sampling events in several of the shallow injection wells. However, the concentrations declined in the final post-injection sampling event. The presence of acetone may be attributable to the degradation of xylene or a laboratory contaminant. Given xylene concentrations are not persistent at the site and the presence of acetone is a temporary by-product of the degradation of xylene, the presence of acetone is not considered to be a significant concern at the site.

5.1.2 Discussion of Results (Shallow Zone)

The field parameter and groundwater chemistry data from prior to, during and up to three weeks after the pilot test injections showed significant changes in pH, dissolved oxygen concentration, sulfate concentration and ferrous and total iron concentrations in the injection wells and the downgradient observation wells and little or no changes in the perimeter observation wells. Based on the observed changes, the pilot test area of influence in the shallow zone is shown on Figure 2. The zone of influence is consistent with the VOC concentration results, which showed reductions in the injection and downgradient observation wells within the zone of influence and little or no change in concentrations in the perimeter observation wells outside the zone.

Using the area of influence shown in Figure 2 (16,400 square feet), an influenced thickness in the shallow zone of 20 feet (from 45 to 65 feet below ground surface), and a formation porosity of 0.3 (30%), approximately 736,000 gallons of groundwater were in the zone of influence. Consequently, the pilot test injection influenced a relatively large volume of impacted groundwater. Additionally, the 29,500 gallons of liquid injected during the pilot test represents 3% of the total quantity (736,000 gallons) within the zone of influence. Therefore, the effects of 3% dilution would be insignificant and the reductions in VOC concentrations in the area of influence can be attributed primarily to the chemical oxidation process.

The total concentration of the five primary chlorinated VOCs were used to prepare isoconcentration contour maps for the shallow zone for the April 1997, the baseline (March/April 1998) and the final post-injection (August 1998) groundwater sampling events, Figures 3, 4, and 5, respectively. For the

April 1997 sampling event, the concentrations detected in April 1998 in newly installed injection wells IW-1 (43,987 ug/l) and IW-3 (50,258 ug/l) were used for contouring purposes. Since the concentrations in the majority of the wells were significantly higher in 1997 than in 1998, it is conservative to assume that the concentrations at IW-1 and IW-3 would have been as high (if not higher) in 1997 as they were in 1998.

A comparison of these figures indicates that the area within the 1,000 ug/l contour decreased from 11,489 ft^2 in April 1997 to 8,480 ft^2 in April 1998 to 3,800 ft^2 in August 1998. At the same time the average concentration between the 1,000 and 10,000 ug/L contour increased from 2,912 ug/l in April 1997 to 3,865 ug/l in April 1998 and then decreased to 2,129 ug/l in August 1998. Similarly, the area within the 10,000 ug/l contour decreased from 3,565 ft^2 in April 1997 to 1,168 ft^2 in April 1998 to 335 ft^2 in August 1998. At the same time the average concentration within the 10,000 ug/l contour increased from 27,551 ug/l in April 1997 to 47,123 ug/l in April 1998 and then decreased to 12,224 ug/l in August 1998. The reductions in both areal extent and concentration indicate the pilot test caused a significant reduction in the mass of VOCs in the shallow zone.

The mass of VOCs dissolved in groundwater within the 100, 1,000 and 10,000 ug/L contours was calculated using the area and average concentration within each interval. Although the estimate is limited to the site property and the 100 ug/l contour extends off-site for the April 1997 sampling event, the mass within the 100 ug/l contour is minimal as compared to the mass within the 1,000 and 10,000 ug/l contours. A thickness of 20 feet and a formation porosity of 0.3 were also used in calculating the dissolved mass of total VOCs in the shallow zone. The adsorbed mass was calculated from the dissolved mass using a distribution coefficient estimated from site hydrogeological and contaminant data. The contaminant mass calculations and assumptions are provided in Appendix D. The mass distribution of VOCs (65% dissolved and 35% adsorbed) is based on an estimated retardation factor of 1.5 (see Appendix D). These calculations indicate the total mass in the shallow zone (45 to 65 feet) within the 100 ug/L contour decreased from approximately 73 pounds in April 1997 to 51 pounds in April 1998 (a 30% reduction) and from 51 pounds in April 1998 to 12 pounds in August 1998 (a 77% reduction). Given the pilot test focused on the source area, the greatest mass reduction was observed in the area within the 10,000 ug/L contour. The calculations indicate the mass within the 10,000 ug/L contour decreased from 32 pounds to 2 pounds between April and August. Similarly, but to a lesser extent, the mass within the 1,000 ug/L contour decreased from 16 pounds to 4 pounds.

