PHILLIPS PETROLEUM COMPANY
BARTLESVILLE, OKLAHOMA 74004 918 661-6600

HEALTH, ENVIRONMENT AND SAFETY

September 8, 1992

Andrew J. English, P.E.
New York State Department
of Environment Conservation
50 Wolf Road
Albany, New York 12233

Re: Remedial Design at the Shore Realty Site

Dear Mr. English;

As you are aware, we have selected Remediation Technologies, Inc. (ReTec) to provide support for the remedial design phase of the selected remedy.

Enclosed is a copy of ReTec's proposal for the remedial design, in which, is contained quite a bit of information on ReTec's overall qualifications and suitability for this effort. Since the date of ReTec's proposal, Mr. John Smith has been replaced with Dr. Alonzo Lawrence, P.E. (registered in the state of New York). Dr. Alonzo will be responsible for ReTec's technical review of the design.

Upon review of the ReTec information should you have any questions, please call me at 918-661-6269.

Yours Truly,

R. Kirk Stumberg
Phillips Petroleum Co.

RKS/dh:36

PROPOSAL TO IMPLEMENT REMEDIAL DESIGN WORK AT THE SHORE REALTY SITE
Greenwood Landing, New York

Prepared for:

The Participating Companies
Beveridge & Diamond, P.C.
Washington, D.C.

Prepared by:

Remediation Technologies, Inc.
9 Pond Lane
Concord, MA 01742

Proposal PEN1387

June 1992

RETEC
REMEDIATION TECHNOLOGIES INC

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Prepared by: ____________

Reviewed by: John W. Lynch

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TABLE OF CONTENTS

NO. DESCRIPTION PAGE NO.

1.0 Introduction 1-1
1.1 Project Description 1-1
1.2 Performance Standards 1-2
1.3 Approach and Methodology 1-3
1.4 Key Components 1-5
1.4.1 Sparging 1-5
1.4.2 Iron Precipitation 1-8
1.4.3 *In Situ* Biodegradation 1-10
1.4.4 Bioventing 1-13
1.4.5 Biofiltration 1-14
1.4.6 Groundwater Treatment 1-14
1.4.7 Existing Infrastructure 1-18

2.0 Scope of Work 2-1
2.1 Pre-Remedial Design Investigation Work Plan 2-1
2.1.1 Work Plan 2-1
2.1.2 Data Review/Scoping 2-3
2.1.3 Site Characterization 2-3
2.1.3.1 Boring and Sampling 2-4
2.1.3.2 Soil Gas Survey 2-6
2.1.3.3 Iron Precipitation Evaluation 2-7
2.1.3.4 Infrastructure Inventory 2-7
2.1.4 Treatability Studies 2-8
2.1.4.1 Biodegradation Pilot Study 2-8
2.1.4.2 Water Treatment Pilot Study 2-14
2.1.5 Conceptual Design 2-15
2.1.5.1 Vapor Extraction/Injection 2-19
2.1.5.2 Groundwater Extraction/Injection 2-19
2.1.5.3 Water Treatment 2-20
2.1.5.4 Vapor Treatment 2-21
2.1.5.5 Infrastructure Decommissioning and Demolition 2-23
2.1.6 Project Operations Plan 2-23
2.1.6.1 Health and Safety Plan 2-24
2.1.6.2 Sampling and Analysis Plan 2-24
2.1.6.3 Quality Assurance Project Plan 2-27
2.1.7 Reporting 2-28
2.2 Remedial Design Work Plan 2-28
2.2.1 Project Objectives 2-28
2.2.2 Design Parameters 2-31
2.2.3 Performance Standards 2-31
2.2.4 Regulatory Requirements 2-32
2.2.5 Administrative Requirements 2-32

TABLE OF CONTENTS (Continued)

NO. DESCRIPTION **PAGE NO.**

2.3 Remedial Design . . . 2-32
2.3.1 30% Design . . . 2-33
2.3.2 60% Design . . . 2-33
2.3.3 90% Design . . . 2-35
2.3.4 100% Design . . . 2-37

3.0 Project Staffing, Management and Reporting . . . 3-1
3.1 Staffing . . . 3-1
3.2 Management and Reporting . . . 3-2
3.2.1 Cost Control . . . 3-3
3.2.2 Subcontract Administration . . . 3-4
3.2.3 Schedule . . . 3-4
3.2.4 Communications . . . 3-5
3.2.5 Quality Control . . . 3-5

4.0 Qualifications and Relevant Experience . . . 4-1
4.1 Groundwater Remediation Under CERCLA . . . 4-1
4.2 New York DEC Related Experience . . . 4-2
4.3 Technology Specific Experience . . . 4-9
4.4 Soil Venting and Groundwater Aeration Services . . . 4-10
4.5 Pump-and-Treat Systems . . . 4-14
4.7 Fate & Transport Analysis . . . 4-19
4.8 Laboratory Treatability Studies and Technology Demonstration Services . 4-23
4.9 Hydrocarbon Recovery Systems . . . 4-28

5.0 Standard Terms and Conditions . . . 5-1

6.0 References . . . 6-1

APPENDIX A Cost Proposal
APPENDIX B Itemized Costs by Tasks
APPENDIX C RD Implementation Schedule
APPENDIX D Project Organization Chart
APPENDIX E Resumes of Project Personnel
APPENDIX F Project Summaries
APPENDIX G Insurance Certificate
APPENDIX H Qualifications of Subcontractors
APPENDIX I Standard Operating Procedures Biodegradation Pilot Study

LIST OF FIGURES

NO.	DESCRIPTION	PAGE NO.
1	Integrated Approach to Pre-Remedial Investigation	1-6
2	Sparging	1-7
3	Water Treatment - Process Flow Diagram	1-17
4	Proposed Soil Boring & Wellpoint Location	2-5
5	Schematic of In Situ Bioremediation Process	4-11
6	Schematic of Groundwater Aeration and Soil Venting	4-15
7	RETEC's Approach for Least Cost Treatment of Contaminated Groundwater	4-18

LIST OF TABLES

NO.	DESCRIPTION	PAGE NO.
1	Table of Contents - Pre-Remedial Design Investigation Work Plan	2-2
2	Summary of Analytical Methods	2-16
3	Table of Contents - Health and Safety Plan	2-25
4	Table of Contents - Sampling and Analysis Plan	2-26
5	Table of Contents - Quality Assurance Project Plan	2-29
6	Remedial Design Documentation	2-34
7	Groundwater Work under CERCLA	4-3
8	Representative New York State and NYDEC Related Experience	4-5
9	Representative In Situ Bioremediation Projects	4-12
10	Representative Soil Venting and Groundwater Aeration Projects	4-16
11	Representative Projects Addressing Treatment of Extracted Groundwater	4-20
12	Representative Modeling Projects	4-24

1.0 INTRODUCTION

Remediation Technologies, Inc. (RETEC) is pleased to submit this proposal to the Participating Companies to implement the Remedial Design (RD) for the Shore Realty Site in Glenwood Landing, Nassau County, New York. RETEC is well qualified to undertake this project. Since it's founding in 1985, RETEC has specialized in the design and implementation of innovative on-site treatment technologies for sites having organic contamination. Among the technologies for which we are nationally recognized as industry leaders are bioremediation and *in situ* treatment technologies. We have successfully designed and implemented these technologies for petroleum companies, utilities and chemical companies at sites regulated under CERCLA, RCRA and numerous state environmental programs.

This proposal has been developed in accordance with the Request for Proposal based upon our understanding of the project as described in the Consent Decree, Record of Decision (NYSDEC, 1991), the Remedial Investigation (Roux, April 1991) and the Feasibility Study (Roux, 1991). Additionally, we have relied upon our experience with the technologies at similar sites in the region and throughout the country.

This proposal is organized in conformance with Attachment 1 of the RFP. Subsequent paragraphs in Section 1.0 present a project description, a summary of the performance standards and RETEC's approach to undertaking this work. Section 2.0 describes the Scope of Work to be undertaken for the Pre-Remedial Design Investigation and Remedial Design activities, including preparation of the appropriate work plans. Project Staffing, Management and Reporting are presented in Section 3.0. RETEC's qualifications are discussed in Section 4.0 followed by our proposed Terms and Conditions. Appendices to this proposal include the Cost Proposal and additional administrative details as requested.

1.1 PROJECT DESCRIPTION

The Shore Realty Site is located on a small peninsula on the east shore of Hempstead Harbor in Nassau County, Long Island, New York. The 3.4 acre site was used as a petroleum products terminal from 1939 to 1972. During the 70's, the facility was used to store both petroleum and other chemical products. From 1980 through January of 1984, the facility was used to blend chemical waste materials for resale as alternative fuels. No commercial activity has occurred at the site since 1984.

During the period of operation, the only major reported release occurred in 1978 when approximately 3,000 gallons of toluene were released from an overturned truck. However, numerous smaller spills are known or suspected to have occurred. In May 1985, the State of New York hired a contractor to remove approximately 700,000 gallons of hazardous waste from the site. The site was added to the National Priorities List in 1986. A series of investigations and a Feasibility Study were conducted between 1987 and 1991, funded by a group of companies who are referred to as the "Participating Companies." The risk assessment, conducted as part of the FS, concluded the primary constituents-of-interest (COI) consist of methylene chloride and benzene. The risks associated with these compounds exceeded the acceptable one-in-one million risk level allowed by New York. In addition to the two constituents identified on the basis of the risk assessment, several COI, consisting primarily of volatile organic compounds, were identified above New York State groundwater standards.

A Record of Decision (ROD) was issued in June 1991 which identified a series of component technologies that would be combined into a remedial action. The remedy, defined by the ROD, is targeted primarily at remediation of the soil and groundwater at the site, under the assumption that remediation of sediment, surface water and air will be achieved naturally after treatment of these primary source zones. The selected remedy requires remediation by a combination of vapor and groundwater extraction coupled with *in situ* biodegradation. Effluent from the groundwater extraction process is to be treated by air stripping with air pollution controls as necessary; effluent from the vapor extraction process is to be treated as necessary to limit air emissions to levels acceptable to NYSDEC and USEPA.

The RFP specifically requests preparation of the Work Plan for undertaking the Pre-Remedial Design Investigation including a biotreatability study, aquifer testing and modeling as well as any limited field investigation, sampling, data collection or monitoring necessary to allow engineering design of the full-scale remediation including careful consideration of cost effectiveness and technical reliability of the various design alternatives. Project Operations plans and any permits necessary to undertake these investigations will be prepared as part of this initial phase of the project. Subsequently, the RFP requests outlining the scope of work for preparing the remedial design.

1.2 PERFORMANCE STANDARDS

The ROD identifies three media to be treated: water, vapor, and the soil mass as a whole. The performance standards to be obtained by implementing the remedy are:

- Reduce the concentration of organic constituents in groundwater to below NYS groundwater standards.

- Reduce the concentration of benzene and methylene chloride in soils to levels constituting acceptable risk.

- Reduce the concentration of all organic constituents within soils to levels constituent with acceptable concentrations of constituents in groundwater.

Treatment technologies are specifically identified in the ROD for water and the soil mass, i.e., a separations technology (air stripping) for water and biodegradation for the saturated soil mass. However, with respect to the vapor treatment, the ROD refers to "air pollution controls" in general (although catalytic oxidation was used as the basis of the Feasibility Study) and an additional performance standard "to limit air emissions to levels acceptable to NYSDEC and USEPA". It is important to note that performance standards for water and vapor are based upon regulatory standards while soil criteria are indirect based upon leaching of the constituents from the soil mass to groundwater. It should also be noted that the ROD allows for renegotiation of the performance standards if process performance demonstrates that continued operation would not provide additional benefit and that further reduction in concentration levels would be impractical.

From the standpoint of the design process, additional performance standards must be established as part of the design approach to allow objective evaluation of various design alternatives, each of which may meet the performance standards established in the ROD. These standards must allow for consideration of the physical and chemical properties of the site hydrogeology and constituents-of-interest as well as integration of the component into the design process of the entire remedy considering impacts of other media, contaminants and the technologies. The integrated analysis of design alternatives against these balancing standards forms the basis of RETEC's approach to this project as discussed below.

1.3 APPROACH AND METHODOLOGY

RETEC's approach to undertaking this project is to integrate the design of the various extraction and treatment components to efficiently and cost-effectively achieve the overall performance standards established in the ROD. This is achieved by establishing performance standards specific to the design process to undertaking a detailed, objective evaluation of various design alternatives and comparing these alternatives to these standards. Specifically, these objectives consist of:

- maximizing the reduction of the COI on-site by optimizing removal;

- minimizing operation and maintenance requirements by maximizing technical reliability of the individual components; and

- minimizing costs for treatment by integrating the treatment technologies associated with each media.

The performance standards established by the ROD can be considered threshold criteria, i.e., the minimum standards that all remedial designs must achieve. The specific performance standards can be considered balancing criteria by which various design alternatives are evaluated and specific solutions selected.

Evaluation of the extraction components identified in the ROD represents an example of how this approach is implemented. To evaluate the extraction components, it is important to consider the fundamentals of these technologies in terms of physical and chemical processes to be able to evaluate the various alternatives in regard to these balancing criteria. In this regard, the ROD recognizes the physical properties of the site, i.e., permeability, by selecting extraction components, and, i.e., vapor and groundwater extraction, which rely upon the flow of liquids and vapors through the soils to remove the contaminants. In addition to the physical properties of the soil mass, these extraction components rely upon the chemical properties of the constituents of interest whereby a phase change of the contaminants from the soil mass to a transfer media must occur, e.g., volatilization to air in the vadose zone or dissolving into water in the saturated zone to remove the contaminants. Once removed from the subsurface, the contaminants are treated at the surface.

Interestingly, the ROD does not explicitly evaluate the chemical properties of the constituents-of-interest to identify which extraction technology may lead to more efficient contaminant treatment. However, it implicitly must assume that contaminant destruction can occur more efficiently in the vapor phase since the surface treatment for water specifies an air stripper which physically separates the contaminant by allowing it to volatilize into air prior to the application of air pollution controls for destruction of the constituents. In addition, the ROD recognizes the inefficiency in the groundwater extraction in terms of removal of the contaminants by providing for *in situ* biodegradation in the saturated zone to expedite reduction of the mass of contaminants.

In the course of preparation of this proposal, RETEC has conducted a preliminary evaluation of various design alternatives to develop a scope of the Pre-Remedial Design Investigation and associated pilot studies. Through this process, we have developed an integrated approach to designing and implementing the remediation of this site which we believe will cost effectively achieve the objectives for this project. This approach is illustrated in the flow diagram presented in Figure 1.

This figure shows specific steps to be undertaken during the Pre-Remedial Design Investigation to provide the data necessary to allow initiation of a detailed engineering design. This figure presents the steps for each media requiring treatment and shows not only how the media are interrelated, but also how the phases of the initial design process are interrelated.

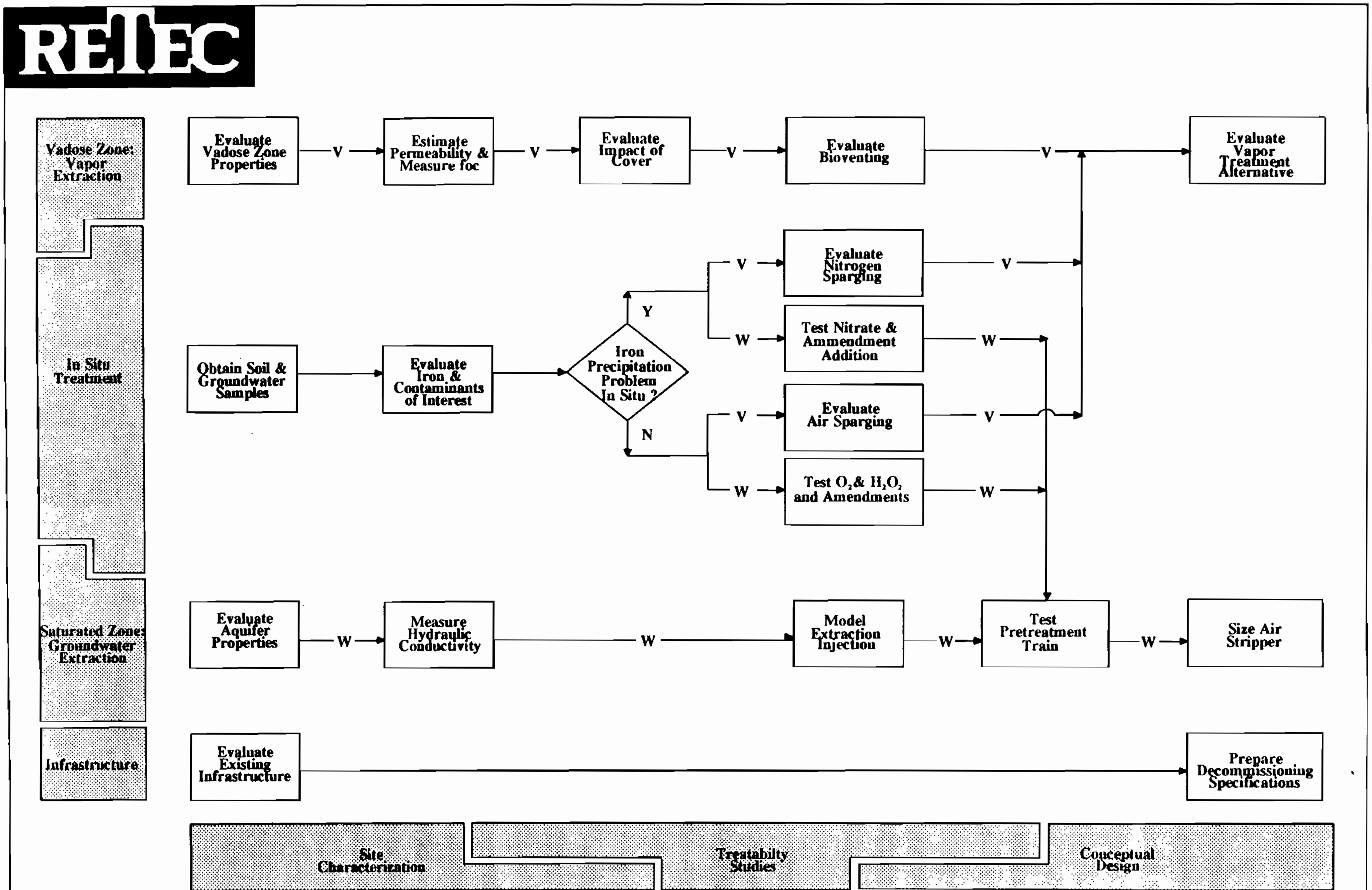
1.4 KEY COMPONENTS

Based upon the preliminary evaluation, RETEC has identified several key components of the project where significant remediation efficiencies or cost savings can be achieved. These key components are discussed in detail below.

1.4.1 Sparging

The analysis of the extraction components listed above identifies the first component which may result in significantly enhanced remedial efficiencies. Specifically, given the volatile nature of the majority of the constituents-of-interest, *in situ* volatilization, not only above the water table but also within the saturated zone, may be very cost-effective in removing a large percentage of COI. Within the saturated zone, this technology is implemented by injecting compressed air (or nitrogen) into the aquifer through wellpoints and recovering the vapors in the vapor extraction system in the vadose zone. The process has been used successfully to remove volatile organic constituents from permeable aquifers and could potentially deliver oxygen for *in situ* biodegradation as well. This technology is illustrated in Figure 2.

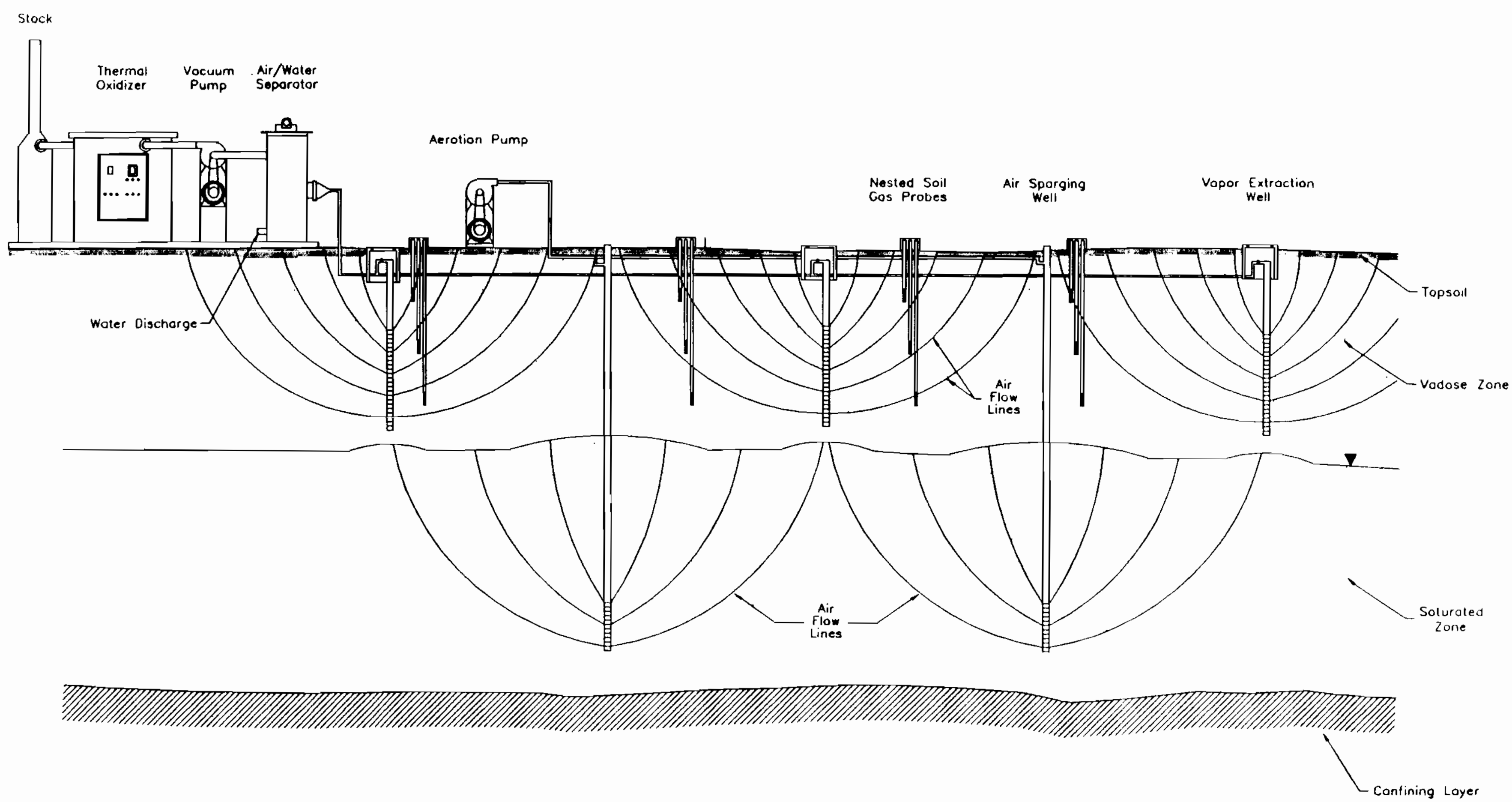
In one recent report (Marley, 1990), a series of aeration probes were placed ten feet below the water table in a fine sandy aquifer contaminated by gasoline. After five years of a



Integrated Approach to Pre-Remedial Investigation

FIGURE 1

RETEC



SUBTECH.DWG

SPARGING

FIGURE 2

combined groundwater pump-and-treat and vapor extraction remediation, groundwater remained significantly above acceptable standards. After 60 days of aquifer aeration, dissolved-phase BTEX constituents were reduced by greater than 80% in both monitoring wells within the treatment zone, and the Dissolved Oxygen (DO) content was increased from 1.4 mg/L to about 7 mg/L.

Greenwood and Hutton (1990) report similar results from a site in California containing TCA and DCE. TCA contamination was as high as 476,000 ppb and DCE levels as high as 1,900 ppb. A groundwater pump-and-treat process, inside a slurry wall that had been constructed around the site, was projected to take at least five years. A series of 37 air injection wells and 8 vacuum wells was installed throughout the two-acre site. After six months of aquifer aeration, the maximum concentrations of TCA and DCE were reduced to 480 and 110 ppb, respectively, and the concentrations in the areas which exceeded drinking water standards were reduced dramatically.

RETEC designed and operated a sparging system at a terminal site which was so successful, sparging supplanted the groundwater pump-and-treat system. At this site, sparging removed over 1,000 pounds of BTEX and gasoline contaminants in the first year of operation compared to removal of 2,500 pounds of contaminants by the pump-and-treat operation which operated for two years. Not only were the removal efficiencies greater by sparging, the cost per pound of contaminant removed 50 times.

The case histories summarized above demonstrate very effective removal of organic constituents from a permeable aquifer through aeration. Since the subsurface conditions at the Shore Realty site are primarily sand, this technique is expected to be very effective at the site. Additionally, as this process relies on the exchange of constituent from the soil mass and groundwater into air bubbles moving through the aquifer, and the *in situ* biodegradation relies on the inverse transport, i.e., oxygen into the aquifer, sparging may serve not only to remove contaminants through volatilization but also supply oxygen for biodegradation.

1.4.2 Iron Precipitation

Inorganics in the groundwater will have significant impact upon the design of the *in situ* remediation system as well as the water treatment technology. Specifically, the high concentrations of reduced iron (Fe^{+2}), probably resulting from the consumption of the dissolved oxygen through natural biodegradation of the organic constituents, may lead to clogging of the aquifer and the air stripper. When water is oxidized, either in the aquifer to support biodegradation or in the an air stripper, the iron will be converted to Fe^{+3}, which combines with water and other minerals causing precipitation. Although certain additives can help to control this problem, the potential operating problems associated with widespread iron precipitation could be dramatic.

RETEC plans to evaluate the potential magnitude of the iron precipitation problem for *in situ* treatment during the early phase of the project, and subsequently develop *in situ* processes which account for these conditions. If iron precipitation is a problem *in situ*, appropriate pretreatment technologies will be included in the water treatment system prior to air stripping. If iron precipitation *in situ* leads to a significant reduction in permeability, sparging with nitrogen will be evaluated. This scenario would also include the evaluation of nitrate as an alternative electron acceptor (to oxygen) for *in situ* bioremediation. After the biodegradable constituents had been degraded under the anaerobic process and soluble iron levels reduced, oxygen could be introduced into the aquifer, if necessary, to complete the process and to return the aquifer to aerobic conditions.

As noted above, iron concentrations in groundwater indicate a pretreatment system will be necessary before the air stripper. The pretreatment system will require a gross separator to prevent fouling of the air stripper by free product or suspended solids. In addition, a chemical oxidation step followed by polymer-enhanced coagulation, flocculation and gravity settling will be necessary to precipitate and remove reduced iron to prevent plugging of the air stripper by iron precipitant.

Iron concentrations as high as 76 ppm have been reported in the RI groundwater analytical data. Typically, vendors recommend a pretreatment step if iron concentrations are above 8 to 10 ppm. Without such a pretreatment process for iron removal, the soluble-reduced ferrous iron (Fe^{+2}) in the groundwater will subsequently oxidize to ferric iron (Fe^{+3}) and thus precipitate as $Fe(OH)_3$ in the air stripping treatment process resulting in a treatment system subject to high maintenance, frequent upsets, high effluent suspended particulate and potential fouling of the process which would interfere with its organic removal efficiency. Additionally, in terms of a potential plugging effects on reinjection, total suspended solids effluent limitations in the range of 1 to 10 ppm are not uncommon. At an anticipated level of approximately 75 ppm influent iron, total suspended solids of greater than 150 ppm can be expected with a distinctive reddish brown coloration to the effluent. Therefore, at a groundwater concentration of approximately 75 ppm, iron must be removed under controlled conditions prior to subsequent treatment for organics.

1.4.3 *In Situ* Biodegradation

In situ bioremediation is an increasingly popular groundwater remediation technique when site conditions and remediation objectives indicate that a simple pump-and-treat process is not sufficiently aggressive to meet groundwater remediation goals and when soils are inaccessible for other types of treatment. This technique is applicable to many common organic contaminants found in groundwater, including toluene, ethylbenzene, styrene, xylenes, and polynuclear aromatic hydrocarbons (naphthalene, phenanthrene, etc.) that have very low aqueous solubilities and thus tend to be sorbed into the natural organics in soil than be flushed from soils in groundwater. As a result, it is very difficult to remove these contaminants using simple soil flushing (groundwater extraction) processes.

In situ bioremediation is designed to degrade organic contaminants in the soil/water matrix, rather than transporting the contaminants through a complex geology for removal on the surface. The process involves the introduction of microbial nutrients (typically, ammonia-nitrogen and orthophosphate) and an oxygen source (or alternative electron acceptor) into a contaminated aquifer to promote the biodegradation of organic materials within this "bioactive zone." Groundwater is withdrawn from the aquifer to establish hydraulic containment and to increase the hydraulic gradient, thus increasing the rate at which groundwater moves through the formation. The captured water is typically treated to remove contaminants, and then a major portion of the water is amended with nutrients and reinjected (Thomas, 1989).

In order to successfully design an *in situ* bioremediation process at a particular site, it is helpful to understand how the general principles of microbiology, hydrogeology and chemistry apply to the process. For example:

- the site must contain bacteria which are capable of degrading the contaminants of interest;

- the hydrogeology of the site must permit the movement of nutrient-enriched water through the contaminated region and allow for the controlled capture of this water;

- the soil and groundwater must be chemically compatible with the nutrient sources provided; and

- the process must deliver sufficient oxygen to degrade non-targeted, as well as targeted, organic constituents which are biodegradable.

Based on characterization data reported on the site and the Biotrol Treatability Study reported in the FS, RETEC expects that native bacteria will be capable of degrading all of the non-chlorinated constituents-of-concern. The chlorinated solvents are not likely to degrade under the treatment conditions, but are likely to be removed through a combination vapor extraction and groundwater extraction.

When estimating the oxygen demand of a site, it is important to account for all biodegradable organic constituents, regardless of whether or not these materials are of regulatory or environmental concern. As a result, any information that is available about the structures of the non-targeted constituents of the site will be useful. RETEC will monitor the changes in the concentrations of TOC and/or TPH in the soils as a means to monitor the fate of these constituents during various treatment processes.

After the oxygen demand of a site is estimated, the time required for remediation using *in situ* biodegradation can be calculated by considering various means to increase oxygen transport (using pure oxygen, hydrogen peroxide, or air sparging, for example), or by adding alternative electron acceptors (nitrate) which are more soluble than oxygen or more tolerant of high iron environments. Several oxygen delivery options appear to warrant consideration at the Shore Realty site, including hydrogen peroxide, oxygen and sparging. Each of these will be discussed below.

Hydrogen Peroxide Under conditions of high hydraulic conductivity and high peroxide stability, hydrogen peroxide can act as a very cost-effective "timed release" agent for dissolved oxygen. A 200 mg/l solution of hydrogen peroxide will release 100 mg/l of dissolved oxygen as it decomposes in the presence of soils. However, if the rate of decomposition is significantly faster than the rate of oxygen demand, then the aquifer becomes supersaturated and the oxygen is wasted. However, given the presence of high iron concentrations and weathered organic constituents at this site, there is a high probability that rapid peroxide decomposition will occur. Under these conditions, there is limited benefit to using hydrogen peroxide as an oxygen source and the maximum delivery rate for dissolved oxygen would be about 40 mg/l (the saturation level of oxygen in water). Hydrogen peroxide stability studies will be performed to evaluate this issue.

Oxygen Addition If peroxide stability is insufficient to warrant the use of hydrogen peroxide at concentrations greater than 100 mg/l, then the choice of using hydrogen peroxide or bubbling oxygen into reinjected water is purely one of economics. Oxygen addition can be achieved through the use of compressed oxygen gas or liquid oxygen. Molecular sieve technology which extracts oxygen from ambient air often provides an economical alternative to the use of pure oxygen gas. Regardless of the source of pure oxygen used for *in situ* bioremediation, no additional testing or evaluation would be required to evaluate this option.

Sparging As noted above, *in situ* air sparging or aquifer aeration is a very promising technique to remove the COI from *in situ*. Oxygen from the injected air will dissolve in the groundwater serving to satisfy the oxygen demand for *in situ* biodegradation. If iron precipitation is shown to be a problem, nitrogen will be used for sparging, thus maintaining anaerobic conditions within the aquifer, and nitrate will be used as an alternate electron acceptor to promote contaminant biodegradation under denitrification conditions.

In order to estimate the time required to complete an *in situ* biodegradation using various oxygen transport options, it is necessary to estimate the total oxygen demand of the site. If sparging is used in combination with vapor extraction, this process will dramatically reduce the concentration of biodegradable organics in the saturated zone prior to starting *in situ* bioremediation. To provide an estimate of the oxygen demand of various areas of the site, RETEC proposes to analyze soils for TPH and perform biotreatability pilot studies on these soils to evaluate oxygen demand. In addition, oxygen uptake and contaminant analysis will be performed to evaluate the benefit of adding ammonia and phosphate.

If iron precipitation is identified as a major issue, nitrate consumption studies will replace oxygen uptake studies. Nitrate alone may not be a sufficient electron acceptor for all of the contaminants present at the site, but nitrate is likely to be effective on the three most prevalent targeted compounds: ethylbenzene, toluene and xylene. The efficiency of this process would be compatible with the injection of nitrogen into the aquifer. There may be some regulatory resistance to injecting nitrate into groundwater at concentrations greater than groundwater standards (45 ppm as nitrate); however, RETEC believes that higher concentrations could be safely added at this site as long as the process were controlled to insure that nitrate does not accumulate in the aquifer. If iron precipitation in the aquifer appears to be a significant obstacle to aerobic processes, the treatability studies associated toward *in situ* bioremediation will include appropriate pilot studies to demonstrate successful remediation using nitrogen and nitrate additions.

1.4.4 Bioventing

Bioventing is an engineered system designed to stimulate biodegradation of organic compounds in unsaturated soils. This phenomena was first documented in 1980 when the Texas Research Institute was performing a pilot study to document enhanced recovery techniques for liquid-phase gasoline. Its ability to account for the mass of spilled material led to further studies which suggested that over 30% of the gasoline had been removed through biodegradation (TRI, 1980). Subsequent observations by those evaluating *in situ* biodegradation in the saturated zone and vapor extraction in the unsaturated zone concluded that biodegradation in the unsaturated zone is often limited by the availability of oxygen (Hinchie, 1992).

Bioventing uses the techniques of vapor extraction to induce air flow through the unsaturated soil, but at much lower rates than are typically used for vapor extraction processes. In addition, moisture, and occasionally nutrients, are added to the soil, either through percolating nutrient-enriched water from the surface, injecting water into wells or trenches within the unsaturated zone or by adding gaseous ammonia to the injected air. The flow rates are maintained at just slightly greater than the oxygen uptake rate, which can be monitored by shutting off the system and observing the rate of oxygen depletion at monitoring points (Downey, 1991).

In the past three years, the process has been used by the US Air Force (Miller, 1991) as well as many environmental consulting engineering firms, and has been shown to be effective under a wide range of site conditions. The controlling parameters appear to be the ability to move air through the site (usually controlled by permeability and degree of water saturation), the biodegradability and volatility of the chemical (if it is very volatile, the rate of volatilization will exceed the rate of biodegradation), moisture content (bacteria are not active under arid conditions) and, in some instances, nutrient availability.

Based on the available data on the permeability and chemical characteristics of the Shore Realty Site, it would appear that volatile emissions could be reduced by at least 50% by operating the vapor extraction system to maximize biodegradation and minimize volatilization. This might allow the extraction unit to operate for shorter periods of time, or to only operate a certain section of the system at any one time to minimize both capital and operating expense. Considering that the ROD also specifies the installation of an asphalt cap, vapor treatment could be almost entirely eliminated by delivering oxygen in an oxygen-enhanced air stream or from hydrogen peroxide. (Carbon dioxide would need to the removed from the air stream under this scenario.)

1.4.5 Biofiltration

Bioventing, described above, involves transporting oxygen-rich air through contaminated soil to enhance biodegradation of the organic constituents. Biofiltration involves transporting extracted soil vapor contaminated with biodegradable organics through an engineered bed of soil (enriched with nutrients and bulking agents). The contaminants sorb to the soil and are degraded, reducing the concentration in the vapor by 90 to 95%, depending upon the design and operating conditions.

Biofilters can be designed in various configurations, either in flat earthen beds or within support structures. They generally include sampling ports and piping to allow for introduction of water and/or nutrients during operation. Operating costs are typically very low. Based on preliminary evaluation of this alternative at the Shore Realty site, it appears that a biofilter could be constructed for $50,000 to $75,000 depending upon the volume and concentration of volatiles expected and whether or not existing tanks were used for the process. RETEC proposes to evaluate this option along with other vapor treatment alternatives.

1.4.6 Groundwater Treatment

Although the ROD specifies air stripping for groundwater treatment, to effectively implement this solution it has been RETEC's experience that a pretreatment step is an absolute necessity. This pretreatment step must remove any free product (Non-Aqueous Phase Liquid - NAPL) and suspended solids to prevent fouling of the air stripper. In addition, the dissolved or reduced iron must be oxidized and removed to prevent plugging of the air stripper by iron precipitate.

Furthermore, additional treatment may be required to remove other inorganic constituents prior to reinjection for the *in situ* biological treatment system. This may be necessary to meet NYSDEC groundwater standards. Specifically, the RI report found that arsenic, cadmium, chromium, lead, and zinc concentrations were above the NYSDEC groundwater standards or guidance values. It should be noted that RETEC will attempt to negotiate alternative groundwater cleanup levels, and a variance may be granted based upon local background concentrations of certain constituents.

RETEC proposes a system comprised of four basic unit processes: Product Recovery - to accomplish total fluids pumping and phase separation; Pretreatment - to provide for iron and mineral removal; Treatment - to provide for organic removal; and Offgas Abatement - to provide appropriate treatment to permit discharge of the associated vapor phase. Specifically, the treatment system will consist of the following five processes in-series:

(1) product recovery;

(2) pH control and chemical oxidation of ferrous iron (Fe^{+2}) using potassium permanganate ($KMnO_4$);

(3) polymer-aided coagulation/flocculation/gravity settling (C-F-GS) of the resulting iron hydroxide floc formed;

(4) filtration of the pretreated groundwater; and

(5) air stripping with appropriate offgas abatement prior to final discharge.

After gross separation to recover free product, the groundwater will be treated primarily for iron removal. Such treatment will involve potassium permanganate ($KMnO_4$) chemical oxidation in conjunction with polymer-enhanced C-F-GS of the precipitated floc solids. Without such a pretreatment process for iron removal, the soluble reduced ferrous iron (Fe^{+2}) in the groundwater will subsequently oxidize to ferric iron (Fe^{+3}) and thus precipitate as $Fe(OH)_3$ in the air stripping treatment process resulting in a treatment system subject to high maintenance, frequent upsets, high effluent suspended particulate and potential fouling of the process which would interfere with its organic removal efficiency.

Also, pH adjustment may be required to remove other inorganic constituents. This may be necessary to meet NYSDEC groundwater requirements prior to reinjection for the *in situ* biological treatment system. For example, the RI report found that arsenic, cadmium, chromium, iron, lead, and zinc concentrations were above the NYSDEC groundwater standards or guidance values. The necessity for treatment of these additional constituents will depend upon negotiations with the NYSDEC, as a variance may be defended based upon background groundwater concentrations for the area. To define an effective groundwater treatment process, RETEC recommends a focused bench-scale treatability program. The treatability test would consist of jar testing to determine recommended chemical oxidant and polymer dosages for iron removal as well as the optimum pH to treat the other inorganic constituents-of-interest.

In terms of its capabilities, $KMnO_4$ is a proven chemical oxidant for both iron and manganese removal and is used for treatment of municipal water supplies. For iron removal from groundwater, it is RETEC's experience that $KMnO_4$ is a better oxidant than hydrogen peroxide (H_2O_2) for this particular application. This is based on the fact that residual H_2O_2 in the groundwater can cause plugging and foaming problems in tertiary treatment processes, such as air stripping. Additionally, with H_2O_2 as the oxidant, the oxidized and precipitated iron solids tend to stay suspended in solution or float to the surface due to the water being supersaturated with oxygen. With $KMnO_4$, the resulting iron hydroxide precipitate forms a very stable sludge with good settling properties especially when further enhanced with polymer coagulation-flocculation.

Chemical oxidation of reduced iron and manganese using potassium permanganate will follow Equations 1 and 2, respectively.

$$KMnO_4 + 3Fe^{+2} + 7H_2O \rightarrow MnO_2(s) + 3Fe(OH)_3(s) + 5H^+ + K^+ \quad (1)$$

$$2KMnO_4 + 3Mn^{+2} + 2H_2O \rightarrow 5MnO_2(s) + 4H^+ + 2K^+ \quad (2)$$

Stoichiometrically, Equation 1 gives a mg $KMnO_4$:mg Fe mass dose ratio of 1:1 with the result being precipitation of both Mn as $MnO_2(s)$ and Fe as $Fe(OH)_3(s)$. Weber (1972) cites this reaction as being rapid and independent of pH between a range of 6 to 10. Likewise, Equation 2 gives a mg $KMnO_4$:mg Mn stoichiometric mass dose ratio of 2:1 with Mn precipitating as $MnO_2(s)$. This reaction is very rapid above a pH of 7 and Mn concentrations in the ppm range. It is also noteworthy that both reactions serve to generate acid. Thus, with the potential for removal of other inorganics, and with Fe measured in the site groundwater at concentrations up to 75 ppm, pH adjustment, via caustic addition, is also provided for. Such iron removal is critical for efficient operation of the downstream treatment processes for organics removal as shown in Figure 3.