In summary, the chemical oxidation pilot test influenced an area around and immediately down-gradient of the injection wells, but had little or no impact on the perimeter wells. Within this area of influence, the VOC concentrations decreased significantly and, correspondingly, the mass of VOCs in the dissolved and adsorbed phases was estimated to decrease dramatically. Three weeks after the test, the pH was returning to baseline levels, dissolved oxygen concentrations were still elevated, and other parameters appeared unchanged.

5.2 Deep Zone Injection

During Phase III of the pilot test approximately 6,504 gallons of Fenton's reagent were injected into six deep injection wells. Baseline groundwater quality data, pilot test field data, and post-injection groundwater quality data were collected from the six deep injection wells and from six nearby deep monitoring wells. An analysis of the data and a discussion of the results are provided below.

5.2.1 Data Analysis (Deep Zone)

Pilot Test Field Parameters

Prior to, during, and immediately following the pilot test injections, field parameters (depth to water, pH, conductivity, turbidity, dissolved oxygen, temperature, oxidation-reduction potential, and hydrogen peroxide concentration) were measured in six deep observation wells. The pilot test field parameter data is provided in Appendix B. The pre-injection depth to water was approximately 45 feet below ground surface, the pH ranged from 5.93 to 6.13, and the dissolved oxygen concentration ranged from 1.27 to 5.56 mg/L. The data collected during and immediately following the injections remained unchanged from the pre-injection data with the following exceptions:

- the dissolved oxygen concentration increased from 1.27 to greater than 20 mg/L and hydrogen peroxide was detected at concentrations ranging from 0.1 to 50 mg/L in MW-21D; and

- the dissolved oxygen concentration increased from 1.92 to greater than 20 mg/L in MW-23.

Based on the field parameters monitored during the injections, deep observation wells MW-21D and MW-23 showed a response to the injection of Fenton's reagent. Changes were not anticipated in observation wells MW-18D, MW-19D, and MW-20D because the screened intervals in these wells are significantly deeper than the screened interval of the deep injection wells (Table 1). However, it should be noted that some of the influence observed in MW-21D, which is screened from 50 to 160 feet, is attributed to the shallow zone injections, since increased dissolved oxygen and hydrogen peroxide concentrations were observed after the Phase II injection into the shallow zone, but before the Phase III injection into the deep zone.

Groundwater Sampling Event Field Parameters

During the baseline and final post-injection groundwater sampling events, field parameters (depth to water, pH, conductivity, turbidity, dissolved oxygen, temperature, oxidation-reduction potential, and hydrogen peroxide concentration) were measured in six deep injection wells and six deep observation wells. The pH and dissolved oxygen results from the groundwater sampling events is summarized in Table 4. The following appreciable changes were observed in the pH and dissolved oxygen concentration in the observation wells from the pre-injection to the post-injection events:

- the pH decreased from 6.00 to 5.69 and the dissolved oxygen concentration increased from 3.7 to 6.9 mg/L in MW-21D; and
- the pH decreased from 5.68 to 5.14 and the dissolved oxygen concentration increased from 3.5 to 19.1 mg/L in MW-23.

These changes are consistent with the field parameter data collected during and immediately following the pilot test. No appreciable changes in field parameters were observed in deep observation wells MW-16D, MW-18D, MW-19D, MW-20D.