Referring to Figure 3, precipitated iron hydroxide sludge produced will be gravity thickened in a sludge thickening step and stored for off-site disposal. At a design flowrate of approximately 60 gpm, it is estimated that approximately 200 gpd of 3-5 percent $Fe(OH)_3$ sludge will be generated. Therefore, the sludge thickening step is provided to permit for further gravity thickening to occur, thereby reducing the amount of generated sludge to dispose. Disposal cost

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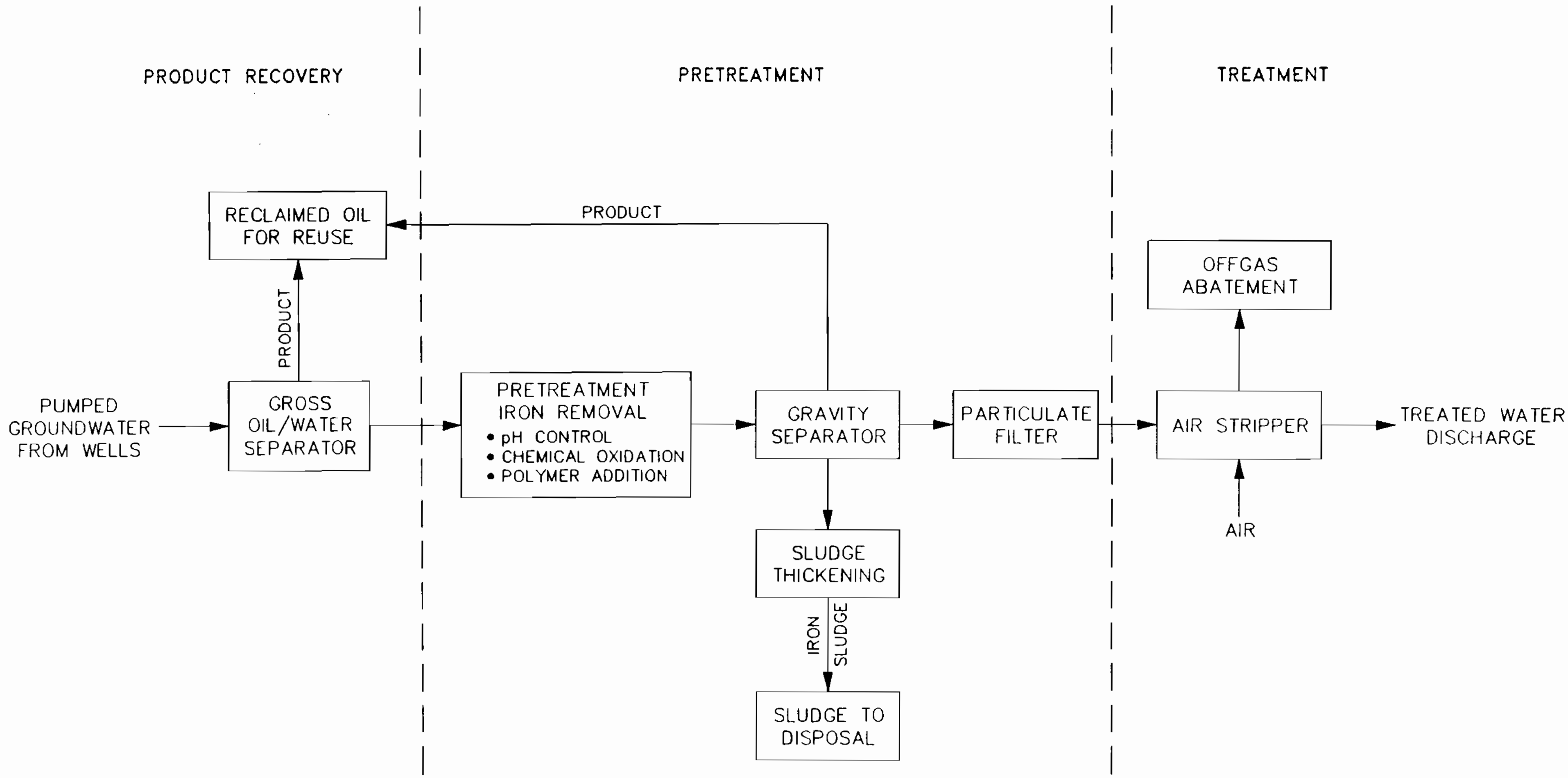

WATER TREATMENT- PROCESS FLOW DIAGRAM

FIGURE 3

for this material is approximately $0.60 per pound plus freight. Any supernatant generated will be reprocessed through the treatment system.

The $KMnO_4$ chemical feed system will consist of a combination solution mix and storage tank, and a chemical metering pump. This system will enable the operator to prepare chemical supplies needed for at least one week. The unit can be adjusted to accommodate different feedrates and a wide range of dilutions. Polymer and caustic feed systems will be designed to accommodate use of neat stock material.

After the $KMnO_4$ chemical oxidation step for iron removal, pH adjustment, and polymer treatment, the groundwater will proceed through a gravity separation step accomplished within an API style separator to remove both emulsified product and hydroxide sludge followed by a subsequent filtration step prior to organic removal. Such a filtration step insures that suspended solids generated by an upset or change in the groundwater characteristics during an unattended period are kept to a minimum. The filter system will consist of two filter housings with replaceable filter cartridges. Two filters will be piped to operate in parallel flow. Therefore, uninterrupted process flow can be maintained while one filter is being serviced. It is impossible at this time to estimate the frequency of cartridge change-out; therefore, upstream and downstream pressure gauges will be provided to indicate headloss through the filter.

To confirm iron removal using potassium permanganate in actual site groundwater, RETEC will conduct a "focused" treatability study. The test program will consist of a series of jar tests to investigate various potassium permanganate dosage requirements in combination with pH adjustment and various polymer dosage requirements. The treatability testing will simulate the processes of $KMnO_4$ oxidation of ferrous iron, pH adjustment, polymer enhanced coagulation/flocculation/gravity settling, and filtration. Inorganic constituents-of-interest levels will be measured after gravity settling and subsequent filtration of the treated groundwater through a filter to further reduce the total suspended solids concentration. The results of this work will confirm the stoichiometric ratio range for potassium permanganate addition as well as the flocculent dosage. This information will be used during the design phase in sizing full-scale equipment.

1.4.7 Existing Infrastructure

Based upon discussions during the site visit, it is our understanding the decommissioning and removal of the tanks, truck loading facility and associated piping is included in the remedial design. This existing infrastructure may impact the project in two ways. First, one or two of the smallest tanks may be useful for the surface treatment technologies. Specifically, one tank could be used as a flow equalization tank. Additionally, a biofilter, if appropriate for the site, could be constructed in one of the product storage tanks. On the other hand, the existing infrastructure will hamper installation of the extraction systems on-site. Similarly, demolition of the infrastructure will be hampered by remediation facilities.

During the Pre-Remedial Investigation, RETEC will undertake an inventory of the existing infrastructure and attempt to locate all underground piping. Based upon this inventory, any facilities which can be reused during the remediation will be identified and any salvage value of the tanks will be determined. Decommissioning specifications can be prepared as the Pre-Remedial Design Investigation is undertaken and an optimum sequencing study completed to identify the appropriate time to undertake decommissioning and removal.

2.0 SCOPE OF WORK

2.1 PRE-REMEDIAL DESIGN INVESTIGATION WORK PLAN

The initial phase of the Remedial Design will be preparation of detailed project plans. Specifically, the Pre-Remedial Investigation Work Plan and associated Project Operations Plans will be prepared. The Work Plan will detail the field activities required to fill the data gaps, treatability studies to evaluate process alternatives and engineering analyses to evaluate design alternatives. Project Operations Plans will include a Sampling and Analysis Plan, a Quality Assurance Plan, and a Health and Safety Plan. Upon approval of these plans by the Participating Companies, these plans will be submitted to NYSDEC. The following sections describe the technical scope associated with these plans and the activities necessary to complete them.

2.1.1 Work Plan

Table 1 provides the outline for the Work Plan. The primary tasks are:

- Review of Available Information,
- Site Characterization Activities,
- Treatability Studies, and
- Conceptual Design.

The objective of the first task is to make best use of available information and limit the extent of subsequent field investigation. The primary focus of the Site Characterization task is
to provide ex d samples for Treatability Studies. The objective of
the Treatabili s treatment process alternatives and provide detailed
assessment c of full-scale operations. The last task includes
engineering revious activities to resolve outstanding issues and
develop a det ull-scale remediation. Each task is discussed in detail
below.

TABLE 1

Table of Contents
Pre-Remedial Design Investigation Work Plan

1. Introduction
    1.1 Site Description
    1.2 Work Plan Organization

2. Background Data
    2.1 Site History
    2.2 Previous Investigations
    2.3 Site Characterization
    2.4 Constituents of Interest
    2.5 Selected Remedy

3. Objectives
    3.1 Site Remedial Objectives
    3.2 Pre-Remedial Investigation Objectives
    3.3 Applicable or Relevant and Appropriate Requirements

4. Site Characterization
    4.1 Soil Gas Survey
    4.2 Drilling and Sampling
    4.3 Iron Precipitation Evaluation
    4.4 Hydraulic Monitoring
    4.5 Infrastructure Inventory

5. Treatability Pilot Studies
    5.1 Biodegradtion Pilot Study
    5.2 Water Treatment Pilot Study

6. Conceptual Design
    6.1 Vapor Extraction/Injection (Sparging)
    6.2 Water Extraction/Reinjection
    6.3 In-situ Biological Treatment
    6.4 Water Treatment
    6.5 Vapor Treatment
    6.6 Infrastructure Decommisioning and Demolistion

7. Project Execution
    7.1 Project Mangement
    7.2 Schedule
    7.3 Reporting

8. References

Appendicies
    A Health and Safety Plan
    B Sampling and Analysis Plan
    C Quality Assurance Projec Plan

2.1.2 Data Review/Scoping

The initial step in preparing the Work Plan will be to undertake a detailed review of available information, specifically, previous reports, including appendices, plant records, and other documents in the administrative record. We have assumed copies of all documents listed in the administrative record can be obtained by RETEC at no cost. Alternatively, we will arrange for copies to be made at an additional cost to the project. After the data review is completed, the facility history, physical setting, and existing site information will be summarized.

A conceptual site model will be developed including the COI, their chemical properties and the physical properties of the site. The model will be used to resolve which specific areas need to be investigated further. In this way, exploration and sampling activities required to provide samples and information for treatability studies or modeling activities will help resolve any outstanding RI issues. Based upon the site background information and conceptual model, site-specific details of the Site Characterization activities will be specified. We do not anticipate the detailed investigation tasks presented in the Work Plan will be different or expanded from the scope of work outlined below as much as we propose to refine exploration locations, sampling intervals and analytical procedures.

In addition to the technical data developed during the RI and FS, site-specific data and local regulations will be collected. This information is necessary to provide a complete Basis of Design including the design precipitation event, snow loads for structures, frost depths and any local construction regulations which will impact remedial operations at the site. Finally, a review of Applicable or Relevant and Appropriate Requirements (ARARs) will be undertaken to identify the current regulatory requirements the specific remedial components will have to meet. A detailed review of the specific regulations will help ensure the appropriate data is collected to allow the design documentation to satisfy the substantive technical requirements of any permits which might otherwise be required.

2.1.3 Site Characterization

The primary objective of the Site Characterization task is to provide engineering parameters for design of the extraction systems (vapor and water) and obtain samples for the Treatability Studies. The largest effort in this regard is associated with determining the aquifer characteristic. Three approaches were considered for determining the aquifer characteristics at the site. These were the conventional pumping test approach and two non-pumping approaches: the inverse problem approach (use of numerical models to calculate values of transmissivity, or hydraulic conductivity, and storativity given known values of flow and hydraulic heads), and the methods of stage-ratio and time-lag (Ferris, 1963) which employ natural fluctuations of groundwater in response to periodic change in tidewater stage. After careful evaluation of the advantages and disadvantages of each approach, RETEC believes the most cost effective and technically advantageous approach would be the tidewater stage approach.

The traditional pumping test approach has the following major drawbacks. First, the potential hazard of seawater intrusion at the site, which is a serious environmental problem in itself; second, the high cost associated with the treatment and discharge of the contaminated water during the test; and third, the high cost associated with conducting the test itself. The major limitation of the inverse problem approach, on the other hand, is the fact that the solution of the inverse formulation is not, in general, unique (Freeze and Cherry, 1979). Specifically, it has been demonstrated that several different transmissivity distributions may generate the same hydraulic head distribution because heads are not particularly sensitive to changes in transmissivity (Gillham and Farvolden, 1974 *in Wang and Anderson (1982)*).

2.1.3.1 Boring and Sampling

To use the tidal fluctuation technique to determine hydraulic conductivity, a hydraulic profile for Unit II and Unit III perpendicular to Hempstead Harbor, will be developed. Each profile will consist of three driven wellpoints installed at distances of 5, 15 and 30 feet from the harbor and equipped with an automatic water-level measuring device. It should be noted that wellpoints were chosen over monitor wells to minimize investigation costs. Refer to Figure 4 for proposed wellpoint locations. In addition, an automatic tide gauge will be constructed. Data from each of these wellpoint clusters will also be used for determining the vertical distribution of hydraulic head and vertical conductivity. Vertical hydraulic head and conductivity will also be measured at three other locations. A shallow and deep wellpoint will be constructed in the center of the tank area. Shallow wellpoints will be driven at DW-2 and DW-3 to allow determination of the vertical head distribution in these areas. Measurement of the vertical hydraulic conductivity will be accomplished by the double-tube method and the infiltration-gradient technique (Bouwer, 1978).

In addition to the driven wellpoints, three soil borings will be drilled on-site to obtain samples for the biodegradation pilot study. Boring locations are shown on Figure 4. Locations

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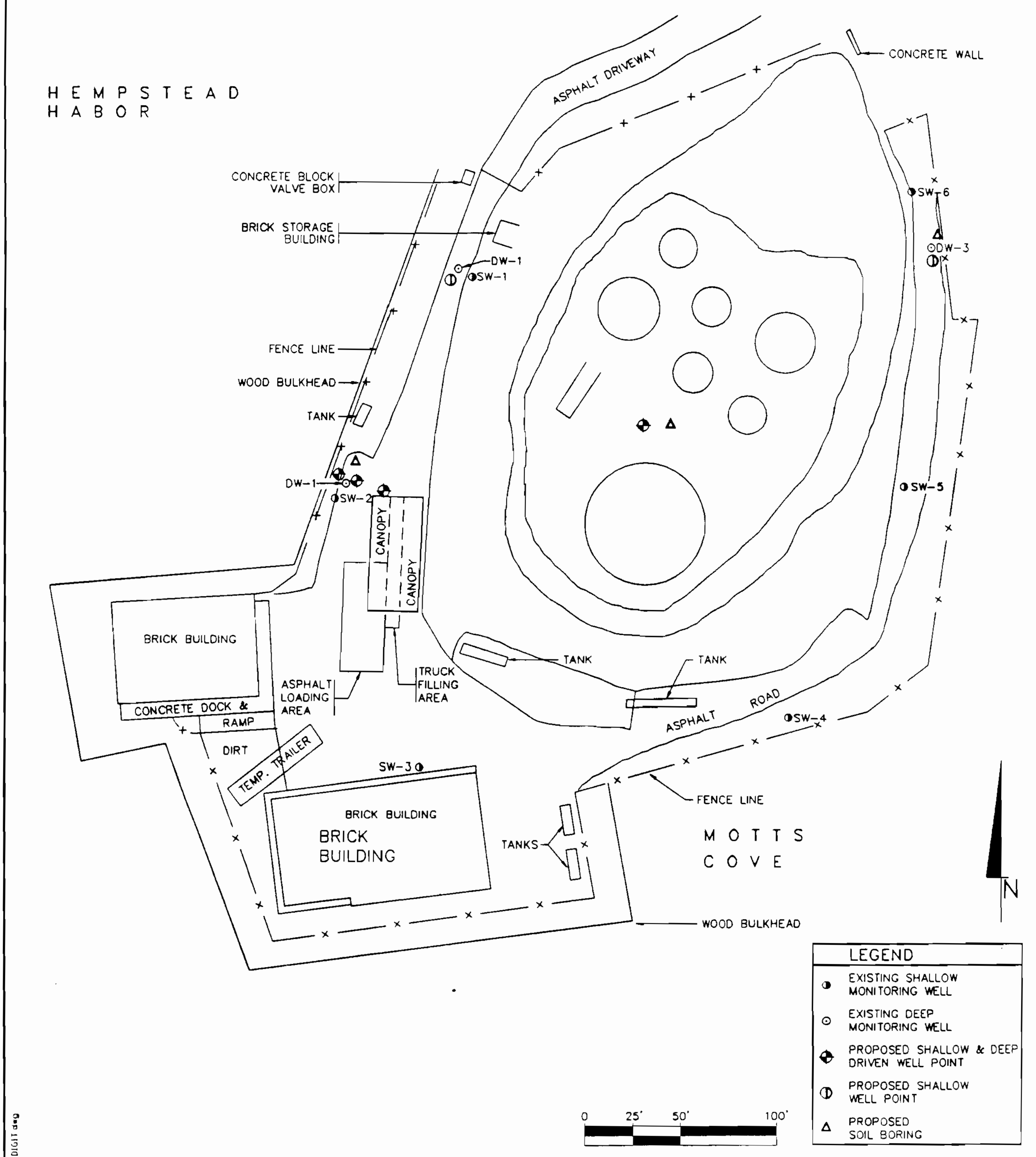

PROPOSED SOIL BORING & WELL POINT LOCATION

FIGURE 4

have been selected to obtain samples which represent the range of soil contaminant and concentrations. In addition, borings will allow confirmation of the hydrogeologic characteristics of the soils in the vicinity of the wellpoints. Soil samples will be collected from three different zones within the Level B horizon:

- near the top of the B horizon (approximately four feet above the static groundwater elevation);

- at the water table interface; and,

- approximately three feet below the water table interface (near the bottom of the B horizon).

The shallow sample represents conditions in the vadose zone at a depth that would be addressed by bioventing. The sample collected at the water table interface would be most likely to reflect conditions resulting from exposure to LNAPL, exhibit the highest contaminant concentrations, and potentially subject to treatment by *in situ* bioremediation through the addition of nutrients and the appropriate electron acceptor. The sample collected from within the saturated zone would probably contain lower concentrations of contaminants, consisting of the more soluble compounds. Remediation of contamination within this horizon would occur primarily through aqueous flushing, stripping from sparging, and *in situ* biodegradation.

In addition to soil samples, groundwater samples will also be collected from three monitoring wells in these same areas chosen to reflect the expected range of dissolved-phase contamination within the site. These samples will be used in the biodegradation and water treatment pilot tests. Finally, dissolved oxygen will be measured in groundwater samples from all monitoring wells.

2.1.3.2 Soil Gas Survey

A limited soil gas survey will be performed to refine the area where the soil venting system needs to be installed. In general, soil gas sample locations will be split spaced between the existing soil gas survey points and concentrated in the locations of proposed extraction facilities. Soil gas samples will be obtained at multiple depths as appropriate until the saturated zone is reached. The objective of the soil gas survey is to confirm the location of the soil gas collection system. Soil gas concentrations and oxygen concentrations will be determined by a variety of techniques including constituent-specific gas detector tubes and an organic vapor analyzer for real-time data gathering.

2.1.3.3 Iron Precipitation Evaluation

As noted in Section 1.0, dissolved iron may precipitate from the water during *in situ* biodegradation as well as in the air stripper. Therefore, as part of the initial site characterization activities, a pilot demonstration will be established and operated during the course of the Site Characterization activities. A composite sample will be obtained from the saturated zone soil samples. A portion of this composite sample will be analyzed for iron concentration, and the remainder will be packed into a plexiglass column, three feet in length and four inches in diameter. The column will be equipped with an air diffuser at the bottom of the column. This column will be secured near a groundwater well within the contaminated portion of the site.

Groundwater will be pumped from the well at a slow rate directly into the column, filling from the top of the column but avoiding the introduction of air. A tube will extend from the bottom of the column, up the outside of the column to within about six inches of the top. This arrangement will insure that the bottom 75% of the column remains saturated with water, irrespective of flow rate. Compressed air will be introduced into the bottom through a diffuser, and the rate of the air flow and water flow balanced in such a way that water leaving the column would contain approximately 6 mg/l of dissolved oxygen. This column would remain in operation at the site for a maximum of three weeks, measuring the dissolved oxygen, total iron and total suspended solids entering and leaving the column four times during this period. In addition, the soils will be analyzed for iron, visually inspected, and subjected to a simple permeability test (timing drainage of the column under ambient conditions) to evaluate changes in the column as a result of this aeration process.

2.1.3.4 Infrastructure Inventory

During preparation of the Pre-Remedial Design Work Plan, available information of the existing infrastructure will be reviewed. Specifically, an attempt will be made to locate engineering plans for the facility. Subsequently, RETEC will research the records in the local fire department, health department, library or other local government agency in an attempt to locate any plans for the site. During the site characterization phase, the various equipment will be inventoried in detail. Tank size and construction details will be recorded along with observations about the general condition and any liquid or sludge which may have to be removed. Pipe size and length will be measured and the location mapped. An attempt will be made to determine if any liquid or sludge remains in each pipe. Pumps, valves and the loadout equipment will be inventoried and mapped to try and identify all underground product pipes.

In addition to the inventory of the product infrastructure, local utility services will be inventoried and mapped. An attempt will be made to locate all water, sewer and storm sewer pipes. Electrical service will be carefully inspected as well. The utility inventory will be verified by researching records in the municipal agencies delivering these services. This data, coupled with the inventory of product equipment, will form the basis of the determination of the potential reuse of the existing infrastructure, any upgrades which must be made to support the remediation, and the specifications for decommissioning and demolition.

2.1.4 Treatability Studies

2.1.4.1 Biodegradation Pilot Study

Data contained in the RI and FS documents suggest that certain conditions may exist at the Shore Realty site that may impact the efficacy of bioremediation and, therefore, require further characterization. Specifically, these conditions include the following:

Biotoxicity - It is known that high concentrations of volatile aromatic compounds may be toxic or inhibitory to microbial processes at elevated concentrations. The RI has shown ETX concentrations in soils exceeding 1,000 mg/Kg in a number of locations at the site, especially along the western portion of the property. These concentrations may be sufficiently high to stress the subsurface microbial community to the extent that contaminant biodegradation rates may be significantly depressed. Additionally, the BioTrol biotreatability studies reported in the FS showed very low microbial densities in the soil samples having the highest ETX concentration (approximately 840 mg/Kg). These samples did not exhibit a significant degree of ETX removal after a 20 day study period, in contrast to the other samples that had lower initial ETX concentrations and higher microbial densities. In addition, the RI data suggests that chlorinated organic compounds may be entering the site soils from an off-site, upgradient source. Not only are these compounds difficult to biodegrade using conventional aerobic bioremediation approaches, they may also be inhibitory to indigenous soil microorganisms.

Mineral Concentrations - The data from soil analyses presented in the RI show iron concentrations in certain soil samples exceeding 10,000 mg/Kg, with dissolved iron concentrations in groundwater samples as high as 76 mg/L. Iron in soils is often implicated in catalyzing the rapid decomposition of hydrogen peroxide, which is typically used as an oxygen source for *in situ* bioremediation. Poor peroxide stability within the soil matrix may lead to degassing and blockage of the formation, and poor peroxide utilization efficiency. High iron concentrations in groundwater may lead to precipitation of iron as ferric hydroxide when oxygen is introduced into the aquifer, potentially leading to fouling and reduced permeability. The soils and groundwater are also shown to be quite high in calcium and magnesium. These minerals tend to react with the inorganic nutrients (nitrogen and phosphorus) that are commonly used in an *in situ* bioremediation program, causing precipitation and fouling problems, in addition to reduced availability to the microorganisms. Therefore, the interaction of the site soils and groundwater with oxygen and nutrients must be evaluated.

Hydrocarbon Matrix - While ETX comprises the organic constituents of highest concentration and greatest regulatory concern, the long history of this site as a petroleum product storage terminal and, more recently, as a chemical waste handling facility, suggests that significant quantities of other hydrocarbons may also be present in the subsurface soils of the site. If other "non-target" hydrocarbons that are readily biodegradable do exist, the degradation of this material may utilize oxygen supplied during an *in situ* bioremediation program and thus may decrease the apparent rate of target compound biodegradation.

The studies are designed to address the impact of the above factors on bioremediation at the site. If these studies confirm the effectiveness of *in situ* bioremediation to enhance the rate and extent of contaminant removal from the subsurface soils and groundwater, the resultant data will be used to provide site-specific design parameters for use in the full-scale remediation system.

Microbial Characterization Procedures

Each of the soil and groundwater samples will undergo testing in the RETEC treatability laboratory for enumeration of total heterotrophic bacteria and specific volatile organic compound (VOC) degraders. Detailed descriptions of the test methods are provided in Standard Operating Procedure (SOP) #510 included in Appendix I. These data will show the relative size of the microbial populations in these areas and will suggest whether exposure to high contaminant concentrations has adversely effected the microbial numbers in the soils and groundwater of the site.

Soil samples from the water table and saturated zones will undergo additional testing to evaluate the response of microbial populations to supplementation with inorganic nutrients (nitrogen and phosphorus). The vadose zone samples will be excluded from these studies since introduction of nutrients into these horizons during a full-scale bioremediation program is procedurally unfeasible. The nutrient stimulation studies will involve preparation of soil slurries to which a solution of nitrogen and phosphorus salts is added. Details of the nutrient stimulation test are provided in SOP #545). A control condition is provided for each sample in which no nutrients are added. The slurries are then shaken for a period of three days, after which samples are removed for enumeration of total heterotrophic bacteria and specific VOC degraders. The test results are then compared to the initial microbial densities and the densities observed in the control slurries to show the extent to which the availability of inorganic nutrients is limiting the size of the microbial populations within the areas of the site that would be influenced by an *in situ* bioremediation process. The results of this test will provide an indication of any benefit derived from nutrient addition as part of an *in situ* bioremediation program.

Chemical Characterization Procedures

Each of the soil samples collected will be analyzed for volatile organic compounds (EPA Method 8240) with a library search for the 15 highest non-target peaks, semi-volatile organic compounds (EPA Method 8270) with a library search for the 15 highest non-target peaks, total nitrogen, total phosphorus, and total iron. The soil samples will also undergo a hydrocarbon characterization procedure to determine total petroleum hydrocarbon concentration, with fractionation into aliphatic, aromatic, polar and asphaltic components. Groundwater samples will be analyzed for the same parameters as the soil samples, plus calcium/magnesium hardness and pH. Library searches for non-target organic compounds are important to reveal the total amount of organic material contained within the site soils and groundwater. If these non-target organic compounds are biodegradable and the mass of this material is large relative to the total amount of ETX, the degradation of the non-target organics will remove the majority of the available oxygen and inorganic nutrients, thus slowing the rate of degradation of the COI. Collectively, the data from the analyses of the soil and groundwater samples will indicate the chemical environment to which the indigenous microbial populations have been exposed, and will reveal the vertical and lateral variability of chemical constituents across the site.

In addition to the analyses of contaminant concentrations, simple screening studies will be performed to evaluate the interactions of the chemical amendments that may be used during an *in situ* bioremediation program with the soils and groundwater of the site. Losses of inorganic nutrients due to adsorption onto site soils will be measured by preparing soil slurries in deionized water using sample material collected from the deep (saturated zone) soil horizons. The slurries will be spiked with a known concentration of a nutrient blend used for *in situ* bioremediation applications (ammonium chloride, monopotassium phosphate, and dipotassium phosphate), mixed for several hours, and the nutrient concentrations remeasured (refer to SOP #730).

Following measurement of nutrient concentrations, a known concentration of hydrogen peroxide will be added to the slurries and samples of the aqueous phase collected at regular intervals for hydrogen peroxide determination. After peroxide concentrations have declined to zero, the slurries will be respiked and the study repeated. The kinetics of hydrogen peroxide decomposition in each sample will then be evaluated to determine the relative rates of decomposition (refer to SOP #735). Changes in decomposition kinetics observed when the slurries are respiked provides an indication of the mechanism of peroxide decomposition (i.e., consumption due to oxidation of reduced materials within the soils, as opposed to catalytic decomposition).

Precipitation due to reaction of the introduced nutrients with dissolved minerals in the groundwater from the site will be measured by first aerating and filtering two groundwater samples to remove any precipitation resulting from oxidation processes. The total suspended solids of the water samples will then be measured, and the water samples spiked with the nutrient solution. Suspended solids in the samples will then be remeasured after 8 and 24 hours of mixing to determine the extent of precipitate formation resulting from the nutrient addition.

Interim Data Evaluation

The data obtained from the studies outlined above will provide an indication of the degree to which oxygen, either from the use of hydrogen peroxide or from sparging, will create problems with iron/mineral precipitation and resultant fouling and loss of aquifer permeability. Oxygen constitutes the preferred electron acceptor for bioremediation since the aromatic compounds of concern at the site are most rapidly biodegraded under aerobic conditions. However, if the preliminary studies indicate that the effectiveness and reliability of *in situ* remediation under aerobic conditions will be compromised by reaction of oxygen with reduced mineral species, it will be necessary to evaluate *in situ* remediation alternatives that make use of anaerobic conditions. The use of nitrate as an electron acceptor has been shown to facilitate the biodegradation of a variety of aromatic compounds by denitrifying microorganisms, although rates of degradation generally are considerably slower than those noted under aerobic conditions. Nevertheless, nitrate has the advantage of being non-reactive with reduced mineral species, is relatively inexpensive compared to chemical oxygen sources, and is highly soluble in water.

If, at this point in the study, problems associated with iron/mineral precipitation under oxygenated conditions are found to be insignificant, a final study will be performed to evaluate the oxygen demand resulting from the biodegradation of the hydrocarbon contaminants. On the other hand, if precipitation problems are observed and it becomes necessary to pursue remediation under anaerobic conditions, it will be necessary to determine the extent to which anaerobic biodegradation of the constituents of concern can be achieved. The following sections outline the procedures for these alternative biotreatability studies.

Oxygen Demand - Slurry Respirometry

The persistence of aromatic hydrocarbons in subsurface environments, assuming that populations of metabolically-competent microorganisms are present, is most often due to the lack of an appropriate electron acceptor to allow the microorganisms to derive energy from the metabolism of these organic compounds. Oxygen is the most common electron acceptor used in attempts to enhance rates of aromatic compound biodegradation. However, selection of appropriate sources of oxygen (i.e., air, pure oxygen, or hydrogen peroxide), as well as addition rates and concentrations, should be determined by an understanding of the rate at which oxygen is utilized. Since oxygen supply can be relatively expensive, especially when hydrogen peroxide or pure oxygen are used as sources, it is important to balance addition rates with consumption rates to maximize rates of contaminant biodegradation while also maximizing utilization efficiency.

This study is designed to measure rates of oxygen uptake by soil slurries contained in a sealed reactor. Rates and total amount of oxygen uptake can then be related to contaminant removal achieved during the study period. A composite soil sample will be prepared from samples collected from the water table interface and saturated zone sampling depths. Eight identical soil slurries will be prepared using groundwater obtained from the site; four slurries will be supplemented with an inorganic nutrient solution while the other four flasks will receive no additional nutrients. The slurries will be prepared in electrolytic respirometer flasks

(Bioscience Management, Inc., Bethlehem, PA). After the soil and water have equilibrated, a portion of each slurry will be removed for analysis of aromatic hydrocarbons (Method 8020) and TPH by GC/FID. Two flasks (one supplemented with nutrients and one without nutrients) will then be sterilized with mercuric chloride to eliminate biological activity. Each of the flasks will then be sealed and will be connected to the electrolytic respirometer instrumentation to continuously monitor oxygen uptake (refer to RETEC SOP #526). As oxygen is used in the biologically active flasks, it is simultaneously replaced by an electrolytic reaction, thus maintaining aerobic conditions within the sealed vessel. Carbon dioxide is also removed from the system using an alkaline trapping agent, insuring that pH is held constant. The sterile flasks serve as controls to monitor nonbiological consumption of oxygen and volatile losses of the contaminants.

The oxygen uptake studies are expected to run approximately two weeks. When the data show that the rate of oxygen utilization has decreased to a constant low level, indicating that the majority of the easily degradable organic material has been consumed, the study will be terminated. At this point, portions of each slurry will be removed as at the beginning of the study, and analyzed for aromatic hydrocarbons and TPH. Collectively, these data will reveal the rate of oxygen consumption and the total oxygen demand exerted in the biodegradation of a measured amount of organic material. The nutrient treatments will indicate the extent to which ambient levels of inorganic nutrients are limiting the rate and extent of contaminant biodegradation.

Biodegradation under Denitrification Conditions

If iron precipitation is identified as a significant problem at the site, a slurry study similar to the biodegradation study outlined above will be performed to evaluate the effectiveness of nitrate addition to stimulate biological contaminant removal under anaerobic conditions. Replicate slurries will be prepared in 100 ml serum vials using a composite soil sample and groundwater obtained from the site. A reducing agent will be added to the slurries to establish anaerobic conditions. One set of vials will be amended with nutrients while the other set will be used to assess degradation under ambient nutrient conditions. Nitrate will be added to all of the reactors, and the reactors will be sealed with no headspace. Finally, controls will be prepared from reactors representing each treatment condition by adding mercuric chloride. Starting concentrations of aromatic hydrocarbons and TPH will be measured by sacrificing an initial set of reactors; thereafter, reactors from each treatment condition (including dead controls) will be sacrificed for analysis at weeks 1, 2, 4, and 6. Nitrate concentrations will be monitored in all reactors and will be maintained at approximately 45 mg/l. The results of this study will indicate the extent to which biodegradation under anaerobic conditions will provide a significant mechanism of reducing contaminant concentrations.

2.1.4.2 Water Treatment Pilot Study

Chemical Oxidation/Coagulation/Flocculation/Gravity Settling (CO/C/F/GS) consists of the removal of metals, oils and grease (O&G), and suspended solids (and associated organics) through chemical oxidation/coagulation/flocculation followed by gravity settling. Chemical oxidation will be achieved by adding potassium permanganate to the groundwater to oxidize the reduced iron in order to precipitate it out of solution. The pH will be adjusted to optimize precipitation of other inorganic constituents of interest. The coagulation/flocculation will be enhanced through the addition of various chemical additives (i.e., polymers) to the groundwater.

In order to evaluate CO/C/F/GS, a series of jar tests will be performed using samples of the groundwater and various chemical additives and doses. First, jar tests will be performed on 500 ml samples of the site groundwater to visually determine the most effective chemical additive and dose. For these tests, $KMnO_4$ will be used to precipitate iron and manganese, and several polymers will be evaluated to remove O&G and enhance the settling of the flocced material. Specifically, $KMnO_4$ will be added to the groundwater based upon the following chemical doses:

- 1 mg $KMnO_4$/ 1 mg iron in groundwater, and
- 2 mg $KMnO_4$/ 1 mg manganese in groundwater.

The various polymers will be visually screened at doses ranging from 0.5 mg/L to several hundred mg/L. Based upon these visual screening tests, the following type scheme will be developed in order to generate treated groundwater samples for chemical analysis:

(1) Addition of 0.1 molar $KMnO_4$ solution based upon 1 mg $KMnO_4$/1 mg iron in groundwater and 2 mg $KMnO_4$/1 mg manganese in groundwater. Rapid mix for approximately one minute.

(2) Addition of cationic polymer at 1 mg/L and rapid mix for approximately one minute.

(3) Addition of anionic polymer 0.5 mg/L and rapid mix for approximately one minute.

(4) Slow mixing of sample for approximately ten minutes.

(5) Gravity settling for >30 minutes.

NOTE: Various dosages of $KMnO_4$, cationic polymer, and anionic polymer will be evaluated.

The supernatant from the CO/C/F/GS step will then be submitted for analysis of the following parameters: pH, BOD, COD, O&G, suspended solids (TSS/VSS/FSS), inorganics, volatile organic compounds (VOCs), and polynuclear aromatic hydrocarbons (PAHs). A sample of the untreated groundwater will also be submitted for the analysis shown in Table 2. The amount of sludge produced per volume of groundwater treated will be estimated (i.e., sludge production).

Filtration will be evaluated in conjunction with the CO/C/F/GS step. In full-scale operations, filtration treatment typically is used to remove suspended solids prior to additional treatment or discharge. Filtration processes include sand filters, membrane filters, and other media-type filters. In order to evaluate the filtration process in the laboratory, a groundwater sample will first be "pretreated" using the steps outlined in the previous CO/C/F/GS discussion (i.e., $KMnO_4$ and polymer addition). Following this pretreatment step, the supernatant will be filtered through a 1.5 μm glass fiber filter. The filtered effluent will then be analyzed for pH, BOD, COD, inorganics, VOCs, and PAHs.

2.1.5 Conceptual Design

As data is generated during the Site Characterization and Treatability phases of the Pre-Remedial Investigation, it will be carefully reviewed and the conceptual designs will be developed for alternative configurations of the remedial components. Only alternatives which achieve the performance standards established in the ROD will be developed. Subsequently, they will be analyzed to determine how effective they are with respect to the balancing criteria, i.e., maximizing reduction of the COI, minimizing O&M and optimizing costs. The analytical methods are briefly discussed below.

TABLE 2

Summary of Analytical Methods

PARAMETER	METHOD WATER	WATER DETECTION LIMIT
CONVENTIONAL:		
pH	SW9040	--
Total Organic Carbon	SW9060	1 mg/L
Total Kjeldahl Nitrogen	EPA 351.3	0.3 mg/L
Ammonia Nitrogen	EPA 350.2	0.3 mg/L
Orthophosphate	EPA 365.2	0.1 mg/L
Nitrate Nitrogen	EPA 353.2	0.1 mg/L
Biochemical Oxygen Demand	EPA 405.1	1 mg/L
Chemical Oxygen Demand	EPA 410.4	10 mg/L
Total Dissolved Solids	EPA 160.1	1 mg/L
Oil and Grease	EPA 413.1	5 mg/L
Total Suspended Solids	EPA 160.2	1 mg/L
Fixed Suspended Solids	EPA 160.4	1 mg/L
Volatile Suspended Solids	EPA 160.4	1 mg/L
Alkalinity	SM 403/406C	5 mg/L
Conductivity	SW 9010	0.2 umhos/cm
Naphthalene	GC-FID	3 μg/L
METALS:		
Antimony	EPA 200.7	60 μg/L
Arsenic	EPA 206.2	10 μg/L
Beryllium	EPA 200.7	5 μg/L
Cadmium	EPA 200.7	10 μg/L
Chromium	EPA 200.7	20 μg/L
Copper	EPA 200.7	10 μg/L
Iron	EPA 200.7	50 μg/L
Ferrous Iron	SM 315B	100 μg/L
Lead	EPA 239.2	5 μg/L

TABLE 2
(Continued)

Summary of Analytical Methods

PARAMETER	METHOD WATER	WATER DETECTION LIMIT
Manganese	EPA 200.7	10 μg/L
Mercury	EPA 245.1	0.2 μg/L
Nickel	EPA 200.7	40 μg/L
Selenium	EPA 270.2	2 μg/L
Silver	EPA 200.7	10 μg/L
Thallium	EPA 200.7	100 μg/L
Zinc	EPA 200.7	10 μg/L
VOLATILE AROMATICS:		
Benzene	SW 8020	0.20 μg/L
Ethyl Benzene	SW 8020	0.20 μg/L
Toluene	SW 8020	0.20 μg/L
Total Xylenes	SW 8020	0.30 μg/L
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs):		
Acenaphthene	SW 8310	2.00 μg/L
Acenaphthylene	SW 8310	2.00 μg/L
Anthracene	SW 8310	0.50 μg/L
Benzo(a)anthracene	SW 8310	0.02 μg/L
Benzo(a)pyrene	SW 8310	0.02 μg/L
Benzo(b)fluoranthene	SW 8310	0.02 μg/L
Benzo(g,h,i)perylene	SW 8310	0.05 μg/L
Benzo(k)fluoranthene	SW 8310	0.02 μg/L
Chrysene	SW 8310	0.15 μg/L
Dibenzo(a,h)anthracene	SW 8310	0.03 μg/L
Fluoranthene	SW 8310	0.20 μg/L
Fluorene	SW 8310	0.20 μg/L

TABLE 2
(Continued)

Summary of Analytical Methods

PARAMETER	METHOD WATER	WATER DETECTION LIMIT
Indeno(1,2,3-cd)pyrene	SW 8310	0.05 μg/L
2-Methylnaphthalene	SW 8310	2.00 μg/L
Dibenzofuran	SW 8310	2.00 μg/L
Phenanthrene	SW 8310	0.50 μg/L
Pyrene	SW 8310	0.20 μg/L
Naphthalene	SW 8310	2.00 μg/L

EPA: Taken from U.S. EPA, 1983.
SW: Taken from SW 846, 1986
SM: Standard Methods

2.1.5.1 Vapor Extraction/Injection

Computer modeling of the soil venting system will be performed to define and design operational parameters of the soil venting system. The computer model, a version of MODFLOW developed by RETEC specifically for optimizing the design of soil venting systems, predicts airflow rates and the area of influence of the soil venting system. Using this model, the locations of extraction wells and trenches can be optimized and the extent of cover defined. One specific element of concern which will be evaluated is the influence of the wooden bulkhead on location of the perimeter recovery trenches.

Subsequently, the contaminant concentrations of the airflow will be predicted and a mass balance made to determine the system's performance. The effect of sparging as a remedial alternative will be evaluated by comparing the physical properties of the COI against the ability to biodegrade them. Specifically, the half-time (i.e., the time for the concentration to decrease by half due to volatilization) for each COI will be compared with their biodegradation half-lives. The impact of air sparging will be modeled in a similar manner: modeling to optimize injection and recovery locations along with airflow rates followed by prediction of contaminant concentrations and calculation of a mass balance. If the results of the biodegradation pilot study indicate bioventing is appropriate at this site, a similar analysis of the bioventing alternative will be undertaken to determine airflow rates and predicted contaminant concentrations. The development of these three vapor effluent alternatives, coupled with the predicted vapor effluent from the air stripper, will form the basis of the conceptual design of the vapor treatment technology as discussed below.

2.1.5.2 Groundwater Extraction/Injection

The design of the groundwater extraction/injection facilities will be based upon the results of groundwater modeling. Modeling will be undertaken with the U.S. Geological Survey modular, three-dimensional, finite-difference flow model, commonly known as MODFLOW. MODFLOW is a widely used and well-documented model that simulates transient or steady-state flow in combinations of confined, unconfined, and leaky aquifers with a variety of boundary conditions and hydrologic stresses, such as wells, areal recharge, evapotranspiration, rivers, and drains. MODFLOW will be used to simulate groundwater flow conditions and to select design parameters such as the location, number, and pumping/injection rates of wells simulated in each alternative. The threat of seawater intrusion at the site makes these parameters extremely important.

MODFLOW will be used to simulate groundwater flow through Unit II and Unit III. Owing to the small saturated thickness of Unit I, the saturated portion of Unit I will be incorporated with Unit II, and Unit IV, a silty clay layer, and will be modeled as an impermeable unit. Therefore, the bottom of the model will be the bottom of Unit III, which will be simulated as an impermeable surface. Recharge from precipitation will also be simulated taking into account the impact of the cover proposed for the vapor extraction component.

Modeling will be conducted under steady-state conditions to reflect the extended length of time expected for the remedy to achieve the desired remediation. To account for the vertical flow components reported between Units II and III (Roux, 1991), groundwater flow will be simulated as three-dimensional. The shoreline along Hempstead Harbor and Motts cover will constitute the physical boundaries around the site. The other boundaries will be located far enough away from the site such that they do not affect simulation of the site. To accomplish this objective, the model area will be considerably expanded beyond the site boundaries to encompass an area of about 1.5 million square feet, which is approximately 10 times the site area. In order to reproduce the regional east-west flow pattern such as depicted by the regional water table map of March-April 1984 (Doriski, 1984 in Roux (1991)), the western and eastern boundaries will be simulated as constant-head boundaries. The northern and southern boundaries will be modeled as no-flow boundaries.

After the model is established, it will be calibrated to the hydraulic monitoring data developed during the Site Characterization phase and reported in the RI. Once the calibration is complete, the design of the extraction/injection facilities can be optimized by undertaking simulation runs with the model. Based upon this analyses, the appropriate pumping rates can be determined and contaminant concentrations in the effluent predicted. Contaminant concentrations in the extracted water will also be predicted considering the influence of air sparging and *in situ* biodegradation. The results of these analyses will be incorporated into the design of the water treatment system.

2.1.5.3 Water Treatment

As noted above, conceptual design of the water treatment system will focus primarily on the design of appropriate pretreatment equipment. Additionally, the performance of the air stripper will be modeled by computer simulation to determine the optimum size, packing distribution, air flow rate and vapor effluent characteristics. Given the various components, the pieces will be integrated to form a complete treatment system and allow conceptual design of the various interconnections between the components, the extraction and injection facilities and the site as a whole (utilities, enclosures, winterization, etc.). In addition to the technical design issues, regulatory design issues will be evaluated including impacts of ARARs and appropriate permitting requirements.

2.1.5.4 Vapor Treatment

The design of the vapor treatment system will depend upon the combined flow rate of all vapor streams, the contaminant concentrations, both initially and over time, and the discharge limitations. The ROD did not specify a single treatment technology although catalytic oxidation was used in the FS as the basis of the analysis. RETEC has identified five specific treatment technologies which would be appropriate at this site and which will be evaluated during the conceptual design phase depending upon the results of the previous phases. These technologies are discussed below.

Thermal oxidation refers to high temperature oxidation of organic vapors. Hydrocarbon oxidation within a single combustion chamber to simple combustion products such as CO_2, H_2O, HCl and SO_2 is typically accomplished at temperatures within the range of 1,500 - 3,000°F. Nitrogen containing compounds (NO_x) may also be formed. Treatment removal efficiency, as measured by Destruction Removal Efficiency (DRE), has been measured at greater than 99% for various organic chemicals; some thermal oxidizers are rated for greater than 99.99% removal.

Catalytic Oxidation refers to a thermal oxidation process which will occur at lower temperature, i.e., 700°F. Typically, vapors are raised to the elevated temperature then passed through a section containing the catalyst, which is able to thermally oxidize the hydrocarbons at the reduced temperature. This type of thermal oxidation is more fuel efficient than common thermal oxidation due to the lower temperature requirements and can therefore be an effective process for low concentration vapor streams. Catalytic oxidizers are subject to potential poisoning of the catalyst, although some poison-resistant catalysts are available. DRE has been measured at greater than 99% but can be reduced as the catalyst becomes poisoned. Typically, capital costs are higher than a common thermal oxidizer with operating costs significantly lower, the present worth for the system will be evaluated to compare the two alternatives.

Regenerative Thermal oxidation refers to a process where oxidized gases in the combustion chamber pass through a porous bed or heat transfer section. This stores approximately 95% of the heat in inert ceramic or silica gravel media through the standard combustion process. By the use of valving, influent vapors are redirected to the heat transfer media where the vapors are preheated through conduction to within 5% of the oxidation temperature. There is a continuous alternating cycle of storing and releasing energy, which permits an uninterrupted flow of influent vapors. The regenerative system is simple and reliable, requiring little or no additional fuel, even when influent hydrocarbon levels approach 5%. Typically, LEL supplemental fuel requirements do not exceed 5% of the amount normally required for common thermal oxidation. In many cases, a pilot burner or electric heating element is sufficient when coupled with the 95% preheat efficiency. Typically, DRE's of 95% are achievable.

Carbon adsorption refers to a process where hydrocarbon gases are forced through a bed of granular activated carbon (GAC). During the adsorption process, hydrocarbon gases are attracted and adhere to the GAC as a result of weak chemical bonds between the COI and active sites on the GAC surface. Typically, units are in series such that the constituents pass though one unit until its adsorbed capacity is exhausted, indicated by detection of hydrocarbon gases in the discharge. The vapor is then directed to a second unit while the first unit is replaced. Most frequently, the spent carbon is sent off-site for disposal or regeneration. Although the technology is very simple to operate and is proven to be highly effective, operation and maintenance costs are high due to the costs for replacement and management of the spent units.

As discussed in Chapter 1, a biofilter may effectively treat the vapor effluent. In this process, the hydrocarbon gases are forced though layers of high quality filter materials on which microorganisms are immobilized. The microorganisms break down the chemical components into CO_2, water and mineral salts. The biodegradation is maintained through the addition of typical amendments including moisture and nutrients. Typically, biofiltration has high capital costs and low maintenance costs. At this site, capital costs may be reasonable if existing infrastructure can be used to contain the biofilter; however, maintenance costs may be high given the need to maintain the temperature of the biofilter above 60° if the system is used during the winter months.

Several treatment technologies are applicable. Additionally, pretreatment of the vapor effluent, specifically dehumidifying the gas prior to treatment, will help reduce costs. During the first step in this phase, the discharge limitations will be determined. Subsequently, the various technology alternatives will be developed in adequate detail to allow evaluation of each alternative in terms of the design-specific performance criteria. Process flow diagrams (PFDs) will be developed and equipment sized for the various combinations of vapor effluent which may have to be treated at this site. Performance of the systems will be predicted for initial vapor concentrations as well as long-term conditions. Any combination of technologies and effluent flows which do not meet discharge limits will be eliminated from further consideration. Capitol and O&M costs will be determined for the remaining alternatives and a detailed analysis performed in light of the site-specific design performance standards to narrow the field of alternatives not only in terms of treatment technologies but also extraction/injection alternatives, i.e., air sparging and bioventing.

2.1.5.5 Infrastructure Decommissioning and Demolition

Based upon the inventory of the existing infrastructure, plans will be generated for decommissioning and demolition. Given the complications the existing facilities pose to construction of the remedy, we propose to prepare detailed plans and specifications which can form the basis of a bid package for this activity. Final design of this component of the remedy will allow implementation simultaneously with remedial design of the other components, thereby ensuring any future construction complications are minimized.

From the inventory, the tonnage of various materials comprising the infrastructure will be estimated and various disposal alternatives evaluated to determine the most advantageous solution. Plans for decommissioning activities, i.e., cleaning and residuals management, will be prepared for regulatory review and any local construction ordinances will be reviewed to identify permit requirements. Technical specifications will be developed in industry standard format (CSI) and qualifications solicited from contractors experienced in this type of demolition.

2.1.6 Project Operations Plan

In addition to the Work Plan detailing the technical work described above, the plan will include appendices describing the Project Operations Plans. Specifically, these include the Health and Safety Plan, Sampling and Analysis Plan and the Quality Assurance Project Plan. The contents of each of these plans is discussed briefly below.

2.1.6.1 Health and Safety Plan

The Health and Safety Plan will address issues pertaining to worker health and safety during the Site Characterization activities. The plan will include:

- identification of hazards;
- associated risks;
- responsible personnel;
- protective equipment;
- decontamination procedures; and
- emergency procedures.

It is expected that most field work will be conducted under Level D protection, although the constant availability of Level C equipment and clothing will be required in the event of unforeseen circumstances. The proposed table of contents for the Health and Safety Plan is provided in Table 3.

2.1.6.2 Sampling and Analysis Plan

With the development of the Work Plan and finalization of the Site Characterization activities, a Sampling and Analysis Plan will be prepared. This document, sometimes referred to as a field operations plan, is a detailed blueprint of the field activities specifying sampling intervals and procedures to be used by the field crews to obtain samples, prepare samples for shipment to the laboratory, and decontamination of exploration and sampling equipment to prevent cross-contamination problems. The Table of Contents of the Plan in shown in Table 4.

Data gathering and field activities will be conducted in accordance with RETEC Standard Operating Procedures (SOPs). RETEC SOPs have been developed as a result of performing dozens of CERCLA RI/FS, RCRA RFIs, and state-regulated site assessments. SOPs have been developed by RETEC for over 70 site assessment and data gathering activities. Our staff is trained in implementing these procedures and routinely employ them to insure the quality of our work.

TABLE 3

Table of Contents
Health and Safety Plan

1.0 GENERAL INFORMATION

2.0 PROJECT DESCRIPTION

3.0 WASTE CHARACTERISTICS

4.0 HAZARD EVALUATION
- 4.1 Chemical Hazard
- 4.2 Physical Hazard

5.0 PROCEDURES
- 5.1 Site Organization
- 5.2 Team Organization
- 5.3 Site Facilities
- 5.4 Site Entry Procedures
- 5.5 Work Limitations
- 5.6 Engineering Controls
- 5.7 Decontamination Procedures
  - 5.7.1 Personnel
  - 5.7.2 Samples and Sampling Equipment
  - 5.7.3 Heavy Equipment
- 5.8 Disposal of Materials Generated On-Site
- 5.9 Maintenance of Site Record
- 5.10 Indoctrination and Safety Meetings

6.0 PERSONNEL PROTECTION
- 6.1 Health Status
- 6.2 Training
- 6.3 Action Levels
- 6.4 Personnel Protection
- 6.5 Emergency and First Aid Equipment and Supply
- 6.6 Heat Stress
- 6.7 Personal Floatation

7.0 AIR MONITORING PROGRAM

- 8.0 CONTINGENCY PLAN
- 8.1 General Information
- 8.2 Specific Responses
  - 8.2.1 Equipment Failure
  - 8.2.2 Injury
  - 8.2.3 Site Security and Control
  - 8.2.4 Fire or Explosion
  - 8.2.5 Communication

9.0 PLAN APPROVAL

10.0 REFERENCES

TABLE 4

Table of Contents
Sampling and Analysis Plan

1.0 SUMMARY OF SITE CONDITIONS
- 1.1 Soils
- 1.2 Water

2.0 CONSTITUENTS OF INTEREST
- 2.1 Volatile Organics
- 2.2 Semi-Volatile Organics
- 2.3 Metals

3.0 SAMPLING PROCEDURES
- 3.1 Borings
- 3.2 Soil Sampling
- 3.3 Wellpoints
- 3.4 Water Level Measurements
- 3.5 Ground Water Sampling
- 3.7 Iron Precipitation Evaluation
- 3.8 QA/QC Sampling

4.0 SAMPLE AND DOCUMENT CUSTODY

2.1.6.3 Quality Assurance Project Plan

The purpose of the Quality Assurance Plan (QAP) is to document the procedures and criteria that will be used to provide accurate, precise, comparable, representative, and complete data collection activities in both the field and laboratory during the performance of the comprehensive site assessment. In general, the QAP:

- identifies quality assurance objectives;

- specifies quality assurance and quality control (QA/QC) procedures that will be implemented to achieve these objectives; and

- describes the project organization and the personnel who will be responsible for assuring the accuracy, integrity, and completeness of the data obtained in this project.

These three areas will be addressed in the QAP for the field work and laboratory analysis facets of the project. Particular attention will be paid to QA/QC procedures for laboratory analysis to prevent rejection of analytical data by NYSEG. More specifically, the QAP will define:

- **Strategy** - description of the intended uses for the data, and the level of precision and accuracy for these uses; and description of methods and procedures to be used to assess the precision, accuracy, and completeness of the measurement data;

- **Sampling and Field Measurements** - selection of appropriate sample locations and depths; statistically significant number of samples; sampling media, conditions, and parameters; frequency and type (composite, grab, etc.) of sampling; QA methods; and sample chain-of-custody; and

- **Sample Analysis** - chain-of-custody procedures; sample storage and holding; sample preparation; analytical procedures; calibration and frequency; data reduction, validation, and reporting; internal QC checks; preventative maintenance procedures; laboratory selection; laboratory corrective action; and turnaround time.

The proposed table of contents for the Quality Assurance Project Plan is provided in Table 5.

2.1.7 Reporting

Upon completion of each task comprising the Pre-Remedial Design Investigation, task completion reports will be prepared. These reports will detail the activities and analyses undertaken and the data generated. Appropriate graphics and summary tables will be included to illustrate the work. Appendices will include all data packages generated and computer model documentation. These reports are considered internal documents which document the progress of the work. Therefore, we will submit these to the Participating Companies for review and comment; however, we do not propose to submit these reports to the regulatory agencies. Upon completion of the project, the task completion reports will be combined to create a detailed report of the Pre-Remedial Design Investigation. Comments by the Participating Companies on the individual task completion reports will be taken into account during the compilation of this document.

2.2 REMEDIAL DESIGN WORK PLAN

RETEC refers to the Remedial Design Work Plan as the Basis of Design Memorandum. The purpose of this document is to clearly describe the project objectives, define design parameters, establish performance criteria and detail regulatory considerations. The Basis of Design memorandum includes a definitive outline of the project scope which should be confirmed by the Participating Companies to ensure a mutual understanding of project requirements. This memorandum establishes all the design parameters for all disciplines.

Specific sections of the Remedial Design Work Plan or Basis of Design Memorandum are presented below.

2.2.1 Project Objectives

This section should clearly define the project's aims, concepts and limitations. The function of the project is clearly defined along with a clear statement of the performance standards for the project as a whole. The characteristics of any specific equipment or process

TABLE 5

Table of Contents
Quality Assurance Project Plan

1.0 INTRODUCTION

2.0 PROJECT ORGANIZATION
- 2.1 Project Structure
- 2.2 Responsibilities of Project Personnel

3.0 QUALITY CONTROL PARAMETERS
- 3.1 Detection Limits
- 3.2 Data Precision and Evaluation
- 3.3 Data Accuracy and Evaluation
- 3.4 Completeness of Data
- 3.5 Representativeness of Data
- 3.6 Comparability of Data

4.0 SAMPLING PROCEDURES
- 4.1 Soil Sampling
- 4.2 Water Level Measurements and Well Integrity Check
- 4.3 Groundwater Sampling
- 4.4 QA/QC Sampling
- 4.5 Sample Preservation and Shipment

5.0 SAMPLE AND DOCUMENT CUSTODY

6.0 EQUIPMENT CALIBRATION, O&M
- 6.1 Responsibilities
- 6.2 General Field Equipment Calibration Procedure
- 6.3 Calibration Failures
- 6.4 Calibration Record
- 6.5 Maintenance

7.0 ANALYTICAL PROCEDURES
- 7.1 General Requirements
- 7.2 Analytical Data Review

8.0 DATA REDUCTION, VALIDATION AND REPORTING
- 8.1 Data Logging and Analysis
- 8.2 Data Validation
  - 8.2.1 Analytical Data
  - 8.2.2 Field Measurement Data
- 8.3 Final Reporting and Archival of Document

TABLE 5 (Continued)

Table of Contents
Quality Assurance Project Plan

9.0 QUALITY CONTROL PROCEDURES
- 9.1 Field Quality Control Procedure
- 9.2 Laboratory Quality Control Procedure
  - 9.2.1 Initial Calibration and Calibration Verification
  - 9.2.2 Continuing Calibration Verification
  - 9.2.3 Method Blank Analysis
  - 9.2.4 Duplicate Sample Analysis
  - 9.2.5 Matrix Spike Analysis
  - 9.2.6 Interference Check Sample Analysis
  - 9.2.7 Analyte Method

10.0 PERFORMANCE AND SYSTEMS AUDITS
- 10.1 Performance Audits
  - 10.1.1 Field Operations Audit
  - 10.1.2 Laboratory Operations Audit
- 10.2 Systems Audit

11.0 PREVENTATIVE MAINTENANCE
- 11.1 Sampling and Analytical Equipment
- 11.2 Support Equipment

12.0 PROCEDURES FOR ASSESSING DATA ACCEPTABILITY
- 12.1 Procedures Used to Assess Data Precision and Accuracy
- 12.2 Checking Procedure
- 12.3 Laboratory Management Review

13.0 CORRECTIVE ACTION

14.0 QUALITY ASSURANCE REPORTS

15.0 FILES AND DOCUMENT CONTROL
- 15.1 Central Project Files
  - 15.1.1 Record Control
  - 15.1.2 Record Status
  - 15.1.3 Record Retention
- 15.2 Laboratory Files

anticipated for use will be clearly identified. Specific characteristics will be identified in detail in the design parameters and performance standards sections.

2.2.2 Design Parameters

Specific design parameters will be concisely stated to provide a uniform understanding of the scope of the project and the methodology to be used. All baseline data will be included. This may include topographic and boundary survey data, available subsurface information including geologic, hydrologic, geotechnical and analytical data. Specific drainage features will be identified with appropriate design data including hydrology of design events. The size and location of existing facilities will be identified including the location and capacities of all utilities (including subsurface utilities). Any relevant restrictions will be clearly identified. These may include zoning restrictions, height restrictions, noise or emission restrictions, etc.

The preliminary layout of equipment and facilities will be included in this section. Individual functions and associated space and utility requirements will be presented. Functional groupings or separations will be shown. Specific design capacities and loads will be identified. Initial concentrations of the COI in the various effluent streams will be presented including typical concentrations and extreme concentrations.

2.2.3 Performance Standards

The various performance standards for each component of the remedy will be specified. These standards include standards to be achieved by the design and analysis process as well as the operational performance of the specific facility. Examples of the standards for the design and analysis process include acceptable factors of safety which the design must achieve when analyzed by a particular model.

Performance standards for the specific features of the facility will be identified. This will include anticipated operational life span of the components, specific constituent concentrations which should be achieved, material handling rates, flow rates, energy efficiency, costs, etc.

2.2.4 Regulatory Requirements

The Remedial Design Work Plan (Basis of Design Memorandum) will identify the applicable regulatory requirements which must be satisfied. This will include not only federal and state regulations but also county or local building codes, zoning restrictions, etc., as well as the Uniform Building Code (UBC). Appropriate design standards of relevant professional and industrial organizations will be identified. This may include the ACI, AISC, ANSI, API, ASCE, ASChE, ASME, ASTM, NFPA, etc. Specific substantive technical state and federal permit requirements will be identified along with the documentation required to satisfy those requirements and a clear identification of the individual(s) responsible for obtaining these permits.

2.2.5 Administrative Requirements

The Remedial Design Work Plan will establish a project schedule, listing dates for information exchange and milestone dates for completion of the various design phases as well as target dates for solicitation of bid, construction and project completion. Any delivery lead times required for major items which are known at this time will be identified. Finally, the schedule will consider any potential delays due to regulatory review.

In addition to the schedule, the Remedial Design Work Plan will establish standards for all documentation including drafting standards and a written distribution list with the name and position of each member of the team, outside consultants, client representative and regulatory contacts.

2.3 REMEDIAL DESIGN

Remedial Design of this site will consist of detail analysis of every element of each remedial component to optimize the size of the component and specify the materials from which it will be made and how it will be constructed on-site. Remedial design is an interactive process whereby the level of detail of the design of each component increases with each design pass. Therefore, the 30%, 60%, 90% and 100% design levels represent common checkpoints in the process; however, the actual level of detail for any component at a point in the process is variable. As an example, RETEC proposes to reach the 90% design level for the decommissioning and demolition component at the end of the Pre-Remedial Design Phase.

Preparation of deliverables and formal review at the end of each phase will be determined in the Remedial Design Work Plan (Basis of Design Memorandum); however, Table 6 provides a general outline of the specific documents which will be available at each stage. Subsequent paragraphs describe the stages in greater detailed.

2.3.1 30% Design

The 30% design phase will consist of integration of the treatability and design studies to create a single set of components and identify conflicts, complications and competing demands of the individual remedial elements on-site. Specific design drawings, which will be developed to presentation quality at this point, include a site plan of existing facilities, topographic maps, geologic maps, cross-sections and process flow diagrams.

In addition to plans, documents to be prepared will include a general project description, descriptions of the specific system concepts, a list of equipment and an integrated cost estimate consisting of minor improvement over the Pre-Remedial Design Cost estimate achieved by integrating the various components. This estimate will serve as a basis for subsequent analyses of design alternatives.

2.3.2 60% Design

The objective of the 60% design phase is to develop the design of each component to the point where compatibility issues of all systems can be resolved. The intent is that final design and construction documents can subsequently be developed with a minimum of cascading revisions, i.e., a change in one component requiring redesign of numerous elements in other components.

All documents produced for review or information exchange will be clearly labeled as 60% design and dated next to this label (as opposed to in the title block). Numerous interim versions of the documents will be prepared during this phase and the subsequent phase, therefore, it is critical to clearly show the date the document was produced to avoid confusion. Interim changes to information previously shown on drawings (as opposed to addition of new information) will be enclosed in "clouds" or "bubbles". Revisions to text will be presented in

TABLE 6

Remedial Design Documentation

Deliverable	Remedial Design Work Plan	30% Design (Preliminary)	60% Design (Inte-rmediate)	90% Design (Pre-Final)	100% Design (Final)
Plans					
Cover Sheet				Draft Final	Final
Site Plan	Preliminary	Revised	Draft Final	Draft Final	Final
Civil Layout		Preliminary	Revised	Draft Final	Final
Sections			Preliminary	Draft Final	Final
Details			Preliminary	Draft Final	Final
Process Flow Diagram (PFD)	Preliminary	Revised	Draft Final	Draft Final	Final
Process and Instrumentation Diagram (P&ID)		Preliminary	Revised	Draft Final	Final
Mechanical Layout		Preliminary	Revised	Draft Final	Final
Details			Preliminary	Draft Final	Final
Electrical Layout			Preliminary	Draft Final	Final
Specifications					
Division I				Outline	Preliminary
Division II		Outline	Preliminary	Draft Final	Final
Equipment/ Material List					
Major		Preliminary	Revised	Draft Final	Final
Minor			Preliminary	Draft Final	Final
Utility Requirements			Preliminary	Draft Final	Final
Cost Estimate					
Capital Equipment	-30% to +50%	±30%	±20%	±10%	±10%
O&M	-30% to +50%	±30%	±20%	±10%	±10%

redline/strikeout format. At the completion of each phase, "clean" copies, i.e., without the "clouding" and redline/strikeouts will be prepared and circulated to all members of the design team.

Numerous design drawings will be developed in the course of this phase. All drawings will be prepared in conformance with RETEC's Drafting Standards at the scale intended for contract drawings. Typical details will be prepared as necessary to establish the workability of each component. The site plan will identify the locations of all systems and include preliminary elevations of key components. Circulation patterns and access locations will be presented along with tie-ins to utilities. Elevations, sections and details will be prepared to show structural depths and heights, hydraulic heads and the relation of the various systems with respect to elevation. Typical sections and details will be prepared at a scale large enough to satisfy major design conditions. Detailed process flow diagrams and single line mechanical layouts will be prepared showing equipment size and location, plumbing, etc., along with preliminary piping and instrumentation diagrams showing instrument and control hardware.

An outline will be prepared of Division I Specifications, i.e., general terms and conditions, contractual considerations and measurement and payment alternatives. Preliminary Division II Specifications will be prepared including descriptions of major systems, equipment and materials and performance or procedural specifications for construction. Preliminary equipment/materials lists will be developed showing quantity, methods and quality of all materials. Potential vendor options may be identified.

A cost estimate will be prepared with an accuracy of $\pm$20% and identifying any cost impacts associated with alternatives unresolved at this stage of design. The project manager will compile the individual estimates and check against the preliminary design documents for accuracy and completeness. A preliminary estimate of the construction schedule will be prepared identifying procurement lead times, and production rates for various site components. Task dependencies will be identified.

2.3.3 90% Design

Developing the design from the 60% to 90% phase consists of the final design effort to prepare drawings and specifications for construction. The documents detailing the final design should evolve smoothly from the information provided in the 60% design documents. The main requirements of this phase includes preparation of contract drawings and technical specifications along with detailed equipment/materials lists and more detailed cost estimates. These documents are developed in final format but referred to as draft. Consideration and incorporation of comments from the regulatory agencies will constitute 100% design and final documents.

All documents produced for review or information exchange will be clearly labeled as 90% design and dated next to the label (as opposed to in the title block). The draft design drawings will be prepared in standard format and presentation and incorporate all of the design developed for each component. Drawings for each component will include references to drawings of other components. An index of drawings will be presented on the cover sheet. All symbols and abbreviations will be clearly explained. All drawings will be carefully checked and approved by the Project Engineer/Scientist. The title blocks will be completed and the approval block initialed by the Project Engineer/Scientist indicating his/her review and approval.

A preliminary draft of Division I specifications, i.e., general conditions applicable to the entire project and contractual elements, will be prepared. Appropriate supplemental conditions will be identified and various alternatives for contractual issues will be considered. This includes a single contract or multiple contracts, contract type, i.e., fixed price, unit price or time and materials, and associated terms for measurement and payment. RETEC will prepare a memorandum for the Participating Companies detailing the advantages and disadvantages associated with each contract type for the specific project.

A final draft of the technical specifications, i.e., Division II specifications, will be prepared. These will be prepared in CSI format and will be consistent for all components and the drawings. The Project Engineer/Scientist will carefully review these specifications in association with the review of the drawings. Approval of the specifications and drawings will be designated by initialling of the title block and specifications cover sheet.

Detailed equipment/materials lists will be prepared in association with the draft design drawings. These lists will include an entry for every piece of equipment or material required for construction. The list will be cross-referenced to the design drawings, showing the sheet number and detail where the equipment or material is first called. Additionally, the list will reference the specifications. Additional information will highlight unique specifications, significant time requirements for procurement and specific vendors when material is available from a sole source. A vendors list will be prepared in addition to the materials list identifying the various sources of material. This list will include the company, contact name, address and telephone number of various vendors. Vendors, who have been contacted during the design phase and are the source of pricing data used in the Cost Estimate, will be noted. In addition to the vendors, this list should identify any manufacturers representatives.

A detailed cost estimate will be prepared. This estimate will reference all appropriate sources of input data and all assumptions will be clearly presented. The accuracy of this estimate will be within $\pm 10\%$. The final two items of the 90% design package will be an estimated construction schedule and a list of contractors capable of implementing the work. The estimated construction schedule will include bidding of the project along with ordering and procurement of equipment and materials.

2.3.4 100% Design

The primary activity between this level of design and the previous phase is undertaking a detailed review of the entire project. The design will be submitted to the Participating Companies for final review and approval. Additionally (and more importantly from a scheduling perspective), the design will be submitted to the appropriate regulatory agencies for review and approval. Incorporation of the comments and changes of the appropriate reviewing groups constitutes 100% design.

In addition to incorporation of the comments and changes required by the Participating Companies and regulatory agencies, finalization of the design drawings requires completion of the title block and stamping the drawings by the appropriate Project Engineers. Any changes to the design drawings will subsequently be recorded by additions to the Revisions section of the drawing's title block.

Based upon the input of the Participating Companies during the review phase, a revised draft of the Division I Specifications will be prepared. This section will include a copy of the proposed construction contract and all appropriate bidding, procurement and payment conditions required by the client. Finalization of the other design documents, including Division II Specifications and the materials lists, will consist of incorporation of comments by the Participating Companies and regulatory agency.

Finalization of the cost estimate and estimated construction schedule may include incorporation of any new information, market conditions, etc. Finally, RETEC will prepare as complete a list of vendors and contractors as appropriate. At the request of the Participating Companies, RETEC may begin contacting these companies to initiate pre-qualification activities prior to bidding.

3.0 PROJECT STAFFING, MANAGEMENT AND REPORTING

3.1 STAFFING

This section introduces the RETEC personnel designated to work on this project. The Project Organization chart is included in Appendix C. Resumes are provided in Appendix D.

Robert N. Block, P.E. - Mr. Robert N. Block, P.E., will serve as Principal-in-Charge and will be the primary point of contact for the Participating Companies. Mr. Block has over 16 years experience and is a registered Professional Engineer in 10 states. As Principal-in-Charge, Mr. Block will have the authority to commit the resources to ensure the project is completed on time and within budget. Mr. Block has lead the remedial design efforts at numerous terminal sites and CERCLA sites. Among the remedial design projects Mr. Block has successfully managed is one of the largest bioremediation projects completed in the country to-date and the first bioremediation undertaken under CERCLA. In addition, Mr. Block has extensive experience with NYSDEC and EPA Region II.

Ken Fantone - Mr. Ken Fantone, a hydrogeologist with over 14 years experience, will manage the Site Characterization phase of the Pre-Remedial Investigation. Mr. Fantone specializes in designing and undertaking aquifer characterization programs. Among the projects Mr. Fantone has lead are the characterization and modeling associated with numerous petroleum products site and *in situ* bioremediations. Mr. Fantone and Mr. Block have collaborated on numerous sites.

Mark Westray - Mr. Mark Westray is an environmental engineer specializing in *in situ* bioremediation. Mr. Westray has over 8 years experience including directing treatability studies and designing pilot- and full-scale *in situ* bioremediations. Among the groundwater remediation projects Mr. Westray managed was the *in situ* bioremediation of a petroleum products site on New York. More recently, Mr. Westray and Mr. Block have worked together evaluating the use of soil venting, air sparging and *in situ* bioremediation at a Superfund Site in upstate New York.

Dan Miller - Mr. Dan Miller is a process engineer with over 11 years experience specializing in remedial design of water and vapor treatment facilities. Mr. Miller is familiar with pretreatment technologies and air strippers as well as numerous vapor treatment technologies having been responsible for the design, construction, startup and operation of these treatment technologies at numerous sites throughout the country. Most recently, Mr. Miller was responsible for designing a groundwater remediation at an MGP site in eastern New York.

The Project Management team will be supported by various staff members chosen for this project based upon their expertise in various technical tasks required at this site. The organization chart and detailed resumes of these individuals are presented in the appropriate appendix. In addition to the technical staff, the project team will be supported by members of RETEC's administrative services group who provide administrative services vital to the successful management of a multi-faceted project such as this.

RETEC has made a corporate commitment to ensure the quality of it's work. This is done by designating a Technical Review Team. The team includes Mr. Block as Principal-In-Charge and Dr. John Smith and Dr. Gaylen Brubaker. Dr. Smith manages RETEC's wastewater design group and has managed numerous water treatment projects associated with groundwater remediations. Dr. Brubacker is a Principal with RETEC with over 15 years experience. Dr. Brubacker is a nationally recognized expert in *in situ* biological treatment.

3.2 MANAGEMENT AND REPORTING

RETEC's approach to project management is focused on five elements: cost control, subcontractor administration, schedule, communications, and quality control. Successful completion of this project requires that all of these elements be executed effectively throughout the project.

Upon receipt of Notice to Proceed, a planning meeting will be held by the project team to initiate the project management activities. The focus of this meeting will be to define a detailed task and subtask structure, scope each task and/or subtask (including defining the cost and schedule), determine labor requirements and make staff assignments, identify potential subcontractors, and establish all aspects of project control, i.e., quality control and communication procedures.

Given the definition of the task and subtask structure, detailed baselines will be established for each of the project management elements and implemented as discussed below. Unique numeric codes will be assigned to each task and subtask which will be used for tracking cost and schedule.

3.2.1 Cost Control

Upon initiation of the project, detailed labor and ODC budgets are prepared for each task and subtask. These budgets specify the level of effort required to complete each task and budgets for Other Direct Costs (ODCs), i.e., subcontract items and expenses. Once the cost baseline is established, it will be used as the basis of comparison throughout implementation to ensure the scope of work is implemented within budget.

Costs are controlled through RETEC's central Project Management Information System (PMIS). Input to this system includes employees' weekly time sheets, purchase orders, and expense reports. All project charges are recorded at the time they are incurred with both the project number and task/subtask number and approved by the employee's supervisor prior to entry into the system. Additionally, ODCs (particularly telephone and shipping) are charged directly to the project as they are incurred.

On a weekly basis, each task manager receives Direct Labor and ODC reports for each task detailing the individual charges to the project and total cost for the preceding week. This information is reviewed to ensure accuracy. The Task Manager advises the project cost accountant of any mischarges and ensures that these charges are immediately corrected. Additionally, on a weekly basis, each task manager receives a detailed Budget Status Report prepared by the PMIS system showing the task budget, the amount invoiced to-date, work-in-progress, and the budget remaining. This data is compared against the baseline initially established to determine the project status and identify any potential problems as they develop. Each Task Manager reviews this information with the Project Manager along with cost-committed data (generated from the purchase orders) against the project baseline.

If problems are identified by the Task Manager, they are immediately brought to the attention of the Project Manager. The Project Manager receives and reviews the PMIS reports for all tasks/subtasks. This independent review provides a double check of the cost status, helping to ensure that problems are identified as they are developed and that appropriate actions are taken.

On the last Friday of each month, the Project Manger receives a Monthly Billable Charges report showing all costs that were incurred during the period. This data will be reviewed with the Task Managers in conjunction with the Budget Status reports, the schedule, and scope of work. Based upon this review, the budget will be evaluated in light of the progress of the work to identify any potential problems which may occur in the upcoming months.

3.2.2 Subcontract Administration

Subcontractors will be required to provide drilling, surveying, and analytical services. The cost estimates included in this proposal are based upon telephone quotes from several vendors for each service. Upon completion of the Work Plan, written bids will be solicited from at least two vendors for each service for the specific Scope of Work specified in the Project Plans. The basis of these bids will be the specifications for the work as detailed in the Project Plans, RETEC's standard subcontract agreement, and all specific terms and conditions flowing down from the contract between the Participating Companies and RETEC.

Subcontractor bids will be reviewed based upon price, qualifications, and the ability to perform the work in a timely fashion. Subcontractor costs and progress will be tracked on a regular basis, along with all other cost and schedule items, allowing the project manger to identify potential problems before they happen, as opposed to trying to correct problems after they have occurred.

3.2.3 Schedule

The tentative project schedule is presented in Appendix C. Upon receipt of notice to proceed, a project schedule will be reviewed by each Task Manager in light of the level of effort required for each subtask, procurement times for various subcontractors, and turn-around times for laboratory analyses. This data will be submitted to the Project Manager for input to RETEC's critical path scheduling software (TIMELINE) to develop the initial framework for the schedule of the entire project. Upon generation of the initial schedule, the Project Manger will review the schedule to identify tasks on the critical path. Additionally, the Project Manager will review the PERT chart to understand the interdependencies of the various tasks and identify any potential conflicts. This information will be included in the planning meetings and used during the scoping to develop a baseline schedule for implementation of the work.

The schedule is updated weekly, or as needed, to achieve "real time" schedule control that allows the Project Manager to learn of problems before or as they occur, rather than documenting problems that are past the point when management action is effective. The schedule becomes an integral part of project communications. Progress on critical tasks will be regularly reviewed and each Task Manager will report on the progress of tasks upon which other Task Managers are dependent.

3.2.4 Communications

Monthly progress reports will be prepared by the Project Manager. Measurement of progress will be made for task/subtask by estimating the percentage of the work completed and providing an estimate of the manhours to complete the balance of work. The original manhours budgeted, or revised manhours, will be used as the denominator in calculating the overall project percent complete. Activities contracted to subcontractors will be tracked with weekly updates reported on standardized progress forms. The Project Manager will conduct weekly status review meetings with project team personnel to determine current project progress. Project analysis will be accomplished weekly using a four-week, look-ahead subset of the project schedule. The result of each weekly progress update will be maintained as part of the project schedule of the same cycle. This will ensure that potential problem areas are identified early, so that corrective action can be implemented in a timely, cost-effective manner to minimize the impact on other activities.

Forecasts of manhours and costs at completion will be developed for each activity using the process described above. Forecast values which exceed the baseline budget will be reviewed by task managers for reasonableness prior to inclusion in project performance reports.

Results and activities of the Pre-Remedial Design Investigation will be communicated to the Participating Companies in the monthly progress reports so the Participating Companies are kept abreast of events as they take place. Regular communication, documented in written form, will attest to the record of activities and events and inform all applicable parties of potential problems before they become impeding issues.

3.2.5 Quality Control

Quality Assurance/Quality Control will be addressed in detail in a site-specific Quality Assurance Plan (QAP) to be prepared in conjunction with the Work Plan immediately after project award. The QAP will be prepared by the Project Manager with input from other team members. A draft of the QAP will be presented to the Technical Review Team for review and comment prior to finalization. The QAP will address field and laboratory activities that are essential to accurate and meaningful data collection.

The mechanisms that will be employed in the Site Characterization and Treatability Studies to ensure quality as described above can be classified as prevention, assessment, and correction as follows:

- prevention of defects in quality through planning and design, documented instructions and procedures, and careful selection and training of skilled, qualified personnel;

- quality assessment through analysis of quality control samples and through a program of formal and informal review; and

- permanent correction of conditions adverse to quality through a corrective actions system.

Project personnel performing key tasks which directly affect the quality of measurement data will each be assigned a copy of this plan. Each plan holder will be responsible for keeping their copy up to date and for maintaining a familiarity with and understanding of all current procedures associated with the tasks assigned to them. Each member of the project team will be responsible for reading and understanding the contents of their plan before beginning work on the project. A conscious effort will be made to select the best trained and qualified staff for specific job tasks.

4.0 QUALIFICATIONS AND RELEVANT EXPERIENCE

RETEC has developed considerable experience in the management of organic chemicals in environmental matrices. Specifically, RETEC has designed, tested, engineered and implemented soil venting, *in situ* and surface bioremediation, groundwater extraction and treatment, and NAPL and DNAPL recovery remedies for petroleum and coal tar contaminated groundwater and soils. RETEC has extensive experience in modeling the fate and transport of organic constituents in the subsurface.

RETEC designed, engineered, constructed and operated the first full-scale application of biological treatment to remedy contaminated soils at a Superfund site. We have, or are currently, operating over fifty full-scale biological remedies at RCRA, Superfund or state sites across the country. RETEC's considerable experience in the application of remedial technologies make us particularly well qualified to design and implement the soil and groundwater remedy specified by the ROD. In addition, our experience in dealing with the administrative aspects of a remedial design helps us to efficiently comply with the extensive administrative requirements of the NYSDEC inactive site and EPA Superfund process.

RETEC has been designated the engineer of record for the RD/RA portion of the response at ten Superfund sites across the country. We have considerable experience and expertise in the application of engineering design skills to Superfund remedial design projects. We have prepared plans and specifications for the construction of facilities for the treatment of contaminated soils and groundwater.

The following is a discussion of RETEC's experience that is specifically related to the site and the types of remedies that are required by the ROD. This is followed by a more general discussion of RETEC's experience in the areas of *in situ* bioremediation, sparging and venting, and other related subsurface remediation services.

4.1 GROUNDWATER REMEDIATION UNDER CERCLA

RETEC has designed and implemented several large and complex groundwater remedies at Superfund sites across the country. RETEC's experience and relevant qualifications related to contaminated groundwater management at Superfund sites is best exemplified by our involvement in the St. Louis Park, Minnesota site. RETEC represented the responsible party at that site and designed, engineered and supervised the construction of a pump-and-treat system for a contaminated aquifer used for potable water. The system consists of recovery wells and a chemical\physical water treatment system that treats contaminated groundwater to drinking water standards. The product of this treatment is, in fact, a source of drinking water to the local community.

The experience that RETEC gained is particularly applicable to the Shore Realty site because of the presence of iron in the groundwater and the need to deal with the iron hydroxide in the treatment train for removing organics. Table 7 is a summary of RETEC's relevant Superfund groundwater experience.

4.2 NEW YORK DEC RELATED EXPERIENCE

RETEC has been the involved in projects in the Long Island area and has considerable experience related to Superfund and remediation related projects in New York State. RETEC has represented clients' interests in negotiation with and responding to issues raised by the NYSDEC. RETEC evaluated the applicability of various remedial alternatives for a petroleum terminal in Long Island City, New York for a major petroleum company that owned the property. The alternatives involved the use of surface bioremediation of petroleum contaminated soils and the recovery of floating product from shallow groundwater.

RETEC has also dealt with the NYSDEC on numerous projects in other regions of New York. We are the environmental engineer on several manufactured gas plant sites in New York State and, as such, we have negotiated with NYSDEC on several soil and groundwater remediation related issues. In addition, we have prepared and reviewed a large volume of Superfund-related design work on a site in western New York. We have performed technology demonstrations for contaminated soils and sediments in New York and performed the permitting and environmental compliance work related to those demonstrations.

Table 8 is a summary of RETEC's experience in New York State and projects on which we dealt with in NYSDEC.