In the deep injection wells the pH ranged from 5.49 (IW-11) to 6.38 (IW-8) prior to the test, from 2.20 (IW-9) to 2.90 (IW-12, and MW-13D) immediately after the test, and from 2.63 (IW-10) to 3.18 (IW-8) three weeks after the test. Therefore, in just three weeks the pH has started to return to the pre-injection levels. Therefore, the pilot test injections did not adversely alter the pH of the aquifer. Dissolved oxygen concentrations ranged from 2.6 (IW-8) to 5.2 mg/L (IW-12 and MW-13D) prior to the test. The dissolved oxygen concentrations were greater than 20 mg/L in all the injection wells immediately after and three weeks after the test.

Groundwater Sampling Event Chemistry Data

During the baseline and final post-injection groundwater sampling events, groundwater samples from the six deep injection wells and six deep observation wells were analyzed for aquifer chemistry parameters (sulfate, alkalinity, chloride, ferrous iron, ferric iron, total iron, TDS, TOC, BOD, and COD). Groundwater samples from MW-18D, MW-19D, MW-20D, and MW-23 were analyzed for RCRA metals (plus manganese). During the two intermediate post-injection sampling events, deep injection well IW-11 and deep observation wells MW-18D, MW-19D, MW-20D, and MW-23 were analyzed for aquifer chemistry parameters. The groundwater sampling event chemistry data is summarized in Table 4. The following trends were observed in these parameters in the observation wells:

- ferrous, ferric, total iron and sulfate concentrations increased in MW-21D.

The injection of Fenton's reagent resulted in the increase in iron and sulfate concentrations in the deep injection wells and deep observation well MW-21D. Consistent with the field parameter data, no appreciable changes in aquifer chemistry parameters were observed in deep observation wells MW-16D, MW-18D, MW-19D, MW-20D, and MW-23. Considering the screen interval of 50 to 160 feet in MW-21D and the proximity of the well to the shallow injection wells, the increase in iron and sulfate concentrations in this well may be attributed to the shallow zone injections.

Groundwater Sampling Event VOC Data

Groundwater samples collected from the deep injection and observation wells during the baseline and three post-injection sampling events were analyzed for VOCs plus tentatively identified compounds. As with the shallow zone, only the five primary chlorinated VOCs of concern (1,1-DCA, 1,2-DCE, 1,1,1-TCA, TCE, and PCE) were evaluated as a part of the pilot test. The groundwater sample results for these five VOCs are summarized in Table 5 and presented as bar graphs in Appendix C. A comparison of the pre- and post-injection results for the five primary VOCs is provided in Table 6. The results of the VOCs detected other than the five primary compounds are summarized in Table 7. The following observations were made for the five primary VOCs in the deep wells:

Six Deep Observation Wells

- the total concentration ranged from 37 to 4,205 ug/l in April 1997, from 42 to 3,010 ug/l in April 1998, and from 33 to 5,243 ug/l in August 1998;

- the average concentration was 1,140 ug/l in April 1997, 1,492 ug/l in April 1998, and 2,266 ug/l in August 1998;

- the above data indicates the pilot test injections had a slight negative affect on the six deep observation wells as concentrations in six wells increased by an average of 774 ug/l (52%) between April and August 1998; however, it should be noted that the largest increase in VOC concentrations were observed in observation wells MW-19D, MW-21D, and MW-23 and based on the screen interval, location of wells, and that no purging was performed during the two July 1998 sampling events and the high purge rates in August 1998, it is plausible that the sample collected from MW-21D was more representative of shallow groundwater.

Six Deep Injection Wells

- the total concentration ranged from 119 to 5,211 ug/l in April 1998 and from 30 to 6,118 ug/l in August 1998;

- the average concentration was 1,810 ug/l in April 1998 and 1,274 ug/l in August 1998;

- the above data indicates the pilot test injections had a positive affect on the six shallow injection wells as concentrations in these nine wells decreased by an average of 536 ug/l (30%) between April and August 1998.

5.2.2 Discussion of Results (Deep Zone)

The field parameter and groundwater chemistry data from prior to, during and up to three weeks after the pilot test showed significant changes in pH, dissolved oxygen concentration, sulfate concentration and ferrous and total iron concentrations in the injection wells, but little or no changes in the observation wells, with the exception of MW-19D and MW-23. Based on the observed changes, the pilot test area of influence in the deep zone is shown on Figure 5. The deep monitoring wells beyond this area of influence had insignificant or no changes in field parameter or groundwater chemistry data.