Table 7
Groundwater Work under CERCLA

Groundwater Treatment
Indiana Superfund Site

RETEC was contracted by an international engineering/construction company to assist them in implementing a pumped groundwater treatment system at a U.S. EPA Superfund site in Gary, Indiana. The site was an abandoned landfill with the soil and groundwater contaminated with a wide variety of organic and inorganic chemicals. As stipulated in the Record of Decision (ROD) for the site, groundwater is to be pumped from fourteen (14) wells at a total combined flowrate of approximately 40 gpm. Once pumped, it is to receive surface treatment in a biological sequencing batch reactor (SBR) process prior to reinjection. On this basis, RETEC was contracted to evaluate, design, and help implement the groundwater treatment system. Specific work performed included review of all historical site data, conceptual design, laboratory treatability testing, detailed process design and equipment specification, construction supervision, start-up, and operator training. Based upon the treatability/design work performed, the system implemented entails pretreatment involving oil/water gravity separation followed by potassium permanganate chemical oxidation/settling for iron removal, followed by biological SBR treatment for organics removal. Sludges from both the pretreatment and the SBR treatment steps are to be dewatered via pressure filtration. It is noteworthy that all (i.e., through implementation) was completed in a very short time period of six (6) months.

Soil Flushing and
In Situ Bioremediation
Montana Superfund Site

RETEC is the prime contractor for a former wood treating site in Montana which has creosote contamination (both volatile and non-volatile aromatic hydrocarbons) in tight soil in two distinct areas of the site. Successful implementation of in situ bioremediation, possibly in combination with hot water flushing, could save the PRP over 30 million dollars when compared with the specified alternative. RETEC wrote the RI/FS, assisted in negotiating the ROD, and wrote the work plan for site characterization and laboratory studies. RETEC completed these studies during the summer and fall of 1991 and is currently performing a detailed remedial design for the site.

Technical Oversight for
In Situ Bioremediation
Petrochemical Site, Texas

RETEC is providing technical oversight for a major in situ bioremediation project at a CERCLA site in the Gulf Coast. This oversight has included reviewing all technical documents pertaining to the design and operation of this multi-million dollar project and meeting monthly with the primary contractor's design team to provide suggestions and recommendations. This process includes over 50 injection or extraction wells covering two aquifers over an area of 11 acres.

Superfund Site
Indiana

RETEC has been contracted to assist the prime contractor in evaluating in situ remediation for an 11-acre Superfund site in northwestern Indiana. The project involves laboratory characterization, treatability studies, and economic evaluations of enhanced NAPL recovery through simple pump-and-treat, enhanced pump-and-treat (using elevated temperature or low levels of surfactants), and in situ bioremediation. The presence of an on-site biological waste water treatment system, groundwater injection system, and a slurry wall will decrease the incremental cost of these options dramatically compared to what this combination of processes could cost at other sites.

Wood Preserving Site Remediation Minnesota

RETEC is operating a land treatment facility for creosote-contaminated soils in Minnesota. RETEC personnel took this project from bench scale to full scale in two years. It is the first EPA-approved biological remediation project implemented at a RCRA and CERCLA site.

Groundwater Treatment Minnesota Superfund Site

RETEC was contracted to evaluate, design, and implement a groundwater treatment system to handle a combined 140 gpm design flow from three gradient control wells at a Superfund site which was a former wood treating and coal-tar refining plant. Specific work performed included review of all historical site data, technology paper screening, engineering evaluation testing (i.e., treatability) conceptual and process design, regulatory permit negotiations, equipment specification and procurement, construction supervision, start-up and operator training. Technologies evaluation during the paper screening included biological fluidized bed, UV/chemical oxidation (ozone, hydrogen peroxide), chemical oxidation, sand filtration, and activated carbon. Based upon the results of this screening and subsequent on-site pilot-scale treatability testing and design work, the full-scale system implemented consists of a potassium permanganate ($KMnO_4$) chemical oxidation/sand filtration step for iron and manganese removal, followed by activated carbon adsorption for removal of soluble organics (i.e., phenolics, and polynuclear aromatic hydrocarbons). Final discharge is to surface water via an NPDES permit.

Groundwater Remediation California Superfund Site

RETEC personnel directed treatability testing which led to the development of a groundwater treatment process at a West Coast Superfund site. The system installed consists of an air stripper to remove volatile organic compounds including short-chain chlorinated hydrocarbons, and a bioreactor to degrade soluable organic compounds, such as aceton and 2-butanone. Contaminated groundwater is passed through the air stripper at a rate of 50 gallons per minute. The effluent from the air stripper then passes through a 10,000 gallong bioreactor and is discharged under an NPDES permit. The treatment system has been operating since December 1986 and meets discharge levels of 5 ppb or less for chlorinated hydrocarbons, 500 ppb or less for ketones, and 1 ppm or less for alcohols and glycols.

Groundwater Modeling Massachusetts Superfund Site

RETEC has been retained to implement a ROD at a complex and controversial Superfund site. Groundwater has been contaminated with a variety of halogenated organics by a variety of PRPs. As a portion of the project, RETEC is using a three-dimensional flow model of the aquifer (MODFLOW). The results of the modeling effort are to determine the effect various pumping scenarios have on the nearby river and wetlands; determine the optimal number, location, and pumping rate of recovery wells in the design of the pump-and-treat remedy; and estimate the time it will take to implement the groundwater cleanup.

Table 8
Representative New York State and NYDEC Related Experience
NYDEC/EPA Region II Table

Groundwater Treatment System Upgrade at a Manufactured Gas Plant Site

RETEC was contacted by a Northeastern utility to upgrade an existing 20 gpm groundwater treatment system at a manufactured gas plant (MGP) site to meet new discharge limitations for organic compounds.

The original groundwater treatment system was designed to remove metal contaminants (i.e., primarily iron) by oxidation with hydrogen peroxide (H^2O^2) and filtration. Due to operational problems caused by residual hydrogen peroxide contacting activated carbon, RETEC recommended potassium permanganate (KMnO4) as a replacement to hydrogen peroxide for iron removal. RETEC undertook bench-scale treatability work to verify the technical feasibility of using potassium permanganate and determined the required chemical feed rates.

RETEC engineered the proposed process changes and negotiated approval with the regulatory agency. The modified groundwater treatment system consisted of KMnO4 chemical oxidation with coagulation/flocculation/gravity separation using polymer followed by filtration and activated carbon adsorption.

RI/FS and Remedial Design Refinery Superfund Site

RETEC was selected to provide engineering design services for the landfill area and oversight of the Remedial Investigation/Feasibility Study for the refinery site.

RETEC procured the contractor to construct the earthen dike to mitigate erosion of waste disposal areas. RETEC also developed the design for a low ground pressure cap to address the consolidation characteristics of soft underlying waste materials. In conjunction with the cap design, RETEC developed a test program to evaluate the effects of the low ground pressure cap on a field-test scale. Based upon the RI/FS, the EPA and NYSDEC required groundwater remediation in the vicinity of an oil/water separator. RETEC evaluated various innovative solutions including *in situ* bioremediation and air sparging and negotiated with the regulatory agencies to use these technologies as opposed to pump-and-treat technologies.

Feasibility Study for MGP Site

RETEC is conducting a feasibility study for a 65-acre site contaminated with a variety of wastes from the operation of manufactured gas plants. At this site, both a water and a coking gas facility were operated from the 1880's through the 1950's. In addition, facilities were constructed and operated to process the by-products from both operations, and at least one stream-electric plant was built and operated. The site is a peninsula in mid-state New York, and is subject to a consent order with the state environmental regulatory agency.

The work completed to date includes identification of and participation in supplemental investigatory activities; identifying applicable, or relevant and appropriate regulatory requirements; identifying response objectives and general remedial responses, and identifying and screening appropriate remediation technologies. Continuing work will follow the EPA requirements and guidelines for remedial activities under Superfund.

Soil Washing and Biological Slurry Reactor Tests on Contaminated Manufactured Gas Plant Site Soils

RETEC was contacted by a New York state utility to examine the ability to remove soil contaminants from a contaminated MGP site soil and to biologically treat the contaminants which report to the aqueous phase extract. The testing program consisted of performing a treatability protocol developed by RETEC for the Gas Research Institute (GRI). This protocol consists of abiotic (non-biological) desorption tests using the contaminated soil and buffered water solutions (i.e., simulated groundwater) followed by biological treatment of the soil in a liquid/solid, continuously stirred tank reactor. The desorption tests provide information regarding the ability to wash the contaminants from the soil; the slurry reactor tests provide data on the biodegradation of the extracted contaminants. In addition to using buffered water, the test program also considered using water with selected additives (e.g., water-soluble solvents or surfactant.)

Use of this protocol provides data released to the biodegradability of MGP site soils. It can be implemented within a four- to six-week time frame, whereas, conventional microcosm work generally takes four to six months to complete.

Bioremediation of Manufactured Gas Plant Site Wastes

RETEC, in conjunction with the Environmental and Water Resources Engineering Program at the University of Texas, is investigating the application of bioremediation to Manufactured Gas Plant (MGP) site residuals. Phase 1 laboratory treatability studies addressed: adsorption/desorption phenomenon associated with soil particles; loss rates of the specified chemicals; and relative mobility and toxicity of the residuals. Phase 2 of the study is examining methods and/or techniques to enhance treatment. The methods and techniques of interest include the application of surfactant and disaggregation techniques. The results of the Phase I and Phase II efforts will provide the basis for the design of a potential site remediation strategy.

Manufactured Gas Plant Site Groundwater POTW Co-Treatment evaluation for three MGP Sites

RETEC was contracted by a New York state utility to investigate the technical feasibility of the co-treatment of manufactured gas plant (MGP) site groundwaters with municipal wastewater in publically owned treatment works (POTW). The work conducted as a result of a recent pilot-scale study which was conducted for the Gas Research Institute (GRI). This GRI study demonstrated that MGP site pumped groundwaters, co-treated with municipal wastewater in a conventional activated sludge treatment POTW, offers a technically viable and cost effective solution for disposition of MGP site groundwaters. The primary objective of this research work was to confirm, through a full-scale field demonstration, that MGP site groundwaters can be effectively treated in an activated sludge POTW.

White Rot Fungus of Coal Tar Contaminated Soils

RETEC is evaluating the treatment of soils contaminated with a Manufactured Gas Plant (MGP) coal tar and box wastes using the white rot fungus, <u>Phanerochaete chrysosporium</u>. Three MGP site soils are being evaluated in this program.

The first step in this program was to determine optimum operating conditions for the white rot fungus for each soil. Both landfarming and composting of contaminated soils were examined. Once optimum operating parameters were determined, the treatability of these soils was assessed in laboratory-scale models of the treatment facility. Of special concern was degradation of PAHs, both in total and by specs. This program is being performed in preparation for a field-scale demonstration for this technology.

Technology Field Demonstration
Harbor Point, NY

RETEC is conducting a technology field demonstration project to investigate the application of remediation technologies to the source materials that are present at MGP sites. These materials include free hydrocarbons (i.e., tars and oils), purifier box wastes, and organic-contaminated soils. The purpose of this multi-year project is to provide full-scale performance and economic data for use in the design and costing of MGP site remediation strategies. Phase I of the project, which involved the selection of the demonstration technologies, the identification of the vendors, and the planning of the demonstration tests is nearing completion. Phase II of the project, test implementation, will begin in 1992 and in 1994.

Feasibility Study
Harbor Point, NY

RETEC is conducting a feasibility study (FS) at this site under an Order on Consent with the New York DEC. The site is a large peninsula (over 100 acres) which was the location of a coal carbonization plant, a carbureted water gas plant, a light oil recovery plant, and a tar emissions plant. The FS must address not only the site wastes but wastes from adjoining properties and contamination in an adjoining river and harbor. Response objectives, ARARs, and general response actions have been defined for the site. This initial remediation technology screening and selected treatability studies have been completed and several integrated remediation strategies have been defined. Plans are to evaluate these strategies on the basis of nine criteria of the U.S. EPA and to select a preferred option for implementation at the site.

Feasibility Study
Saratoga Springs, NY

RETEC is conducting a feasibility study (FS) at this site which is one of only seven MGP sites that are on the National Priorities List. The site is relatively small but was intensively used as an industrial site throughout its history. In addition, it is located over a geologic fault which is a major groundwater source for the area. The primary remediation concerns at the site involves the protection of the groundwater while minimizing the disruption to the current site activities. Response objectives, ARARs and general response actions have been defined for the site. The initial remediation technology screening and selected treatability studies have been completed and several integrated remediation strategies have been defined. An initial evaluation of these strategies has been conducted and the economics for their implementation have been estimated. Further evaluation of the strategies is planned on the basis of nine criteria of the U.S. EPA and a preferred option for implementation at the site will be selected.

Site Remediation Strategy
Oneontal, NY

RETEC developed a site remediation strategy with the objective of mitigating the future migration of site chemicals in the groundwater. This required the development of a site remedial action objective; the identification and screening of general response actions; the development, screening, and detailed analysis of site remediation alternatives, and the definition of supplemental work required for the implementation of the preferred site remedial option. The recommended site remedial option included a groundwater pump-and-treat system with final discharge to a Publicly Owned Treatment Works. The preferred remedial option for the site has been submitted to the state regulatory agency for their review and comment.

New York State Utility
Cortland/Homer, NY

RETEC developed a site remediation strategy with the objective of mitigating the future migration of site chemicals in the groundwater. This required the development of a site remedial action objective; the identification and screening of general response actions; the development, screening, and detailed analysis of site remediation alternatives, and the definition of supplemental work required for the implementation of the preferred site remedial option. The recommended site remedial option included a groundwater pump-and-treat system with final discharge to a Publicly Owned Treatment Works. The preferred remedial option for the site has been submitted to the state regulatory agency for their review and comment. At the same time, RETEC has assisted in the planning of a multi-year research program to investigate alternative on-site groundwater treatment technologies. Funding for the research program has not yet been authorized.

Groundwater Treatment
Plattsburgh, NY

RETEC provided technical support for the upgrade of a groundwater treatment system to meet the new discharge limits for soluble organics. This support consisted of a treatability study to demonstrate the technical viability of the proposed system modifications; the preparation of engineering design report; and a full-scale field demonstration of the treatment system upgrade. Lastly, RETEC established recommended operating procedures and provided operator training for the treatment system. Work was completed following system installation and operator training.

4.3 TECHNOLOGY SPECIFIC EXPERIENCE

In Situ Bioremediation Services

RETEC personnel have performed over 60 site assessments, designs and/or process implementations involving *in situ* bioremediation of contaminated aquifers. This experience includes:

- performing laboratory and field testing, data review and conceptual design for over 40 sites, covering a wide range of hydrogeological and contaminant characteristics;

- performing detailed treatability studies and economic evaluations on over 30 sites containing petroleum products (gasoline, jet fuel, diesel and fuel oils), chlorinated solvents, pesticides, PAHs, pentachlorophenol, non-chlorinated solvents and a wide range of specialty chemicals; and

- designing and operating numerous projects including sites in California, New Jersey, Rhode Island, Florida, Missouri, Indiana, Texas, Louisiana, Wisconsin and Washington.

RETEC combines this broad experience with *in situ* bioremediation and a thorough understanding of contaminant transport issues to develop integrated groundwater remediation strategies. This process usually involves three phases:

- **Initial Assessment** provides an initial evaluation of the technical feasibility and economic benefit of using *in situ* bioremediation at a site. This phase involves review of existing contamination data and hydrogeological characteristics; identification of data gaps and critical design issues. The assessment can be easily enhanced by including a modest amount of laboratory testing for microbial and soil characterization.

- **Design Studies** include a more detailed examination of the hydrogeological characteristics of the site, nutrient requirements and nutrient/soil interactions. Data gaps may be filled at this time by additional field and laboratory testing. Various types of biodegradation studies may also be performed depending upon the size and complexity of the site. Groundwater modeling is typically used to evaluate various groundwater injection and recovery options. Groundwater treatment and/or disposal options for the recovered groundwater are evaluated at this time. Field pilot studies may be required for complex sites. This phase is completed by the preparation of a full engineering design and detailed work plan for the implementation of the full-scale system.

- **Construction and Operation** involves installation of injection and recovery trenches or wells, nutrient storage and delivery systems, pumps, meters, controls and often a surface groundwater treatment system. System start-up and process stabilization typically takes one to two months, followed by process monitoring, data review and process optimization. Groundwater data is reviewed quarterly to examine process performance and evaluate potential modification in operating parameters. Soil coring is usually performed periodically during the project to insure uniform treatment.

This phase approach to *in situ* bioremediation projects allows clients to make educated decisions about remediation options as site data is collected. While *in situ* bioremediation is a very aggressive means of remediating contaminated aquifers that can be highly cost-effective, it is not appropriate for every groundwater remediation project. RETEC has a thorough understanding of the technical, economic and regulatory issues related to *in situ* bioremediation and is prepared to help its clients identify the remediation option most appropriate for their needs.

Figure 5 provides a schematic of the *in situ* bioremediation process. Table 9 provides a summary of representative RETEC *in situ* bioremediation projects.

4.4 SOIL VENTING AND GROUNDWATER AERATION SERVICES

RETEC personnel have designed and operated soil venting systems for a wide variety of contaminants ranging from petroleum hydrocarbons to chlorinated solvents. Our staff has experience with the design of soil venting systems in both fine-grained and coarse-grained soils, using both vertical and horizontal extraction wells. In certain situations, RETEC has designed and installed a soil venting system with an *in situ* groundwater aeration system. Groundwater aeration consists of the installation of aeration points several feet below the seasonal low water

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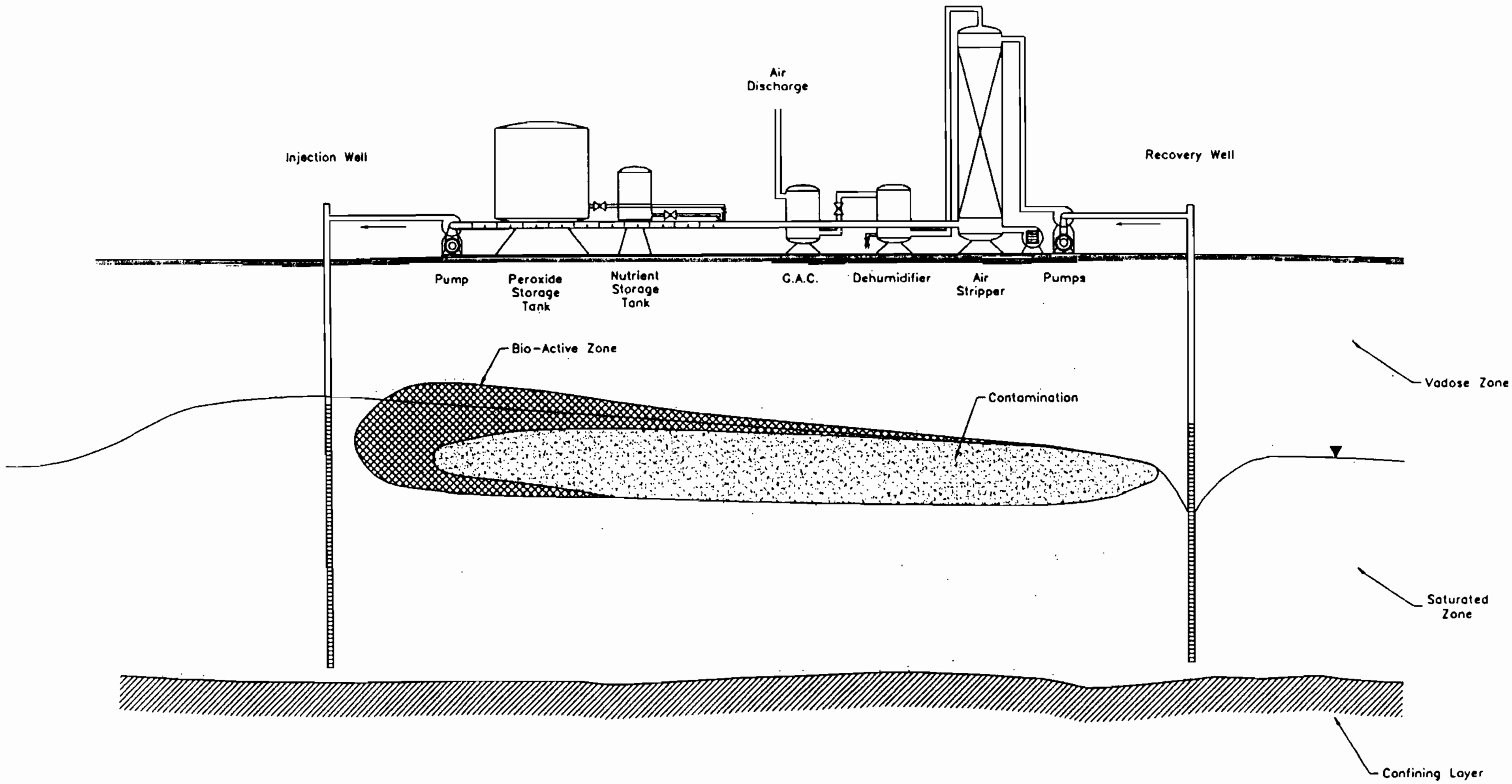


SUBTECH DWG

In Situ Bioremediation

FIGURE
5

Table 9

REPRESENTATIVE IN SITU BIOREMEDIATION PROJECTS

Subsurface Remediation Studies Gulf Coast Petrochemical Plant	RETEC is evaluating the cost benefit of soil flushing, in situ bioremediation, and soil venting for a chemical plant in Texas in a series of sand lenses contaminated with volatile aromatics, polyaromatic hydrocarbons, chlorinated and non-chlorinated solvents. Laboratory treatability studies were performed during the summer and fall of 1991. Field pilot studies of in situ vapor extraction, soil washing and in situ bioremediation were completed in January 1992. These studies have produced the information required to select and design a long-term remediation process.
Soil Flushing and In Situ Bioremediation Montana Superfund Site	RETEC is the prime contractor for a former wood treating site in Montana which has creosote contamination (both volatile and non-volatile aromatic hydrocarbons) in tight soil in two distinct areas of the site. Successful implementation of in situ bioremediation, possibly in combination with hot water flushing, could save the PRP over 30 million dollars when compared with the specified alternative. RETEC wrote the RI/FS, assisted in negotiating the ROD, and wrote the work plan for site characterization and laboratory studies. RETEC completed these studies during the summer and fall of 1991 is are currently performing a detailed economic and technical evaluation of these alternatives.
In Situ Bioremediation of Coal Tar Wastes Former Manufactured Gas Plant, Iowa	RETEC is providing technical consulting to an environmental engineering firm for a former manufactured gas plant in Iowa that contains coal tars 35-50 feet below surface. RETEC assisted in writing the FS and negotiating the ROD, and designed the laboratory and pilot studies to evaluate in situ bioremediation. RETEC is performing the laboratory studies in its laboratories and is supervising the two-year field pilot study.
In Situ Bioremediation of PCP Midwest Wood Preserving Site	RETEC personnel designed and installed an in situ bioremediation process for pentachlorophenol remediation. Nitrate was used as the biological oxidizing agent at this site.
Gasoline Contamination of Limestone Aquifer	RETEC personnel designed an aquifer remediation project which included nine injection wells and nine recovery wells in a limestone aquifer. A soil venting system was also installed to complement the in situ bioremediation process. After a year, all residual vapors were removed from the unsaturated zone and TPH levels decreased in most wells. Remediation was achieved in less than three years.

In Situ Bioremediation of Gasoline Spill California Service Station	RETEC personnel designed and provided operational oversight for the first in situ bioremediation system in California. The project treated gasoline in soils with rapid, natural groundwater movement. Remediation was completed in less than three years.
Technical Oversight for In Situ Bioremediation Petrochemical Site, Texas	RETEC is providing technical oversight for a major in situ bioremediation project at a CERCLA site in the Gulf Coast. This oversight has included reviewing all technical documents pertaining to the design and operation of this multi-million dollar project and meeting monthly with the primary contractor's design team to provide suggestions and recommendations. This process includes over 50 injection or extraction wells covering two aquifers over an area of 11 acres.
Design of In Situ Treatment System New Jersey Fuel Oil Spill	RETEC designed an in situ bioremediation process which combines vapor extraction, groundwater recovery with surface treatment using activated carbon, and reinjection of treated groundwater and nutrients. The system will treat residual fuel oil in both the saturated and unsaturated zones of the site.
In Situ Bioremediation of Diesel Spill Pipeline Site, North Carolina	RETEC designed an in situ bioremediation process to enhance the degradation and flushing of diesel contaminants from below a roadway in North Carolina to protect a freshwater stream that is used as a source of water for a trout farm.
Wetlands Remediation East Coast Refinery	RETEC reviewed existing hydrogeological data at this site, East performed treatability studies, and characterized soils to evaluate the potential for enhancing in situ bioremediation of oily dredge sediments. Computer simulations were used to evaluate several alternative containment systems. Natural biodegradation is being performed through a passive bioremediation process.
Field Demonstration Projects	RETEC personnel have participated in the design, operation, and interpretation of operating and monitoring programs for field demonstration projects funded by API, the US Air Force, and the EPA.
Former Wood Treating Site	RETEC is the prime contractor for a PRP committee to cleanup a former wood treating site in Mississippi. The site contains creosote and PCP in sandy soils which are adjacent to a creek. Aquifer characterization and product recovery activities are nearly complete, and a pilot study area has been selected for in situ bioremediation testing in 1992.
Superfund Site Indiana	RETEC has been contracted to assist the prime contractor in evaluating in situ remediation for an 11-acre superfund site in northwestern Indiana. The project involves laboratory characterization, treatability studies, and economic evaluations of enhanced NAPL recovery through simple pump-and-treat, enhanced pump-and-treat (using elevated temperature or low levels of surfactants), and in situ bioremediation. The presence of an on-site biological waste water treatment system, groundwater injection system, and a slurry wall will decrease the incremental cost of these options dramatically compared to what this combination of processes could cost at other sites.

table elevation within the measured zone of influence of the soil venting systems. Compressed air is injected into the saturated zone through these points and moves laterally outward and upward through the water table to the vadose zone where it is captured by the soil venting system. In the process, the injected air picks up VOCs from the groundwater and the capillary fringe zone and transports them to the soil venting system for removal from the subsurface. Under the right conditions, this process can dramatically speed up remediation of groundwater and soil.

Figure 6 provides a schematic of a soil venting system. Table 10 summarizes representative RETEC soil venting and groundwater aeration projects.

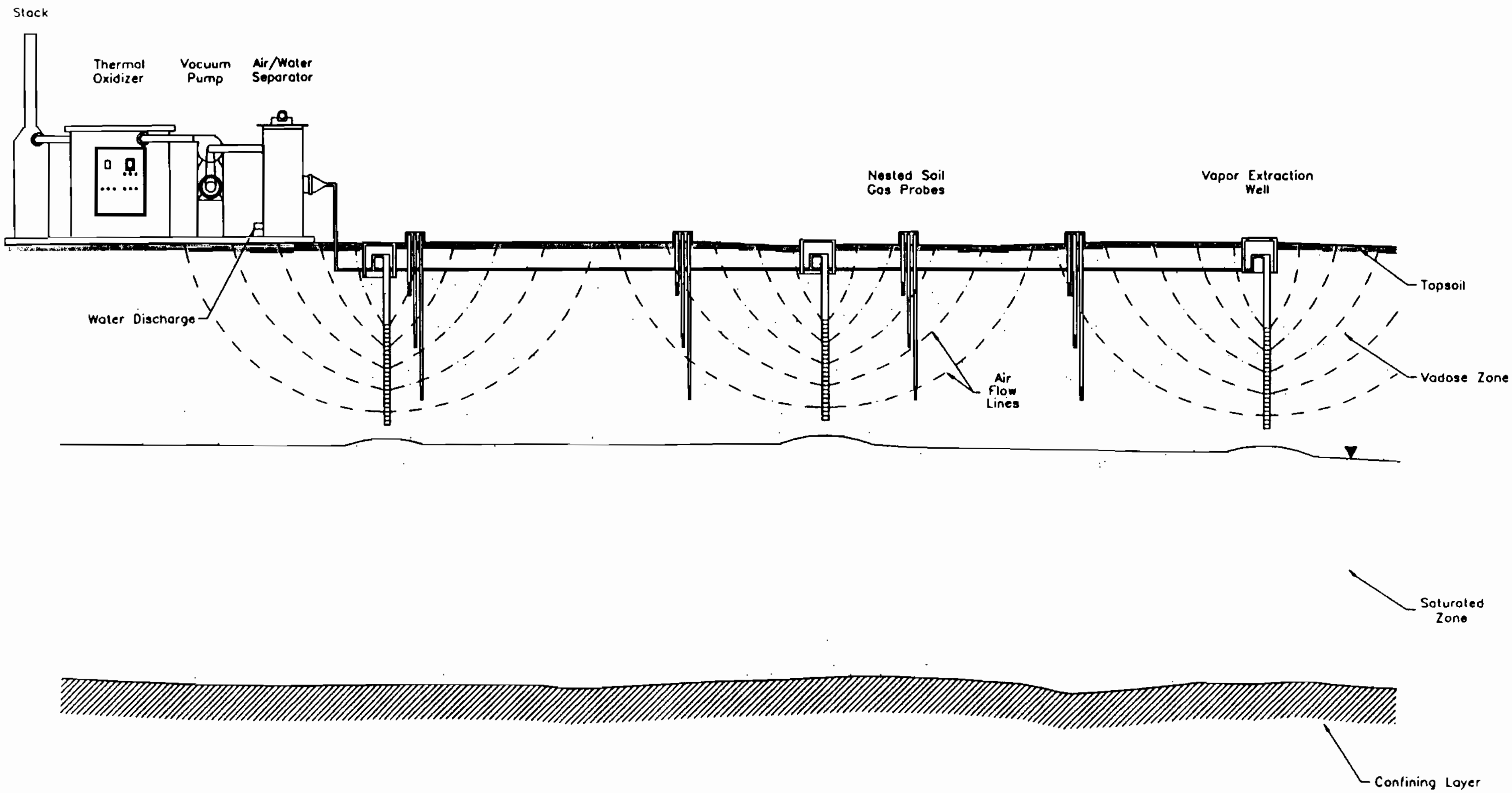
4.5 PUMP-AND-TREAT SYSTEMS

RETEC's hydrogeologists and engineers have installed groundwater extraction systems and containment systems at numerous hydrocarbon spill sites. To efficiently design these systems, RETEC undertakes a variety of aquifer tests such as slug tests, packer tests, and pump tests to characterize the aquifer(s). These data are then used in various groundwater models to predict the aquifer's response to various pumping conditions.

RETEC's engineers are intimately familiar with the physical/chemical and biological treatment processes that may be used to treat extracted groundwater. Our engineers have designed, installed and operated groundwater and wastewater treatment systems at Superfund sites, manufactured gas plant sites, coke manufacturing and coal tar distillation plants, wood treating plants, and industrial wastewater treatment plants. To arrive at a least-cost solution, RETEC follows a comprehensive five (5) step procedure. Figure 7 presents this approach. The five (5) steps shown are performed in sequence with the overall objective of implementing a groundwater management system that achieves the remedial objectives of implementing a groundwater management system that achieves the remedial objectives at least cost. The numerical order of the steps is intended to provide a sequence whereby the client can review each step and provide input for direction of subsequent tasks.

RETEC evaluates a number of potential treatment and discharge options for the purpose of providing an optimal treatment system which best serves to meet a client's particular needs. RETEC is able to do this efficiently because of its focus on a particular set of industries related

RETEC



SUBTECH.DWG

Vapor Extraction

FIGURE 6

TABLE 10
REPRESENTATIVE SOIL VENTING AND GROUNDWATER AERATION PROJECTS

Soil Venting of Chlorinated Solvents Manufacturing Plant, New Jersey	RETEC designed and installed a pilot-scale soil venting system for a site contaminated with a wide variety of hydrocarbons and halogenated hydrocarbons. The site is an active packaging plant that is regulated under New Jersey's RCRA laws. As a part of the design, RETEC modeled the site using a finite difference model to estimate the total recovery and component recovery of hydrocarbon versus time. In addition, RETEC modeled vapor flow of the soil venting system by using a modified single phase flow finite difference model.
Venting of Petroleum Hydrocarbons Fuel Oil Spill, New Jersey	RETEC designed an in situ bioremediation process which combines soil venting and groundwater recovery with surface treatment using activated carbon, and reinjection of treated groundwater and nutrients to the saturated and unsaturated zones of the site.
Soil Venting of Ink and Dye Contamination Manufacturing Plant, Kentucky	RETEC designed and installed a soil venting system to remove low level contamination of volatile hydrocarbons at an industrial facility involving inks and dyes. Soil contamination was detected during removal of several underground storage tanks. The soil venting system included three vertical extraction wells and carbon adsorption canisters. Soils at the site include sand and clay.
Soil Venting of Gasoline Spill Petroleum Products Terminal, Idaho	RETEC designed, permitted, and installed a soil venting system for a 60,000 gallon gasoline spill at a petroleum products storage terminal. Pilot testing and air modeling were conducted to provide data needed to acquire air permits for the treatment facility. Off-gases from the extraction wells are being discharged to a thermal oxidizer for treatment. A system of air-sparging wells was added to aerate the aquifer and replace the groundwater containment system
Bioventing of Petroleum Hydrocarbons Petroleum Products Terminal Rhode Island	RETEC is completed a pilot study to evaluate stimulation of natural biodegradation of petroleum contaminants in the vadose zone using soil venting to provide increased oxygen to contaminated areas. Soil moisture and nutrients were introduced to the subsurface through a series of horizontal trenches. Laboratory analyses of soil samples showed positive rates of removal.
Soil Venting for Remediation of Product Storage Areas, Gulf Coast Refinery	RETEC recently completed a Feasibility Study to evaluate remediation alternatives for gasoline contaminated soil and groundwater at a refinery product storage tank farm. Thermal desorption, biotreatment, soil venting, and off-site disposal alternatives were analyzed. Soil venting with vacuum enhanced recovery of free-phase gasoline hydrocarbons was selected as the most cost-effective alternative. Due to the shallow water table at the site, horizontal wells/trenches will be installed for soil venting. To enhance recovery of free-phase hydrocarbons and lower the water table at the site,

vacuum pumps will be utilized for groundwater and hydrocarbon recovery.

Soil Venting and In Situ Aquifer Aeration
Warehouse Facility, Pennsylvania

RETEC recently designed and completed start-up of a full-scale soil venting system to remove volatile organics from beneath a ten-acre warehouse facility. Due to the large impermeable barrier caused by the warehouse floor, air inlet wells were constructed to provide supplemental air to the extraction wells. Cleanup criteria for the site are based on reducing contaminant levels in groundwater. If additional treatment is needed after venting, a groundwater aeration system will be installed to enhance performance of the soil venting system.

Bioventing and Biofiltration
Petroleum Products Terminal
Rocky Mountain Region

RETEC designed a bioventing and biofiltration system to Rocky remediate hydrocarbons at a petroleum marketing terminal. A pilot-scale venting system was operated at the site for 72 hours to evaluate the effectiveness of soil venting. Based on the results of the pilot test, a full-scale bioventing and biofiltration system was designed, consisting of three deep venting wells and one shallow venting well. Performance predictions indicate that as much as 80 percent of the gasoline hydrocarbons will be degraded in situ by bioventing and that greater than 90 percent of the volatile hydrocarbons in the off-gases will be degraded by the biofiltration system.

Soil Venting/Groundwater Aeration
Adhesive Processing Plant, Ohio

RETEC designed, installed, and started-up a pilot-scale soil venting/groundwater aeration (SV/GAS) system at an adhesive processing plant. The chemicals-of-interest at the site included the BTEX series of compounds, primarily toluene. Contamination was found in the unsaturated zone, and in the groundwater in the upper level of the saturated zone. The SV/GAS was installed to serve as a plume control measure to prevent contaminants from moving further downgradient. As part of the conceptual design and engineering of the system, RETEC used a computer model simulating site conditions to predict operational parameters. A soil gas survey was performed on the site to aid in the field placement of the system, to assure that the system would straddle the contaminant plume. A 100 foot horizontal soil venting system was installed in the unsaturated zone. Five air injection wells were installed into the saturated zone below the depth of the contamination. The SV/GAS was started-up and operated by RETEC on a pilot basis. Over the one month pilot operation period, approximately 350 lbs of solvent was recovered from the subsurface plume. The off-gas from the system was treated with activated carbon.

RCRA Corrective Action
Petrochemical Plant
Gulf Coast Region

RETEC conducted pilot testing of a sol venting system to remove volatile aromatics and chlorinated solvents from a series of sand lenses. The pilot study was conducted to develop data to select and design a long-term remediation process. The pilot study was conducted as part of the Corrective Measures Study for RCRA Corrective Action.

Confidential Client, Ohio,
Chemical Production Plant

RETEC personnel designed and installed a soil venting system to cleanup solvents in an area where a new building will be installed. The installation of this system will allow building construction to proceed over the area of impact.

Figure 7
RETEC's Approach For Least Cost Treatment of Contaminated Groundwater

Step 1
Characterize Site Conditions

- Determine Design Flowrate
- Identify Chemicals-of-Interest and Respective Concentrations
- Develop Implementation Schedule
- Develop Operating Schedule

PURPOSE: Sets Design Conditions.

Step 2
Initial Screening

- Review Site Data
- Screen Disposition Options
- Screen Treatment Alternatives

PURPOSE: Determines Realistic Alternatives.

Step 3
Engineering Evaluation Testing

- Collect Samples and Characterize
- Laboratory Bench-Scale Testing
- Pilot-Scale Testing
- Compile Data and Report Findings

PURPOSE: Provides Actual Engineering Data for Design Optimization with Confirming Discharge Quality Attainable for Selected Alternatives.

Step 4
Detailed Engineering Evaluation

- Evaluate & Select Optimal Treatment System
- Prepare Conceptual Design of Optimal System
- Report Findings
- Engage in Regualtory Negotiations

PURPOSE: Selects the Least Cost and Technically Feasible Treatment System and Disposition Option.

Step 5
Implementation

- Obtain Permits
- Prepare Detailed Process Design
- Procure Equipment
- Supervise Construction
- Start-Up and Operator Training
- Operation (optional)

PURPOSE: Finalize Design, Install and Start-Up System.

to coal- and oil-based production processes. RETEC possesses an extensive in-house database allowing quick and efficient technology screening for treatment of pumped contaminated groundwaters. Additionally, RETEC personnel have performed well over 200 technology screenings focused on pumped groundwater treatment and discharge; many of these screenings involved treatability testing which led to full-scale design and implementation.

Table 11 provides a summary of representative RETEC groundwater treatment and process wastewater treatment projects.

4.7 FATE & TRANSPORT ANALYSIS

RETEC applies subsurface computer models when necessary to gain a better understanding of media flow to:

- evaluate plume extent (concentration gradients, possible migration pathways, travel times);
- evaluate sensitivity of different media parameters to migration potential; and
- estimate media concentrations at reception locations for risk assessment.

RETEC also uses computer models for subsurface media remediation, such as design evaluation for plume capture, source containment, and subsurface treatment, as well as prediction of subsurface treatment times.

RETEC's approach to subsurface modeling typically follows these nine steps:

1. Definition of project objectives.
2. Review of site data.
3. Conceptual model development.
4. Translation of model and site data into model-ready data.
5. Calibration of model.
6. Verification of model.
7. Sensitivity check of model parameters.
8. Model predictions.
9. Model report.

Table 11
REPRESENTATIVE PROJECTS ADDRESSING TREATMENT OF EXTRACTED GROUNDWATER

GROUNDWATER TREATMENT
Minnesota Superfund Site

RETEC was contracted to evaluate, design, and implement a groundwater treatment system to handle a combined 140 gpm design flow from three gradient control wells at a Superfund site which was a former wood treating and coal-tar refining plant. Specific work performed included review of all historical site data, technology paper screening, engineering evaluation testing (i.e., treatability), conceptual and process design, regulatory permit negotiations, equipment specification and procurement, construction supervision, start-up and operator training. Technologies evaluated during the paper screening included biological fluidized bed, UV/chemical oxidation (ozone, hydrogen peroxide), chemical oxidation, sand filtration, and activated carbon. Based upon the results of this screening and subsequent onsite pilot-scale treatability testing and design work, the full-scale system implemented consists of a potassium permanganate ($KMnO_4$) chemical oxidation/sand filtration step for iron and manganese removal, followed by activated carbon adsorption for removal of soluble organics (i.e., phenolics and polynuclear aromatic hydrocarbons). Final discharge is to surface water via an NPDES permit.

GROUNDWATER TREATMENT
Alabama Wood Treating Site

As part of a site remediation of creosote-contaminated soil and debris in a swampy area at a wood treating facility in Alabama, RETEC evaluated, designed, and implemented a system to collect and treat contaminated groundwater and surface water. To facilitate excavation of the soil and debris, a system was installed to collect both standing surface water as well as groundwater flowing to the surface under artesian conditions. From a common collection sump, the water was pumped to a primary separator for product recovery and removal of debris. After this, the water was treated at a rate of approximately 70 gpm via chemical coagulation/flocculation for emulsified oil removal, sand filtration and activated carbon column adsorption. Preliminary engineering evaluation work included both a paper screening and laboratory treatability testing chemical coagulation/flocculation, gravity separation, air stripping, activated carbon adsorption and biological treatment as potential treatment processes prior to selection of the system finally installed. Generated waste solids from the full-scale treatment system were dewatered via a filter press and subsequently disposed of in a permitted landfill. During a five (5) month period, approximately 5,000,000 gallons of water was collected, treated and discharged under an NPDES permit, with no violations occurring.

GROUNDWATER REMEDIATION
California Superfund Site

RETEC personnel directed treatability testing which led to the development of a groundwater treatment process at a west coast Superfund site. The system installed consists of an air stripper, to remove volatile organic compounds including short-chain chlorinated hydrocarbons, and a bioreactor to degrade soluble organic compounds, such as acetone and 2-butanone. Contaminated groundwater is passed through the air stripper at a rate of 50 gallons per minute. The effluent from the air stripper then passes through a 10,000 gallon bioreactor and is discharged under an NPDES permit. The treatment system has been operating since December 1986 and meets discharge levels of 5 ppb or less for chlorinated hydrocarbons, 500 ppb or less for ketones, and 1 ppm or less for alcohols and glycols.

GROUNDWATER TREATMENT BY UV/OZONE
Former Wood Treating Site

RETEC personnel performed a technology evaluation to address treatment of approximately 100 gpm of pumped groundwater at a former creosote wood treating plant site. The groundwater contained visible oils, phenolics, and PAHs. Technologies evaluated on a laboratory-scale included oil/water gravity separation followed by either chlorine dioxide, UV/ozone, or activated carbon column adsorption. Results of the treatability work, in conjunction with preliminary engineering evaluations, supported the selection of oil/water gravity separation followed by UV/ozone chemical oxidation as the best alternative. A full-scale system was designed, constructed, and has been operational since 1986 with the treated discharge routed to a POTW.

BIOLOGICAL CO-TREATMENT OF GROUNDWATER WITH MUNICIPAL WASTEWATERS
Coal-Tar Site Groundwaters

RETEC personnel performed an on-site pilot-scale treatability study to evaluate the capability of co-treating manufactured gas plant (MGP) site pumped groundwaters with municipal wastewaters at Publicly Owned Treatment Works (POTW) employing activated sludge biological treatment. Purgeable aromatics, phenolics, metals, and polynuclear aromatic hydrocarbons were specifically addressed to evaluate mechanisms of volatilization, adsorption, and biodegradation. Data from this study demonstrated that MGP site groundwaters can be effectively co-treated with municipal wastewaters in POTW activated sludge facilities.

GROUNDWATER REMEDIATION
Industrial Plant

RETEC personnel performed key tasks in an RI/FS for restoring a 90-acre site, including the management of contaminated groundwater. Treatability work was performed which evaluated activated carbon adsorption, *in situ* treatment, air stripping, UV/ozone, and oil/water separation processes.

GROUNDWATER TREATMENT
Texas Petroleum Refinery

Due to the recently imposed toxicity characteristics (TCLP) requirements, a refinery which was deep well injecting contaminated groundwater being pumped for gradient control purposes, was required to treat a benzene level less than 500 ppb. After and initial paper screening, it was decided that both carbon adsorption and air stripping offered technically viable options. Subsequent treatability work confirmed that carbon adsorption offered a slightly better alternative in terms of both cost and ease of operation. On this basis, RETEC followed through with detailed process design, equipment procurement, construction supervision, start-up and operator training of a full-scale 100 gpm system. It is noteworthy that all work cited was performed over a six (6) week period.

SITE GROUNDWATER POTW CO-TREATMENT EVALUATION
Manufactured Gas Plant Sites

Remediation Technologies, Inc. (RETEC) was contracted by a northeast utility to investigate the technical feasibility of the co-treatment of manufactured gas plant (MGP) site groundwaters with municipal wastewaters in Publicly Owned Treatment Works (POTW). The work was conducted as a result of a recent pilot-scale study which was conducted by RETEC for the Gas Research Institute (GRI). The investigation included modelling of a groundwater pumping system along with modelling of POTW co-treatment conditions for three different MGP sites. The results of these evaluations supported that the three different MGP site groundwaters can be effectively co-treated with respective municipal wastewaters in respective activated sludge treatment POTWs, and thus, offer technically viable and cost-effective solutions for remediation of the three MGP sites. RETEC is presently working with the utility in terms of full-scale demonstrations and subsequent permanent groundwater pumping systems for the sites with little or no pretreatment prior to POTW permitted discharge.

BIOLOGICAL TREATMENT OF CONTAMINATED GROUNDWATER
Former Wood Treating Site

A pilot-scale trailer-mounted submerged fixed-film bioreactor was designed and operated by RETEC to evaluate the feasibility of biologically pretreating groundwaters from an abandoned wood treating site where creosote (PAH), pentachlorophenol (PCP) and metals have entered the shallow groundwater. PAH removals of more than 95 percent were achieved within the first two months of system operation and were maintained even at the shortest attempted hydraulic retention time of 1.5 days. No significant PCP removals were achieved during the first several months of acclimation, after which 75 to 90 percent reductions were achieved. This increase in PCP removal was significantly affected by the reactor hydraulic retention times, with retention times of between 4 to 5 days providing the best treatment. When pilot-scale treatment operations commenced, the chemical concentrations were one order of magnitude higher than expected, thus necessitating the addition of an activated carbon adsorption unit downstream of the trailer-mounted biological system prior to discharge to the local POTW.

GROUNDWATER TREATMENT
Indiana Superfund Site

RETEC was contracted by an international engineering/construction company to assist them in implementing a pumped groundwater treatment system at a U.S. EPA Superfund site in Gary, Indiana. The site was an abandoned landfill with the soil and groundwater contaminated with a wide variety of organic and inorganic chemicals. As stipulated in the Record of Decision (ROD) for the site, groundwater is to be pumped from fourteen (14) wells at a total combined flowrate of approximately 40 gpm. Once pumped, it is to receive surface treatment in a biological sequencing batch reactor (SBR) process prior to reinjection. On this basis, RETEC was contracted to evaluate, design, and help implement the groundwater treatment system. Specific work performed included review of all historical site data, conceptual design, laboratory treatability testing, detailed process design and equipment specification, construction supervision, start-up, and operator training. Based upon the treatability/design work performed, the system implemented entails pretreatment involving oil/water gravity separation followed by potassium permanganate chemical oxidation/settling for iron removal, followed by biological SBR treatment for organics removal. Sludges from both the pretreatment and the SBR treatment steps are to be dewatered via pressure filtration. It is noteworthy that all work (i.e., through implementation) was completed in a very short time period of six (6) months.

RETEC uses computer models to simulate all phases of fluids and contaminants in the subsurface environment. These include dissolved species in groundwater, subsurface gas flow and contaminants, and non-aqueous phase liquids (free and residual liquid hydrocarbons). RETEC's analytical and numerical computer modeling capabilities including two- and three-dimensional finite difference and finite element models. Frequently, however, more straightforward analytical solutions can be utilized for groundwater projects. In addition to their use in the design of subsurface remediation systems, computer models are also applied by RETEC to perform quantitative risk assessments to determine appropriate remedial responses, or to negotiate alternative cleanup levels.

RETEC has completed numerous RCRA and CERCLA projects that have involved mathematical modeling of the movement of hazardous constituents in groundwater, unsaturated zone soils, and air (Table 12). RETEC has also been involved in state-of-the-art research using laboratory and field studies to demonstrate the applicability of different mathematical models to real-life situations. RETEC has developed a number of mathematical models for simulating other environmental transport and fate processes. These include models for estimating vapor-phase intrusion into buildings and models for evaluating chemical fate in stream ecosystems. In addition, RETEC uses a variety of finite difference models to evaluate operating parameters and estimate contaminant recovery from the unsaturated zone during soil venting.

4.8 LABORATORY TREATABILITY STUDIES AND TECHNOLOGY DEMONSTRATION SERVICES

RETEC operates three laboratory test facilities for the evaluation and development of on-site remediation technologies. The treatability laboratories are located in Seattle, Boston and Pittsburgh. The laboratories are equipped to perform bench- and pilot-scale studies for a wide variety of thermal, biological, physical, and chemical treatment technologies.

RETEC has performed over 200 treatability projects which have focused on applying specific technologies to actual problems and providing the engineering design information necessary to implement cost-effective remediation plans. The laboratories specialize in developing integrated on-site treatment systems and providing objective evaluations of potentially applicable technologies. The laboratories have also participated in state-of-the-art applied research programs on innovative treatment techniques, including biological and thermal

TABLE 12
REPRESENTATIVE MODELING PROJECTS

Groundwater Modeling
Montana Railroad Fueling Site

RETEC conducted a groundwater investigation and corrective action program at a railroad fueling facility containing diesel fuel and chlorinated organic compounds. Site characterization activities included monitor well installation and sampling, test pit excavations, soil borings, aquifer testing and soil gas surveys. A groundwater model was developed for the site to stimulate stresses on the unconfined aquifer upon placement of several product recovery wells. A two-dimensional finite difference model was used to model the capture zone and required pumping rates. Design of a groundwater treatment system was based on model results.

Groundwater Modeling
Superfund Site

As part of the investigation of a CERCLA wood preserving site in Montana, groundwater modeling was used to simulate the transport of contaminants in a surficial aquifer over time. The maximum extent of the plume migration was determined after the model was calibrated to current site conditions. A two-dimensional advection-dispersion model was employed to characterize solute transport.

Groundwater Modeling
Washington Petroleum Refinery

RETEC was contracted to design a dewatering system under a RCRA land treatment unit at a refinery in Washington. The groundwater flow surrounding the land treatment unit was modeled with MODFLOW, using initial and boundary conditions derived from a site wide hydrogeological investigation. The model was calibrated using information from the past few years, then a series of transient simulations were run varying the number and spacing of drains, as well as the amount of recharge. The results of the simulations were used to determine if the water table could be kept at least three feet below the lower treatment zone at all times of the year. In addition, a determination was made on the quantity of water that would be drained on a monthly basis and sent to the wastewater treatment plant.

Groundwater Modeling
Delaware Petroleum Refinery

RETEC was contracted to identify and cost a number of options for dealing with groundwater contamination emanating from a RCRA oily waste impoundment. Oil escaped the unit and was being transported as immiscible product floating on the water table towards the Delaware River. As part of the investigation, RETEC modeled the aquifer using MODFLOW. The model was calibrated to the past water table, and then a series of transient runs were made with a variety of recovery designs. The number, orientation, and pumping rates of various drains, wells, and combination drains/wells were evaluated. A final design was selected that provided free product recovery, hydraulic containment of the groundwater, and protection of the river, at a minimal cost.

Confidential Client, New Jersey
Packaging Plant

RETEC designed a phased vapor extraction system (VES) for a site contaminated with a wide variety of hydrocarbons and halogenated hydrocarbons. The site is an active packaging plant and is regulated under New Jersey's ECRA laws. As a part of the system expansion design, RETEC modeled the site using VENTING to estimate the total recovery and component recovery of various contaminants versus time. In addition, RETEC is modeling vapor flow of the VES system by using a modified single phase flow finite difference model.

In Situ Bioremediation Projects

RETEC routinely uses its groundwater modeling capabilities as a tool to design in situ bioremediation aquifer cleanups. For example, RETEC recently designed and installed a cleanup system for a fuel oil contaminated aquifer in New Jersey. The site is a residential property located within a half mile of the ocean. RETEC modeled the aquifer in an area surrounding the property to determine the number, placement, pumping rate, and capture zones of the injection/extraction wells in order to maximize the delivery of oxygen and nutrients to the contaminated areas.

Computer Aided Design of Diesel Recovery System

RETEC is using computerized numerical models to evaluate diesel and groundwater remediation alternatives at a railway facility along the Arkansas River. A previous site investigation lead by RETEC showed that liquid hydrocarbon was present in soil borings and wells in a 13-acre area. In order to prevent free product and groundwater from moving into the river, the model will simulate groundwater and liquid hydrocarbon containment and recovery. Disposal options for the water to be tested by the model include recirculation to the aquifer, discharge to the river under an NPDES permit, and discharge to the POTW which currently accepts wastewater from the existing oil/water separator on the site.

Groundwater Modeling Former Wood Treating Site, Mississippi

RETEC is developing conceptual and numerical models of a former wood treating site to characterize the alluvial aquifer, to simulate transport of contaminants through the aquifer over time to support risk-based cleanup criteria, and to evaluate the feasibility of the proposed in-situ bioremediation pilot test. Field-measured data were used in both analytical and numerical models which simulated the transport of a conservative groundwater tracer through the proposed in-situ bioremediation pilot test area. These simulations were then used to assist in the design of the groundwater tracer test, which was conducted to better define aquifer hydraulic parameters and to simulate the in-situ pilot test. Using field-measured results from the tracer test, the capture zone of the extraction well was modeled to aid in understanding the tracer test results, to maximize contaminant pump-and-treat recovery, and to refine the in-situ pilot test design.

Groundwater Modeling Texas Chemical Facility

RETEC is currently involved in a RCRA corrective action program at a petro chemical facility in south Texas. RETEC was contracted to evaluate a number of innovative technologies including in-situ bioremediation, soil flushing, and vapor extraction. Six month pilot tests of both in-situ bioremediation and vapor extraction have recently been completed. RETEC is currently evaluating full-scale alternatives and is in the process of modeling a fully three dimensional groundwater flow and pathline analysis with MODFLOW and MODPATH. In addition, RETEC is also modeling vapor flow for the full-scale design of potential vapor extraction system.

Groundwater Modeling Northwest Wood Treating Facility

RETEC is currently involved in a groundwater corrective action program at a RCRA wood treating facility in the northwest US. As part of the corrective action program, RETEC has conducted pilot in-situ bioremediation studies and product recovery tests, prepared an ACL (Alternate Concentration Limit) Petition, and initiated groundwater flow and transport modeling using MOC, MODFLOW, and BioPlume II to support the bioremediation corrective action strategy.

Minnesota Groundwater Capture Modeling

A subsurface remedial design consisting of extraction wells and spray evaporation/treatment ponds was determined to be the most practicable alternative for treatment of groundwater contaminated by an abandoned landfill site. Groundwater modeling was used to determine location, pumping rates, and number of recovery wells required to contain the plume of contaminated groundwater. The impact of recharge from the treatment ponds was also evaluated. A finite-element groundwater model developed by Colorado State University was used to evaluate flow conditions. Data from an aquifer pump test were used to calibrate the model. Sensitivity analyses on hydraulic conductivity, porosity, and recharge parameters were conducted. Final output consisted of 2-D contour maps delineating the capture zone of the various design possibilities.

Groundwater Modeling Former Wood Treating Site Minnesota

RETEC is currently involved in a land wood treatment and RCRA groundwater corrective action program at a former wood treating facility in Minnesota. As part of the corrective action program, gradient-control wells were installed and utilized to capture a contaminant plume moving downgradient from the site. Additional plume capture was required. RETEC was contracted to evaluate the capture zone that would develop by installing a fourth gradient-control well. RETEC completed the capture zone modeling using the WHPA (Wellhead Protection Area Delineation) model. The model utilizes a modified version of RESSQ, a semi-analytical model. WHPA was utilized to delineate capture zones for a system of four wells with variable pumping rates.

desorption technologies and development of methods to evaluate and treat soils and sludges contaminated with coal tars.

The facilities and services available for treatability testing include bench- and pilot-scale reactors suitable for evaluating treatment of soils, sludges, and groundwater. Treatment options include aerobic and anaerobic bioremediation, soil washing, thermal desorption, and volume reduction (e.g., dewatering). Water treatment technologies tested at RETEC include neutralization/precipitation, UV/chemical oxidation, activated sludge and fixed-film biotreatment, air stripping, flocculation/coagulation, filtration, oil/water separation, and carbon adsorption. RETEC can also investigate *in situ* applications of these technologies with a special emphasis on bioremediation and soil venting.

RETEC treatability testing equipment includes the following:

- **Bench-Scale Liquid/Solids Bioreactors** - 1- to 26-gallon reactors with mechanical impellers and aeration suitable for testing slurry-phase biological treatment.

- **Bench-Scale Solid-Phase Bioreactors** - Reactors simulating solid-phase biological treatment systems including glove boxes with air-flow controls for measuring volatile emissions.

- **Mobile Pilot-Scale Water Treatment Systems** - Available equipment includes activated sludge units, air strippers, activated carbon columns, and a fixed-film bioreactor.

- **Pilot-Scale Thermal Desorption Units** - Two fixed-base units for thermal treatability testing. One has a capacity of 100 lb/hr. and the other has a capacity of 1,000 lb/hr. A mobile unit is also under development.

- **Bench-Scale Soil Columns** - 6-inch to 6-foot long columns for testing *in situ* bioremediation and soil flushing.

- **Bench-Scale Filter Press** - Units capable of assessing dewatering capabilities of soils and sludges.

4.9 HYDROCARBON RECOVERY SYSTEMS

RETEC has designed, negotiated and implemented hydrocarbon recovery systems at numerous petroleum marketing facilities, railroad fueling sites and wood treating sites. Our experience with product recovery includes installation of both french drain systems and product recovery wells. RETEC has installed and understands the appropriate applications of both single-phase and dual-phase pump systems. Additionally, RETEC has experience in the recovery of both floating product (petroleum fuels) and sinking organic phases (coal tars, creosote, etc.).

As a technology leader, RETEC has participated in the development of two innovative technologies for hydrocarbon recovery.

1) recovery of dense viscous hydrocarbons, such as coal tars, from the subsurface using hot water or steam, and

2) enhanced recovery of hydrocarbons from low permeability environments using vacuum-enhanced extraction technology.

In the first case, RETEC, in association with Western Research Institute, has combined enhanced product recovery with *in situ* biological degradation methods. The enhanced recovery technique, developed for secondary recovery and proven in oil fields throughout the world, uses hot water or steam to recover a large fraction of the organic liquid by changing the viscosity and density of the liquid. Once the organic fluid density becomes less than that for water, it will become buoyant and begins to move upward towards the water table. Heating the aquifer reduces the viscosity of both the organic liquid and water, making both more mobile and flowable. The organic fluids and injected water are recovered using conventional water-flood hydrocarbon recovery techniques. Subsequently, the injection and recovery wells are used for *in situ* biological treatment. Important synergies exist between these two technologies which offer the potential for complete site restoration. In recognition of the great potential of these two technologies, RETEC and WRI are performing formal demonstrations of these processes in the U.S. EPA SITE Program.

For low permeability environments, RETEC has begun to apply vacuum-enhanced extraction technology commonly used in the dewatering industry to improve hydrocarbon recovery rates in low permeability environments. This technology is most useful when site permeabilities are on the order of 10^{-3} to 10^{-5} cm/sec or when transmissivities are small (30 to

300 gal/d/ft) within a thin perched saturated zone. The production of groundwater and hydrocarbons is enhanced by reducing the total hydraulic head inside the well to levels that cannot be reached by liquid pumping alone. Wells, that would otherwise be pumped dry at pumping rates of a few gallons per minute, can be made to produce a more sustained yield of either water or fluid product. The vacuum-enhanced approach to fluid removal is more aggressive than conventional pumping and will enlarge the zone of hydraulic influence of the recovery well.

5.0 STANDARD TERMS AND CONDITIONS

RETEC has prepared this proposal based upon our Standard Commercial Terms which are presented in Attachment 1 (RETEC Standard Commercial Terms). Attachment 2 is a copy of our Master Professional Services Agreement which provides our proposed terms for undertaking this work.

RETEC's Cost Proposal is presented in Appendix A. This cost proposal represents our estimate to undertake the work as described in Section 2. RETEC will commit to undertake the preparation of the draft Pre-Remedial Design Investigation Work Plan and the draft Remedial Design Work Plan (Basis of Design Memorandum) on a fixed price basis. RETEC will commit to the cost of implementing the scope of work described in Section 2.1 for the Pre-Remedial Design Investigation; however, RETEC will not provide drilling, surveying and analytical subcontractors on a fixed-price basis.

ATTACHMENT 1

SERVICE COST SCHEDULE

LABOR BILLING RATES:

Work performed on Time & Materials (T&M) contracts will be billed as follows, based on hourly rates for staff in the following categories:

Professional Category	Job Classification Title	Hourly Billing Rate
P-1	Technician I	$ 20.00
P-2	Technician II	$ 23.00
P-3	Technician III	$ 26.00
P-4	Technician IV	$ 29.00
P-5	Technician V	$ 32.00
P-6	Tech. VI / Eng. / Sci. I	$ 36.00
P-7	Tech. VII / Eng. / Sci. II	$ 40.00
P-8	Tech. VIII / Eng. / Sci. III	$ 45.00
P-9	Tech. IX / Staff Eng. / Sci. I	$ 50.00
P-10	Tech. X / Staff Eng. / Sci. II	$ 56.00
P-11	Tech. XI / Staff Eng. / Sci. III	$ 63.00
P-12	Tech. XII / Project Eng/Sci. I	$ 71.00
P-13	Tech. XIII / Project Eng/Sci. II	$ 79.00
P-14	Project Eng. / Sci. III	$ 89.00
P-15	Senior Eng. / Sci. I	$ 99.00
P-16	Senior Eng. / Sci. II	$107.00
P-17	Senior Eng. / Sci. III	$115.00
P-18	Managing Eng. / Sci. I	$123.00
P-19	Managing Eng. / Sci. II	$130.00
P-20	Managing Eng. / Sci. III	$140.00

Hourly rates shown above are fully loaded, including fringe benefits, overhead and fee. These rates are applicable to all technical and administrative support efforts (including secretarial performed directly for the Owner. Hours billed to projects will include reasonable time for local and/or inter-city travel. No more than 8 hours of travel will be charged per day; travel time outside of regular business hours will not be charged. Client-authorized overtime hours will be billed at the above rates for non-hourly (exempt) employees and at 130% of the above rates for hourly (non-exempt) employees. Expert witness testimony and active participation in hearings or legal deposition will be billed at 150% of the above rates.

OTHER DIRECT COST BILLING RATES:

Other Direct Costs (ODC) incurred on behalf of the Owner as it's agent or otherwise, will be billed on the following basis:

At Cost Plus Ten (10) Percent
Travel and travel-related expenses
Shipping and Freight Charges
Equipment Purchases and Rentals
Outside Computer Usage
Communication Expenses (Long Distance, Overnight Postage)
Expendable Materials and Supplies
Subcontractors (Analytical Labs, Drillers, Contractors, etc.)

At Current List Prices
In-house Laboratory Analysis
Facsimile & Reproduction Copies
Internal Computer Usage
ReTeC Equipment Leases and Rentals
Special Fees / Permits / Insurance / License Charges

ATTACHMENT 2

REMEDIATION TECHNOLOGIES, INC
SAMPLE MASTER PROFESSIONAL SERVICES AGREEMENT

THIS AGREEMENT is made this ____ day of _____ , 1992 by and between:

(hereinafter called "Owner")

Remediation Technologies, Inc.
9 Pond Lane
Concord, MA 01742
Federal ID No. 04-2896814

(hereinafter called "ReTeC"), and

WITNESSETH:

ARTICLE 1 - SCOPE OF SERVICES, hereinafter referred to as the "Work". ReTeC shall provide qualified personnel to perform engineering, scientific, technical, procurement and remediation management services on a task-by-task basis in connection with the identification and remediation of hazardous wastes which may be present on various Owner properties throughout the United States. Individual tasks will be authorized by written Work Orders (Exhibit A) issued from time to time by Owner and accepted in writing by ReTeC.

Each work order hereunder shall refer to this Agreement, shall be governed by the terms and provisions hereof, and shall indicate the scope of and include any required data or specifications for the Work to be performed pursuant thereto. ReTeC shall not proceed with any phase of any Work prior to the receipt of a written work order describing such work and its written acceptance of such order.

ARTICLE 2 - INTENT. Owner desires to complete the Work in an economical manner consistent with the Scope of Services. ReTeC, recognizing the trust and confidence established with Owner by virtue of this Agreement, agrees to use its best efforts in furnishing skill and judgement in the scheduling and execution of the Work consistent with the interests of Owner and in accordance with its requests and approvals.

ARTICLE 3 - INVOICING AND PAYMENT. Owner shall pay ReTeC for services rendered in accordance with ReTeC's Service Cost Schedule (Attachment 1). The following procedures will be followed in making reimbursement under this Agreement:

(a) No less than once per month during the progress of the work, ReTeC shall provide an invoice of all costs incurred by the ReTeC during the period covered by the invoice.

(b) Invoices are due 30 days after the date of the invoice.

(c) ReTeC shall maintain accurate accounting records of all reimbursable costs paid or incurred by ReTeC in connection with the work and shall permit Owner to have access during regular business hours to all records, account books, vouchers, invoices, and payroll related to direct costs of the Work. In the event Owner desires to perform an audit of ReTeC's direct cost records, it shall be completed within one (1) year after the final billing is presented to Owner.

(d) For work orders performed on a lump sum or fixed price basis, payment will be made in accordance with the payment schedule established at the time the work order is issued by Owner. Owner's audit rights under 3(c) above do not apply to lump sum or fixed price work orders.

ARTICLE 4 - COMPLIANCE WITH LAWS. ReTeC agrees to comply with all applicable local, state, and federal laws and regulations pertaining to the Work under this Agreement.

ARTICLE 5 - INDEPENDENT CONTRACTOR. The relationship of ReTeC to Owner shall be that of an independent contractor.

ARTICLE 6 - TERMINATION. This Agreement shall continue in force until completion of the Work; provided, however, that Owner and ReTeC shall have the right to terminate this Agreement pursuant to the provisions of this Article.

(a) This Agreement may be terminated in whole or in part by either party in the event of a default consisting of substantial failure by either party to fulfill its obligations under this Agreement; provided, that no such termination may be effected unless the defaulting party is given written notice of default and a reasonable opportunity to cure the default.

(b) This Agreement may be terminated in whole or in part in writing by Owner for its convenience; provided, that no such termination may be effected unless ReTeC is given not less than ten (10) days written notice of intent to terminate.

(c) If termination is effected under Paragraph 6(b), Owner will pay ReTeC all reimbursable costs which are due as of the effective date of termination, and in addition, those reimbursable costs incurred in good faith by ReTeC after the effective date of termination in connection with demobilization of equipment and personnel, and subcontract and vendor settlements.

(d) Upon receipt of termination notice pursuant to Paragraphs 6(a) and 6(b) above, ReTeC shall (1) promptly discontinue all Work affected (unless the notice directs otherwise), and (2) deliver to Owner all data, drawings, specifications, reports, summaries, and such other information and materials as may have been accumulated by ReTeC in performing the Work, whether completed or in process, with the exception of one record copy of such information which shall be kept by ReTeC.

(e) The rights and remedies of Owner and ReTeC provided in this Article are in addition to any rights and remedies provided by law or under this Agreement.

ARTICLE 7 - NOTICES. Owner's representative and address for notices and communications is:

Name:
Company:
Address:

The Representative shall be available as necessary for issuing work orders, change orders, inspecting and approving the Work, and for approving invoices and other records of ReTeC. Owner's representative may delegate Owner's work and authority to others as desired, confirming such action in writing to ReTeC.

ReTeC's Representative and address for notices and communications is:

Name:	Mr. Robert Block
Company:	Remediation Technologies, Inc.
Address:	9 Pond Lane Concord, MA 01742

ReTeC's representative shall be available for conferring with, receiving requests, and taking communications from Owner. ReTeC's representative may delegate ReTeC's work and authority to others as he/she desires, confirming such action in writing to Owner.

ARTICLE 8 - ACCESS TO WORK. Owner shall have access at all reasonable times to all Work done and product made by or for ReTeC pursuant to any Work Order hereunder and such Work and product shall be the property of Owner at all times. ReTeC shall turn over to Owner all such Work done and product made upon timely request of Owner during the progress of the Work or at the expiration or termination of the Work to be performed under any order hereunder. ReTeC reserves the right to withhold Work or product in Owner is in arrears pursuant to Article 3 of the Agreement.

ARTICLE **9 - CONFIDENTIALITY.** ReTeC will, for the duration of this Agreement and for a period of five (5) years thereafter, retain in confidence all technical information designated in writing as "CONFIDENTIAL" and disclosed by Owner to ReTeC except:

(a) Owner's technical information previously known to ReTeC;

(b) Owner's technical information which becomes known to ReTeC through legal means;

(c) Owner's technical information which is public knowledge or subsequently becomes public knowledge through no fault of ReTeC and without breach of this Agreement.

Neither party shall be liable for the inadvertent or accidental disclosure of such technical information, if such disclosure occurs, despite the exercise of the same degree of care as such party normally takes to preserve and safeguard its own confidential information.

ARTICLE 10 - LIABILITY AND INDEMNIFICATION.

(a) ReTeC shall indemnify, defend and save Owner harmless from and against all demands, suits, judgement, expenses, attorney's fees, and losses for or in connection with bodily injury (including death) to persons or damage to tangible property arising out of or in connection with the negligent performance of ReTeC, its agents, or employees under this Agreement.

(b) It is recognized that Owner may assert that certain third persons or parties may rightfully bear the ultimate legal responsibility for any and all hazardous materials, pollutants or contaminants which may currently be present on or have originated from its properties.

It is further recognized that certain state and federal statutes related to hazardous waste work provide that individuals and firms may be held liable for damages and claims related to such work under a doctrine of joint and several strict liability. It is not the intention of this Agreement that ReTeC be exposed to any hazardous waste liability arising out of pre-contract site contamination, the activities of others, including Owner, or for any liabilities which may arise from the non-negligent performance by ReTeC of the Work hereunder. Accordingly, for purposes of this Agreement only, and except as provided under paragraph 10(a) above regarding the negligent performance of ReTeC, Owner shall reimburse ReTeC for or otherwise indemnify, defend and save ReTeC harmless from any and all demands, suits, judgement, expenses, attorney's fees, and losses arising out of or in connection with bodily injury (including death) to persons or damage to property which may arise from the presence or origination of hazardous substances, pollutants or contaminants on Owner's property, irrespective of whether such materials were generated or introduced before or after execution of this Agreement and irrespective of whether Owner was aware of or directly involved in the generation or introduction of such materials; provided, however, that nothing hereinabove set forth is intended to shift any responsibility for employee claims that the parties may bear under the Worker's Compensation laws of the state in which the Work is to be performed.

(c) ReTeC shall under no circumstances be considered the generator of any hazardous substances, pollutants or contaminants encountered or handled in the performance of the Work. Without contradiction of any assertion by Owner or third party liability as described in paragraph 10(b) above and for purposes of this Agreement only, it is agreed that any hazardous materials, pollutants or contaminants generated or encountered in the performance of the Work shall be the responsibility of Owner and shall be disposed of under a RCRA hazardous waste Generator Number obtained by and carried in the name of Owner.

(d) Neither party shall have any liability to the other party for loss of product, loss of profit, loss of use, or any other indirect, incidental, special or consequential damages incurred by the other party, whether brought on an action for breach of contract warranty, tort, or strict liability, and irrespective of whether caused or allegedly caused by either party's negligence. Nothing in this provision is intended to affect liability arising from actions brought by third parties.

ARTICLE 11 - INSURANCE. ReTeC shall procure and continuously maintain property, casualty and liability insurance on the kinds and in the amounts shown on the sample Certificate of Insurance in Attachment II to this Agreement. While coverage as shown in Attachment II has been arranged as of the effective date of this Agreement, it is recognized that changes in the insurance market and periodic negotiation of policy renewals may make it impossible for ReTeC to maintain for the life of this Agreement the exact coverage specified. In such event, ReTeC will use its best efforts to obtain the nearest equivalent coverage reasonably available, and Attachment II or any other affected provision of this Agreement will be equitably adjusted and modified in writing accordingly.

ReTeC 's insurance policies listed in Attachment II shall be endorsed to provide that Owner will be given 30 days notice in writing of any cancellation of the policies. Before Work is begun under this Agreement, ReTeC shall provide Owner with certificates of insurance for coverage listed in Attachment II, including a statement that the policies have been endorsed as required herein.

ARTICLE 12 - FORCE MAJEURE. Either party shall be excused from performance of its obligations under this Agreement, other than payment of monies when due, in the event and to the extent that such performance is delayed or prevented by any cause or event beyond the reasonable control of such party including, but not limited to, any act of God or of the public enemy, war, insurrection, riot, civil disturbances, labor dispute, delay in delivery of machinery and equipment, fire, flood, washouts, storms, landslides, explosions, any embargo, or any act or order of any military or civil authority, including courts. Within a reasonable period of time after a party determines that an event of force majeure exists which delays or prevents the performance of its obligations under this Agreement, such party shall give the other party notice

thereof, and such party shall use all reasonable efforts to eliminate such event insofar as possible with a minimum of delay. Nothing herein contained shall require such party to submit to what it considers to be unreasonable conditions or restrictions.

ARTICLE 13 - SUCCESSORS AND ASSIGNS. This Agreement shall inure to the benefit of and be binding upon the parties hereto and their respective successors and assigns. Neither party may assign its interests herein (unless the assignee assumes in writing assignor's obligations hereunder) without the prior written consent of the other party, which consent will not be unreasonably withheld. No assignment shall operate to relieve the assignor of its obligations under this Agreement.

ARTICLE 14 - ATTACHMENTS. The following Attachments hereby become a part of this Agreement:

Exhibit A	Sample Work Order
Attachment I	Services Cost Schedule
Attachment II	Sample Certificate of Insurance

IN WITNESS WHEREOF, the parties have caused these presents to be executed on the date first hereinabove written.

REMEDIATION TECHNOLOGIES, INC.	________________________, INC.
by:	by:
________________________	________________________
Signature	Signature
________________________	________________________
Name Title	Name Title

EXHIBIT A
MASTER PROFESSIONAL SERVICES AGREEMENT

WORK ORDER NO. ______

In accordance with the Master Professional Services Agreement between ReTeC and Owner dated MAY 15, 1992, this Work Order describes the Scope of Services, Time Schedule and Price and Payment Terms for the Project known as:

Scope of Services:

Time Schedule:

Price:

Payment Terms:

Acceptance of the terms of this Work Order is acknowledged by the following signatures of the Authorized Representatives of the parties to the Agreement. This Work Order consists of this document and any supplemental pages attached and referenced hereto.

APPROVAL AND ACCEPTANCE:

REMEDIATION TECHNOLOGIES, INC.
by:

____
Signature

____
Name Title

____
Date

______________________, INC.
by:

____
Signature

____
Name Title

____
Date

6.0 REFERENCES

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APPENDIX A

COST PROPOSAL

RETEC's total estimated cost for implementing the Remedial Design at the Shore Realty Site is $288,200. The cost is summarized on Table 1 and detailed in Appendix B. This cost proposal represents our estimate to undertake the work as described in Section 2. RETEC will commit to undertake the preparation of the draft Pre-Remedial Design Investigation Work Plan and the draft Remedial Design Work Plan (Basis of Design Memorandum) on a fixed price basis with the following conditions:

- the cost includes preparations of the internal draft and revisions of the draft to satisfy the Participating Companies and submittal to NYSDEC and EPA;

- the cost does not include negotiations with NYSDEC and EPA Region II or revisions to work plans to satisfy the regulatory agencies;

- current background data are available to RETEC in appropriate format and at no cost (e.g., current site survey data, property lines, topography are available in AutoCAD data files).

- local legal and administrative approvals necessary for undertaking the predesign work have been obtained (e.g., property access agreements).

- we have assumed the monthly committee meetings are held by teleconference except during client review of deliverables. At that time, the monthly committee meetings will be held in New York City and will be attended by RETEC.

- other specific technical conditions and assumptions included in the text of this proposal.

The fixed-price cost will be $29,000 and $20,000 for the Pre-Remedial Design Investigation Work Plan and the Remedial Design Work Plan, respectively.

RETEC is willing to undertake implementation of the Pre-Remedial Design Investigation on a fixed-cost basis. In the course of negotiations with the regulatory agencies, RETEC will prepare revised fixed-cost proposals to implement the Pre-Remedial Design given the changes in scope required to achieve regulatory approval. If the scope is not modified, RETEC will commit to the cost of implementing the scope of work described in Section 2.1 for the Pre-Remedial Design Investigation; however, RETEC will not provide drilling, surveying and analytical subcontractors on a fixed price basis. As described in Section 3.0, our estimate costs for subcontractors is based upon telephone quotes. Prior to initiating this work, RETEC will solicit written quotes from a minimum of two vendors along with written qualifications to undertake this work.

Table 1
Cost Summary
Remedial Design
Shore Reality Property
Glenwood Landing, New York

Task	Task Description	Labor Hrs.	Labor $	ODC	Subs	Totals
100	Pre-Remedial Design Work Plan	324	23,812	2,600	0	26,412
200	Pre-Remedial Design Activities					
210	Site Characterization	268	16,444	13,725	12,000	42,169
220	Treatability Studies	272	16,464	4,740	28,800	50,004
230	Conceptual Design	426	26,674	2,160	0	28,834
290	Project Mananagement	144	10,384	700	0	11,084
200	Pre-Remedial Investgation	1,110	69,966	21,325	40,800	132,091
300	Remedial Design Work Plan	263	16,811	1,400	0	18,211
400	Remedial Design					
410	Vapor Extraction/Injection	261	16,259	1,020	0	17,279
420	Water Extraction/Injection	206	14,394	960	0	15,354
430	Water Treatment	354	21,678	1,350	0	23,028
440	Vapor Treatment	187	12,637	960	0	13,597
450	In-Situ Biodegradation	144	9,332	290	0	9,622
490	Project Mananagement	70	5,706	700	0	6,406
400	Remedial Design	1,222	80,006	5,280	0	85,286
	Subtotal	2,919	190,595	30,605	40,800	262,000
	Contingency (10%)					26,200
	Total Project Cost					$288,200

APPENDIX B

ITEMIZED COSTS BY TASKS

Table B-1
Cost Estimate
Remedial Design
Shore Reality Property
Glenwood Landing, New York

Task	Task Description	Labor Hrs.	Labor $	ODC	Subs	Totals
100	Pre-Remedial Design Work Plan					
110	Data Review/Scoping	36	3,204	0	0	3,204
120	Site Characterization	36	2,348	0	0	2,348
130	Treatability Studies	56	3,640	0	0	3,640
140	Conceptual Design	32	2,064	0	0	2,064
150	Project Plans					
	Health & Safety Plan	34	2,118	0	0	2,118
	Sampling and Analysis Plan	34	2,118	0	0	2,118
	Quality Assurance Plan	34	2,118	0	0	2,118
160	Meetings	40	4,344	1,800	0	6,144
170	Project Management	22	1,858	800	0	2,658
100	Pre-Remedial Design Work Plan	324	23,812	2,600	0	26,412
200	Pre-Remedial Design Activities					
210	Site Characterization					
	Boring and Sampling	88	5,416	8,900	12,000	26,316
	Soil Gas Survey	108	6,772	3,010	0	9,782
	Iron Precipitation Evaluation	28	1,576	1,505	0	3,081
	Infrastructure Inventory	44	2,680	310	0	2,990
210	Site Characterization	268	16,444	13,725	12,000	42,169
220	Treatability Studies					
	Biodegradation Pilot Study	0	0	0	0	0
	Microbial Characterization	32	2,216	1,590	0	3,806
	Chemical Characterization	110	5,786	590	23,100	29,476
	Interim Data Evaluation	36	2,780	100	0	2,880
	Oxygen Demand	36	2,148	1,590	0	3,738
	Water Treatment Pilot Study	58	3,534	870	5,700	10,104
220	Treatability Studies	272	16,464	4,740	28,800	50,004
230	Conceptual Design					
	Vapor Extraction/Injection	66	3,998	320	0	4,318
	Groundwater Extraction/Injection	124	8,188	400	0	8,588
	In-situ Biodegradation	82	5,538	320	0	5,858
	Water Treatment	78	5,058	400	0	5,458
	Vapor Treatment	18	966	320	0	1,286
	Infrastructure	58	2,926	400	0	3,326
230	Conceptual Design	426	26,674	2,160	0	28,834
290	Project Management					
	Subcontractor Administration	36	1,932	20	0	1,952
	Cost Control	32	2,064	20	0	2,084
	Meetings	28	2,900	630	0	3,530
	Reporting	48	3,488	30	0	3,518
290	Project Mananagement	144	10,384	700	0	11,084
200	Pre-Remedial Investgation	1,110	69,966	21,325	40,800	132,091
300	Remedial Design Work Plan					
310	Vapor Extraction/Injection	34	1,902	0	0	1,902
320	Groundwater Extraction/Injection	60	3,404	0	0	3,404
330	Water Treatment	52	3,004	0	0	3,004
340	Vapor Treatment	35	1,947	0	0	1,947
350	In-Situ Biodegradation	40	2,516	0	0	2,516
360	Project Management	18	1,630	1,400	0	3,030
370	Meetings	24	2,408	0	0	2,408
300	Remedial Design Work Plan	263	16,811	1,400	0	18,211

Table B-1
Cost Estimate
Remedial Design
Shore Reality Property
Glenwood Landing, New York

Task	Task Description	Labor Hrs.	Labor $	ODC	Subs	Totals
400	Remedial Design					
410	Vapor Extraction/Injection					
	Civil Design	19	1,149	170	0	1,319
	Process Flow Diagram	30	2,038	170	0	2,208
	P&ID	42	2,614	170	0	2,784
	Equipment	46	2,894	170	0	3,064
	Specifications	52	3,260	170	0	3,430
	Operation & Maintenance Plan	72	4,304	170	0	4,474
410	Vapor Extraction/Injection	261	16,259	1,020	0	17,279
420	Water Extraction/Injection					
	Civil Design	70	4,962	160	0	5,122
	Process Flow Diagram	0	0	160	0	160
	P&ID	0	0	160	0	160
	Equipment	60	4,052	160	0	4,212
	Specifications	34	2,374	160	0	2,534
	Operation & Maintenance Plan	42	3,006	160	0	3,166
420	Water Extraction/Injection	206	14,394	960	0	15,354
430	Water Treatment					
	Civil Design	12	856	225	0	1,081
	Process Flow Diagram	96	6,064	225	0	6,289
	P&ID	44	2,900	225	0	3,125
	Equipment	50	2,878	225	0	3,103
	Specifications	54	3,214	225	0	3,439
	Operations & Maintenance Plan	98	5,766	225	0	5,991
430	Water Treatment	354	21,678	1,350	0	23,028
440	Vapor Treatment					
	Civil Design	9	639	160	0	799
	Process Flow Diagram	22	1,818	160	0	1,978
	P&ID	48	3,364	160	0	3,524
	Equipment	46	2,846	160	0	3,006
	Specifications	28	1,796	160	0	1,956
	Operations & Maintenance Plan	34	2,174	160	0	2,334
440	Vapor Treatment	187	12,637	960	0	13,597
450	In-Situ Biodegradation					
	Equipment	46	2,978	170	0	3,148
	Specifications	34	2,250	60	0	2,310
	Operation & Maintenance Plan	64	4,104	60	0	4,164
450	In-Situ Biodegradation	144	9,332	290	0	9,622
490	Project Management					
	Subcontractor Administration	10	606	20	0	626
	Cost Control	24	1,704	20	0	1,724
	Meetings	16	1,696	630	0	2,326
	Reporting	20	1,700	30	0	1,730
490	Project Mananagement	70	5,706	700	0	6,406
400	Remedial Design	1,222	80,006	5,280	0	85,286
	Subtotal	2,919	190,595	30,605	40,800	262,000
	Contingency (10%)					26,200
	Total Project Cost					$288,200