The zone of influence is consistent with the VOC concentration results, which showed significant reductions in concentration were limited to the injection wells and little or no change in concentrations in the wells outside the zone. These results, indicating a limited extent of influence, can be attributed to the following:

- only 6,504 gallons (or 24% of the total quantity) of Fenton's reagent were injected into the deep wells, which was planned due to the need to focus in the shallow zone containing significantly higher VOC concentrations;

- the screened intervals in deep monitoring well MW-18D, MW-19D, and MW-20D are significantly deeper than the deep injection wells where the Fenton's reagent was injected; and

- monitoring well MW-16D, while screened at a comparable interval to the deep injection wells, is located too far from the injection wells to be influenced, especially given the limited volume injected.

Using the area of influence shown in Figure 6 (5,790 square feet), an influenced thickness in the deep zone of 20 feet (from 75 to 95 feet below ground surface), and a formation porosity of 0.3, approximately 260,000 gallons of groundwater were in the zone of influence. Similar to the shallow zone, the 6,504 gallons of liquid injected during the pilot test represents 2.5% of the 260,000 gallons within the zone of influence. Therefore, the effects of 2.5% dilution would be insignificant and the reductions in VOC concentrations in the area of influence can be attributed primarily to the chemical oxidation process.

The total concentration of the five primary chlorinated VOCs were used to prepare isoconcentration contour maps for the deep zone for the baseline (March/April 1998) and the final post-injection (August 1998) groundwater sampling events, Figures 7 and 8, respectively. An isoconcentration contour map was not prepared for the deep zone for the April 1997 groundwater sampling event given the limited number of wells (five), the differences in screened intervals, and their linear alignment. A comparison of the Figures 7 and 8 indicates that from April to August the area within the 100 ug/L contour decreased from 9,967 ft^2 to 6,303 ft^2 and the average concentration between the 100 and 1,000 ug/L contour increased slightly from 432 ug/l to 437 ug/l. Similarly, from April to August the area within the 1,000 ug/L contour decreased from 4,788 ft^2 to 2,455 ft^2 and the average concentration within the

1,000 ug/L contour increased from 2,946 ug/l to 5,328 ug/l. Although the average concentration within the 1,000 ug/L contour increased, the mass of VOCs was reduced slightly due to the reduction in areal extent.

The mass of VOCs dissolved in groundwater within the 100 and 1,000 ug/L contours was calculated using the area and average concentration within each interval. A thickness of 20 feet and a formation porosity of 0.3 were also used in calculating the dissolved mass of total VOCs in the deep zone. The adsorbed mass was calculated from the dissolved mass using a distribution coefficient determined from site hydrogeological and contaminant data. The contaminant mass calculations and assumptions are provided in Appendix D. The mass distribution of VOCs (65% dissolved and 35% adsorbed) is based on a retardation factor of 1.5 (see Appendix D). These calculations indicate the total mass in the deep zone (75 to 95 feet) within the 100 ug/L contour decreased slightly from approximately 9.4 pounds in April to 8.5 pounds in August, a 10% reduction.

In summary, the chemical oxidation pilot test influenced an area around and immediately downgradient of the injection wells, but had little or no impact on the deep observation wells. Within this area of influence, the areal extent of VOCs decreased and, correspondingly, the mass of VOCs in the dissolved and adsorbed phases was estimated to decrease. Three weeks after the test, the pH was returning to baseline levels, dissolved oxygen concentrations were still elevated, and other parameters appeared relatively unchanged.

5.3 Air Monitoring Results

Air monitoring was performed in the following three areas during the pilot test: inside the building, outside the building in the work area, and within select injection and observation wells. The results of the air monitoring are provided in Appendix E. A discussion of the results for each area is provided below.