APPENDIX C

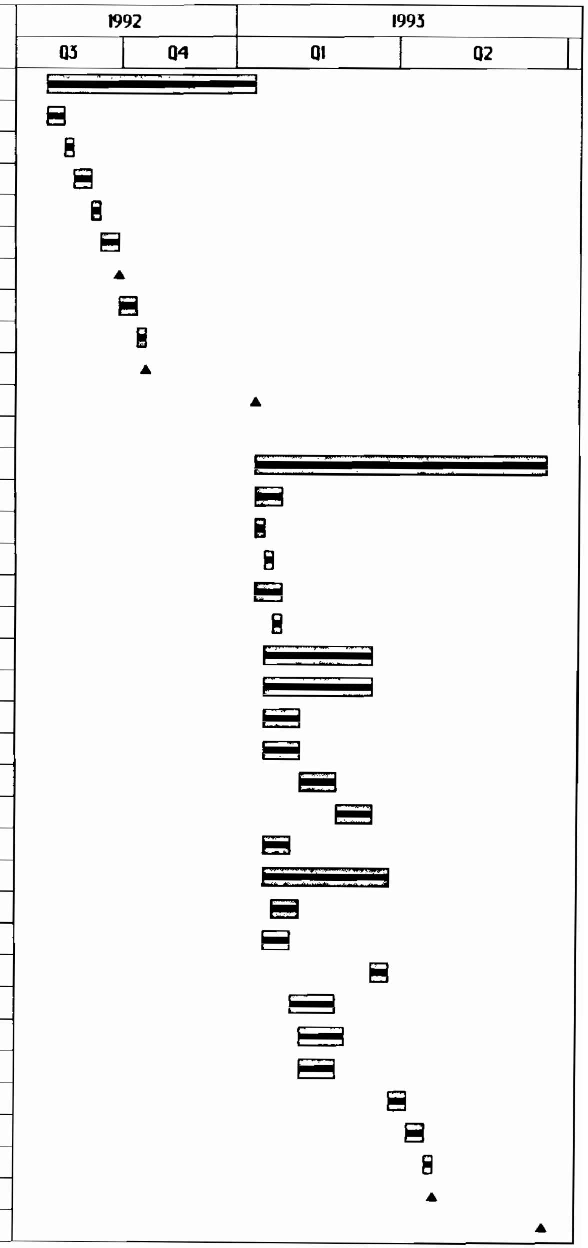
RD IMPLEMENTATION SCHEDULE

Schedule for Pre-Remedial Design Investigation

Shre Realty Property

Glenwood Landing, New York

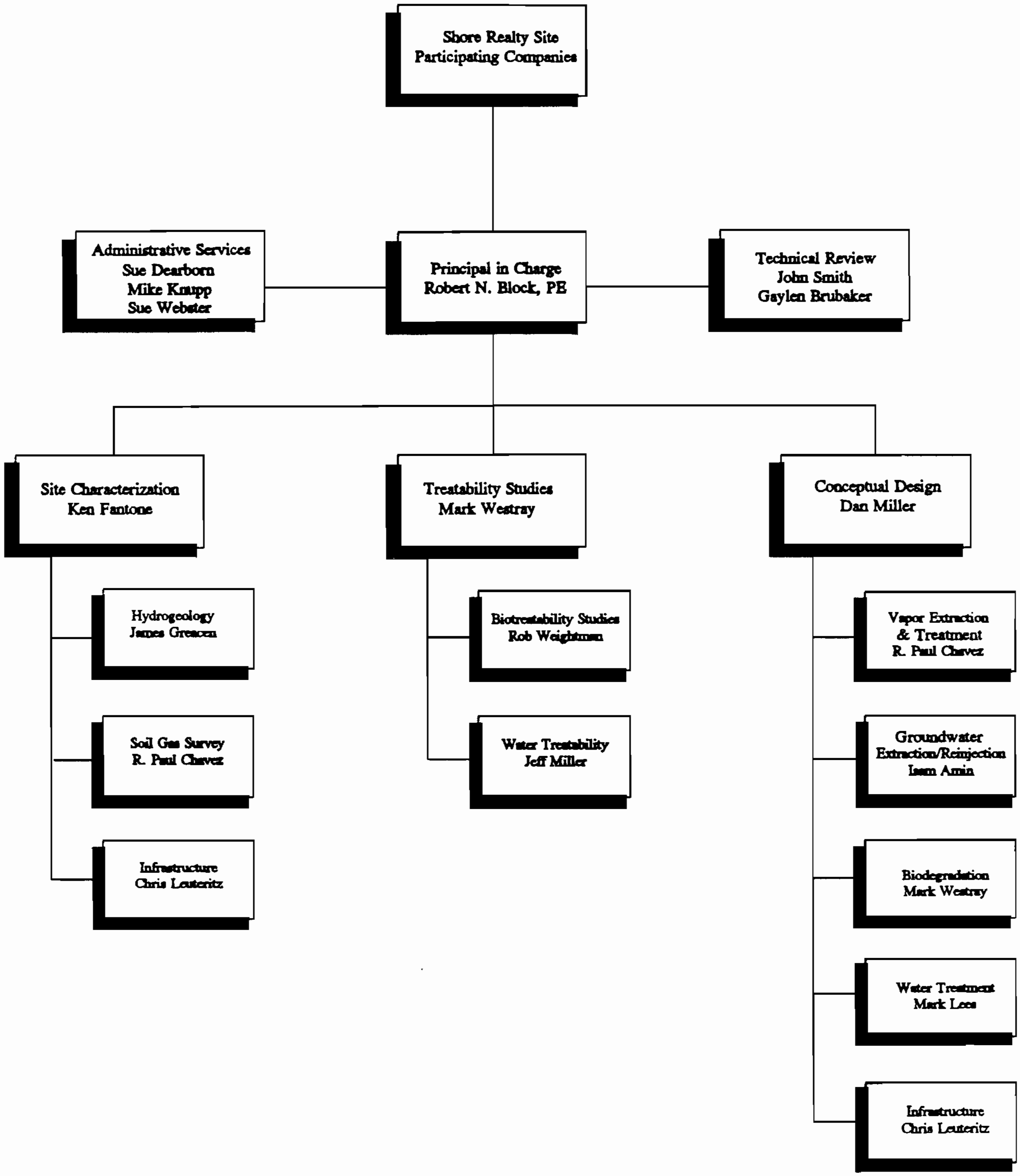
WBS	Task Name	Start Date	End Date	Duratn (Wks)	Status
100	Pre-Remedial Design Work Plan	3-Aug-92	11-Jan-93	23	C
110	Data Review/Scoping	3-Aug-92	14-Aug-92	2	C
120	Site Characterization	17-Aug-92	21-Aug-92	1	C
130	Treatability Studies	24-Aug-92	4-Sep-92	2	C
140	Conceptual Design	8-Sep-92	14-Sep-92	1	C
150	Project Plans	15-Sep-92	28-Sep-92	2	C
	Internal Draft	29-Sep-92	29-Sep-92	0	C
	Client Review	29-Sep-92	12-Oct-92	2	C
	Revision	13-Oct-92	19-Oct-92	1	C
	Draft Wk Plan Submit to EPA	20-Oct-92	20-Oct-92	0	C p
	EPA Review/Approval	12-Jan-93	12-Jan-93	0	C s
200	Pre-Remedial Design Activities	12-Jan-93	20-Jun-93	32	C
210	Site Characterization	12-Jan-93	26-Jan-93	3	C
	Boring and Sampling	12-Jan-93	16-Jan-93	1	C p
	Soil Gas Survey	17-Jan-93	21-Jan-93	1	
	Iron Precipitation Eval	12-Jan-93	26-Jan-93	3	s
	Infrastructure Inventory	22-Jan-93	26-Jan-93	1	
220	Treatability Studies	17-Jan-93	17-Mar-93	12	C
	Biodegradation Pilot Study	17-Jan-93	17-Mar-93	12	C
	Microbial Characterization	17-Jan-93	5-Feb-93	4	
	Chemical Characterization	17-Jan-93	5-Feb-93	4	C
	Interim Data Evaluation	6-Feb-93	25-Feb-93	4	C
	Oxygen Demand	26-Feb-93	17-Mar-93	4	C
	Water Treatment Study	17-Jan-93	31-Jan-93	3	
230	Conceptual Design	17-Jan-93	27-Mar-93	14	
	Vapor Extraction/Injection	22-Jan-93	5-Feb-93	3	
	GW Extraction/Injection	17-Jan-93	31-Jan-93	3	
	In-Situ Bio	18-Mar-93	27-Mar-93	2	C
	Water Treatment	1-Feb-93	25-Feb-93	5	
	Vapor Treatment	6-Feb-93	2-Mar-93	5	
	Infrastructure	6-Feb-93	25-Feb-93	4	
	Pre-Remedial Des Inv Report	28-Mar-93	6-Apr-93	2	C
	Client Review	7-Apr-93	16-Apr-93	2	C
	Revision	17-Apr-93	21-Apr-93	1	C
	Submit Report to EPA	22-Apr-93	22-Apr-93	0	C p
	EPA Review/Approval	21-Jun-93	21-Jun-93	0	C s



APPENDIX D

PROJECT ORGANIZATION CHART

RETEC



Project Organization Chart

FIGURE D-1

APPENDIX E

RESUMES OF PROJECT PERSONNEL

REMTEC

ROBERT N. BLOCK, P.E.

PRINCIPAL GEOTECHNICAL ENGINEER

PROFESSIONAL HISTORY

Remediation Technologies, Inc. 1985 to present
Environmental Research & Technology, Inc., 1984 to 1985
Fox and Associates, Inc., 1977 to 1984
Walter P. Moore, Inc., 1976 to 1977

EDUCATION

S.M.C.E Massachusetts Institute of Technology
B.S.C.E. Tufts University

AFFILIATIONS

American Society of Civil Engineers
Boston Society of Civil Engineers
International Society of Soil Mechanics and Foundation Engineers
United States Committee on Large Dams
Tau Beta Pi

TECHNICAL SPECIALTIES

Geotechnical/Hydrogeologic Engineering: Site assessment, soils, groundwater and contaminant characterization; analytical modeling, soil behavior, ground water modeling, soil/groundwater interaction; engineering design; surface and subsurface structures, groundwater extraction systems, vadose zone remediation systems.

Hazardous Waste Engineering: Remedial planning and design; containment facilities, liner systems, caps; biological treatment systems, groundwater treatment systems, soil venting systems. Preparation of feasibility studies, remedial action plans, construction plans and specifications.

Construction Management: Estimating, scheduling, cost control and construction quality assurance.

PROFESSIONAL EXPERIENCE

Massachusetts Superfund Site: Project Coordinator for RD/RA at Superfund site with soils and groundwater contaminated by VOCs, PNAs, pesticides, PCBs and metals. Remedial elements include off-site disposal, incineration and in-situ volatilization of soils as well as groundwater remediation by pumping and treating. Negotiated scope of work for RD/RA activities as well as implementable remediation criteria and compliance monitoring.

New England Superfund Site: Principal-in-Charge of Remedial Investigation and Feasibility Study of Superfund site consisting of waste oil recycling, drum refurbishing and automobile salvage facilities. Contaminated media include soils and groundwater. Contaminants of concern include volatile, semi-volatile and halogenated organics and metals.

Aluminum Die-Casting Facility: Technical consultant supporting negotiations for remedies, clean-up criteria and RD/RA Consent Decree for PCB contaminated sediments, sludges, soils and groundwater. The total volume of contaminated sediments, soils and sludges exceeded 500,000 cubic yards. Remedial components included dredging contaminated sediments from a major river, excavation and treatment of lagoon sludges and contaminated soils, containment and capping of landfills, and groundwater treatment.

Metal Recycling Facility: Directed Remedial Investigation and Feasibility Study at PCB contaminated scrap metal facility regulated under CERCLA. RI included assessment of potential contamination in soils and groundwater. Feasibility Study included evaluation of containment and fixation technologies along with incineration.

Petroleum Refinery: Project Manger for remedial design of landfill at closed refinery regulated under CERCLA. Evaluated engineering properties of oil saturated landfill material by test fill and laboratory investigation; characterized groundwater contamination. Material properties required designed of state-of the-art light-weight RCRA cap and slurry wall for containment. Provided construction oversight for landfill consolidation/capping and construction of perimeter dike including contractor bidding and selection process.

Petroleum Refinery: Project manager for Remedial Investigation and Feasibility Study of an abandon refinery complex. Technical oversight of supplemental investigation of soils, groundwater and facilities undertaken to refine nature and extent of contamination. Evaluated potential remedial technologies including in-situ and ex-situ bioremediation and ability of various innovative groundwater treatment technologies, as well as pump and treat scenarios in terms of technical impracticability and achieving MCLs.

Petroleum Products Terminal: Evaluated feasibility of biological treatment for remediation of contaminated soils and groundwater. Undertook treatability study modeling volatilization associated with excavation/material handling and biodegradation. Prepared Remedial Action Plan, detailing construction plans and specifications. Managed implementation of full-scale remedial operations. During 3 years of operations, over 150,000 cubic yards of soils were treated to 50 ppm TPH, free product was removed from groundwater and groundwater remediation system was designed, installed and operated.

Petroleum Products Terminal: Project Manger for the evaluation of remediation alternatives at an abandoned #6 fuel oil and bunker C oil storage facility. Supervised treatability study which demonstrated biological treatment as a practical alternative. Prepared Remedial Action Plan detailing full-scale treatment operations.

Petroleum Products Terminal: Principal-in-Charge of remediation of contaminated soils at two products terminals remediated under state regulations. Bioremediation facilities were designed at both sites which allowed construction of a stockpile biological treatment facility.

Wood Treatment Plant: Prepared closure plan and construction documents for 4 wastewater treatment impoundments. Designed cap for impoundments for closure of the impoundments after removal of contaminated soils and sludges. Designed double lined waste pile and 20 acre biological treatment facility for contaminated soils and sludges. Prepared construction documents and supervised construction.

Wood Treatment Plant: Negotiated an Emergency Removal of creosote contaminated soils and sludges from swamp on the shores of a Lake. Prepared closure plan for 2 RCRA impoundments on-site including design of asphalt cap over backfilled impoundments. Prepared construction documents and supervised remediations.

Wood Treating Plant: Designed waste pile and full-scale treatment facility at first biological treatment facility undertaken under Superfund. Prepared construction documents, supervised bidding and managed construction.

Municipal Landfill: Prepared Remedial Action Plan for removal of drums and contaminated soils from industrial waste cell in county landfill. Identified alternative incineration technology which allowed completion of remediation under budget. Prequalified contractors and supervised bid and selection process.

Municipal Landfill: Principal-in-Charge of technical oversight of RI/FS at a municipal landfill Superfund site. Activities include assessment of groundwater contaminations, impacts of contaminant migration on adjacent wetland and soil gas monitoring.

Municipal Landfill: Technical oversight of redesign and construction of failed landfill cap. The side slopes of the landfill were construction over soft organic soils which lead to end-of-construction failure. Directed technical efforts leading to design of an alternative cap with equivalent performance of RCRA cap.

ISAM E. AMIN
SENIOR HYDROGEOLOGIST

PROFESSIONAL HISTORY

Hydro-Search, Inc., 1990 to 1991
University of Khartoum, 1987 to 1990
UNESCO, 1989 to 1990
Water Resources Center, Desert Research Institute, 1986 to 1987
University of Khartoum, 1977 to 1987

EDUCATION

Ph.D. (Hydrology/Hydrogeology) University of Nevada
M.S. (Groundwater Hydrology) New Mexico Institute of Mining & Technology
B.S. (Geology/Hydrology) University of Khartoum

AFFILIATIONS

National Water Well Association

TECHNICAL SPECIALTIES

Groundwater contamination and remediation. Numerical modeling of groundwater flow and solute transport. Water resource evaluation and development. Dewatering/depressurization.

REPRESENTATIVE PROJECT EXPERIENCE

Superfund Site, California: Applied the CFEST Code (Coupled Fluid, Energy, and Solute Transport) to model groundwater flow and solute transport at a site extensively contaminated by TCE and PCE. The model was used to evaluate alternate designs for the remedial system at the site.

Mining Site, Nevada: Participated in modeling groundwater contamination, primarily with chloride, by the USGS Mass-Transport Model (MOC). Modeling results were used to design a remedial system for the site.

UNESCO: Directed modeling of a regional confined aquifer using a two-dimensional finite difference model. Supervised the design of the grid, setting of the initial and boundary conditions, selection of specific locations for additional data, model verification and calibration. In the second project, directed the design of shallow wells drilled in an alluvial aquifer. The design included determination of casing diameter, screen length, diameter and slot size.

Mining Sites, Nevada: Evaluated the impacts of seepage from artificial ponds on regional groundwater systems at several mines.

Water Resources Center, Desert Research Institute: Developed a probabilistic model for the analysis of chemical transport in steady and nonsteady hydrologic systems. The model takes the form of the 3-parameter gamma distribution, and accounts for seven mixing possibilities: perfect or complete mixing, piston flow or no mixing, the mixing type in between perfect and piston flow (partial mixing) and their combinations.

Mining Sites: Analyzed aquifer test and water-quality data at several mines in Nevada, California and Bolivia. Results of the analyses were successfully used in the simulation of mine dewater/depressurization.

Water Supply Project, Nevada: Contributed in building a database which included groundwater levels, water-quality analyses, aquifer test results, and well construction data.

SELECTED PUBLICATIONS

Amin, Isam E. 1987. A General Mathematical Model for the Interpretation of Tracer Data and Calculation of Transit Times in Hydrologic Systems. Ph.D. Dissertation; University of Nevada-Reno, Nevada.

Amin, Isam E. 1983. Modeling of Sediment Transport in Rio Puerco, New Mexico. Masters Thesis; New Mexico Institute of Mining & Technology, Socorro, New Mexico.

GAYLEN R. BRUBAKER
SENIOR SCIENTIST

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1988 to present
International Technology Corporation, 1986 to 1988
FMC Corporation, 1976 to 1986

EDUCATION

Ph.D. (Organic Chemistry) University of Illinois
B.A. (Chemistry) North Central College

AFFILIATIONS

American Chemical Society
The Association of Groundwater Scientists and Engineers - A division of NWWA

TECHNICAL SPECIALTIES

In situ biological treatment of organic wastes. Technical oversight of Remedial Investigations/Feasibility Studies. Feasibility and design studies for petroleum hydrocarbon and industrial contaminants. Remediation strategies at complex sites.

REPRESENTATIVE PROJECT EXPERIENCE

Manufacturing Facility in New Jersey: Task Manager to evaluate a range of remedial options for a chemical formulation facility in New Jersey. The evaluations incorporated both a pilot and laboratory studies of vapor extraction and biodegradation. Contaminants include chlorinated solvents, aromatic solvents and non-volatile hydrocarbons.

Petrochemical Facility - Texas: Project Director for a detailed economic/performance evaluation of vapor extraction, groundwater flushing and in situ bioremediation at an 11-acre contaminant plume. The study has involved characterization, laboratory and pilot studies.

Former Wood Treating Facilities: Technical Advisor for an innovative groundwater corrective action plan for three wood treating sites. The resulting studies included hot water flushing, in situ bioremediation, pump tests, tracer studies and geological investigations.

Former Manufactured Gas Plant: Task Manager for use of bioremediation to treat contamination from various areas of a former manufactured gas plant. A workplan has been approved by the EPA for pilot studies and lab studies for in situ bioremediation and these studies are in process.

Manufacturing Facility - Missouri: Project Manager for the design and operation of a combined soil-gas venting/in situ bioreclamation project in a fractured limestone formation. The venting system was designed to address gasoline which had migrated into fractures above the water table while the bioreclamation addressed the material which was below the water surface. This project was performed under contract to a regional hydrogeological contractor.

Gulf Coast Superfund Site: Senior technical advisor for in situ bioremediation at a large superfund project which includes treatment of two aquifers over a 10-acre area.

Industrial Chemical Manufacturing Facility - New Jersey: Task Manager for treatability and design studies for in situ bioremediation of fuel oil contamination in the unsaturated and saturated zones of an operating chemical manufacturing facility. Treatability studies also evaluated the options of water flushing and surfactant flushing. The resulting remediation involves the venting and flushing of volatile organics, groundwater recovery/treatment and extensive excavation.

EA Engineering/US Air force - Florida: Project Director for the design and execution of a field demonstration of in situ bioreclamation on jet fuel in a shallow, sandy aquifer. The project also involved laboratory degradation studies and extensive investigations related to the poor stability and transport of hydrogen peroxide through soils from this site.

Chemical Manufacturing Company - New Jersey: Project Manager for the design and execution of a feasibility study for the in situ biodegradation and soil flushing of a mixture of soils. These studies led to the development of a remediation strategy involving installation of a slurry wall around the site, followed by soil flushing and then bioremediation within the slurry wall. Contaminants include chlorinated and non-chlorinated solvents, phthalates and polynuclear aromatic compounds.

Fuel Oil Spill in New Jersey: Task Manager to design, construct and operate an in situ bioremediation process to remove fuel oil from beneath a home in New Jersey. The remediation process incorporated groundwater injection, vapor extraction and nutrient addition.

SELECTED PUBLICATIONS/PRESENTATIONS

"Microbial Processes in the Microbial Degradation of Groundwater Contaminants", a three-day short course sponsored by the National Water Well Association. 1988 through 1991.

"Soil Bioremediation Short Course". College of Engineering, University of Texas at Austin. 1989 and 1990.

In situ Bioremediation of Contaminated Aquifers: A Practical Guide to Evaluation and Conceptual Design at Superfund Sites" A one-day short course at HMCRI in 1990 and 1991.

Brubaker, G.R., "In situ Bioremediation of Groundwater" in Geotechnical Practice for Waste Disposal, D.E. Daniel, ed., Chapman and Hall, London, in press.

Brubaker, G.R., "In situ Bioremediation of Contaminated Aquifers - Assessing Hydrogeological Issues", in Proceedings of HAZTECH International '89. Cincinnati, Ohio, International Research, Inc. (Bellevue, Washington). Sept. 12-14, 1989.

Brubaker, G.R., "Screening Criteria for In situ Bioremediation of Contaminated Aquifers" in Proceedings of 2nd Annual Hazardous Materials Management Conference, Central,Tower Conference Management Company, Glen Ellyn, Illinois. March 14-16, 1989.

Brubaker, G.R., R.A. Brown, and R. D. Norris, "Aquifer Restoration with Enhanced Bioreclamation", Pollution Engineering, November, 1986, pp 25-28.

Brubaker, Gaylen R. and E.L. Crockett, "In situ Aquifer Remediation using Enhanced Bioreclamation", presented at Haz Mat East, Atlantic City, New Jersey. June 2-4, 1986.

RETEC

R. PAUL CHAVEZ

SENIOR PROJECT SCIENTIST

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1988 to present
Advanced Mineral Technologies, Inc., 1983 to 1988
U.S. Veterans Administration Medical Center, Research Service, 1981 to 1983

EDUCATION

B.S. (Biology with Environmental Science Option)
New Mexico Institute of Mining and Technology

TECHNICAL SPECIALTIES

Soil gas surveys, soil venting systems, and groundwater aeration.
Construction, start-up, and operation of pilot- and full-scale remediation systems.
Industrial wastewater and groundwater treatment.
Laboratory-,pilot-,and full-scale treatment technologies.

REPRESENTATIVE PROFESSIONAL EXPERIENCE

Project manager for a soil venting/groundwater aeration system for VOC plume control at an adhesive processing plant.

Project Scientist for pilot- and full-scale soil venting systems.

Project Scientist for a soil gas survey at two operating petroleum refineries.

Project Manager and Project Scientist for preliminary site investigations and soil gas surveys at industrial manufacturing plants and gasoline service stations.

Project Engineer responsible for onsite construction supervision, start-up, and operator training for a 200,000 gpd groundwater treatment plant at a former coal-tar refinery and wood treating site.

Site Engineer for construction, start-up, and operation of a 100,000 gpd water treatment plant for treatment of surface waters at a creosote wood preserving plant.

Senior Staff Scientist for development of laboratory and field protocols for treatment evaluation of contaminated groundwaters and soils from manufactured gas plant sites.

Senior Staff Scientist for laboratory and pilot evaluation of treatment technologies for groundwater treatment from a former wood preserving/coal-tar processing plant.

Senior Staff Scientist for evaluation of technologies for treatment of sludges and wastewaters associated with the wood preserving industry.

Senior Field Engineer for treatment of 20,000 gallons of chromate-contaminated industrial wastewater for surface discharge at a major public utility.

Field Engineer for treatment of two 100,000 gallon lagoons with lead contaminated wastewater at a lead-acid battery manufacturer.

Field Engineer for treatment of chrome, nickel, cadmium, and copper contaminated industrial wastewater streams from commercial electro-platers.

Senior Laboratory Technologist for characterization of industrial wastewater streams.

Senior Laboratory Technologist for evaluation of removal/recovery technologies, including ion exchange, bio-recovery, precipitation, and electro-winning for heavy metals from industrial wastewater streams.

Laboratory Technician for evaluation of microbes for recovery of precious metals from low grade sulfide ores.

PUBLICATIONS

Smith, J.R., Chavez, R.P., Miller, D.L., and Gutierrez, M., *Sand Filtration/Activated Carbon Treatment of Pumped Groundwaters from a Coal-Tar Superfund Site for NPDES Discharge*. Presented at Water Pollution Control Federation 63rd Annual Conference, Washington, D.C., October 7-11, 1990.

Smith, J.R., Chavez, R.P., Miller, D.L., and Matsik, G.A., *Sand Filtration/Activated Carbon Treatment of Pumped Groundwaters from a Coal-Tar Superfund Site for NPDES Permit*. Presented at the 23rd Mid-Atlantic Waste Conference, Pittsburgh, Pennsylvania, June 4-7, 1991.

KENNETH S. FANTONE
HYDROGEOLOGIST

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1986 to present
ANR Production Company, 1983 to 1986
Nevada Resources Inc., 1981 to 1982
Chromalloy American Corp., 1980 to 1981
Bendix Field Engineering Corp., 1979 to 1980
Scientific Applications, Inc., 1978 to 1979

EDUCATION

M.S. South Dakota School of Mines and Technology
B.S. The Pennsylvania State University

PROFESSIONAL ORGANIZATIONS

Association of Groundwater Scientists & Engineers/NWWA
American Association of Petroleum Geologists
Rocky Mountain Association of Geologists

TECHNICAL SPECIALTIES

Design and Implementation of aquifer characterization programs, including monitoring networks, pump test, slug tests, and tracer tests for both CERCLA and RCRA facilities. Design, analysis, and installation of free product hydrocarbon systems at both abandoned and active refineries. Groundwater modeling of flow and transport using analytical, finite difference, and finite element models, as well as multiphase flow modeling and analysis of hydrocarbon recovery systems. Determination of Hydraulic capture zones, well locations, and pumping rates for in situ bioremediation, pump and treat, and hydraulic containment. Subsurface geology, carbonate and clastic depositional environments, borehole geophysics, geologic mapping, structural geology, geochemistry, and geostatistics.

PROFESSIONAL EXPERIENCE

Active Petroleum Refinery, Pennsylvania: Project Manager for a refinery-wide hydrogeologic investigation. Tasks included soil gas survey, soil borings, monitoring well installation, chemical and physical analysis of soil and water, and evaluating corrective action alternatives for free phase product and dissolved phase groundwater.

Former Petroleum Refining Site, Ohio: Project Manager for a hydrogeologic investigation. The project entailed determining the extent and volume of free product hydrocarbon, determining stratigraphic controls on the product trapping mechanisms, and evaluating alternative remedial actions.

Active Petroleum Refinery, Montana: Project Hydrogeologist responsible for conducting an extensive groundwater flow and particle tracking model for an RFI. The purpose of the modeling effort was to evaluate and compare both physical and hydraulic groundwater containment options, as well as to aid in their design and to evaluate the understanding of the local and regional aquifer hydrodynamics. One alternative was chosen, and a detailed design was implemented including the use of a particle tracking analysis to determine groundwater capture zones.

Active Petroleum Refinery, Delaware: Project Hydrogeologist responsible for groundwater modeling of an oil recovery operation. The project involved determining the efficiency of three separate free product and groundwater capture designs and recommending the installation of one of the designs.

Active Petroleum Refinery, Washington: Project Hydrogeologist responsible for designing a groundwater dewatering system under a RCRA land treatment unit. The groundwater flow in the vicinity of the land treatment unit was modeled with MODFLOW, and then a series of transient simulations were made varying the number and spacing of drains. The results of the simulations were used to determine if the water table could be kept at least three feet below the lower treatment zone and how much water would be drained on a monthly basis and sent to the wastewater treatment plant.

Active Petroleum Refinery, Ohio: Project Hydrogeologist responsible for designing and installing a RCRA groundwater monitoring network for a land treatment facility. The project involved monitoring both the vadose zone and the saturated zone, preparation of the annual groundwater assessment reports, and characterization of the site geology and hydrogeology. Further efforts at this refinery involved writing the Corrective Measure Technologies report in support of the RFI.

Former Wood Treating Site, Mississippi: Project Hydrogeologist responsible for determining migration pathways for a site contaminated by creosote. Responsibilities include redesigning and installing a free product recovery system, as well as designing a plume recovery and in situ bioremediation system. Flow, transport, and biodegradation are being modeled to determine: the effect various pumping scenarios have on the nearby river; the optimal number, location, and pumping rates of free product recovery wells and injection/extraction wells for the in situ bioremediation design; and time required to implement the aquifer cleanup.

Manufacturing Facility, New Jersey: Project Hydrogeologist responsible for designing and installing a vapor extraction system for a site contaminated with a wide variety of halogenated organics and hydrocarbons. As part of the design, the site was modeled to estimate the total recovery and component recovery of hydrocarbon versus time. An evaluation was made of the effects of spill composition, temperature, and gas pumping rate on hydrocarbon recovery.

Residential Site, New Jersey: Project Hydrogeologist responsible for designing and installing an in situ bioremediation aquifer cleanup. Responsibilities included determining the number, placement, pumping rate, and capture zones of the injection/extraction wells in order to maximize the delivery of oxygen and nutrients to the contaminated areas. The system was designed with the aid of computer simulations of the aquifer.

Chemical Manufacturer, Texas: Project Hydrogeologist responsible for designing and installing a vapor extraction system. In addition to the VES project, groundwater flow modeling and pathline analysis was conducted as an aid in designing the full-scale implementation of an in situ bioremediation system.

REMTEC

JAMES R. GREACEN
PROJECT SCIENTIST

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1989 to present
Groundwater Technology, Inc., 1987 to 1989

EDUCATION

B.A. (Geology) Harvard University

AFFILIATIONS

National Water Well Association
Association of Ground Water Scientists and Engineers

TECHNICAL SPECIALTIES

Geologic and hydrogeologic site investigation, separate-phase petroleum recovery, soil venting, ground water extraction, and ground water treatment.

REPRESENTATIVE PROJECT EXPERIENCE

Retail Gasoline Service Station: Project Manager for a petroleum recovery project. Duties included design and installation of above- and below-grade soil venting systems utilizing a combination of bioremediation and regenerable vapor-phase carbon absorption units. Supervision of the installation and maintenance of a hydrocarbon recovery system collecting over 2,400 gallons of gasoline from an underground storage tank leak.

Petroleum Products Terminal: Installed and operated a vacuum extraction system utilizing thermal oxidation as vapor-phase treatment at a 10 acre site in Idaho. The system removed over 60,000 pounds of hydrocarbons during the first six months of operation. System performance evaluation included optimizing hydrocarbon extraction rates and thermal oxidizer removal efficiency, analyzing extracted vapors to determine mass removal, and determining system range of influence in three dimensions.

Ink Blending Facility: Project Manager for a remediation project involving soils contaminated with volatile organic components of ink. The project includes the design and installation of a vapor extraction system, treatment of off-gasses with vapor-phase carbon, and verification of contaminant reduction.

Massachusetts Superfund Site: Project Manager for the Remedial Design/Remedial Action phase of a Superfund Site. The Record of Decision for the site requires the client to conduct remedial design/remedial action on a property contaminated with chlorinated volatile organics, pesticides and PCBs. Remedial action dictated in the Record of Decision includes both in-situ volatilization and incineration of soils, and ground water extraction and treatment.

Retail Gasoline Service Station: Project Manager for a multi-phase remediation project involving of hydrocarbon recovery by water table depression and product pumping, and ground water remediation by air stripping including a chemical feed system to pretreat ground water. Supervision responsibilities also included the design and implementation of a below-grade soil venting system with treatment of soil gas by catalytic incineration, and development of methods to optimize air stripper and recovery well efficiency.

Petroleum Products Terminal: Project Manager for a pilot system for in situ vadose zone bioremediation of petroleum contaminated soils. The project included design, construction, and operation of a treatment system utilizing below grade trenching to inject water, nutrients and oxygen. Data were collected throughout the project to monitor contaminant concentration and biological activity.

New England Superfund Site: Project Manager for the Remedial Investigation of an aquifer contaminated by chlorinated volatile organics from several sources. The investigation includes delineation of source areas, plume definition, and providing data to evaluate remedial options for restoring the aquifer as a drinking water supply.

Transformer Manufacturing Facility: Project Manager for recovery project involving chlorinated organic solvents and PCBs. Installation of water table depression and petroleum recovery system designed to prevent off-site migration of contamination.

Municipal Landfill: Project Manager providing oversight on behalf of the EPA for RI/FS work conducted for a municipal landfill in New Hampshire. Soils and ground water at the site are contaminated by landfill leachate, including chlorinated and non-chlorinated volatile organics. Activities included supervising field oversight support and reviewing Remedial Investigation and Feasibility Study reports.

Petroleum Refinery: Provided technical support to assist in the negotiation of a Record of Decision (ROD) at a former refinery site in New York. Support included determining the impact of metals, chlorinated and non-chlorinated volatile organics in groundwater and soils. Remedial design considerations included the impact of groundwater extraction on adjacent surface waters and efficiencies of various treatment technologies.

Petroleum Products Terminal: Supervision of petroleum recovery and ground water extraction and treatment at a 20 acre petroleum storage facility. Responsibilities include design and implementation of methods to prevent off-site migration of dissolved petroleum constituents in ground water and development of methods to recover separate-phase petroleum at the site.

Plastics Manufacturing Facility: Supervision of a recovery project for a plastics manufacturing facility. Implementation of passive recovery techniques utilizing an electric petroleum pump to recover separate-phase chlorinated organic solvents. Duties include review of field activities, ground water contouring, and reporting generation.

Ink Blending Facility: Project Manager for a site assessment of a former ink blending facility in Connecticut. Supervision of field activities evaluating site conditions included soil and groundwater sampling and analysis, and documentation of results.

Public Utility, Electric Generating Station: Project Manager for a site investigation/remedial options assessment of a leaking underground gasoline storage tank. The site investigation included a soil gas survey, soil sampling, and groundwater monitoring well installation and sampling in alluvial deposits adjacent to a large river. Remedial options evaluated were no action, soil venting, air sparging, and in situ bioremediation.

Wood Treating Plant: Task Manager for the Superfund groundwater remedy at a railroad tie treating plant. The remedy includes the design of groundwater contamination systems for both a confined high permeability aquifer and groundwater in an overlaying till contaminated with PAHs and pentachlorophenol.

New England Superfund Site: Prepared a design for a soil and groundwater remedy on a property contaminated with chlorinated volatile organics. The remedial design consisted of a combination of soil vapor extraction and aquifer aeration to treat 7,500 cubic yards of soils and the underlying aquifer.

REMTEC

MARK G. LEES

PROJECT ENGINEER

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1990 to present
Baker/TSA, Inc., 1985 to 1990
Economy Shotblasting and Painting, 1983 to 1985

EDUCATION

B.S. (Chemical Engineering) Virginia Polytechnic Institute

TECHNICAL SPECIALTIES

Evaluation of environmental engineering processes to select optimum process for individual applications.
Detailed design of treatment facilities.
Hazardous materials/waste assessments.
Utility waste management.

REPRESENTATIVE PROJECT EXPERIENCE

Project Manager/Engineer for design and installation of a 0.1 MGD groundwater treatment system using carbon adsorption for benzene removal. Responsibilities included a technical evaluation via a laboratory treatability study, and an economic evaluation of treatment alternatives; evaluation, specification, and procurement of process equipment and controls; main office-plant-contractor liaison; construction supervision; and system start-up. In addition, an operations and maintenance manual was provided. The system was completely designed and installed in a two month period to meet a regulatory imposed deadline.

Project Manager/Engineer currently involved in a number of projects dealing with remediation of manufactured gas plant (MGP) sites. Mr. Lees is a key participant in a research project to field test a number of selected remediation technologies at an MGP site. In addition, Mr. Lees is a project engineer participating in feasibility studies for both federal and state Superfund sites in New York.
Project Engineer responsible to investigate and evaluate feasible waste management practices for six SO_2 control technologies for the Electric Power Research Institute (EPRI). Responsibilities included waste characterization, waste quality calculation, transfer, pretreatment, storage system design, and cost analysis. Utilization potential of the advanced SO_2 waste also was investigated. Co-author for six EPRI publications.

Project Engineer for design and installation of wastewater pretreatment systems for motor repair shops. This work included evaluating design alternatives, specification and procurement of equipment, main office-plant-contractor liaison, construction supervision, and system start-up.

Project Engineer responsible for performing an economic evaluation of wastewater treatment/recycle options identified for a utility owned coal-fired electric generating station with a FGD SO_2 control system.

Project Engineer responsible for conducting hazardous waste/material surveys at U.S. Army bases in Germany. The survey's purpose was to: (1) determine hazardous material procurement procedures; (2) estimate hazardous material usage rates; (3) estimate hazardous waste generation rates; (4) inspect hazardous waste/material storage facilities; and (5) assess hazardous waste collection and disposal procedures.

RETEC

W. CHRISTIAN LEUTERITZ
ENVIRONMENTAL ENGINEER

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1988 - Present

EDUCATION

B.S. (Civil Engineering), University of Maine, 1988

AFFILIATIONS

E.I.T. Certified (Maine), 1988

TECHNICAL SPECIALTIES

Environmental Engineering: Site exploration and characterization; site engineering, excavation, biological treatment, and construction management; land treatment facility design and cost estimating.

REPRESENTATIVE PROJECT EXPERIENCE

Abandoned Petroleum Products Terminal in Rhode Island: Supervised site operations during biological remediation and excavation of an inactive 26-acre facility with contaminated soils in excess of 150,000 cubic yards. Performed site investigation and contaminant characterization. During the course of operations, free product and groundwater contamination were encountered, necessitating design and implementation of recovery and treatment or disposal. Prepared quarterly RIPDES reports. Prepared monthly, quarterly, and annual progress reports and provided construction management. Prepared and maintained annual budget estimates.

Active Petroleum Refinery in Delaware: Performed quarterly contaminant migration investigation for a 30 acre land treatment facility. Collected and reduced data for submission to state regulatory agency and EPA in compliance with No Migration Petition.

Active Petroleum Refinery in New York: Prepared cost estimate and performed technical specifications review. Provided technical and management support for remedial efforts. Provided technical review of construction documents for a major earthwork project.

Abandoned Petroleum Marketing Facility in New Jersey: Supervised site operations during the biological remediation of excavated soils at a bulk petroleum terminal. Performed a treatability study to determine feasibility of enhanced natural degradation as a remediation technique. Developed a suitable method of degradation that biologically reduced contaminant levels of stockpiled soils. Provided technical expertise to gain NJDEP approval of the process and methodology.

Active Petroleum Marketing Terminal in New Jersey: Supervised site operations during biological remediation of petroleum contaminated soils. Provided engineering design for support systems, i.e. irrigation, aeration, and nutrient amendments. Provided guidance for the development of an NJDEP approved soil sampling plan to technically support biological degradation.

Fueling Facility in Montana: Collected, reduced, and prepared data from the removal of storage tanks, piping, and contaminated soils/gravels. Contaminants included volatile and semi-volatile organics, metals, and pesticides.

Municipal Landfill Site in New Hampshire: Provided engineering support in development of a technical oversight work plan for wetlands/flood plains assessment.

Active Railroad Facilities: Gathered and analyzed data for several sites. Developed a feasibility study for disposal options of various wastes including track pan grit and oil/water separator sludge.

Active Railroad Facilities: Reviewed operations on client's various sites. Reviewed Clean Air Act, Clean Air Act Amendments of 1990, and air pollution regulations from nine states. Determined implications of these regulations on current operations.

Abandoned Railroad Maintenance Facility in Illinois: Performed site exploration activities. Gathered and reduced data collected from the site. Performed UST removal. Prepared and submitted report to state regulatory agency.

Abandoned Fertilizer Marketing Facility in Illinois: Performed site investigation, collecting samples, identifying hazards and recording inventory of products on site. Developed multi-phased remediation alleviating problems associated with the site focusing on utilization of products (fertilizers, pesticides, herbicides, etc.) and contaminated media to supplement typical applications on agricultural lands.

Former Manufactured Gas Plant in Iowa: Supervised construction of a unique land treatment demonstration unit (LTDU) for coal tar contaminated materials. An optimum biological treatment method will be determined by experimenting on these contaminated materials with several enhanced biological treatment options within this LTDU.

Active Steam Electric Station in Pennsylvania: Performed site exploration activities including soil gas survey, soil borings, and monitoring well installation. Collected and prepared data for development of Remedial Option Assessment Report recommending best remedial alternative.

Presentations

Schmidt, H.K. and Leuteritz, W. C., "Ex-Situ Biological Remediation" to New England Section of Air and Waste Management Association.

REITEC

DANIEL LEE MILLER, E.I.T.

SENIOR PROJECT ENGINEER

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1989 to present
GMG Associates, Inc., 1988 to 1989
Advanced Mineral Technologies, Inc., 1984 to 1988
F.B. Leopold Co., Inc., 1979 to 1984

EDUCATION

B.S. (Engineering Physics, Chemistry), West Virginia Wesleyan College

PROFESSIONAL REGISTRATIONS

E.I.T. - Colorado, 1989

TECHNICAL SPECIALTIES

Soil Venting and Groundwater Aeration Systems
Industrial Wastewater/Groundwater Treatment
Environmental Process Equipment Design and Cost Estimating

PROFESSIONAL EXPERIENCE

Project Engineer for the design, procurement, installation and start-up of a soil venting system for remediation of a toluene/TCA spill from beneath a 250,000 square feet existing warehouse.

Project Engineer for the design and procurement of a soil venting/thermal oxidation system for treatment of a leaded gasoline spill.

Project Manager/Engineer for the conceptual and detailed design, equipment specification and procurement, equipment installation and construction management, operation and maintenance manual development, start-up and operator training for a 0.2 MGD pumped groundwater sand filtration/ activated carbon treatment system for the removal of PAHs and phenol prior to NPDES discharge.

Project Engineer for design review and controls integration for a 0.1 MGD pumped groundwater oil/water separation/activated carbon treatment system for removal of benzene to levels below the TCLP limits to permit for reinjection.

Project Engineer for the design and implementation of a short term 0.1 MGD surface water sand filtration/activated carbon treatment system for creosote contaminated waters from a surface impoundment prior to NPDES discharge.

Project Engineer for the treatment of 20,000 gallons of chromate contaminated industrial wastewater for surface discharge at a major public utility.

Project Engineer for the treatment of two 100,000 gallon lagoons with lead contaminated wastewater at a lead-acid battery plant.

Project Manager/Engineer for the design, fabrication, installation, and start-up of an on line treatment system for the removal/recovery of copper and lead from a printed circuit board manufacturers process wastewater.

Project Engineer for treatment of chrome, nickel, cadmium, copper, and zinc contaminated wastewaters from commercial electro-platers.

Project Manager for the development of a pilot-scale production facility to demonstrate the ability of full-scale production of an innovative base product for the treatment of soluble metals.

Project Engineer responsible for evaluating process equipment at suppliers' test facilities to determine suitability to the manufacturing process of the base product for soluble metals removal.

Project Engineer responsible for the preliminary design engineering and cost analysis for the full-scale production plant, estimated $2 million capital cost project.

Field Service Coordinator acted as the internal contact for field operations and supervised the start ups of the wastewater treatment systems.

Project Engineer responsible for designing and coordinating field trials to demonstrate an innovative technology for the treatment of soluble metals from industrial wastewaters.

Process Engineer for the design engineering and cost analysis of fluid bed, canister, and dispersed bed wastewater treatment systems.

Project Engineer responsible for the commercialization of the prototype products, maintaining project budgets, and meeting deadlines.

Project Engineer responsible for coordinating new process design from the bench-scale to field operations, with input from R&D, suppliers, and engineers.

Project Engineer responsible for preparing engineering design procedures for new products.

Field Engineer for the Alfred Merrit Smith WTP Project in Las Vegas, NV a multi-million dollar plant expansion.

Field Engineer for the Niagara Falls WWTP project in Niagara Falls, NY a retrofit of the existing plant utilizing deep bed activating carbon filters as secondary treatment.

PUBLICATIONS

Smith, J.R., Chavez, R.P., Miller, D.L., and Gutierrez, M., *Sand Filtration/Activated Carbon Treatment of Pumped Groundwaters from a Coal-Tar Superfund Site for NPDES Discharge*. Presented at Water Pollution Control Federation 63rd Annual Conference, Washington, D.C., October 7-11, 1990.

Smith, J.R., Chavez, R.P., Miller, D.L., and Matsik, G.A., *Sand Filtration/Activated Carbon Treatment of Pumped Groundwaters from a Coal-Tar Superfund Site for NPDES Permit*. Paper to be Presented at the 23rd Mid-Atlantic Waste Conference, Pittsburgh, Pennsylvania, June 4-7, 1991.

JEFFREY A. MILLER
PROJECT ENGINEER

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1991 to Present
Stuart-Ironsides, Inc., 1986 to 1991
West Virginia University, 1983 to 1986

EDUCATION

M.S. (Petroleum Engineering) West Virginia University
B.S. (Petroleum Engineering) Marietta College

TECHNICAL SPECIALITIES

Computer Modeling
Interpreting Subsurface Pressure Measurements

PROFESSIONAL EXPERIENCE

Project Engineer for soil venting/groundwater aeration system. Responsible for system design, installation, start-up and pilot operation. The system include a horizontal soil gas collection system and five groundwater air injection wells. Offgas from the system was treated with activated carbon.

Project Engineer for conceptual design for refinery storm sewer system.

Certified interim inspector and installer for underground storage tanks in Pennsylvania.

Plant engineer and manager for 1.5 million gallon per year manufacturer of specialty lubricants primarily used in aluminum rolling. Responsible for all phases of production operation and management.

Field Engineer for treating 10,000 gallon/day oil-contaminated water. Responsible for testing, treating, and releasing.

Project Coordinator for U.S. D.O.E. Eastern Tight Gas Formations Data Base Project.

Project Engineer responsible for design, installation, and start-up of a soil venting/groundwater aeration system.

PRESENTATIONS AND PUBLICATIONS

S. Ameri, K. Aminion, J.A. Miller, D. Doricich, West Virginia University and A.B. Yust II. U.S. D.O.E./METC. *A Systematic Approach for Economic Development of the Devonian Shale Gas Resources*, Presented at the 1985 Society of Petroleum Engineers (SPE Paper 14504), 1985 Eastern Regional Meeting.

RETEC

JOHN R. SMITH

PRINCIPAL/CIVIL/ENVIRONMENTAL ENGINEER

PROFESSIONAL HISTORY

Remediation Technologies, Inc., 1988 to present
Keystone Environmental Resources, 1985 to 1988
Koppers Company, 1978 to 1985
Calceronis and Spina, 1978
Erie County Department of Sewerage Management, 1978
State University of New York at Buffalo, 1976 to 1978

EDUCATION

Ph.D.	(Civil/Environmental Engineering) Carnegie-Mellon University
M.S.	(Civil/Environmental Engineering) State University of New York
B.S.	(Civil Engineering) State University of New York at Buffalo
B.S.	(Forest Engineering) State University of New York at Syracuse

PROFESSIONAL REGISTRATIONS

P.E. - Pennsylvania

TECHNICAL SPECIALTIES

Management of sites contaminated with coal tar and wood treating chemicals.

Execution of lab- and field-scale treatability studies in support of full-scale site remediation; engineering evaluation, design and implementation of physical/chemical and biological treatment processes for the treatment of soils, groundwater, and process wastewaters contaminated with coal tar and petroleum related chemicals; execution of process wastewater characterization studies; in situ anaerobic treatment of coal tar related chemicals.

REPRESENTATIVE PROJECT EXPERIENCE

Given Expert Witness Testimony related to wood treating sites.

Creosote, Penta, Cellon, NCX, and CCA Wood Preserving Plant, California: As part of an RI/FS study, conducted pilot- and lab-scale treatability work examining treatment of on-site and off-site groundwater, plant wastewaters, and contaminated soils/sludges. Treatment process evaluated included chemical coagulation/flocculation, aeration tank treatment, trickling filter treatment, activated carbon, chemical oxidation, and biological filtration. Also performed plant-uptake study of trace organics present in groundwater used for irrigation of agricultural crop plants. Fish bioassays of the treated effluent were also carried out.

Chemical Processing Plant, Pennsylvania: Pilot-scale treatability work examining reverse osmosis treatment followed by post-treatment evaluation of organics removal by both chemical oxidation, and activated carbon adsorption of several plant effluent streams and contaminated groundwater. Fish toxicity testing of the treated effluent was also performed.

Creosote, CCA, and Penta Wood Preserving Plant, Colorado: Treatability/characterization work, conceptual design, process design, construction supervision, and start-up of a treatment system comprised of coagulation/flocculation pretreatment followed by chemical oxidation of plant wastewaters prior to discharge to a POTW.

Previously Operated Penta and Creosote Wood Preserving Plant, New Hampshire: Characterization/treatability work, conceptual design, process design review, construction supervision, and start-up of a treatment system comprised of chemical pretreatment for oil/water separation followed by chemical oxidation of pumped contaminated groundwater prior to discharge to a POTW. Pilot- and lab-scale evaluation of land treatment of contaminated soils as part of RI/FS work.

Wood Preserving Sites, California, New Hampshire, Illinois, and Maryland: Pilot- and bench-scale evaluation of land treatment of contaminated soils and sludges.

Confidential Client: Implemented an in situ groundwater treatment system in conjunction with above ground treatment at a pentachlorophenol window treating site. Treatment system implemented involved pumping groundwater, treating it by oil/water separation, UV/Ozone, and activated carbon adsorption processes followed by chemical addition to maintain in situ biological activity prior to groundwater reinjection.

Petroleum Refining Site, Texas: Designed and implemented a 70 gpm groundwater treatment system comprised of oil/water separation and activated carbon treatment. Such treatment was needed to comply with RCRA TC requirements prior to deep well injection.

Coke Manufacturing, Coal-Tar Distillation Site, Minnesota: Managed a project from paper screening of applicable technologies through design and implementation of a 140 gpm groundwater treatment system comprised of sand filtration with potassium permanganate chemical oxidation for iron removal followed by activated carbon treatment prior to NPDES discharge.

SELECTED PRESENTATIONS AND PUBLICATIONS

Smith, J.R. and J.K. Fu, "Treatment of Coal Gasification Wastewaters," Presented to Study-Visit Group for Wastewater Treatment involved in High Pressure Coal Gasification Plants to U.S.A., Bureau of Science and Technology - Ministry of Construction - The People's Republic of China, Chicago, Illinois, April 1988.

Smith, J.R., Panel Member on The United States Environmental Protection Agency Workshop on Biotechnology and Pollution Control, Bethesda, Maryland, March 20-21, 1986.

Smith, J.R., et al., "Application of Biodegradation Screening Protocol to Contaminated Soils from Manufactured Gas Plant Sites", Proceedings of the Institute of Gas Technology Symposium on Gas, Oil, and Coal Biotechnology, The Royal Sonesta Hotel, New Orleans, LA, December 11-13, 1989.

Smith, J.R. and R.L. Weightman, "Co-Treatment of Manufactured Gas Plant Site Groundwaters with Municipal Wastewaters, Final Technical Report Prepared for the Gas Research Institute, Chicago, IL, GRI-88/0218, NTIS No. PB-8911524D/XAB, August 1988.

Ryan, J.R., and J.R. Smith, "Land Treatment of Wood-Preserving Wastes." Proceedings of the National Conference on Hazardous Wastes and Hazardous Materials. Hazardous Materials Control Research Institute, Washington, DC, p. 80-86, 1986.

ROBIN L. WEIGHTMAN

ENVIRONMENTAL SCIENTIST

PROFESSIONAL HISTORY

Remediation Technologies, Inc. 1988 to present
Keystone Environmental Resources, Inc. 1986 to 1988
(Subsidiary of Koppers Company, Inc.)
Koppers Company, Inc. 1981 to 1986
Westinghouse Electric Corp. 1979 to 1981

EDUCATION

B.S. Pennsylvania State University, University Park, PA
Environmental Resource Management

TECHNICAL SPECIALTIES

Designing, implementing, and evaluating laboratory and pilot-scale soil and water treatability studies.
Field operations including start-up and sampling.
Performing environmental reviews.

BACKGROUND AND EXPERIENCE

Mr. Weightman has been involved in many engineering and environmental studies. These studies included biological sampling, water and wastewater characterization, soil and water treatability studies, wastewater treatment system conceptual design and full-scale start-up. He has considerable experience in the operation of bench- and pilot-scale wastewater treatment systems, as well as laboratory experience. His relevant experience includes:

Project Scientist for wastewater characterization and treatability studies for several wood treating plants. His work included operation of bench- and pilot-scale wastewater treatment units, data compilation, and report preparation.

Project Manager for a research institute involving former manufactured gas plants. Project included the establishment of site investigation protocols and remediation alternatives. Major tasks included technical writing, budget control, project schedules, and overall project management.

Served as a primary project team member responsible for completing feasibility studies at several manufactured gas plant sites. Primarily responsible for remedial alternative screening and subsequent detailed evaluations.

Project Scientist for a emergency response resulting from a spill of wood treating solution. Project included water and soil sampling, coordination with EPA and state officials, site survey and volume estimates, and site remediation.

Conducted a treatability program including both laboratory- and pilot-scale studies addressing the following technologies for MGP groundwater: gravity separation , oil/water separation, sand filtration, chemical oxidation, carbon adsorption, and air stripping.

Managed a pilot-scale study to evaluate MGP groundwater treatment at a POTW. This study lead to a subsequent study involving a full-scale field demonstration of MGP groundwater treatment at several POTW's.

Project Scientist for a conceptual design, full-scale start-up and operation of a wastewater treatment system for a wood treating plant. Major tasks included preparation of a conceptual design and an operations manual for the full-scale system.

Project Scientist for a baseline study to collect water quality data and fish tissue analysis as part of a Remedial Investigation/Feasibility Study (RI/FS).

Project Scientist/Senior Environmental Technician for a variety of projects that included: water sampling, biological sampling, surveying, stream gauging and flow measurement, laboratory testing, bench- and pilot-scale operations, data compilation, report preparation, wastewater treatment conceptual design, and project proposal preparation.

Senior Environmental Technician for a baseline study for a proposed peat harvesting site. Major tasks included stream gauging, water quality sampling, and biological sampling.

PUBLICATIONS

Smith, J.R., R.L. Weightman, et al., "Co-Treatment of Manufactured Gas Plant Site Groundwaters with Municipal Wastewaters, Presented at the 61st Annual Water Pollution Control Federation Conference, Dallas, Texas, October 2-6, 1988.

MARK S. WESTRAY

PROJECT SCIENTIST

PROFESSIONAL HISTORY

Remediation Technologies, 1990 to present
Westinghouse Environmental & Geotechnical Services, Inc., 1988 to 1990
IT Corporation, 1986 to 1988
FMC Corporation Aquifer Remediation Systems, 1984 to 1986

EDUCATION

M.S. (Environmental Sciences and Engineering) University of North Carolina
B.S. (Biology) University of North Carolina

AFFILIATIONS

American Society for Microbiology
Association of Groundwater Scientists and Engineers
Society for Environmental Toxicology and Chemistry
Subcommittee on Bioremediation, Hazardous Waste Treatment Council

TECHNICAL SPECIALTIES

Bioremediation techniques for treatment of contaminated soil, groundwater, sludges and wastewater; design of groundwater injection/recovery systems; design of land treatment and composting systems; in situ bioremediation systems design; biological feasibility/treatability studies and pilot-scale systems; integration of remedial processes.

REPRESENTATIVE PROJECT EXPERIENCE

Chemical Manufacturers: Project Manager for the evaluation of subsurface remediation alternatives at a polyolefin plant in southeast Texas. Project included laboratory and field pilot studies to address the efficacy of in situ soil flushing, bioremediation and vacuum extraction. An economic and engineering evaluation was also performed to project the ultimate costs and effectiveness of the various remedial approaches when applied to the entire 12-acre site.

Wood Treating Site, Mississippi: Project Manager for a former wood treating site, which involved the coordination of subsurface remedial activities, continuing on-site and off-site contaminant investigation, and Consent Order compliance. The project also involved laboratory treatability studies and field pilot to evaluate the effectiveness of in situ bioremediation to treat residual PAH contamination.

Wood Treating Site, Alabama: Co-Project Manager for remedial and investigatory activities in compliance with RCRA Post-Closure and HSWA permits. Requirement for Corrective Measures Studies included treatability studies to evaluate biological treatment of PAH-contaminated groundwater and PAH/PCP contaminated soils.

Electric Utility, Virginia: Project Manager for soils and hydrogeologic investigations and risk assessment associated with the decommissioning of a power generating station on the Virginia Eastern shore.

State Superfund Site, North Carolina: Project Manager for the preparation of an RI Work Plan, performance of the RI/FS, and removal of USTs, lagoon closure, and associated remedial activities at a former industrial processing facility.

Petroleum Marketing Facility, Washington, DC: Project Manager for in situ bioremediation project. Directed the engineering design and implementation of the remediation program that included groundwater recovery, pH adjustment, air stripping, hydrogen peroxide and nutrient addition, and reinjection through a system of infiltration galleries and injection wells.

State Superfund Site Remediation, North Carolina: Project Manager for soil bioremediation project in Snow Hill, North Carolina. Project responsibilities included design and evaluation of a composting system pilot study and design,implementation and supervision of a full-scale composting system to treat soils contaminated with phthalates.

North Carolina Municipality: Project Manager for composting bioremediation project for treatment of 2,000 cubic yards of petroleum contaminated soil. Project responsibilities include system design, coordination of excavation and treatment activities.

Lead Groundwater Remediation, New York: Project Manager for the engineering design of an in situ bioremediation program for treating gasoline contamination in a drinking water aquifer in Lower New York State. The design featured a 300-foot injection trench.

Chemical Manufacturer: Project Manager for the feasibility assessment and process design for application of in situ bioremediation at a Superfund site in Ocean County, New Jersey.

Petroleum Company: Project Manager for an in situ bioremediation pilot project for treatment of phenolic contamination of a deep aquifer at an oil refinery in southeast Louisiana.

Westinghouse Environmental Services: Program Manger for the Bioremediation Center of Excellence at Westinghouse in Cary, North Carolina. Responsibilities included business and technology development, design of bioremediation feasibility/treatability studies, supervision of a 1,200 square foot remediation testing laboratory and project management.

PUBLICATIONS

Lang, D.J., S.T. Joyce, and M.S. Westray, "Land Treatment of Petroleum Contaminated Soils with Sewage Sludge," New England Environmental Expo, 1990.

Westray, M.S., "Design Considerations for In Situ Bioremediation," Underground Storage Tank Management and Hydrocarbon Contamination Cleanup, Resource Education Institute, Inc., 1988.

Downey, D.C., R.E. Hinchee, and M.S Westray, "Enhanced Bioremediation of a JP-4 Contaminated Aquifer," Environmental Risk: Recognition, Assessment, and Management, SETAC, 1987.

Westray, M.S., "Groundwater Microbiology: Observations and Comments," AGU Chapman Conference, Snowbird, Utah, 1986.

APPENDIX F

PROJECT SUMMARIES

RETEC

SUPERFUND SITE INVESTIGATION AND BIOREMEDIATION OF TWO CREOSOTE WASTE IMPOUNDMENTS

Extensive groundwater and soil contamination occurred from leakage from unlined surface impoundments, spills around product handling areas, and leaks from underground piping at this CERCLA site in Minnesota.

ReTeC personnel completed an RI/FS and Risk Assessment based on information from numerous borings and test pit excavations in the impoundments and around the site. Quantities of sludges and contaminated soils were also determined. Over 30 groundwater monitoring wells were installed at three different depths to characterize the horizontal and vertical extent of groundwater contamination. A 72-hour pump test was conducted to define aquifer parameters for design of a gradient control well system. Predicted cones of depression and capture zones for the gradient control well system were compared to the groundwater plume to ensure that all contaminated groundwater was being intercepted. A NPDES permit was obtained for discharge of the extracted groundwater to the Mississippi River.

ReTeC personnel prepared design and construction documents, and managed construction of an on-site biotreatment facility. Laboratory and field plot treatability studies were conducted to demonstrate the feasibility of biological treatment and to develop design and operating criteria for the facility. Based on the treatability studies, a 3-acre lined facility was constructed in 1985 to treat approximately 10,000 cubic yards of sludge and contaminated soils. This was the first biological treatment system for decontaminating CERCLA wastes in the country.

All site investigations were conducted according to EPA protocols for Superfund investigations. Detailed work plans were prepared specifying project management plans, data management plans, QA/QC plans, and health and safety procedures to be followed for the investigation. ReTeC personnel actively participated in negotiations with the Environmental Protection Agency and the Minnesota Pollution Control Agency to define the scope of site investigation activities. Due to ReTeC's pragmatic approach to the investigation and remediation of the site, several million dollars were saved during the study and remediation phases of the project.

RETEC

SUPERFUND SITE REMEDIAL DESIGN AND REMEDIAL ACTION

EPA issued a Record of Decision (ROD) on a 15-acre parcel where soils and groundwater contaminated by chlorinated solvents, pesticides, PAHs, and PCBs had been discovered. The ROD specified four remedial elements including incineration of soils, *in situ* volatilization of chlorinated solvents in soils, off-site disposal of miscellaneous debris, and pumping and treating of groundwater contaminated by chlorinated solvents.

The PRP responsible for this site retained ReTeC to negotiate the Consent Decree and Scope of Work for implementation of the ROD and to subsequently design and implement the Remedial Action. Extensive negotiations were successful in allowing off-site incineration as opposed to on-site incineration as specified in the ROD to equally effective but less expensive alternatives.

Remedial design required detailed characterization of the engineering properties of the various contaminated media, groundwater modeling to determine the most efficient extraction system design and pilot-scale testing of the various treatment technologies followed by design of the full-scale remediation. Detailed construction documents will be prepared including plans and specifications. Upon final approval of the remedial design, detailed project operation plans will be prepared and the remedial action implemented.

RETEC

SOIL WASHING AND BIOLOGICAL SLURRY REACTOR TESTS ON CONTAMINATED MANUFACTURED GAS PLANT SITE SOILS

RETEC was contracted by a New York state utility to examine the ability to remove soil contaminants from a contaminated MGP site soil and to biologically treat the contaminants which report to the aqueous phase extract. The testing program consisted of performing a treatability protocol developed by RETEC for the Gas Research Institute (GRI). This protocol consists of abiotic (non-biological) desorption tests using the contaminated soil and buffered water solutions (i.e., simulated groundwater) followed by biological treatment of the soil in a liquid/solid, continuously stirred tank reactor. The desorption tests provide information regarding the ability to wash the contaminants from the soil; the slurry reactor tests provide data on the biodegradation of the extracted contaminants. In addition to using buffered water, the test program also considered using water with selected additives (e.g., water-soluble solvents or surfactants).

Use of this protocol provides data related to the biodegradability of MGP site soils. It can be implemented within a four- to six-week time frame, whereas, conventional microcosm work generally takes four to six months to complete.

RETEC

FEASIBILITY STUDY FOR MGP SITE

RETEC is conducting a feasibility study for a 65-acre site contaminated with a variety of wastes from the operation of manufactured gas plants. At this site, both a water gas and a coking gas facility were operated from the 1880s through the 1950s. In addition, facilities were constructed and operated to process the by-products from both operations, and at least one steam-electric plant was built and operated. The site is a peninsula in mid-state New York, and is subject to a consent order with the state environmental regulatory agency.

The work completed to date includes identification of and participation in supplemental investigatory activities; identifying applicable, or relevant and appropriate regulatory requirements; identifying response objectives and general remedial responses, and identifying and screening appropriate remediation technologies. Continuing work will follow the EPA requirements and guidelines for remedial activities under Superfund.

REMEDIATION OF A PETROLEUM PRODUCTS TERMINAL

A petroleum products terminal was decommissioned and was proposed for redevelopment as a residential complex by an independent real estate developer. ReTeC was retained by the terminal owner to review site characterization data and develop a remedial action plan. Based upon the nature and concentration of contamination at the site, as wells as the proposed time frame for the sale and redevelopment, biological treatment was identified as the most cost-effective technology by the goals of the remediation.

To further define the type and extent of contamination on site, ReTeC performed a subsurface site investigation. In addition to establishing limits of excavations, this task defined areas of mixed contamination and areas contaminated by a single product. This in turn allowed for areas to be segregated and remediated in a specialized manner thereby improving the overall throughput on the site.

ReTeC undertook a bench-scale treatability study to demonstrate applicability, as well as define full-scale operation parameters for the biological treatment technology. From this, ReTeC developed the Remedial Action Plan including site engineering, design of treatment technology, surface drainage, subsurface dewatering, groundwater treatment, and product recovery. ReTeC assisted the owner in negotiating regulatory approval of the remedial action plan including clean-up criteria.

ReTeC solicited bids from earth moving contractors and performed bid evaluation and contract negotiations. ReTeC has operated the biological treatment system and acted as project manager-in-charge of the earth moving subcontractor and the analytical laboratory. In association with the biological treatment, ReTeC is demonstrating *in situ* biological treatment of fuel oil constituents in the vadose zone. In this pilot-scale system, ReTeC is sparging oxygen through the soil mass and is periodically adding moisture and nutrients.

BIOREMEDIATION OF PETROCHEMICAL SLUDGES AT A MAJOR TERMINAL FACILITY

ReTeC was contracted to provide environmental engineering and field services for the bioremediation and closure of a 10-million gallon holding basin in Texas. The primary objective of this project is to biologically treat the petroleum/petrochemical sludges to the greatest extent possible before stabilizing of the treated residuals and capping of the site. Four million gallons of sludges are currently being treated in place. Downdraft surface aerators were installed to provide mixing and aeration while minimizing volatilization of hazardous compounds. Nutrients (nitrogen and phosphorus) are added weekly to ensure optimum carbon to nitrogen to phosphorus ratios.

ReTeC's services on this project have included:

- design of the treatment system and preparation of a comprehensive work plan;
- site preparation;
- aeration/mixing equipment installation;
- equipment operation;
- system monitoring/maintenance (sampling and analysis); and
- review, interpretation, and reporting of performance results.

SITE INVESTIGATION AND PRODUCT RECOVERY FOR MONTANA RAILROAD FUELING FACILITIES

Subsurface investigations are being conducted by ReTeC to evaluate the areal extent and product thickness of diesel fuel on a shallow aquifer system at these railroad fueling facilities in Montana. Monitor wells were drilled and soil test pits were dug near the fueling areas to locate the contamination. Investigations have identified contamination source, type, product thickness and areal extent of miscible and immiscible groundwater contamination. Characterization of the aquifer established values for hydraulic conductivity, storativity, porosity, aquifer thickness, geologic lithology and groundwater flow direction.

Fuel oil product has been discovered at one site; recovery systems were designed and fuel recovery systems are now in operation. Soil remediation systems for the sites are currently being designed and proposed methods include biological land treatment or composting. Groundwater remediation at one site is being planned and includes product recovery, oil/water separation and injection of treated water via an infiltration gallery to the aquifer.

SITE INVESTIGATIONS AND RESPONSE ACTIONS

Organic and inorganic wood preservatives have entered the soils, shallow groundwater and a small stream at this abandoned wood treating facility in Oregon. ReTeC provided expert witness testimony to support a case between the property owner and the bankrupt site operators. The property owner was awarded funds for site clean-up costs.

Site characterization activities by ReTeC and others have shown that organic and inorganic wood preservatives have entered the soils, shallow groundwater and a stream on-site. Under the terms of an EPA emergency order, contaminated groundwater and storm water were contained and stored in on-site tanks. A submerged fixed-film bioreactor was designed and operated by ReTeC to biologically remove creosote (PAH) and pentachlorophenol (PCP) constituents prior to carbon treatment and POTW discharge.

Soils were excavated from the stream and oil absorbent booms and pads were installed and maintained. The treating facility was demolished and all waste residues treated and disposed of.

ReTeC evaluated treatment alternatives for contaminated soils including an incineration test burn and slurry-phase biological treatment. Additional site investigations are now being conducted under State oversite and final documents will be prepared to characterize the extent of and develop a recommended alternative for soil, surface water, and groundwater contamination.

PETROLEUM MARKETING TERMINAL SOIL VAPOR EXTRACTION

ReTeC is responsible for design, installation, and start-up of a soil vapor extraction system to remediate an unleaded gasoline release to the soil at a petroleum marketing terminal in Boise, Idaho. The release of 66,000 gallons of product contaminated the underlying soil and resulted in free product accumulation on the water table.

Located in a commercial/residential area, the site is situated on older river alluvium composed of silt, sand, and gravel deposits totalling about 50 feet thick. The saturated alluvium is the local water table aquifer which has been affected by the spill. The water table ranges from 20 to 30 feet below the surface with off-site migration of 10 to 50 feet per day. Annual groundwater fluctuation is 10 feet, creating a smear zone in the vadose zone, thus complicating recovery. Data from a vapor extraction pilot test at the site was used to optimize remedial design.

The ReTeC vapor extraction design consists of three main components: vapor extraction wellpoints, a blower and piping to extract and transport air, and an exhaust air treatment system. Exhaust air from the vacuum blower is incinerated with a thermal oxidizer to comply with State air discharge permit requirements. ReTeC estimates a 160-foot radius of influence at two extraction wells (combined flow is 250 SCFM) to recover the equivalent of 22 gallons/hour of liquid hydrocarbons during initial operation. Extraction is anticipated to decrease with time over an estimated two-year remediation period.

APPENDIX G

INSURANCE CERTIFICATES

ACORD CERTIFICATE OF INSURANCE

ISSUE DATE (MM/DD/YY): 2/04/92

PRODUCER

FRANK B. HALL & CO. OF MA, INC
99 HIGH STREET
BOSTON, MA 02110-3271

617-482-3100

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW.

COMPANIES AFFORDING COVERAGE

COMPANY LETTER	
A	PLANET INSURANCE COMPANY
B	FIRST STATE INSURANCE
C	HARTFORD UNDERWRITERS
D	
E	

INSURED

REMEDIATION TECHNOLOGIES, INC.
1301 W. 25TH STREET, SUITE 406
AUSTIN

TX 78705

COVERAGES

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED, NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

CO LTR	TYPE OF INSURANCE	POLICY NUMBER	POLICY EFFECTIVE DATE (MM/DD/YY)	POLICY EXPIRATION DATE (MM/DD/YY)	LIMITS	
A	GENERAL LIABILITY [X] COMMERCIAL GENERAL LIABILITY [X] CLAIMS MADE [ ] OCCUR. [ ] OWNER'S & CONTRACTOR'S PROT. [ ]	NGB125938702	2/02/92	2/02/93	GENERAL AGGREGATE	$ 2,000,000
					PRODUCTS-COMP/OP AGG.	$ 2,000,000
					PERSONAL & ADV. INJURY	$ 2,000,000
					EACH OCCURRENCE	$ 2,000,000
					FIRE DAMAGE (Any one fire)	$ 50,000
					MED. EXPENSE (Any one person)	$ 5,000
A	AUTOMOBILE LIABILITY [ ] ANY AUTO [X] ALL OWNED AUTOS [X] SCHEDULED AUTOS [X] HIRED AUTOS [X] NON-OWNED AUTOS [ ] GARAGE LIABILITY [X] MCS-90 END'T	NKA125887902	2/02/92	2/02/93	COMBINED SINGLE LIMIT	$ 2,000,000
					BODILY INJURY (Per person)	$
					BODILY INJURY (Per accident)	$
					PROPERTY DAMAGE	$
B	EXCESS LIABILITY [X] UMBRELLA FORM [ ] OTHER THAN UMBRELLA FORM	RENEWAL OF US0003248	2/02/92	2/02/93	EACH OCCURRENCE	$ 3,000,000
					AGGREGATE	$ 3,000,000
C	WORKER'S COMPENSATION AND EMPLOYERS' LIABILITY	72WJCM3711W	1/01/92	1/01/93	[ ] STATUTORY LIMITS	
					EACH ACCIDENT	$ 1,000,000
					DISEASE-POLICY LIMIT	$ 1,000,000
					DISEASE-EACH EMPLOYEE	$ 1,000,000
A	OTHER CONSULTANTS ENVIRONMENTAL LIABILITY	NTF201572401	2/02/92	2/02/93	$2000000 EACH CLAIM 2000000 AGGREGATE 250000 SIR	

DESCRIPTION OF OPERATIONS/LOCATIONS/VEHICLES/SPECIAL ITEMS

CERTIFICATE HOLDER

SAMple

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, THE ISSUING COMPANY WILL ENDEAVOR TO MAIL 30 DAYS WRITTEN NOTICE TO THE CERTIFICATE HOLDER NAMED TO THE LEFT, BUT FAILURE TO MAIL SUCH NOTICE SHALL IMPOSE NO OBLIGATION OR LIABILITY OF ANY KIND UPON THE COMPANY, ITS AGENTS OR REPRESENTATIVES

AUTHORIZED REPRESENTATIVE

[signature]

292840000

APPENDIX H

QUALIFICATIONS OF SUBCONTRACTORS

SUBCONTRACTOR QUALIFICATIONS

As noted in the proposal, the only subcontractors RETEC will use are for drilling, surveying and analytical services. Quotes have been solicited from reputable contractors who have worked with RETEC in the past and are qualified to undertake this work; however, these quotes have not been confirmed in writing at the time this proposal was prepared nor were qualifications received. RETEC is proposing to solicit written proposals from a minimum of two vendors of these services and will provide qualifications and detailed cost breakdowns at that time.

APPENDIX I

STANDARD OPERATING PROCEDURES

BIODEGRADATION PILOT STUDY

RETEC

STANDARD METHOD FOR MICROBIAL ENUMERATIONS

Approval: [signature] Date: 1-22-1991

Approval: [signature] Date: 1-22-1991

1.0 SCOPE

Microbial enumerations are performed to estimate both the total number of organisms in an environmental sample, and the number of organisms capable of degrading specific compounds of interest. Microbial enumerations using plate count and most probable number (MPN) determinations provide a measure of total microbial biomass in a sample. The potential for biodegradation of chosen contaminants in a given environment may then be inferred from enumeration data. Microbial counts can also be used to assess the potential toxicity of the contaminants present at a site to microorganisms, and the response of microorganisms to alternative management practices.

Enumerations are a relatively inexpensive method of measuring the overall biological health of a given sample and for verifying the presence and abundance of specific physiological types of organisms (such as oil-or PAH-degrading organisms).

2.0 SIGNIFICANCE AND USE

Microbial enumerations may be performed to estimate the total viable microbial biomass within a given sample, to assess the potential toxicity of the contaminants present at a site, and subsequently to examine the response of microorganisms to alternative treatability practices.

Using a selective plate count technique in which an organic contaminant is incorporated into the microbiological media as the sole source of carbon and energy, specific nutritional groups of microorganisms or "specific degraders" may be enumerated. This standard method includes methods for enumerating total aerobic heterotrophic microorganisms, polynuclear aromatic hydrocarbon (PAH) degraders, volatile organic degraders and oil degraders.

3.0 MATERIALS

The following materials (in addition to standard laboratory equipment) are needed to perform microbial enumerations:

- test tubes and racks;
- pipet 0.1-1 ml;
- vortex shaker;
- petri dishes;
- autoclave;
- "hockey stick" (glass rod bent at 90° angle);
- spin plate;
- bunsen burner;
- Quebec colony counter;
- Laminar flow microbiological hood;
- media;
  - plate count agar (Difco 0479)
  - noble agar (Difco 0142)
- chemicals;
  - NaCl
  - KOH
- - chemicals for minimal salts;

- $(NH_4)_2SO_4$	- KH_2PO_4
- K_2HPO_4	- $MgSO_4$
- $CaCl_2.2H_2OFe$	- $SO_4.7H_2O$
- $CuSO_4.5H_2O$	- $CoCl_2.6H_2O$
- $MnCl_2.4H_2O$	- $NaMoO_4.2H_2O$
- $ZnCl_2.7H_2O$	

- specific carbon sources;
  - phenanthrene
  - naphthalene
  - oil (motor oil)
  - toluene
  - biphenyl
  - salicylate
  - pentachlorophenol
  - hexadecane
  - cyclohexane
  - pristane
  - dodecane
  - butylcyclopentane

4.0 PROCEDURES

4.1 General Microbial Enumerations

The enumeration of microorganisms within a soil or aqueous sample generally requires serial dilutions of the sample into a sterile diluent solution prior to transfer to a growth medium. Since plates containing too many colony forming units (greater than 300) cannot accurately be counted, and plates with too few colony forming units (less than 30) must be discarded from the counting procedure for statistical considerations, serial dilutions are performed to ensure countable results. For soil microbial enumerations, one gram of soil is aseptically transferred to nine ml of sterile saline solution (0.85 percent). For microbial determinations in a liquid sample (slurry, water inoculum, etc.), one ml of liquid is aseptically transferred to nine ml of sterile diluent with appropriate serial dilutions following. The optimal number of colonies per plate is between 30 and 300.

After achieving the desired dilutions, spread plates are prepared by transferring a 0.1-ml aliquot of sample to the appropriate medium surface and spreading with a flame-sterilized hockey stick to evenly cover the agar surface. Sample dilutions are routinely plated in duplicate to ensure greater accuracy. The plates are incubated in an inverted position to eliminate condensation on the agar surface. Inoculated plates are generally incubated at room temperature for 48 to 72 hours. Enumeration of specific degraders usually requires longer incubation, generally five days. After incubation, colonies are enumerated on each plate using a Quebec colony counter. To calculate the number of colony forming units per ml or gram of original sample, counts are multiplied by the inverse of the dilution factor used and then corrected for the quantity plated (see section 5.0, Calculations).

4.2 Total Aerobic Heterotrophic Microorganisms

For detection of total aerobic heterotrophic microorganisms, a general growth medium containing a source of carbon, nitrogen and phosphorous, such as plate count agar (Difco 0479) is used. Methods for detection of total heterotrophs are described in Clark, 1982 and AWPA, 1986. The agar is prepared according to label instructions and sterilized using an autoclave (121.6°C at 15 pounds of pressure) for 45 minutes. The agar is cooled in a water bath (40°F) and approximately 15-ml portions are poured into petri plates. The plates are allowed to solidify at room temperature.

The samples for microbial enumeration are serially diluted in duplicate per sample. Spread plates are prepared from the diluent sample tubes to achieve dilution factors of 10^4 - 10^8. The plates are incubated for 48 to 72 hours and enumerated as described in Section 4.1.

4.3 Polynuclear Aromatic Hydrocarbon (PAH) Degraders

To enumerate PAH degraders, phenanthrene is added to Noble agar plates (Difco 0142; 10 grams per liter of deionized, organic-free water) as the sole source of carbon. A minimal salts solution (method modified from Shiaris and Cooney, 1983) is also added. Due to the low water solubility of phenanthrene the compound is dissolved in acetone (five grams of phenanthrene per liter acetone) and a two-ml portion of the phenanthrene-acetone mixture is spread evenly on the surface of a prepared agar plate. Plates are allowed to dry (and acetone to evaporate) overnight. After drying, the phenanthrene appears as a cloudy film on the agar surface.

The sample dilutions generally plated are between 10^3 and 10^5. Dilutions are plated by aseptically transferring 0.1 ml aliquots to the agar surface while the plate is positioned and spinning on the spin plate apparatus. A "hockey stick" is used to evenly spread the inoculum. The plates are incubated at room temperature for three to five days. PAH degrading colonies are differentially identified as those colonies surrounded by zones of clearing. Viewing the phenanthrene plates with an ultraviolet light source may intensify clearing zones making enumeration an easier task.

4.4 Other Specific Degraders

To enumerate specific VOA degrading organisms, a sealed incubator is used in addition to materials listed in Section 3.0. A desiccator which allows a controlled volume of volatile organics (i.e., toluene, diesel) to enter the system is used as the incubator. To prevent toxicity, the incubator is vented at intervals with air. During incubation, the inoculated plates are placed in an inverted position and petri plate covers are not utilized which allows gas exchange between the incubator and the agar surface. Noble Agar plates containing minimal salts are prepared as described in Section 4.3. Serial dilutions are performed and appropriate dilutions plated on the minimal salts media. The inoculated plates are then incubated in the sealed chamber as described in the previous paragraph. The plates are incubated at room temperature and vented with the VOAs twice a day for approximately one hour. Between venting periods with VOA compounds, the chamber is flushed with air. The plates are incubated for 4 to 6 days, then counted using a Quebec colony counter.

4.5 Degraders of Volatile Organic Aromatic (VOA) Compounds

Four enumerating specific microbial nutritional groups or "specific degraders", a minimal salts medium (see Appendix), prepared in organic-free deionized water, supplemented with the test compound serving as the sole carbon source for growth is used. Water-soluble compounds with low volatility can be added directly to the medium (salicylate, glucose, pentachlorophenol, etc.). For those compounds which are either water insoluble or highly volatile such as biphenyl or naphthalene, a small amount (one mg) of the compound is placed in the lid of agar plate following inoculation and the plate is sealed with parafilm. The compound is therefore not allowed to contact the media surface.

As previously described, samples are serially diluted in duplicate or triplicate per sample. The tube contents which are generally plated are those with dilution factors in the range of 10^3 to 10^6. The dilution factor may be adjusted accordingly using site information. The plates are incubated for three to five days prior to enumerating all colony forming units on the plate surface.

4.5.1 Hydrocarbon Degraders

Specific classes of hydrocarbon degraders are enumerated using a modification of the method described by Seki (1973). A hydrocarbon emulsion is first prepared by mixing 2.5 grams of a specific hydrocarbon and 0.05 g of Tween 80 in 97.5 ml of sterile deionized (organic-free) water. Hydrocarbons including hexadecane, pristane, cyclohexane, butylcyclopentane and dodecane may be used. Compounds having a flash point above sterilization temperature may be autoclaved for 20 minutes, however, preparation in sterile water, using sterile glassware and aseptic technique is sufficient to exclude contamination of hydrocarbon stock solutions. Following preparation, hydrocarbon mixtures are emulsified using an ultrasonic oscillator for 10 minutes.

Nobel Agar, which contains no organic or inorganic constituents, is prepared by adding 10 g of agar per liter of organic-free deionized water. The agar base is amended with inorganic nutrients by the addition of 100 ml of a 10X solution of minimal salts medium (prepared in organic-free water). The medium is sterilized in the autoclave for 45 minutes.

Specific hydrocarbon plates are then prepared by aseptically transferring 250 microliters of the hydrocarbon stock to a sterile petri plate, pouring 15-ml of Nobel Agar into the plate and swirling to disperse the hydrocarbon emulsion throughout the medium. The concentration of hydrocarbon present is approximately 470 ppm. Plates are allowed to gel and then stored at 20°C overnight prior to use.

Subtraction of counts obtained on media without added hydrocarbons (Nobel Agar alone and Nobel Agar plus 10 ppm Tween 80) eliminates overestimates from both the growth of oligotrophic microorganisms and organisms capable of growth on trace organic contaminants.

Hydrocarbon degraders are enumerated by serially diluting samples, and preparing spread plates with dilution factors in the range of 10^3 to 10^8. The dilution factor may be adjusted accordingly using site information. The plates are incubated for five days prior to enumerating all colony forming units on the plate surface.