5.3.1 Indoor Air Monitoring

The indoor air monitoring results indicate that no elevated concentrations of gases were detected inside the building which could be attributed to the pilot test injections. Readings of LEL, CO, H_2S, and HCN were not detected and oxygen concentrations remained at 20.9% for the duration of the pilot test. The only gases detected indoors during the pilot test (except for O_2) were occasional low levels of VOCs, CO_2, and Cl_2. The detected VOC readings, which ranged from 1 to 10 parts per million by volume (ppmv), were determined to be caused by the renovation activities (spackling, painting) being conducted in the building. The highest detected CO_2 concentrations, which ranged from 0.05 to 0.15%, were detected inside the building on July 8th, one day before the pilot test injections were started. The detected Cl_2 concentrations, which ranged from 0.02 to 0.24 ppmv, were detected periodically throughout the monitoring, including prior to the start of injections. The New York State Department of Health (NYSDOH) representative observing the pilot test activities believed the low concentrations of Cl_2 could be attributed to either background concentrations or problems associated with instrument sensitivity.

5.3.2 Outdoor Air Monitoring

The outdoor air monitoring results were similar to the indoor results, with only low levels of certain gases detected. Readings of LEL and CO were not detected and oxygen concentrations remained at 20.9%. Although low concentrations of VOCs, CO_2, H_2S, Cl_2, and HCN were detected, the readings were below their respective outdoor action levels. The highest concentrations detected outdoors were as follows: 1 ppmv VOCs , 0.05% CO_2, 1 ppmv H_2S, 0.36 ppmv Cl_2, and 1 ppmv HCN.

5.3.3 Injection and Observation Well Air Monitoring

The concentrations of all gases monitored during the pilot test, except for Cl_2, were higher inside the injection and observation wells during active injection as compared to the indoor and outdoor ambient readings. The highest readings of VOCs (190 ppmv), LEL (3%), and HCN (80 ppmv) were detected in shallow injection well IW-1 while injecting Fenton's reagent during Phase II. Both O_2 and CO were detected above the instrument operating ranges (30% for O_2 and 300 ppmv for CO) in several of the injection wells during injection of Fenton's reagent. The highest CO_2 (3.4%) and lowest O_2 (15.9%) readings were detected in shallow injection well IW-5 after the injection of the acidified water during Phase I. Concentrations of H_2S were not detected, with the exception of two readings (1 and 2.8

ppmv) from shallow injection well IW-6. Concentrations of Cl_2 detected within the injection and observation wells (0 to 0.26 ppmv) were similar to those obtained indoors and outdoors, indicating the pilot test injections did not cause a measurable increase in Cl_2 concentrations.

6.0 CONCLUSIONS

The pilot test results indicate that *in-situ* chemical oxidation can be used to effectively address the dissolved and adsorbed phase VOCs present at the site. Significant reductions in VOC concentrations were observed in the areas influenced by the pilot test injections. The reductions in VOC concentrations were most pronounced in the shallow zone wells where the majority of the Fenton's reagent was injected. The estimated mass of contaminants decreased in both the shallow and deep zones. Little or no changes were observed in VOC concentrations (or other groundwater quality parameters) in the wells outside the zones of influence. Air monitoring results from the building and the pilot test work area indicate that the injections can be performed safely.

7.0 RECOMMENDATIONS

Based on the results of the July 1998 *in-situ* chemical oxidation pilot test, the results of the August 1998 groundwater sampling event, and prior characterization of the site conditions, the following actions are recommended to address the remaining dissolved and adsorbed phase VOCs present at the site:

- properly seal/abandon well MW-21D, which is screened across the shallow and deep zones (from 50 to 160 feet below grade), to eliminate a path for vertical migration of VOCs to the deep zone;

- conduct injections of Fenton's reagent into the shallow groundwater zone on a periodic basis (i.e. monthly, bi-monthly, quarterly) and expand the injection well network to include downgradient observation wells MW-7, MW-8, MW-9, MW-10, and MW-11 to address the chlorinated VOCs in this portion of the shallow groundwater zone;

- conduct injections of Fenton's reagent on a periodic basis into vadose zone wells screened from approximately 15 to 25 feet below grade to address residual contamination in the vadose/capillary zone in the vicinity of IW-1, IW-3, IW-4, and MW-13;

- conduct injections of Fenton's reagent into the deep groundwater zone following the remediation of the shallow zone groundwater and install additional deep zone observation wells to determine the effects of remediation.