4.6 Oil Degraders

The most probable number (MPN) method represents an alternative to the plate count method for determination of specific groups of viable organisms. The MPN method is a practical analysis based on a Poisson distribution. Successive dilution of the sample is carried out to the point of extinction at which no growth is observed. In the MPN method a sample is serially diluted with five replicates at each dilution. For estimating the concentration of oil degrading organisms, the test procedure is designed so that increases in turbidity (growth) with formation of small oil droplets can be seen, and subsequently scored as positive. Each replicate is scored as positive or negative with no attempt to quantify the number of microorganisms within a positively scored replicate. The number of positives and negatives at the dilution step before the extinction point is used in conjunction with appropriate statistical tables to obtain the number of oil degrading microorganisms.

For enumeration of oil degraders, test tubes containing 8 to 10 ml of minimal salts (MS) media and 50 to 100 microliters (ul) of sterile motor oil (sole carbon source) are prepared and sterilized. Five MPN tubes are then inoculated with 0.1 ml for each ten-fold dilution to be tested (generally 10^4 to 10^7). The inoculated tubes are then incubated at a 50 degree angle on a shaker table (250 rpm) for five days. Positive tubes are identified and enumerated. An MPN statistical table (see Appendix) is then used to obtain the actual number of oil degraders present in a sample.

4.7 Differentiation of Cultures

Differentiation and identification of dominant microbial taxa from an environmental sample may be accomplished by a series of microbiological enrichment and isolation techniques. Preliminary recognition tests, including Gram stains for morphological identification, motility, oxidase and catalase tests, and oxidation fermentation tests may be performed. API Analytab Products (API, Plainview, New York) Rapid NFT and 20E biochemical test strip systems may then be used for differentiation and identification of individual isolates.

In cases where biochemical testing of microbial isolates using the API NFT and 20E strips do not yield code identification numbers registered in the API identification data base, isolates in pure culture are submitted to Microcheck, Inc. (Northfield, VT) for identification by cellular fatty acid analysis. Briefly, the bacterial identification system used by Microcheck consists of extraction of bacterial cellular fatty acids and analysis by gas chromatography using a flame ionization detector. Fatty acid separation is accomplished using a five percent methyl phenyl silicone capillary column. Fatty acids are identified by retention times, and profiles of unknowns compared to the fatty acid profiles of database strains. The comparison of the fatty acid profile of the unknown to those in the database is accomplished by principal component analysis and pattern recognition.

5.0 CALCULATIONS

Colony forming units (CFU) = number of colonies counted times the inverse of the corresponding dilution factor, divided by the volume plated. The results are expressed as 10^x cells/(g or ml).

6.0 QUALITY ASSURANCE AND CONTROL

All standard lab and sampling procedures (ReTec Laboratory QA/QC Manual) are followed to ensure accurate and reliable data are generated. Lab procedures ensure the equipment is cleaned and are adequate for the objectives of the study to minimize ambiguous results. Sampling methods are done in accordance with stated objectives and in a manner which is representative of test conditions established for the study. Sample design and data interpretation are in accordance with statistical methodologies to ensure definitive conclusions of the experiment.

The work area in which microbial enumerations are to be performed should be a non-porous surface which can be disinfected on a routine basis. The preferred working area is within a laminar flow hood.

The samples should be analyzed as soon as possible after collection to minimize changes in bacterial population. If the samples cannot be analyzed within 8 hours of collection, the sample should be maintained at a temperature below 4°C, but not frozen. Samples must be analyzed within 30 hours of receipt. The plates should be counted promptly following the appropriate incubation period.

Sterile plates or liquid media are included with all sample sets to ensure that laboratory contamination has not occurred.

All work performed is recorded in a permanent laboratory notebook for future reference. Analytical results are stored in a central lab file with the copies attached in the laboratory notebook. Chain-of-Custody and request for analysis sheets accompany all samples entering and exiting the lab. A copy of the Chain-of-Custody is kept on file until completion of the study.

7.0 RESPONSIBILITIES

The project engineer/scientist is responsible for the sampling procedures, sampling design and operating parameters for each experiment. The project engineer also prepares the final report and maintains the project files and notebook.

The project manager is expected to coordinate scheduling and provide oversight to ensure the specific objectives of each test are met.

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All personnel involved in use of hazardous agents obtain yearly medical examinations and surveillance and are provided with proper protective equipment necessary for the safe performance of their jobs. Personal protective equipment includes, but is not limited to, safety glasses with side shields, gloves, a clean lab coat and/or apron and a respirator. A standard operating procedure for the selection, care and proper use of respirators is available and is based on the OSHA Respiratory Protection Standard (29 CFR 1910.134). Work practices are designed using proper engineering controls (fume hoods) so that an employee's exposure to hazardous chemicals in the laboratory is minimized.

9.0 REFERENCES

Alexander, M. 1982. "Most-Probable-Number Method for Microbial Populations", Methods of Soil Analysis. pp. 1467-72.

AWPA. 1986. "Heterotrophic Plate Count", Standard Methods for the Examination for Water and Wastewater, 16th ed.. pp. 860-69.

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APPENDIX

Minimal Salts Media (MS)

Autoclave media with the first three compounds, cool, then add the other compounds (previously autoclaved).

	per liter of DI H_2O
$(NH_4)_2SO_4$	200 mg
KH_2PO_4	350 mg
K_2HPO_4	775 mg
$MgSO_4$	100 mg (2 ml of 5g/100 ml)
$CaCl_2$ $2H_2O$	70 mg (1 ml of 7g/100 ml)
Metals Stock	1 ml

pH should be 7.0-7.2, adjust with KOH (0.1 N) if necessary.

Metals Stock - 100 ml of stock solution containing:

	mg/100 ml of DI H20
$FeSO_4$ $7H_2O$	200
$CuSO_4$ $5H_2O$	2
$CoCl_2$ $6H_2O$	2
$MnCl_2$ $4H_20$	20
$NaMoO_4$ $2H_2O$	10
$ZnSO_4$ $7H_2O$	10

Autoclave

For a solid minimal salts media, combine MS with 12 g/l agar. Add agar to carbon (if water-soluble and low volatility), ammonium, and phosphate solution and autoclave. Allow to cool to 40°C in water bath before adding other salt and metal stock solutions.

MOST-PROBABLE-NUMBER METHOD FOR MICROBIAL COUNT

Table of most probable numbers for use with 10-fold dilutions and 5 tubes per dilution (Cochran, 1950).

P_1	P_2	Most probable number for indicated values of P_3					
		0	1	2	3	4	5
0	0	-	0.018	0.036	0.054	0.072	0.090
0	1	0.018	0.036	0.055	0.073	0.091	0.11
0	2	0.037	0.055	0.074	0.092	0.11	0.13
0	3	0.056	0.074	0.093	0.11	0.13	0.15
0	4	0.075	0.094	0.11	0.13	0.15	0.17
0	5	0.094	0.11	0.13	0.15	0.17	0.19
1	0	0.020	0.040	0.060	0.080	0.10	0.12
1	1	0.040	0.061	0.081	0.10	0.12	0.14
1	2	0.061	0.082	0.10	0.12	0.15	0.17
1	3	0.083	0.10	0.13	0.15	0.17	0.19
1	4	0.11	0.13	0.15	0.17	0.19	0.22
1	5	0.13	0.15	0.17	0.19	0.22	0.24
2	0	0.045	0.068	0.091	0.12	0.14	0.16
2	1	0.068	0.092	0.12	0.14	0.17	0.19
2	2	0.093	0.12	0.14	0.17	0.19	0.22
2	3	0.12	0.14	0.17	0.20	0.22	0.25
2	4	0.15	0.17	0.20	0.23	0.25	0.18
2	5	0.17	0.20	0.23	0.26	0.29	0.32
3	0	0.078	0.11	0.13	0.16	0.20	0.23
3	1	0.11	0.14	0.17	0.20	0.23	0.27
3	2	0.14	0.17	0.20	0.24	0.27	0.31
3	3	0.17	0.21	0.24	0.28	0.31	0.35
3	4	0.21	0.24	0.28	0.32	0.36	0.40
3	5	0.25	0.29	0.32	0.37	0.41	0.45
4	0	0.13	0.17	0.21	0.25	0.30	0.36
4	1	0.17	0.21	0.26	0.31	0.36	0.42
4	2	0.22	0.26	0.32	0.38	0.44	0.50
4	3	0.27	0.33	0.39	0.45	0.52	0.59
4	4	0.34	0.40	0.47	0.54	0.62	0.69
4	5	0.41	0.48	0.56	0.64	0.72	0.81

Table of most probable numbers for use with 10-fold dilutions and 5 tubes per dilution (Cochran, 1950) - (continued)

P_1	P_2	Most probable number for indicated values of P_3					
		0	1	2	3	4	5
5	0	0.23	0.31	0.43	0.58	0.76	0.95
5	1	0.33	0.46	0.64	0.84	1.1	1.3
5	2	0.49	0.70	0.95	1.2	1.5	1.8
5	3	0.79	1.1	1.4	1.8	2.1	2.5
5	4	1.3	1.7	2.2	2.8	3.5	4.3
5	5	2.4	3.5	5.4	9.2	16	-

Calculations

To calculate the most probable number of organisms in the original sample, select as P_1 the number of positive tubes in the least concentrated dilution in which all tubes are positive or in which the greatest number of tubes is positive, and let P_2 and P_3 represent the numbers of positive tubes in the next two higher dilutions. Then find the row of numbers in Table 100-1 in which P_1 and P_2 correspond to the values observed experimentally. Follow that row of numbers across the table to the column headed by the observed value of P_3. The figure at that point of intersection is the probable number of organisms in the quantity of the original samples presented in the inoculum added in the second dilution.

REIEC

STANDARD METHOD FOR STIMULATION TESTING

Approval: *[signature]* Date: 1-22-1991

Approval: *[signature]* Date: 1-22-91

1.0 SCOPE

This standard operating procedure (SOP) describes the methods for stimulation tests. This test involves incubating the contaminated waste in a sealed flask for generally 3-7 days. Typically, at least two treatments are compared. One set of flasks has only oxygen added (provided by the shaking action and gas transfer from the atmosphere). The other flasks have oxygen plus inorganic nutrients added. Counts of total numbers of aerobic heterotrophic microorganisms, and of other organisms of interest, are performed before and after the incubation to assess the microbial response to conditions conducive of growth.

2.0 SIGNIFICANCE AND USE

Stimulation tests are performed to determine whether the microbial population can increase to significant levels under optimal conditions. A secondary objective is to identify the environmental factors currently limiting microbial growth in the sample. The test can also include chemical analyses for the compound(s) of interest to rapidly assess the biodegradability of the compound(s) under optimal conditions. The stimulation test is an inexpensive first step to establish treatability, and is often followed by more extensive bench-scale testing.

While microbial counts can provide presumptive evidence for the feasibility of bioremediation at a given site, it is often useful to include initial and final chemical analyses as well. These analyses are necessary to prove that the compound(s) of interest are degraded during an incubation designed to promote high levels of microbial activity. In such cases, sterile controls are generally performed to prove that compound disappearance is due to biological activity. The sterilizing agents used include mercuric chloride, heat, formalin or radiation depending on the nature of the materials tested.

The test can be modified to study the impacts of other factors, such as individual nutrients, growth factors, or organic compounds added to stimulate cometabolism or to measure the potential toxicity of the material (by comparing the responses at different dilutions of the waste). The test can also be modified to include the use of respiration as a measure of overall biological activity in response to nutrients and oxygen (SOP 502), or mineralization of ^{14}C-labelled target compounds to study the specific biodegradation of contaminants of interest (SOP 540).

3.0 MATERIALS

The following materials (in addition to standard laboratory equipment) are needed for stimulation test set up and monitoring:

1. 250 ml flasks,
2. aquarium pump,
3. plastic tubing,
4. Site soil or waste samples,
5. Groundwater sample (preferred but optional),
6. orbital shaker table, and
7. Chemicals: KH_2PO_4, K_2HPO_4, and $(NH4)_2SO_4$.

4.0 PROCEDURE

4.1 Preparation of samples:

1. If the sample is a soil or concentrated waste; homogenize, determine the dry weight and total volatile organic carbon.

2. Measure the pH.

3. Enumerate total aerobic heterotrophic microorganisms and other organisms of interest (e.g., specific degraders). See SOP 510 on Microbial Enumerations for details.

4.2 Set up of test:

1. Calibrate each 250 ml flask from 100-200 ml by 50- ml increments.

2. Set up duplicate flasks containing diluted soil or concentrated waste with site groundwater if available, or deionized water otherwise. This test is done to determine whether microbial numbers will respond to aerobic conditions alone, supplied through shaking the samples to encourage aeration. The resulting solids loading is 20 percent (on a dry weight basis) in a total volume of 150 ml.

3. In order to assess nutrient stimulation, add the soil or concentrated waste to site groundwater or deionized water containing the following nutrients: 100 ppm nitrogen as $(NH_4)_2SO_4$ and 10 ppm phosphorous (as KH_2PO_4). The flasks are otherwise identical to the aeration only flasks described in step 3. Duplicate flasks are set up for each treatment.

4. Set up duplicate flasks with the free product or target compound added to ensure that sufficient carbon is available. Additions are typically at 100 mg/L unless solubility or toxicity considerations warrant otherwise.

5. If needed, a sterile control is set up similar to above treatments with sterilizing agents added. The sterilizing agents include mercuric chloride (1%), heat (autoclaving if contaminants are not volatile), formalin (1%), or radiation (3 Mrad gamma-irradiation), depending on the nature of the materials tested. Sterile controls prove that compound disappearance is due to biological activity.

6. Seal flasks with cotton and incubate at 22 degrees C for 3-7 days on an orbital shaker at 200 rpm to promote aeration. Incubation for 3 days is most common unless there is an indication that a long lag period is likely. The objective is to let the microbial population to grow to stationary phase.

4.3 <u>Sampling:</u>

1. One-ml samples are taken at the end of the incubation. Total aerobic microorganisms are enumerated, as well as specific degraders of interest. The results are compared to the initial numbers (Section 4.1) to determine the degree of stimulation.

2. Initial and final chemical analyses may be performed to show that the compound(s) of interest are degraded during the incubation.

5.0 QUALITY ASSURANCE AND CONTROL

All standard lab and sampling procedures (ReTec Laboratory QA/QC Manual) are followed to ensure that accurate and reliable data are generated. Lab procedures ensure the equipment is cleaned and adequate for the objectives of the study in order to minimize ambiguous results. Sampling methods are done in accordance with stated objectives and in a manner which is representative of test conditions established for the study. Sample design and data interpretation are in accordance with statistical methodologies to ensure definitive conclusions of the experiment.

All work performed is recorded in a permanent laboratory notebook for future reference. Analytical results are stored in a central lab file with copies pasted into the laboratory notebook. Chain-of-Custody and request for analysis sheets accompany all samples entering and exiting the lab. A copy of the Chain-of-Custody is kept in file until completion of the study.

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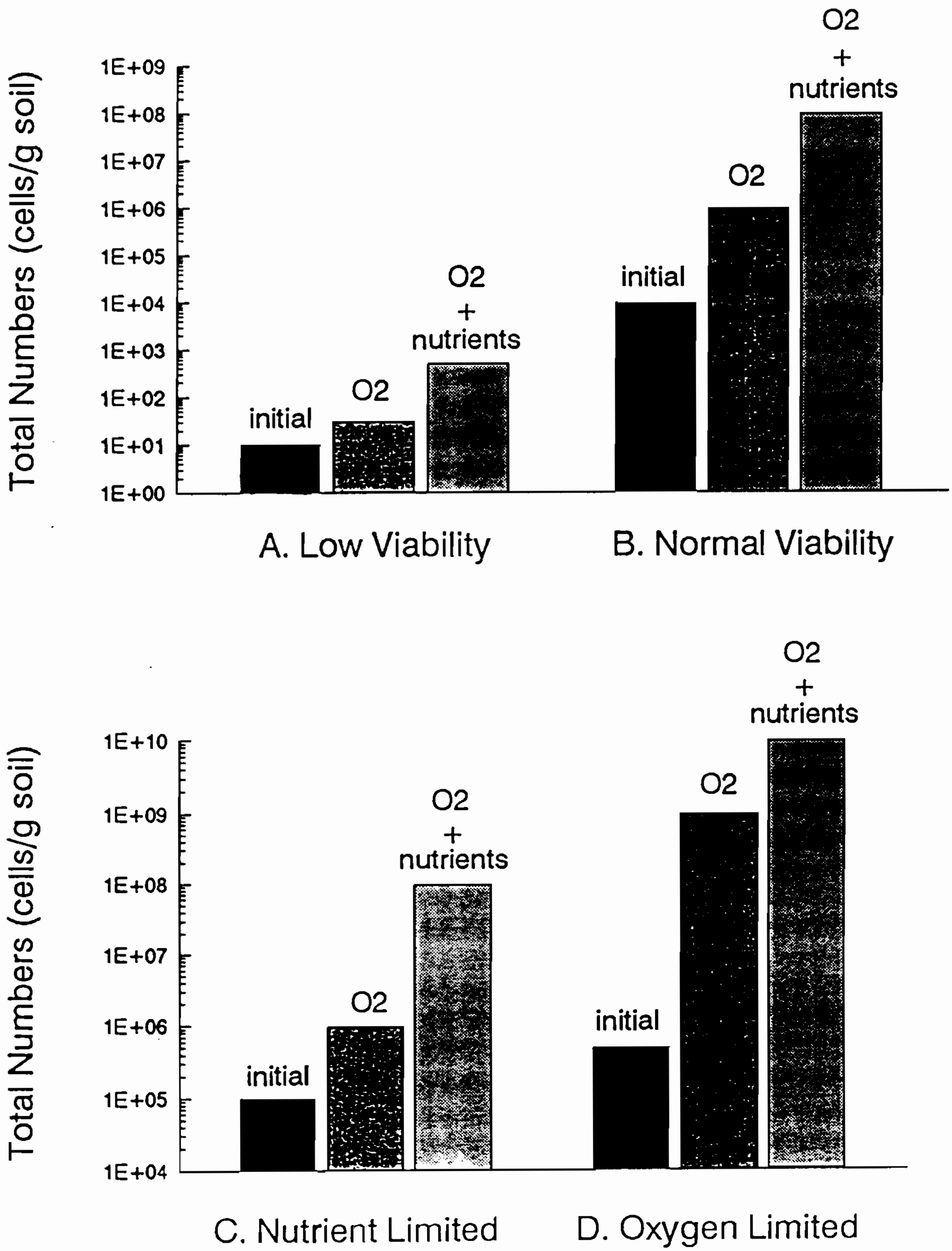
MICROBIAL VIABILITY/STIMULABILITY



REITEC

STANDARD METHOD FOR RESPIROMETRY USING THE BI-1000 AUTOMATED RESPIROMETER

Approval: [signature] Date: 4-8-92

Approval: [signature] Date: 4-8-92

1.0 SCOPE

This SOP describes the methods to be used to perform respirometry testing of soil, slurry, or liquid samples using the Bioscience (Bethlehem, PA) BI-1000 Automated Respirometer. Respirometry may also be performed using the Gilson Volumetric Respirometer (see SOP 525). However, the BI-1000 offers several advantages over the Gilson instrument including continuous automated data recording, improved sensitivity, automatic computational and graphics functions, and real-time graphical results monitoring.

The BI-1000 is exclusively designed for use with aerobic samples.

2.0 SIGNIFICANCE AND USE

Respirometry provides a convenient and rapid method to determine the level of biological activity in waste samples (soil, water or slurry) by measuring the oxygen consumption rates of the test samples. The biological activity in a sample may be affected by microbial biomass, nutrient levels, sample biotoxicity, pH and dissolved solids levels, and other chemical/physical factors. Experiments in which respirometric measurements are made while experimental conditions are manipulated can provide information on how to optimize biological activity in a test waste and thus expedite bioremediation processes.

The uses of the BI-1000 respirometer include, but are not limited to, the following:

- **Solids Loading Optimization Testing** (Respirometric measurements of a sample slurry over a range of solids loadings to determine the loading at which biological activity is optimized).

- **Carbon/Nutrient Limitation Testing** (Respirometric measurements of test samples with and without carbon/nutrient amendments to determine whether these conditions are limiting).

- **Sample Biotoxicity Testing** (Respirometric measurements of test samples over a range of waste component concentrations to determine the level at which the waste components demonstrate biotoxicity).

- **Inoculum Compatibility Testing** (Respirometric monitoring of the success or failure of microbial inoculum to adapt to a sample matrix).

3.0 MATERIALS

The following equipment and materials are required to perform respirometric testing with the BI-1000:

- BI-1000 Automated Respirometer with data disk and software;
- test incubation flasks (500 or 1000 mL) with electrolytic cell and CO_2 scrubber assemblies;
- test soil/waste;
- magnetic stir bars;
- deionized water, clean site water or clean site soils; and
- chemicals (nitrogen and phosphorus nutrient salts, contaminants of concern, nitrification inhibitors, etc.).

Refer to the BI-1000 instructions manual for information on maintenance, operation and calibration of the instrument.

4.0 PROCEDURES

The number and type of experimental conditions selected for the respirometry test will depend on objectives of the study set forth in the treatability work plan. Most experiments involve comparison of at least two test conditions (i.e., unamended v. nutrient amended soils, or clean v. contaminated waste-slurry samples. Other experiments, such as biotoxicity testing, may involve three or four test conditions (i.e., 0, 2, 5, 10, 25 ppm TCE in groundwater samples).

Prior to conducting respirometry tests, an understanding of the physical and chemical properties of the test sample may be required. The information obtained from baseline analyses of the waste can be critical for establishing the appropriate test conditions and/or interpreting the results of the tests. The baseline data may suggest approaches for optimizing biological activity which would otherwise be overlooked. Soil matrix properties of interest may include pH, texture, field capacity, total organic carbon, nutrient (i.e., nitrogen and phosphorus) concentrations, and contaminant concentrations. Waste properties of interest may include pH, moisture content, solids content, oil and grease (as a gross organics indicator), and the concentrations of any specific constituents that may, based on site history, be a potential microbial toxicant.

4.1 Preparation of Sample Chambers

1. Check the BI-1000 instrument log to determine whether recalibration of the electrolytic cells is required, and calibrate if necessary.

2. Prepare each test sample as described in the work plan. This may include screening of soil samples to remove debris and gravel, preparation of slurry samples with the desired solids loadings, dilution of waste soils or water with uncontaminated site soil/water samples, or addition of sample amendments such as nutrients or microbial inocula.

3. Load the prepared waste sample into the appropriate, sterile sample chamber. A magnetic stirring bar should be added to liquid or slurry-phase wastes. Maintain careful records of all sample preparation and sample chamber loading activity (i.e., amount of waste added to the chamber).

4. Assemble the electrolytic cell, CO_2 scrubber and gas volume transducer for each sample chamber (refer to BI-1000 instrument manual). Common problems with the apparatus assembly include improper electrode placement (i.e., electrodes bent and touching glass walls of apparatus) and incorrect electrolyte and/or CO_2 absorbent levels.

5. Check the water level and temperature in the water bath and the check the operation of the internal barometer. Make adjustments if necessary.

6. Assemble each sample chamber and connect each to the cell control unit via the cell's electrical cable. Position each chamber in the water bath and adjust operation of the magnetic stirrer (liquid and slurry samples).

4.2 Operation of Respirometer (Refer to instrument operating instructions)

1. Boot up the computer and access the main BI-1000 operation program.

2. Access each new sample cell and set the cell's operating parameters (refer to instrument manual).

3. Perform cell leak test for each sample chamber, and reassemble cell if necessary.

4. Start each cell (refer to instrument manual).

5. After several hours of operation, check the progress of the experiment using the Display Graph function (refer to manual). Compare the observed results with the expected results. Adjust the cell's operating parameters if necessary.

6. Check the progress of the experiment daily and save cell data to disk. Correct any operations problems (such as stir bar decoupling) and record relevant information in the project laboratory notebook. Check water bath temperature and level and adjust if necessary.

7. At the end of the experiment save final data to disk. Convert data to the desired format (refer to project work plan) and prepare test narrative for client, if appropriate.

8. Record instrument usage in BI-1000 instrument log and on project charge sheets.

9. Clean all BI-1000 apparatus used, including glassware and electrodes, and return to appropriate places.

5.0 CALCULATIONS

Data processing by the BI-1000 is automatic. However, each cell's operating parameters should be checked against the sample preparation records to ensure that all computations were made with the appropriate assumptions.

If cell data is transferred to a different software package (such as LOTUS or FREELANCE) the data should be checked to ensure that no errors occurred during data transferral.

Oxygen consumption by the sample is equivalent to the oxygen production by the oxygen electrodes during cell operation (converted to mg/L or mg/Kg based on sample quantity).

The oxygen uptake rate (OUR) of the sample is the oxygen consumption by the sample with respect to time.

The oxygen consumption rate change is the change in oxygen uptake rate with respect to time. A change in OUR might be expected if a sample amendment was added either at the beginning or in the middle of an experiment.

6.0 QUALITY ASSURANCE AND CONTROL

All standard lab and sampling procedures (ReTec Laboratory QA/QC Manual) are followed to ensure accurate and reliable data are generated. Lab procedures ensure the equipment is cleaned and adequate for the objectives of the study to minimize ambiguous results. Sampling methods are done in accordance with stated objectives and in a manner which is representative of test conditions established for the study. Sample design and data interpretation are in accordance with statistical methodologies to ensure definitive conclusions of the experiment.

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BI-1000 usage, maintenance and calibration records are kept in the permanent BI-1000 instrument log. Calibration of the BI-1000 is performed every 2 months during regular operation.

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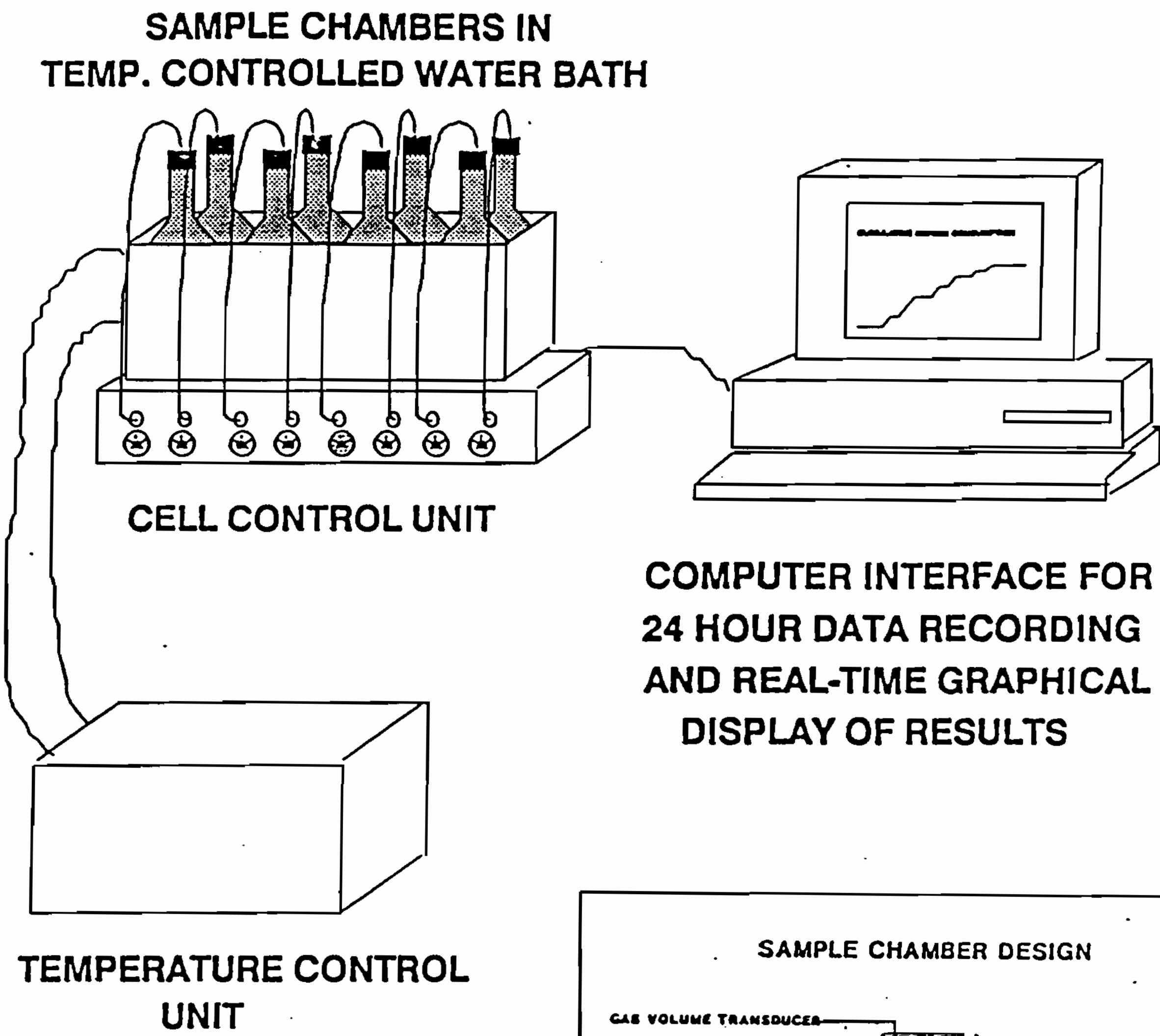
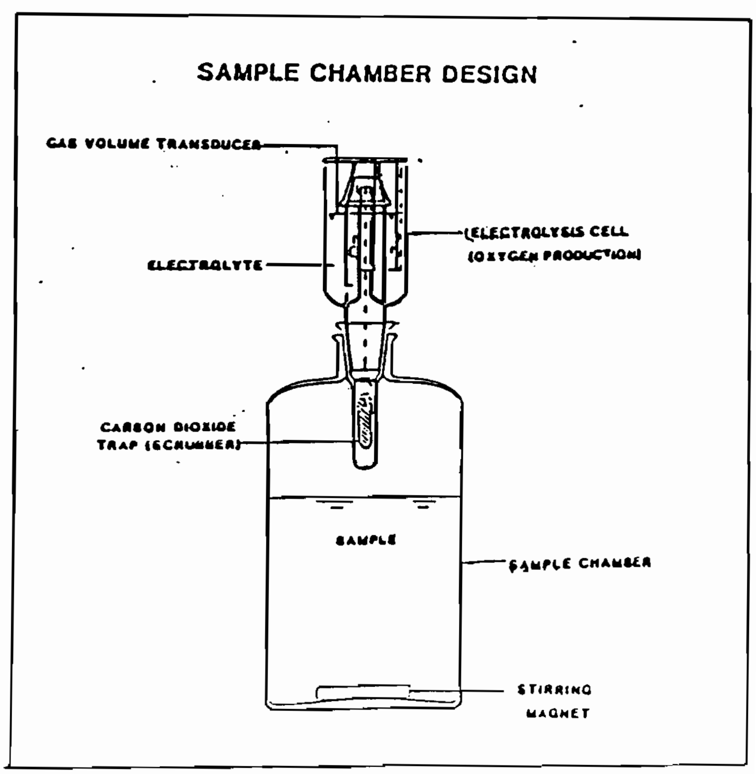
BIOSCIENCE BI-1000 AUTOMATED RESPIROMETER





STANDARD METHOD FOR NUTRIENT ADSORPTION TESTING

APPROVAL: ______________ DATE: 2-26-92

APPROVAL: ______________ DATE: 2-26-92

1.0 SCOPE

This standard operating procedure (SOP) describes the methods for testing nutrient adsorption by soils. This test involves spiking a soil slurry with a known nutrient concentration and measuring nutrients in the water portion after 24 hours.

2.0 SIGNIFICANCE AND USE

Nutrient adsorption testing provides an indication of the extent of nutrient binding by soil. Results of this testing reveals possible concerns about the availability of nitrogen and phosphorous to microorganisms during in situ treatment. Further testing may include soil column testing to determine if nutrient interactions will decrease permeability, and to evaluate rates of nutrient transport through site soils.

The adsorption of nutrients by soil particles is most likely due to high concentrations of calcium and magnesium. Additional testing to be performed on soils that show high nutrient adsorptive capability includes pretreatment with polyphosphates which attach to binding sites that could potentially adsorb nutrients.

3.0 MATERIALS

The following materials (in addition to standard laboratory equipment) are needed for nutrient adsorption testing set up and monitoring:

1. 250-ml Erlenmeyer flask
2. cover for flasks (foil)
3. ammonium chloride (NH_4Cl)
4. potassium phosphate mono- and di-basic (KH_2PO_4 and K_2HPO_4)
5. potassium tripolyphosphates
6. shaker table
7. centrifuge
8. filtering apparatus

4.0 PROCEDURE

4.1 Set Up and Sampling

1. Make a nutrient stock of 500 ppm nitrogen as NH_4Cl and 500 ppm phosphate as an equimolar mixture of KH_2PO_4 and K_2HPO_4 in deionized water (DI). Adjust pH to 7.0.

2. Make a 10% slurry (x grams of soil:x grams of nutrient stock) for each soil in a total volume of 200 mL. Place each slurry in a 250 mL flask and adjust pH to 7.0.

3. Cover each flask.

4. Place each flask on a shaker table (150 rpm) and incubate at room temperature for 24 hours.

5. After 24 hours, separate the soil and water portions by centrifugation and/or filtering.

6. Submit an initial nutrient stock sample and the final water portion from each slurry sample (properly preserved) for nutrient analysis of ammonia-nitrogen and orthophosphate.

7. Compare the nutrient concentrations in the initial and final samples to determine the extent of nutrient adsorption.

4.5 <u>Optional</u>

1. If a groundwater sample collected from the same site is available, it can be used in place of DI water for each slurry.

2. If high nutrient adsorption (greater than 50% of initial concentration) is observed, then the soil can be pretreated with polyphosphates (100 ppm) prior to testing.

3. Make a slurry with 100 ppm polyphosphate solution. Place on shaker table for approximately 1 hour.

4. Centrifuge and decant aqueous phase.

5. Repeat nutrient adsorption test.

5.0 QUALITY ASSURANCE AND CONTROL

All standard lab and sampling procedures (ReTeC Laboratory QA/QC Manual) are followed to ensure that accurate and reliable data are generated. Lab procedures ensure the equipment is cleaned and adequate for the objectives of the study in order to minimize ambiguous results. Sampling methods are done in accordance with stated objectives and in a manner which is representative of test conditions established for the study. Sample design and data interpretation are in accordance with statistical methodologies to ensure definitive conclusions of the experiment.

All work performed is recorded in a permanent laboratory notebook for future reference. Analytical results are stored in a central lab file with copies pasted into the laboratory notebook. Chain-of-Custody and request for analysis sheets accompany all samples entering and exiting the lab. A copy of the Chain-of-Custody is kept on file until completion of the study.

6.0 RESPONSIBILITIES

The project engineer/scientist is responsible for the lab, sampling procedures, sampling design and operating parameters for each experimental procedure. The project engineer also prepares the final report and maintains the project file and notebook.

The project manager is expected to coordinate scheduling and provide oversight to ensure the specific objectives of each test are met. The laboratory technician is responsible for the execution of the laboratory tests. Standard lab procedures are followed to ensure accuracy and precision. He/she is also expected to record the methods, observations and deviations of each test in the dedicated lab notebook for that specific project.

7.0 HEALTH AND SAFETY

A comprehensive health and safety program has been developed and is maintained at ReTeC's laboratory facilities. All analytical chemistry and treatability work is conducted in accordance with the Corporate Chemical Hygiene Plan and the Health and Safety Program.

All technical and support staff receive regular training and instruction in safe work practices and in procedures for dealing with accidents involving test substances. All laboratory operations are approved by the laboratory manager prior to implementation. Select carcinogens, reproductive toxins and substances having a high degree of acute toxicity are used only in posted, "Designated Areas".

Formal laboratory inspections are conducted on a quarterly basis to ensure compliance with existing laboratory policies and government regulations. Work place air samples and wipe samples are conducted for determination of the amount and nature of airborne and/or surface contamination, and for use in the evaluation and maintenance of appropriate laboratory conditions. Air sampling is accomplished using the NIOSH grab sampling method with Drager colorimetric tube apparatus. Results of air monitoring are posted as required by the OSHA Lab Standard (29CFR 1910.1450).

Material Safety Data Sheets (MSDS) for all chemicals in the laboratory are maintained in three ring binders. All laboratory employees are trained in accessing and proper interpretation of MSDS files. The MSDS documents are readily available to employees and are located just adjacent to the laboratory, in the Health and Safety Officers possession. This area is accessible to all employees, at all times. In addition to the MSDS files, a number of other technical references which provide information pertaining to proper hazardous chemical handling procedures, proper disposal practices of chemicals in laboratories and various encyclopedias of chemicals, drugs and biologicals are available.

All personnel involved in use of hazardous agents obtain yearly medical examinations and surveillance and are provided with proper protective equipment necessary for the safe performance of their jobs. Personal protective equipment includes, but is not limited to, safety glasses with side shields, gloves, a clean lab coat and/or apron and a respirator. A standard operating procedure for the selection, care and proper use of respirators is available and is based on the OSHA Respiratory Protection Standard (29 CFR 1910.134). Work practices are designed using proper engineering controls (fume hoods) so that an employee's exposure to hazardous chemicals in the laboratory is minimized.

STANDARD METHOD FOR PEROXIDE STABILITY TESTING

APPROVAL: [signature] DATE: 2-26-92

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1.0 SCOPE

This standard operating procedure (SOP) describes the methods for peroxide stability testing. This test involves spiking a sample with a known concentration of hydrogen peroxide, and measuring the peroxide concentration at intervals for a 24 hour period.

2.0 SIGNIFICANCE AND USE

The stability of hydrogen peroxide (H_2O_2) in a soil and groundwater sample collected from the same site is tested to determine the feasibility of using peroxide as an alternate oxygen source during in situ bioremediation. The rate of peroxide decomposition is calculated from a decay curve. This value can be used to help determine the concentration of peroxide required for full-scale in situ bioremediation and the subsequent rate of oxygen delivery to the contaminated areas of the site.

Peroxide decomposition can occur chemically or biologically. Chemically, reduced minerals (e.g., iron) or possibly organic materials can catalyze peroxide decomposition. Aerobic and facultative microorganisms which are catalase or peroxidase positive have the capability to decompose peroxide.

To determine whether peroxide degradation is caused by chemical or biological reactions, samples are respiked after a 24 hour period and further losses of peroxide are monitored. After respiking, chemical degradation will normally decrease, while microbial decomposition should not be significantly affected. Polyphosphates can be added to deactivate minerals that catalyze peroxide decomposition.

This method is limited to measuring short term peroxide degradation. It does not account for long term acclimation of catalase positive microorganisms which could cause significant peroxide decomposition.

3.0 MATERIALS

The following materials (in addition to standard laboratory equipment) are needed for H_2O_2 stability testing set up and monitoring:

1. 100 ml volumetric flask
2. Hamilton syringes; 0-10 ul and 0-1000 ul
3. 10 ml test tubes with lids
4. 500 ml Erlenmeyer flask
5. 1 ml and 10 ml pipets
6. Foil
7. H_2O_2 test kit: Lamotte (Chestertown, MD) kit #3188/HP-40
8. Hydrogen Peroxide
9. Magnetic stir plate
10. Filtering apparatus
11. Centrifuge
12. Spectrophotometer
13. Tripolyphosphate ($Na_5P_3O_{10}$), optional

4.0 PROCEDURE

4.1 Preparation of Sample

Obtain a soil and groundwater sample for testing which have been collected from the same site.

1. Homogenize soil and determine the dry weight.

4.2 Measuring Peroxide Concentration

1. Obtain a clear liquid sample by centrifuging and/or filtering.

2. Perform dilution with deionized (DI) water, if necessary, to achieve a H_2O_2 concentration in the range of 0-50 ppm.

3. From this sample place 0.5 ml in a test tube and add 9.5 ml of DI water.

4. Obtain Lamotte test kit. Add one DPD tablet to test tube. Cover, and shake 3 minutes until tablet(s) is completely dissolved.

5. Add 4 drops of the reagent, and wait exactly 2 minutes for full color to develop, then measure absorbance at 550 nm using a spectrophotometer. Determine the H_2O_2 concentration by using the standard curve (see section 4.3).

4.3 <u>Spectrophotometer Preparation</u>

1. Warm up spectrophotometer (see manual), set wavelength to 550 nm and switch to visible light.

2. Make a blank using groundwater (or DI) sample to zero the spectrophotometer.

3. Make a standard curve from 0-50 ppm H_2O_2 by measuring triplicate standard H2O2 solutions of incremental concentrations (i.e., 10, 20, 30, 40 and 50 ppm).

4. Graph the standard curve, absorbance vs. time.

4.4 <u>Set Up and Monitoring</u>

1. In a 500 ml flask, make a 10 % solids loading soil:groundwater to a total volume of 200 ml.

2. Cover entire flask with foil to avoid any degradation of H_2O_2 by light.

3. Spike slurry with 500 ppm H_2O_2 and record time as time zero. Place flask on a magnetic stir plate for the duration of the test.

4. Measure H_2O_2 concentrations at intervals for a 24 hour period. The time intervals depend on the speed of H_2O_2 decomposition (suggest: 0,1,2,6 and 24 hours).

5. After 24 hours (if any decomposition has been observed), respike with 500 ppm H_2O_2 and measure concentrations at intervals up to 48 hours (suggest: 26, 30 and 48 hour).

6. Determine the rate of peroxide decomposition by making a decay curve (i.e., graph peroxide concentration (ppm) vs. time). From this graph, kinetic analyses can be performed.

4.5 Optional

1. If a groundwater sample is not available, the groundwater can be substituted for DI water in the slurry. This would require that DI water be used in place of groundwater for the blank and the standard curve.

2. If rapid peroxide degradation is observed, the soil can be pretreated with $Na_5P_3O_{10}$ to inhibit chemical decomposition.

5.0 QUALITY ASSURANCE AND CONTROL

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6.0 RESPONSIBILITIES

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